Appendix E-2

Comment Letters

ALAMEDA COUNTY COMMUNITY DEVELOPMENT AGENCY
PLANNING DEPARTMENT

CHRIS BAZAR
AGENCY DIRECTOR

ALBERT LOPEZ
DEPARTMENT DIRECTOR

224 W. WINTON AVE. ROOM 111, HAYWARD, CA 94544 P. 510-670-5400 F. 510-785-8793
ACGOV.ORG/CDA

EAST COUNTY BOARD OF ZONING ADJUSTMENTS

FRANK IMHOF, CHAIR
DEREK EDDY
SCOTT BAYER

STAFF: NILMA SINGH

Thursday, September 12, 2019

Regular Meeting Agenda – 1:30 pm
City of Pleasanton – Council Chambers
200 Old Bernal Avenue, Pleasanton, Ca

Only items on the agenda may be acted upon. Open Forum is available for anyone wishing to speak on an item not listed on the agenda. To address the Commission, please complete a speaker slip and turn it in to the Secretary, once recognition is received from the Chair, walk to the rostrum and state your name, address and comments. Each speaker may be limited to three minutes.

Field Trip ~ Cancelled

Regular Meeting

Time: 1:30 p.m.
Place: City of Pleasanton Council Chambers
200 Old Bernal Avenue, Pleasanton

A. Call to Order

B. Roll Call

C. Pledge of Allegiance

D. Open Forum

E. Neighborhood Preservation and Zoning Ordinance Abatement

1. **Vacant lot on Hartford Avenue, Livermore CA 94550**
APN: 902-0009-003-01
Hearing regarding violation of Alameda County Neighborhood Preservation Ordinance Section 6.65.030 A(1, 9, 10) and B(6) based on overgrown vegetation and weeds. Staff recommendation is to declare a public nuisance and require abatement of the violation of the property.

F. Alcoholic Beverage Sale Regulation Administrative Hearing ~ There are no items

G. Approval of Minutes from Previous Meeting ~ August 22, 2019
Attachment

H. Consent Calendar ~ There are no items.

I. Regular Calendar

2. **DARK HEART NURSERY/GRACE, CONDITIONAL USE PERMIT, PLN2018-00236 ~** Application to allow a cannabis cultivation operation, in an "A" (Agricultural) District, located at 5987 Mission Road, Sunol area of unincorporated Alameda County, designated Assessor's Parel Number: 096-0001-004-03.
Staff Planner: Sonia Urzua
Continued from March 28 and August 22, 2019
Attachment

3. **SAND HILL WIND, CONDITIONAL USE PERMIT, PLN2017-00201 - HEARING TO RECEIVE PUBLIC COMMENT ON THE DRAFT SUBSEQUENT ENVIRONMENTAL IMPACT REPORT (DSEIR) -** Application to allow repowering of an estimated 671 existing or previously existing wind energy turbine sites with up to 40 new turbines with a maximum production capacity of 144.5 megawatts (MW), using turbines rated between 2.3 and 3.8 MW (potentially up to 4.0 MW) per turbine, on fifteen (15) nearly contiguous parcels on approximately 2,600 acres in the eastern portion of the Altamont Pass Wind Resource Area, bordering both sides of Altamont Pass Road west of Grant Line Road, both sides of Mountain House Road north of Grant Line Road, generally west of Bethany Reservoir and southeast of the intersection of Christensen and Bruns Roads, bearing Assessor's Parcel Numbers (APNs): 99B 7750-6; 99B-6325-1-4; 99B-6325-1-3; 99B-7375-1-7; 99B-7400-1-5; 99B 7300-1-5; 99B-7050-4-6; 99B-7050-1-9; 99B-7050-4-1: 99B-7350-2-1; 99B 7350-2-15; 99B-7350-2-5; 99B-7500-3-2; 99B-7500-3-1; and 99B-7600-1-1. Subject to certification at a future meeting of the Final Subsequent Environmental Impact Report, tiered under the Program Environmental Impact Report certified by the EBZA on November 12, 2014, pursuant to CEQA Guidelines, Sections 15162 and 15168.
Staff Planner: Andrew Young
Public Comment Only
Attachment

J. Staff Comments & Correspondence

K. Board Announcement, Comments & Reports

L. Adjournment

Next Meeting:
Thursday, September 26, 2019

MINUTES OF MEETING
EAST COUNTY BOARD OF ZONING ADJUSTMENTS
SEPTEMBER 12, 2019
(Approved November 14, 2019)

FIELD TRIP – *Cancelled*

REGULAR MEETING

CALL TO ORDER: *The Chair called the meeting to order at 1:40 p.m.*

MEMBERS PRESENT: Members Frank Imhof and Derek Eddy

MEMBERS EXCUSED: Members Scott Beyer, Vice-Chair

OTHERS PRESENT: Sonia Urzua, Senior Planner; Andrew Young, Senior Planner; Paul daSilva, Zoning Investigator; Heather Littlejohn, County Counsel's Office; and Nilma Singh, Recording Secretary.

There were approximately nineteen people in the audience.

PLEDGE OF ALLEGIANCE

OPEN FORUM: Open forum is provided for any members of the public wishing to speak on an item not listed on the agenda. Each speaker is limited to three (3) minutes. *No one requested to be heard under open forum.*

NEIGHBORHOOD PRESERVATION AND ZONING ORDINANCE ABATEMENT

1. **Vacant lot on Hartford Avenue, Livermore CA 94550**
   APN# 902-0009-003-01
   Hearing regarding violation of Alameda County Neighborhood Preservation Ordinance Section 6.65.030 A(1, 9, 10) and B(6) based on overgrown vegetation and weeds. Staff recommendation is to declare a public nuisance and require abatement of the violation of the property.

The owner was not available. The Chair made the motion to adopt staff recommendation and declare the property a public nuisance and require abatement to be completed within 10 days. Member Eddy seconded and the motion carried unanimously, 2/0.

ALCOHOLIC BEVERAGE SALE REGULATION ADMINISTRATIVE HEARING - *None*

APPROVAL OF MINUTES FROM PREVIOUS MEETINGS

1. **APPROVAL OF BOARD MINUTES ~** August 22, 2019 – *continued.*

CONSENT CALENDAR: *No items*

REGULAR CALENDAR:

2. **DARK HEART NURSERY/GRACE, CONDITIONAL USE PERMIT, PLN2018-00236 ~** Application to allow a cannabis cultivation operation, in an "A" (Agricultural) District, located at 5987 Mission Road, Sunol area of unincorporated Alameda County, designated Assessor's Parel Number: 096-0001-004-03.
   Staff Planner: Sonia Urzua
   Continued from March 28 and August 22, 2019

Ms. Urzua summarized the staff report.

Public testimony was called for. Dan Grace, President of Dark Heart Nurseries, in response to the Board, explained that the next step after this approval is to obtain a State License and complete improvements per the State requirements.

Public testimony was closed. *Member Eddy made the motion to move staff recommendation for an approval subject to the recommended conditions. The Chair seconded and the motion carried unanimously, 2/0, with Member Beyer excused.*

3. **SAND HILL WIND, CONDITIONAL USE PERMIT, PLN2017-00201 - HEARING TO RECEIVE PUBLIC COMMENT ON THE DRAFT SUBSEQUENT ENVIRONMENTAL IMPACT REPORT (DSEIR) -** Application to allow repowering of an estimated 671 existing or previously existing wind energy turbine sites with up to 40 new turbines with a maximum production capacity of 144.5 megawatts (MW), using turbines rated between 2.3 and 3.8 MW (potentially up to 4.0 MW) per turbine, on fifteen (15) nearly contiguous parcels on approximately 2,600 acres in the eastern portion of the Altamont Pass Wind Resource Area, bordering both sides of Altamont Pass Road west of Grant Line Road, both sides of Mountain House Road north of Grant Line Road, generally west of Bethany Reservoir and southeast of the intersection of Christensen and Bruns Roads, bearing Assessor's Parcel Numbers (APNs): 99B 7750-6; 99B-6325-1-4; 99B-6325-1-3; 99B-7375-1-7; 99B-7400-1-5; 99B 7300-1-5; 99B-7050-4-6; 99B-7050-1-9; 99B-7050-4-1: 99B-7350-2-1; 99B 7350-2-15; 99B-7350-2-5; 99B-7500-3-2; 99B-7500-3-1; and 99B-7600-1-1. Subject to certification at a future meeting of the Final Subsequent Environmental Impact Report, tiered under the Program Environmental Impact Report certified by the EBZA on November 12, 2014, pursuant to CEQA Guidelines, Sections 15162 and 15168.
   Staff Planner: Andrew Young
   Public Comment Only

Andrew Young, project planner, with a powerpoint presentation, discussed the following: Summary of the Project; Project Layouts; Environmental Review Program EIR; Program EIR-Other Projects. Sally Zeff, ICF, Environmental Consultant, continued with powerpoint and discussed the SDEIR--Significant Unavoidable Impacts; Alternatives Analyzed; Process Followed; Planning Considerations; Summary of Visual Impacts and Biological Resources Impact; Micro-Siting Report; Changes and Additions to DEIR Monitoring Measures; and, Visual Analysis.

Public testimony was called for. Korina Cassidy, applicant, also with a powerpoint presentation, discussed the following: Project Overview; Layout Map-Comparison of Golden Hills and Sand Hill; PEIR and Sand Hill; Benefits to Local Community; Project Schedule; Avian Micro-Siting; and Conclusion.

Adrian Dykzeul expressed his concerns re lack of a response to his October 23, 2018 complaint regarding noise from #23 turbine and re-iterated that he would like #23 removed. PH-1

Public testimony was closed. The Board requested clarification regarding the possibility of re-locating #23. Ms. Cassidy replied that there is no alternative location due to micro-siting and according to the noise study, the noise level is within the threshold. The Board requested a map of all the turbines that are being removed, a map of other project turbines and requested clarification re removal of infrastructure.

No action was taken and the matter was continued to October 24, 2019.

STAFF COMMENTS & CORRESPONDENCE: *Staff announced that the September 26th meeting has been cancelled and the next meeting is October 24, 2019.*

COMMISSION ANNOUNCEMENTS, COMMENTS AND REPORTS: *None*

ADJOURNMENT: *There being no further business, the meeting adjourned at 2:33 p.m.*

ALBERT LOPEZ, SECRETARY
EAST COUNTY BOARD OF ZONING ADJUSTMENTS

Letter 1

Shawn Smallwood, PhD
3108 Finch Street
Davis, CA 95616

Andrew Young, Senior Planner
Planning Department
Alameda County Community Development Agency
County of Alameda
224 W. Winton Avenue, Room 110
Hayward, CA 94544

18 September 2019

RE: Sand Hill Supplemental EIR

Dear Mr. Young,

1-1

After reviewing the Sand Hill SEIR and its attachments, I am compelled to provide comments. I am compelled because I found many inaccuracies, misleading statements, and glaring omissions in the SEIR, including around my own work related to micro-siting of the proposed Sand Hill turbines. While reading the SEIR attachments, I learned for the first time that another micro-siting report (Estep 2019) was prepared as an alternative to ours (Smallwood and Neher 2018). Until the SEIR's public circulation, I had no idea that Estep had prepared a competing risk assessment, nor that he had criticized our work. To justify Estep's (2019) report while sidelining ours, Estep (2019), along with Anonymous[1] (2019), made criticisms and assertions that misrepresent our approach and recommendations, and which warrant responses. To more effectively reveal their misrepresentations, I provide some background that explains our micro-siting approach and why it was best-suited to meet the County's mitigation standard for siting wind turbines in repowered projects in the Altamont Pass Wind Resource Area (APWRA).

1-2

The County's standard reads, "*All project proponents will use the best information available to site turbines to reduce avian collision risk: avian use of the area; topographic features known to increase collision risk (trees, riparian areas, water bodies, and wetlands); and the latest models of collision risk)*" (ICF 2014:3.4-104). How did this standard come about?

1-3

Origin and Purpose of Careful Micro-siting

As I understand the history of wildlife-wind energy issues in the APWRA, one or more biologists from the California Energy Commission (CEC) had visited the APWRA in the late 1980s and noticed dead raptors at wind turbines. The CEC contracted with Estep to assess potential impacts of the APWRA's wind turbines on raptors. He did not have much to work with in 1989, as there was no fatality monitoring and no preceding history

[1] Anonymous is so-cited because it lacked a by-line, affiliation, or date. I assume, but I do not know, that the document was prepared by S-Power. The file name was 'Sand Hill Micrositing Alternative Summary v190405.'

of wind turbine fatalities in the USA, but he warned of a potential problem for raptors in the APWRA and he concluded it qualified as an environmental concern. From that starting point, research was initiated to estimate the magnitude of impacts and to identify causal factors that could inform mitigation solutions. Funded by the CEC, Orloff and Flannery (1992) reported on the first major study with these goals in mind. Starting at about the same time, a series of weaker studies generated alternative results to those of the groundbreaking study of Orloff and Flannery. This same strategy has been used repeatedly in response to major studies in the APWRA since Orloff and Flannery, claiming lower fatality rates, presenting alternative collision mechanisms, claiming background mortality as the true source of wind turbine-caused fatalities, and formulating mitigation measures and plans lacking in empirical foundation and standing little chance of success. 1-3 cont.

I began research in the APWRA in 1999, joining an in-progress study funded by the CEC and National Renewable Energy Lab (NREL), and which turned out to be the third major study of wildlife and wind energy in the APWRA, following Orloff and Flannery's (1992) effort and Granger Hunt's golden eagle telemetry study. Smallwood and Thelander (2004, 2005) was received similarly to Orloff and Flannery (1992), replete with harsh criticisms and competing results from the wind industry, including environmental consultants often working for wind companies. But Smallwood and Thelander (2004, 2005) reinforced the important results from Orloff and Flannery (1992), pointing the way towards mitigation solutions. Data from the Smallwood and Thelander effort resulted in numerous additional reports, papers, and theses, many of them peer-reviewed and published in the scientific literature. They covered behavior patterns (Rugge 2001, Hoover 2001, Hoover and Morrison 2005, Smallwood et al. 2009a), the role of prey species on raptor behavior patterns (Smallwood et al. 2001), fatality estimation methodology (Smallwood 2007) and fatality estimates (Smallwood et al. 2007, Smallwood and Thelander 2008, Smallwood and Karas 2010), mitigation (Smallwood 2008, 2009), and careful micro-siting to minimize raptor mortality (Smallwood and Spiegel 2005a,b,c). We had learned a great deal about the types and magnitudes of impacts and their contributing factors.

By the end of the second major study I had seen enough to realize that much more needed to be done to address the impacts. I personally found many dead and injured birds – birds with wings lopped off, birds split in half, and birds bashed to pieces. I estimate that by now the APWRA has killed hundreds of thousands of birds, including more than 2,000 golden eagles and more than 60,000 raptors. My options were either to advocate against wind power or to use what I'd learned to test the safety of new wind turbine models and to develop macro- and micro-siting tools to minimize wind energy impacts going forward. By this time period I was visiting wind projects around the world, where local biologists would, as an amusing aside, ask me to identify the one or few wind turbines that killed disproportionate numbers of this or that raptor species. I picked the offending turbines every time. I realized I had learned enough already to effectively micro-site wind projects. But I also knew that I needed to know more, and I needed a scientific tool to reinforce my recommendations. I chose to proceed with additional research programs to develop micro-siting as a mitigation option.

With funding from various sources, including CEC, East Bay Regional Park District, East Contra Costa County Habitat Conservancy, and mitigation funds from NextEra for its repowering projects, I led studies on the burrowing owl distribution across the APWRA from 2011 (Smallwood et al. 2013) through 2019, thousands of behavior surveys during day and night from 2012 through 2019, and fatality monitoring at old turbines (Smallwood 2018, Smallwood et al. 2010, 2018) and new turbines (Brown et al. 2016). Some of this work was summarized in Smallwood (2016). I collaborated with Doug Bell on tracking golden eagles in the APWRA using GPS transmitters (Smallwood et al. 2017a,b), and I collaborated with Lee Neher on development of slope measurements from a digital elevation model of the APWRA. As each repowering project was pursued, we prepared map-based collision hazard models, each modeling effort relying on updated data and each benefitting from the lessons learned from previous repowering efforts. And as we proceeded, we tested our performance in every way possible (e.g., Smallwood and Neher 2017, Smallwood et al. 2017, and see Figure 26 in Smallwood and Neher 2018). On behalf of our clients, and on behalf of the birds at issue, we endeavored to more than meet the County's mitigation standard on turbine siting. 1-3 cont.

By the time we were recruited by ICF[2] to provide micro-siting recommendations on the Sand Hill project, we had gained knowledge and developed our skills far beyond our starting point with the Tres Vaqueros and Vasco Winds projects, the latter of which proved very successful in terms of fatality reductions of targeted raptor species (Brown et al. 2016). We'd also micro-sited wind turbines for Ogin, Inc. at Sand Hill the year earlier, where for three years I had also overseen fatality monitoring, burrowing owl surveys, diurnal raptor behavior surveys, and nocturnal surveys using a thermal-imaging camera for bats, owls, nocturnal migrants, and terrestrial mammals. We were much more familiar with wildlife and wind turbines at Sand Hill than any other biologist could have been; we were suited for the job.

Rationale for Alternative Siting Analysis 1-4

Estep (2019) and Anonymous (2019) justify the alternative micro-siting analysis with a series of criticisms and false characterizations of our approach. Their criticisms, however, were founded on red-herring arguments, mischaracterizations of our work, and apparent misunderstanding of our methods which could have been rectified by asking us for clarifications where needed. None of the complaints about our work were brought to our attention until the public circulation of the SEIR.

The core criticisms include (1) inadequate evidence that our approach is effective; (2) limitations in our model; (3) lack of clarity behind our micro-siting recommendations; (4) speculation that modern wind turbines pose different collision risks from old-generation turbines. In this order I address these criticisms in the paragraphs that follow.

(1) Effectiveness.—According to Estep (2019:3), "*…due to concerns regarding the effectiveness of the model and the lack of clear rationale in the results and* 1-5

[2] We declined to subcontract to ICF. We ended up contracting with S-Power directly.

recommendations, sPower decided to conduct an additional siting assessment of the proposed project." He adds, "*Although the collision hazard model approach seems to include the necessary model attributes, to date there have been few opportunities to test its effectiveness*" (Estep 2019:7), and "*To date, there is little evidence that would confirm the effectiveness of micro-siting of turbines in a repowered landscape due to application of the model*" (Estep 2019:7). Citing a monitoring report from Golden Hills, Estep claims that model performance has varied. What he is saying, in various ways, is that our collision micro-siting approach proved ineffective at Golden Hills. 1-5 cont.

What Estep does not address is that our micro-siting recommendations have been only that – recommendations. We never controlled project size or turbine size, nor did we ever decide on turbine locations or grading practices. These decisions are made by the wind companies. No micro-siting recommendations, whether based on predictive models or hazard ratings or both, can perform any more effectively than they are followed by those receiving the recommendations. Estep and Anonymous blame the messenger for outcomes at Golden Hills, but without making the case that the message was flawed.

Regarding evidence of the performance of or approach, I am not sure that Estep has been paying attention. Brown et al. (2016) and Smallwood et al. (2017) provided such evidence of performance at Vasco Winds. Each of our project-specific micro-siting reports included assessments of performance. Smallwood and Neher (2017) summarized the performance of each model version from Tres Vaqueros through Vasco Winds, Golden Hills, Patterson Pass, Golden Hills North, Ogin's version of Sand Hill repowering, and Summit Winds. Smallwood (2018) provided an Addendum to Smallwood and Neher (2017), in which he tested model performance at Golden Hills by using first-year fatality monitoring data. Most of these reports are cited in County of Alameda (2019:3.4-7). Attached to my comments, herein, is an update to Smallwood (2018), incorporating the second year of fatality monitoring data from Golden Hills (Smallwood 2019, Attachment).

Our micro-siting recommendations performed well at Golden Hills (Smallwood 2019). Relating golden eagle fatalities to the factors underlying our siting recommendations, I revealed that 4 turbines with the highest risk have so far suffered 10 times the golden eagle fatality rate of 22 turbines with the lowest risk (Smallwood 2019). I can measure this outcome because the turbine layout did not follow directly from our recommendations, just as the currently proposed Sand Hill layout does not follow directly from Estep's recommendations, nor from ours. Differences between recommended and actual turbine layouts enable a performance test of the former. Smallwood and Neher (2015) provided sound recommendations based on mostly accurate predictions, although time will tell whether a few of our predictions will hold up.

One Golden Hills turbine that I predicted would kill multiple red-tailed hawks, has so far not done so, and another turbine I predicted would kill few red-tailed hawks actually killed 6 red-tailed hawks during the first year of monitoring, although I will add that that number was 0 in the second year. But as I explained earlier, our approach builds on both successes and errors – wherever we believe we got it wrong, we learn from our errors. In response to the Golden Hills turbine that killed 6 red-tailed hawks in year one, I subsequently spent many hours watching red-tailed hawk behavior around that turbine. In doing so, I learned that red-tailed hawks pass over that ridge in abundance during evening hours, all of them heading west, presumably to roost sites. Prior to that, behavior surveys and utilization surveys had been restricted to mornings through mid-afternoons, but performing surveys in the evening has revealed intense activity by American kestrels and burrowing owls during that time, as well significant flight patterns of red-tailed hawks and golden eagles just at the time when visibility wanes. All of this experience – the failures along with the successes at Golden Hills – were brought to the benefit of micro-siting at Sand Hill. 1-5 cont.

(2) Model limitations.—Estep (2019:6) could have been more specific where he says, "*…there are limitations in the current application of the model that potentially reduce its effectiveness and may restrict its utility*." Like what? We acknowledge model limitations, and our report is replete with caveats of potential limitations and biases. Every micro-siting approach will have limitations. The rating system used by Estep was much more limited, such as no substantial scientific foundation. 1-6

According to Estep (2019:6), "*… it is unclear how the specificity of the model outcomes corresponds to higher certainty with regard to a potential reduction in fatalities of target species*." Clarity can be found, however, in Figure 26 of or report, where measured fatality rates are compared to model predictions. In Figure 26 we show the magnitudes of effect, as well as confidence intervals. We also discuss how our past efforts performed in terms of fatality reductions at the repowered Vasco Winds project, where the reduction was measured as part of a before-after, control-impact experimental design (also see Brown et al. 2016). It is hard for me to imagine what specificity Estep thinks we are missing. But one thing I know with certainty is that Estep's approach provided no specificity at all in how his ratings correspond to potential fatality reductions. Estep explains that his assignment of risk designations "*do not otherwise indicate that a site will have more or less collision events than another, only that based on these factors, the potential for more or less collision events is assumed*."

Estep then proceeds to cast doubt on the information we used to learn about collision risk. He says, "*…particularly evident in the use of avian flight and behavior data, which is largely based on presumably inexact observational field mapping and its association with landforms – in contrast to the specificity of the digital elevation model*." An example that is "particularly evident" should not be premised on anything presumed. We managed the error in the data, including in the digital elevation model (DEM) of the landscape, which Estep appears to kindly assume was exact. (It was not, and we took great pains to correct the DEM and to derive slope attributes that were appropriate in the face of the uncertainty we experienced.) The flight behavior data were collected with plenty of error, and so were the telemetry data, but none of these data were related to any single analytical cell values of the DEM, as explained in our report. We opted to derive slope measurements from the DEM, which we then used to derive slope features, and it was the latter measurement resolution to which we related flight and telemetry data. Estep's presumption was incorrect, as we related behavior

1-6 cont.

data to landscape features measured at appropriate spatial grain to overcome quantified levels of error in the data. The fuzzy logic approach itself assumes fuzzy rather than hard boundaries around avian responses to landscape features – an analytical approach that again refutes Estep's assertion that we related messy behavior data to individual DEM grid cells. We did not.

Estep (2019:6) then speculates, "*…attempting to precisely describe high risk conditions through a standardized modeling procedure may not be well-supported given the complexity and uncertainty of bird movements and continued lack of supporting data with regard to specific causes of collision events – particularly with new-generation turbines.*" What is uncertain about a bird's movement? We recorded thousands of bird flights, and using telemetry data we recorded tens of thousands of golden eagle flights, many of them in the context of modern wind turbines. We mapped the locations of hundreds of burrowing owl nests, and we spent hundreds of hours observing them at night, including in close proximity to modern wind turbines. From these data we observed strong patterns, including patterns that correlated with measured fatality rates and observed near-miss collisions at both old and modern wind turbines. We challenged our model predictions by comparing them to experience-based hazard ratings, and by applying them to wind turbines that were either not micro-sited for avian safety or were micro-sited using an earlier model. Without actually observing bird behaviors around wind turbines, it is difficult to imagine how one can improve on collision risk assessments performed by someone who has. And without standardizing the appropriate methods, it is hard to imagine how one performs scientific investigation.

Estep (2019:6) raises a red herring argument while mischaracterizing our approach, "*Although certainly valid in a general sense, it's unclear how the model outcomes result in small changes to turbine siting that would not be otherwise apparent during a field assessment.*" In truth, our micro-siting recommendations were based on a combination of model predictions, experience, and hazard ratings made during site visits. Our recommendations cannot be attributed solely to model predictions, because they were not. But Estep might ask himself a similar question: 'How is it clear that Estep's hazard ratings result in small changes in turbine siting that are not otherwise supported by years of supporting data and analysis?'

Estep (2019:6) offers no evidence in support of his claim that our use of fatality data from old-generation turbines was inappropriate. He also ignores that we also used fatality data from modern wind turbines in the APWRA. Furthermore, he neglects to consider that his hazard rating approach was derived from fatality data collected from old-generation wind turbines – data that he and I were supplied when we set out to rate collision hazard of thousands of old-generation wind turbines nearly a decade ago. Unlike what the SRC had available for developing the hazard ratings, however, both our modeling approach and my application of the hazard ratings benefitted from fatality monitoring data from modern wind projects from Buena Vista to Vasco Winds to Golden Hills.

To justify Estep's effort, Anonymous (2019) cites our caveat, "*map-based collision hazard maps need to be interpreted carefully, meaning the hazards of specific terrain* *and wind situations . . . should always trump model predictions.*" However, our caveat in no way advocated for confusing our risk assessment by initiating another one. With our report, we had already provided the care in interpretation of model predictions, and this care carried to our micro-siting recommendations. 1-6 cont.

(3) Unclear rationale for siting recommendations.—Estep (2019:13) says that Smallwood and Neher's (2017) micro-siting recommendations "*lacked clear rationale or a clear relationship between the model results and determinations*." We were never asked to provide such rationale, nor was doing so an identified task in our Statement of Work with S-Power. Nevertheless, our report summarized our SRC-style hazard rating, our hazard class predictions from our models, and a history of fatality monitoring results at nearby old-generation wind turbines (Table 11). It also summarized our hazard concerns for each site, as well as a column dedicated to micro-siting recommendations (Table 12). With past repowering projects, we have elaborated on site-specific recommendations in person with company engineers and planners when it came to actually making siting decisions. In this case, we were never asked to participate with siting decisions. Had we been asked to elaborate on site-specific recommendations, we would have done so. 1-7

(4) Speculated changes in risk profile with modern turbines.—Estep (2019:6) speculates "*What may be regarded as a high-risk site for old generation turbines may be less risky in a repowered landscape with fewer, larger turbines and with the vastly different structural and operational aspects between old- and new-generation turbines*." I am unclear over how this possibility justified Estep's approach over ours, but I submit that I have brought ample experience of such changes to my micro-siting recommendations. I have been involved with every repowering project in the APWRA since Buena Vista, and I collected and analyzed relevant data extending all the way from the APWRA's first-generation turbines to the most recently constructed turbines. With every repowering effort, I have tested model performance and improved our understanding of how modern turbines altered collision risk. Estep, on the other hand, brought none of this experience to his alternative siting assessment. 1-8

Mischaracterization of our Approach 1-9

Estep (2019) and Anonymous (2019) mischaracterize our micro-siting approach with a series of inaccurate and misleading statements. For example, Estep (2019:6) attributes objectives to our effort that do not appear in our report – objectives such as increasing certainty and providing "*precise recommendations*." Estep's characterization of certainty seems out of place in prediction science, in which predictions are never certain.

Anonymous (2019) says we relied on 3 predictor variables, including flight behaviors, fatality data, and terrain features. Estep (2019) repeated this same characterization, which is incomplete and oversimplified. We also relied on GPS telemetry data and on burrowing owl locations, and we expressed the data from these larger factors as metrics, which are explained in our report.

According to Anonymous (2019), "*Smallwood and Neher (2018) concluded that, with micro-siting, the Project would be expected to reduce fatalities of raptors and birds as a group compared to the pre-repowering baseline, …*" We did not predict reduced fatalities of birds as a group. In fact, we included a statement of concern regarding small bird fatalities and bat fatalities resulting from the project. As for the target raptor species, we predicted reduced fatality rates (page 2), which is not the same as project-wide fatalities. In fact, we caveated in two places that we made no predictions or statement of opinion about the size and capacity of the project. With reduced fatality rates, the project can still result in a net increase in fatalities if the project's size is much larger than the project that existed before repowering. For example, the Sand Hill project my colleagues and I monitored for fatalities had an installed capacity of 23.123 MW,[3] and our estimated bird fatality rate ranged up to 41 bird fatalities per MW per year (Smallwood 2016, Smallwood et al. 2018). If repowering reduced that rate by half but the project was 109 MW in size, as proposed by Anonymous (2019), then project-wide bird fatalities would increase by 2.35-fold, from 948 to 2,235 per year. I am not saying that is the case here, but rather that there is a distinction between fatality rates and project fatalities, and one needs to be careful how these metrics are interpreted. 1-9 cont.

Anonymous (2019) describes how micro-siting recommendations for various turbines would have interfered with desired energy generation, and how S-Power resolved the problem by resorting to a smaller turbine. Anonymous claims these changes reduced collision risk to birds, but the opposite could be true for the target species for which the micro-siting recommendations were prepared. Using turbines with lower energy-generating capacities can result in more wind turbines on the project site, which was a factor that contributed to the higher-than expected fatalities of golden eagles and red-tailed hawks at Golden Hills compared to at Vasco Winds. Had Golden Hills been composed of 2.3-MW turbines instead of 1.79-MW turbines, it would have had 11 fewer turbines, or 23% fewer. Anonymous is incorrect in claiming that smaller turbines will be safer for birds, unless the reduced turbine size is not compensated by more turbines on the project site.

Anonymous summarizes S-Power's actions as 19 wind turbine relocations, reduced project capacity, and higher minimum rotor-to-ground clearances. I disagree with the closing sentence, which reads "*Each of these steps is expected to reduce bird and bat mortality based on input obtained from the Smallwood and Neher (2018) and Estep (2019) micro-siting studies prepared for the Project*." Smallwood and Neher (2018) provided no suggestions on minimum ground clearance because we assumed it would meet the standard set in the County's PEIR, which specifies a minimum rotor-to-ground clearance of 29 m. We also provided no suggestion on project size, because doing so was outside our scope of work.

Exhibit 1 in Anonymous (2019) lists hazard class predictions from Smallwood and Neher (2018), but only for golden eagle. We provided predictions for red-tailed hawk, American kestrel, and burrowing owl. Our micro-siting recommendations also considered collision risk to these other species.

[3] This rated capacity corresponded with 403 wind turbines at Sand Hill.

Reviewing Exhibit 1 in Anonymous (2019), I have to disagree with 8 turbine relocations that were attributed to Smallwood and Neher's (2018) recommendations. Some of these decisions involved turbine sites I rated very high for collision risk, including one site rated 10 – the highest risk I could have assigned. I did not recommend turbines be sited at any place where I assessed high collision risk. 1-9 cont.

Alternative Analysis Approach 1-10

Despite earlier asserting that raptor movements are too uncertain and complex to have contributed anything meaningful to our models, Estep (2019:7) says his approach "*focuses primarily on topographic and wind conditions and proximity to other risk factors, and how these conditions influence raptor movement and behavior that may correspond with collision events*." One of the differences between our approaches is that Neher and I actually observed and quantified and analyzed the factors that Estep says he relied upon for rating collision risk. We described our data sources, how we processed the data, and how we tested hypotheses to provide weighting factors of predictor variables used in our models. Estep (2019) describes no raptor movement or behavior data he might have collected or analyzed in relation to the factors he says he relied on.

Under Field Methods, Estep lists data he collected for his ratings of collision risk, including constructability data that he elsewhere says he did not use. No explanation is provided about how these data contributed to his hazard ratings. Additionally, some of Estep's data were of questionable value for micro-siting, including the following examples:

Proximity to rock piles would be irrelevant because those rock piles will disappear with grading for turbine pads and access roads.

Ground squirrel abundance will change drastically with annual weather and squirrel abatement, and squirrel colonies shift locations naturally every few years or so, so these data were unstable and unreliable as a micro-siting hazard predictor.

Constructability has no bearing on collision hazard that I'm aware of.

As for the other data collected, Smallwood and Neher (2017) described how each slope attribute was measured and how each contributed to collision hazard models. Estep provides no such explanations. How does proximity to hilltop factor into Estep's rating, for example? Estep says the data were entered into a standardized field form, but did not explain how the data were processed or used to generate ratings.

Estep explains that he assigned relative risk designations to turbines, including Very High Risk, High Risk, Moderate-High Risk, Moderate Risk, Moderate-Low Risk, and Low Risk. He says these designations "*generally correspond to the relative numerical relationships used in the SRC hazard rating system*." But what were the precise rating values that would correspond with the risk designations? Smallwood and Neher (2017) explained how each hazard class was calculated. So, too, should Estep explain how his rating system derives from the data he collected or how it relates to the SRC's approach. 1-10 cont.

Estep provides descriptions of each candidate turbine site, and then summarizes his interpretation of the collision risk profile posed by the site. I will select two of these sites to exemplify our differences in interpretation (below). First, however, I must object to Estep's claim that Smallwood and Neher (2018) made no siting recommendation at Site 4. We recommended not pursuing this site.

Estep explains that the collision risk he sees at Site 4 is the steepness of the northwest slope, which is likely to draw red-tailed hawks who would kite in the deflected updrafts. He also explains that steep slopes are used for golden eagle movement, but he cites no evidence supporting his assertion. These are Estep's issues, along with the existence of a stock pond, which the reader is supposed to assume must have something to do with raptor collision risk. But the issue with the site as I saw it was the confluence of steeply-descending, deep ravines on the west and north sides of the site, coupled with our 6 years of experience performing fatality monitoring and visual scan surveys at that site as well as at 14 or so other sites in the area. Our first golden eagle fatality find on the project site was found there in 1998, and the site proved to be dangerous to raptors ever since. Golden eagles and red-tailed hawks glide down the ravines from Golden Hills to the confluence of ravines at Site 4, where intra- and inter-specific interactions are often intense. My colleagues and I have many times observed golden eagles chasing each other or combating red-tailed hawks at that very site. And we have many times witnessed near-miss collisions with the wind turbines there, as well as with the utility lines. Due to terrain-focused social interactions, near-misses occur frequently at Site 4, often leaving behind flight feathers as additional evidence. Moving the turbine to the top of the hill does not resolve the collision risk of this site, as many of the incoming eagles fly right over that hill. Eagles go there because other eagles are already there. Only last week I watched 2 golden eagles approach that Site because another 2 eagles were perched there, so I had 4 golden eagles at Site 4 at the same time. Eagles gliding down the ravine from the west reach the site's northwest-facing slope at high speed, then quickly ascend over the slope in the deflected updraft, and they are doing this while distracted by the presence of other eagles, red-tailed hawks, or common ravens.

Furthermore, moving the turbine to where Estep recommended would place the turbine in our model-predicted hazard class 3, and possibly in class 4 – the most hazardous classification in our system. Our collision hazard model predicted Estep's siting would be more dangerous than the original site.

The other site I will address is Site 1. Estep explains that he recommended moving the turbine away from the site I recommended because it would put it closer to lower terrain. All of our experience suggests his rationale was unsound, as turbines constructed on lower terrain are often more hazardous to eagles. In fact, our micro-siting reports have carried the caveat that our map output does not depict valley bottom terrain as hazardous because we generally recommend against siting turbines on such low terrain.

The image Estep used to characterize site 1 and his recommended siting improvement was also misleading, as it gives a wrong impression of what the site looks like on the ground and how it should be interpreted in terms of collision risk. GoogleEarth images can be tilted to change perspective, which is what has happened in Estep's report. His image implies that the terrain slopes down towards the west from his recommended turbine site, a continuous decline to Gate 19 visible in the background, but it actually rises before again falling in elevation. The original site was at the apex of the southeast side of a topographic saddle, which is often overflown by golden eagles and ferruginous hawks. Eagles often perch on the transmission towers crossing the saddle or on the electric distribution poles[4] there, and these perched eagles often distract those flying through the saddle. I recommended shifting the site east-northeast to give it more distance from that saddle while only giving up 14 feet in elevation. Estep's recommendation was to put the turbine lower yet by another 19 feet. To accommodate that site, grading for the pad would likely put the turbine downwind of a cut slope similar to that of a nearby turbine at Golden Hills North, where last year I observed the behavior of a golden eagle moments before it fatally collided with that turbine. I disagree that Estep's siting recommendation improved on ours. 1-10 cont.

What was Accomplished? 1-11

In addition to the 8 site relocations for we were given false credit (discussed earlier), our recommendations were rejected at another 15 turbine sites. Altogether, the average hazard rating among the turbine sites at which our recommendations were rejected was 7.54, which was 13% higher than the average among the other sites of 6.66. In other words, our recommendations were rejected where they could have most minimized collision risk to golden eagles, red-tailed hawks, American kestrels, and burrowing owls.

I could not interpret the actions taken for some of the turbine sites listed in Exhibit 1 of Anonymous (2019), so I cannot assess their collision risk. Also, the actions taken in response to Estep's recommendations might have increased collision risk or reduced it, but without more thoroughly examining the modified sites I will not draw any conclusions about any of them other than Sites 1 and 4, discussed earlier.

Rotor-to-Ground Clearance 1-12

Anonymous (2019) reported on a project revision that raised the minimum ground clearance of the turbine rotor from 14.1 m to 24.7 m. Later in the document, when summarizing micro-siting recommendations for turbines 9, 29 and 37, it turns out the ground clearance for these turbines would be 22 m. Minimum rotor-to-ground clearance should be 29 m, According to the PEIR. For the record, Neher and I had no knowledge of the ground clearance having been 14.1 m, 22 m, or 24.7 m, all of which would be too low for minimizing bird collision risk in the APWRA. Had we been aware, we likely would not have agreed to work on the project.

[4] These poles have also frequently electrocuted golden eagles, red-tailed hawks, and common ravens, and did so again only last year.

Additional SEIR Comments

According to County of Alameda (2019:3.4-9), "*The monitoring effort* [at Golden Hills] *indicated potentially higher mortality rates than those estimated in the PEIR, particularly for golden eagles and red-tailed hawks*." However, the PEIR rates were of the wrong baseline for comparison to Golden Hills (see Smallwood 2019 attached to these comments). 1-13

According to County of Alameda (2019:3.4-9), "*The first year of Golden Hills data (H. T. Harvey & Associates 2018a) reflected monitoring during northern California's wettest year on record*." The wettest year on record was 1982-1983, when northern California experienced extensive flooding from >34 inches of rain. But what does this have to do with fatality rates caused by wind turbines? The connection seems speculative, at best.

Alameda County (2019:3.4-9) claims that the increased fatality rate of burrowing owls during the second year of monitoring at Golden Hills was "inexplicable." It was not. I monitored breeding-season burrowing owls every year since 2011. As the second year of fatality monitoring got underway, I informed County of Alameda's TAC that the previous year's burrowing owl productivity had been exceptionally high, which indicated more burrowing owls would be present that year and the monitor would experience a higher burrowing owl fatality rate. That is exactly what happened. 1-14

According to County of Alameda (2019:3.4-9), "*…APWRA-wide avian monitoring study … already reflected significant mortality reductions resulting from seasonal shutdown and the removal of high-risk turbines in accordance with the 2007 settlement agreement*." In fact, there was no effect attributed to the winter shutdown. And in fact, the hazardous turbine removals could not possibly have accounted for more than an 8% fatality reduction. The reduction measured by the County's monitor was attributable to turbine attrition, a declining monitoring effort, and a poor choice in the fatality rate metric, which was restricted to operable turbines based on the unfounded assumption that inoperable turbines do not kill birds. During 3 years of monitoring at Sand Hill, and during a before-after, control-impact experiment involving a wind project that was entirely shutdown during the after phase of the experiment, my co-investigators and I documented that inoperable turbines killed no fewer birds that operable turbines. We lacked sufficient sample size to come to any conclusion about the effects of turbine operability on golden eagle fatalities, but for birds as a group, there was no effect. 1-15

County of Alameda (2019:3.4-10) writes, "*With regard to bats, it is worth noting that the first-year monitoring report for the Vasco Winds project (Brown et al. 2013), erroneously reported overall bat mortality rates*." This is not true. There was no error in this reporting. We simply did not have sufficient bat carcasses for use in integrated detection trials. We used the same method as in Smallwood (2013). Advances in science do not qualify earlier scientific steps as "erroneous." The error was in the County adopting that first-year fatality rate as the PEIR threshold for bat mitigation, despite my warning the County not to do so. At a meeting of the East County Board of Zoning Adjustments, while the PEIR was in draft form, I warned the Board, an 1-16 employee of ICF, and County staff that the bat fatality rate they had adopted from our first-year report for use as the mitigation threshold would be blown away by the successful completion of our integrated detection trials in year two at Vasco Winds. My warning was ignored. The error is the County's, not mine. 1-16 cont.

The bat threshold error will only worsen with the use of skilled detection dogs in fatality monitoring – and detection dogs absolutely should be used for fatality monitoring going forward in order to obtain more accurate, precise fatality estimates. Proper use of dogs greatly increases the number of bats found, as well as the fatality estimates of bats in the APWRA. In one study where our dogs overlapped human searchers at the same turbines over the same season and using the same search radius, and despite our dogs having searched those turbines 25% fewer times than the human searcher, the dogs found 71 bats whereas the human searchers found 1. We obtained a less dramatic, but similar result for birds, especially small birds. 1-17

According to County of Alameda (2019:3.4-11), micro-siting studies were performed for proposed repowering projects in the APWRA, but "*many of these projects were never constructed*." In fact, 3 projects were not constructed – Tres Vaqueros, Patterson Pass, and Ogin's version of Sand Hill. We did not prepare a micro-siting study for AWI's version of Summit Winds, but I did make site visits as a preliminary step for that project. Another wind project that we did help with micro-siting is currently under construction. 1-18

According to County of Alameda (2019:3.4-11), "*In summary, of multiple micrositing studies undertaken in the APWRA, only two— Vasco Winds and Golden Hills—have been associated with projects that were subsequently completed and for which monitoring results are available*." This statement, however, is not entirely accurate. We have extended our collision hazard models to other repowered projects, including Buena Vista and Diablo Winds, where we tested model performance via documented fatality rates at those projects. We presented results of these tests at multiple professional meetings.

County Alameda (2019:3.2-12) writes, "*Thus, Smallwood (2018) effectively cited topographic changes due to new access road and turbine pad construction as a potential cause for an increase in golden eagle mortality at Golden Hills*." No, I did not. The golden eagle fatality rate at Golden Hills did not increase; I concluded the opposite in Smallwood (2018). The County continues, "*However, the extent to which these factors actually influence potential mortality remains speculative*." It is more than speculative that certain grading outcomes affect collision risk – it is inference drawn from hypothesis-testing (see Smallwood 2019). 1-19

Regarding golden eagle population sizes and local area populations, County of Alameda (2019:3.4-13) engages in a remarkable level of speculation. The County arrives at a Local Area Population (LAP) of 840 golden eagles through a series of assumptions linked together speculatively and in favor of minimalizing population-level impacts. This important impact assessment should be performed by an expert, not the County's consultant.

In the context of siting wind turbines per repowering, County of Alameda (2019:3.5-15) claims "*The Scientific Review Committee (SRC) for the APWRA, which convened between 2006 and 2015 also produced guidelines for siting wind turbines to reduce avian fatalities in the APWRA*." In fact, the SRC prepared guidelines for relocating hazardous old-generation wind turbines. Those turbines no longer exist. The SRC's guidelines were not prepared for modern wind turbines in repowering or new siting, although some of the factors considered by the SRC for old-generation turbines would apply, with modifications, to micro-siting of modern turbines. 1-20

County of Alameda (2019:3.4-15) shares that "*The monitoring program ran continuously between 2005 and 2015, and annual estimates of turbine-related avian fatality rates and estimates of the total number of birds killed each year are available for each bird year from 2005 through 2015*." In fact, Sand Hill was monitored for fatalities, use rates, and behavior beginning in 1999. Why does the SEIR not present annual summaries of these data, or any sort of analysis? 1-21

After considerable speculation and shoulder-shrugging, County of Alameda (2019:3.4-41) concludes that not enough is known about bat mortality in the APWRA to predict project impacts on bats. This analysis is deficient, just as it was for birds. Despite differences in methodology, fatality rate estimates are close among Vasco Winds, Golden Hills, and Buena Vista. The Buena Vista estimate comes even closer to par with Vasco Winds and Golden Hills after using dogs there in 2017. The County should expect the same level of impacts at Sand Hill, as there is absolutely no reason not to. 1-22

County of Alameda (2019:3.4-16) claims, "*Relatively little is known about bat biology as it relates to fatality risk at wind energy facilities*." Instead of misinforming decision-makers and the public about an issue that very likely is ecologically more important than golden eagle fatalities, the County's consultant could start a little research into this with a Google search on bats and wind turbines. Doing so would reveal a large research literature on bats and wind turbines, and a large collection of monitoring reports including bat fatalities. I suggest looking up names such as Kunz, Horn, Cryan, Behr, Baerwald, Rydell, Frick, Barclay, Weller, Arnett, Hein, Hayes, and Long – names of some of the many researchers reporting on primary research of bat biology as it relates to wind turbine collision risk. The SEIR cites not a single paper resulting from this research. In fact, a great deal is known. A lot of what has been learned about this topic has been learned right here in the Altamont Pass. Right at Sand Hill, in particular, I reported what I observed over hundreds of hours on a thermal-imaging camera, quantifying bat flight patterns, passage rates through wind turbine rotors, and behaviors (Smallwood 2016a,b, unpublished data in review). At Vasco Winds, acoustic detectors were set up to monitor bat activity at different height domains both before and after the project was built, so learned which species flew low and which flew high, and which were documented as wind turbine fatalities. Linked to all of this information, I used a thermal-imaging camera to record flight patterns, collisions, and to notice that myotine bats, which acoustic detectors found to fly low to the ground, actually ascend to the low reach of the rotor zone when they'd pass by or under a wind turbine. Through local research, we also established that operational curtailment is effective with bats. The SEIR needs to be revised to honestly deal with the issue of bat collisions with wind turbines, and in doing so, it needs to summarize what we know about bats and wind turbines. 1-22 cont.

1-23
County of Alameda (2019:3.4-33) erroneously concludes bald eagles lack "*suitable nesting or foraging habitat (large lakes, reservoirs, or rivers) … in the Project area*." Not only have I seen and recorded bald eagles foraging on the project site many times, I have also photographed them. On 18 May 2019, I reported to S-Power of my finding a successful breeding pair of bald eagles at Bethany Reservoir. They trained their fledgling chick to forage on the project site.

Regarding Swanson's hawk (2019:3.4-33), the County says "*…the species could forage in annual grassland throughout the Project area*." Swanson's hawk most certainly do forage on the project site. I have documented Swanson's hawks on site many times. Swanson's hawks were also documented as wind turbine collision victims in the Altamont Pass as well as at Solano. 1-24

Regarding American badgers, I have seen badgers on site many times while performing nocturnal surveys using a thermal-imaging camera. 1-25

The County says the likelihood of peregrine falcons occurring on site is low, but I have seen them there in the past. Just over the last month or two, I have seen peregrine falcons nearby the project site at two locations. 1-26

1-27
Regarding tricolored blackbirds, I have documented nesting colonies at multiple locations around the APWRA. They forage on the project site during winter in groups of hundreds and even thousands.

County of Alameda (2019) also should have cited the findings of Smallwood (2017) on the overlapping of monitoring efforts between ICF and my team of fatality searchers on Sand Hill over a three-year period. My crew searched at a 5-day interval, whereas ICF searched at a 39-day interval. The differences in findings were substantial, not due to any deficiency of the searchers, but to the search interval upon which Alameda County's monitor implemented from 2005 through 2014. ICF's searchers, working at the longer interval between searches, found 28% of the fatalities than did my crew working the shorter interval, and this difference translated into fatality rates that were 77% lower for small birds and 61% lower for all raptors. Over that same time period, the crew searching every 5 days found fatalities representing nearly 3 times the number species as did ICF's crew, and their species identification errors were much lower. What this means is that the fatality estimates from Alameda County's monitor were biased low over a long time period, 2005-2014. And it means that one can expect much higher fatality rates of birds and bats, and many more species, than could be predicted from the Alameda County monitoring effort. A more reliable baseline be found in Smallwood (2017) and Smallwood et al. (2018). 1-28

In Table 3.4-67 and other similar tables comparing fatality estimates among APWRA projects, where did County of Alameda find the numbers? Many of them are wrong, 1-29 including fatality rates and annual fatalities. The fatality numbers representing Vasco Winds are twice the numbers reported in Brown et al. (2016). Somebody made some mistakes. These mistakes carried through to the text as well. For example, Brown et al. (2016) most definitely did not report 0.15 golden eagle fatalities/MW in year two at Vasco Winds (County of Alameda 2019:3.4-71). 1-29 cont.

According to County of Alameda (2019:3.4-91), "*The calculated average and weighted average mortality rates across all repowering projects, applied to the Sand Hill Project was 8.3* [golden eagle] *fatalities per year*." Actually, it would by 14.4 golden eagle fatalities per year for a 144.5-MW project (excluding an estimate from Diablo winds and using more accurate fatality estimates from the other monitoring reports of repowering project impacts). The SEIR needs to be revised in order to discuss this contribution to golden eagle fatalities along with other built projects to determine whether the County's not-to-exceed threshold of annual golden eagle fatalities would, in fact, be exceeded. One can anticipate 6 fatalities per year at Summit Winds, 6 at Golden Hills North, and one already knows of about 12 per year at Golden Hills, so among these projects there will be 24 golden eagle fatalities per year in Alameda County as of next year. This number will exceed the 18 identified in the PEIR as the number not to exceed in Alameda County. A revised SEIR needs to address this 33% exceedance and what to do about it. 1-30

REFERENCES CITED

Alameda County SRC (J. Burger, Smallwood, K. S., S. Orloff, J. Estep, and J. Yee). 2007. First DRAFT of Hazardous Rating Scale First DRAFT of Hazardous Rating Scale. SRC document P69, County of Alameda, Hayward, California.

Alameda County SRC (Smallwood, K. S., S. Orloff, J. Estep, J. Burger, and J. Yee). 2010. Guidelines for siting wind turbines recommended for relocation to minimize potential collision-related mortality of four focal raptor species in the Altamont Pass Wind Resource Area. SRC document P70, County of Alameda, Hayward, California.

Anonymous. 2019. Micro-sited Smaller Turbine Layout Alternative. Location unknown.

Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas. 2016. Final 2012-2015 Report Avian and Bat Monitoring Project Vasco Winds, LLC. Prepared for NextEra Energy Resources, Livermore, California.

County of Alameda. 2019. Sand Hill Wind Project Draft Subsequent Environmental Impact Report. Prepared by ICF International. Hayward, CA.

Estep, J. 2019. Assessment of proposed wind turbine sites to minimize raptor collisions at the Sand Hill Wind Repowering Project in the Altamont Pass Wind Resource Area. Report to ICF International, Sacramento, CA, and S-Power, San Francisco, CA.

Hoover, S. L. 2001. The response of raptors and other prey to topographical features at the Altamont Wind Resource Area. M.S. Thesis, California State University, Sacramento. 83 pp.

Hoover, S. L., and M. L. Morrison. 2005. Behavior of red-tailed hawks in a wind turbine development. Journal of Wildlife Management 69:150-159.

ICF International. 2018. Biological Resources Evaluation for the Sand Hill Wind Repowering Project. Prepared for Sand Hill Wind, LLC, Salt Lake City, Utah.

Rugge, L. M. 2001. An avian risk behavior and mortality assessment at the Altamont Pass Wind Resource Area in Livermore, California. M.S. Thesis, California State University, Sacramento. 156 pp.

Smallwood, S. 2010. Old-generation wind turbines rated for raptor collision hazard by Alameda County Scientific Review Committee in 2010, an Update on those Rated in 2007, and an Update on Tier Rankings. SRC document P155, County of Alameda, Hayward, California.

Smallwood, K. S. 2016a. Bird and bat impacts and behaviors at old wind turbines at Forebay, Altamont Pass Wind Resource Area. Report CEC-500-2016-066, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2016-066

Smallwood, K. S. 2016b. Report of Altamont Pass research as Vasco Winds mitigation. Report to NextEra Energy Resources, Inc., Office of the California Attorney General, Audubon Society, East Bay Regional Park District.

Smallwood, K. S. 2017. Long search intervals under-estimate bird and bat fatalities caused by wind turbines. Wildlife Society Bulletin 41:224-230.

Smallwood, K. S. 2018. Addendum to Comparison of Wind Turbine Collision Hazard Model Performance: One-year Post-construction Assessment of Golden Eagle Fatalities at Golden Hills. Report to Audubon Society, NextEra Energy, and the California Attorney General.

Smallwood, K. S. 2019. Addendum to Comparison of Wind Turbine Collision Hazard Model Performance: One-year Post-construction Assessment of Golden Eagle Fatalities at Golden Hills. Report to County of Alameda as an Attachment to comments on the Sand Hill SEIR.

Smallwood, K. S. and J. Estep. 2010. Report of additional wind turbine hazard ratings in the Altamont Pass Wind Resource Area by Two Members of the Alameda County Scientific Review Committee. SRC document P153, County of Alameda, Hayward, California.

Smallwood, K. S., and L. Neher. 2009. Map-Based Repowering of the Altamont Pass Wind Resource Area Based on Burrowing Owl Burrows, Raptor Flights, and Collisions with Wind Turbines. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. CEC-500-2009-065. Sacramento, California. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-065

Smallwood, K. S., and L. Neher. 2017. Comparing bird and bat use data for siting new wind power generation. Report CEC-500-2017-019, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019.pdf and http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019-APA-F.pdf

Smallwood, K. S., and L. Neher. 2018. Siting wind turbines to minimize raptor collisions at Sand Hill Repowering Project, Altamont Pass Wind Resource Area. Report to S-Power, Salt Lake City, Utah.

Smallwood, K. S. and L. Spiegel. 2005a. Assessment to support an adaptive management plan for the APWRA. Unpublished CEC staff report, January 19. 19 pp.

Smallwood, K. S. and L. Spiegel. 2005b. Partial re-assessment of an adaptive management plan for the APWRA. Unpublished CEC staff report, March 25. 48 pp.

Smallwood, K. S. and L. Spiegel. 2005c. Combining biology-based and policy-based tiers of priority for determining wind turbine relocation/shutdown to reduce bird fatalities in the APWRA. Unpublished CEC staff report, June 1. 9 pp.

Smallwood, K. S. and C. Thelander. 2004. Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. 500-01-019. Sacramento, California.

Smallwood, K. S. and C. Thelander. 2005. Bird mortality at the Altamont Pass Wind Resource Area, March 1998 – September 2001 Final Report. National Renewable Energy Laboratory, NREL/SR-500-36973. Golden, Colorado.

Smallwood, K. S., C. G. Thelander. 2008. Bird Mortality in the Altamont Pass Wind Resource Area, California. Journal of Wildlife Management 72:215-223.

Smallwood, K. S., L. Neher, and D. A. Bell. 2009. Map-based repowering and reorganization of a wind resource area to minimize burrowing owl and other bird fatalities. Energies 2009(2):915-943. http://www.mdpi.com/1996-1073/2/4/915

Smallwood, K. S., L. Neher, and D. A. Bell. 2017. Siting to Minimize Raptor Collisions: an example from the Repowering Altamont Pass Wind Resource Area. M. Perrow, Ed., Wildlife and Wind Farms - Conflicts and Solutions, Volume 2. Pelagic Publishing, Exeter, United Kingdom. www.bit.ly/2v3cR9Q

Smallwood, K. S., L. Neher, and D. A. Bell. 2017. Mitigating golden eagle impacts from repowering Altamont Pass Wind Resource Area and expanding Los Vaqueros Reservoir. Report to East Contra Costa County Habitat Conservation Plan Conservancy and Contra Costa Water District.

Smallwood, K. S., L. Rugge, and M. L. Morrison. 2009a. Influence of Behavior on Bird Mortality in Wind Energy Developments: The Altamont Pass Wind Resource Area, California. Journal of Wildlife Management 73:1082-1098.

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management 74: 1089-1097 + Online Supplemental Material.

Smallwood, K. S., C. G. Thelander, M. L. Morrison, and L. M. Rugge. 2007. Burrowing owl mortality in the Altamont Pass Wind Resource Area. Journal of Wildlife Management 71:1513-1524.

Smallwood, K. S., L. Neher, D. Bell, J. DiDonato, B. Karas, S. Snyder, and S. Lopez. 2009b. Range management practices to reduce wind turbine impacts on burrowing owls and other raptors in the Altamont Pass Wind Resource Area, California. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. CEC-500-2008-080. Sacramento, California.

Smallwood, K. S., D. A. Bell, E. L. Walther, E. Leyvas, S. Standish, J. Mount, B. Karas. 2018. Estimating wind turbine fatalities using integrated detection trials. Journal of Wildlife Management 82:1169-1184.

1-31

ATTATCHMENT 1

Addendum to Comparison of Wind Turbine Collision Hazard Model Performance: One-year Post-construction Assessment of Golden Eagle Fatalities at Golden Hills

K. Shawn Smallwood

16 September 2019

In response to an assertion that micro-siting to minimize raptor impacts at Golden Hills proved ineffective (Estep 2019), I prepared this update to my 2018 Addendum of a report Lee Neher and I prepared as an evaluation of collision hazard model performance (Smallwood and Neher 2017a). This update was supported by additional wind turbine fatality data from Golden Hills and Golden Hills North, some of them from the second year monitoring report at Golden Hills, and some of them from my own discoveries of fatalities while performing research in the Altamont Pass. I am now aware of 28 golden eagle fatalities at Golden Hills, including 26 found by the monitor during the first two years of fatality monitoring, 1 found during the third year of monitoring and which will appear in the final report of monitoring, and 1 found by me prior to the commencement of monitoring. This number of golden eagle fatalities totals four times as many as found during three years of fatality monitoring at the similar-sized repowered Vasco Winds project (Brown et al. 2016), despite the two projects' installed capacity being nearly equal. An obvious question is whether the collision hazard models used to guide micro-siting (Smallwood and Neher 2015) were effective at Golden Hills. Another related question is whether anything can be learned from the data to improve future repowering projects, as was intended in the 2010 Settlement Agreement among Audubon Society, NextEra Energy, and the California Attorney General.

The question of whether map-based collision hazard models were effective is difficult to answer because most of the wind turbines were sited to minimize collision risk predicted by the models. Also, the maps produced to depict model predictions of collision hazard were not the only tool used for micro-sting. Expert opinion accompanied the collision hazard models because the models could not account for all of the collision risk posed by complex terrain features and potential changes to terrain made by grading for wind turbine pads and access roads. Expert opinion was provided principally in the form of qualitative hazard ratings on a 0-10 scale, similar to the ratings of old-generation wind turbines made by the Alameda County Scientific Review Committee during the years 2007-2010. I summarized these hazard ratings in a 3 December 2014 report, and I modified or added ratings as the Golden Hills layout changed through the planning period. Expert opinion was also expressed by statements of concern over whether and to what degree the terrain would be altered by grading for wind turbine pads and access roads (Smallwood and Neher 2015). The collision hazard models have always served as a starting point against which other factors are weighed, including other risk factors, collision risk to other focal raptor species, siting constraints such as infra-structure and residence set-back requirements, and company decisions on minimum project size and wind turbine size.

1-31 cont.

Relative abundance of golden eagles increased over the last two years outside Golden Hills, and over the last year within Golden Hills (Figure 1), but an opportune before-after, control-impact (BACI) comparison reveals no effect on golden eagle abundance caused by the repowering project (Figure 2). Without comparing fatality rates in an experimental design, such as the BACI design that was available for the Vasco Winds repowering project (Brown et al. 2016), it cannot be known whether the collision hazard models were truly effective at Golden Hills. Unlike the case of Vasco Winds, fatality rates at Golden Hills cannot be compared to fatality rates estimated from concurrent monitoring at other wind projects in the APWRA because no such monitoring existed until last year at Golden Hills North. The only means to assess micro-siting is to compare (1) post-repowering fatalities to pre-repowering fatalities at the same wind turbines that were replaced by the new project, and (2) the pattern of fatalities among wind turbines I assessed for collision hazard prior to construction.

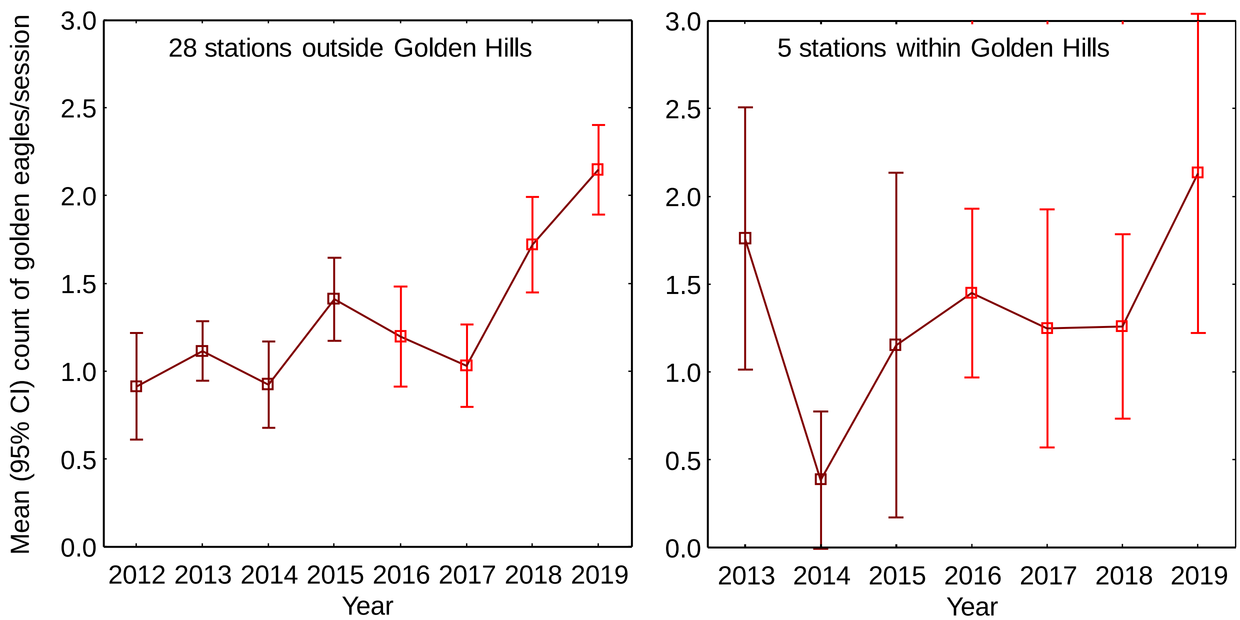
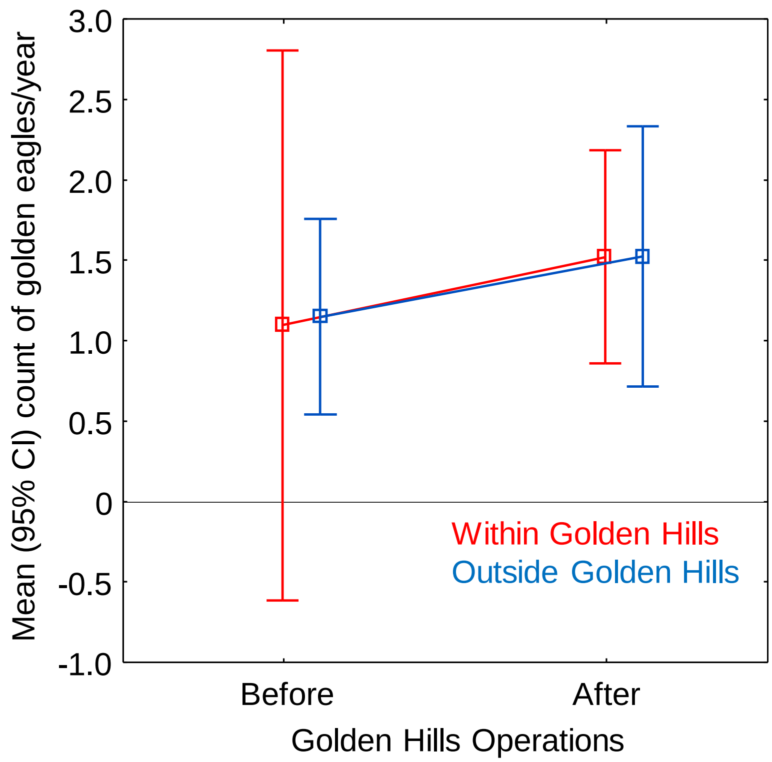


Figure 1. *Annual relative abundance of golden eagles among 28 Altamont Pass behavior observation stations outside Golden Hills (left) and 5 behavior stations located within the Golden Hills project boundary (right graph). The year 2017 would largely correspond with the first year of fatality monitoring at Golden Hills, although operations began in January 2016 (red symbols). Data were from Smallwood, unpublished 2019.*

1-31 cont.

__Figure 2.__ Opportune Before-After, Control-Impact (BACI) experimental comparison of golden eagle abundance observed within and outside Golden Hills, 2013-2019. Lines connecting the before and after means are nearly equal, meaning there was no effect of the Golden Hills repowering project on golden eagle abundance. No statistical analysis was needed.



Comparison of fatalities before and after repowering

The annual monitoring reports produced by H.T. Harvey and Associates have so far compared post-repowering fatalities to those of the old-generation wind turbines across the entire Altamont Pass Wind Resource Area. H.T. Harvey's comparison would have the reader conclude that golden eagle fatalities increased by 67% after Golden Hills was repowered, but the opposite was true when the baseline includes the turbines that were replaced instead of all of the old-generation turbines that composed the APWRA from 2005-2013. This comparison has been misleading for three reasons. The first reason was that wind projects varied in their fatality rates of each species, including golden eagle. Some projects rarely killed golden eagles, so including them in a Golden Hills baseline was inappropriate. The second reason H.T. Harvey's comparison was inappropriate was because the old-generation turbines that had been identified by the Alameda County Scientific Review Committee were undergoing removal from the APWRA, entire projects were being shut down, such as Tres Vaqueros and Venture, and each year an increasing proportion of turbines within most projects were shut down due to attrition. The third reason was that Alameda County's monitor shifted and reduced its monitoring coverage in response to project shutdowns and turbine attrition, thereby introducing substantial biases into the way fatalities/MW/year were measured and reported. Much more care is needed in comparing fatality rates to assess the relative impacts of Golden Hills.

Based on fatality rates preceding repowering (Smallwood and Neher 2017b), it is likely that the number of fatalities would have been higher in the absence of micro-siting.

1-31 cont.

After all, estimates of golden eagle fatalities at the specific old-generation wind turbines replaced by Golden Hills (same project area and same rated capacity) numbered 17 and 19 in 2006 and 2007 (Smallwood and Neher 2017b), or nearly twice the estimated post-repowering number in 2017 and 2018. At Golden Hills, repowering has halved golden eagle fatalities despite the increase in abundance of golden eagles on the project site since repowering. (Note that I do not compare pre-Golden Hills golden eagle fatalities from 2008 through 2013 because hazardous turbines were being removed as recommended by the Alameda County Scientific Review Committee.) Golden eagle fatalities were reduced by Golden Hills repowering. But it is also possible that fatalities could have been reduced further with greater diligence to micro-siting and grading.

Pattern of Fatalities among Turbines Assessed for Collision Hazard

Assessing the effectiveness of the collision hazard models would be challenging because most wind turbines were located outside predicted hazard classes 3 and 4 for golden eagle. But there were other factors that contributed to my micro-siting recommendations, and those other factors were complementary to the model predictions. And because the micro-siting of wind turbines at Golden Hills did not adhere strictly to my recommendations due to turbine crowding (discussed below), setback requirements, constructability, or due to any other considerations of which I might be unaware, the effectiveness of my collision hazard assessment leading to micro-siting recommendations can be assessed among the wind turbines within the project. My recommendations started from map-based collision hazard models, but were additionally based on SRC-style hazard ratings grading concerns, and terrain settings that were not addressed in the models but which I had learned to worry about.

The Golden Hills project is similar in rated capacity to Vasco Winds, but differed in several other respects. Contrary to Vasco Winds, going into the Golden Hills micro-siting we were aware of the potential impacts on collision risk due to grading because at Vasco Winds we had found golden eagle and red-tailed hawk fatalities where grading had altered the terrain around the associated turbines (Smallwood and Neher 2015). Our collision hazard models had not anticipated the levels of grading apparently necessary for constructing large, modern wind turbines in the Altamont Pass. Going forward I had to consider potential grading impacts for each site independent of collision hazard model predictions, and I shared my concerns with each client upon each repowering project. Also contrary to Vasco Winds, at Golden Hills I rated the proposed turbine locations for collision hazard based on my experience with the issue, using the SRC scale of 0-10. Finally, the 1.79-MW turbines at Golden Hills numbered 48, or 14 (41%) more than the 2.3-MW turbines built at Vasco Winds, and these 48 went onto a land area that was about 67% of the area of Vasco Winds. The wind turbine density at Golden Hills was more than twice that of Vasco Winds, leaving fewer opportunities for micro-siting to minimize collision hazard and likely creating more locations where grading was needed to accommodate pads and access roads.

For the factors I assessed above and beyond the collision hazard models, and which contributed to my micro-siting recommendations, I developed a Combined Hazard Sore as an index of the factors contributing to my recommendations. This index appears

1-31 cont.

below. My SRC-style ratings were provided to NextEra after my site visits, but they did not appear in my micro-siting report. They differed from SRC ratings by not factoring in the status of adjacent turbines or electric distribution lines, as both of these factors would be irrelevant in a repowered project. Separate from the models, and because we had not yet incorporated this factor into our collision hazard models, I considered whether a turbine would be low on a declining ridge or slope face. I saw turbines on relatively lower terrain as more dangerous to golden eagles, including sites such as 11, 12, and 15. At Vasco Winds we had found golden eagle fatalities at turbines that were on relatively low terrain, such as turbines 5 and 11. I also considered whether a turbine was near a terrain feature long known to associate with disproportionately more fatalities, including major ridge saddles, valley bottoms, and breaks in slope. I did this because characterizing these terrain features using GIS was difficult, although in later versions of the models we improved our ability to do this. As for grading, we were still unaware of how engineers would grade for turbine pads and access roads; all we could do at the time was to warn the client to avoid sites where grading would leave berms or cut slopes on the prevailing upwind aspects of the turbine pads, or where grading would create substantial breaks in slope or enhance or create ridge saddles. In the scoring system below, I measured the heights and distances of cut slopes and berms from turbines after the turbines were constructed.

Scoring System leading to Combined Hazard Class

	Score
SRC-style rating of collision hazard (SRC)	0-10
Low on Declining Ridge or Slope (Low)	1
Near terrain feature: major saddle, valley, slope break (T)	1
Grading (G)	
Berm bank height = 0 m or Distance to berm/bank ≥40 m	0
Berm bank height >0 and ≤3 m and Distance to berm/bank <40 m	1
Berm bank height >3 m and Distance to berm/bank <40 m	2

$$\text{Combined Hazard Score (CHS)} = \frac{SRC}{10} + \frac{G}{2} + Low + T$$

Combined Hazard Class	
CHS ≤1	1
CHS >1 and ≤2	2
CHS >2 and ≤2.8	3
CHS >2.8	4

I related the number of golden eagles per turbine to Combined Hazard Class at Golden Hills and to all but one of the repowered projects in the APWRA (Figure 3). Golden eagle fatalities/turbine increased with Combined Hazard Class, and the fatality rate in

Class 4 was 10 times that of Class 1 at Golden Hills. In Class 4, I know of 8 golden eagles to have been killed at only 4 turbines, including 4 at only one of these turbines where I warned a turbine would pose substantial collision risk to golden eagles. At all of the repowered projects except Golden Hills North, golden eagle fatalities/turbine numbered 5 times higher in Class 4 than in Class 1. I am disappointed with the performance of Class 3 at Golden Hills (thus far), but Class 4 demonstrates that the micro-siting recommendations were sound. 1-31 cont.

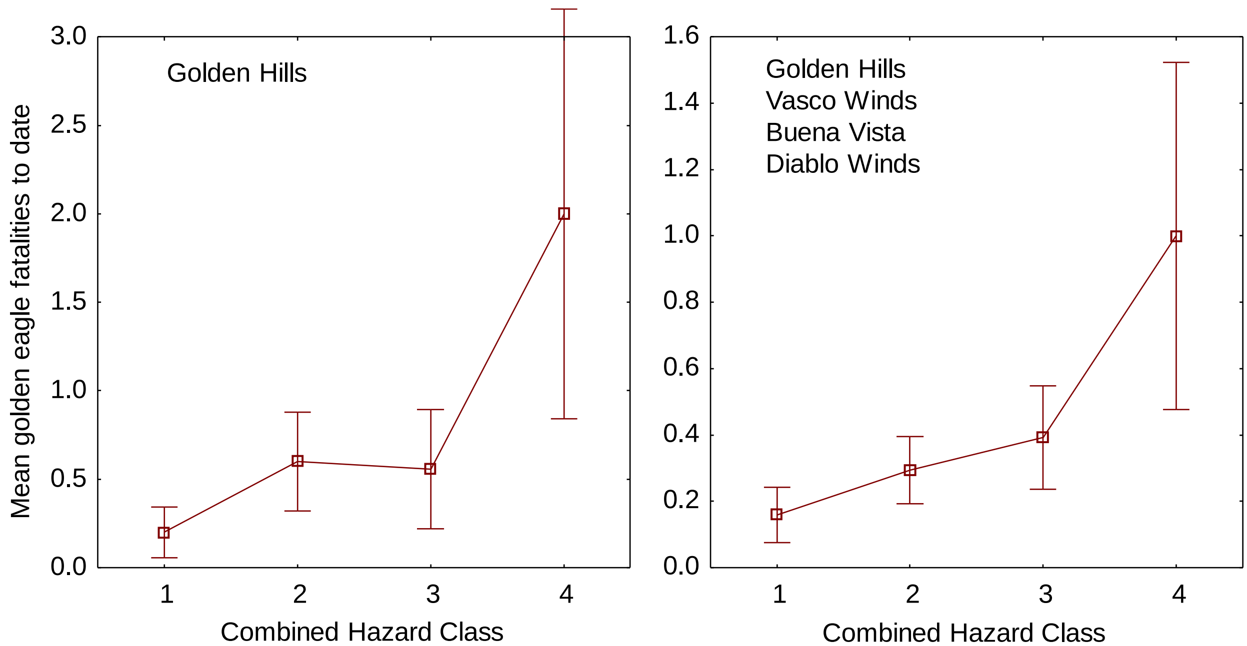


Figure 3. *Golden eagle fatalities per turbine relative to Combined Hazard Class at Golden Hills (left) and all repowered projects with modern turbines except for Golden Hills North (right), which has not yet reported fatality monitoring results.*

My post-hoc assessment of micro-siting performance no doubt suffers some validity shrinkage, but I doubt that this shrinkage was very large. Some of the turbine sites that made me nervous in 2015 have since validated my concern, although there were some sites that, at the time, would have surprised me. However, I learned much more since 2015, following hundreds of hours of observing and quantifying behaviors, having observed where fatalities occurred, and having developed more collision hazard models, so I am more prepared to avoid surprises.

Has Anything been Learned?

Returning to the second question about whether anything can be learned from the data to improve future repowering projects, the patterns reported herein suggest that the collision hazard modeling process revealed terrain settings that increase collision hazard. A decade ago the Alameda County Scientific Review Committee issued wind turbine relocation guidelines based on terrain settings *suspected* to be more hazardous to golden eagles and other raptors. We now *know* that ridge saddles and low-lying terrain are more hazardous, after having recorded many near-misses of flying golden

1-31 cont.

eagles and having collected the GPS transmitters off of golden eagles tracked to their final locations at wind turbines (Bell 2017). I found one of these eagles at a wind turbine within a ridge saddle. Another was found near a turbine at the bottom of a declining ridgeline. One was found at a turbine on a break in slope. Another was found low on a declining ridgeline within a broad ridge saddle. Another of our telemetered golden eagles, which was struck by a turbine blade but is still alive in the wild, was injured by a turbine within a complex ridge saddle on relatively low terrain (surrounded by higher ridges). These findings corresponded with the hundreds of documented fatalities of non-telemetered eagles among wind turbines in the Altamont Pass Wind Resource Area. We learned that collision hazard mapping needs to be combined with SRC-style hazard ratings to account for the effects of higher terrain around proposed turbines sites, and to account for interaction effects of construction grading with declining ridgelines and slopes that might create breaks in slope or enhance ridge saddles.

By drawing inferences from many hypothesis tests, we have learned a great deal about causal factors. But minimizing collision risk will, at least in some cases, require more than the application of collision hazard modeling and expert judgment; it will require sacrifices in project size and micro-siting to optimize wind generation. It will also require reduced grading that avoids leaving tall berms or deeply cut slopes near the turbine.

REFERCNES CITED

Bell, D. A. 2017. GPS Satellite Tracking of Golden Eagles (*Aquila chrysaetos*) in the Altamont Pass Wind Resource Area (APWRA) and the Diablo Range: Final Report for Phases 1 and 2 of the NextEra Energy Settlement Agreement. Supplement - Inactive Birds. East Bay Regional Park District, Oakland, California.

Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas. 2016. Final 2012-2015 Annual Report Avian and Bat Monitoring Project Vasco Winds, LLC. Prepared for NextEra Energy Resources, Livermore, California.

Estep, J. 2019. Assessment of proposed wind turbine sites to minimize raptor collisions at the Sand Hill Wind Repowering Project in the Altamont Pass Wind Resource Area. Report to ICF International, Sacramento, CA, and S-Power, San Francisco, CA.

Smallwood, K. S. 2016b. Report of Altamont Pass research as Vasco Winds mitigation. Report to NextEra Energy Resources, Inc., Office of the California Attorney General, Audubon Society, East Bay Regional Park District.

Smallwood, K. S. 2017a. The challenges of addressing wildlife impacts when repowering wind energy projects. Pages 175-187 in Köppel, J., Editor, Wind Energy and Wildlife Impacts: Proceedings from the CWW2015 Conference. Springer. Cham, Switzerland.

Smallwood, K. S. 2017b. Monitoring birds. M. Perrow, Ed., Wildlife and Wind Farms -

Conflicts and Solutions, Volume 2. Pelagic Publishing, Exeter, United Kingdom. www.bit.ly/2v3cR9Q

Smallwood, K. S., and L. Neher. 2015. Siting wind turbines to minimize raptor collisions at Golden Hills Repowering Project, Altamont Pass Wind Resource Area. Report to NextEra Energy Resources, Livermore, California.

Smallwood, K. S., and L. Neher. 2016. Siting wind turbines to minimize raptor collisions at Summit Winds Repowering Project, Altamont Pass Wind Resource Area. Report to Salka, Inc., Washington, D.C.

Smallwood, K. S., and L. Neher. 2017a. Comparison of wind turbine collision hazard model performance prepared for repowering projects in the Altamont Pass Wind Resources Area. Report to NextEra Energy Resources, Inc., Office of the California Attorney General, Audubon Society, East Bay Regional Park District.

Smallwood, K. S., and L. Neher. 2017b. Comparing bird and bat use data for siting new wind power generation. Report CEC-500-2017-019, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019.pdf and http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019-APA-F.pdf

DEPARTMENT OF TRANSPORTATION
DISTRICT 4
OFFICE OF TRANSIT AND COMMUNITY PLANNING
P.O. BOX 23660, MS-10D
OAKLAND, CA 94623-0660
PHONE (510) 286-5528
TTY 711
www.dot.ca.gov

Letter 2

Making Conservation a California Way of Life.

September 20, 2019

SCH #2010082063
GTS # 04-ALA-2017-00452
GTS ID: 8888
ALA-580-PM 2.44

Andrew Young, Planner
County of Alameda
224 W. Winton Avenue, Suite 110
Hayward, CA 94544

Sand Hill Wind Project – Draft Subsequent Environmental Impact Report (DSEIR)

Dear Andrew Young:

2-1

Thank you for including the California Department of Transportation (Caltrans) in the environmental review process for the Sand Hill Wind Project. In tandem with the Metropolitan Transportation Commission's (MTC) Sustainable Communities Strategy (SCS), Caltrans' mission signals our continuing approach to evaluate and mitigate impacts to the State's multimodal transportation network. Caltrans' Strategic Management Plan 2015-2020 aims, in part, to reduce Vehicle Miles Traveled (VMT) and Greenhouse Gas emissions (GHG) in alignment with state goals and policies. Our comments are based on the August 2019 DSEIR.

Project Understanding
The project applicant, Sand Hill Wind, LLC proposes the Sand Hill Wind Repowering Project (Project) on 15 privately owned parcels in the Altamont Pass Wind Resource Area. The proposed Project would install up to 40 new wind turbines and is expected to utilize turbines with generating capacities between 2.3 and 4.0 megawatts (MW) each, all generally similar in size and appearance, to develop up to 144.5 MW of generating capacity. The Project is proposed as a Conditional Use Permit (Alameda County Planning case PLN2017-00201) and is reviewed in the SEIR pursuant to the California Environmental Quality Act (CEQA) Guidelines, Section 15162, as a project tiered under the Altamont Pass Wind Resource Area Repowering Program EIR (PEIR), which the County of Alameda certified in December 2014. The project is directly adjacent to Interstate (I-) 580 and access is provided from West Grant Line Road.

Landscape Architecture/Aesthetics 2-2

The stretch of I-580 directly adjacent to the project area is classified as an eligible scenic highway. Visual impacts caused by the project may be seen from travelers on I-580. After the description of proposed work and temporary alterations to the site for construction, include language for the replacement of grassland landscape. Erosion control and hydroseeded replacement native grasses is recommended on all areas impacted by turbine work and new roadways.

Construction-Related Impacts

Visual impacts from construction operations can be reduced by placing unsightly material and equipment in staging areas where they aren't as visible and/or covering the items where possible. Utilizing directional lighting and/or shielding for night work would help reduce light trespass affecting motorists where work is occurring near I-580 or local roads. After construction, areas 2-3 cleared for contractor access and trenching operations should be treated with appropriate erosion control measures.

Potential impacts to the State Right-of-Way (ROW) from project-related 2-4 temporary access points should be analyzed. Mitigation for significant impacts due to construction and noise should be identified in the DSEIR. Project work that requires movement of oversized or excessive load vehicles on state roadways requires a transportation permit that is issued by Caltrans. To apply, visit: https://dot.ca.gov/programs/traffic-operations/transportation-permits.

Prior to construction, coordination is required with Caltrans to develop a Transportation Management Plan (TMP) to reduce construction traffic impacts to the STN.

Lead Agency

As the Lead Agency, the County of Alameda is responsible for all project 2-5 mitigation, including any needed improvements to the State Transportation Network (STN.) The project's fair share contribution, financing, scheduling, implementation responsibilities and lead agency monitoring should be fully discussed for all proposed mitigation measures.

Encroachment Permit 2-6

Please be advised that any work or traffic control that encroaches onto the State ROW requires a Caltrans-issued encroachment permit. To obtain an encroachment permit, a completed encroachment permit application, environmental documentation, six (6) sets of plans clearly indicating the State ROW, and six (6) copies of signed, dated and stamped (include stamp expiration date) traffic control plans must be submitted to: Office of Encroachment Permits, California DOT, District 4, P.O. Box 23660, Oakland, CA 94623-0660. To download the permit application and obtain more information, visit https://dot.ca.gov/programs/traffic-operations/ep/applications. 2-6 cont.

Thank you again for including Caltrans in the environmental review process. Should you have any questions regarding this letter, please contact Andrew Chan at 510-622-5433 or andrew.chan@dot.ca.gov.

Sincerely,

Mark Leong
District Branch Chief
Local Development - Intergovernmental Review

c: State Clearinghouse

Letter 3

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

September 23, 2019

Andrew Young
Senior Planner
Alameda County CDA/Planning Dept.
224 W. Winton, Room 111
Hayward, CA 94544

Subject: Sand Hill Wind Project Draft Subsequent Environmental Impact Report

Dear Mr. Young,

3-1

Bay Area Air Quality Management District (Air District) staff has reviewed the County of Alameda's (County) Draft Subsequent Environmental Impact Report (DSEIR) prepared for the Sand Hill Wind Project (Project). The Project applicant proposes to develop or repower 15 project parcels with up to 40 new fourth-generation wind turbines, including supporting roadways, power collection systems, transformers and other infrastructure.

Air District staff greatly appreciates the opportunity to work with the County to address the potentially significant air quality impacts estimated for this Project. Project design features and the mitigation measures identified in the DSEIR will substantially lessen the local and regional air quality impacts from construction and operation of the Project.

3-2

However, even with these Project design features and on-site mitigation measures, the DSEIR finds that air quality impacts from the Project still exceed the County's thresholds of significance. Therefore, Mitigation Measure AQ-2c: Reduce construction-related air pollutant emissions to below BAAQMD NOx thresholds (M-AQ-2c) proposes the Project applicant provide funds to achieve additional emission reductions to reduce air emissions below the thresholds of significance. To this end, M-AQ-2c states that the Project applicant would provide funding to the Air District to fund emissions reduction projects in the region in order to offset the remaining criteria pollutant emissions generated by project construction.

Please be aware that the Air District does not currently have a fee program for offsetting emissions. These are occasionally conducted on a case-by-case basis based on available projects. We recommend that M-AQ-2c replace "Air District" with "governmental entity". This will allow the project applicant to seek additional options if the Air District has no available projects at the time.

3-3

Air District staff is available to assist the County to address these comments. If you have any questions, please contact Areana Flores, Environmental Planner, at (415) 749-4616 or aflores@baaqmd.gov.

Sincerely,

Greg Nudd
Deputy Air Pollution Control Officer

cc: BAAQMD Director John J. Bauters
BAAQMD Director Pauline Russo Cutter
BAAQMD Director Scott Haggerty
BAAQMD Director Nate Miley

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Bay Delta Region
2825 Cordelia Road, Suite 100
Fairfield, CA 94534
(707) 428-2002
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Letter 4

October 3, 2019

Mr. Andrew Young, Project Planner
County of Alameda
Planning Department, Community Development Agency
244 W. Winton Avenue, Room 111
Hayward, CA 94544
andrew.young@acgov.org

Subject: Sand Hill Wind Repowering Project, Draft Subsequent Environmental Impact Report, SCH #2010082063, Alameda County

Dear Mr. Young:

4-1

The California Department of Fish and Wildlife (CDFW) received a Notice of Availability from the Alameda County Planning Department (County), as the Lead Agency, for the Draft Subsequent Environmental Impact Report (DSEIR): Sand Hill Wind Project, PLN2017-00201 (Project) pursuant to the California Environmental Quality Act (CEQA) (Pub. Resources Code, § 21000 et seq.; hereafter CEQA; Cal. Code Regs., § 15000 et seq.; hereafter CEQA Guidelines). The Project is tiered under the Altamont Pass Wind Resource Area (APWRA) Repowering Program Environmental Impact Report (PEIR; SCH #2010082063) certified by the East County Board of Zoning Adjustments on November 12, 2014. The Project is an application for a Conditional Use Permit (CUP) to repower (i.e., replace) an estimated 671 existing or previously existing wind energy turbine sites with up to 40 new turbines. The Project is proposed on 15 nearly contiguous parcels extending over approximately 2,600 acres within the northeasterly quadrant of the Alameda County portion of the APWRA.

CDFW provided comments, dated October 25, 2018, on the Notice of Public Hearing and Staff Report from the County for the Sand Hill CUP application (Application No. PLN2017-00201) and the 2018 Sand Hill Wind Repowering Project Environmental Analysis (EA). CDFW also provided comments on the Notice of Preparation (NOP) for the Subsequent Environmental Impact Report in a letter dated February 12, 2019. CDFW is also a member of the Alameda County Wind Repowering/Avian Protection Technical Advisory Committee (TAC) and has participated in several meetings hosted by the County to discuss the proposed Project.

CDFW is providing comments and recommendations on the DSEIR regarding those activities involved in the Project that are within CDFW's area of expertise and relevant to its statutory responsibilities (Fish and Game Code, § 1802), and/or which are required to be approved by CDFW (CEQA Guidelines, §§ 15086, 15096 and 15204). The County provided an extension to the deadline for submitting comments on the DSEIR to October 4, 2019.

CDFW ROLE

CDFW is a Trustee Agency with responsibility under CEQA (Pub. Resources Code, § 21000 et seq.) pursuant to CEQA Guidelines section 15386 for commenting on projects that could impact fish, plant, and wildlife resources. CDFW is also considered a Responsible Agency if a project would require discretionary approval, such as a California Endangered Species Act (CESA) permit, a Lake or Streambed Alteration (LSA) Agreement, or other provisions of the Fish and Game Code that afford protection to the state's fish and wildlife trust resources. 4-1 cont.

REGULATORY REQUIREMENTS

California Endangered Species Act
Please be advised that a CESA permit must be obtained if the Project has the potential to result in "take" of plants or animals listed under CESA, either during construction or over the life of the Project. Issuance of a CESA permit is subject to CEQA documentation; the CEQA document must specify impacts, mitigation measures, and a mitigation monitoring and reporting program. If the Project will impact CESA listed species, early consultation is encouraged, as significant modification to the Project and mitigation measures may be required in order to obtain a CESA Incidental Take Permit (ITP).

CEQA requires a Mandatory Finding of Significance if a project is likely to substantially restrict the range or reduce the population of a threatened or endangered species. (Pub. Resources Code, §§ 21001, subd. (c), 21083; CEQA Guidelines, §§ 15380, 15064, and 15065). Impacts must be avoided or mitigated to less-than-significant levels unless the CEQA Lead Agency makes and supports Findings of Overriding Consideration (FOC). The CEQA Lead Agency's FOC does not eliminate the Project proponent's obligation to comply with Fish and Game Code section 2080.

Lake and Streambed Alteration
CDFW requires an LSA Notification, pursuant to Fish and Game Code section1600 et. seq., for Project activities affecting lakes or streams and associated riparian habitat. Notification is required for any activity that may substantially divert or obstruct the natural flow; change or use material from the bed, channel, or bank including associated riparian or wetland resources; or deposit or dispose of material where it may pass into a river, lake or stream. Work within ephemeral streams, washes, watercourses with a subsurface flow, and floodplains are subject to notification requirements. CDFW will consider the CEQA document for the Project and may issue an LSA Agreement. CDFW may not execute the final LSA Agreement (or ITP) until it has complied with CEQA as a Responsible Agency.

PROJECT DESCRIPTION SUMMARY

Proponent: Sand Hill Wind, LLC (Sand Hill), a subsidiary of sPower (Sustainable Power Group)

Description and Location: The Project is located at 12040 Altamont Pass Road (address for one of the 15 parcels) extending over approximately 2,600 acres in the APWRA. The Project is located north and south of Altamont Pass Road between two-thirds and two miles west of Grant Line Road, east and west of Mountain House Road between one-quarter and two miles north of Grant Line Road, west of the Delta-Mendota Canal one mile northwest of Mountain House Road, west of Bethany Reservoir and southeast of the intersection of Christensen and Bruns Roads. The Project would allow repowering of an estimated 671 existing or previously existing wind energy turbine sites with up to 40 new turbines with a maximum production capacity of 144.5 megawatts (MW), using turbines rated between 2.3 and 3.8 MW (potentially up to 4.0 MW) per turbine. 4-1 cont.

As discussed in our NOP comment letter, dated February 12, 2019, the Project description should include a complete and detailed description of current site conditions, describe activities that result in all types of ground disturbance, and include information on work areas, temporary and permanent access roads, equipment staging and storage areas, and changes in topography as a result of grading. However, the DSEIR does not provide sufficient detail on all components of the Project such as location and extent of road widening areas. This information is needed to adequately assess all Project-related impacts on biological resources.

IMPACTS ANALYSIS

The DSEIR, prepared pursuant to Section 15162 of the CEQA Guidelines, is intended to identify the environmental impacts of the Project, recommends measures to reduce or avoid potential environmental damage resulting from the Project, and identifies alternatives to the proposed Project. However, the PEIR did not contemplate the changed circumstances and severity of substantial effects that now impact future projects within the APWRA. In addition, the PEIR did not analyze a project of this size and scope.

CDFW offers the below comments and recommendations to assist the County in adequately identifying and/or mitigating the Project's significant, or potentially significant, direct and indirect impacts on fish and wildlife (biological) resources. These comments and recommendations are based on the requirement for the environmental document to include the following information:

Biological Resources

Special-Status Plants 4-2

The DSEIR, p. 3.4-18, identifies 19 special-status plant species that have moderate to high potential to occur within the Project area. Please be advised that Livermore tarplant (*Deinandra bacigalupii*) is incorrectly listed as California Rare Plant Rank 1B.2. This species was listed as endangered under CESA in 2016.

Mitigation Measure BIO 1, p. ES-8 defers to PEIR BIO-1a-1 that requires surveys for special-status plants and best management practices if special-status plants are found. However, CEQA requires that significant impact determinations and formulation of mitigation measures must occur before project approval.

CDFW advises that if Livermore tarplant is found within the Project area during surveys and the Project cannot be designed to completely avoid individuals of this species, then take authorization should be obtained within an appropriate timeframe prior to initiation of Project construction. CDFW recommends that the County include, as a Condition of Approval, that the Project proponent will obtain an ITP from CDFW for take authorization of Livermore tarplant if the species is documented on-site and take cannot be completely avoided. CDFW also recommends that the DSEIR include appropriate and effective compensatory measures such as those presented below to offset any potential impacts of the Project to Livermore tarplant. 4-2 cont.

1- On-site preservation of a viable population of Livermore tarplant. The on-site proposed mitigation area should be surveyed during the appropriate blooming season to determine whether populations of the species being significantly impacted by the Project are also present within areas that will be preserved. If populations of the species are present within the preservation area, it should be determined by a qualified botanist or plant ecologist, in consultation with CDFW, whether these populations to be preserved would adequately compensate, or partially compensate, for lost populations resulting from implementation of the Project. If it is determined that populations of the impacted species are absent from the proposed mitigation site, or that they are present but their preservation would only partially mitigate for lost populations, then additional mitigation measures described below should be implemented.

2- Off-site mitigation. Mitigation for impacted plant species could be accommodated through restoration or preservation at an off-site location. The mitigation site must be confirmed to support populations of the impacted species and must be preserved in perpetuity via deed restriction, establishment of a conservation easement, or similar preservation mechanism. A qualified botanist or plant ecologist should prepare a Preservation Plan or Long-Term Management Plan for the site containing at a minimum: a monitoring plan and performance criteria for the preserved plant population; a description of remedial measures to be performed in the event that performance criteria are not met; a description of maintenance activities to be conducted on the site, including weed control, trash removal, irrigation, and control of herbivory by livestock and wildlife; and an adequate funding mechanism to ensure long-term management of the mitigation site.

Special-Status Wildlife 4-3

Please be advised that the DSEIR contains numerous inconsistencies that make it difficult for CDFW to adequately review and assess all potential impacts of the Project on biological resources. For example, the DSEIR, p. 3.4-19, identified a total of 31 special-status wildlife species with a potential to occur in the Project vicinity and lists 17 special-status wildlife species that could be supported by the existing habitat on-site. The DSEIR states, "A description of suitable habitat and likelihood of occurrence in the Project area for these species is provided in Table 3.4-3 and discussed below." However, there are several species such as golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaeetus leucocephalus*) and norther harrier (*Circus hudsonius*) that have a high potential to be present on-site but are not discussed. Northern harrier (*Circus cyaneus*) a State Species of Special Concern, is listed on p. 3.4-20 but is missing from Table 3.4-3 and is not discussed further.

Table 3.4-3 also has several errors regarding listing status. As previously mentioned, Livermore tarplant is currently listed as endangered, and while not present in the Project area, Delta smelt (*Hypomesus transpacificus*) is state endangered and foothill yellow-legged frog (*Rana boylii*) is a state candidate for listing under CESA. California black rail (*Laterallus jamaicensis coturniculus*), bald eagle and American peregrine falcon (*Falco peregrinus*) are all state Fully Protected (Fish and Game Code, § 3511) so take, either during Project construction or turbine operations, must be avoided. Page 3.4-38 incorrectly describes white tailed kite (*Elanus leucurus*) as state threatened and fully protected; however, white tailed kites are not state threatened, but are fully protected. 4-3 cont.

CDFW therefore recommends that the DSEIR include an accurate list of all special-status species and their habitats that could be present within the Project area in order to conduct a thorough analysis of all Project-related impacts from both Project construction and future maintenance and operations of the turbines that could adversely affect these species.

IMPACTS AND MITIGATION MEASURES

2019 Updated PEIR Mitigation Measure BIO-5a: Implement best management practices to avoid and minimize effects on special-status amphibians. 4-4

DSEIR p. 3.4-54 requires a qualified biologist to conduct pre-construction surveys immediately prior to ground disturbing activities (including equipment staging, vegetation removal, grading) of *all suitable habitats within 300 feet of the work area.*

California tiger salamander, California red-legged frog and western spadefoot toad (*Spea hammondii*, a State Species of Special Concern) use small mammal burrows in the upland habitat as juveniles and adults. Western spadefoot toads are also known to dig their own burrows which could be as deep as three feet. Excavation of burrows are likely the only method by which pre-construction surveys of all suitable habitat could be achieved. Further, due to their cryptic nature it is unlikely western spadefoot toads could be detected if they are in self-constructed burrows. CDFW does not recommend excavating burrows that are not located in the work area; however, if burrow excavation is proposed to be conducted, an excavation and relocation plan should be prepared.

Impact BIO-6: Potential disturbance or mortality of and loss of suitable habitat for western pond turtle (less-than-significant with mitigation). p. 3.4-55 4-5

If western pond turtles (*Actinemys marmorata*), State Species of Special Concern, are found in the work area, CDFW recommends protecting suitable aquatic habitat for this species with a 400-foot buffer. If an exclusion fence is installed it should be inspected each morning by a qualified biologist for turtles that may become trapped on either side of the fence.

Impact BIO-8: Potential construction-related disturbance or mortality of special-status and non–special-status migratory birds (less-than-significant with mitigation). p. 3.4-59 4-6

Swainson's hawk

The DSEIR indicates (p. 3.4-21) that the Project is located within 0.25 mile of known Swainson's hawk nests (*Buteo swainsoni*) which is a species listed as threatened under CESA. Based on our records, a Swainson's hawk nest has been documented less than 1,000 feet from the Project area boundary (CNDDB 2019). A Swainson's hawk nest has also recently been documented approximately 450 feet south of Christensen Road in a *Eucalyptus* spp. grove which would be approximately 1,000 feet from the northwestern Project area boundary. Historically, Swainson's hawk nested north of Christensen Road. CDFW staff also observed Swainson's hawks flying over the Project area as recently as July 31, 2019.

Potential impacts of Project construction include loss of foraging habitat and disruption of breeding activities due to increased dust, noise, and human presence. CDFW recommends that the DSEIR include a measure to conduct pre-construction surveys for Swainson's hawk by a qualified raptor biologist with survey experience and conducted in a manner that maximizes the potential to observe the adult Swainson's hawks and the nest/chicks via visual and audible cues. Surveys should be conducted within all potential nest trees within a five-mile radius of the Project. Surveys should be repeated within the five-mile radius if a survey season ensues or elapses before the onset of Project related activities. If construction begins mid-survey season the year after the initial surveys, then the surveys should continue for that part of the season before construction. CDFW recommends using the *Swainson's Hawk Survey Protocols, Impact Avoidance, and Minimization Measures for Renewable Energy Projects in the Antelope Valley of Los Angeles and Kern Counties, California* (California Energy Commission and Department of Fish and Wildlife, June 2, 2010) available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=83991&inline. The Recommended Timing and Methodology for Swainson's Hawk Nesting Surveys in California's Central Valley (Swainson's Hawk Technical Advisory Committee, May 31, 2000) should also be consulted and is available at https://www.wildlife.ca.gov/Conservation/Birds/Swainson-Hawks. 4-6 cont.

CDFW considers the overall risk of take to Swainson's hawk as high considering both the recent and historical nesting activity and recent observations of nesting adults near the Project area. CDFW recommends including Swainson's hawk as a covered species in the ITP application for take coverage for both construction and operations and maintenance of the Project. CDFW recommends that the County include the need for take coverage for Swainson's hawk as a condition of approval in the DSEIR.

CDFW recommends that, in order to reduce impacts to ground nesting birds, such as northern harriers, if ground disturbing activities occur during nesting season (February 1-September 1), the DSEIR must specify that a qualified biologist will conduct pre-construction surveys immediately prior to ground disturbing activities (including equipment staging, vegetation removal, grading). The biologist should survey the work area and all suitable nesting habitat within a minimum of 500 feet of the work area. The DSEIR should include appropriate and effective avoidance measures with an adequate protective buffer, and on-site monitoring of any active nests, during all phases of Project construction.

2019 Updated PEIR Mitigation Measure BIO-8a: Implement measures to avoid and minimize potential impacts on special-status and non–special-status nesting birds. 4-7

Tricolored blackbird

The DSEIR indicates (p. 3.4-22) that perennial wetland drainage habitat within the Project area provides suitable nesting substrate for tricolored blackbirds (*Agelaius tricolor*) which is a species listed as threatened under CESA. The DSEIR also states that although no confirmed nesting has been documented within the Project area, two confirmed nesting colonies have been documented along Altamont Pass Road and the California Aqueduct adjacent to the Project area (DSEIR p. 3.4-35) (CNDDB 2019). The DSEIR indicates on page 3-59 that a 250-foot buffer will be surveyed if potential tricolored blackbird nesting substrates are present yet on page 3.5-60, a no-activity zone would be established around an active nest and could be between 50 feet and one mile from the nest. CDFW does not consider a 250-foot survey area as sufficient to detect all possible tricolored blackbird nesting activity and to determine an appropriate protective buffer. Please be advised that if take cannot be completely avoided during construction, the Project proponent should apply for take authorization under CESA for tricolored blackbird, in addition to coverage for operation and maintenance of the turbine faculties. 4-7 cont.

The updated Mitigation Measures BIO-8a, bullet one, indicates that removal of suitable nesting habitat (shrubs and trees) would occur during the non-breeding season (September 1-January 31) for nesting birds. The DSEIR does not clearly specify the location and extent of suitable nesting habitat proposed to be removed. Due to high site fidelity shown by raptors such as Swainson's hawk, white tailed kite, and golden eagles, removal of known nest sites, historic nest sites and/or adjacent suitable habitat should be completely avoided or greatly limited within the Project area. Removal of such nesting habitat could be considered a significant impact. If impacts to known, historic or suitable nesting habitat cannot be completely avoided, the DSEIR should include appropriate compensatory mitigation to offset the impacts.

For all nesting bird species, once construction work begins, the survey effort should continue to ensure any nest starts established after the work commences are identified. In addition to direct impacts, such as nest destruction, nesting birds might be affected by noise, vibration, odors and movement of workers or equipment. Identified active nests should be surveyed for the first 24 hours prior to any construction-related activities to establish a behavioral baseline of the adults and any nestlings. Once work commences, all active nests should be frequently monitored by the qualified biologist to detect any signs of disturbance and behavioral changes as a result of the Project. Even within species, disturbance distances can vary according to time of year or geographical location. Abnormal nesting behaviors which may cause reproductive harm include, but are not limited to: defensive flights/vocalizations directed towards Project personnel, standing up from a brooding position, interrupted feeding patterns, and flying away from the nest. If signs of disturbance and behavioral changes are observed, the biologist should have the authority to cease work causing that change and implement the necessary noise minimization buffer distance to ensure complete nest protection. Project activities within line of sight of the nest should not resume until the biological monitor confirms that the bird's behavior has normalized or the young have left the nest.

Impact BIO-11: Avian mortality resulting from interaction with wind energy facilities (significant and unavoidable). 4-8

The DSEIR states on page 3.4-73 that there is only one recorded Swainson's hawk fatality in the APWRA (in an area of non-repowered turbines), and that no Swainson's hawk fatalities have been detected at other wind energy projects in the APWRA (Diablo Winds, Buena Vista, Vasco Winds or Golden Hills). The DSEIR then concludes that that the annual estimated mortality rate for Swainson's hawk is approximately zero (as presented in Table 3.4-8). CDFW acknowledges the low overall fatality rate of Swainson's hawk recorded within the APWRA due to turbine collisions; however, based on the recent Swainson's hawk nesting activity in close proximity to the proposed Project boundaries as discussed in this letter above, CDFW does not agree that the mortality rate for this CESA-listed species would remain at or near zero at the Project site during operation of the turbines. CDFW therefore recommends that the County include, as a condition of approval, that the Project proponent seek take authorization for Swainson's hawk for mortality associated with turbine operations. 4-8 cont.

CDFW continues to be greatly concerned with golden eagle fatalities documented within the APWRA due to turbine collisions. Monitoring programs at existing wind energy facilities also report high mortality rates for the other raptors considered focal species under the PEIR, namely red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*) and burrowing owl (*Athene cunicularia*). Monitoring data also show high fatality of other birds as well as bats. As stated in this letter above, golden eagles are designated as Fully Protected under Fish and Game Code section 3511 which states that a fully protected bird cannot be taken at any time. It is also unlawful to take, possess or destroy any birds in the order Falconiformes or Stringiformes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code. It is also unlawful to take or possess any migratory non-game bird as designated in the Migratory Bird Treaty Act (Fish and Game Code, § 3513). CDFW therefore recommends that the County work with Project proponents in coordination with state and federal wildlife agencies such as the U.S. Fish and Wildlife Service to develop feasible and effective methods to curtail avian fatalities within the APWRA.

PEIR Mitigation Measure BIO-11a (p. 3.4-75): Prepare a Project-specific avian protection plan. 4-9
CDFW strongly recommends that a robust adaptive management program for birds and bats be prepared for the proposed Project that requires more immediate and significant reductions in identified fatalities at offending turbines or, if necessary, Project-wide curtailment of turbines during certain times of the day or year to significantly reduce unavoidable effects on focal raptor species and/or bats. More stringent adaptive management measures could include turbine curtailment or shut downs during specific times of the day/night or months of the year when raptors or bats are more likely to be present, real time turbine curtailment using the latest detection technology, implementing changes in turbine cut in speed upon specified triggers, and other effective and legally-enforceable measures after one year of Project monitoring.

BIO-11a requires preparation of avian protection plan that also includes methods used to discourage prey for raptors. While Mitigation Measure BIO-11f indicates that rodenticide will not be utilized on the Project site to avoid the risk of raptors scavenging the remains of poisoned animals, it is unclear whether these methods for discouraging or preventing fossorial mammals from becoming established within the Project area would result in additional loss of habitat for species dependent on existing burrows such as California tiger salamander and burrowing owl. If these methods result in loss of important habitat for special-status species then those impacts should be further discussed and analyzed, and compensatory mitigation included in the DSEIR. 4-10

PEIR Mitigation Measure BIO-11b: Site turbines to minimize potential mortality of birds. 4-11
CDFW has reviewed several micro-siting analyses and Project design layouts and does not consider any of these alternatives as sufficient to significantly reducing the avian fatality rate to the fullest extent possible. CDFW recommends that further consideration be given and presented in the Avian Protection Plan to other feasible alternatives for reducing avian and bat fatalities resulting from the proposed Project, including serious consideration of the no-Project

alternative, reduction in Project size (number and size of turbines), and various turbine micro-siting arrays to avoid and minimize impacts to avian species, especially the four focal raptor species described in the PEIR, namely golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*) and burrowing owl (*Athene cunicularia*) as well as other birds and bats. 4-11 cont.

PEIR Mitigation Measure BIO-11g: Implement postconstruction avian fatality monitoring for all repowering projects. 4-12

The DSEIR p. 3.4-77 requires that a post-construction monitoring program be conducted at each repowering project for a minimum of three years beginning on the commercial operation date (COD) of the Project. CDFW recommends extending the post-construction monitoring to a minimum five years to account for environmental changes, such as drought or abnormally high rain events or operational changes, such as shutting down turbines due to nesting raptors, that may cause inaccurate fatality reports.

FILING FEES 4-13

The Project, as proposed, would have an impact on fish and/or wildlife, and, as stated above, CDFW strongly recommends that CDFW's concerns and recommendations be addressed in the SEIR. Filling fees for CEQA documents are payable upon filing of the Notice of Determination by the Lead Agency and serve to help defray the cost of environmental review by CDFW. Payment of the fee is required in order for the underlying project approval to be operative, vested, and final. (Cal. Code Regs., tit. 14, § 753.5; Fish and Game Code, § 711.4; Pub. Resources Code, § 21089).

CONCLUSION

CDFW appreciates the opportunity to comment on the proposed Project to assist the County in identifying and mitigating Project impacts on biological resources. Questions regarding this letter or further coordination should be directed to Ms. Marcia Grefsrud, Environmental Scientist, at (707) 644-2812 or Marcia.Grefsrud@wildlife.ca.gov; or Ms. Brenda Blinn, Senior Environmental Scientist (Supervisory), at (707) 944-5541 or Brenda.Blinn@wildlife.ca.gov.

Sincerely,

Gregg Erickson
Regional Manager
Bay Delta Region

cc: Office of Planning and Research, State Clearinghouse, SCH #2010082063
Ryan Olah, U.S. Fish and Wildlife Service – ryan_olah@fws.gov
Heather Beeler, U.S. Fish and Wildlife Service – heather_beeler@fws.gov
Craig Weightman, CDFW Bay Delta Region
Lt. Clint Garrett, CDFW Law Enforcement Division

Letter 5

XAVIER BECERRA
Attorney General

State of California
DEPARTMENT OF JUSTICE

1515 CLAY STREET, 20TH FLOOR
P.O. BOX 70550
OAKLAND, CA 94612-0550

Telephone: (510) 879-0754
Facsimile: (510) 622-2700
E-Mail: Tara.Mueller@doj.ca.gov

October 4, 2019

Andrew Young, Senior Planner
Planning Department
Alameda County Community Development Agency
County of Alameda
224 W. Winton Avenue, Room 110
Hayward, CA 94544

VIA E-MAIL AND REGULAR MAIL: Andrew.Young@acgov.org

RE: ***Comments on Draft Subsequent Environmental Impact Report***:
Sand Hill Wind, LLC, Conditional Use Permit Application, PLN2017-00201

Dear Mr. Young:

5-1

We submit this letter on behalf of the Attorney General in his independent capacity on the County of Alameda's (County's) draft Subsequent Environmental Impact Report (DSEIR) for the proposed Sand Hill Wind Repowering Project, Conditional Use Permit Application, PLN2017-00201 (Project). The Attorney General is the chief law enforcement officer of the State of California and has the authority to file civil actions in order to protect public rights and interests, including actions to protect the natural resources of the State. (Cal. Const., art. V, § 13; Cal. Gov. Code §§ 12511, 12600-12612; *D'Amico v. Bd. of Medical Examiners*, 11 Cal.3d 1 (1974).)

The County initially circulated the SEIR for a 45-day public comment period on August 9, 2019. On September 16, 2019, at the request of the Attorney General's Office and others, the County agreed to extend the public comment period on the SEIR for an additional two weeks to October 4, 2019. As the County is aware, the Attorney General's Office has submitted two prior comment letters on this Project, on October 22, 2018, and February 13, 2019, which we hereby incorporate by reference:

I. SUMMARY, BACKGROUND AND CONTEXT

The Project will place up to 40 new, 2.3 to 4.0 megawatt (MW) turbines in the eastern portion of the Alameda County side of the Altamont Pass Wind Resources Area (Altamont Pass), for a total maximum operating capacity of 144.5 MW. (DSEIR, 2-3.) The Project would be located on

5-1 cont.

fifteen parcels extending over 2,600 acres. (*Id.*, 2-1.) The Project applicant is Sand Hill Wind, LLC, a subsidiary of S-Power.

As with the prior comment letters of the Attorney General's Office, this letter focuses on the Project's potentially significant effects on avian and bat resources. As requested in the DSEIR (page 1-10), these comments focus on the extent to which the DSEIR adequately analyzes those effects, and contains a reasonable range of feasible alternatives and mitigation measures that would avoid or reduce such effects. This comment letter also addresses other new information that has become available since the County's certification of the 2014 PEIR and which affects how the site-specific effects of the Project are likely to be different in nature and extent from the general impacts on avian and bat resources that were analyzed in the PEIR.[1]

5-2

In summary, these comments conclude that the DSEIR does not comply with CEQA because it does not adequately and objectively analyze the full nature and extent of the effects of the proposed Project on avian and bat resources. The DSEIR's cumulative impact analysis is very deficient, and the DSEIR does not consider the alternatives of reducing the total number of turbines and avoiding the highest risk proposed turbine sites; nor does it include sufficient additional mitigation measures for the anticipated adverse cumulative and other effects of this Project on avian and bat resources.[2] We therefore respectfully request that the DSEIR be revised in response to these and other public comments and recirculated for public review. (Pub. Resources Code, § 21092.1; Cal. Code Regs., tit. 14, § 15088.5, subd. (a).)[3]

The Attorney General's Office certainly recognizes the importance, in this era of increasing climate change, of developing more renewable energy resources in the State of California to meet California's renewable energy goals. Nevertheless, renewable energy projects, like any other development project, still must comply with the fundamental policy of CEQA that "public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects." (Pub. Resources Code, § 21002; see also *id.*, § 21002.1, subds. (a)-(b).)

---

[1] This includes additional new information that has become available since the County's circulation of the NOP for the DSEIR in January 2019, discussed below.

[2] This statement is made with the caveat that, on September 27, 2019, the Project applicant forwarded to the Attorney General's Office an email with a link to a new, fairly detailed mitigation plan, entitled "Bird and Bat Conservation Strategy for the Sand Hill Wind Repowering Project," prepared by ICF International and dated September 2019 (BBCS). The email, sent by the Project applicant to County staff on the same date, requests that BBCS be included as an appendix to the final SEIR. We appreciate the opportunity and certainly intend to provide a thorough review of what appears to be a substantive and meaningful mitigation document. However, our Office did not have sufficient time to review it prior to submitting these comments, given that we only received it a week in advance of the comment deadline on the DSEIR. **In the meantime, the BBCS should be circulated to the general public and the Alameda County Technical Advisory Committee (TAC) for review prior to certification of the final SEIR**.

[3] References to title 14 of the California Code of Regulations, section 15000 *et seq.*, are hereafter cited as the CEQA "Guidelines."

It is particularly important that this requirement be satisfied for new wind energy projects going forward in light of increasing scientific understanding of the impacts of modern wind energy projects on birds and bats. Many bird species affected by wind energy are protected under various federal and state laws, including the federal and state Endangered Species Acts, federal Migratory Bird Treaty Act, federal Bald and Golden Eagle Protection Act, and multiple provisions of the California Fish and Game Code. The golden eagle in particular is a "fully protected species" under California Law. (Fish & G. Code, § 3511, subd. (b)(7).) Additionally, on September 27, 2019, Governor Newsom signed AB 454 (Kalra) into law, which amends Fish and Game Code section 3513 to reinstate now-repealed federal Migratory Bird Treaty Act regulations protecting migratory birds as a matter of *state* law. (AB 454, Chap. 349, Stats. of 2019.) 5-2 cont.

A very recent study, published in *Issues in Ecology* and authored by T.D. Allison *et al*., estimates that: 5-3

> Using adjusted fatality rate data from publicly available studies [for land-based wind energy projects], estimates of average cumulative annual bird fatalities in the continental U.S. published in 2013 and 2014 ranged from approximately 230,000 to 600,000 birds per year, [and] estimates of cumulative bat fatalities published during that same period ranged from 200,000 to 800,000 bats per year.

(T.D. Allison *et al*., Issues in Ecology, Report 21, Fall 2019, *Impacts to Wildlife of Wind Energy Siting and Operation in the United States*, p. 6.) These overall estimated cumulative effects of existing wind energy projects are admittedly uncertain and not as high as the total impacts to birds and bats from other anthropogenic causes such as raptor shootings, vehicle and building collisions, and bat white nose syndrome. (*Ibid*.) The cumulative effects of wind energy are still significant, however, in light of other new information regarding markedly declining bird and bat populations in the Pacific Northwest and nationwide. (See, e.,g, K. V. Rosenberg *et al*., *Decline of the North American Avifauna*, Science 10.1126/science.aaw1313, 2019; T.J. Rodhouse *et al*., *Evidence of Region-Wide Bat Population Decline From Long-Term Monitoring and Bayesian Occupancy Models With Empirically Informed Priors*, Ecology and Evolution, Aug. 2019.)

In fact, new studies reveal that the ongoing cumulative effects of wind energy are already having population-level effects on affected bird and bat species. The Allison study states that:

> Demographic models, such as population viability analyses designed around the biology of specific species, suggest the population size or dynamics of some species may be negatively affected from increases in mortality from collisions at wind turbines, particularly as more turbines are placed within the species' range.

(T.D. Allison *et al.*, p. 8.) In addition, "modeling results suggest some of these [affected migratory bat] species are at risk of population decline due to collision fatalities." (*Ibid*.; see also T.J. Rodhouse *et al*., pp. 7-8 [describing probable impact of wind turbines in Pacific Northwest on populations of hoary bats].)

5-3 cont.

Another recent study reports that wind turbines in North America have resulted in an estimated 840,500 to 1.7 million bat deaths between 2000 and 2011, which estimate is projected to increase with installation of more wind energy capacity. (E.B. Arnett, *Mitigating Bat Collision*, Chap. 8 in Wildlife and Windfarms Onshore: Monitoring and Mitigation (M.R. Perrow, ed.), 2017, p. 168; see also K.S. Smallwood *et al*., *Relating Bat and Bird Passage Rates to Wind Turbine Collision Fatalities*, Report for East Contra Costa County Habitat Conservancy, July 2019 at p. 1, and K.S. Smallwood *et al*., *Effects of Wind Turbine Curtailment on Bird and Bat Fatalities*, Report for East Contra Costa County Habitat Conservancy, July 2019 at p. 1 [both discussing cumulative impacts of wind turbine operations on bats in North America of between an estimated 600,000 to 888,000 fatalities per year].)

The Altamont Pass and surrounding region also are widely known to "support some of the highest known densities of golden eagle nesting territories in the world." (PEIR, 3.4.105; *see also id*., E-36 [U.S. Fish and Wildlife Service (FWS) comment letter on PEIR].) At the same time, golden eagle surveys conducted in the Altamont Pass region by biologists at the U.S. Geological Survey (USGS) between 2014 and 2018 indicate that the ongoing high fatalities due to collisions with wind turbines are causing this region to be a population sink for golden eagles. (D. Weins and P. Kolar, USGS, *Golden Eagle Population Monitoring in the Vicinity of the Altamont Pass Wind Resource Area, California, 2014 – 2018*, July 2019, pp. 7-8; see also PEIR, 3.4-105—106; PEIR, E-33 [FWS comment on PEIR that it has "determined that the current take rate for the [Altamont Pass] golden eagle local-area population is approximately 12% annually," and that "this level of ongoing take is having a negative effect on the local-area population of golden eagles and could affect the sustainability of this population"].)[4] The most recent USGS golden eagle survey data also shows that significant portions of the Project site are particularly high use areas for golden eagles. (P. Kolar, USGS, statement at Alameda Co. Technical Advisory Com. (TAC) Meeting, Sept. 19, 2019.)

The 2019 Science study cited above, which documents a nearly 30% decline in bird species in North American since 1970, "signals an urgent need to address threats to avert future avifaunal collapse and associated loss of ecosystem integrity, function and services." (K. V. Rosenberg *et al*., Science 10.1126/science.aaw1313, 2019 at p. 1; see also *id*. at p. 3.) Such efforts start at the project level. As the 2019 T.D. Allison study notes, "[s]pecies-specific levels of fatality at wind energy facilities are more useful for regulatory decisions and conservation planning related to wind energy than the cumulative national estimates that garner more attention." (T.D. Allison *et al.* at p. 6.) In short, we can, and must, do better at the project-specific level for wind energy projects going forward in light of this increasing body of scientific knowledge.

[4] The PEIR also notes that "it is believed that the [Altamont Pass] may support the largest number of breeding [burrowing owl] pairs in the Bay Area," and that these populations also may not currently be sustainable in some years due to ongoing impacts from wind turbine operations. (PEIR, 3.4-105; *see also id*., E-37 [FWS comments on PEIR re impacts of wind projects in Altamont Pass on burrowing owls].)

II. OVERVIEW OF BASIC CEQA REQUIREMENTS FOR ADEQUACY OF AN EIR 5-4

"[T]he foremost principle under CEQA is that the Legislature intended the act 'to be interpreted in such manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language.'" (*Muzzy Ranch Co. v. Solano County Airport Land Use Com.* (2007) 41 Cal.4th 372, 381, quoting *Laurel Heights Improvement Assn. v. Regents of Univ. of Calif.* (1988) 47 Cal.3d 376, 390.) To further that purpose, "CEQA contains a 'substantive mandate' requiring public agencies to refrain from approving projects with significant environmental effects if 'there are feasible alternatives or mitigation measures' that can substantially lessen or avoid those effects." (*County of San Diego v. Grossmont–Cuyamaca Community College Dist*. (2006) 141 Cal.App.4th 86, 98, quoting *Mountain Lion Found. v. Fish and Game Comn.* (1997) 16 Cal.4th 105, 134 and Pub. Resources Code, § 21002.) While CEQA does "permit[] government agencies to approve projects that have an environmentally deleterious effect," it "also requires them to justify those choices in light of specific social or economic conditions." (*Sierra Club v. State Bd. of Forestry* (1994) 7 Cal.4th 1215, 1233, citing Pub. Resources Code, § 21002; see also *id*., § 21002.1, subd. (c).)

"[T]he EIR is the heart and soul of CEQA." (*Planning & Cons. League v. Dept. of Water Resources* (2000) 83 Cal.App.4th 892, 910; see also *Citizens of Goleta Valley v. Bd. of Supervisors* (1990) 52 Cal.3d 553, 564.) The fundamental purpose of an EIR "is to inform the public and its responsible officials of the environmental consequences of their decisions *before* they are made." (*Citizens of Goleta Valley, supra*, 52 Cal.3d at p. 564.) The EIR "protects not only the environment but also informed self-government." (*Ibid.*; see also *PCL, supra*, 83 Cal.App.4th at p. 910 [an EIR "is the mechanism prescribed by CEQA to force informed decision making and to expose the decision-making process to public scrutiny"].) The purpose of an EIR is "not to generate paper, but to compel government at all levels to make decisions with environmental consequences in mind." (Guidelines, § 15004, subd. (g).). Thus, "given the key role of the [EIR] in carrying out CEQA's requirements, 'the integrity of the process is dependent on the adequacy of the EIR.'" (*Calif. Native Plant Society v. City of Santa Cruz* (2009) 177 Cal.App.4th 957, 977-980 (*CNPS*), quoting *Save Our Peninsula Committee v. Monterey County Bd. of Supervisors* (2001) 87 Cal.App.4th 99, 117.)

"Under CEQA, the public agency bears the burden of affirmatively demonstrating that, notwithstanding a project's impact on the environment, the agency's approval of the proposed project followed meaningful consideration of alternatives and mitigation measures." (*Mountain Lion Foundation, supra*, 16 Cal.4th at p. 134.) "An agency may utilize staff or consultants to prepare the EIR but it must use its independent judgment in considering the information." (*CNPS, supra,* 177 Cal.App.4th at p. 979; see Guidelines, § 15084, subds. (a), (d), (e).) "Because the EIR must be certified or rejected by public officials, it is a document of accountability." (*Laurel Heights, supra*, 47 Cal.3d at p. 392.)

In determining the legal adequacy of an EIR, the courts have not required "[t]echnical perfection" or "exhaustive analysis," but "have looked … for adequacy, completeness and a good-faith effort at full disclosure.'" (*CNPS, supra*, 177 Cal.App.4th at p. 979, quoting *Concerned Citizens of South Central Los Angeles. v. Los Angeles Unified School Dist*. (1994) 24

Cal.App.4th 826, 836; see Guidelines, § 15151.) "An EIR will be found legally inadequate—and subject to independent review for procedural error—where it omits information that is both required by CEQA and necessary to informed discussion." (*Bay Area Citizens v. Assn. of Bay Area Govts*. (2016) 248 Cal.App.4th at p. 997, quoting *CNPS*, *supra*, 177 Cal.App.4th at p. 986; see also *Sierra Club v. County of Fresno* (2018) 6 Cal.5th 502, 514-515.) 5-4 cont.

"When the informational requirements of CEQA are not met but the agency nevertheless certifies the EIR as meeting them, the agency fails to proceed in a manner required by law and abuses its discretion." (*Cherry Valley Pass Acres and Neighbors v. City of Beaumont* (2010) 190 Cal.App.4th 316, 327.) "The error is prejudicial 'if the failure to include relevant information precludes informed decisionmaking and informed public participation, thereby thwarting the statutory goals of the EIR process." (*Id*. at p. 328, quoting *San Joaquin Raptor/Wildlife Rescue Center v. County of Stanislaus* (1994) 27 Cal.App.4th 713, 721–722.) Of key relevance here, whether an EIR's "description of an environmental impact is insufficient because it lacks analysis or omits the magnitude of the impact is not a substantial evidence question. A conclusory discussion of an environmental impact that an EIR deems significant can be determined by a court to be inadequate as an informational document without reference to substantial evidence." (*Sierra Club v. County of Fresno, supra*, 6 Cal.5th at p. 514.)

The substantial evidence standard applies to judicial review of an agency's *factual* findings and determinations in an EIR. (*Bay Area Citizens, supra*, 248 Cal.App.4th at p. 997; *San Joaquin Raptor/Wildlife Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645, 654.) "Substantial evidence" is "enough relevant information and reasonable inferences from this information that a fair argument can be made to support a conclusion, even though other conclusions might also be reached." (Guidelines, § 15384, subd. (a).) However, "[a]rgument, speculation, unsubstantiated opinion or narrative, evidence which is clearly erroneous or inaccurate, or evidence of social or economic impacts which do not contribute to or are not caused by physical impacts on the environment does not constitute substantial evidence." (*Ibid*.)

With these foundational principles of CEQA in mind, we now turn to our specific comments on various sections of the DSEIR.

III. SPECIFIC COMMENTS ON THE DSEIR 5-5

A. <u>The DSEIR Must Include an Exiting Conditions Baseline, In Addition to an Historic Conditions Baseline, to Ensure Meaningful Analysis of the Project's Effects</u>

In order for an EIR to accurately assess the degree of significance of a proposed project's environmental effects, it normally must evaluate those effects against a "baseline" of environmental conditions in existence at the time of publication of the NOP for the EIR in question. (Guidelines, §§ 15125, subd. (a)(1), 15126.2, subd. (a).) In general, "CEQA requires an EIR to "focus on impacts to the existing environment, not hypothetical situations" and thus "the impacts of a proposed project are ordinarily to be compared to the actual environmental conditions existing at the time of CEQA analysis." (*San Franciscans for Livable Neighborhoods v. City and County of San Francisco* (2015) 26 Cal.App.5th 596, 614-615, quoting *County of*

5-5 cont.

Amador v. El Dorado County Water Agency (1999) 76 Cal.App.4th 931, 955 and *Communities for a Better Envt. v. SCAAQMD* (2010) 48 Cal.4th 310, 321, 323; see also *Neighbors for Smart Rail v. Exposition Metro Line Construction Authority* (2013) 57 Cal.4th 439, 448.)

An agency may use a baseline of previously existing, historic conditions, but only where conditions have changed or fluctuated over time, and only if an historic conditions baseline is "necessary to provide the most accurate picture practically possible of the project's impacts." (Guidelines, § 15125, subd. (a)(1).) Thus, an agency may depart from the "existing conditions" baseline under CEQA only where "factual circumstances" justify this and "when necessary to prevent misinforming or misleading the public and decision makers." (*Neighbors for Smart Rail*, *supra*, 57 Cal.4th at p. 448.) The rationale for this rule is that "an inappropriate baseline may skew the environmental analysis flowing from it, resulting in an EIR that fails to comply with CEQA." (*Citizens for East Shore Parks v. State Lands Com*. (2011) 202 Cal.App.4th 549, 557.)

Here, the environmental analysis in the biological resources section of the DSEIR relies on a now-hypothetical historic conditions baseline of previously operating old-generation turbines for purposes of evaluating the ongoing operational impacts of the Project on birds and bats. (DSEIR, 3.4-37 [stating that the baseline is the average annual fatality rate per MW of the old-generation turbines from 2005-2011, as provided in the Alameda County Avian Fatality Monitoring Program]; see also *id*., 3.4-6 [stating that "[m]uch of the Project area is occupied by a previously operating wind farm"].) The vast majority of the old-generation turbines were required to be shut down and removed by the end of 2015 under the Attorney General's 2010 settlement agreement with Next Era Energy and the County's prior conditional use permits, and all remaining turbines (formerly operated by Altamont Winds, Inc.) were to be shut down and removed by the end of 2018.

While use of an "historic conditions" baseline of all previously operating old-generation turbines does provide a helpful and useful comparative analysis between the effects of the old-generation vs. the new-generation turbines, the County also must compare the Project's effects against the actual environmental conditions currently existing on the Project site. Indeed, the DSEIR itself admits that "about half of the [Project] area has not contained wind turbines for about two decades." (DSEIR, 2-2.)

In particular, a current conditions baseline is important in order to adequately assess the cumulative effects of the Project going forward. Even if the average annual fatality rate per MW for the new-generation turbines is less for some affected species than for the old-generation turbines (which is still an open question), these effects are still highly cumulatively significant, as discussed in detail in Part III.C, *infra*. The DSEIR's focus on comparison between a repowered vs. non-repowered landscape has the effect of masking these cumulative effects.

Moreover, the DSEIR does not adequately or accurately describe even the historic conditions baseline for purposes of comparison with the Project. For example, the DSEIR does not answer such fundamental questions as:

5-5 cont.

1) Exactly how many old generation turbines (vs. former potential turbine *sites*) were previously operating on the entire 2,600-acre Project site?
2) Where were each of these old turbines located in relation to the proposed new turbine sites?
3) What were the models, sizes and owners/operators of these old turbines?
4) Were any of these old turbines rated as very high, high, or moderately high-risk turbines by the former Alameda County Scientific Review Committee?
5) What did the prior monitoring data show for the turbines in this area?

For the current conditions baseline, the DSEIR further needs to address:

6) When were the old turbines shut down? When were the turbines and components removed?
7) Do any old generation turbines remain on the Project site? If so, what turbines and where?
8) Are any of these turbines still operating and if so, which ones? If not operating, do any of these turbines provide raptor perching and nesting opportunities and if so, where?
9) Will all of the old turbines be shut down and removed as part of the Project?

In addition, and of critical importance, the DSEIR inaccurately states that there are no known golden eagle or bald eagle nesting locations within the project site. (DSEIR, 3.4-33.) In fact, nesting data has been provided to the Project applicant by USGS researchers which indicates nesting golden eagles in and adjacent to the Project site. (*Id*., 3.4-13; Email from D. Weins (USGS), to Heather Beeler (FWS), Douglas Bell (EBRPD), Renee Culver (Next Era) and Tara Mueller (Attorney General), dated Aug. 1, 2019.) In addition, Dr. Shawn Smallwood notes in his comments on the DSEIR, September 18, 2019, that he observed and reported to the Project applicant on May 18, 2019, a successful breeding pair of bald eagles at Bethany Reservoir adjacent to the Project site, and also has observed bald eagles foraging on the Project site. (K.S. Smallwood, Sept. 2019 at p. 15.) 5-6

In sum, the DSEIR must be revised to include a complete and accurate current conditions baseline and meaningful information concerning historic conditions that will enable the County and the public to adequately and accurately compare the effects of the Project against an accurate, realistic and informative environmental baseline. 5-7

B. <u>The DSEIR Contains an Incomplete and Misleading Discussion of Project Impacts on Bird and Bat Resources</u>

"As a general matter the EIR must present facts and analysis, not simply the bare conclusions or opinions of the agency. The discussion of impacts is acceptable if it provides sufficient information and analysis to allow the public to discern the basis for the agency's impact findings. Thus, the EIR should set forth specific data, as needed to meaningfully assess whether the proposed activities would result in significant impacts." (*Bay Area Citizens*, *supra*, 248 Cal.App.4th at p. 977, quoting *Californians for Alternatives to Toxics v. Calif. Dept. of Food and* 5-8

Agric. (2005) 136 Cal.App.4th 1, 13; see also *Laurel Heights*, *supra*, 47 Cal.3d at pp. 404–405 ["[w]ithout meaningful analysis … in the EIR, neither the courts nor the public can fulfill their proper roles in the CEQA process"].) 5-8 cont.

CEQA Guidelines section 15126.2, subdivision (a) provides that:

> Direct and indirect significant effects of the project on the environment shall be clearly identified and described, giving due consideration to both the short-term and long-term effects. The discussion should include *relevant specifics of* the area, the resources involved, physical changes, alterations to ecological systems, and changes induced in … other aspects of the resource base…

(*Ibid*., emphasis added.) The "relevant specifics" must include a discussion of the precise nature and magnitude of significance of the project's anticipated effects if it is reasonably scientifically possible to do so, and if it is not scientifically possible, to explain why. (*Sierra Club v. County of Fresno*, *supra*, 6 Cal.5th at pp. 519-520.)

Here, the DSEIR omits certain information that is important for the County and the public to meaningfully assess the actual extent of the Project's significant effects on avian and bat resources, and the DSEIR also contains certain other information that is incorrect and/or misleading. (Guidelines, § 15384, subd. (a) ["[a]rgument, speculation, unsubstantiated opinion or narrative, [or] evidence which is clearly erroneous or inaccurate" does not constitute substantial evidence].) Consequently, the DSEIR must be revised to include the missing and corrected information, as discussed below. 5-9

First, the DSEIR misstates the new monitoring data.[5] The H.T. Harvey first- and second- year monitoring reports for the Golden Hills Project in Alameda County documented actual, not *potential*, golden eagle, red tailed hawk and bat fatalities. (Cf. DSEIR, 3-3, 3.4-9; H.T. Harvey, Feb. 2018 at vi-vii; H.T. Harvey, Dec. 2018 at iv-v.)

Second, the DSEIR inappropriately attempts to dismiss the significance of the new monitoring data for Golden Hills and the final three-year monitoring report for the Vasco Winds Project in Contra Costa County. For example, the DSEIR is correct that the new monitoring reports do indicate a lower average annual fatality rate per MW of installed capacity for *all raptors combined* than for the old-generation turbines. (DSEIR, 3.4-9; see H.T. Harvey, Dec. 2018 at xiii [rate is 1.30 to 2.17 average annual fatalities per MW for Golden Hills vs. 2.43 annual fatalities per MW for the old turbines].) However, the Golden Hills monitoring reports indicate an *increase* in average annual fatality rates per MW, from the rates of the old turbines, for golden

[5] *See* .H.T Harvey & Assoc., *Golden Hills Wind Energy Center Post Construction Fatality Monitoring Report: Year 2,* Draft Report, Dec. 2018; H.T Harvey & Assoc., *Golden Hills Wind Energy Center Post Construction Fatality Monitoring Report: Year 1*, Final Report, Feb. 2018; and Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas, *Final 2012-2015 Report Avian and Bat Monitoring Project Vasco Winds, LLC*, 2016.

(continued…)

eagles in both years of monitoring, and for red tailed hawks and burrowing owls in one year of monitoring.[6] 5-9 cont.

As another example of the DSEIR's somewhat misleading analysis of the new monitoring data, the DSEIR states, without explanation, that the monitoring results from "a single project during abnormally wet years … cannot be extrapolated to conclude decisively that the proposed Project or repowered wind turbines overall would result in new significant effects or a substantial increase in the severity of effects." (DSEIR, 2-24; see also *id*., 3.4-37—42 [discussing uncertainty in the recent monitoring data].) The DSEIR goes on to state that "[a] body of information spanning multiple projects and multiple years of monitoring is necessary to form conclusions regarding the effects of powering with fourth-generation turbines as represented by the proposed Project." (*Id*., 2-24; see also *id*., 3-3—3-4 [stating that recent monitoring data does not provide "definitive or conclusive determinations about future mortality rates for birds and bats"].)

But CEQA does not demand "conclusive" evidence in order to evaluate the relative significance of a project's impacts. Rather, CEQA simply requires the lead agency to make a reasoned, good-faith attempt to quantify or qualify project impacts in light of the most recent available information. (See Guidelines, § 15003, subd. (i); *Sierra Club v. City of Fresno*, *supra*, 6 Cal.5th at pp. 519-520 ["a sufficient discussion of significant impacts requires not merely a determination of whether an impact is significant, but some effort to explain the nature and magnitude of the impact"; "scientific certainty is not the standard"]; see also *id.* at p. 514 ["an EIR's designation of a particular adverse environmental effect as 'significant' does not excuse the EIR's failure to reasonably describe the nature and magnitude of the adverse effect"].)

Despite its repeated conclusion that the new fatality monitoring data is preliminary and uncertain, the DSEIR fortunately does use this new data to project the estimated ranges of average annual fatalities per MW of the four focal raptor species due to ongoing Project operations. (See DSEIR, 3.4-66—74.) However, this analysis does not sufficiently describe the "nature and magnitude" of these impacts (*Sierra Club v. Fresno*, *supra*, 6 Cal.5th at pp. 519-520), but simply concludes that the impacts are "significant" and that the DSEIR's mitigation measures will "reduce" these impacts on identified special status bird species. (DSEIR, 3.4-70—74.)

The DSEIR also contains a number of errors in the estimated annual fatality rates for the Project. 5-10
For example, the lowest average annual fatality rate per MW for golden eagles for repowering projects with comparable sized turbines as the proposed project (the 78.2 MW Vasco Winds project, which used 2.3 MW turbines) is .04 golden eagle deaths per MW per year, which would result in a minimum of 5.8 total eagle deaths per year for the 144.5 MW proposed project, not *one* golden eagle death as indicated in the DSEIR. (Cf. H.T. Harvey, Dec. 2018 at xiii with

---

[6] See H.T. Harvey, Feb. 2018 at xii & Dec. 2018 at xiii [identifying .(a) **.13 to .17** annual golden eagle deaths per MW for Golden Hills vs**. .09** for the old turbines; .(b) **.37 to .91** annual red tailed hawk deaths per MW for Golden Hills vs. **.40** for the old turbines; and (c) **.05 to 1.10** annual burrowing owl deaths per MW for Golden Hills vs. **.67** for the old turbines].

DSEIR, 3.4-71.) In fact, according to the DSEIR, the Buena Vista repowering project, which at 38 MW is about a quarter of the size of the proposed Project, has killed an average of 5.8 eagles per year. (DSEIR, 3.4-67.) So, it is unclear how the DSEIR estimates that the 144.5 Project could possibly kill only *one* eagle per year under any scenario. Similarly, the lowest applicable annual fatality rate per MW for red tailed hawks is .37 (from the first year of monitoring at Golden Hills), which would result in an estimated minimum of 53.4 red tailed hawk deaths per year, not 15, as indicated in the DSEIR. (Cf. H.T. Harvey, Dec. 2018 at xiii with DSEIR, 3.4-73.) 5-10 cont.

Finally, both the PEIR and DSEIR require each project proponent to conduct surveys in and surrounding the Project site for nesting habitat of golden eagles and other special status bird species (such as tri-colored blackbird, Swainson's hawk and burrowing owl), and to survey for bat roosting habitat. (See PEIR 3.4-90—91, 3.4-109, 3.4-127—128, 3.4-133; DSEIR at 3.4-58—61, 3.4-75, 3.4-85, 3.4-88.) The Attorney General's Office's February 2019 comment letter on the NOP requested that the DSEIR provide maps of the locations of this nesting habitat, overlain with maps of the proposed turbine locations, "[i]n order to provide a reasonable assessment of the nature and extent of the [Project's] impacts on special status bird and bat species and their habitat." (AG NOP Ltr., Feb. 2019 at p. 16.) Unfortunately, the DSEIR does not provide this information. 5-11

Our NOP letter further requested that the DSEIR "analyze the extent to which construction and operation of the [P]roject … will adversely affect nesting, roosting and foraging habitat for all raptors, other special status bird species such as the … tri-colored blackbird, and bats." (AG NOP Ltr., Feb. 2019 at p. 16.) However, the DSEIR provides only a very general analysis of the impacts of Project construction and operation on bird and bat nesting, roosting and foraging habitat in and around the Project site. (DSEIR, 3.4-21—22, 3.4-32—35, 3.4-58—61, 3.4-84—85.) In addition, the DSEIR concludes, without supporting facts and analysis, that the DSEIR's construction buffer zones will reduce impacts to protected bird species to a level of insignificance. (DSEIR, 3.4-59, 3.4-61.) This is not sufficient to adequately inform the public and agency decision makers as to the site-specific nature and extent of the Project's anticipated impacts on these species and their habitat. 5-12

The nesting data provided in the DSEIR also is not accurate. For example, as noted in Part III.A, *supra*, the DSEIR erroneously states that there are no known golden eagles or bald eagles nesting in the Project area, contrary to available recent USGS survey data. (DSEIR, 3.4-33.) In addition, Dr. Smallwood's burrowing owl nesting surveys documented a high density of burrowing owl nests in the Project site in 2011, but the DSEIR states that only one burrowing owl nest was found in 2017. (Cf. K.S. Smallwood, *et al.*, *Nesting Burrowing Owl Density and Abundance in the Altamont Pass Wind Resource Area, California*, Wildlife Society Bulletin 37(4):787–795, 2013, pp. 791-794 with DSEIR, 3.4-22.) These discrepancies need to be explained. (See *San Joaquin Raptor Rescue*, *supra*, 27 Cal.App.4th at p. 741 [EIR's impact analysis must be supported by "complete and accurate facts and analysis"].) 5-13

In sum, the DSEIR should be revised to address the foregoing errors and omissions in the impact analyses for birds and bats. 5-14

C. The DSEIR's Cumulative Impacts Analysis Is Inadequate

5-15

An EIR must discuss a project's cumulative effects when the project's "incremental effect is cumulatively considerable," e.g., the incremental effects "are significant when viewed in connection with the effects of" past projects, other current projects and probable future projects. (Guidelines, §§ 15065, subd. (a)(3), 15130, subd. (a); see also *id.*, § 15355, subd. (b), Pub. Resources Code, § 21083, subd. (b)(2).) "Assessment of a project's cumulative impact on the environment is a critical aspect of the EIR." (*Los Angeles Unif. School Dist. v. City of Los Angeles* (1997) 58 Cal.App.4th 1019, 1025.) "One of the most important environmental lessons evident from past experience is that environmental damage often occurs incrementally from a variety of small sources. These sources appear insignificant, assuming threatening dimensions only when considered in light of the other sources with which they interact." (*Kings County Farm Bureau v. City of Hanford* (1990) 221 Cal.App.3d 692, 720 [invalidating EIR that "avoid[ed] analyzing the severity of the problem and allow[ed] the approval of projects which, when taken in isolation, appear insignificant, but when viewed together, appear startling"].)

In order to satisfy CEQA's requirements, "the cumulative impact analysis must be substantively meaningful." (*Joy Road Area Forest and Watershed Assn. v. Calif. Dept. of Forestry & Fire Protection* (2006) 142 Cal.App.4th 656, 676.) "A cumulative impact analysis which understates information concerning the severity and significance of cumulative impacts impedes meaningful public discussion and skews the decisionmaker's perspective concerning the environmental consequences of the project, the necessity for mitigation measures, and the appropriateness of project approval." (*Mountain Lion Coalition v. Fish & Game Com*. (1989) 214 Cal.App.3d 1043, 1051.)

The CEQA Guidelines provide that the cumulative impact analysis may be presented as either "[a] list of past, present and probable future projects producing related or cumulative impacts, including, if necessary, those projects outside the control of the agency" or "[a] summary of projections contained in an adopted local, regional or statewide plan" that "describes or evaluates conditions contributing to the cumulative effect." (Guidelines, § 15130, subd. (b)(1).) The EIR must define the geographic scope of the cumulative impact area and "provide a reasonable explanation" for this scope. (*Id.*, § 15130, subd. (b)(3).) When using a list of projects, the EIR must specify the location and type of each project, summarize and analyze the expected cumulative effects of these projects, and "examine reasonable, feasible options for mitigating or avoiding the project's contribution to any significant cumulative effects." (*Id.*, § 15130, subds. (b)(2), (b)(4)-(5).)[7]

[7] The Guidelines' provisions for incorporating by reference a cumulative impact analysis in a prior PEIR (*id.*, § 15130, subds. (d)-(e)) do not apply here due, *inter alia*, to the significant new information and changed circumstances surrounding the Project which indicate more extensive and severe cumulative effects than anticipated in the 2014 PEIR, as explained in the Attorney General's October 2018 and February 2019 comment letters.

(continued…)

Applying these principles, the DSEIR's cumulative impact analysis is seriously inadequate. The DSEIR identifies a list of approved, pending and reasonably foreseeable future wind projects on the *Alameda County* side of the Altamont Pass region, totaling 475.8 MW, including the proposed 144.5 MW Project.[8] (DSEIR, 2-22.) However, despite stating that the geographic area of the cumulative impact analysis is the entire Altamont Pass region and Montezuma Hills Wind Resource Area in Solano County (DSEIR, 5-3), the DSEIR does not identify *any* wind projects currently operating on the Contra Costa side of Altamont Pass (e.g., the 78.2 MW Vasco Winds Project and the 38 MW Buena Vista Project) or in Montezuma Hills. (See DSEIR, 2-22.) 5-16

The DSEIR also implicitly acknowledges that the 475.8 MW total of operating, approved and proposed wind projects for Alameda County will exceed the 450 MW cap in the 2014 PEIR, but improperly defers discussion of this issue, stating that "the County will not approve a project that results in more than 450 MW of production capacity in the [Altamont Pass] without additional CEQA review to address the cumulative environmental impacts that were not addressed in the PEIR." (DSEIR, 2-22—2-23.) But CEQA requires that this cumulative impact analysis be performed *now*, because the likelihood of exceedance of the 450 MW cap, and associated cumulative impacts, are currently reasonably foreseeable and not speculative. (*Laurel Heights, supra*, 47 Cal.3d at p. 398; see *Joy Road Area Assn.*, *supra*, 142 Cal.App.4th at pp. 679-680 ["future housing development is a reasonably foreseeable consequence of this proposed timber harvest" and therefore must be included in cumulative impact analysis]; Guidelines, § 15355.)

Moreover, the DSEIR does not discuss, or make an attempt to quantify or qualify, the cumulative projected levels of ongoing annual avian and bat fatalities that are anticipated to be caused by future *operation* of all operating, approved but not yet operating, and reasonably foreseeable future wind projects in the Altamont Pass and surrounding region. Rather, the DSEIR only identifies, in a very conclusory and cursory fashion, the cumulative biological impacts on special status species, avian and bat resources and their habitat due to impact of project *construction*. (DSEIR, 5-3, 5-6; see *San Joaquin Raptor Rescue*, 27 Cal.App.4th at p. 741 ["because other development projects are neither listed nor adequately discussed in the FEIR and the conclusions reached in the DEIR concerning the effects of cumulative development are not supported by complete and accurate facts and analysis, the cumulative discussion is inadequate as a matter of law"].)

---

[8] As indicated in the chart on page 2-22 of the DSEIR, this total includes: (1) the not-yet-operational 25.1 MW Rooney Ranch project, another S-Power project at Altamont Pass, which was approved on land owned by the City of Santa Clara as within the scope of the 2014 PEIR on June 25, 2019; and (2) the 20.5 MW Diablo Winds Project, which has been operating since 2005 and which the DSEIR states is part of the environmental baseline in the PEIR and therefore is excluded from the impact analysis. (DSEIR, 2-21—22.) As discussed, however, the cumulative impact analysis must consider *all* existing, approved and reasonably foreseeable future projects, including those considered to be part of the "baseline." (Guidelines, §§ 15130, subd. (b)(1)(A), 15355, subd. (b).)

As discussed in our prior comment letters, it is possible to make a reasonable attempt at projecting the cumulative total projected annual raptor and bat fatalities based on prior and current monitoring data for operational projects in the Altamont Pass and Montezuma Hills wind resources areas and other available information. 5-16 cont.

For example, the H.T. Harvey first- and second-year monitoring reports for the 85.9 MW Golden Hills Project in Alameda County documented 12 golden eagle deaths in the first year of operation, and 14 golden eagle deaths in the second year. The reports also documented 70 red-tailed hawk deaths in the first year of operation and 30 red-tailed hawks in the second year. (H.T. Harvey, Feb. 2018 at vii; H.T. Harvey, Dec. 2018 at iv-v.) In addition to the Golden Hills monitoring data, the final three-year monitoring report for the 78.2 MW Vasco Winds Project in Contra Costa County estimated that this project killed 2-6 golden eagles and 4-39 red tailed hawks annually during the three-year monitoring period. (Brown, *et al*., 2016 at Table ES-1 at 7.)[9] Applying the range of average annual fatality rates in monitoring results from these most recent repowering projects (Golden Hills and Vasco Winds), as reported in H.T. Harvey, the 144.5 MW Project is estimated to result in 5.8 to 21.7 additional eagle deaths per year and 63.6 to 92.5 red tailed hawk deaths. (DSEIR, 3-4.71, 3.4-73; H.T. Harvey, Dec. 2018 at xiii.) These numbers add up to an estimated range of 19.8 to 41.7 golden eagle deaths and 97.6 to 201.5 red tailed hawk deaths every year from just 308.6 MW of the 592 MW of the projected total amount of final installed capacity on both the Alameda and Contra Costa sides of Altamont Pass.[10]

The cumulative impact analysis must then add to the above totals the estimated ranges of fatalities from: (1) other operational projects for which monitoring results are not yet available; (2) projects approved but not yet constructed; and (3) other reasonably foreseeable future projects. The 46 MW Golden Hills North Project is operational and has just completed its first year of monitoring; results are not yet available. Two other Alameda County-approved repowering projects, the 54 MW Summit Wind Project and 19.8 MW Patterson Pass Project, as well as the very recently approved 25.1 MW Rooney Ranch Project, are likely to commence construction soon, and the 80 MW Mulqueeny Ranch Project is expected to submit an application soon.[11]

---

[9] There are two other currently operational projects in the Altamont Pass for which fatality data is available but which are not in the Attorney General's possession: the 38 MW Buena Vista Project in Contra Costa County, which completed monitoring in 2011, and the 20.5 MW Diablo Winds project in Alameda County, which has been operating since 2005 and also is no longer being monitored.

[10] The total MW figure is obtained as follows. *Alameda County*: Diablo Winds (operational, 20.5 MW), Golden Hills (operational, 85.9 MW), Golden Hills North (operational, 46 MW), Patterson Pass (approved, 19.8 MW), Summit Wind (approved, 54 MW), Rooney Ranch (approved, 25.1 MW), Sand Hill (proposed, 144.5 MW), Mulqueeny Ranch (proposed, 80 MW). (DSEIR, 2-22.) *Contra Costa County*: Buena Vista (operational, 38 MW) and Vasco Winds (operational, 78.2). (The 42 MW Tres Vaqueros project in Contra Costa County is not included in this total because, although approved in 2011, it does not appear that it will ever be constructed.) Total: 592 MW for *Altamont Pass alone*, excluding projects in the Montezuma Hills Wind Resources Area in Solano County.

[11] See K.S. Smallwood, Sept. 2019 at p. 16 [applying the DSEIR's approach to calculating the average annual fatalities per MW, as corrected based on the most recent monitoring data, the total number

(continued…)

In contrast to the above projected fatalities of up to 41.7 golden eagles and up to 201.5 red tailed hawks for only 308 MW of installed capacity, the PEIR estimated that annual golden eagle fatalities would be 5-18 golden eagles and 45 to 111 red-tailed hawks per year for the entire 450 MW of potential capacity in Alameda County. (PEIR, 3.4-120.) Further, based on its 2014 estimate of 47 eagle deaths per year for all wind turbines operating on both the Alameda County and Contra Costa County portions of Altamont Pass,[12] the FWS recommended that annual golden eagle fatalities for all projects on the Alameda County side of Altamont Pass be limited to less than 29 eagles. (*Id.*, E-36.) Thus, the DSEIR must be revised to address the near-certainty that Project operations will result in a cumulative exceedance of the PEIR's program-wide estimates and FWS estimates for annual fatalities of golden eagles (and likely of red-tailed hawks) at Altamont Pass.[13] 5-17

Cumulative impacts of ongoing wind operations at Altamont Pass are also likely to be significant for burrowing owls. As mentioned, the PEIR states that Altamont Pass "may support the largest number of breeding [burrowing owl] pairs in the Bay Area," and that these populations also may not currently be sustainable in some years due to ongoing impacts from wind turbine operations. (PEIR, 3.4-105.) The FWS commented on the PEIR that "[b]urrowing owl mortalities at the repowered Diablo Winds project [at Altamont Pass] continue to be high. If this mortality rate continues, the local population may be extirpated in the foreseeable future." (*Id.*, E-37.) Unfortunately, the second-year monitoring report for Golden Hills documented 25 burrowing owl deaths, and the final three-year monitoring report for the Vasco Winds project estimated 29 burrowing owl deaths, in one year. (H.T. Harvey, Dec. 2018 at iv; Brown, *et al.*, 2016 at Table ES-1 at 7.) The DSEIR further estimates that the Project will result in an additional 12-121 burrowing owl deaths per year. (DSEIR, 3.4-70.) 5-18

For bats, the H.T. Harvey report documented 229 bat fatalities for the first year of operation of the Golden Hills Project, and 124 documented fatalities (and 500 estimated fatalities, including 197 hoary bats) for the second year. (H.T. Harvey, Feb. 2018 at vii; H.T. Harvey, Dec. 2018 at iv, vi.) The Vasco Winds final three-year monitoring report estimated between 242 and 862 bat fatalities per year at that project. (Brown, *et al.*, 2016 at Table ES-1 at 7.) The DSEIR estimates 5-19

---

of annual golden eagle fatalities for Golden Hills, Golden Hills North and Summit Winds in Alameda County, plus the proposed Project, would result in 38.4 golden eagle fatalities per year; this estimate is low, as it does not even include projects currently operating on the Contra Costa County side of Altamont Pass and other approved and foreseeable wind energy projects in Alameda County].)

[12] To our knowledge, the FWS has not yet updated this estimate in light of the monitoring results for the first two years of operation of the Golden Hills Project and final three-year monitoring report for Vasco Winds.

[13] This conclusion is not undermined by the DSEIR's speculation regarding the possible extent of the golden eagle population in the broader "local area population" within 109 miles of the Project site, based upon an unsupported extrapolation of USGS golden eagle survey data from 2014 from a much smaller area in the Altamont Pass and Diablo Range. (See DSEIR, 3.4-12—14, citing D. Wiens, *Estimation of Occupancy, Breeding Success, and Abundance of Golden Eagles (Aquila chrysaetos) in the Diablo Range, California, 2014*, USGS Open File Report 2015-1039.)

(continued…)

5-19 cont.

that the Project will result in an additional 463-566 bat deaths per year (DSEIR, 3.4-87), for a total of between 1058 and 2157 bat deaths per year for only 308.6 MW of installed capacity. This total does not include estimates from the remaining 283.4 MW of currently operating, approved and anticipated projects at Altamont Pass.

By contrast, the PEIR estimated that repowering for the entire 450 MW alternative would result in only between 756 to 1,764 annual bat fatalities for the entire 450 MW program on the Alameda County side of Altamont Pass. (PEIR, 3.4-139.) The PEIR also estimated bat fatalities would range from 1.68 to 3.92 annual fatalities per MW, while the H.T. Harvey reports for the Golden Hills Project found actual bat fatality rates were between 5.45 to 5.82 annual fatalities per MW (but ranging between 2.26 to 6.46 fatalities/MW/year). (*Cf.* PEIR at 3.4-132 and H.T. Harvey, Feb. 2018 at 44, 52, H.T. Harvey, Dec. 2018 at 62.)[14] The Golden Hills and Vasco Winds monitoring data and other even more recent reports confirm the PEIR's and DSEIR's overall conclusion that the new, larger turbines have even greater impacts on bat mortality than had previously been documented at the old-generation turbines and estimated in the PEIR. (See, e.g., Brown, *et al*., 2016, Table ES-1, p. 7; H.T. Harvey, Feb. 2018 at vii; H.T. Harvey, Dec. 2018 at iv; Rodhouse et al. at pp. 7-8; K.S. Smallwood and D. Bell, *Relating Bat and Bird Passage Rates to Wind Turbine Collision Fatalities*, East Contra Costa County Habitat Conservancy, July 2019, at p. 1; see PEIR, 3.4-132, 3.4-138—139 and DSEIR, 3.4-87—88.)

The need for an adequate cumulative impact analysis of the impacts of ongoing wind turbine operations on bats in the Altamont Pass takes on even more importance in light of other new information regarding declining bat populations. For example, the DSEIR states that hoary bats and Mexican free-tailed bats have comprised the majority of bat fatalities documented at Altamont Pass to date, and are likely to make up the majority of fatalities caused by the Project. (DSEIR, 3.4-11, 3.4-15, 3.4-86—87.) As noted in Part I, *supra*, a recent study finds that hoary bats are experiencing a severe decline throughout the Pacific northwest. (Rodhouse *et al*., pp. 7-8.)

5-20

In sum, the DSEIR must be revised to include a legally sufficient and adequately informative cumulative impact analysis, discussing the current biological status of the four focal raptor species (golden eagle, red-tailed hawk, burrowing owl and American kestrel) and all affected bat species, and the overall impacts to those populations in the Altamont Pass and broader Diablo region from currently operating, approved and anticipated wind energy projects and other causes, such as drought, climate change, habitat loss, rodenticides, electrocution, road kills, etc., based on the best available current information. As required by CEQA Guidelines section 15130, subdivision (b)(5), the DSEIR also must include a strengthened suite of mitigation measures to address these significant cumulative effects, as discussed further in Part III.E, *infra*.

---

[14] Bat fatality rates for the Vasco Winds Project ranged from 3.09 to 11.02 fatalities/MW/year. (Brown, *et al*., 2016, Table ES-1 at 7.)

5-21

D. <u>By Omitting an Alternative that Considers a Reduced Number of High-Risk Turbine Sites, the DSEIR Fails to Include a Reasonable Range of Feasible Alternatives</u>

"The core of an EIR is the mitigation and alternatives sections." (*Citizens of Goleta, supra*, 52 Cal.3d at p. 564.) CEQA Guidelines section 15126.6, subdivision (a) provides that "[a]n EIR shall describe a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives." (Guidelines, § 15126.6, subd. (a), emphasis added; see also *id*., § 15126.6, subd. (f), *Citizens of Goleta, supra*, 52 Cal.3d at p. 566.) The "reasonable range of potentially feasible alternatives" must be selected on the basis of "foster[ing] informed decision-making" and "meaningful public participation." (Guidelines, § 15126.6, subds. (a), (f).)

The EIR's alternatives discussion must "focus on alternatives to the project or its location which are capable of avoiding or substantially lessening any significant effects of the project, even if these alternatives *would impede to some degree the attainment of the project objectives, or would be more costly*." (Guidelines, § 15126.6, subd. (b), emphasis added; *see also id*., § 15126.6, subds. (c), (f).) The EIR must "include sufficient information about each alternative to allow meaningful evaluation, analysis, and comparison with the proposed project." (*Id*., § 15126.6, subd. (d); see also *Laurel Heights, supra*, 47 Cal.3d at p. 404 ["[t]o facilitate CEQA's informational role, the EIR must contain facts and analysis, not just the agency's bare conclusions or opinions"].) The EIR also must discuss the lead agency's reasoning for selecting the alternatives to be discussed in detail, and the reasons for rejecting other alternatives as infeasible. (Guidelines, § 15126.6, subds. (a), (c).)

CEQA defines "feasible" as "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors," including but not limited to site suitability, economic viability, and availability of infrastructure. (Pub. Resources Code, § 21061.1; Guidelines, §§ 15126.6, subd. (f)(1), 15364.) The determination of whether to include an alternative in an EIR is based on whether the alternative is "*potentially* feasible" (*South County Citizens for Smart Growth v. County of Nevada* (2013) 221 Cal.App.4th 316, 327, emphasis added, citation omitted; see also *Sierra Club v. County of Napa* (2004) 121 Cal.App.4th 1490, 1504, fn. 5 [EIR "is required to make an in-depth discussion of those alternatives identified as at least potentially feasible"].) The determination whether a given alternative is *actually* feasible is made after the lead agency determines whether to approve the project and makes the findings required by Public Resources Code section 21081 and Guidelines section 15091. (*South County Citizens, supra*, 221 Cal.App.4th at p. 327; see also *CNPS, supra*, 177 Cal.App.4th at p. 981.)

Moreover, "[t]he fact that an alternative may be more expensive or less profitable is not sufficient to show that the alternative is financially infeasible. What is required is evidence that the additional costs or lost profitability are sufficiently severe as to render it impractical to proceed with the project." (*Citizens of Goleta Valley v. Board of Supervisors* (1988) 197 Cal.App.3d 1167, 1181; accord *Uphold Our Heritage v. Town of Woodside* (2007) 147

5-21 cont.

Cal.App.4th 587, 599-600; *Center for Biol. Diversity v. County of San Bernardino* (2010) 185 Cal.App.4th 866, 883 (*CBD*).)

In sum, "[a]n alternatives analysis in an EIR is intended to facilitate consideration of whether an environmentally superior alternative could meet most project objectives; therefore, the key to the selection of the range of alternatives is to identify alternatives that meet most of the project's objectives but have a reduced level of environmental impacts." (*Bay Area Citizens*, *supra*, 248 Cal.App.4th at p. 1014, internal quotations and citation omitted; see also *Habitat and Watershed Caretakers v. City of Santa Cruz* (2013) 213 Cal.App.4th 1277, 1304 ["[a] potentially feasible alternative that might avoid a significant impact must be discussed and analyzed in an EIR"].)

5-22

Siting wind projects on a macro scale to avoid biologically sensitive areas (such as the high densities of golden eagle populations occurring at Altamont Pass), might be the best option for avoidance and minimization of ongoing harm to raptors from operation of wind projects. (See *Eagle Conservation Plan for the Shiloh IV Wind Project*, Montezuma Hills Wind Resources Area, ICF Intl., Aug. 2012, pp. 1-5—1-6.) However, macro-siting (e.g. avoidance of siting wind energy projects at high-risk locations altogether) is not currently a viable option for Altamont Pass, since both Alameda and Contra Costa Counties previously made the determination to redevelop this area with repowered wind turbines.

Absent macro siting, it is generally recognized that the next best option for avoidance and minimization of ongoing raptor fatalities due to operation of wind turbines is micro-siting to include appropriate set-backs from known raptor nesting sites (see, e.g., *ibid*.), and to avoid locations on the project site that are generally known to be hazardous to raptors, such as "along the edges of steep slopes, on downslope benches, within depressions such as swales, saddles and notches, or along descending ridge slopes following a slope break." (J. Estep, *Assessment of Proposed Wind Turbine Sites to Minimize Raptor Collisions at the Sand Hill Wind Repowering Project*, Mar. 2019, at p. 4; see also K. Smallwood, *Siting Wind Turbines to Minimize Raptor Collisions at Sand Hill Repowering Project*, Aug. 2018, at p. 2.)

Here, in addition to the CEQA-mandated "No Project-No Repowering" alternative, the DSEIR analyzes one other alternative that involved some degree of micro-siting the proposed turbine locations: the "Pre Micro-Sited Layout Alternative" (so-called "Layout 5")[15] This alternative "would involve the same number of turbines" as the proposed Project, but would substitute

[15] The "repowering by others" alternative is not really a separate alternative and is more in the nature of a projection of reasonably foreseeable potential future conditions under the "no project" alternative, as the DSEIR concedes at pp. 4-7 and 4-9. (See Guidelines, § 15126.6, subd. (e)(3)(B) ["[i]f disapproval of the project under consideration would result in predictable actions by others, such as the proposal of some other project, this 'no project' consequence should be discussed"].) Moreover, it is unclear how this alternative meets the CEQA requirement that it avoid or reduce one or more significant effects of the proposed project. (Guidelines, § 15126.6, subds (a)-(c), (f).) Finally, the details of any potential future repowering project proposed by another entity are too speculative to be meaningfully discussed as a separate alternative.

(continued…)

5-22 cont.

smaller 2.8 or 2.3 MW size turbines (instead of the proposed 3.8 MW turbines) for 35 these 40, and would relocate 19 of the 40 turbines. (DSEIR, ES-3, 4-4, 4-15.) This alternative would reduce the total Project MW from 144.5 to 109 MW, and the total rotor-swept area by 13% by using 2.8 or 2.3 MW turbines at some turbine sites instead of 3.8 MW turbines. (*Ibid*.) In addition, this alternative increases the average blade height above ground for the smaller sized turbines, from 14.1 m to 24.7 m above ground. (DSEIR, ES-4, 4-4, 4-15.)[16]

However, as indicated in the chart attached hereto as Exhibit A, the "Pre-Micro-Sited Layout Alternative" actually involves a minimal degree of micro-siting in response to the two experts' recommendations. For example, this alternative still retains all but 3 of the 18 of the very high, high and moderate-high risk turbine sites identified in the project micro-siting reports prepared by Dr. Shawn Smallwood and Jim Estep (including four sites which Dr. Smallwood recommended avoiding altogether).[17] Where there was a choice between a higher and a relatively lower risk nearby location for a given high risk turbine site, the micro-sited alternative in most cases selected the higher-risk location, and did not adopt the experts' recommended or preferred location, based on unexplained and conclusory assertions of "wake effect" or "setback requirements." (See Ex. A hereto; Micro-Sited Smaller Turbine Layout Alternative & Ex. 1; Estep, Table 1 and appendices.) In addition, as to six of the higher risk sites, the turbines were not moved at all as per the experts' recommendations, again based on unspecified "wake effect" or setback limitations. (*Ibid*.) Of the 19 relocated turbines in this alternative, only 6 were at high risk sites and the remainder were at low to moderate risk sites where turbine relocation is not as critical. (*Ibid*.)

5-23

The micro-sited alternative also does not consider proximity of the proposed turbine sites to known golden eagle and bald eagle nests within two miles of the Project site and nests of state-listed threatened bird species (tri-colored blackbird and Swainson's Hawk) within the Project area. (Estep, pp. 5, 7-8.) Both the DSEIR and PEIR require surveys within 2 miles of Project site for active or alternative golden eagle nests and active golden eagle territories, and require turbine micro-siting to account for these areas. (DSEIR, 3.4-75; see also DSEIR, 3.4-59—60 [surveys required for golden eagle nests within 2 miles of project construction]; PEIR, 3.4-90, 3.4-109.) The siting analysis also does not appear to consider the impacts of locating turbines near burrowing owl and Swainson's hawk nesting habitat in the Fletcher Conservation Land Bank northwest of the Project site, and near a California Department of Fish and Wildlife (CDFW) conservation easement for burrowing owl west of the Project site.

---

[16] The "Pre-Micro-Sited Layout Alternative" is described in more detail in the document circulated for public review with the DSEIR entitled "Micro-Sited Smaller Turbine Layout Alternative" (no author, no date, but presumably prepared by the Project applicant).

[17] The chart attached hereto as Exhibit A was prepared by comparing the recommendations in K. Smallwood, *Siting Wind Turbines to Minimize Raptor Collisions at Sand Hill Repowering Project*, Aug. 2018 and J. Estep, *Assessment of Proposed Wind Turbine Sites to Minimize Raptor Collisions at the Sand Hill Wind Repowering Project*, Mar. 2019 (see esp. Table 1 of that report and the accompanying four appendices) with the Project applicant's document entitled "Micro-Sited Smaller Turbine Layout Alternative" (see esp. Exhibit 1 to that report).

With regard to siting to minimize bat collisions, PEIR Mitigation Measure Bio-14a provides that "[t]o generate site-specific 'best information' to inform turbine siting and operation decisions, a bat habitat assessment and roost survey will be conducted in the project area to identify and map habitat of potential significance to bats, such as potential roost sites … and water sources. Turbine siting decisions will incorporate relevant bat use survey data and bat fatality records published by other projects in the [Altamont Pass]." (PEIR, 3.4-133.) It is not clear that the micro-sited alternative accounted for this PEIR mitigation measure. It also is unclear the extent to which the micro-sited alternative accounted for increased risks due to grading of turbine sites or risks to the other three focal raptor species besides golden eagles. (Estep, pp. 5, 7-8; K.S. Smallwood, Sept. 18, 2019, p. 8.) 5-24

Finally, while certainly likely to be an improvement over the proposed Project in terms of impacts on affected avian and bat resources, the DSEIR and supporting documents contain no analysis of the relative extent to which the reduced turbine sizes and reduced rotor swept area in the micro-sited alternative are expected to reduce the Project's impacts on such resources based on the best available data. Rather, the DSEIR only contains conclusory assertions that the micro-sited alternative "is expected to reduce avian and bat fatalities" and that the impacts of this alternative would be "less severe" due to a decrease in total rotor swept area and increased blade height above ground. (See DSEIR, 4-14—4-15; see also *id.*, pp. 4-8, 4-18.) However, Dr. Smallwood notes that "[m]inimum rotor-to-ground clearance should be 29 m" in order to reduce such impacts, but that the micro-sited alternative only raises ground clearance to an average of 24.7 m. (K.S. Smallwood, Sept. 18, 2019, p. 11; *cf.* DSEIR, ES-4, 4-4, 4-15.) 5-25

Due to the foregoing identified uncertainties regarding the extent to which the micro-sited alternative will reduce the Project's significant effects (particularly the cumulative effects identified in Part III.C, *supra*), in addition this alternative, the DSEIR should consider a second reduced Project size alternative that consists of fewer than 40 turbines and which avoids all or the majority of the highest risk turbine sites and known nesting areas for sensitive bird and bat species, as recommended by Smallwood and Estep and the federal and state wildlife agencies. An alternative that eliminates some or all of these high-risk sites still could meet most of the Project objectives identified in the EIR, and is at least potentially feasible. (DSEIR, ES-2, 4-2—4-3; see *Friends of the Eel River v. Sonoma County Water Agency* (2003) 108 Cal.App.4th 859, 872-873 [holding EIR inadequate for failure to discuss "project alternatives that would mitigate any significant *cumulative* impact" of the proposed project], emphasis added.) 5-26

The DSEIR did not consider a reduced project size alternative of less than 40 turbines in its initial screening process, so does not include any explanation as to why this alternative would be infeasible. (DSEIR, 4-4—4-7.) A conclusory statement from the project applicant, that turbine sites cannot be eliminated or moved due to unspecified "wake effect" or "setback requirements" cannot be used as justification for not examining this alternative in detail. (See, e.g., *CBD, supra*, 185 Cal.App.4th at pp. 884-885 [conclusory statement by applicant's consultant that private financing for a more expensive project alternative was unavailable did not constitute substantial evidence supporting EIR's conclusion that the alternative was infeasible].)

E. The DSEIR Fails to Include a Sufficient Suite of Mitigation Measures to Reduce or Avoid the Project's Impacts on Avian and Bat Resources 5-27

As discussed, "[t]he 'core' of an EIR is the mitigation and alternatives sections." (*Citizens of Goleta, supra*, 52 Cal.3d at p. 564.) CEQA Guidelines section 15126.4, subdivision (a)(1) sets forth the basic CEQA requirements for mitigation measures in an EIR. An EIR must "describe feasible measures which could minimize significant adverse impacts," distinguishing between measures proposed by the project proponent versus other measures proposed by the lead agency and responsible or trustee agencies or other persons. (Guidelines, § 15126.4, subds. (a)(1) & (a)(1)(A).) "Mitigation measures must be fully enforceable through permit conditions, agreements, or other legally-binding instruments." (*Id*., § 15126.4, subd. (a)(2). "For each significant effect, the EIR must identify specific mitigation measures; where several potential mitigation measures are available, each should be discussed separately, and the reasons for choosing one over the others should be stated." (*Sacramento Old City Assn. v. City Council* (1991) 229 Cal.App.3d 1011, 1027.)

Mitigation measures must be designed to: (1) avoid "the impact altogether by not taking a certain action or parts of an action;" (2) minimize "impacts by limiting the degree or magnitude of the action and its implementation;" (3) rectify "the impact by repairing, rehabilitating, or restoring the impacted environment;" (4) reduce or eliminate "the impact over time by preservation and maintenance operations during the life of the action;" or (5) compensate "for the impact by replacing or providing substitute resources or environments." (Guidelines, § 15370.) An EIR must include facts and analysis "to support the inference that the mitigation measures will have a quantifiable 'substantial' impact on reducing [a project's] adverse effects," although the measures need not necessarily reduce an impact to below the threshold of significance. (*Sierra Club*, 6 Cal.5th at p. 522.)

An EIR's finding that a mitigation measure is economically or otherwise infeasible must be supported by substantial evidence in the record. (See *County of San Diego v. Grossmont-Cuyamaca Commun. College Dist*. (2006) 141 Cal.App.4th 86, 108 ["[w]ithout evidence of the amount of any such cost, we must conclude there is no substantial evidence to support the District's claim that mitigation of the adverse project-related off-campus traffic impacts is economically infeasible"].) The conclusion that a project's adverse environmental effects have been adequately mitigated also must be based on substantial evidence. (*Laurel Heights, supra,*47 Cal.3d at pp. 407-408.)

We appreciate the DSEIR's inclusion of some improved and strengthened mitigation measures for impacts of Project construction on nesting bird habitat, particularly the addition of a 250-foot construction buffer for tri-colored blackbird nesting habitat and the inclusion of additional compensatory mitigation measures for project construction in and near wetland areas. (DSEIR, 3.4-58—60; 3.4-93; 3.4-95.) However, with the exception of a few additional measures for monitoring the significance of Project operations on bats, the DSEIR includes very few meaningful changes to the PEIR's mitigation program for the ongoing impacts of Project 5-28 operation on birds and bats.[18] The DSEIR appears to take the opposite of a precautionary approach, citing continuing uncertainty in the repowering fatality data as a justification for making few substantive changes in the PEIR's mitigation program for turbine operations. The reality is that the fatality data at Altamont Pass has *always* been uncertain and will likely continue to be for some time to come. 5-28 cont.

Such uncertainty does not obviate the County's responsibility to consider all feasible mitigation measures under CEQA, particularly in the face of growing evidence of the major cumulative effects of wind turbine operations, discussed in Parts I and III.C, *supra*. (See *Sierra Club v. County of Fresno, supra*, 6 Cal.5th at p. 520 ["in reviewing an EIR's discussion, we do not require technical perfection or scientific certainty"]; Guidelines, § 15130, subd. (b)(5) [requiring mitigation measures for a projects' significant cumulative effects]; see E.B. Arnett, *Mitigating Bat Collision*, Chap. 8 in *Wildlife and Wind Farms, Conflicts and Solutions, Vol. 2: Onshore: Monitoring and Mitigation* (M.R. Perrow, ed.), 2017, p. 167 ["[e]ven in the absence of population data, broad implementation of operational mitigation at wind farms globally is recommended as this offers an ecologically sound strategy for reducing bat fatalities with modest economic losses in most locations"].)

The DSEIR makes only one, relatively minor substantive change to the PEIR's mitigation measures for wind turbine operations, requiring that, with respect to the PEIR's compensatory mitigation requirements, the estimated costs for raptor rehabilitation "are adjusted for inflation according to the Consumer Price Index" after ten years of project operations. (DSEIR, 2-25; see also *id*., 3-4, 3.4-81—82.) In addition, with respect to the PEIR's monitoring program, the DSEIR simply states that "[d]elays in obtaining County and [TAC] approval of the APP [avian protection plan] and monitoring are expected to be substantially reduced because of the experience that the TAC has acquired since the PEIR was certified." (DSEIR, 3-5; see also *id*., 2-28.)

Our Office's February 2019 comment letter included a detailed discussion of how the DSEIR could include a strengthened and improved suite of mitigation measures for this Project, and other projects going forward, in light of new information that modern wind turbines are having more substantial direct, and indirect and cumulative impacts on birds and bats than was previously anticipated in the PEIR. (AG NOP Ltr. at pp. 18-23.) These recommendations include, but are not limited to: 5-29

(1) More stringent turbine micro-siting and/or a reduced Project size, based on the best available science, that avoids the most dangerous zones for raptors on the Project site, including by eliminating some turbine sites (discussed in Part III.D, *supra*);

(2) A more robust compensatory mitigation program, including a substantial increase in compensatory mitigation fees, similar to that set forth in the 2010 Attorney General-

[18] Again, this statement is made with the caveat that our office received a substantive proposed mitigation plan (the BBCS) on September 27, 2019, which was not circulated for public review with the DSEIR and which we did not have time to review in detail prior to the comment deadline on the DSEIR.

5-29 cont.

Audubon-Next Era settlement agreement, but as adjusted for inflation and/or based on a quantified resource equivalency analysis using the projected number of unavoidable, ongoing avian and bat fatalities from the Project;

(3) A more robust monitoring program, such as using a longer than three-year monitoring period, more frequent search intervals (e.g., weekly instead of monthly) of a significant percentage of the total number of Project turbines, monitoring of the entire rotor-swept area, use of integrated detection trials, thermal image monitoring for bats, and use of skilled dog detection teams; and

(4) An improved adaptive management program to require more immediate and significant reductions in fatalities after one year of monitoring, including through real-time turbine curtailment using the latest "detect and deter" technology, seasonal and/or temporal turbine curtailment, especially during the fall migration period, and/or changes in turbine cut in speeds. The adaptive management program must be based on biologically meaningful triggers in light of the overall Project effects, including cumulative effects, and the most current population, use, behavior, and other relevant data for the affected raptor and bat species, as reviewed and recommended by the TAC.

Since the County's circulation of the NOP, even more scientific information has been published which supports the probable effectiveness of some of the mitigation strategies proposed in our comment letter, particularly for large raptors and bats.[19]

With regard to the impacts of wind turbine operations on bats, the DSEIR does include some significant additions to the bat monitoring protocol, including decreasing the time between searches for bat carcasses, and using bat carcasses in detection probability trials. (DSEIR, 3.4-89—90.) However, additional adaptive management measures should be considered in light of the new information discussed above.

For example, the DSEIR states that the majority of bat fatalities at wind projects in North America occurs in late summer early fall during their migration season, supporting the hypothesis that seasonal nighttime curtailment could be helpful. (DSEIR, 3.4-16, 3.4-86.) This conclusion also is supported by the most recent scientific literature. (See K.S. Smallwood and D. Bell, *Effects of Wind Turbine Curtailment on Bird and Bat Fatalities*, East Contra Costa County Habitat Conservancy, July 2019 at p. 1 ["[b]ecause the migration season is relatively brief, a

[19] These include, but are not limited to T.D. Allison *et al*., Issues in Ecology, Report 21, Fall 2019, *Impacts to Wildlife of Wind Energy Siting and Operation in the United States*, pp. 14-17; K.S. Smallwood et al., *Skilled Dog Detections of Bat and Small Bird Carcasses in Wind Turbine Fatality Monitoring*, East Contra Costa County Habitat Conservancy, July 2019; K.S. Smallwood and D. Bell, *Effects of Wind Turbine Curtailment on Bird and Bat Fatalities*, East Contra Costa County Habitat Conservancy, July 2019; see also H.T. Harvey, AWWI Technical Report: *Evaluating a Commercial-Ready Technology for Raptor Detection and Deterrence at a Wind Energy Facility in California*, Sept. 2018; McClure et al., *Automated Monitoring for Birds In Flight: Proof of Concept With Eagles at a Wind Power Facility*, Biological Conservation 224 (2018) 26–33.

seasonal curtailment strategy would greatly reduce bat fatalities while losing only a small fraction of a wind project's annual energy generation," although this might not benefit many species of birds]; see also *id*. at pp. 9-11.) 5-29 cont.

As another example, new research confirms that increasing turbine cut-in speed by a specific amount, as determined based on the most recent scientific data, or "feathering blades and slowing rotor speed … substantially reduces bat fatalities during predictable high-risk periods." (See E.B. Arnett, *Mitigating Bat Collision*, Chap. 8 in *Wildlife and Wind Farms, Conflicts and Solutions, Vol. 2: Onshore: Monitoring and Mitigation* (M.R. Perrow, ed.), 2017, p. 167; see also T.D. Allison et al., 2019 at p. 15; E.B. Arnett, et al, *A Synthesis of Operational Mitigation Studies to Reduce Bat Fatalities at Wind Energy Facilities in North America*, Report Submitted to the National Renewable Energy Lab., Bat Cons. Intl., 2013.) The DSEIR's bat adaptive management program should be revised to require these measures, which already mandates additional mitigation measures for bats to "be developed as new technologies or science supports doing so." (DSEIR, 3.4-91—92.)

Finally, the DSEIR appears to acknowledge that Project construction and operation has at least the potential to cause take of tri-colored blackbird, which was listed in 2018 a threatened species under the California Endangered Species Act (CESA), as well as the CESA-listed Swainson's Hawk and other special status bird species protected under the Fish and Game Code (DSEIR, 3.4-58—59; 3.4-73.) This is based on the potential for destruction or disturbance of active bird nests, eggs and chicks in or adjacent to the Project site during construction, and previous monitoring results for other repowered projects in Altamont Pass have documented three tri-colored blackbird deaths. (See DSEIR, 3.4-21—22; 3.4-33; 3.4-35; 3.4-58—59; 3.4-73.) Thus, as also recommended by CDFW, the DSEIR should require the Project applicant to obtain an incidental take permit under CESA for any potential take of tri-colored blackbird and Swainson's Hawk due to Project construction if take will not be completely avoided, as well as Project operations. (DSEIR, 3.4-59.) This will necessitate, *inter alia*, protocol-level preconstruction surveys, and biological justification for any construction and operation nest site buffers established based on on-site monitoring both before and during construction, as specified by CDFW. 5-30

<u>CONCLUSION</u>

We appreciate the County's consideration of this comment letter. Should you have any questions concerning this letter, please do not hesitate to contact me. 5-31

Sincerely,

Tara T. Mueller

TARA L. MUELLER
Deputy Attorney General

For XAVIER BECCERA
Attorney General

Exhibit A

Smallwood and Estep Sand Hill Micro Siting Recommendations and Sand Hill Response: Pre-Micro Sited Layout Alternative (Proposed Layout 5)[1]

Green: expert recommended site to use or avoid
Red: Sand Hill proposed siting that differs from expert recommendations
Purple: Sand Hill proposed siting that complies with expert recommendations

High to Moderate-High Risk Turbine Sites

Turbine Site No.	Micro Siting Rec	Sand Hill Prop. Layout 5
Site No. 4		
4A [High] (Lay. 1-3)	Reloc. 225 ft S to top of hill	Not using this site
4B [High] (Layout 4)	Reloc. 225 ft S to top of hill **[Smallwood rec avoiding this site]**	Turbine moved unspecified number of feet and increased in size from 2.3 MW to 2.8 MW
Site No. 13		
13A [High] (Layout 1)	Eliminate site	Not using this site
13B [High] (Layout 2)	Eliminate site	Not using this site
13C [High] (Layout 3)	Reloc. 400 ft NE to top of hill [2nd alt]	Not using this site
13D [High] (Layout 4)	Reloc. 50 ft to top of hill [1st rec alt]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW
Site No. 16		
16A [High] (Lay. 1, 4)	Reloc. upslope 90 ft E-SE [Slight reduc./still a very risky site]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW
16B [High] (Layout 2)	Reloc. upslope 120 ft E-SE **[Recom. Loc.]**	**Cannot use** site due to wake effect
16C [High] (Layout 3)	Reloc. 500-600 feet E-SE to next ridge	Not using this site

---

[1] Sources: K. Smallwood, *Siting Wind Turbines to Minimize Raptor Collisions at Sand Hill Repowering Project*, Aug. 2018 and J. Estep, *Assessment of Proposed Wind Turbine Sites to Minimize Raptor Collisions at the Sand Hill Wind Repowering Project*, Mar. 2019 and appendices to that report, and "Micro-sited Smaller Turbine Layout Alternative" and Exhibit 1 to that report.

Site No. 18		
18A [High] (Lay. 1, 4)	Reloc. 290 ft NE to top of ridge [Only slight reduc. and may result in addl. risk]	Turbine moved per Estep and size reduced from 3.8 MW to 2.8 MW
18B [Mod-High] (Lay. 2)	Reloc. 100 ft NE along ridgetop [Only slight reduc. and may result in addl. risk. **Recom. Loc.]**	**Not using** this site due to wake effect
18C [Mod-High] (Lay. 3)	No suitable reloc. site	Not using this site
Site No. 21		
21A [High] (Layout 1)	Reloc. 360 ft NW to top of hill	Not using this site
21B [Mod] (Layout 2)	No suitable reloc. site/lowest risk site of 4 **[Recom. Loc.]**	**Not using** this site due to wake effect
21C [Mod-High] (Lay. 3)	No suitable reloc. site	Not using this site
21D [High] (Layout 4)	**No suitable reloc. site**	Turbine size reduced from 3.8 MW to 2.8 MW
Site No. 27		
27A [High] (All Lay.)	Reloc. 200 ft S to top of hill [Alt: move 275 ft N to top of diff hill]	**Could not move** S due to setback reqmts and **could not move** N due to wake effect. Turbine size reduced from 3.8 MW to 2.8 MW
Site No. 28		
28A [High] (Lay. 1-3)	Reloc. 150 ft NW to top of hill	Not using this site
28B [High] (Lay. 4)	Reloc. 150 NW to top of hill **[Recom. Loc.]**	**Could not move** due to wake effect. Turbine size reduced from 3.8 MW to 2.8 MW
Site No. 30		
30A [High] (Lay. 1-4)	**No suitable reloc. site**	Moved slightly based field visit. Estep conf slightly better loc. Turbine size reduced from 3.8 MW to 2.8

5-32 cont.

Site No. 34

34A [High] (All Lay.)	Reloc. 350 ft E-SE to top of hill **[Smallwood rec avoiding site]**	**Could not move** due to setback reqmts. Turbine size reduced from 3.8 MW to 2.8 MW

Site No. 37

37A [High] (All Lay.)	Reloc. 140 ft S-SW from swale to flat ground or 300 ft W towards road	**Could not move** due to wake effect. Turbine size reduced from 3.8 MW to 2.3 MW

Moderate to Moderate High-Risk Turbine Sites

Turbine Site No.	Micro Siting Rec	Sand Hill Prop. Layout 5
Site No. 14		
14A [High] (Lay. 1, 4)	Reloc. 130 ft N on ridge [Does not reduce risk from slope accelerated winds]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW
14B [Low-Mod] (Lay. 2)	**Recom. Loc.**	**Cannot use** site due to wake effect
14C [Mod] (Layout 3)	No recom	Not using this site
Site No. 15		
15A [High] (Lay. 1, 4)	Reloc. 140 ft NW to top of ridge [Does not reduce risk from slope accelerated winds]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW
15B [Mod] (Layout 2)	Reloc. 200 ft NW to top of ridge	Not using this site
15C [Mod] (Layout 3)	Reloc. 450 ft NW to top of hill **[Recom. Loc.]**	**Cannot use** this site due to wake effect
Site No. 17		
17A [Mod] (Lay. 1, 4)	Reloc 230 ft N to top of ridge **[Recom. Loc.]**	**Could not move** turbine due to wake effect; turbine size reduced from 3.8 to 2.8 MW
17B [Mod High] (Lay. 2)	No suitable reloc. site	Not using this site
17C [Mod] (Layout 3)	Reloc. 250 ft W-NW upslope	Not using this site

Site No. 19		
19A [Mod-High] (Lay. 1, 4)	No suitable reloc. site	Turbine size reduced from 3.8 MW to 2.3 MW
19B [Mod] (Layout 2)	No suitable reloc. site	Not using this site
19C [Low-Mod] (Lay. 3)	Reloc. 200 ft S to top of hill **[Recom. Loc.]**	**Not using** this site due to wake effect and addl ground disturbance
Site No. 22		
22A [Mod-High] (Lay. 1)	Reloc. 200 ft away from east slope	Not using this site
22B [Mod-High] (Lay. 2)	No suitable reloc. site	Not using this site
22C [Mod-High] (Lay. 3)	No suitable reloc. site	Not using this site
22D [Mod] (Layout 4)	No suitable reloc. site/safest loc **[Recom. Loc.]**	Turbine size reduced from 3.8 MW to 2.8 MW
Site No. 23		
23A [Mod-High] (All Lay.)	Reloc. 100 ft S to top of hill	**Could not move** turbine due to setback requirements/size increased from 2.3 MW to 2.8 MW
Site No. 25		
25A [Mod-High] (All Lay.)	No suitable reloc. site **[Smallwood rec avoiding site]**	Turbine size reduced from 3.8 MW to 2.8 MW
Site No. 29		
29A [High] (Lay 1-3)	No suitable reloc. site	Not using this site
29B [Mod] (Lay 4)	Reloc. 140 ft E-NE across rd **[Recom. Loc.]**	Turbine moved 165 ft SE away from edge of swale [**Note**: orig. Estep rec. could not be done due to setback reqmts. Estep confirmed this loc. is low to mod. risk. Reduced turbine size from 3.8 MW to 2.3 MW.]

FALL 2019 • REPORT NO. 21

ISSUES IN ECOLOGY

PUBLISHED BY THE ECOLOGICAL SOCIETY OF AMERICA


IMPACTS TO WILDLIFE OF WIND ENERGY SITING AND OPERATION IN THE UNITED STATES


esa

Taber D. Allison, Jay E. Diffendorfer, Erin F. Baerwald, Julie A. Beston, David Drake, Amanda M. Hale, Cris D. Hein, Manuela M. Huso, Scott R. Loss, Jeffrey E. Lovich, M. Dale Strickland, Kathryn A. Williams, Virginia L. Winder

IMPACTS TO WILDLIFE OF WIND ENERGY SITING AND OPERATION IN THE UNITED STATES

Taber D. Allison, Jay E. Diffendorfer, Erin F. Baerwald, Julie A. Beston, David Drake, Amanda M. Hale, Cris D. Hein, Manuela M. Huso, Scott R. Loss, Jeffrey E. Lovich, M. Dale Strickland, Kathryn A. Williams, Virginia L. Winder

SUMMARY

Electricity from wind energy is a major contributor to the strategy to reduce greenhouse gas emissions from fossil fuel use and thus reduce the negative impacts of climate change. Wind energy, like all power sources, can have adverse impacts on wildlife. After nearly 25 years of focused research, these impacts are much better understood, although uncertainty remains. In this report, we summarize positive impacts of replacing fossil fuels with wind energy, while describing what we have learned and what remains uncertain about negative ecological impacts of the construction and operation of land-based and offshore wind energy on wildlife and wildlife habitat in the U.S. Finally, we propose research on ways to minimize these impacts.

TO SUMMARIZE:

1. ***Environmental and other benefits*** of wind energy include near-zero greenhouse gas emissions, reductions of other common air pollutants, and little or no water use associated with producing electricity from wind energy. Various scenarios for meeting U.S. carbon emission reduction goals indicate that a four- to five-fold expansion of land-based wind energy from the current 97 gigawatts (GW) by the year 2050 is needed to minimize temperature increases and reduce the risk of climate change to people and wildlife.
2. ***Collision fatalities of birds and bats*** are the most visible and measurable impacts of wind energy production. Current estimates suggest most bird species, especially songbirds, are at low risk of population-level impacts. Raptors as a group appear more vulnerable to collisions. Population-level impacts on migratory tree bats are a concern, and better information on population sizes is needed to evaluate potential impacts to these species. Although recorded fatalities of cave-dwelling bat species are typically low at most wind energy facilities, additional mortality from collisions is a concern given major declines in these species due to white-nose syndrome (WNS). Assessments of regional and cumulative fatality impacts for birds and bats have been hampered by the lack of data from areas with a high proportion of the nation's installed wind energy capacity. Efforts to expand data accessibility from all regions are underway, and this greater access to data along with improvements in statistical estimators should lead to improved impact assessments.
3. ***Habitat impacts*** of wind energy development are difficult to assess. An individual wind energy facility may encompass thousands of acres, but only a small percentage of the landscape within the project area is directly transformed. If a project is sited in previously undisturbed habitat, there is concern for indirect impacts, such as displacement of sensitive species. Studies to date indicate displacement of some species, but the long-term population impacts are unknown.
4. ***Offshore wind energy development*** in the U.S. is just beginning. Studies at offshore wind facilities in Europe indicate some bird and marine mammal species are displaced from project areas, but substantial uncertainty exists regarding the individual or population-level impacts of this displacement. Bird and bat collisions with offshore turbines are thought to be less common than at terrestrial facilities, but currently the tools to measure fatalities at offshore wind energy facilities are not available.

The wind energy industry, state and federal agencies, conservation groups, academia, and scientific organizations have collaborated for nearly 25 years to conduct the research needed to improve our understanding of risk to wildlife and to avoid and minimize that risk. Efforts to reduce the uncertainty about wildlife risk must keep up with

COVER PHOTOS: a) Golden eagle b) Judith Gap Wind Energy Center in Montana c) Mexican free-tailed bats exiting Bracken Bat Cave in Texas d) Greater sage-grouse. *PHOTO CREDITS:* a) Susanne Nilsson b) Credit-Invenergy LLC, National Renewable Energy Laboratory c) Ann Froschauer, U.S. Fish & Wildlife Service d) Jeannie Stafford, U.S. Fish & Wildlife Service the pace and scale of the need to reduce carbon emissions. This will require focusing our research priorities and increasing the rate at which we incorporate research results into the development and validation of best practices for siting and operating wind energy facilities.

We recommend continued focus on (1) species of regulatory concern or those where known or suspected population-level concern exists but corroborating data are needed, (2) research improving risk evaluation and siting to avoid impacts on species of concern or sensitive habitats, (3) evaluation of promising collision-reducing technologies and operational strategies with high potential for widespread implementation, and (4) coordinated research and data pooling to enable statistically robust analysis of infrequent, but potentially ecologically significant impacts for some species.

INTRODUCTION

Electricity from wind energy is a major contributor to reducing greenhouse gas emissions from fossil fuel use and thus to reducing the impacts of climate change. Wind energy, however, like all power sources, can have adverse impacts on wildlife, including injury and death of birds and bats from turbine collisions, and the loss and fragmentation of species' habitat.

Awareness of the impact of wind energy production on wildlife in the U.S. arose in the late 1980s when attention focused on turbine collision fatalities of raptors, notably golden eagles and red-tailed hawks, at one of the nation's first large-scale wind energy facilities in California's Altamont Pass Wind Resource Area. As wind energy development has expanded to other parts of the country, research has extended to include habitat impacts as well as fatalities, and concerns have emerged regarding impacts to the habitat of grassland songbirds and grouse species in the Great Plains, forest interior bird species on ridgelines in the East, and terrestrial vertebrates including ungulates and desert tortoises.

Although some bat fatalities had been observed in early studies, research related to bat-wind interactions increased dramatically after 2003 when 1,400 to 4,000 bat fatalities were estimated to have occurred in a six-week period at the Mountaineer Wind Energy Center in West Virginia. In some regions, such as the eastern and mid-western U.S., estimated bat mortality from collisions has been substantially higher than that of birds. With the introduction of offshore wind energy development in the U.S., the list of potentially affected wildlife has expanded to include seabirds, marine mammals, sea turtles, fish, and other aquatic taxa, and considerable efforts are underway to understand, and avoid and minimize potential impacts.

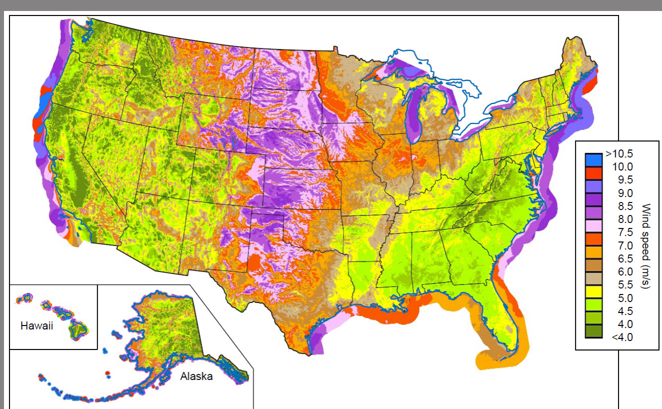
The pace and scale of wind energy development over the past 15 years *(see Box 1)* has generated concern about the risk that wind energy development presents to wildlife. This concern has led to increased investment in research. Since the early 1990s, in a partnership unique among energy industries, the wind energy industry, state and federal agencies, conservation groups, and scientific organizations have collaborated to promote and conduct research to address the concerns about wildlife impacts. Collaboration has been motivated by the desire to balance wildlife conservation with the need for rapid and deep cuts in greenhouse gas emissions to prevent the predicted, substantial impacts of anthropogenic climate change to the physical, human, and biological systems of the planet.

This *Issues in Ecology* is intended to further this collaborative spirit by reviewing the benefits of wind energy and evaluating what is known and what remains uncertain about the negative ecological impacts of the siting and operation of land-based and offshore wind energy on wildlife and wildlife habitat in the U.S. We begin with a brief review of the potential benefits of electricity from wind energy; evaluate negative impacts resulting from siting, construction, operation, and maintenance of wind energy facilities in the U.S.; and propose research to reduce uncertainty and minimize the adverse impacts of wind energy on wildlife. A detailed comparison of the ecological effects of electricity generation from different sources is beyond the scope of this Issue, as are the full life cycle impacts of the wind energy industry (e.g., the manufacturing of turbine components).

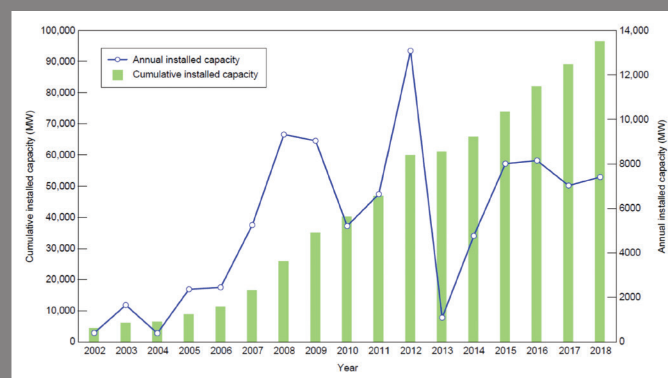
BOX 1. SOME BASIC FACTS ABOUT WIND ENERGY

Wind energy potential varies substantially within the U.S. (Box 1 Figure 1), and installed capacity also varies regionally, reflecting a variety of factors affecting economic viability of wind energy projects. Installed wind energy capacity in the U.S. has grown substantially from approximately 4,000 megawatts (MW) in 2001 to more than 97 GW at the end of March 2019, most of which are installed at more than 1,000 utility-scale projects in 41 states (Box 1 Figure 2). Wind energy accounted for approximately 7% of the total electricity generated by all energy technologies in 2018 in the U.S. and along with solar energy represents the fastest-growing source of electricity in the U.S. (https://www.eia.gov/todayinenergy/detail.php?id=38053). Almost all the growth in wind energy is occurring at land-based facilities. The first offshore wind energy facility in the U.S. began operation off Block Island (Rhode Island) in 2016, and other offshore projects are proposed for the East and West Coasts, the Great Lakes, and Hawaii.

The towers of most modern land-based turbines range in height from 60 to 80 m (200 to 260 feet), and individual turbine blades range in length from 38 to 50 m (125 to 165 feet) resulting in a maximum potential height of approximately 130 m (425 feet) and a rotor-swept area of 0.45 to 1.34 ha (1.1 to 3.3 acres). Due to advances in technology to expand power output and efficiency, turbine tower heights and rotor diameters are increasing; since 2016 more than 5,000 turbines have been installed with a combined height of more than 500 feet. Relative to earlier models, the number of blade revolutions per minute has decreased from 60 to 80 rpm to 11 to 20 rpm, but blade tip speeds have remained about the same, ranging from 230 to 300 kph (140 to 180 mph) under normal operating conditions. Turbines in modern wind energy facilities are spaced hundreds of meters apart, with larger turbines typically having wider spacing.



Box 1 Figure 1. Land-based and offshore annual average wind speed at 80 m above ground level across the continental United States. Source: Wind resource estimates were developed by AWS Truepower LLC. Web: http://www.awstruepower.com. Map developed by National Renewable Energy Lab. Spatial resolution of wind resource data is 2.0 km.



Box 1 Figure 2. Growth in the electricity produced by wind energy over time. Source: American Wind Energy U.S. Wind Industry Fourth Quarter 2018 Association Market Report, Released January 30, 2019, www.awea.org

ENVIRONMENTAL BENEFITS OF WIND ENERGY

Generation of electricity from wind has several environmental benefits that represent important drivers for the expansion of wind energy capacity in the U.S. *(Figure 1)*. These include (1) zero carbon emissions; (2) reduced air pollution including nitrogen oxides, sulfur oxides, and mercury; (3) no or little water withdrawal, water consumption, and impacts to water quality; and (4) the long-term availability of the wind resource. Further, there is the reduced potential for catastrophic events associated with other sources of electricity, such as nuclear accidents, which can have enormous ecological impacts.

A major ecological benefit of wind energy is the near-zero greenhouse gas emissions (e.g., CO_2, emitted when fossil fuels are burned, and CH_4 emitted when mining and burning natural gas) from wind energy facilities while generating electricity. Increasing greenhouse gas emissions are projected to raise global average surface temperatures by 3˚ to 4˚ Celsius

(C) above preindustrial age averages within this century. Predictions about the severe consequences to human society of increasing greenhouse gases are well described, and there is scientific consensus that rising global temperatures substantially increase the risk of species extinctions and major disruption of terrestrial and marine ecosystems across the globe.

Limiting the magnitude of warming and its impacts on humans and biodiversity will require deep reductions in greenhouse gas emissions. Various modeling efforts indicate that a large proportion of these reductions can come from wind-generated electricity. For example, the Western Wind and Solar Integration Study showed that achieving 33% wind and solar-generated electricity in the Rocky Mountain and West Coast states could avoid 29% to 34% of power-sector CO_2 emissions from the Western grid.[13] In 2015, installed wind energy in the United States was estimated to have reduced direct power-sector CO_2 emissions by 132 million metric tonnes, more than 6% of U.S. CO_2 emissions from fossil fuel burning.[28] Various scenarios indicate that meeting U.S. emissions reduction goals will require expansion of land-based wind energy from the current 97 GW (as of the end of March 2019) to approximately 320 GW by 2050.[28]

Reductions of other common air pollutants from wind energy generation can also have substantial benefits for human and ecosystem health. Wind energy produces no particulate matter or mercury and other toxins that directly affect human and wildlife health. In 2015, electricity generated by wind was estimated to have avoided 176,000 and 106,000 metric tonnes of sulfur dioxide and nitrogen oxide emissions, respectively.[28]

In contrast to nearly all other electricity sources, including some forms of solar energy production, wind energy facilities withdraw, divert, and consume little or no water when generating electricity. Wind energy facilities, therefore, can be located in areas of the country where there is limited water availability, or where there are concerns about drought and water scarcity. Wind power generation in 2013 is estimated to have reduced power-sector water consumption by 73 billion gallons, or roughly 226 gallons per person in the U.S.[28] Thermal power plants withdraw more fresh water than any other industry in the United States, and water withdrawals can have additional impacts, including the destruction of aquatic organisms by trapping or entraining. Water use in hydraulic fracturing to mine natural gas can range from 2 to 7 million gallons per operation.

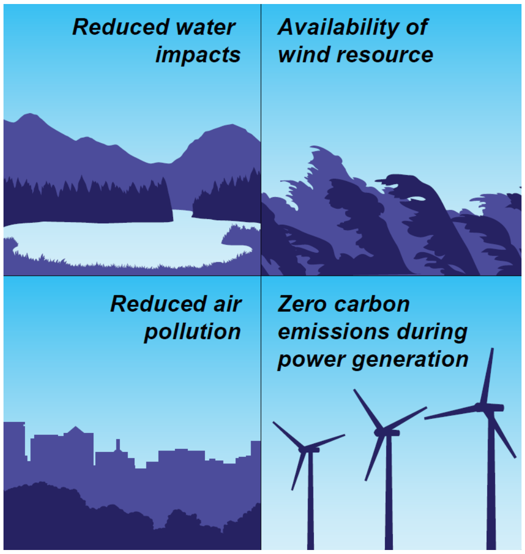


Figure 1. *Four main benefits of wind energy relative to fossil fuels.*

Wind is the result of incoming solar radiation that is converted to kinetic energy, and therefore the production of electricity from wind is assumed to be sustainable indefinitely as long as the sun shines. Scientific studies suggest that there are theoretical limits to the amount of energy that can be extracted efficiently from wind, but there is no "fundamental barrier" to obtaining the world's current power requirements and achieving emission reduction goals to mitigate the effects of climate change on humans and wildlife.

ADVERSE IMPACTS OF WIND ENERGY ON WILDLIFE

This section reviews what we have learned about the impacts and potential impacts of wind energy development on wildlife including:

- Bird and bat fatalities resulting from collision with turbines at land-based facilities
- Impacts to species' habitat
- Impacts related to offshore wind energy development

We first describe estimates of bird and bat collision mortality and assessments of population-level effects.

BIRD AND BAT FATALITIES AT LAND-BASED WIND ENERGY FACILITIES

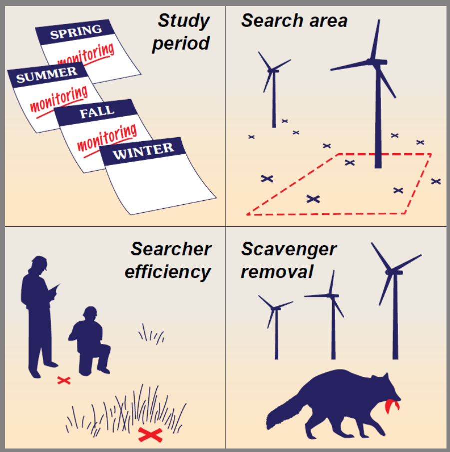
Fatalities of birds and bats from collisions with wind turbines have been documented at nearly every wind facility where studies have been conducted, and possibly the most commonly asked question about wind energy impacts on wildlife is—how many fatalities are there?

National average adjusted fatality rates *(as defined in Box 2)* reported in recent peer-reviewed national reviews vary from approximately three to six birds and four to seven bats per MW of installed wind energy capacity per year. The range of reported fatality rates can vary substantially among projects both within and among geographic regions. For example, reported adjusted fatality rates of small passerines vary across avifaunal regions in the U.S. ranging from about 1.2 to 1.4 fatalities per MW per year in northern forests, to 2.6 to 3.8 in the eastern U.S.[11] Some of the highest bat fatality rates have been reported at projects in eastern forests and the forest-agricultural matrix

BOX 2. ESTIMATING BIRD AND BAT COLLISION FATALITIES AT WIND ENERGY FACILITIES

Collision fatalities are estimated based on carcass searches conducted under operational wind turbines. Raw counts from searches underestimate the number of collision fatalities and must be adjusted for four primary sources of detection error described below. Standardized protocols are widely used to estimate these four sources of error and develop less biased estimates of collision fatalities.

- **Study period.** Many fatality-monitoring studies in the U.S. are not conducted during the winter because the activity of many species is reduced due to hibernation or migration; nonetheless, fatalities can occur. To compare annual fatality rates, estimates for some studies must be extrapolated beyond their period of monitoring.
- **Search area.** Search plots are usually centered on an individual wind turbine, but often terrain and vegetation cover prevent searching of the entire plot. Models of carcass densities at different distances from the turbine can be used to estimate the fraction of carcasses landing outside the search area, allowing researchers to adjust for unsearched area. Typically, only a sample of turbines is searched requiring extrapolation to the entire facility, although variation among turbines could occur.
- **Scavenger removal.** Animal scavengers can remove carcasses from the search area before searchers can find them. Bird and bat carcasses are placed within search plots and checked periodically over a set time period to determine how long a carcass will remain present and recognizable by a searcher. Results are used to estimate the probability of a carcass persisting between one carcass search and the next.
- **Searcher efficiency.** Searcher efficiency measures the proportion of carcasses present at the time of a search that a searcher can find. Carcasses of different sizes are placed within areas assumed to differ in detection rates. The proportion of placed carcasses found by searchers estimates searcher efficiency for combinations of carcass size and visibility class.



Box 2 Figure 1. Sources of detection error when estimating fatalities from collisions with wind turbines.

Fatality estimators: These are statistical equations that calculate an estimate of the total number of fatalities from raw carcass counts and information from trial carcasses used to estimate the different sources of detection error. A new generalized estimator (Gen-Est) uses data collected during carcass searches and estimates of detection rates to more accurately estimate the number of fatalities and to provide an accurate measure of precision associated with that estimate.

Adjusted fatality estimates are reported as fatalities per turbine or per MW installed capacity per season or year and are often reported for different groups, such as small birds, raptors, or bats, each of which may have different searcher efficiencies, scavenger removal rates, and spatial and temporal distributions. Possible sources of errors generally not accounted for in calculating fatality estimates include background fatalities (birds and bats dying from causes other than collisions) and fatally injured birds and bats that are able to fly beyond the limits of the search area.

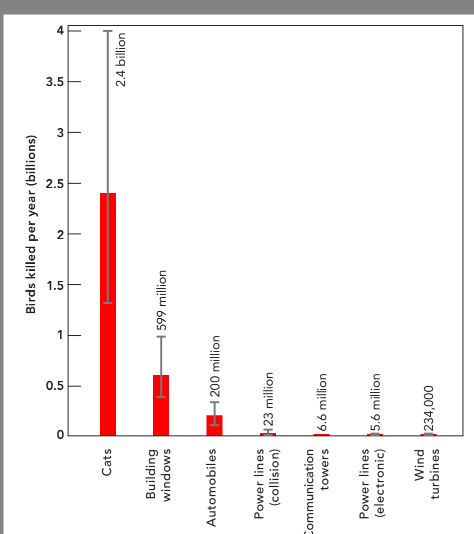
of the upper Midwest, but there is also substantial variation in reported bat fatalities within those regions. For example, fatality rates of 40 to 50 bats per MW per year have been reported for projects along forested ridgelines of the central Appalachians, substantially higher than those reported at other projects in the northeastern U.S.[2]

Using adjusted fatality rate data from publicly available studies, estimates of average cumulative annual bird fatalities in the continental U.S. published in 2013 and 2014 ranged from approximately 230,000 to 600,000 birds per year,[15] estimates of cumulative bat fatalities published during that same period ranged from 200,000 to 800,000 bats per year.[2]

The accuracy of these estimates is uncertain for several reasons. For example, results from fatality-monitoring studies are only available for a subset of all wind energy facilities in the U.S. Some regions with high installed wind energy capacity, such as Texas, have relatively few available studies. Thus, national estimates may not be accurate unless they adequately account for regional variation in levels of bird and bat fatalities. Further, although survey methods are becoming more standardized, older studies included in cumulative estimates varied more widely in methods and may have had insufficient sampling intensity, leading to questions about the validity of aggregating estimates from different studies. Collaborative efforts continue to increase access to fatality studies and to improve the accuracy of project-level fatality estimates.

Like wind energy, substantial uncertainty exists around estimates of fatalities caused by other anthropogenic sources such as poisoning or collisions with buildings. However, our best estimates suggest total bird fatalities at wind turbines are low relative to other sources of anthropogenic mortality *(see Box 3)*. For bats, wind turbines and white-nose syndrome (a fungal disease) cause high numbers of fatalities in the U.S.

These overall comparisons mask important differences in the types of birds and bats killed by different anthropogenic sources. For example, wind turbines kill raptors in greater proportions than are killed by cats, and cats kill more passerines than are killed by turbines. For the golden eagle, a well-studied raptor, more individuals die from illegal shooting than from collisions with vehicles and wind turbines. Species-specific levels of fatality at wind energy facilities are more useful for regulatory decisions and conservation planning related to wind energy than the cumulative national estimates that garner more attention.



Box 3 Figure 1. Comparison of total annual bird mortality in the U.S. and Canada from different direct mortality sources. Reprinted from Loss et al. (2015) with permission.

BOX 3. WIND ENERGY IN CONTEXT OF OTHER ANTHROPOGENIC SOURCES OF BIRD AND BAT FATALITIES

There are several well-known anthropogenic causes of fatalities of birds and bats. The magnitude of these fatalities has been estimated for birds in the U.S.; bat fatalities from anthropogenic sources may be substantial but have not been quantified to the same extent. Major sources of bird mortality include domestic cats, collisions with communication towers, vehicles, and building windows, collisions and electrocutions at power lines, and exposure at oil pits. Predation by the domestic cat is estimated to be the largest direct source of bird mortality by far, causing between 1.4 and 4.0 billion fatalities in the U.S. each year.[18] Collision deaths from sources other than wind energy number in the hundreds of millions (Box 3 Figure 1). Poisoning by agricultural pesticides and other toxins is another direct source of bird and bat mortality, but no reliable estimate exists for this source of mortality in the U.S.; a Canadian study estimated 2.7 million birds killed annually by these chemicals.[6] More detailed analysis reveals important species-specific differences among the different mortality sources. For example, oil spills and fisheries bycatch (incidental catch of non-target species) affect seabirds and waterfowl, while the fatalities caused by cats consist primarily of small song birds and terrestrial game birds.

BIRDS

Three-hundred species of birds have been reported as collision fatalities at U.S. wind facilities for which data are available. Most of the observed fatalities (approximately 57%) are small passerines such as the horned lark or red-eyed vireo. Diurnal raptors constitute about 9% of total observed fatalities, and these percentages are higher in the western U.S. where these species are more abundant. To date, fatalities of water birds and waterfowl (e.g., ducks, gulls and terns, shorebirds, loons, grebes, and others) have been observed infrequently at land-based wind energy facilities. Differences among species in the number of observed fatalities should be interpreted with caution. Raptor carcasses, and large birds in general, are more likely to be found during fatality searches than smaller birds.

Birds, particularly night-migrating songbirds, collide in high numbers with tall stationary objects such as communication towers and buildings. Lighting, particularly in periods of low visibility, is thought to be a factor attracting migrating birds to communications towers and buildings. However, the lighting currently approved by the Federal Aviation Administration and typically used at wind turbines does not appear to contribute to bird fatalities.

It seems likely that the abundance and behavioral characteristics of a bird species influence its risk of collision, although the relative importance of these factors for determining collision risk of different species is poorly understood. Abundance may be one of the most important predictors of collisions for raptors,[26] and raptors as a group appear to be among the most vulnerable to collisions. Conversely, crows and ravens, large and conspicuous birds, are among the most common birds seen flying within the rotor-swept area of wind turbines, but they are found infrequently during fatality surveys. Landscape features (e.g., woodlots, wetlands, and certain landforms) may also influence collision risk. For example, these features influence raptor abundance by concentrating prey or creating favorable conditions for nesting, feeding, and flying. While landscape features may influence the abundance of other bird species, no clear relationship between bird abundance and fatalities of most other bird species has been shown.

Technological advances that increase turbine height and rotor-swept area are expected to increase the power generation capacity and efficiency of wind turbines enabling wind energy to expand to regions of the country where relatively little wind energy development exists today. Radar studies indicate that 90% of avian nocturnal migrants fly above the height of the current rotor-swept zone of turbines (140 m; 460 feet) in most operating wind energy facilities. Land-based wind turbines have been developed that extend almost twice the height of existing turbines reaching higher into the space used by nocturnal migrants, and there are concerns that this will increase bird collisions.

The few published studies have been contradictory in their findings regarding the effects of increased turbine height or increased MW capacity on fatality rates of birds. For raptors, however, repowering at Altamont Pass, where smaller turbines have been replaced by fewer, taller turbines, may decrease fatalities in this group. Given the trend toward larger, more powerful turbines and uncertainty about their impacts on the number of fatalities, further analysis of this relationship for birds is warranted.

BATS

Twenty-two of the 47 species of bats that occur in the continental U.S. have been recorded as fatalities at U.S. wind energy facilities. Three migratory tree-roosting species (hoary bat, eastern red bat, and silver-haired bat) constitute approximately 72% of the reported fatalities in available fatality monitoring studies at U.S. wind facilities. The species composition of bat fatalities varies regionally depending on the available pool of bat species. For example, in southwestern U.S., the Mexican free-tailed bat can constitute 50% or more of the bat carcasses found at facilities that overlap this species' range. Relatively high proportions of cave-hibernating bat fatalities (e.g., big brown bat and little brown bat) have been observed at some wind energy facilities in the upper Midwest compared to facilities in other regions in the U.S. Studies generally have shown a peak in bat fatalities in late summer and early fall, coinciding with the migration and mating season of tree-roosting bats, and a smaller peak in fatalities has been observed during spring migration.

Numerous hypotheses have been proposed for why bats, especially migratory tree-roosting bats, are killed in large numbers at some wind energy facilities in some regions of the U.S. Some of these hypotheses suggest that bats are attracted to turbines, perhaps by the sounds produced by rotating turbine blades, the possible concentration of insects near turbines, or because of bat mating behavior. Infrared imagery has shown bats exploring the nacelles, towers, and blades of wind turbines from the leeward direction, especially at low wind speeds.[8] It has been hypothesized that some bat species perceive wind turbines as trees and are attracted to the turbines for roosting, foraging, or mating. Analysis of bat carcasses beneath turbines found large percentages of mating-ready male hoary, eastern red, and silver-haired bats, indicating that sexual readiness coincides with the period of high levels of fatalities in these species. Bats rarely collide with stationary anthropogenic structures, and there are no reported fatalities at stationary wind turbines or meteorological towers. Bat fatalities have shown a positive correlation with tower height, but there are few analyses of this relationship with large datasets.

The hypothesis that bats may suffer fatal internal injuries, such as hemorrhaging in the lungs (barotrauma), when they experience a rapid drop in air pressure as they pass between rotating turbine blades, gained rapid public awareness when first proposed. More recent studies involving detailed analysis of bat carcasses have suggested that the proportion of fatalities that can be solely attributed to barotrauma as opposed to collisions may be much lower than originally thought.

EFFECTS OF COLLISION MORTALITY ON THE STATUS OF WILDLIFE POPULATIONS

Assessing the population-level effect of collision fatalities is difficult because the potential for this effect depends on multiple factors, including a species' population size, other sources of mortality, and the species' reproductive potential. As discussed previously, the uncertainty around existing fatality estimates leads to uncertainties around the potential for population-level effects. While recognizing these limitations, several studies have attempted to assess the potential for population declines from wind turbine collisions. Demographic models, such as population viability analyses designed around the biology of specific species, suggest the population size or dynamics of some species may be negatively affected from increases in mortality from collisions at wind turbines, particularly as more turbines are placed within the species' range.

For most songbirds in the U.S. for which data are available, cumulative collision mortality at wind energy facilities has been estimated to represent less than 0.01% of estimated population size.[11] In North America, most small songbird species have relatively high natural annual mortality, even as adults, and high reproductive potential indicating that population impacts from collisions at wind turbines are unlikely at current levels of installed wind capacity.

Long-lived species, including most raptors, that have higher adult survival and fewer offspring each year, may be more susceptible than short-lived species to population-level effects from collisions with wind turbines. Few peer-reviewed studies in the U.S. have investigated population-level effects of wind energy on any raptor species. Studies of the unusually high fatalities of golden eagle at the Altamont wind facility in California indicated that increased mortality from collisions did not cause a decline of the local population although recent research indicates that these fatalities are offset by immigration of young eagles into the area.[16] In Europe, where raptor numbers tend to be lower than in the U.S., a local decline attributed to the Smøla wind energy facility in Norway has been observed for white-tailed eagles,[9] and modeling results have suggested that some raptor species in Europe are at risk of population declines due to collision fatalities at wind turbines.[22]

Most species of bats have low reproductive potential and high adult survivorship. Little is known about population size or trends in migratory tree-roosting bats, the group of bats with highest reported turbine-related fatalities across the U.S., but modeling results suggest some of these species are at risk of population decline due to collision fatalities.[12] The ecological consequences of turbine-caused mortality of cave-dwelling bats such as the little brown bat, northern long-eared bat, or Indiana bat may be significant because of already high mortality and recent population declines caused by white-nose syndrome (WNS). At some facilities in the Northeast and Midwest little brown bats accounted for up to 60% of detected fatalities. Once common, this species has declined substantially due to WNS. Northern long-eared bat, recently listed as federally threatened due to population declines from WNS, and the federally endangered Indiana bat have also been recorded as fatalities, albeit rarely. The declining status of many cave-dwelling bat species raises concerns about the ecological consequences of any additional mortality.

ADVERSE IMPACTS TO SPECIES' HABITAT

Wind energy facilities can extend over thousands of acres, although the actual amount of land changed by project-related structures, including access roads and turbine pads, constitutes only a small fraction of that area. The magnitude of adverse impacts due to land transformation and the spatial extent of facilities will vary with each project, landscape, and species (see Figure 2). Wind energy facilities constructed on previously undisturbed landscapes may have a greater impact than projects built on land that has been transformed by human activity. For example, facilities installed in agricultural lands can take advantage of the existing road networks and use approximately one-sixth of the available land per MW compared to facilities placed in forested areas.

The total amount of land transformed by the development of a wind energy facility varies substantially from 0.11 to 4.3 ha/MW of installed capacity, which may constitute 5% to 10% of the total project area.[10] Some of the land transformation is temporary, for example, from burying cables or building staging areas. These disturbed areas can be restored or may recover naturally. Roads, which constitute approximately 40% of the transformed land area, and turbine pads are permanent through the life of the facility, but, theoretically, these could also be restored when a facility is decommissioned.

Land transformation associated with development of a wind energy facility has the potential to remove or fragment habitat for one or more species. Habitat fragmentation is the loss and separation of habitat into smaller segments. Individuals in the remaining habitat segments may exhibit decreased survival, reproduction, distribution, or use of the area. Construction, operation, and maintenance of a wind energy facility also results in increased human activity, and this activity may disturb sensitive species and cause displacement from otherwise suitable habitat. Disturbance from the operation of a wind energy facility may also disrupt movement or migration patterns. Development and operation of a wind energy facility may have differential effects on predators, prey, or competing species, thus affecting ecological interactions among species.

Figure 2. *Wind energy facilities located in different landscape types: a) flat, agricultural lands (photo credit: Emily Zink, West Inc). b) turbines along a ridgeline (photo credit: Tom Walsh, CC by-SA 3.0), and c) turbines following a hilltop in deciduous forest (photo credit: Dhaluza at English Wikipedia, CC by 3.0).*

Detailed studies evaluating these potential effects are limited, because sufficient testing of effects may require expensive studies

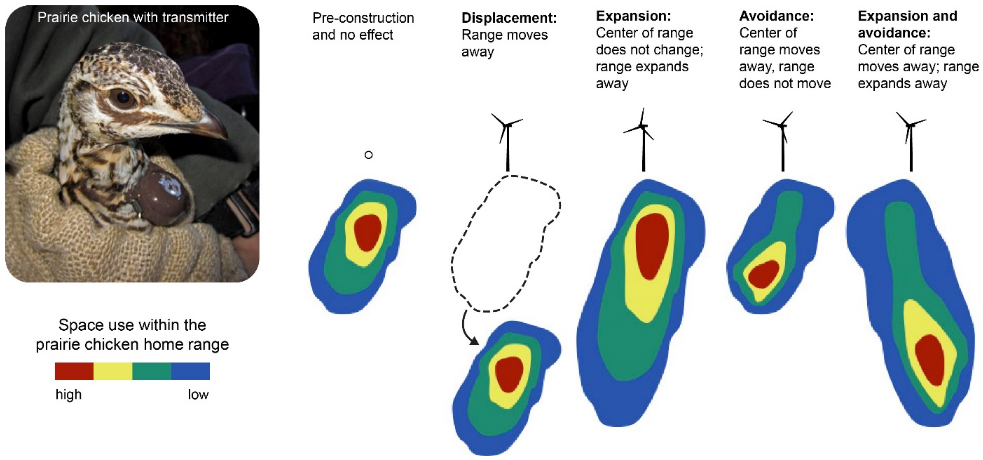


Figure 3. *Possible responses of prairie chicken and sage grouse before and after construction of a wind facility. Studies show responses are not consistently observed across species or locations. See text for further discussion of results (photo credit: U.S. Geological Survey, adapted from Winder et al. 2014)[29]*

that run for several years, and because such studies need to be replicated at multiple wind energy facilities. Many of the available studies have focused on grassland and shrub land birds, whose populations already appear to be declining with large-scale transformation of their habitat to agriculture, range management, or other types of energy development. These studies consistently show species-specific responses. For example, a 10-year study of nine grassland songbird species at three wind energy facilities in the Dakotas indicated that seven of these species declined but the effects were delayed until a few years after construction.[23] Two species showed no effect or experienced a temporary increase in abundance. Adverse and positive effects were not consistently observed across the three wind energy facilities.

A multi-year study comparing response of greater prairie-chickens to development of a wind energy project in Kansas versus a control site also showed mixed effects. Female survival significantly increased in proximity to the wind energy facility between pre-construction and post-construction periods, and no negative effect from proximity was observed on nest site selection or nest survival. Female greater prairie-chickens increased the size of their home range and avoided areas close to wind turbines within their home ranges after wind energy development *(Figure 3)*. Persistence of leks, which are male displaying and breeding areas, may also decrease in proximity to wind turbines. In a Wyoming study, female greater sage-grouse utilized areas farther from disturbed areas around a wind facility for brood rearing and summer habitat use, but otherwise no significant negative effects of wind energy on this species were detected.[17]

Bat acoustic activity is higher in forest gaps and edges than in interior forest. Wind turbine installation increases both the amount of forest edge and the number of forest gaps, and it is hypothesized that these changes result in increased bat activity potentially explaining the higher bat fatalities reported at some projects in forest regions. There has been little evaluation of this hypothesis. There are a few studies evaluating potential habitat impacts for other terrestrial vertebrates. Long-term studies on Agassiz's desert tortoises at a wind facility near Palm Springs, California indicated that adult females survived at higher rates near turbines, but fewer tortoises were utilizing the area around the facility suggesting displacement may not be apparent without almost 20 years of monitoring.[20] A study of a transplanted elk population during construction and operation of a wind energy facility in Oklahoma found turbines did not affect elk use of the surrounding area before and after construction. Winter survival of pronghorn was not affected by proximity to a wind energy facility in Wyoming.

Wind energy facilities can affect downwind microclimates by mixing different thermal layers in the atmosphere.[25] Observed effects include higher near-surface air temperatures at night and lower temperatures during the day *(Figure 4)*. Computer simulations suggest these effects extend downwind of the facility, but the distance depends on wind speed and topography. Whether the microclimate changes resulting from the operation of wind facilities affect wildlife, positively or negatively, is unknown.

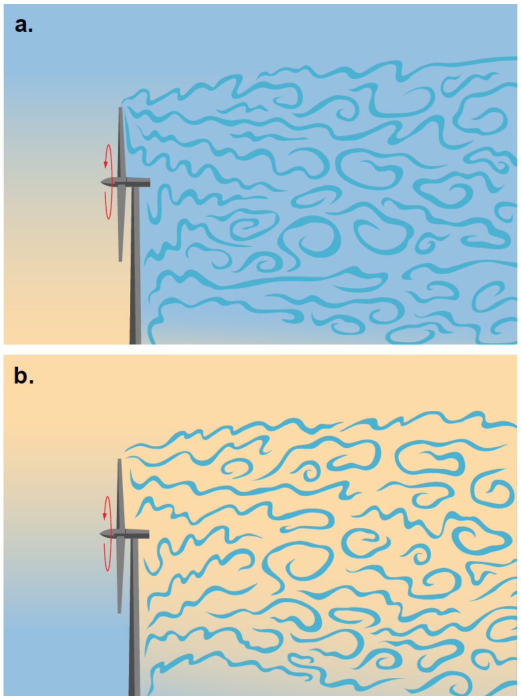


Figure 4. *Depiction of how turbulence from wind turbines can affect air temperature. When cool air (blue) is over warm air (tan) (a), turbulence mixes cool air down and warm air up, cooling the surface. The opposite can happen when warm air is above cool air (b).*

OFFSHORE WIND ENERGY DEVELOPMENT

Only one offshore wind facility is operating in the U.S. off Block Island, RI. However, offshore wind energy appears poised for major expansion with numerous leases for development in state and federal waters. The scope and degree of impacts to wildlife from offshore wind energy facilities are less understood than land-based wind energy development, but research collaboratives are being formed to reduce that uncertainty. Concerns about potential wildlife impacts are based on inferences drawn from impacts documented at wind facilities from northern Europe and from other offshore development activities, the latter of which inform questions on the potential impacts to sea turtles and large cetaceans, which are not well represented in studies at European offshore wind facilities.

Offshore wind energy facilities present similar concerns as land-based wind energy regarding ecological impacts, primarily collision mortality of birds and bats and displacement of birds. Additional concerns have focused on species found in the marine environment, such as mortality and injury, displacement, and prey-mediated impacts on fishes, marine mammals, and marine reptiles. Artificial reef effects from the hard surfaces provided by turbine installations may also affect the composition and distribution of ecological communities, with variable effects to individual species. Underwater noise, particularly from seismic surveys and construction activities, has the potential to cause physical injury to acoustically sensitive species at close range and a variety of behavioral changes farther away from the noise source.

INJURIES AND FATALITIES

There is limited documentation of bird and bat fatalities due to the challenges of conducting fatality monitoring in the offshore environment. Alternative approaches such as cameras and visual observations have limitations that have prevented their widespread implementation, including a narrow field of view (for cameras) and poor species detection or species identification capabilities, particularly for smaller-bodied species. Efforts to infer collision risk in the U.S. have thus largely focused on evaluating avian and bat activity offshore. Siting and permitting decisions for many European offshore wind facilities are informed by collision risk models, which have been created to predict the number of avian collisions for offshore wind energy facilities. However, these models are highly sensitive to uncertainties in input data. The few empirical studies at land-based wind facilities that have compared model-estimated collision risk to actual mortality rates found only a weak relationship between the two, and due to logistical difficulties, the accuracy of these models has not been evaluated in the offshore environment.

Offshore avian activity appears to vary with distance from shore, submarine topography, time of year, and weather conditions. Recent offshore surveys and subsequent modeling in the eastern U.S. have indicated that seabird abundance and species diversity generally decrease with increasing distances from shore, though the distributions of individual species vary widely. Both seabirds and many land birds migrate over open water, and some water bodies such as the Great Lakes are crossed by large numbers of terrestrial migrants during migration. Bird fatalities have been reported at offshore oil and gas structures under certain weather conditions and when such structures are brightly lit. However, the lighting used at offshore wind farms in the U.S. for marine navigation and to mark an aviation hazard may be less likely to attract birds.

Visual and acoustic surveys in the U.S. show bats forage and migrate over the ocean at distances > 40 km from shore, although the magnitude of this activity is unknown. In Europe, bats have been recorded foraging and roosting 15-80 km offshore on wind turbines and oil and gas platforms in the North Sea. It is unknown whether bats are attracted to offshore wind turbines, but their presence at offshore structures indicates a potential for collisions.

Sound from human activity propagated underwater can affect marine mammals and acoustically sensitive fishes. The magnitude of these effects depends on a variety of factors, including the frequency, intensity, and duration of the sounds, water depth, the species being exposed, and the animal's life history stage and behavior at the time of exposure. Potential injurious effects from exposure to high intensity sound such as naval sonar include death and temporary or permanent hearing loss. No evidence of such effects has been found for pile driving (during installation of turbines) at offshore wind facilities to date, and the potential for auditory injury from pile driving noise has been estimated to occur within a fairly small radius (100 m in one study). A variety of mitigation measures have been proposed to minimize sound impacts, including the use of Marine Mammal Observers to halt potentially harmful activity when animals are observed and scheduling construction activity when sensitive species are absent.

Collisions with vessels are a primary source of mortality for some large whale species, and there is some potential for collisions with vessels during construction and operation activities for offshore wind facilities. Potential mitigation approaches include reducing vessel speed during locations or time periods when species of concern may be present.

AVOIDANCE AND DISPLACEMENT

Several species of seabirds have been shown to fly around offshore wind facilities and individual turbines, and it is estimated that over 95% of individual seabirds flying by offshore wind energy facilities do not approach turbines closely enough to be at risk of collision.[7] The degree of avoidance behavior likely is species-specific and dependent on the situation. Available studies suggest it is unlikely that resulting increased flight times and energy use lead to negative impacts to migrating birds, at least at current buildout scenarios. Avoidance of wind turbines may represent a more significant burden to individuals making multiple, daily trips between feeding and roosting or nesting areas.

Offshore wind facilities may also displace waterfowl and seabirds from use areas (e.g., feeding and roosting grounds). Some species are displaced only by construction activities, or for just a few years after operation begins, while species such as red-throated loon and northern gannet experience displacement for several years, and possibly indefinitely. Other species may be attracted to perches on structures or increases in food availability. Displacement may have population-level impacts for at least a few species, but efforts to model these effects are just beginning.

Acoustic disturbance from pile driving was recently determined to be the highest impact of all offshore wind energy development activities on marine mammals in Europe.[5] One study indicated that harbor porpoises could hear pile-driving noise over 80 km away,[27] and several studies have estimated that reductions in local activity and potential displacement during installation of monopoles occurred up to 20 km from the noise source. Construction noise may also affect acoustically sensitive fish species, particularly during sensitive life history periods.

Operational turbines emit low levels of underwater noise. Harbor seals have displayed little or no long-term displacement during operations. Harbor porpoises have displayed a high level of variability in observed displacement responses, which has been hypothesized to relate to local food availability or pre-existing levels of underwater noise at the development sites. Turtles can hear low-frequency underwater noise emitted during seismic surveys, pile driving activities, and wind turbine operations, but the effects are poorly understood. Some fish species may hear noise of operating turbines from 25 km away, but physiological or avoidance responses would be predicted at much closer ranges, perhaps in the <10 m range.[1]

Vessel activity associated with construction and maintenance of offshore wind facilities may also displace or attract animals, depending on the species and the intensity of the disturbance. Bottlenose dolphins, for example, may be attracted to and "bowride" near vessels, while many large whales, sea turtles, and some waterfowl such as scoters may avoid areas of high vessel activity.

HABITAT/PREY IMPACTS

Displacement or other behavioral impacts to prey fish during the construction period may influence seabird distributions and reproductive success. Underwater structures also change local habitat, by attracting benthic organisms that attach to the underwater structures and form artificial reefs, which have the potential to attract foraging marine mammals, sea turtles, and fishes, among other taxa. It is not fully understood whether these artificial reefs increase the carrying capacity of ecosystems to support predator populations or aggregate individuals already present. Recent evidence suggests that wind farms in the North Sea may support increased populations of blue mussels, which are a key species for local food webs,[24] but it is likely that a range of site-specific factors influence the degree to which artificial reef effects support productivity at higher trophic levels.

Electromagnetic fields (EMF) are generated by cables that carry electricity from wind turbines. Many species of fish, bottom dwelling elasmobranchs (sharks, rays and skates), and possibly sea turtles are sensitive to EMF, though there appear to be little or no observed effects for most taxa. Bottom-dwelling species sensitive to EMF have been shown to be attracted to cable routes along the sea bed, though it is unclear whether such attraction is a biologically significant effect. Recent research from the Pacific offshore environment indicated that this effect dissipated quickly with distance, and there was a lack of response detected in both fish and invertebrates.[19]

STRATEGIES TO AVOID AND MINIMIZE ADVERSE IMPACTS

In this section, we describe strategies currently in use or in development to avoid and minimize adverse impacts to wildlife from wind energy construction and operation. In the U.S. these efforts are focused almost entirely on land-based wind energy facilities.

AVOIDANCE: SITING

Avoidance of adverse impacts is typically addressed through siting practices, which can be further defined as:

- Macro-siting—locating individual projects within a landscape, or
- Micro-siting—locating individual turbines and associated infrastructure within a project boundary

Many states and federal agencies have developed guidelines for siting practices intended to avoid adverse impacts of wind energy development to wildlife for both land-based and offshore wind. These guidelines include identifying areas with high conservation value, such as wetlands, unique or rare natural communities, major avian migratory routes, or critical habitat for endangered species that could be avoided either by macro- or micro-siting. Effective guidelines require a clear understanding of the species of concern and evaluation of the risk posed to these species.

Several decision-support tools are available to aid wind project developers and permitting agencies in the early planning stages of project siting by providing searchable spatial data layers that identify areas of conservation concern. Published models identify areas of overlap of wind energy potential and landscape use by some species. In addition, recent publications have provided detailed recommendations on field protocols and study designs for risk assessment consistent with most state and federal guidelines. The voluntary U.S. Fish and Wildlife Service Land-Based Wind

Energy Guidelines provide a tiered approach to risk assessment and recommendations on how to site wind facilities and mitigate risk to wildlife, primarily birds and bats. The Bureau of Ocean Energy Management has identified offshore wind lease areas based in part on an evaluation of available wildlife survey data and has developed wildlife survey guidelines for offshore wind energy facilities.

There is interest in predicting collision risk to birds and bats, and it is logical to assume that collision risk is related to activity and exposure, in other words, the time a species spends within the rotor-swept area. Land-based siting guidelines therefore have recommended collecting activity data to support the prediction of collision fatality risk for birds and bats. Bird activity at land-based projects is typically estimated from visual surveys and radar, and bat acoustic activity is typically used to estimate relative bat activity. There is some evidence that raptor activity is correlated with raptor collision fatalities, but for most other groups of birds and bats there has been a lack of success in relating activity data to the observed level of fatalities.

Estimating avoidance behavior is also important in evaluating collision fatality risk both at land-based and offshore wind energy facilities, and estimation has been attempted for some bird species, notably raptors and seabirds. Except for a few species, such as golden and bald eagles,[21] in the U.S. there is a lack of guidance regarding how to use estimates of bird and bat activity to make siting decisions.

Siting of wind energy facilities and individual turbines can also be designed to reduce impacts of habitat loss or fragmentation or to avoid disturbing unique plant community types or habitat for an endangered species. The U.S. Fish and Wildlife Service's Land-Based Wind Energy Guidelines describe a path for estimating habitat fragmentation risk, and a process for identifying species that may be sensitive to habitat fragmentation. Project siting intended to avoid impacts to species' habitat is often hampered by lack of knowledge about how individual species will respond to the project. For some species, the response to roads or other disturbances may be well known, while for other species this information may be entirely lacking.

IMPACT REDUCTION: TURBINE SHUTDOWN

Shutting down of turbine operation, often referred to as curtailment or operational minimization, is intended to reduce bird and bat collision fatalities at wind turbines by "feathering"—changing the angle of turbine blades to slow blade rotation during periods where risk of collisions is high.

TURBINE SHUTDOWN TO REDUCE BAT FATALITIES

Several studies evaluating the effect of turbine curtailment at low wind speeds have documented significant reductions in bat fatalities. For example, curtailing blade rotation when wind speeds are below 5.0-6.5 meters per second (m/s) reduced bat fatalities by 50% or more.[4] Fatalities of individual bat species typically are not frequent enough to determine whether shutting down turbines is more effective for some species than others.

Turbines are designed to begin generating power above a certain wind-speed threshold, or "cut-in speed," typically set by the manufacturer at 2.5 to 3.5 m/s, but turbine blades rotate even when wind speed is below the manufacturer's cut-in speed—thereby presenting a collision risk to bats, although electrical power is not being generated. Recently, member companies of the American Wind Energy Association agreed to voluntarily reduce or "curtail" turbine blade rotation below the cut-in speed at night during fall migration to reduce bat-collision fatalities. Some states have instituted threshold levels of bat fatalities, which if exceeded would require curtailment of turbine operation below "designated" wind speeds at the wind facility.

Restricting turbine operation at low wind speeds reduces power production and that reduction increases with wind speed. The amount of reduction depends on the wind speed chosen for curtailment and the wind-speed characteristics of the project location. Because of concerns about reduction in power production, research is underway to evaluate whether incorporating bat activity and environmental variables, such as temperature or changes in barometric pressure, can be used in addition to wind speed to optimize reductions in bat fatalities while minimizing the reduction in energy production.

TURBINE SHUTDOWN TO REDUCE BIRD FATALITIES

The effectiveness of turbine shutdown in reducing bird fatalities has rarely been evaluated experimentally. For example, there is no published experimental evidence that stopping turbines reduces collision fatalities of songbirds, the largest group of bird collision fatalities reported at wind turbines. Turbine shutdown has been implemented to reduce raptor fatalities. Turbine shutdown at the Altamont Pass Wind Resource Area was implemented between 2005 and 2011 to reduce fatalities of four target raptor species—golden eagle, red-tailed hawk, American kestrel, and burrowing owl—during the period of highest raptor activity (November through February). The target reduction of 50% was not achieved, but fatalities of red-tailed hawk did decline significantly.[14] Fatalities of golden eagle also declined, but low numbers of fatalities made interpretation difficult. Kestrel and burrowing owl fatalities appeared to increase following implementation of turbine shutdowns, suggesting the fatalities of these species are due to causes other than collisions at wind turbines.

Wind energy companies have employed human observers to detect target species and to signal for shutdown of specific turbines or turbine strings, a process called "informed curtailment" that aims to reduce the amount of time that turbines are not generating power. Automated detection technologies are being used to track California condors with GPS transmitters, detect and shut down turbines with camera-based systems to reduce eagle collisions, and detect large raptors with ground-based radar.

MINIMIZATION: FOR BIRDS AND BATS

Because of concerns about power loss and the practicality of implementing curtailment in low wind regions, there has been substantial investment in developing technologies that reduce fatalities of birds and bats while allowing turbines to operate normally. One approach being tested is to use sound to deter birds and bats away from turbine blades (Figure 5). For example, all bat species in the U.S. echolocate by emitting high-frequency (ultrasonic) sounds and interpreting the reflected echoes from objects in their surroundings. These sounds allow bats to orient, capture prey, and communicate in the dark. Bat scientists have hypothesized that broadcasting ultrasound from wind turbines may "jam" a bat's ability to perceive its own echoes and cause bats to avoid wind turbines.

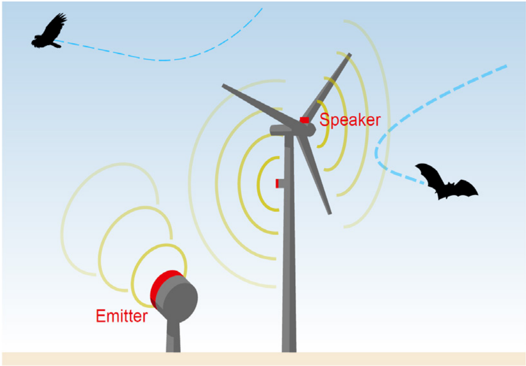


Figure 5. *Deterrent devices installed on the ground or on turbines are intended to reduce collision risk by keeping birds and bats away from turbines.*

Several tests of ultrasonic acoustic deterrence were being completed at the time of publication of this issue, but results were not yet published. Preliminary results are promising, suggesting an effectiveness approaching that of curtailment for some bat species.[3] One wind company is installing 2nd-generation acoustic deterrents at its facility in Texas. Research is ongoing to improve effectiveness, including understanding species-specific differences in response and the optimal placement and orientation of speakers on turbines. In addition to ultrasonic deterrence, research is underway to investigate ultraviolet light as a bat deterrent and to develop surface materials that reduce the attractiveness of wind turbines to bats.

Acoustic deterrents for birds, particularly raptors, have been used at European wind energy facilities and are undergoing testing in the U.S. Experimental evaluation of the effectiveness of this technology in reducing golden eagle fatalities is underway, and preliminary results indicate the deterrent affects eagle behavior reducing collision risk.

Acoustic deterrence also is under consideration to minimize impacts in the offshore environment. The approach, referred to as "ramping up," involves gradually increasing intensity of construction noise so that sensitive aquatic species will avoid the construction area and will no longer be present in the area by the time noise reaches levels that could cause harm. The approach is controversial; however, there is no clear evidence of effectiveness and the practice results in longer periods of construction noise overall. It is also a common practice to curtail some types of offshore construction activities when certain aquatic animals are observed in the immediate vicinity to avoid exposing them to potentially injury-inducing noise. Stoppage of construction activities does not address the potential for other types of impacts, such as behavioral modifications and masking of communication, over a much larger geographic area than can be monitored by observers. New mitigation approaches, such as bubble curtains that minimize sound propagation, have the potential to shrink this impact zone.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This *Issues in Ecology* describes what is currently known about the risk wind energy poses to wildlife, how to avoid and minimize that risk, and where uncertainties remain. Wind energy is also considered to have important environmental benefits, and the rapid expansion of wind energy is considered an essential part of the strategy to reduce carbon emissions and air pollution and mitigate the worst effects of climate change on wildlife and human society. Various scenarios for meeting U.S. emission reduction goals indicate that a four- to five-fold expansion of land-based wind energy from the current 97 gigawatts (GW) by the year 2050 is needed.

Given the environmental benefits of wind energy, a focus on rapid improvement and implementation of effective strategies will help reduce the negative impacts of this rapidly growing technology on wildlife. The wind energy industry, state and federal agencies, conservation groups, academia, and scientific organizations have collaborated to promote research needed to reduce these uncertainties in risk to wildlife and to avoid and minimize that risk. However, the pace and scale of wind energy installations and the amount of new wind energy facilities needed to reduce carbon emissions indicate that we must further focus our research priorities, improve coordination and sharing of research results, and increase the rate at which we incorporate research results into the development and validation of best practices.

We provide a brief list of priority recommendations for future research below. Many of these recommendations were first made when concerns about wind energy's impacts on wildlife emerged in the 1990s. This does not mean we have made little progress on these concerns. To the contrary, progress has been substantial. What this replication indicates is that we have been asking the right questions, but that they are challenging questions, and that obtaining more answers remains a priority.

Our general research recommendations include (1) focusing on species of regulatory concern or those where known or suspected population-level concern exists but corroborating data are needed *(Figure 6)*, (2) conducting research that improves risk evaluation and siting to avoid impacts, (3) evaluation of promising collision-reducing technologies and operational strategies with high potential for widespread implementation, and (4) coordinating research and pooling data to enable statistically robust analysis of infrequent, but potentially ecologically significant impacts.

Specific recommendations include:

Continue research to improve risk assessment and siting of wind energy facilities. Numerous authors suggest siting of wind energy facilities and individual turbines may be the best approach for reducing impacts to some species. For example, avoiding placement of turbines near bat hibernacula, or near migratory routes of raptors, may reduce collisions. There is, however, much more to learn about the factors that contribute to collision fatality risk: how birds and bats are distributed across space, flight activity, and migratory behavior. For example, understanding how raptors use topography during flight may facilitate micro-siting individual turbines to reduce collision risk. Likewise, knowing the location of areas of concentrated migration of birds and bats

Species of management concern with evidence of impacts

	**Prairie Grouse**	• Lesser and Greater Prairie-Chicken, Greater Sage-Grouse • Species under ESA review: lesser prairie chicken • Concerns: Possible habitat loss and fragmentation, displacement and demographic impacts • Mitigation: lek buffers, avoidance of core habitat
	**Raptors**	• Bald and Golden Eagle, Ferruginous Hawk, Swainson's Hawk • Legal protection: Bald and Golden Eagle Protection Act and/or Migratory Bird Treaty Act • Concerns: Collisions, possible nesting disturbance • Mitigation: detection and informed curtailment; deterrence; under study
	**Bats**	• Hoary Bat, Eastern Red Bat, Silver-haired Bat, Mexican Free-tailed Bat • Legal protection: none for these four species • Collision mortality: the four species constitute ~80% of fatalities nationwide • Mitigation: Curtailment at low wind speeds, ultrasonic acoustic deterrence under study

Species of management concern with regulatory concerns

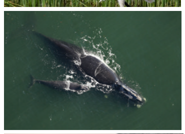
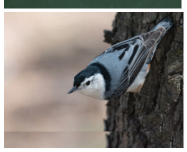
	**Endangered Species**	• California Condor, Whooping Crane • Legal protection: Federal Endangered Species Act • Concerns: Collision mortality, no collisions of either species reported to date • Mitigation: detection and deterrence or curtailment under study
	**Marine Mammals and Reptiles**	• North Atlantic Right Whale, Kemp's Ridley, Leatherback • Legal protection: Federal Endangered Species Act • Concerns: Injury or disturbance from underwater noise, vessel collisions • Mitigation: construction curtailment or sound reduction and reduced vessel speed need study
	**Songbirds**	• Cerulean Warbler, Grasshopper Sparrow, Le Conte's Sparrow • Legal Protection: Migratory Bird Treaty; mostly abundant, some species of conservation concern due to habitat loss • Concerns: Collisions for some declining forest species, displacement for grassland species • Mitigation: FAA-approved lighting to reduce attraction of night migrants

Figure 6. *Species groups that have been a focus of concern regarding the potential for adverse impacts from wind energy development. Each grouping describes: 1) key species, 2) their conservation status, 3) potential impacts, and 4) potential mitigation approaches. The included species are a representative, but not comprehensive list of the major groups for which there is concern. The species are organized into two groups: 1) species with a science-based concern for significant adverse impacts from wind energy (see text), and 2) species where environmental regulations require actions to mitigate effects of wind energy development, although impacts from wind development are still being explored. (photo credits: Prairie grouse - Patty McGann; eagle – Jason Mrachina; bat – Cris Hein – BCI; whooping crane – Jason Mrachina; right whale and calf- Florida Fish and Wildlife Conservation Commission, CC BY NC-ND 2.0; white-breasted nuthatch- Russ, CC BY 2.0)*

may facilitate the siting of entire facilities. Additional research is also needed to further evaluate the sensitivity of some species, such as grassland songbirds, sage grouse, and prairie chickens to the presence of wind turbines.

Continue and expand investment in the development and evaluation of technologies and operational strategies that minimize collision fatalities of bats, raptors, and other protected species and are feasible to use at a wide range of facilities.

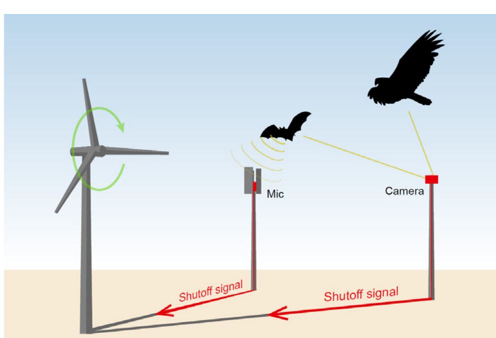


Figure 7. *Automated detection and shutdown technology uses microphones and/or cameras to identify species and can shutdown turbines when necessary.*

We support increased investment in the promising efforts to utilize technology and artificial intelligence to decrease impacts of wind energy to wildlife. For bats, research on 'smart curtailment' involves testing additional environmental variables, such as temperature and barometric pressure that affect bat activity, in addition to wind speed, or studying behavior of bats around turbines to decrease bat fatalities while reducing power loss. The use of camera-based systems that employ machine-learning to 'inform' turbine shutdowns and reduce collision risk to eagles and condors is expanding at wind energy facilities in the western U.S.

Acoustic deterrents for bats and detection-deterrent systems for raptors have been developed and new approaches to improve these technologies are in development (Figure 7). Coordinated and independent research-based evaluation of these technologies supported by government agencies and the wind industry is now underway at multiple wind energy facilities, but more is needed for these technologies to gain widespread adoption by the industry and wildlife agencies.

Conduct replicated studies focused on terrestrial and marine species assumed to be at greatest risk of direct and indirect habitat impacts. Some of the greatest wind resources coincide with some of the most imperiled natural landscapes in the U.S., such as the temperate grasslands of the Northern Great Plains. Well-designed studies are needed on species considered likely to be affected by this development. Habitat-based impacts, including displacement, may not be apparent for several years after construction and operation of a wind energy facility, indicating the need for long-term research. Existing research should be evaluated to determine whether it is appropriate to extrapolate results from related species, for example, from greater prairie-chicken to lesser prairie-chicken, or from oil and gas development to wind. This evaluation could guide future research.

Promote coordinated research at multiple wind energy facilities to enable statistically robust analysis of fatalities and strategies to minimize them. Information critical to informed decision making about wind energy and wildlife interactions is laborious and expensive to collect. For example, detecting rare events—such as the collision fatality of an Indiana bat—is extremely difficult. As noted earlier, current estimates of fatalities are highly uncertain, in part because the facilities sampled do not represent the distribution of turbines across the U.S. Improving our ability to estimate the number of fatalities, or to determine displacement of rare species by wind development, requires coordinated research across multiple facilities. Coordination will facilitate adequate sampling and the pooling of data from multiple studies—using a common database such as the American Wind Wildlife Institute's (AWWI) American Wind Wildlife Information Center (AWWIC)—to facilitate meta-analysis of results. In addition, coordination across facilities will allow more rapid and efficient testing of curtailment strategies, deterrent technologies, or automated shutdown methods.

Develop accurate demographic data for key species of concern to evaluate the population-level significance of collision fatalities and other impacts (e.g., displacement), and establish appropriate mitigation targets. We cannot easily take information about estimated fatalities, changes in behavior, and habitat loss from wind energy, and consider how these affect populations. In some cases, doing so requires basic information that is currently not available. We note that the challenge of understanding impacts to populations is not unique to wind energy development. The potential for cumulative impacts is assumed for threatened and endangered species, but for other taxa, evaluating the necessary level of minimization to maintain populations requires a better understanding of their demographic attributes. For example, the demographic consequences of reducing migratory tree bat fatalities through curtailment at low wind speeds is unknown because of the lack of knowledge regarding population numbers for these species. Quantitative methods, such as demographic models, are well-developed in applied ecology and will likely continue to play a large role in estimating population impacts from wind energy. Many of the suggested research topics above will help generate the types of data required to parameterize these models and improve the quality of their predictions. Understanding when fatalities caused by wind turbines are compensatory (i.e., the turbine-caused deaths would have taken place naturally) or add to the background rate of death is a key issue when considering population-level impacts from wind energy, or from any anthropogenic activity.

The above topics focus attention on those species for which there is greatest concern based on current knowledge. The growth of wind energy and advances in turbine technology will likely increase the exposure of wildlife to potential adverse impacts. Advances in turbine technology may allow wind energy development in regions where it currently is rare, and thus expose new species to potential impacts. We should be prepared to address new concerns as they emerge and also continue to look for solutions that would allow increased wind energy supply and reduced effects on wildlife.

Making significant progress on these research priorities will provide critical knowledge necessary for informed management practices. A great deal of our understanding of the adverse impacts of wind energy and how to mitigate these impacts comes from research at operating wind energy facilities that is funded by government agencies, academia, conservation organizations, and the wind energy industry, either voluntarily or as required by the regulatory process. There are diverse stakeholder groups working on these myriad issues, and collectively they have played a critical role in closing gaps in our understanding and evaluating methods to reduce collisions. Such groups include the National Wind Coordinating Collaborative (NWCC) Wildlife Workgroup founded in 1994, the Bats and Wind Energy Cooperative (BWEC) founded in 2003, and the AWWI founded in 2008. Most recently, the wind industry created the Wind Wildlife Research Fund in 2018. These initiatives demonstrate a commitment to finding science-based solutions to achieve the environmental benefits of wind energy while minimizing its environmental consequences.

FOR FURTHER READING

Cryan, P. and R. Barclay. 2009. Causes of bat fatalities at wind turbines: Hypotheses and predictions. *Journal of Mammalogy* **90:** 1330-1340.

de Lucas, M., M. Ferrer, M.J. Bechard, A.R. Muñoz. 2012. Griffon vulture mortality at wind farms in southern Spain: Distribution of fatalities and active mitigation measures. *Biological Conservation* **147:** 184-189.

Hayes, M. A., L.A. Hooton, K. L. Gilland, C. Grandgent, R. L. Smith, S. R. Lindsay, J. D. Collins. S. M. Schumacher, P. A. Rabie, J. C. Gruver, J. Goodrich-Mahoney. 2019. A smart approach for reducing bat fatalities and curtailment time at wind energy facilities. *Ecological Applications* **29**: e01881.

Huso, M., D. Dalthorp, T.J. Miller, and D. Bruns. 2016. Wind energy development: Methods to assess bird and bat fatality rates post-construction. *Human–Wildlife Interactions* **10:** 62-70.

Lovich, J.E. and J. R. Ennen. 2013. Assessing the state of knowledge of utility-scale wind energy development and operation on non-volant terrestrial and marine wildlife. *Applied Energy* **103:** 52–60.

May R., A.B. Gill, J. Koppel, R.H.W. Langston, M. Reichenbach, M. Scheidat, S. Smallwood, C.C. Voigt, O. Huppop, M. Portman. 2017. Future research directions to reconcile wind turbine–wildlife interactions. *In: Köppel J. (eds) Wind Energy and Wildlife Interactions.* Springer International Publishing, pp 255-276.

McClure, C. J. W., L. Martinson, T. D. Allison. 2018. Automated monitoring for birds in flight: Proof of concept with eagles at a wind power facility. *Biological Conservation* **224**: 26-33.

Schuster, E., L. Bulling, J. Köppel. 2015. Consolidating the state of knowledge: A synoptical review of wind energy's wildlife effects. *Environmental Management* **56:** 300–331.

U.S. Fish & Wildlife Service. 2012. U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines. U.S. Fish & Wildlife Service. Washington, D.C.

LITERATURE CITED

Note: In preparing this *Issues in Ecology*, we reviewed hundreds of peer-reviewed publications and reports, only a handful of which are cited in this publication and listed below. To see the full bibliography, please visit https://www.esa.org/issue21bibliography.

1. Andersson, M.H. 2011. *Offshore wind farms-ecological effects of noise and habitat alteration on fish.* Doctoral dissertation. Stockholm University. Available at https://www.researchgate.net/publication/267817047

2. Arnett E.B. and E.F. Baerwald. 2013. Impacts of wind energy development on bats: implications for conservation. In: *Bat Evolution, Ecology, and Conservation,* pp. 435-456. Springer New York.
3. Arnett, E.B., C.D. Hein, M.R. Schirmacher, M.M.P. Huso, and J.M. Szewczak. 2013. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. *PLOS ONE* **8:** e65794.
4. Arnett, E.B., M.M.P. Huso, M.R. Schirmacher, and J.P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. *Frontiers in Ecology and the Environment* **9:** 209-214.
5. Bergström, L., L. Kautsky, T. Malm, R. Rosenberg, M. Wahlberg, N.A. Capetillo, and D. Wilhelmsson. 2014. Effects of offshore wind farms on marine wildlife – a generalized impact assessment. *Environmental Research Letters* **9:** 034012.
6. Calvert, A.M., C.A. Bishop, R.D. Elliot, E.A. Krebs, T.M. Kydd, C.S. Machtans, and G.J. Robertson. 2013. A synthesis of human-related avian mortality in Canada. *Animal Conservation Ecology* **8:** 11.
7. Chamberlain, D.E., M.R. Rehfisch, A.D. Fox, M. Desholm, and S.J. Anthony. 2006. The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. *Ibis* **148:** 198–202.
8. Cryan, P.M., P. Gorresen, C.D. Hein, M.R. Schirmacher, R.H. Diehl, M.M. Huso, D.T.S. Hayman, P.D. Fricker, F.J. Bonaccorso, D.H. Johnson, K. Heist, and D.C. Dalton. 2014. Behavior of bats at wind turbines. *Proceedings of the National Academy of Sciences* 111:15126-15131.
9. Dahl, E.L., K. Bevanger, T. Nygård, E. Røskaft, and B.G. Stokke. 2012. Reduced breeding success in White-tailed Eagles at Smøla windfarm, western Norway, is caused by mortality and displacement. *Biological Conservation* **145:** 79-85.
10. Diffendorfer J.E. and R.W. Compton. 2014. Land cover and topography affect the land transformation caused by wind facilities. *PLOS ONE* **9:** e88914.
11. Erickson, W.P., M.M. Wolfe, K J. Bay, D.H. Johnson, and J.L. Gehring. 2014. A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. *PLOS ONE* **9:** e107491.
12. Frick, W.F., E.F. Baerwald, J.F. Pollock, R.M.R. Barclay, J.A. Szymanski, T.J. Weller, A. L. Russell, S.C. Loeb, R. A. Medellin, L. P. McQuire. 2017. Fatalities at wind turbines may threaten population viability of a migratory bat. *Biological Conservation* **209:** 172-177.
13. GE Energy. 2010. Western Wind and Solar Integration Study. National Renewable Energy Laboratory (NREL). Golden, CO, USA, 2010.
14. ICF International. 2013. Altamont Pass Wind Resource Area bird fatality study, bird years 2005–2011. August. M96. (ICF 00904.08.) Sacramento, CA. Prepared for Alameda County Community Development Agency, Hayward, CA.
15. Johnson, D. H., S. R. Loss, K. S. Smallwood, and W. P. Erickson. 2016. Avian fatalities at wind energy facilities in North America: a comparison of recent approaches. *Human-Wildlife Interactions* **10:** 7–18.
16. Katzner, T.E., D.M. Nelson, M.A. Braham, J.M. Doyle, N.B. Fernandez, A.E. Duerr, P.H. Bloom, M.C. Fitzpatrick, T.A. Miller, R.C.E. Culver, L. Braswell &. J.A. DeWoody. 2017. Golden eagle fatalities and the continental-scale consequences of local wind-energy generation. *Conservation Biology.* 31: 406-415.
17. LeBeau C.W., G.D. Johnson, M.J. Holloran, J.L. Beck, R.M. Nielson, M.E. Kauffman, E.J. Rodemaker, and T.L. McDonald. 2017. Greater sage-grouse habitat selection, survival, and wind energy infrastructure. *The Journal of Wildlife Management* **81:** 690-711.
18. Loss, S.R., T. Will, and P.P. Marra. 2015. Direct mortality of birds from accidental anthropogenic causes. *Annual Review of Ecology Evolution and Systematics* **46:** 99-120.
19. Love, M.S., M.M. Nishimoto, S. Clark, and A.S. Bull. 2015. Identical response of caged rock crabs (Genera Metacarcinus and Cancer) to energized and unenergized undersea power cables in Southern California, USA. *Bulletin of the Southern California Academy of Sciences*: Vol. 114: Iss. 1.
20. Lovich, J.E., and J.R. Ennen. 2017. Reptiles and amphibians. In, pp. 97-118. Perrow, M. (ed.), *Wildlife and Wind Farms: Conflicts and Solutions, Volume 1 Onshore.* Pelagic Press. Exeter, U.K.
21. New, L., E. Bjerre, B. Millsap, M.C. Otto, and M.C. Runge. 2015. A collision risk model to predict avian fatalities at wind facilities: An example using golden eagles, *Aquila chrysaetos. PLOS ONE* **10:** e0130978.
22. Schaub, M. 2012. Spatial distribution of wind turbines is crucial for the survival of red kite populations. *Biological Conservation* **155:** 111–118.

23. Shaffer, J.A. and D.A. Buhl. 2015. Effects of wind-energy facilities on breeding grassland bird distributions. *Conservation Biology* **30:** 59-71.

24. Slavik, K., C. Lemmen, W. Zhang, O. Kerimoglu, K. Klingbeil, K.W. Wirtz. 2017. The large scale impact of offshore wind farm structures on pelagic primary productivity in the southern North Sea. *Hydrobiologia*. 10.1007/s10750-018-3653-5.

25. Slawsky, L.M., L. Zhou, S.B. Roy, G. Xia, M. Vuille, and R.A. Harris. 2015. Observed thermal impacts of wind farms over northern Illinois. *Sensors (Switzerland)* **15:** 14981–15005.

26. Strickland M.D., E.B. Arnett, W.P. Erickson, D.H. Johnson, G.D. Johnson, M.L. Morrison, J.A. Shaffer, and W. Warren-Hicks. 2011. Comprehensive guide to studying wind energy/wildlife interactions. Prepared for the National Wind Coordinating Collaborative, Washington, DC.

27. Thomsen, F., K. Lüdemann, R. Kafemann, W. Piper. 2006. Effects of offshore wind farm noise on marine mammals and fish. On Behalf of COWRIE Ltd., Hamburg, Germany, 62 pp.

28. U.S. Department of Energy. 2015. *Wind Vision: A new era for wind power in the U.S.* DOE/GO-102015-4557.

29. Winder, V.L., L.B. McNew, A.J. Gregory, L.M. Hunt, S.M. Wisely, B.K. Sandercock. 2014. Space use by female Greater Prairie-Chickens in response to wind energy development. *Ecosphere* **5:** 1-17.

ACKNOWLEDGEMENTS

The authors wish to thank Susan Savitt Schwartz for her edits to this paper. We also thank Cliff Duke, Sasha Reed, Jennifer Riem, Jill Parsons, and Chelsea Fowler at the Ecological Society of America for editorial support and Mona Khalil at USGS and two anonymous reviewers for their thorough review. Jeremy Havens at USGS developed and edited the figures. We thank AWWI Partners and Friends for providing financial and logistical support. Support also came from the Land Change Science and Energy Resources Programs at USGS. The views expressed in this paper do not necessarily represent the views of the U.S. Government or any of its departments. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

ABOUT THE SCIENTISTS

Taber D. Allison, American Wind Wildlife Institute, Washington, DC 20005

Jay E. Diffendorfer, U.S. Geological Survey, Geosciences and Environmental Change Science Center, Denver, CO 80225

Erin F. Baerwald, Department of Biology, University of Regina, Regina, SK, Canada S4S 0A2

Julie A. Beston, Department of Biology, University of Wisconsin-Stout, Menomonie, WI 54751

David Drake, Russell Labs, University of Wisconsin, Madison, WI 53706

Amanda M. Hale, Biology Department, Texas Christian University, Fort Worth, TX 76129

Cris D. Hein, Bat Conservation International, Austin, TX 78716

Manuela M. Huso, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, OR 97331

Scott R. Loss, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078

Jeffrey E. Lovich, U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, AZ 86001

M. Dale Strickland, WEST, Inc., Cheyenne, WY 82001

Kathryn A. Williams, Biodiversity Research Institute, Portland, ME 04103

Virginia L. Winder, Department of Biology, Benedictine College, Atchison, KS 66002

LAYOUT

Gillian Kirkpatrick, King Graphic Design

ABOUT ISSUES IN ECOLOGY

Issues in Ecology uses commonly understood language to report the consensus of a panel of scientific experts on issues related to the environment. The text for *Issues in Ecology* is reviewed for technical content by external expert reviewers, and all reports must be approved by the Editor-in-Chief before publication. This report is a publication of the Ecological Society of America. ESA and *Issues in Ecology* editors assume no responsibility for the views expressed by the authors of this report.

ADDITIONAL COPIES

This report and all previous *Issues in Ecology* are available electronically for free at: https://www.esa.org/publications/issues/

Print copies may be ordered online or by contacting ESA:

Ecological Society of America, 1990 M Street NW, Suite 700, Washington, DC 20036

202-833-8773, esahq@esa.org

esa

ISSUES IN ECOLOGY

ECOLOGICAL SOCIETY OF AMERICA

Received: 2 May 2019 | Revised: 6 August 2019 | Accepted: 7 August 2019
DOI: 10.1002/ece3.5612

ORIGINAL RESEARCH

Ecology and Evolution Open Access WILEY

Evidence of region-wide bat population decline from long-term monitoring and Bayesian occupancy models with empirically informed priors

Thomas J. Rodhouse[1] | Rogelio M. Rodriguez[2] | Katharine M. Banner[3] | Patricia C. Ormsbee[4] | Jenny Barnett[5] | Kathryn M. Irvine[6]

[1]National Park Service and Human and Ecosystem Resiliency and Sustainability Lab, Oregon State University-Cascades, Bend, OR, USA

[2]Human and Ecosystem Resiliency and Sustainability Lab and Northwestern Bat Hub, Oregon State University-Cascades, Bend, OR, USA

[3]Department of Mathematical Sciences, Montana State University, Bozeman, MT, USA

[4]Willamette National Forest, Springfield, OR, USA

[5]Mid-Columbia River National Wildlife Refuge Complex, U.S. Fish and Wildlife Service, Burbank, WA, USA

[6]Northern Rocky Mountain Science Center, US Geological Survey, Bozeman, MT, USA

Correspondence
Thomas J. Rodhouse, National Park Service, Oregon State University-Cascades, 1500 SW Chandler Ave., Bend, OR 97702, USA.
Email: Tom_Rodhouse@nps.gov

Present address
Patricia C. Ormsbee, Human and Ecosystem Resiliency and Sustainability Lab, Oregon State University-Cascades, 1500 SW Chandler Ave., Bend, OR 97702, USA

Funding information
Oregon Department of Fish and Wildlife, Grant/Award Number: ORPIN # ODFW-2903-16; Pacific Northwest Cooperative Ecosystem Studies Unit, Grant/Award Number: P15AC01598; US National Park Service; US Fish and Wildlife Service; US Forest Service; US Bureau of Land Management; US Geological Survey

Abstract

Strategic conservation efforts for cryptic species, especially bats, are hindered by limited understanding of distribution and population trends. Integrating long-term encounter surveys with multi-season occupancy models provides a solution whereby inferences about changing occupancy probabilities and latent changes in abundance can be supported. When harnessed to a Bayesian inferential paradigm, this modeling framework offers flexibility for conservation programs that need to update prior model-based understanding about at-risk species with new data. This scenario is exemplified by a bat monitoring program in the Pacific Northwestern United States in which results from 8 years of surveys from 2003 to 2010 require updating with new data from 2016 to 2018. The new data were collected after the arrival of bat white-nose syndrome and expansion of wind power generation, stressors expected to cause population declines in at least two vulnerable species, little brown bat (*Myotis lucifugus*) and the hoary bat (*Lasiurus cinereus*). We used multi-season occupancy models with empirically informed prior distributions drawn from previous occupancy results (2003–2010) to assess evidence of contemporary decline in these two species. Empirically informed priors provided the bridge across the two monitoring periods and increased precision of parameter posterior distributions, but did not alter inferences relative to use of vague priors. We found evidence of region-wide summertime decline for the hoary bat ($\hat{\lambda}$ = 0.86 ± 0.10) since 2010, but no evidence of decline for the little brown bat ($\hat{\lambda}$ = 1.1 ± 0.10). White-nose syndrome was documented in the region in 2016 and may not yet have caused regional impact to the little brown bat. However, our discovery of hoary bat decline is consistent with the hypothesis that the longer duration and greater geographic extent of the wind energy stressor (collision and barotrauma) have impacted the species. These hypotheses can be evaluated and updated over time within our framework of pre–post impact monitoring and modeling. Our approach provides the foundation for a strategic evidence-based conservation system and contributes to a growing preponderance of evidence from multiple lines of inquiry that bat species are declining.

KEYWORDS
acoustic recording units, Chiroptera, extinction risk, monitoring, North American Bat Monitoring Program, population decline, trend, ultrasonic acoustic detectors

1 | INTRODUCTION

Evidence-based conservation of at-risk species is challenged by lack of information about population trends over time, particularly for those species that are cryptic and difficult to survey. In situations where directly counting individual organisms is infeasible, occupancy modeling of detection/nondetection survey data provides an alternative to abundance models for detecting regional-scale population declines (Jones, 2011; MacKenzie et al., 2002; Noon, Bailey, Sisk, & McKelvey, 2012). Multi-season occupancy models (e.g., MacKenzie, Nichols, Hines, Knutson, & Franklin, 2003; Royle & Kery, 2007) support inferences about changing occupancy probabilities and dynamic site turnover parameters over time. These parameters reflect changes in species distribution but are also expected to reflect the underlying latent changes in population size (Gaston et al., 2000; Holt, Gaston, & He, 2002; Zuckerberg, Porter, & Corwin, 2009) and extinction risk (Noon et al., 2012), albeit with some amount of elasticity (e.g., Kery & Royle, 2016; Royle & Kery, 2007; Steenweg, Hebblewhite, Whittington, Lukacs, & McKelvey, 2018). When harnessed to a Bayesian inferential paradigm, this modeling framework offers considerable flexibility for regional conservation monitoring programs that need to update prior model-based understanding with new data as they become available (e.g., Dorazio & Johnson, 2003; Ellison, 2004). Rather than starting anew after each cycle of data collection, model-fitting, evaluation, and inference, Bayes theorem allows for previous modeling results, in the form of posterior probability distributions, to be used as prior probability distributions that formally represent best-available understanding about model parameters (Crome, Thomas, & Moore, 1996; Hobbs & Hooten, 2015; McCarthy & Masters, 2005). With new data, this prior understanding can in turn be updated and represented as new, updated posteriors, with an expectation that clarity about population distribution and abundance, in the form of precision, will increase over time (Morris, Vesk, McCarthy, Bunyavejchewin, & Baker, 2015). In this way, the empirically informative Bayesian inferential paradigm, when harnessed to replicate geographically extensive large-sample encounter surveys, provides a way to “scaffold”, or build upon, prior knowledge to improve conservation decision-making.

This scenario is exemplified by a bat monitoring program in an ~440,000 km^2 region of the Pacific Northwestern United States (Figure 1) in which the occupancy modeling results from 8 years of monitoring, which ended in 2010 (Rodhouse et al., 2012, 2015), require updating with new survey data gathered during 2016–2018 for contribution to the North American Bat Monitoring Program (NABat; Loeb et al., 2015). There is urgency to this opportunity to scaffold upon prior information because bat populations in the region are facing potentially catastrophic declines (e.g., O'Shea, Cryan, Hayman, Plowright, & Streicker, 2016) from the recent arrival of the bat disease white-nose syndrome (Lorch et al., 2016) and the rapidly expanding footprint of the wind power industry (Arnett et al., 2016). The cumulative impacts by these novel threats are likely exacerbated by accelerated environmental changes (Jones, Jacobs, Kunz, Willig, & Racey, 2009; Jung & Threlfall, 2016), including global entomofauna die-off (Sanchez-Bayo & Wyckhus, 2019), which is particularly worrisome given that the majority of North American bat species are insectivorous. In general, there is a global paucity of empirical knowledge about bat population trends and fewer still that evaluate trends over broad regions and long time periods (Jones et al., 2009). But there is growing evidence that many species are experiencing evolutionarily unprecedented, massive declines (O'Shea et al., 2016). Our emphasis on geographically extensive regional inference is noteworthy because bats are so vagile that a local-scale decline, for example one detected within a small national park, is difficult to interpret and use to motivate conservation without broader context (e.g., via replication elsewhere).

Here, we ask whether there is evidence of regional summertime decline in the northwestern United States after three additional years of surveys for two vulnerable species, the little brown bat (*Myotis lucifugus*) and the hoary bat (*Lasiurus cinereus*). We focus on the little brown bat because it has been listed as threatened in Canada (Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2013) and considered for similar protection in the United States (Federal Register, 2015) following precipitous declines in eastern North America from white-nose syndrome (Dzal, McGuire, Veselka, & Fenton, 2011; Frick et al., 2010) and because the disease was first confirmed in the northwestern portion of our study region (Figure 1) in 2016 from a dead little brown bat (Lorch et al., 2016). We focus on the hoary bat because it is the most frequently encountered species in carcass recoveries at wind power generation facilities in many regions of North America and thought to be at risk of widespread decline (Arnett et al., 2016; Cryan & Barclay, 2009; Frick et al., 2017). We build upon the same dynamic occupancy model used by Rodhouse et al., (2015) and use their 2010 posterior estimates to create empirically informed priors as a way to formally incorporate best-available information about occupancy parameters into an updated assessment of decline.

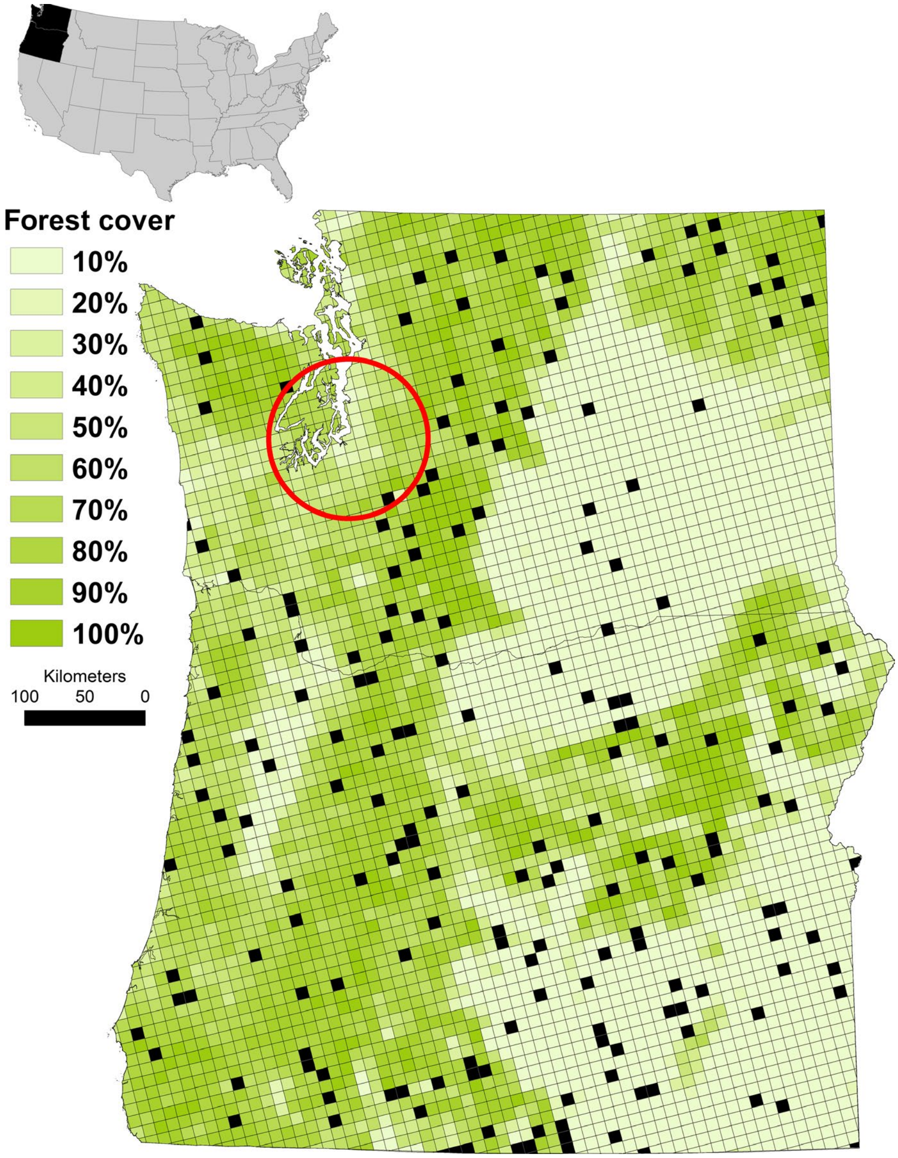


FIGURE 1 The study area, Oregon and Washington, USA, overlaid with the grid-based sampling frame, average % forest cover of each frame sample unit (grid cell), and the 190 sample units surveyed during 2016–2018 (black squares) that follow a spatially balanced master sample design. The area where white-nose syndrome has been confirmed circa 2019 is circled in red

2 | METHODS

2.1 | Study area and biogeographic gradients

We monitored bats during summer (June–September) via coordinated acoustic surveys across Oregon and Washington states, in the northwestern region of the United States (Figure 1). The region is divided in half by the north–south trending Cascade Range that creates a distinct rain shadow over the eastern half of the region and a west-to-east forest cover gradient that is a dominant biogeographic influence on bats (Figure 1). The forest cover gradient in the region is strongly correlated with net primary productivity (ρ = 0.7) and moderately so with precipitation and elevation (Rodhouse et al., 2012, 2015). The little brown bat and hoary bat range widely across the region and are found in all habitat types but are associated with forested landscapes more than nonforested shrub steppe (Hayes, 2003; Kalcounis-Rüppell, Psyllakis, & Brigham, 2005; Rodhouse et al., 2015). Forests and also topographic roughness (*SD* of elevation) provide the keystone structures (sensu Tews et al., 2004; e.g., live and dead standing trees, crevices in large cliffs) used by bats for summer and winter roosting that are additional biogeographic drivers of bat distributional patterns in the region (Humphrey, 1975; Pierson, 1998; Rodhouse et al., 2015). Forest cover (% of sample unit classified as any forest type), elevation (sample unit mean), 30-year mean annual precipitation (sample unit mean), and topographic roughness (*SD* of sample unit elevation) were included as occupancy model covariates both during initial modeling by Rodhouse et al., (2015) and in the present study.

2.2 | Study survey design

Our study protocol is described in detail by Rodriguez et al. (2019). We used a grid-based sampling frame of 100-km^2 square cells mapped across the study area to structure surveys and analyses (Figure 1). In 2003–2010 (Period 1), a combination of capture and acoustic surveys was conducted across the region in 241 grid cells (see Rodhouse et al., 2015, p. 1404). In 2016–2018 (Period 2), acoustic surveys were conducted in 190 grid cells, informed by a statistical power analysis (Banner, Irvine, Rodhouse, Donner, & Litt, 2019; Figure 1). During Period 1, grid cells were selected using a combination of constrained simple random sampling and nonrandom contributions from land management agencies and researchers using compatible methodology (see Rodhouse et al., 2015 for additional details). During Period 2, grid cells were selected using the NABat spatially balanced (via the Generalized Random Tessellation Stratified design; Rodhouse et al., 2012; Rodhouse, Vierling, & Irvine, 2011; Stevens & Olsen, 2004) randomized master sample (Larsen, Olsen, & Stevens, 2008; Loeb et al., 2015). Approximately 80% (n = 155) of the 190 grid cells surveyed during Period 2 were chosen following the spatially balanced order of the master sample. Twenty per cent were chosen from the Period 1 legacy sample in order to provide spatio-temporal overlap between the two periods. This was less than the rule-of-thumb threshold suggested by Irvine, Rodhouse, Wright, and Olsen (2018) that, if exceeded, would require a more complex likelihood weighting in subsequent modeling in order to mitigate for an unrepresentative sample. This large (n = 190) and spatially balanced random sample is representative of the region of interest and supports robust scope of inference.

Spatially replicated within-season (June–September) single-night surveys were conducted in grid cells. Multiple-night replicates were avoided in order to maintain backward compatibility with the Period 1 revisit design and because Wright, Irvine, and Rodhouse (2016; and others, see Hayes, 1997) found evidence of serial correlation suggesting a lack of independence in bat activity among consecutive nights. Numbers of within-season revisits ranged from 1 to 12 per season in Period 1 and were standardized to four visits during Period 2. Surveys during Period 1 consisted of mist net capturing and/or recording of bats with Pettersson D240x and D500x ultrasonic detectors (Pettersson Elektronik) along watercourses. Survey method was included as a detection model covariate during initial modeling by Rodhouse et al. (2015). Period 2 surveys were conducted only by recording bats with Pettersson D500x ultrasonic detectors. Duration of surveys varied during Period 1 from 2 hr to overnight, but lasted all night during Period 2. Duration was included as a detection model covariate for the Period 1 model. Survey date was included as a detection model covariate for both periods. Species identification methods from captures and bat call recordings used during Period 1 were described in detail by Rodhouse et al., (2015), but included the use of version 3 of the Sonobat software program (Sonobat; https://sonobat.com/) to process and assign call files to species and ad hoc manual verification by a single expert (J. Szewczak). During survey Period 2, all call files were processed and assigned to species using version 4 of Sonobat and also verified manually by a single expert (R. Rodriguez) but that followed the REMOVE workflow strategy outlined by Banner et al. (2018, p. 6147) to remove all false-positive identification error from the data set prior to analysis so that the standard (false-negative only) occupancy model could be used. Manual verification was conducted specifically to eliminate false-positive errors by carefully examining highest-quality call files used to make species detection decisions from each survey (e.g., focusing only on the few decision-pivotal call files per species per survey night). Only the unambiguous call files assigned to little brown bat and hoary bats were used as evidence for detection. This REMOVE verification strategy is inherently conservative and elevates false-negative error but our false-negative errors (detection probabilities) were still acceptable (>40%, see Section 3) to obtain unbiased occurrence model parameter estimates.

2.3 | Statistical analysis

We analyzed survey data from Period 2 only, using the results (specifically the estimated posterior mean and precision from occupancy model parameters) from Period 1 to construct empirically informative priors. Detection history matrices containing 190 rows and 12 columns (four single-night visits per season) were constructed for Period 2, with matrix elements assigned a 1 for unambiguous detection or 0 otherwise. We used the same autoregressive multi-season occupancy model (Royle & Dorazio, 2008) for Period 2 as for Period 1 presented by Rodhouse et al., (2012, 2015). Drawing on the Royle and Dorazio, (2008) autoregressive parameterization of the dynamic occupancy model, the initial occupancy state $z(i,t)$ for sample unit (grid cell) i in the first year (t = 1) of sampling was modeled as.

$z(i,1) \sim \text{Bernoulli}(\Psi_{1i})$ for $i = 1,\ldots, n$, with $\text{logit}(\Psi_{1i}) = \beta_0 + \beta_1\text{ForestCover}_i + \beta_2\text{Elevation}_i + \beta_3\text{Precipitation}_i + \beta_4\text{Topographic Roughness}_i$. Subsequent survey years ($z[i,t]$ for t = 2 and 3) were modeled conditional on the previous state, $z(i,t)|z(i,t-1) \sim \text{Bernoulli}\{\pi_{ti}\}$, with $\text{logit}(\pi_{ti}) = a_t + b_t\, z(i,t-1) + \beta_1\text{ForestCover}_i + \beta_2\text{Elevation}_i + \beta_3\text{Precipitation}_i + \beta_4\text{Topographic Roughness}_i$. The four environmental covariates were mean-centered and standardized for computational efficiency and so that interpretation of derived parameters could be made at average environmental conditions (i.e., when coefficients were 0). The derived parameters $\phi_t = \text{logit}^{-1}(a_t + b_t)$ represented the probability of a unit remaining occupied by a species (e.g., survival) and $\gamma_t = \text{logit}^{-1}(a_t)$ the probability of a unit becoming newly occupied (e.g., colonization) for each given time step (t−1 to t). The occupancy probabilities in years $t = 2,\ldots,T$ were calculated recursively as $\Psi_t = \Psi_{t-1}\phi_t + (1 - \Psi_{t-1})\gamma_t$. We used the total unit occurrence growth rate over Period 2, $\lambda = \Psi_{2018}/\Psi_{2016}$, as our trend metric. Given mean-centering of covariates, λ is interpreted as an overall region-wide measure of net decline. Exploration of how derived parameter values vary along the environmental gradients could be accomplished by plugging in different covariate values (i.e., at high and low elevations), which we do by obtaining posterior distributions of $\Psi_{2018,i}$ for each of the 4,500 grid cells in the study region and mapping posterior means to show an updated species distribution map of region-wide occurrence probabilities for comparison with the 2010 map. We used a simpler detection model than Rodhouse et al. (2015), including survey date as a covariate but no additional covariates for method and duration, given the survey design standardization of those two variables during Period 2, where $y_j(i,t) \mid z(i,t) \sim \text{Bernoulli}\ \{p_{i,t}{}^* z(i,t)\}$and $\text{logit}(p_{i,t}) = \alpha_0 + \alpha_1\text{date}_{i,t}$.

TABLE 1 Posterior distribution means and standard deviations from Period 1 (2010) used as empirically informed priors for Period 2 (2016–2018) models

Parameters	Little brown bat	Hoary bat
β_0	3.53 ± 1.62	0.15 ± 1.15
α	0.14 ± 1.57	−0.68 ± 1.52
β	3.49 ± 1.76	4.32 ± 1.94
$\beta_{\text{elevation}}$	−0.29 ± 0.27	−0.52 ± 0.29
$\beta_{\text{precipitation}}$	1.59 ± 0.97	−0.41 ± 0.30
$\beta_{\text{topographic roughness}}$	0.00 ± 0.29	−0.08 ± 0.21
β_{forest}	0.46 ± 0.34	0.64 ± 0.26

Given the differences in the survey methodology and call processing and species identification workflow, we only used vague Normal(0,10) priors for detection-level parameters, effectively fitting our detection model without prior knowledge (i.e., from "scratch"). We used independent, empirically informed priors on the occupancy-level parameters [$\boldsymbol{\beta}$, a_t, b_t]. Informative priors were specified as Normal distributions with mean and standard deviation based on the posterior distributions estimated from the final year (2010) of Period 1 models provided by Rodhouse et al., (2015; Table 1). We compared our results with the same model but where vague priors (Normal[0,10]) were used instead. Vague priors, also referred to as uninformative or weakly informative priors (Northrup & Gerber, 2018), are regularizing priors (Gelman, Simpson, & Betancourt, 2017) that stabilize the posterior distributions for parameters {$\boldsymbol{\beta}$, a_{t-1}, b_{t-1}} within a reasonable range on the logit scale but do not represent any substantive knowledge about their values a priori.

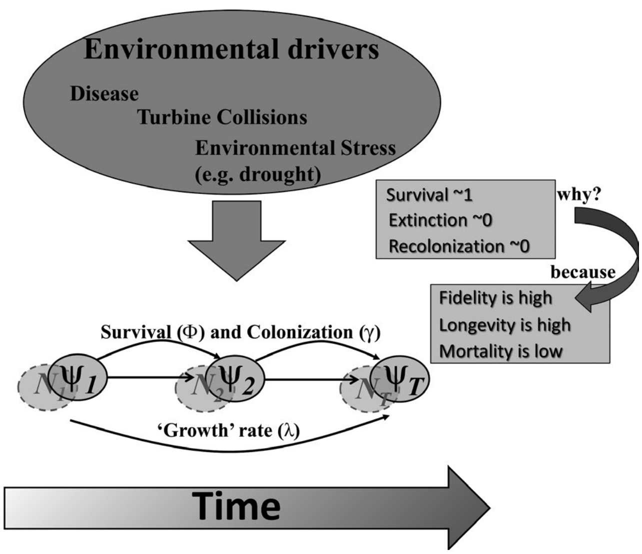


FIGURE 2 Conceptual diagram of occurrence state change (superimposed over latent abundance *N*) over time as a function of survival, recolonization, and extinction of sample unit occurrences from 1 year to the next. The net result of change can be characterized by the occurrence growth rate λ. The diagram outlines (right) hypothesized expectations for background rates of these parameters, drawing on knowledge of temperate-zone bat life history strategies, but suggests extrinsic environmental drivers (e.g., disease, top of diagram) may alter these background rates, elevating adult bat mortality rates

In Figure 2, we conceptualize this model parameterization as hypothesized inter-annual change in occurrence states (and in latent abundance), as a conditional Markov process governed by the dynamic rate parameters of sample unit occurrence survival (ϕ) and recolonization (γ), summarized by λ. We expect the background rates for these dynamic parameters to be stable and near 1 for ϕ and near 0 for γ because of the slow life history strategies of bats (low fecundity, adult longevity, and low adult mortality; Barclay & Harder, 2003; O'Shea et al., 2016; Promislow & Harvey, 1990) and high site fidelity (e.g., Barclay & Brigham, 2001; Lewis, 1995). We expect that novel extrinsic factors, particularly white-nose syndrome (for little brown bat) and widespread wind energy development and associated collision and barotrauma (for hoary bat) will influence those dynamic rate parameters (O'Shea et al., 2016), reflected in declining $\hat{\psi}$ and $\hat{\lambda} < 1$.

We used OpenBUGS 3.2.3 (Lunn, Spiegelhalter, Thomas, & Best, 2009), launched from R 3.5.1 (R Core Team, 2018) with the R2OpenBUGS library (Sturtz, Ligges, & Gelman, 2005) to implement Bayesian estimation of model parameters via Markov chain Monte Carlo (MCMC) samples from posterior distributions. Posterior summaries were based on 10,000 MCMC samples of the posterior distributions from three chains run simultaneously, thinned by a factor of 3, following an initial burn-in of 5,000 MCMC iterations. We assessed convergence of MCMC chains with trace plots and the Gelman-Rubin diagnostic,; convergence was reached for all parameters according to the criteria $|\hat{R}-1|<0.1$. We evaluated prior sensitivity by comparing inference and by examining vague and informative prior and posterior density plots. We evaluated model predictive performance with posterior summaries of the area under the curve of the receiver operating characteristic (AUC; Zipkin, Campbell Grant, & Fagan, 2012) and compare against summaries provided by Rodhouse et al., (2015). We evaluated evidence of residual spatial autocorrelation by estimating the Moran's *I* statistic for the occupancy residuals (Wright, Irvine, & Higgs, 2019) at distance thresholds from 10 km (adjacent neighbors) to 50 km. Our spatially balanced master sample design reduced spatial proximity of sample units, and we found no evidence of autocorrelation.

3 | RESULTS

Our results provide evidence of decline in net summertime regional hoary bat occurrence probability during 2016–2018 relative to 2010 (Figure 3a) but no evidence of decline for the little brown bat (Figure 3b). These conclusions were supported by both the empirically informed and vague priors models (Figures 3 and 4). Choice of prior did not influence overall conclusions for trend although empirically informed priors provided more precise estimates (posterior probabilities with narrower 95% credible intervals; Figures 3 and 4) and therefore strengthened evidence of hoary bat decline. Estimates of trend ($\hat{\lambda}$) during 2016–2018 for hoary bat was

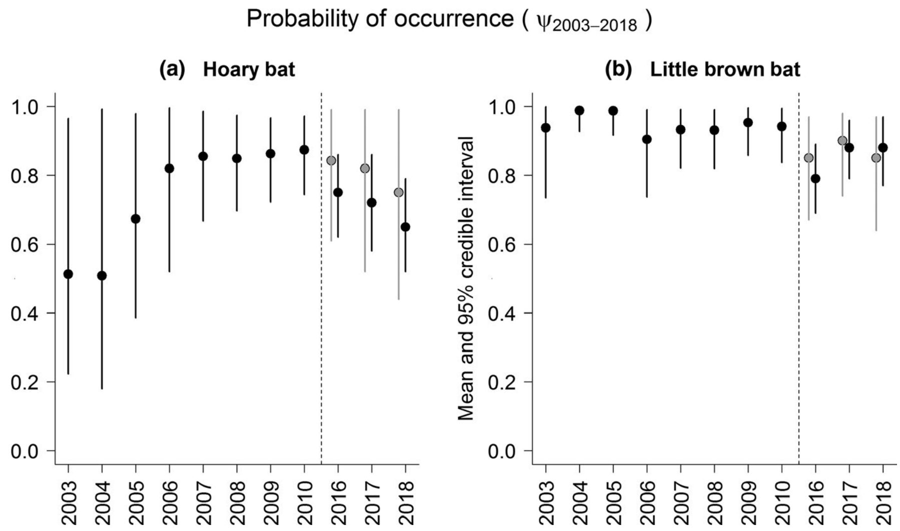


FIGURE 3 Posterior mean and 95% credible intervals for $\hat{\psi}$ from models fit to (a) hoary bat (*Lasiurus cinereus*) and (b) little brown bat (*Myotis lucifugus*) survey data. Comparisons are made for 2016–2018 between vague priors (gray) and empirically informative priors (black)

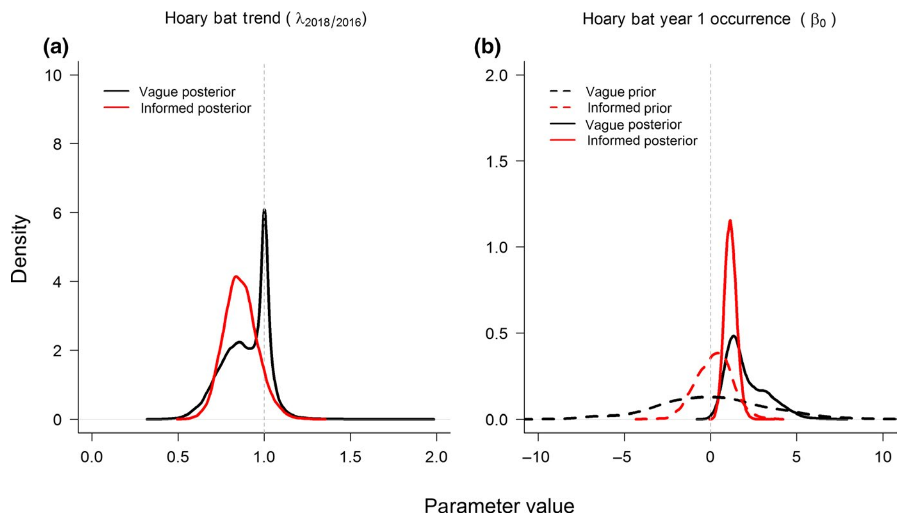


FIGURE 4 Comparison of empirically informed (red) and vaguely informed (black) priors and posteriors for hoary bat (left, a) trend and (right, b) year 1 occurrence probability (intercept parameter, logit scale; see Section 2 for auto-logistic parameterization and use of Normal priors)

0.86 ± 0.10 (0.89 ± 0.12 when vague priors were used; Figure 4a), an average annual rate of decline since 2010, manifesting a ≈2%/year decline in net occurrence probability (i.e., from $\hat{\psi}_{2010}$ = 0.87 to $\hat{\psi}_{2018}$ = 0.65), and $\hat{\lambda}$ = 1.1 ± 0.10 (1.01 ± 0.10 when vague priors were used) for little brown bat. Detection probabilities were stable among years within each period but increased from ~25% for both species in Period 1 (see Rodhouse et al., 2015) to ~40% for hoary bat and ~50% for little brown bat in Period 2.

Mapped hoary bat occurrence predictions illustrated the overall net decline in the region for this species between 2010 and 2018 (Figure 5). Predictive performance of the 2018 hoary bat occurrence probability model, as measured by AUC posterior summary, was 0.80 (95% credible interval 0.74–0.86), an improvement over the 2010 predictions (AUC = 0.75) achieved by Rodhouse et al. (2015). For reference, we overlaid published wind turbine locations (Hoen et al., 2018) on our hoary bat occurrence probability maps which showed that development has not substantially increased since 2010 and that development is concentrated in the center of the study region along the breaks of the Columbia River along the Oregon/Washington border (Figure 5). We did not update predictive maps for little brown bat given the evidence of no change since 2010 in occurrence probability (flat trend; Figure 3b and λ ~ 1).

Inferences on the effect sizes of the environmental covariates forest cover, elevation, precipitation, and topographic roughness did not vary for either species in direction and magnitude between Period 1 and Period 2 nor between vague and empirically informed prior models (Appendix S1). However, precision of estimated effect sizes increased when informative priors were used, strengthening the influence of forest cover on hoary bat occurrence. Strength of evidence for the positive influence of precipitation on little brown bat occurrence also increased in Period 2, illustrated by the right shift along the *x* axis in Appendix S1 (Figure S2d).

4 | DISCUSSION

We found evidence of decline for the summertime hoary bat population in the Pacific Northwest over the period 2003–2018, most notably since ~2007, but no evidence of decline during the same time period for the little brown bat. White-nose syndrome was first

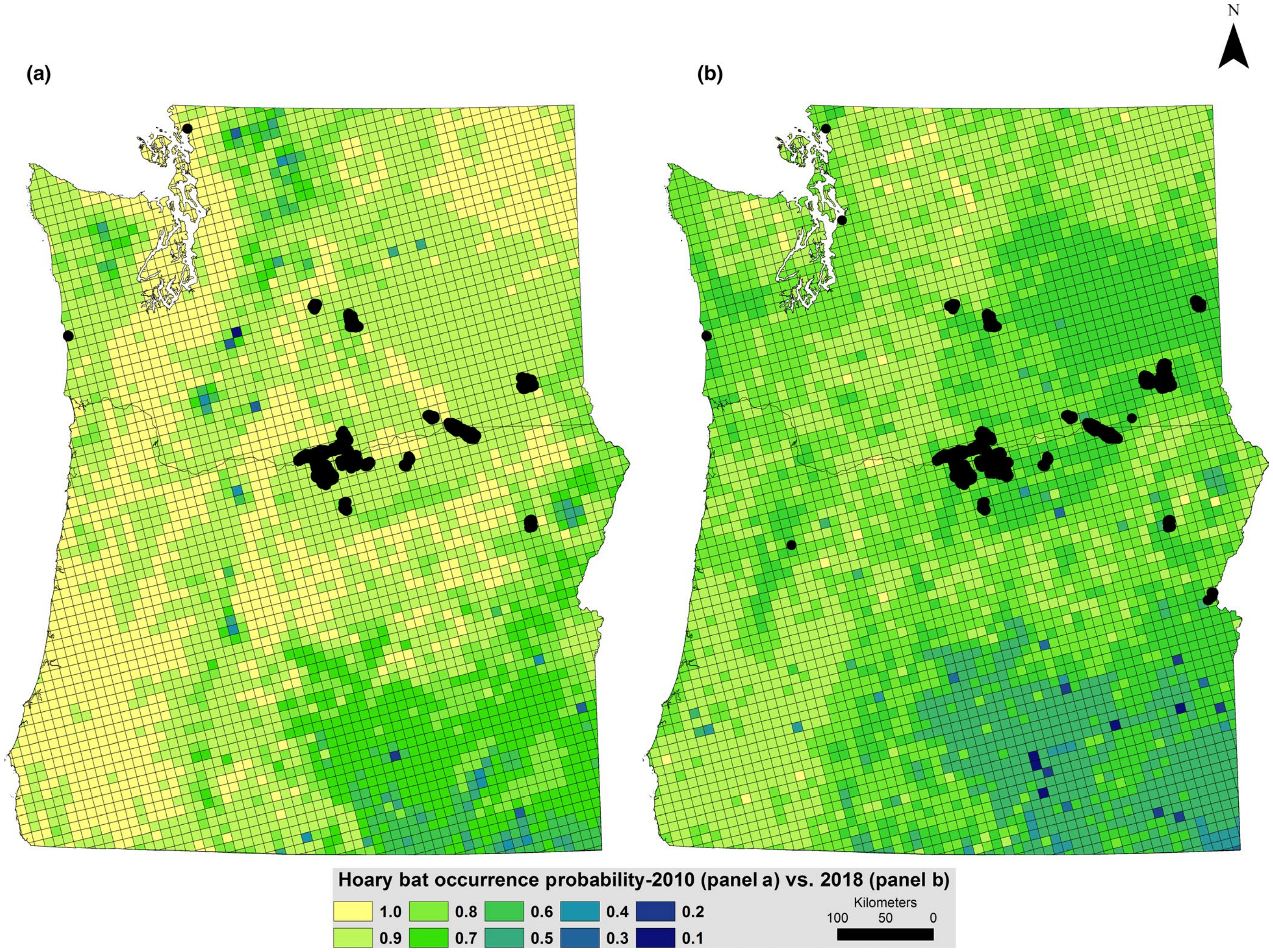


FIGURE 5 Comparative maps of 2010 (a, modified from Rodhouse et al., 2015) and 2018 (b) hoary bat predicted occurrence probabilities ($\hat{\psi}_i$). Wind energy turbines (Hoen et al., 2018) are shown with black symbols circa 2010 in (a) and circa 2018 in (b). cf. with continent-wide wind energy facility distribution at https://eerscmap.usgs.gov/uswtdb/ and also the Hayes et al. (2015) overlay of continental hoary bat seasonal migration distribution maps and wind facility distribution circa 2015

reported in the region in 2016 but has not yet resulted in widespread regional impact to the little brown bat as has occurred in eastern North America (Frick et al., 2015). At the time of data collection (2016–2018), reports of the disease within our study region had not yet spread outside of the Puget Sound region of NW Washington and had not yet been reported in surrounding states (Idaho, Montana, Nevada, California). Wind energy development, however, is much more extensive in western North America (although not conspicuously so within our study region relative to other regions of North America; cf. Figure 5 and Hayes, Cryan, & Wunder, 2015) and is likely to have caused many hoary bat fatalities over a longer period of time (e.g., since ~2000; Arnett et al., 2016; O'Shea et al., 2016). We emphasize that model uncertainty (e.g., wide credible intervals in early years of study), bat longevity, a 5-year gap in monitoring between Period 1 and Period 2, and only 3 years of additional data in Period 2 make these findings best considered as provisional evidence of decline that can guide conservation decisions, including the motivation to continue to allocate resources for further research and monitoring. However, given the laxity (curvature) in the occupancy–abundance relationship, evaluating population decline with occupancy models is inherently conservative, and our finding of hoary bat decline is alarming. Compelling empirical evidence of regional and range-wide bat decline is difficult to obtain and rarely reported, and our study is unique in geographic and temporal extent, with evident implications for potential hoary bat extirpation risk proposed by Frick et al. (2017) if our observed hoary bat trend continues. Likewise, if WNS continues to spread throughout the region and exhibit the same levels of morbidity as has been reported from eastern North America then our monitoring and modeling framework, with many years of pre-WNS prior information now available, provides the foundation for evaluating post-WNS host population impacts as a replicated before–after impact study.

The evidence for hoary bat population decline and for species–environment relationships (i.e., hoary bats and forest cover and little brown bats and precipitation) provided by our study was strengthened when empirically informed priors were used. This is consistent with previous applications of informative priors to ecological research (e.g., Morris et al., 2015), and our study contributes a new demonstration of the utility of using informative priors to gain efficiencies in long-term studies and monitoring. Historically, concerns were raised about the subjectivity and potential biases of using informative priors in Bayesian analyses that exerted too much influence on posterior distributions (e.g., Dennis, 1996), but with contemporary computing power, it has become straightforward to examine the influences of prior specification strategies (e.g., Dorazio & Johnson, 2003; Morris et al., 2015; Northrup & Gerber, 2018). Informative priors increase effective sample size (e.g., Hobbs & Hooten, 2015; McCarthy et al., 2005), and in our study, this benefit was realized by spanning the gap in data collection between 2010 and 2016. Data gaps are a common challenge for long-term studies, and the improved ability to span gaps will be appealing to monitoring practitioners.

The overlay of wind turbine locations on our predictive hoary bat occurrence maps revealed that turbine density has not increased greatly over the course of study and, in general, is not very extensive relative to other regions of the country (cf. https://eerscmap.usgs.gov/uswtdb/viewer/). Hoary bat migration patterns are still not well described, and it remains unclear where the hoary bats that occur in our study region during summer monitoring are being killed (Cryan, 2003; Cryan & Brown, 2007; Hayes et al., 2015). Cryan (2003) and Hayes et al. (2015) developed maps of seasonal hoary bat occurrence patterns that suggest bats that occur in our region during summer could spend winters in and migrate through regions where turbine densities are much higher, offering a possible explanation for decline in the Northwestern United States. Although available evidence supports the working hypothesis that regional hoary bat decline is likely caused by elevated adult mortality from turbine collisions and barotrauma during fall migration, our results reflect net cumulative impacts, and a limitation of our study is the imprecision with which stressor impacts can be ascribed. In part, one solution to this limitation is to strive for broader regional and range-wide replication of coordinated monitoring as advocated via NABat by Loeb et al. (2015) and using the modeling framework demonstrated here. A second solution will be to close the information gap about bat migration and other bat natural history using novel methods such as transmitter suturing developed by Castle, Weller, Cryan, Hein, and Schirmacher (2015) that has revealed long-distance movements of hoary bats (Weller et al., 2016). A third solution will be to integrate geographically extensive coordinated acoustic surveys into a conservation information system that draws on multiple lines of evidence.

Toward this third solution, we envision that our monitoring and modeling approach can provide the base of a strategic conservation information system "pyramid" (Figure 6), as has been done similarly through the integration of focal apex sites and broad-scale occupancy modeling by the Amphibian and Reptile Monitoring Initiative (see https://armi.usgs.gov/program_design.php). Figure 6 illustrates the inherent trade-offs in surveying across geographic extents with large sample sizes and depth of information content from more focused intensive study that can be ameliorated through strategic

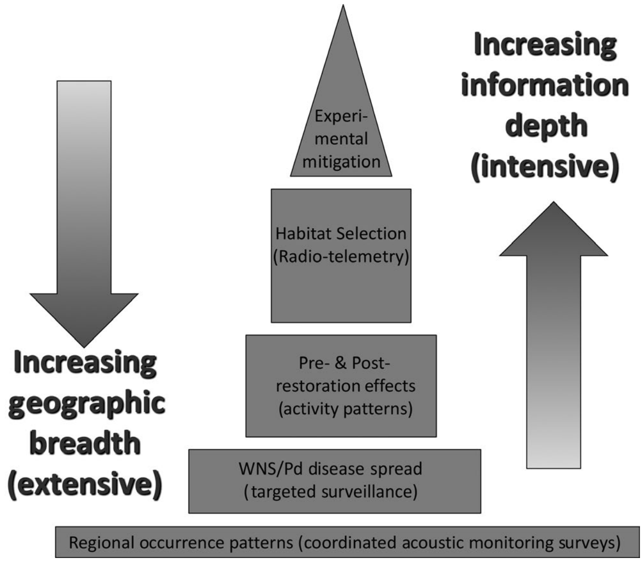


FIGURE 6 Conceptual diagram of an information pyramid that describes the inherent trade-off between geographic extent and informational intensity of monitoring and supporting research that can be integrated into a rich model-based information system for guiding evidence-based bat conservation. Our geographically extensive monitoring from coordinated acoustic surveys and modeling of those data provides a robust "base" of the pyramid that can help identify when and where targeted and more informationally deep studies can be effective. Intensive local-scale studies have been integrated into our grid-based monitoring framework to simultaneously pursue local and regional objectives

integration. For example, with respect to apparent hoary bat decline, our study, as a fundamental baseline, could be a catalyst for increased mitigation of wind turbine collisions via curtailment at low wind speed (Arnett, Huso, Schirmacher, & Hayes, 2011) and other actions (e.g., acoustic deterrence, Arnett, Hein, Schirmacher, Huso, & Szewczak, 2013). If done in a strategic manner (e.g., using experimental design), this can become a way to inform collective learning and adaptive management (Hayes et al., 2019). As another example, studies of the effects of forest thinning for forest fire fuels reduction on bats in the region's national parks (A. Chung-MacCoubrey and S. Mohren, National Park Service, personal communication) have been nested within NABat grid cells, creating an opportunity for data collected during more-informative but geographically less-extensive focal studies to contribute simultaneously to our periodic region-wide trend assessments. It is in this way that the coarse-grained grid-based NABat monitoring can become relevant at local-scales, building bottom-up engagement for a regional conservation program that requires top-down coordination.

For the present study, region-wide net hoary bat decline was hypothesized to be the result of fatalities at wind energy facilities outside the study region and during autumn (see Figure 4 in Hayes et al., 2015) unobserved by our study. We did not consider whether hoary bat occurrence trend over time might also co-vary over space along, for example, forest cover or elevation gradients, but our framework could support pursuit of these questions, particularly if the energy facility footprint expands in the region along these environmental gradients (e.g., if predominantly in open agricultural and steppe landscapes) and compelling hypotheses about spatial variation in hoary bat decline are articulated. However, we find it more tangible at present that if WNS impacts on the little brown bat population become more widespread (i.e., from carcass recoveries throughout the region), a plausible hypothesis of an interaction between precipitation and little brown bat decline could be proposed because the disease has been reported to occur along precipitation and humidity gradients in eastern North America (Langwig et al., 2012) and our region has strong moisture gradients that may strongly influence disease spread and morbidity. This hypothesis could be evaluated with our empirical monitoring-data-model framework via inclusion of an interaction between the precipitation covariate (and other relevant covariates) and the dynamics of colonization and survival as $b_t{}^*z(i,t-1) + \beta_3\text{Precipitation}_i + \beta_5\text{Precipitation}_i{}^*z(i,t-1)$ (Royle & Dorazio, 2008).

In conclusion, empirically informed Bayesian modeling, fueled by large monitoring datasets that accumulate over time and that are underpinned by a robust survey design (e.g., our NABat spatially balanced master sample) provides a powerful and flexible foundation for building an adaptive, evidence-based conservation information system. The long-standing logistical challenges associated with studying bats that preclude directly estimating bat population sizes and demographic rates require the kinds of solutions that we demonstrate and discuss. Multiple lines of evidence, even if indirect, will be required to triangulate toward answers about the status and trends of bat populations.

ACKNOWLEDGMENTS

This work was jointly funded by the Oregon Department of Fish and Wildlife, US National Park Service, US Fish and Wildlife Service, US Forest Service, and US Bureau of Land Management via an Oregon State Wildlife Grant (ORPIN # ODFW-2903-16) and Pacific Northwest Cooperative Ecosystem Studies Unit task agreement P15AC01598. K. Banner and K. Irvine provided additional funding for by the US Geological Survey. M. Shinderman, S. Reif, J. Chapman, K. Van Norman, M. Verant, D. Louie, A. Chung-MacCoubrey, and K. Kilbride provided support and guidance on project administration, study design, and interpretation of results for land managers. B. Reichert provided guidance on study integration with the North American Bat Monitoring Program and provided helpful feedback on conceptual diagrams and manuscript content. J. Szewzcak provided input on call processing workflow. T. Chestnut organized local field work at national parks in Washington. D. Popp provided GIS support. T. Hawkins, E. Beuttenmuller, and multiple additional individuals from Oregon State University-Cascades Northwestern Bat Hub, Oregon Department of Fish and Wildlife, US National Park Service, US Fish and Wildlife Service, US Forest Service, US Bureau of Land Management, and The Nature Conservancy assisted with field data collection and data management. M. Verant and two anonymous reviewers provided helpful comments that improved the quality of the manuscript. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

CONFLICT OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

TJR, RMR, PCO, JB, and KMI designed and implemented the study. RMR coordinated region-wide data acquisition. TJR conducted the modeling and KMB and KMI reviewed statistical procedures. TJR drafted the manuscript. All authors contributed to and edited the manuscript.

DATA AVAILABILITY STATEMENT

The dataset and corresponding BUGS modeling code are archived on the National Park Service Integrated Resource Management Applications (IRMA) portal at: https://irma.nps.gov/DataStore/Reference/Profile/2264920.

ORCID

Thomas J. Rodhouse https://orcid.org/0000-0001-5953-9113
Katharine M. Banner https://orcid.org/0000-0002-7103-0042
Kathryn M. Irvine https://orcid.org/0000-0002-6426-940X

REFERENCES

Arnett, E. B., Baerwald, E. F., Mathews, F., Rodrigues, L., Rodriguez-Duran, A., Rydell, J., … Voigt, C. C. (2016). Impacts of wind energy development on bats: A global perspective. In C. C. Voigt & T. Kingston (Eds.), *Bats in the anthropocene: Conservation of bats in a changing world*. Basel, Switzerland: Springer International.

Arnett, E. B., Hein, C. D., Schirmacher, M. R., Huso, M. M. P., & Szewczak, J. M. (2013). Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. *PLoS ONE*, *8*, e65794.

Arnett, E. B., Huso, M. M. P., Schirmacher, M. R., & Hayes, J. P. (2011). Altering turbine speed reduces bat mortality at wind-energy facilities. *Frontiers in Ecology and Evolution*, *9*, 209–214. https://doi.org/10.1890/100103

Banner, K. M., Irvine, K. M., Rodhouse, T. J., Donner, D., & Litt, A. R. (2019). Statistical power of dynamic occupancy models to identify temporal change: Informing the North American Bat Monitoring Program. *Ecological Indicators*, *105*, 166–176. https://doi.org/10.1016/j.ecolind.2019.05.047

Banner, K. M., Irvine, K. M., Rodhouse, T. J., Wright, W. J., Rodriguez, R. M., & Litt, A. R. (2018). Improving geographically-extensive acoustic survey designs for modeling species occurrence with imperfect detection and misidentification. *Ecology and Evolution*, *8*, 6144–6156. https://doi.org/10.1002/ece3.4162

Barclay, R. M. R., & Brigham, R. M. (2001). Year-to-year reuse of tree-roosts by California bats (*Myotis californicus*) in southern British

Columbia. *The American Midland Naturalist*, *146*, 80–85. https://doi.org/10.1674/0003-0031(2001)146[0080:YTYROT]2.0.CO;2

Barclay, R. M. R., & Harder, L. D. (2003). Life histories of bats: Life in the slow lane. In T. H. Kunz & M. B. Fenton (Eds.), *Bat ecology*. Chicago, IL: University of Chicago Press.

Castle, K. T., Weller, T. J., Cryan, P. N., Hein, C. D., & Schirmacher, M. R. (2015). Using sutures to attach miniature tracking tags to small bats for multimonth movement and behavioural studies. *Ecology and Evolution*, *5*, 2980–2989.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (2013). *COSEWIC assessment and status report on the little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) and tri-colored bat (*Perimyotis subflavus*) in Canada*. Ottawa, ON: Committee on the Status of Endangered Wildlife in Canada.

Crome, F. H. J., Thomas, M. R., & Moore, L. A. (1996). A novel Bayesian approach to assessing impacts of rain forest logging. *Ecological Applications*, *6*, 1104–1123. https://doi.org/10.2307/2269595

Cryan, P. M. (2003). Seasonal distribution of migratory tree bats (*Lasiurus* and *Lasionycteris*) in North America. *Journal of Mammalogy*, *84*, 579–593. https://doi.org/10.1644/1545-1542(2003)084<0579:SDOMTB>2.0.CO;2

Cryan, P. M., & Barclay, R. M. R. (2009). Causes of bat fatalities at wind turbines: Hypotheses and predictions. *Journal of Mammalogy*, *90*, 1330–1340. https://doi.org/10.1644/09-MAMM-S-076R1.1

Cryan, P. M., & Brown, A. C. (2007). Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. *Biological Conservation*, *139*, 1–11. https://doi.org/10.1016/j.biocon.2007.05.019

Dennis, B. (1996). Discussion: Should ecologists become Bayesians? *Ecological Applications*, *6*, 1095–1103. https://doi.org/10.2307/2269594

Dorazio, R. M., & Johnson, F. A. (2003). Bayesian inference and decision theory – A framework for decision making in natural resource management. *Ecological Applications*, *13*, 556–563. https://doi.org/10.1890/1051-0761(2003)013[0556:BIADTA]2.0.CO;2

Dzal, Y., McGuire, L. P., Veselka, N., & Fenton, M. B. (2011). Going, going, gone: The impact of white-nose syndrome on the summer activity of the little brown bat (*Myotis lucifugus*). *Biology Letters*, *7*, 392–394.

Ellison, A. M. (2004). Bayesian inference in ecology. *Ecology Letters*, *7*, 509–520. https://doi.org/10.1111/j.1461-0248.2004.00603.x

Federal Register (2015). *Endangered and threatened wildlife and plants; threatened species status for the norther long-eared bat with 4(d) rule; final rule and interim rule*. CFR 50, Part 17, Vol. *80*, No. 63: 17974–18033.

Frick, W. F., Baerwald, E. F., Pollock, J. F., Barclay, R., Szymanski, J. A., Weller, T. J., … McGuire, L. P. (2017). Fatalities at wind turbines may threaten population viability of a migratory bat. *Biological Conservation*, *209*, 172–177. https://doi.org/10.1016/j.biocon.2017.02.023

Frick, W. F., Pollock, J. F., Hicks, A. C., Langwig, K. E., Reynolds, D. S., Turner, G. G., … Kunz, T. H. (2010). An emerging disease causes regional population collapse of a common North American bat species. *Science*, *329*, 679–682. https://doi.org/10.1126/science.1188594

Frick, W. F., Puechmaille, S. J., Hoyt, J. R., Nickel, B. A., Langwig, K. E., Foster, J. T., … Kilpatrick, A. M. (2015). Disease alters macroecological patterns of North American bats. *Global Ecology and Biogeography*, *24*, 741–749. https://doi.org/10.1111/geb.12290

Gaston, K. J., Blackburn, T. M., Greenwood, J. J. D., Gregory, R. D., Quinn, R. M., & Lawton, J. H. (2000). Abundance-occupancy relationships. *Journal of Applied Ecology*, *37*, 39–59. https://doi.org/10.1046/j.1365-2664.2000.00485.x

Gelman, A., Simpson, D., & Betancourt, M. (2017). The prior can often only be understood in the context of likelihood. *Entropy*, *19*, 555.

Hayes, J. P. (1997). Temporal variation in activity of bats and the design of echolocation monitoring studies. *Journal of Mammalogy*, *78*, 514–524. https://doi.org/10.2307/1382902

Hayes, J. P. (2003). Habitat ecology and conservation of bats in western coniferous forests. In C. J. Zabel & R. G. Anthony (Eds.), *Mammal community dynamics in coniferous forests of western North America—Management and conservation*. Cambridge, UK: Cambridge University Press.

Hayes, M. A., Cryan, P. M., & Wunder, M. B. (2015). Seasonally-dynamic presence-only species distribution models for a cryptic migratory bat impacted by wind energy development. *PLoS ONE*, *10*, e0132599. https://doi.org/10.1371/journal.pone.0132599

Hayes, M. A., Hooton, L. A., Gilland, K. L., Grandgent, C., Smith, R. L., Lindsay, S. R., … Goodrich-Mahoney, J. (2019). A smart curtailment approach for reducing bat fatalities and curtailment time at wind energy facilities. *Ecological Applications*, *29*, e01881. https://doi.org/10.1002/eap.1881

Hobbs, N. T., & Hooten, M. B. (2015). *Bayesian models: A statistical primer for ecologists*. Princeton, NJ: Princeton University Press.

Hoen, B. D., Diffendorfer, J. E., Rand, J. T., Kramer, L. A., Garrity, C. P., & Hunt, H. E. (2018). *United States wind turbine database*. U.S. Geological Survey, American Wind Energy Association, and Lawrence Berkeley National Laboratory. Data release: USWTDB V1.3 (January 7, 2019). Retrieved from https://eerscmap.usgs.gov/uswtdb

Holt, A. R., Gaston, K. J., & He, F. (2002). Occupancy-abundance relationships and spatial distribution: A review. *Basic and Applied Ecology*, *3*, 1–13. https://doi.org/10.1078/1439-1791-00083

Humphrey, S. R. (1975). Nursery roosts and community diversity of nearctic bats. *Journal of Mammalogy*, *56*, 321–346. https://doi.org/10.2307/1379364

Irvine, K. M., Rodhouse, T. J., Wright, W. J., & Olsen, A. R. (2018). Occupancy modeling species-environment relationships with non-ignorable sampling designs. *Ecological Applications*, *28*, 1616–1625.

Jones, G., Jacobs, D. S., Kunz, T. H., Willig, M. R., & Racey, P. A. (2009). Carpe noctem: The importance of bats as bioindicators. *Endangered Species Research*, *8*, 93–115. https://doi.org/10.3354/esr00182

Jones, J. P. G. (2011). Monitoring species abundance and distribution at the landscape scale. *Journal of Applied Ecology*, *48*, 9–13. https://doi.org/10.1111/j.1365-2664.2010.01917.x

Jung, K., & Threlfall, C. G. (2016). Urbanisation and its effects on bats – A global meta-analysis. In C. C. Voigt & T. Kingston (Eds.), *Bats in the Anthropocene: Conservation of bats in a changing world*. Basel, Switzerland: Springer International.

Kalcounis-Rüppell, M. C., Psyllakis, J., & Brigham, R. M. (2005). Tree roost selection by bats: An empirical synthesis using metaanalysis. *Wildlife Society Bulletin*, *33*, 1123–1132. https://doi.org/10.2193/0091-7648(2005)33[1123:TRSBBA]2.0.CO;2

Kery, M., & Royle, J. A. (2016). *Applied hierarchical modelling in ecology: Analysis of distribution, abundance, and species richness in R and BUGS*. Amsterdam, the Netherlands: Elsevier.

Langwig, K. E., Frick, W. F., Bried, J. T., Hicks, A. C., Kunz, T. H., & Kilpatrick, A. M. (2012). Sociality, density-dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome. *Ecology Letters*, *15*, 1050–1057. https://doi.org/10.1111/j.1461-0248.2012.01829.x

Larsen, D. P., Olsen, A. R., & Stevens, D. L., Jr. (2008). Using a master sample to integrate stream monitoring programs. *Journal of Agricultural, Biological, and Environmental Statistics*, *13*, 243–254. https://doi.org/10.1198/108571108X336593

Lewis, S. E. (1995). Roost fidelity of bats: A review. *Journal of Mammalogy*, *76*, 481–496. https://doi.org/10.2307/1382357

Loeb, S. C., Rodhouse, T. J., Ellison, L. E., Lausen, C. L., Reichard, J. D., Irvine, K. M., … Johnson, D. H. (2015). *A plan for the North American bat monitoring program (NABat)*. General Technical Report GTR-SRS-208, USFS Southern Research Station, Asheville, SC.

Lorch, J. M., Palmer, J. M., Lindner, D. L., Ballmann, A. E., George, K. G., Griffin, K., … Blehert, D. S. (2016). First detection of bat white-nose syndrome in Western North America. *mSphere*, *1*, e00148-16. https://doi.org/10.1128/mSphere.00148-16

Lunn, D., Spiegelhalter, D., Thomas, A., & Best, N. (2009). The BUGS project: Evolution, critique, and future directions. *Statistics in Medicine*, *28*, 3049–3067. https://doi.org/10.1002/sim.3680

MacKenzie, D. I., Nichols, J. D., Hines, J. E., Knutson, M. G., & Franklin, A. B. (2003). Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. *Ecology*, *84*, 2200–2207. https://doi.org/10.1890/02-3090

MacKenzie, D. I., Nichols, J. D., Lachman, G. B., Droege, S., Royle, J. A., & Langtimm, C. A. (2002). Estimating site occupancy rates when detection probabilities are less than one. *Ecology*, *83*, 2248–2255. https://doi.org/10.1890/0012-9658(2002)083[2248:ESORWD]2.0.CO;2

McCarthy, M. A., & Masters, P. (2005). Profiting from prior information in Bayesian analyses of ecological data. *Journal of Applied Ecology*, *42*, 1012–1019. https://doi.org/10.1111/j.1365-2664.2005.01101.x

Morris, W. K., Vesk, P. A., McCarthy, M. A., Bunyavejchewin, S., & Baker, P. J. (2015). The neglected tool in the Bayesian ecologist's shed: A case study testing informative priors' effect on model accuracy. *Ecology and Evolution*, *5*, 102–108. https://doi.org/10.1002/ece3.1346

Noon, B. R., Bailey, L. L., Sisk, T. D., & McKelvey, K. S. (2012). Efficient species-level monitoring at the landscape scale. *Conservation Biology*, *26*, 432–441. https://doi.org/10.1111/j.1523-1739.2012.01855.x

Northrup, J. M., & Gerber, B. D. (2018). A comment on priors for Bayesian occupancy models. *PLoS ONE*, *13*(2), e0192819. https://doi.org/10.1371/journal.pone.0192819

O'Shea, T. J., Cryan, P. M., Hayman, D. T. S., Plowright, R. K., & Streicker, D. G. (2016). Multiple mortality events in bats: A global review. *Mammal Review*, *46*, 175–190. https://doi.org/10.1111/mam.12064

Pierson, E. D. (1998). Tall trees, deep holes, and scarred landscapes: Conservation biology of North American bats. In T. H. Kunz & P. A. Racey (Eds.), *Bat biology and conservation*. Washington, DC: Smithsonian Institution Press.

Promislow, D. E. L., & Harvey, P. H. (1990). Living fast and dying young: A comparative analysis of life-history variation among mammals. *Journal of Zoology*, *220*, 417–437. https://doi.org/10.1111/j.1469-7998.1990.tb04316.x

R Core Team (2018). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Rodhouse, T. J., Ormsbee, P. C., Irvine, K. M., Vierling, L. A., Szewczak, J. M., & Vierling, K. T. (2012). Assessing the status and trend of bat populations across broad geographic regions with dynamic distribution models. *Ecological Applications*, *22*, 1098–1113. https://doi.org/10.1890/11-1662.1

Rodhouse, T. J., Ormsbee, P. C., Irvine, K. M., Vierling, L. A., Szewczak, J. M., & Vierling, K. T. (2015). Establishing conservation baselines with dynamic distribution models for bats facing imminent decline. *Diversity and Distributions*, *21*, 1401–1413.

Rodhouse, T. J., Vierling, K. T., & Irvine, K. M. (2011). A practical sampling design for acoustic surveys of bats. *Journal of Wildlife Management*, *75*, 1094–1102. https://doi.org/10.1002/jwmg.151

Royle, J. A., & Dorazio, R. M. (2008). *Hierarchical modeling and inference in ecology*. London, UK: Elsevier.

Rodriguez, R. M., Rodhouse, T. J., Barnett, J., Irvine, K. M., Banner, K. M., Lonneker, J., & Ormsbee, P. C. (2019). *North American Bat Monitoring Program regional protocol for surveying with stationary deployments of echolocation recording devices: Version 1.0, Pacific Northwestern US*. Natural Resource Report NPS/UCBN/NRR—2019/1975. Fort Collins, CO: National Park Service. Retrieved from https://irma.nps.gov/DataStore/Reference/Profile/2265647

Royle, J. A., & Kery, M. (2007). A Bayesian state-space formulation of dynamic occupancy models. *Ecology*, *88*, 1813–1823. https://doi.org/10.1890/06-0669.1

Sanchez-Bayo, F., & Wyckhus, K. A. G. (2019). Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation*, *232*, 8–27. https://doi.org/10.1016/j.biocon.2019.01.020

Steenweg, R., Hebblewhite, M., Whittington, J., Lukacs, P., & McKelvey, K. (2018). Sampling scales define occupancy and underlying occupancy-abundance relationships in animals. *Ecology*, *99*, 172–183. https://doi.org/10.1002/ecy.2054

Stevens, D. L., & Olsen, A. R. (2004). Spatially balanced sampling of natural resources. *Journal of the American Statistical Association*, *99*, 262–278. https://doi.org/10.1198/016214504000000250

Sturtz, S., Ligges, U., & Gelman, A. (2005). R2WinBUGS: A package for running WinBUGS from R. *Journal of Statistical Software*, *12*, 1–16.

Tews, J., Brose, U., Grimm, V., Tielborger, K., Wichmann, M. C., Schwager, M., & Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. *Journal of Biogeography*, *31*, 79–92. https://doi.org/10.1046/j.0305-0270.2003.00994.x

Weller, T. J., Castle, K. T., Liechti, F., Hein, C. D., Schirmacher, M. R., & Cryan, P. M. (2016). First direct evidence of long-distance seasonal movements and hibernation in a migratory bat. *Scientific Reports*, *6*, 34585. https://doi.org/10.1038/srep34585

Wright, W. J., Irvine, K. M., & Higgs, M. D. (2019). Identifying occupancy model inadequacies: Can residuals separately assess detection and presence? *Ecology*, *100*, e02703. https://doi.org/10.1002/ecy.2703

Wright, W. J., Irvine, K. M., & Rodhouse, T. J. (2016). A goodness-of-fit test for occupancy models with correlated within-season revisits. *Ecology and Evolution*, *6*, 5404–5415. https://doi.org/10.1002/ece3.2292

Zipkin, E. F., Campbell Grant, E. H., & Fagan, W. F. (2012). Evaluating the predictive abilities of community occupancy models using AUC while accounting for imperfect detection. *Ecological Applications*, *22*, 1962–1972. https://doi.org/10.1890/11-1936.1

Zuckerberg, B., Porter, W. F., & Corwin, K. (2009). The consistency and stability of abundance-occupancy relationships in large-scale population dynamics. *Journal of Animal Ecology*, *78*, 172–181. https://doi.org/10.1111/j.1365-2656.2008.01463.x

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Rodhouse TJ, Rodriguez RM, Banner KM, Ormsbee PC, Barnett J, Irvine KM. Evidence of region-wide bat population decline from long-term monitoring and Bayesian occupancy models with empirically informed priors. *Ecol Evol*. 2019;00:1–11. https://doi.org/10.1002/ece3.5612

Cite as: K. V. Rosenberg *et al.*, *Science*
10.1126/science.aaw1313 (2019).

Decline of the North American avifauna

Kenneth V. Rosenberg[1,2]*, Adriaan M. Dokter[1], Peter J. Blancher[3], John R. Sauer[4], Adam C. Smith[5], Paul A. Smith[3], Jessica C. Stanton[6], Arvind Panjabi[7], Laura Helft[1], Michael Parr[2], Peter P. Marra[8]†

[1]Cornell Laboratory of Ornithology, Cornell University, Ithaca, NY 14850, USA. [2]American Bird Conservancy, Washington, DC 20008, USA. [3]National Wildlife Research Centre, Environment and Climate Change Canada, Ottawa, ON K1A 0H3, Canada. [4]Patuxent Wildlife Research Center, United States Geological Survey, Laurel, MD 20708-4017, USA. [5]Canadian Wildlife Service, Environment and Climate Change Canada, Ottawa, ON K1A 0H3, Canada. [6]Upper Midwest Environmental Sciences Center, United States Geological Survey, La Crosse, WI, USA. [7]Bird Conservancy of the Rockies, Fort Collins, CO 80521, USA. [8]Migratory Bird Center, Smithsonian Conservation Biology Institute, National Zoological Park, PO Box 37012 MRC 5503, Washington, DC 20013-7012, USA.

*Corresponding author. Email: kvr2@cornell.edu

†Present address: Department of Biology and McCourt School of Public Policy, Georgetown University, 37th and O Streets NW, Washington, DC 20057, USA.

Species extinctions have defined the global biodiversity crisis, but extinction begins with loss in abundance of individuals that can result in compositional and functional changes of ecosystems. Using multiple and independent monitoring networks, we report population losses across much of the North American avifauna over 48 years, including once common species and from most biomes. Integration of range-wide population trajectories and size estimates indicates a net loss approaching 3 billion birds, or 29% of 1970 abundance. A continent-wide weather radar network also reveals a similarly steep decline in biomass passage of migrating birds over a recent 10-year period. This loss of bird abundance signals an urgent need to address threats to avert future avifaunal collapse and associated loss of ecosystem integrity, function and services.

Slowing the loss of biodiversity is one of the defining environmental challenges of the 21st century (*1*–*5*). Habitat loss, climate change, unregulated harvest, and other forms of human-caused mortality (*6*, *7*) have contributed to a thousand-fold increase in global extinctions in the Anthropocene compared to the presumed prehuman background rate, with profound effects on ecosystem functioning and services (*8*). The overwhelming focus on species extinctions, however, has underestimated the extent and consequences of biotic change, by ignoring the loss of abundance within still-common species and in aggregate across large species assemblages (*2*, *9*). Declines in abundance can degrade ecosystem integrity, reducing vital ecological, evolutionary, economic, and social services that organisms provide to their environment (*8*, *10*–*15*). Given the current pace of global environmental change, quantifying change in species abundances is essential to assess ecosystem impacts. Evaluating the magnitude of declines requires effective long-term monitoring of population sizes and trends, data which are rarely available for most taxa.

Birds are excellent indicators of environmental health and ecosystem integrity (*16*, *17*), and our ability to monitor many species over vast spatial scales far exceeds that of any other animal group. We evaluated population change for 529 species of birds in the continental United States and Canada (76% of breeding species), drawing from multiple standardized bird-monitoring datasets, some of which provide close to fifty years of population data. We integrated range-wide estimates of population size and 48-year population trajectories, along with their associated uncertainty, to quantify net change in numbers of birds across the avifauna over recent decades (*18*). We also used a network 143 weather radars (NEXRAD) across the contiguous U.S. to estimate long-term changes in nocturnal migratory passage of avian biomass through the airspace in spring from 2007 to 2017. The continuous operation and broad coverage of NEXRAD provide an automated and standardised monitoring tool with unrivaled temporal and spatial extent (*19*). Radar measures cumulative passage across all nocturnally migrating species, many of which breed in areas north of the contiguous U.S. that are poorly monitored by avian surveys. Radar thus expands the area and the proportion of the migratory avifauna that is sampled relative to ground surveys.

Results from long-term surveys, accounting for both increasing and declining species, reveal a net loss in total abundance of 2.9 billion (95% CI = 2.7-3.1 billion) birds across almost all biomes, a reduction of 29% (95% CI = 27-30%) since 1970 (Fig. 1 and Table 1). Analysis of NEXRAD data indicate a similarly steep decline in nocturnal passage of migratory biomass, a reduction of 13.6 ± 9.1% since 2007 (Fig. 2A). Reduction in biomass passage occurred across the eastern U.S. (Fig. 2, C and D), where migration is dominated by large numbers of temperate- and boreal-breeding songbirds; we observed no consistent trend in the Central or Pacific flyway regions (Fig. 2, B to D, and table S5). Two completely different and independent monitoring techniques thus signal major population loss across the continental avifauna.

Species exhibiting declines (57%, 303/529) based on long-term survey data span diverse ecological and taxonomic groups. Across breeding biomes, grassland birds showed the largest magnitude of total population loss since 1970—more than 700 million breeding individuals across 31 species— and the largest proportional loss (53%); 74% of grassland species are declining. (Fig. 1 and Table 1). All forest biomes experienced large avian loss, with a cumulative reduction of more than 1 billion birds. Wetland birds represent the only biome to show an overall net gain in numbers (13%), led by a 56% increase in waterfowl populations (Fig. 3 and Table 1). Surprisingly, we also found a large net loss (63%) across 10 introduced species (Fig. 3, D and E, and Table 1).

A total of 419 native migratory species experienced a net loss of 2.5 billion individuals, whereas 100 native resident species showed a small net increase (26 million). Species overwintering in temperate regions experienced the largest net reduction in abundance (1.4 billion), but proportional loss was greatest among species overwintering in coastal regions (42%), southwestern aridlands (42%), and South America (40%) (Table 1 and fig. S1). Shorebirds, most of which migrate long distances to winter along coasts throughout the hemisphere, are experiencing consistent, steep population loss (37%).

More than 90% of the total cumulative loss can be attributed to 12 bird families (Fig. 3A), including sparrows, warblers, blackbirds, and finches. Of 67 bird families surveyed, 38 showed a net loss in total abundance, whereas 29 showed gains (Fig. 3B), indicating recent changes in avifaunal composition (table S2). While not optimized for species-level analysis, our model indicates 19 widespread and abundant landbirds (including 2 introduced species) each experienced population reductions of >50 million birds (data S1). Abundant species also contribute strongly to the migratory passage detected by radar (*19*), and radar-derived trends provide a fully independent estimate of widespread declines of migratory birds.

Our study documents a long-developing but overlooked biodiversity crisis in North America—the cumulative loss of nearly 3 billion birds across the avifauna. Population loss is not restricted to rare and threatened species, but includes many widespread and common species that may be disproportionately influential components of food webs and ecosystem function. Furthermore, losses among habitat generalists and even introduced species indicate that declining species are not replaced by species that fare well in human-altered landscapes. Increases among waterfowl and a few other groups (e.g., raptors recovering after the banning of DDT) are insufficient to offset large losses among abundant species (Fig. 3). Importantly, our population loss estimates are conservative since we estimated loss only in breeding populations. The total loss and impact on communities and ecosystems could be even higher outside the breeding season if we consider the amplifying effect of "missing" reproductive output from these lost breeders.

Extinction of the Passenger Pigeon (*Ectopistes migratorius*), once likely the most numerous bird on the planet, provides a poignant reminder that even abundant species can go extinct rapidly. Systematic monitoring and attention paid to population declines could have alerted society to its pending extinction (*20*). Today, monitoring data suggest that avian declines will likely continue without targeted conservation action, triggering additional endangered species listings at tremendous financial and social cost. Moreover, because birds provide numerous benefits to ecosystems (e.g., seed dispersal, pollination, pest control) and economies (47 million people spend 9.3 billion U.S. dollars per year through bird-related activities in the U.S. (*21*)), their population reductions and possible extinctions will have severe direct and indirect consequences (*10*, *22*). Population declines can be reversed, as evidenced by the remarkable recovery of waterfowl populations under adaptive harvest management (*23*) and the associated allocation of billions of dollars devoted to wetland protection and restoration, providing a model for proactive conservation in other widespread native habitats such as grasslands.

Steep declines in North American birds parallel patterns of avian declines emerging globally (*14*, *15*, *22*, *24*). In particular, depletion of native grassland bird populations in North America, driven by habitat loss and more toxic pesticide use in both breeding and wintering areas (*25*), mirrors loss of farmland birds throughout Europe and elsewhere (*15*). Even declines among introduced species match similar declines within these same species' native ranges (*26*). Agricultural intensification and urbanization have been similarly linked to declines in insect diversity and biomass (*27*), with cascading impacts on birds and other consumers (*24*, *28*, *29*). Given that birds are one of the best monitored animal groups, birds may also represent the tip of the iceberg, indicating similar or greater losses in other taxonomic groups (*28*, *30*).

Pervasiveness of avian loss across biomes and bird families suggests multiple and interacting threats. Isolating spatio-temporal limiting factors for individual species and populations will require additional study, however, since migratory species with complex life histories are in contact with many threats throughout their annual cycles. A focus on breeding season biology hampers our ability to understand how seasonal interactions drive population change (*31*), although recent continent-wide analyses affirm the importance of events during the non-breeding season (*19*, *32*). Targeted research to identify limiting factors must be coupled with effective policies and societal change that emphasize reducing threats to breeding and non-breeding habitats and minimizing avoidable anthropogenic mortality year-round. Endangered species legislation and international treaties, such as the 1916 Migratory Bird Treaty between Canada and the United States, have prevented extinctions and promoted recovery of once-depleted bird species. History shows that conservation action and legislation works. Our results signal an urgent need to address the ongoing threats of habitat loss, agricultural intensification, coastal disturbance, and direct anthropogenic mortality, all exacerbated by climate change, to avert continued biodiversity loss and potential collapse of the continental avifauna.

REFERENCES AND NOTES

1. M. C. Urban, Climate change. Accelerating extinction risk from climate change. *Science* **348**, 571–573 (2015). doi:10.1126/science.aaa4984 Medline
2. R. Dirzo, H. S. Young, M. Galetti, G. Ceballos, N. J. B. Isaac, B. Collen, Defaunation in the Anthropocene. *Science* **345**, 401–406 (2014). doi:10.1126/science.1251817 Medline
3. S. L. Pimm, C. N. Jenkins, R. Abell, T. M. Brooks, J. L. Gittleman, L. N. Joppa, P. H. Raven, C. M. Roberts, J. O. Sexton, The biodiversity of species and their rates of extinction, distribution, and protection. *Science* **344**, 1246752 (2014). doi:10.1126/science.1246752 Medline
4. A. D. Barnosky, N. Matzke, S. Tomiya, G. O. U. Wogan, B. Swartz, T. B. Quental, C. Marshall, J. L. McGuire, E. L. Lindsey, K. C. Maguire, B. Mersey, E. A. Ferrer, Has the Earth's sixth mass extinction already arrived? *Nature* **471**, 51–57 (2011). doi:10.1038/nature09678 Medline
5. W. Steffen, J. Crutzen, J. R. McNeill, The Anthropocene: Are humans now overwhelming the great forces of Nature? *Ambio* **36**, 614–621 (2007). doi:10.1579/0044-7447(2007)36[614:TAAHNO]2.0.CO;2 Medline
6. S. R. Loss, T. Will, P. P. Marra, Direct Mortality of Birds from Anthropogenic Causes. *Annu. Rev. Ecol. Evol. Syst.* **46**, 99–120 (2015). doi:10.1146/annurev-ecolsys-112414-054133
7. A. M. Calvert, C. A. Bishop, R. D. Elliot, E. A. Krebs, T. M. Kydd, C. S. Machtans, G. J. Robertson, A Synthesis of Human-related Avian Mortality in Canada. *Avian Conserv. Ecol.* **8**, art11 (2013). doi:10.5751/ACE-00581-080211
8. D. U. Hooper, E. C. Adair, B. J. Cardinale, J. E. K. Byrnes, B. A. Hungate, K. L. Matulich, A. Gonzalez, J. E. Duffy, L. Gamfeldt, M. I. O'Connor, A global synthesis reveals biodiversity loss as a major driver of ecosystem change. *Nature* **486**, 105–108 (2012). doi:10.1038/nature11118 Medline
9. G. Ceballos, P. R. Ehrlich, R. Dirzo, Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proc. Natl. Acad. Sci. U.S.A.* **114**, E6089–E6096 (2017). doi:10.1073/pnas.1704949114 Medline
10. C. J. Whelan, Ç. H. Şekercioğlu, D. G. Wenny, Why birds matter: From economic ornithology to ecosystem services. *J. Ornithol.* **156** (S1), 227–238 (2015). doi:10.1007/s10336-015-1229-y
11. M. Galetti, R. Guevara, M. C. Côrtes, R. Fadini, S. Von Matter, A. B. Leite, F. Labecca, T. Ribeiro, C. S. Carvalho, R. G. Collevatti, M. M. Pires, P. R. Guimarães Jr., P. H. Brancalion, M. C. Ribeiro, P. Jordano, Functional extinction of birds drives rapid evolutionary changes in seed size. *Science* **340**, 1086–1090 (2013). doi:10.1126/science.1233774 Medline
12. G. C. Daily, Ed., *Nature's Services: Societal Dependence on Natural Ecosystems* (Island Press, Washington, DC, 1997).
13. S. Bauer, B. J. Hoye, Migratory animals couple biodiversity and ecosystem functioning worldwide. *Science* **344**, 1242552 (2014). doi:10.1126/science.1242552 Medline
14. K. J. Gaston, R. A. Fuller, Commonness, population depletion and conservation biology. *Trends Ecol. Evol.* **23**, 14–19 (2008). doi:10.1016/j.tree.2007.11.001 Medline
15. R. Inger, R. Gregory, J. P. Duffy, I. Stott, P. Voříšek, K. J. Gaston, Common European birds are declining rapidly while less abundant species' numbers are rising. *Ecol. Lett.* **18**, 28–36 (2015). doi:10.1111/ele.12387 Medline
16. M. L. Morrison, in *Current Ornithology*, R. F. Johnston, Ed. (Springer US, Boston, MA, 1986; https://link.springer.com/10.1007/978-1-4615-6784-4_10), pp. 429–451.
17. J. Burger, M. Gochfeld, Marine birds as sentinels of environmental pollution. *EcoHealth* **1**, 263–274 (2004). doi:10.1007/s10393-004-0096-4
18. See supplementary materials.
19. A. M. Dokter, A. Farnsworth, D. Fink, V. Ruiz-Gutierrez, W. M. Hochachka, F. A. La Sorte, O. J. Robinson, K. V. Rosenberg, S. Kelling, Seasonal abundance and survival of North America's migratory avifauna determined by weather radar. *Nat. Ecol. Evol.* **2**, 1603–1609 (2018). doi:10.1038/s41559-018-0666-4 Medline
20. J. C. Stanton, Present-day risk assessment would have predicted the extinction of the passenger pigeon (*Ectopistes migratorius*). *Biol. Conserv.* **180**, 11–20 (2014). doi:10.1016/j.biocon.2014.09.023
21. U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau, "National Survey of Fishing, Hunting, and Wildlife-Associated Recreation" (2016).
22. C. H. Sekercioğlu, G. C. Daily, P. R. Ehrlich, Ecosystem consequences of bird declines. *Proc. Natl. Acad. Sci. U.S.A.* **101**, 18042–18047 (2004). doi:10.1073/pnas.0408049101 Medline
23. J. D. Nichols, M. C. Runge, F. A. Johnson, B. K. Williams, Adaptive harvest management of North American waterfowl populations: A brief history and future prospects. *J. Ornithol.* **148** (S2), 343–349 (2007). doi:10.1007/s10336-007-0256-8
24. C. A. Hallmann, R. P. B. Foppen, C. A. M. van Turnhout, H. de Kroon, E. Jongejans, Declines in insectivorous birds are associated with high neonicotinoid concentrations. *Nature* **511**, 341–343 (2014). doi:10.1038/nature13531 Medline
25. R. L. Stanton, C. A. Morrissey, R. G. Clark, Analysis of trends and agricultural drivers of farmland bird declines in North America: A review. *Agric. Ecosyst. Environ.* **254**, 244–254 (2018). doi:10.1016/j.agee.2017.11.028
26. J. De Laet, J. D. Summers-Smith, The status of the urban house sparrow Passer domesticus in north-western Europe: A review. *J. Ornithol.* **148** (S2), 275–278 (2007). doi:10.1007/s10336-007-0154-0
27. F. Sánchez-Bayo, K. A. G. Wyckhuys, Worldwide decline of the entomofauna: A review of its drivers. *Biol. Conserv.* **232**, 8–27 (2019). doi:10.1016/j.biocon.2019.01.020
28. B. C. Lister, A. Garcia, Climate-driven declines in arthropod abundance restructure a rainforest food web. *Proc. Natl. Acad. Sci. U.S.A.* **115**, E10397–E10406 (2018). doi:10.1073/pnas.1722477115 Medline
29. D. L. Narango, D. W. Tallamy, P. P. Marra, Nonnative plants reduce population growth of an insectivorous bird. *Proc. Natl. Acad. Sci. U.S.A.* **115**, 11549–11554 (2018). doi:10.1073/pnas.1809259115 Medline
30. R. E. A. Almond, M. Grooten, "Living Planet Report - 2018: Aiming Higher" (WWF, Gland, Switzerland, 2018).
31. P. P. Marra, E. B. Cohen, S. R. Loss, J. E. Rutter, C. M. Tonra, A call for full annual cycle research in animal ecology. *Biol. Lett.* **11**, 20150552 (2015). doi:10.1098/rsbl.2015.0552 Medline
32. F. A. La Sorte, D. Fink, P. J. Blancher, A. D. Rodewald, V. Ruiz-Gutierrez, K. V. Rosenberg, W. M. Hochachka, P. H. Verburg, S. Kelling, Global change and the distributional dynamics of migratory bird populations wintering in Central America. *Glob. Change Biol.* **23**, 5284–5296 (2017). doi:10.1111/gcb.13794 Medline
33. A. C. Smith, AdamCSmithCWS/Estimating_Change_in_NorthAmerican_Birds, Zenodo, (2019); https://doi.org/10.5281/zenodo.3218403
34. A. M. Dokter, L. Veen, J. H. Spaaks, adokter/vol2bird: vol2bird, Version 0.4.0, Zenodo (2019); https://doi.org/10.5281/zenodo.3369999
35. A. M. Dokter, S. Van Hoey, P. Desmet, adokter/bioRad: bioRad, Version 0.4.0, Zenodo (2019); https://doi.org/10.5281/zenodo.3370005.
36. J. R. Sauer, W. A. Link, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski Jr., The North American Breeding Bird Survey 1966–2011: Summary Analysis and Species Accounts. *North American Fauna* **79**, 1–32 (2013). doi:10.3996/nafa.79.0001
37. K. V. Rosenberg, P. J. Blancher, J. C. Stanton, A. O. Panjabi, Use of North American Breeding Bird Survey data in avian conservation assessments. *Condor* **119**, 594–606 (2017). doi:10.1650/CONDOR-17-57.1
38. J. C. Stanton, P. J. Blancher, K. V. Rosenberg, A. O. Panjabi, W. E. Thogmartin, Estimating uncertainty of North American landbird population sizes. *Avian Conserv. Ecol.* **14**, art4 (2019). doi:10.5751/ACE-01331-140104
39. North American Bird Conservation Initiative, The state of Canada's birds, 2012. *Environment Canada, Ottawa, ON* (2012); http://www.stateofcanadasbirds.org/.
40. North American Bird Conservation Initiative, U.S. Committee, "The State of the

Birds, United States of America" (U.S. Department of Interior, Washington, DC, 2009).
41. B. Collen, J. Loh, S. Whitmee, L. McRae, R. Amin, J. E. Baillie, Monitoring change in vertebrate abundance: The living planet index. *Conserv. Biol.* **23**, 317–327 (2009). doi:10.1111/j.1523-1739.2008.01117.x Medline
42. S. N. Wood, *Generalized Additive Models: An Introduction with R* (Chapman and Hall/CRC, 2017).
43. W. A. Link, J. R. Sauer, Bayesian Cross-Validation for Model Evaluation and Selection, with Application to the North American Breeding Survey. *Ecology* **97**, 1746–1758 (2016). doi:10.1890/15-1286.1 Medline
44. K. Rosenberg, J. Kennedy, R. Dettmers, R. Ford, D. Reynolds, J. Alexander, C. Beardmore, P. Blancher, R. Bogart, G. Butcher, Partners in flight landbird conservation plan: 2016 revision for Canada and continental United States. *Partners in Flight Science Committee* (2016).
45. T. Rich, C. Beardmore, H. Berlanga, P. Blancher, M. Bradstreet, G. Butcher, D. Demarest, E. Dunn, W. Hunter, E. Iñigo-Elias, Partners in Flight North American landbird conservation plan. Ithaca, NY: Cornell Lab of Ornithology (2004).
46. S. Brown, C. Hickey, B. Gill, L. Gorman, C. Gratto-Trevor, S. Haig, B. Harrington, C. Hunter, G. Morrison, G. Page, National shorebird conservation assessment: Shorebird conservation status, conservation units, population estimates, population targets, and species prioritization. *Manomet Center for Conservation Sciences, Manomet, MA* (2000).
47. J. A. Kushlan, M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Syderman, J. L. Trapp, J. Wheeler, K. Wohl, *Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1* (U.S. Fish and Wildlife Service, 2002).
48. North American Bird Conservation Initiative, The State of North America's Birds, 2016. *Environment and Climate Change Canada: Ottawa, Ontario* (2016); http://www.stateofthebirds.org/2016/.
49. Partners in Flight, Avian Conservation Assessment Database, version 2017 (accessed 5 November 2018); http://pif.birdconservancy.org/ACAD.
50. J. R. Sauer, W. A. Link, Analysis of the North American Breeding Bird Survey Using Hierarchical Models. *Auk* **128**, 87–98 (2011). doi:10.1525/auk.2010.09220
51. J. R. Sauer, D. K. Niven, K. L. Pardieck, D. J. Ziolkowski Jr., W. A. Link, Expanding the North American Breeding Bird Survey Analysis to Include Additional Species and Regions. *J. Fish Wildl. Manag.* **8**, 154–172 (2017). doi:10.3996/102015-JFWM-109
52. J. R. Sauer, K. L. Pardieck, D. J. Ziolkowski Jr., A. C. Smith, M.-A. R. Hudson, V. Rodriguez, H. Berlanga, D. K. Niven, W. A. Link, The first 50 years of the North American Breeding Bird Survey. *Condor* **119**, 576–593 (2017). doi:10.1650/CONDOR-17-83.1
53. J. A. Veech, K. L. Pardieck, D. J. Ziolkowski Jr., How well do route survey areas represent landscapes at larger spatial extents? An analysis of land cover composition along Breeding Bird Survey routes. *Condor* **119**, 607–615 (2017). doi:10.1650/CONDOR-17-15.1
54. M. F. Delany, R. A. Kiltie, R. S. Butryn, Land cover along breeding bird survey routes in Florida. *Florida Field Naturalist* **42**, 15–28 (2014).
55. J. A. Veech, M. F. Small, J. T. Baccus, Representativeness of land cover composition along routes of the North American Breeding Bird Survey. *Auk* **129**, 259–267 (2012). doi:10.1525/auk.2012.11242
56. C. M. E. Keller, J. T. Scallan, Potential Roadside Biases Due to Habitat Changes along Breeding Bird Survey Routes. *Condor* **101**, 50–57 (1999). doi:10.2307/1370445
57. J. B. C. Harris, D. G. Haskell, Land Cover Sampling Biases Associated with Roadside Bird Surveys. *Avian Conserv. Ecol.* **2**, art12 (2007). doi:10.5751/ACE-00201-020212
58. S. L. Van Wilgenburg, E. M. Beck, B. Obermayer, T. Joyce, B. Weddle, Biased representation of disturbance rates in the roadside sampling frame in boreal forests: Implications for monitoring design. *Avian Conserv. Ecol.* **10**, art5 (2015). doi:10.5751/ACE-00777-100205
59. M. G. Betts, D. Mitchell, A. W. Diamond, J. Bêty, Uneven Rates of Landscape Change as a Source of Bias in Roadside Wildlife Surveys. *J. Wildl. Manage.* **71**, 2266 (2007). doi:10.2193/2006-004
60. C. U. Soykan, J. Sauer, J. G. Schuetz, G. S. LeBaron, K. Dale, G. M. Langham, Population trends for North American winter birds based on hierarchical models. *Ecosphere* **7**, e01351 (2016). doi:10.1002/ecs2.1351
61. J. Bart, S. Brown, B. Harrington, R. I. Guy Morrison, Survey trends of North American shorebirds: Population declines or shifting distributions? *J. Avian Biol.* **38**, 73–82 (2007). doi:10.1111/j.2007.0908-8857.03698.x
62. R. Kenyon Ross, P. A. Smith, B. Campbell, C. A. Friis, R. Guy Morrison, Population trends of shorebirds in southern Ontario, 1974-2009. *Waterbirds* **35**, 15–24 (2012). doi:10.1675/063.035.0102
63. M. E. Seamans, R. D. Rau, "American woodcock population status, 2017" (U.S. Fish and Wildlife Service, Laurel, Maryland, 2017); https://www.fws.gov/birds/surveys-and-data/reports-and-publications/population-status.php.
64. U.S. Fish and Wildlife Service, "Waterfowl population status, 2017" (U.S. Department of the Interior, Washington, D.C. USA, 2017); https://www.fws.gov/birds/surveys-and-data/reports-and-publications.php.
65. D. Anthony, Fox, James O Leafloor, "A global audit of the status and trends of Arctic and Northern Hemisphere goose populations" (Conservation of Arctic Flora and Fauna International Secretariat, Akureyri, Iceland, 2018).
66. D. J. Groves, "The 2015 North American Trumpeter Swan Survey" (U.S. Fish and Wildlife Service, Juneau Alaska, 2017); https://www.fws.gov/birds/surveys-and-data/reports-and-publications.php.
67. K. V. Rosenberg, P. J. Blancher, in *Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference 2002*, C. J. Ralph, T. D. Rich, Eds. *PSW-GTR-191* (USDA Forest Service, Albany, CA, 2005), vol. 191, pp. 57–67.
68. P. Blancher, K. Rosenberg, A. Panjabi, B. Altman, J. Bart, C. Beardmore, G. Butcher, D. Demarest, R. Dettmers, E. Dunn, Guide to the Partners in Flight Population Estimates Database. Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No 5. *US Geological Survey Patuxent Wildlife Research Center, Laurel, Md* (2007); https://www.partnersinflight.org/resources/pif-tech-series/.
69. P. J. Blancher, K. V. Rosenberg, A. O. Panjabi, B. Altman, A. R. Couturier, W. E. Thogmartin, Handbook to the partners in flight population estimates database, version 2.0. *PIF Technical Series* (2013); http://pif.birdconservancy.org/PopEstimates/.
70. W. E. Thogmartin, F. P. Howe, F. C. James, D. H. Johnson, E. T. Reed, J. R. Sauer, F. R. Thompson III, A review of the population estimation approach of the North American Landbird Conservation Plan. *Auk* **123**, 892–904 (2006). doi:10.1093/auk/123.3.892
71. Sea Duck Joint Venture, "Recommendations for Monitoring Distribution, Abundance, and Trends for North American Sea Ducks" (U.S. Fish and Wildlife Service, Anchorage, Alaska and Canadian Wildlife Service, Sackville, New Brunswick, 2007); http://seaduckjv.org.
72. B. A. Andres, P. A. Smith, R. G. Morrison, C. L. Gratto-Trevor, S. C. Brown, C. A. Friis, Population estimates of North American shorebirds, 2012. *Bull. Wader Study Group* **119**, 178–194 (2012).
73. U.S. Shorebird Conservation Partnership, "Shorebird Flyway Population Database" (2016) (accessed 28 February 2018); https://www.shorebirdplan.org/science/assessment-conservation-status-shorebirds/.
74. P. G. Rodewald, Ed., *The Birds of North America* (Cornell Laboratory of Ornithology, Ithaca, NY, 2018; https://birdsna.org).
75. A. O. Panjabi, P. J. Blancher, W. E. Easton, J. C. Stanton, D. W. Demarest, R. Dettmers, K. V. Rosenberg, Partners in Flight Science Committee, "The Partners in Flight handbook on species assessment Version 2017," *Partners in Flight Technical Series No. 3. Bird Conservancy of the Rockies* (Partners in Flight, 2017).
76. Wetlands International, Waterbird Population Estimates (2018); wpe.wetlands.org.
77. S. Bauer, J. W. Chapman, D. R. Reynolds, J. A. Alves, A. M. Dokter, M. M. H. Menz, N. Sapir, M. Ciach, L. B. Pettersson, J. F. Kelly, H. Leijnse, J. Shamoun-Baranes, From Agricultural Benefits to Aviation Safety: Realizing the Potential of Continent-Wide Radar Networks. *Bioscience* **67**, 912–918 (2017). doi:10.1093/biosci/bix074 Medline
78. T. D. Crum, R. L. Alberty, The WSR-88D and the WSR-88D Operational Support Facility. *Bull. Am. Meteorol. Soc.* **74**, 1669–1687 (1993). doi:10.1175/1520-

0477(1993)074<1669:TWATWO>2.0.CO;2
79. A. M. Dokter, F. Liechti, H. Stark, L. Delobbe, P. Tabary, I. Holleman, Bird migration flight altitudes studied by a network of operational weather radars. *J. R. Soc. Interface* **8**, 30–43 (2011). doi:10.1098/rsif.2010.0116 Medline
80. K. G. Horton, B. M. Van Doren, F. A. La Sorte, E. B. Cohen, H. L. Clipp, J. J. Buler, D. Fink, J. F. Kelly, A. Farnsworth, Holding steady: Little change in intensity or timing of bird migration over the Gulf of Mexico. *Glob. Change Biol.* **25**, 1106–1118 (2019). doi:10.1111/gcb.14540 Medline
81. S. Ansari, S. Del Greco, E. Kearns, O. Brown, S. Wilkins, M. Ramamurthy, J. Weber, R. May, J. Sundwall, J. Layton, A. Gold, A. Pasch, V. Lakshmanan, Unlocking the Potential of NEXRAD Data through NOAA's Big Data Partnership. *Bull. Am. Meteorol. Soc.* **99**, 189–204 (2018). doi:10.1175/BAMS-D-16-0021.1
82. A. D. Siggia, R. E. Passarelli, in *Proc. ERAD* (2004), vol. 2, pp. 421–424.
83. J. N. Chrisman, C. A. Ray, in *32nd Conference on Radar Meteorology* (2005).
84. R. L. Ice, R. D. Rhoton, D. S. Saxion, C. A. Ray, N. K. Patel, D. A. Warde, A. D. Free, O. E. Boydstun, D. S. Berkowitz, J. N. Chrisman, J. C. Hubbert, C. Kessinger, M. Dixon, S. Torres, in *23rd International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology* (2007).
85. P. M. Stepanian, K. G. Horton, V. M. Melnikov, D. S. Zrnić, S. A. Gauthreaux Jr., Dual-polarization radar products for biological applications. *Ecosphere* **7**, e01539 (2016). doi:10.1002/ecs2.1539
86. A. M. Dokter, P. Desmet, J. H. Spaaks, S. van Hoey, L. Veen, L. Verlinden, C. Nilsson, G. Haase, H. Leijnse, A. Farnsworth, W. Bouten, J. Shamoun-Baranes, bioRad: Biological analysis and visualization of weather radar data. *Ecography* (2018). doi:10.1111/ecog.04028
87. R. J. Doviak, D. S. Zrnić, *Doppler Radar and Weather Observations* (Dover, Mineola, NY, ed. 2, 2006).
88. T. Chen, C. Guestrin, in *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining - KDD '16* (ACM Press, San Francisco, CA, 2016), pp. 785–794; https://dl.acm.org/citation.cfm?doid=2939672.2939785.
89. T. Chen, T. He, M. Benesty, V. Khotilovich, Y. Tang, *xgboost: Extreme Gradient Boosting* (2017); https://github.com/dmlc/xgboost.
90. J. Davis, M. Goadrich (ACM, 2006), pp. 233–240.
91. C. R. Vaughn, Birds and insects as radar targets: A review. *Proc. IEEE* **73**, 205–227 (1985). doi:10.1109/PROC.1985.13134
92. E. J. Pebesma, Multivariable geostatistics in S: The gstat package. *Comput. Geosci.* **30**, 683–691 (2004). doi:10.1016/j.cageo.2004.03.012
93. P. M. Stepanian, C. E. Wainwright, Ongoing changes in migration phenology and winter residency at Bracken Bat Cave. *Glob. Change Biol.* **24**, 3266–3275 (2018). doi:10.1111/gcb.14051 Medline
94. A. L. Russell, M. P. Cox, V. A. Brown, G. F. McCracken, Population growth of Mexican free-tailed bats (Tadarida brasiliensis mexicana) predates human agricultural activity. *BMC Evol. Biol.* **11**, 88 (2011). doi:10.1186/1471-2148-11-88 Medline
95. V. A. Drake, D. R. Reynolds, *Radar Entomology: Observing Insect Flight and Migration* (Cabi, 2012).
96. S. N. Wood, Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models: Estimation of Semiparametric Generalized Linear Models. *J. R. Stat. Soc. Series B Stat. Methodol.* **73**, 3–36 (2011). doi:10.1111/j.1467-9868.2010.00749.x
97. Kamil Barton, "MuMIn: Multi-Model Inference" (R package version 1.42.1, 2018); https://CRAN.R-project.org/package=MuMIn.
98. K. P. Burnham, D. R. Anderson, *Model selection and Multimodel Inference: A Practical Information-Theoretic Approach* (Springer, New York, ed. 2., 2010).
99. D. Bates, M. Mächler, B. Bolker, S. Walker, Fitting Linear Mixed-Effects Models Using lme4. *J. Stat. Softw.* **67**, (2015). doi:10.18637/jss.v067.i01
100. D. W. Winkler, S. M. Billerman, I. J. Lovette, *Bird families of the World: An Invitation to the Spectacular Diversity of Birds* (Lynx Edicions, 2015).
101. R. T. Chesser, K. J. Burns, C. Cicero, J. L. Dunn, A. W. Kratter, I. J. Lovette, P. C. Rasmussen, J. V. Remsen Jr., D. F. Stotz, B. M. Winger, K. Winker, Fifty-ninth Supplement to the American Ornithological Society's Check-list of North American Birds. *Auk* **135**, 798–813 (2018). doi:10.1642/AUK-18-62.1

ACKNOWLEDGMENTS

This paper is a contribution of The Partners in Flight International Science Committee and the American Ornithologist Society Conservation Committee, and the study benefited from many discussions with these groups. Steve Bessinger, John Fitzpatrick, Scott Loss, T. Scott Sillett, Wesley Hochachka, Daniel Fink, Steve Kelling, Viviana Ruiz-Gutierrez, Orin Robinson, Eliot Miller, Amanda Rodewald, and three anonymous reviewers made suggestions to improve the paper. Jillian Ditner and Matt Strimas-Mackey helped with figures and graphics. Tim Meehan provided an analysis of trends from National Audubon's Christmas Bird Count. We thank the hundreds of volunteer citizen-scientists who contributed to long-term bird-monitoring programs in North America and the institutions that manage these programs. Photos in Fig. 3 from Macaulay Library, Cornell Lab of Ornithology. **Funding:** NSF LTREB DEB1242584 to PPM; AWS Cloud Credits for Research to AMD; NSF ABI Innovation DBI-1661259. **Author contributions:** All authors conceived of the idea for the paper; ACS, PJB, AMD, JRS, PAS, and JCS conducted analyses; KVR, AMD and PPM primarily wrote the paper, although all authors contributed to the final manuscript. **Competing interests**: M. P. is President, and a member of the Board of Directors of American Bird Conservancy. All remaining authors declare no competing interests. **Data and materials availability:** All data and software are archived and available on Zenodo (*33*–*35*) and will be published in future versions of the Avian Conservation Assessment Database (http://pif.birdconservancy.org/ACAD/).

SUPPLEMENTARY MATERIALS

science.sciencemag.org/cgi/content/full/science.aaw1313/DC1
Materials and Methods
Figs. S1 to S7
Tables S1 to S5
Databases S1 and S2
References (*36*–*101*)

20 November 2018; resubmitted 23 May 2019
Accepted 5 September 2019
Published online 19 September 2019

10.1126/science.aaw1313

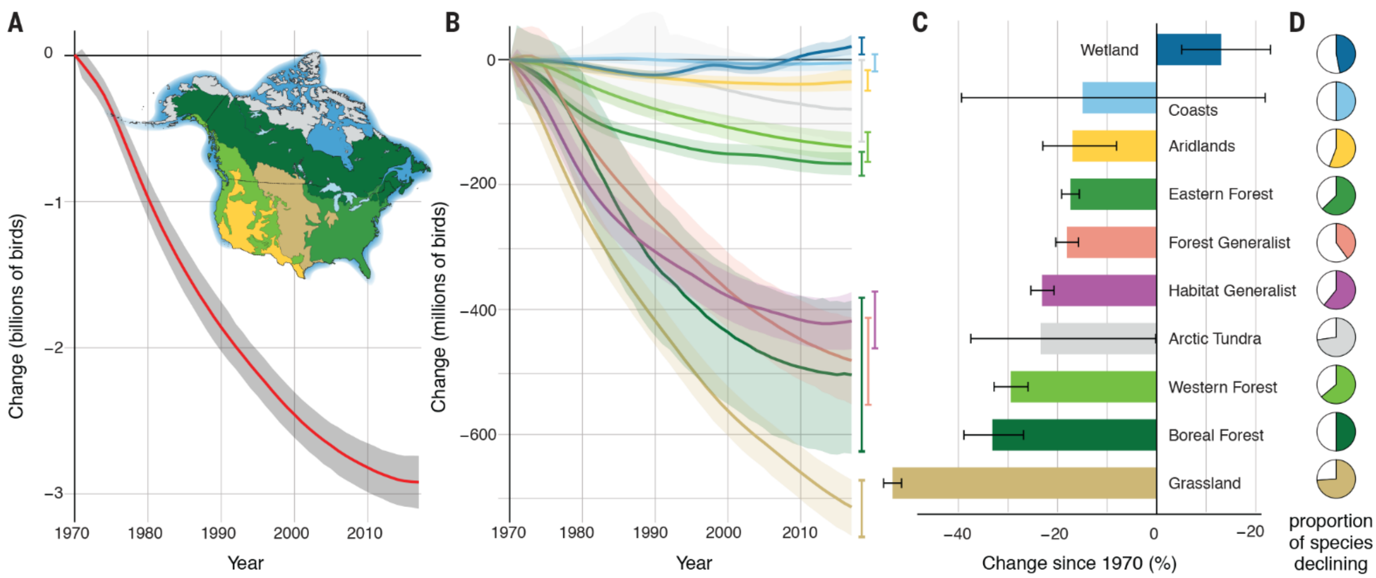


Fig. 1. Net population change in North American birds. (**A**) By integrating population size estimates and trajectories for 529 species (*18*), we show a net loss of 2.9 billion breeding birds across the continental avifauna since 1970. Gray shading represents ± 95% credible intervals around total estimated loss. Map shows color-coded breeding biomes based on Bird Conservation Regions and land cover classification (*18*). (**B**) Net loss of abundance occurred across all major breeding biomes except wetlands (see Table 1). (**C**) Proportional net population change relative to 1970, ±95% C.I. (**D**) Proportion of species declining in each biome.

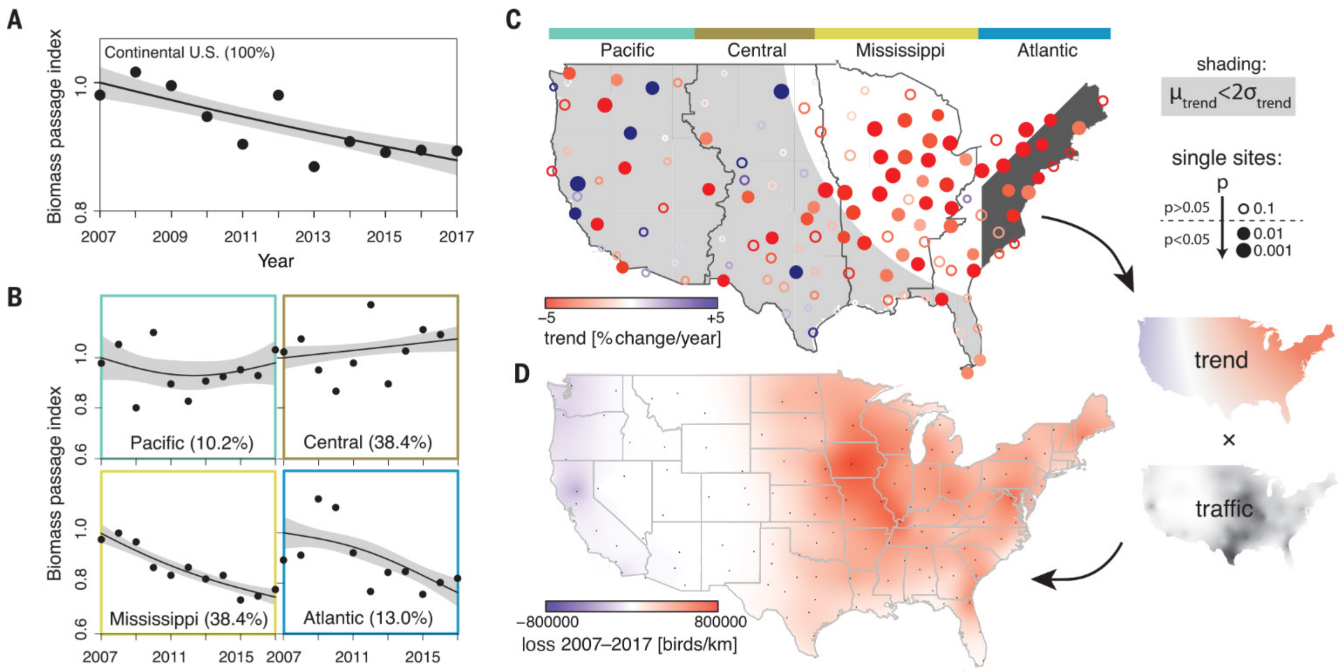


Fig. 2. NEXRAD radar monitoring of nocturnal bird migration across the contiguous U.S. (A) Annual change in biomass passage for the full continental U.S. (black) and (B) the Pacific (green), Central (brown), Mississippi (yellow), and Atlantic (blue) flyways (borders indicated in panel C), with percentage of total biomass passage (migration traffic) for each flyway indicated; Declines are significant only for the full U.S. and the Mississippi and Atlantic flyways (tables S3 to S5). (C) Single-site trends in seasonal biomass passage at 143 NEXRAD stations in spring (1 Mar – 1 Jul), estimated for the period 2007-2017. Darker red colors indicate higher declines and loss of biomass passage, while blue colors indicate biomass increase. Circle size indicates trend significance, with closed circles being significant at a 95% confidence level. Only areas outside gray shading have a spatially consistent trend signal separated from background variability. (D) 10-year cumulative loss in biomass passage, estimated as the product of a spatially-explicit (generalized additive model) trend, times the surface of average cumulative spring biomass passage.

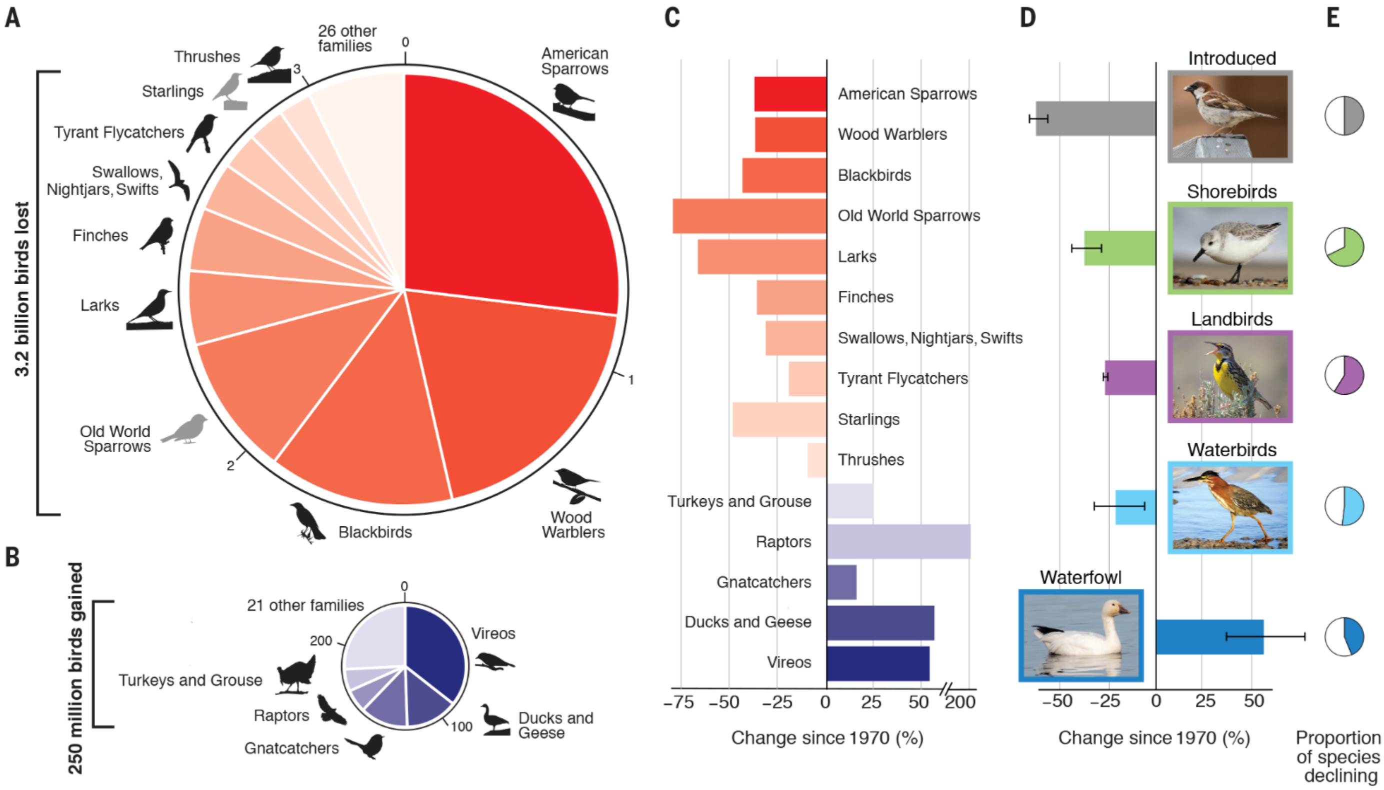


Fig. 3. **Gains and losses across the North American avifauna over the last half century.** (**A**) Bird families were categorized as having a net loss (red) or gain (blue). Total loss of 3.2 billion birds occurred across 38 families; each family with losses greater than 50 million individuals is shown as a proportion of total loss, including two introduced families (gray). Swallows, nightjars, and swifts together show loss within the aerial insectivore guild. (**B**) 29 families show a total gain of 250 million individual birds; the five families with gains greater than 15 million individuals are shown as a proportion of total gain. Four families of raptors are shown as a single group. Note that combining total gain and total loss yields a net loss of 2.9 billion birds across the entire avifauna. (**C**) For each individually represented family in B and C, proportional population change within that family is shown. See Table S2 for statistics on each individual family. (**D**) *Left,* proportion of species with declining trends and, *Right*, percentage population change among introduced and each of four management groups (*18*). A representative species from each group is shown (top to bottom, house sparrow, *Passer domesticus*; sanderling, *Calidris alba*; western meadowlark, *Sturnella neglecta*; green heron, *Butorides virescens*; and snow goose, *Anser caerulescens*).

Table 1. Net change in abundance across the North American avifauna, 1970-2017. Species are grouped into native and introduced species, management groups (landbirds, shorebirds, waterbirds, waterfowl), major breeding biomes, and nonbreeding biomes (see data S1 in (*18*) for assignments and definitions of groups and biomes). Net change in abundance is expressed in millions of breeding individuals, with upper and lower 95% credible intervals (CI) shown. Percentage of species in each group with negative trend trajectories are also noted. Values in bold indicate declines and loss; those in italics indicate gains.

Species Group	Number of Species	Net Abundance Change (Millions) & 95% CI			Percent Change & 95% CIs			Proportion Species in Decline
		Change	LC95	UC95	Change	LC95	UC95	
Species Summary								
All N. Am. Species	529	**-2,911.9**	-3,097.5	-2,732.9	**-28.8%**	-30.2%	-27.3%	57.3%
All Native Species	519	**-2,521.0**	-2,698.5	-2,347.6	**-26.5%**	-28.0%	-24.9%	57.4%
Introduced Species	10	**-391.6**	-442.3	-336.6	**-62.9%**	-66.5%	-56.4%	50.0%
Native Migratory Species	419	**-2,547.7**	-2,723.7	-2,374.5	**-28.3%**	-29.8%	-26.7%	58.2%
Native Resident Species	100	*26.3*	7.3	46.9	*5.3%*	1.4%	9.6%	54.0%
Landbirds	357	**-2,516.5**	-2,692.2	-2,346.0	**-27.1%**	-28.6%	-25.5%	58.8%
Shorebirds	44	**-17.1**	-21.8	-12.6	**-37.4%**	-45.0%	-28.8%	68.2%
Waterbirds	77	**-22.5**	-37.8	-6.3	**-21.5%**	-33.1%	-6.2%	51.9%
Waterfowl	41	*34.8*	24.5	48.3	*56.0%*	37.9%	79.4%	43.9%
Aerial Insectivores	26	**-156.8**	-183.8	-127.0	**-31.8%**	-36.4%	-26.1%	73.1%
Breeding Biome								
Grassland	31	**-717.5**	-763.9	-673.3	**-53.3%**	-55.1%	-51.5%	74.2%
Boreal forest	34	**-500.7**	-627.1	-381.0	**-33.1%**	-38.9%	-26.9%	50.0%
Forest Generalist	40	**-482.2**	-552.5	-413.4	**-18.1%**	-20.4%	-15.8%	40.0%
Habitat Generalist	38	**-417.3**	-462.1	-371.3	**-23.1%**	-25.4%	-20.7%	60.5%
Eastern Forest	63	**-166.7**	-185.8	-147.7	**-17.4%**	-19.2%	-15.6%	63.5%
Western forest	67	**-139.7**	-163.8	-116.1	**-29.5%**	-32.8%	-26.0%	64.2%
Arctic Tundra	51	**-79.9**	-131.2	-0.7	**-23.4%**	-37.5%	-0.2%	56.5%
Aridlands	62	**-35.6**	-49.7	-17.0	**-17.0%**	-23.0%	-8.1%	56.5%
Coasts	38	-6.1	-18.9	8.5	-15.0%	-39.4%	21.9%	50.0%
Wetlands	95	*20.6*	8.3	35.3	*13.0%*	5.1%	23.0%	47.4%
Nonbreeding Biome								
Temperate North America	192	**-1,413.0**	-1,521.5	-1,292.3	**-27.4%**	-29.3%	-25.3%	55.2%
South America	41	**-537.4**	-651.1	-432.6	**-40.1%**	-45.2%	-34.6%	75.6%
Southwestern Aridlands	50	**-238.1**	-261.2	-215.6	**-41.9%**	-44.5%	-39.2%	74.0%
Mexico-Central America	76	**-155.3**	-187.8	-122.0	**-15.5%**	-18.3%	-12.6%	52.6%
Widespread Neotropical	22	**-126.0**	-171.2	-86.1	**-26.8%**	-33.4%	-19.3%	45.5%
Widespread	60	-31.6	-63.1	1.6	-3.7%	-7.4%	0.2%	43.3%
Marine	26	**-16.3**	-29.7	-1.2	**-30.8%**	-49.1%	-2.5%	61.5%
Coastal	44	**-11.0**	-14.9	-6.7	**-42.0%**	-51.8%	-26.7%	68.2%
Caribbean	8	-6.0	1.4	-15.7	12.1%	-2.8%	31.7%	25.0%

Science

Decline of the North American avifauna

Kenneth V. Rosenberg, Adriaan M. Dokter, Peter J. Blancher, John R. Sauer, Adam C. Smith, Paul A. Smith, Jessica C. Stanton, Arvind Panjabi, Laura Helft, Michael Parr and Peter P. Marra

published online September 19, 2019

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.

East Bay Regional Park District
2950 PERALTA OAKS COURT • OAKLAND • CALIFORNIA • 94605-0381 • T: 1-888-EBPARKS • F: 510-569-4319 • TRS RELAY: 711 • EBPARKS.ORG

Letter 6

October 4, 2019

Andrew Young
Alameda County Planning Department/Community Development Agency
Community Development Agency
224 West Winton Ave. Rm. 111
Hayward, CA 94544-1215

RE: Comments on Sand Hill Wind Project Draft Subsequent Environmental Impact Report (DSEIR), Sand Hill Wind Repowering Project, County Planning Application PLN2017-00201.

Dear Mr. Young:

6-1

The East Bay Regional Park District ('District') appreciates the opportunity to comment on the Sand Hill Wind Project Draft Subsequent Environmental Impact Report (DSEIR) prepared by ICF (ICF 00723.18) August 2019, as follow-up to the Sand Hill Wind Repowering Project that was tiered under the Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report (PEIR, State Clearing House #2010082063), certified November 12, 2014, County Planning Application PLN2017-00201.

Wind energy production in the Altamont Pass Wind Resource Area (APWRA) represents a significant and unavoidable impact to wildlife. Short of retiring the APWRA as an energy production area to eliminate these impacts (Bell and Smallwood 2010), the next best option is to repower the APWRA in a careful manner using the best available science to minimize the immediate impacts as well as cumulative impacts. With these caveats, the District supports careful repowering of old-generation turbines in the APWRA and has over a decade of experience in working with wind turbine operators to balance the need for wind energy with the protection of natural, cultural, and visual resources in the Altamont region. District Staff serve on the Technical Advisory Committee for wind energy development for the Contra Costa County Conservation and Development Agency, and have an extensive record of conducting research with collaborators aimed at reducing the impacts of wind energy generation on volant animals (birds and bats), including but not limited to changing grazing practices to redistribute raptor prey species (ground squirrels), conducting avian and bat flight behavior observations and satellite tracking of golden eagles to inform collision hazard maps (risk maps) that inform micro-siting of wind turbines, and numerous carcass searcher and scavenger removal studies to better estimate avian and bat fatality rates in wind farms. Risk maps have been produced for the four focal species of raptors (golden eagle, red-tailed hawk, American Kestrel and burrowing owl) that were identified as the standard by which to achieve a 50% reduction in their respective fatality rates through implementation of various mitigation measures, (2007 Settlement Agreement between Audubon, Californians for Renewable Energy (CARE) and several wind energy companies). 6-1 cont.

The District has a long-standing record of monitoring populations of raptors, especially golden eagle, burrowing owl and prairie falcon, species whose local populations are at risk due to the additive mortality rates caused by wind energy generation in the APWRA.

Comments below refer to indicated sections of the DSEIR, and includes additional comments based on sPower's presentation to the Alameda County "Technical Advisory Committee (TAC)" on September 19, 2019, as well as information contained in four additional reports specifically prepared for the Project: "Siting wind turbines to minimize raptor collisions at Sand Hill Repowering Project, Altamont Pass Wind Resource Area" by K.S. Smallwood and L. Neher (Smallwood and Neher 2018); Assessment of proposed wind turbine sites to minimize raptor collisions at the Sand Hill Repowering Project in the Altamont Pass Wind Resource Area" (Estep 2019), and "Micro-sited smaller turbine layout alternative" by Anonymous (Anonymous 2019).

DSEIR 2.1 Project Description: The Sand Hill Wind Repowering Project (Project) proposes the installation of up to 40 fourth-generation wind turbines with a generating capacity between 2.3 and 4.0 megawatts (MW) each, on privately owned parcels across 2,600 acres in the Altamont Pass Wind Resource Area (APWRA) in eastern Alameda County. A total generating capacity of up to 144.5 MW is proposed. The DSEIR presents 3 Project Alternatives (ES4): No Project – Repowering by Others; No-Project – No Repowering; and Smaller-Turbine – Pre-Micro-Sited Layout 3. The latter involves reducing per turbine capacity from greater than 3.0 MW to 2.8 or 2.3 MW, which would reduce the overall Project's rated capacity from 144.5 MW to 109.5 MW.
Regardless of rated capacity, the DSEIR presents 3 turbine layout plans, each comprised of 40 turbine sites in the project area (Figs. 2-2a, b, c). Two additional turbine layout plans were developed post-DSEIR (Estep 2019; Anonymous 2019). All layout plans involve siting all 40 proposed wind turbines.

Project Scope: even at the proposed reduced capacity of 109.5 MW, the Project scope is massive and would represent approximately 24% of the APWRA's maximum rated capacity of 450 MW as set in the 2014 PEIR (PEIR 2014). The DEIR states on p 2.21 "*County staff has concluded that, although the future projects identified in the PEIR should be considered in allocating the total nameplate capacity, subsequent projects will be reviewed on a first-come, first-served basis*." This approach essentially negates the ability of the County to assess cumulative impacts of each subsequent project on the overall impact of the APWRA at final build-out and results in inadequate assessment of cumulative impacts by each subsequent project. The current DEIR's Project is no exception, as its assessment of cumulative impacts is inadequate (see below). Given this, a more robust analysis of Project-specific current and cumulative impacts should be undertaken prior to approval of nameplate capacity, and the latter should be limited to the extent dictated by the impacts analysis, likely resulting in much lower capacity than 109.5 MW. 6-2

2014 PEIR and APWRA maximum nameplate capacity of 450 MW: Table 2-6 presents approved, operational and proposed projects in the APWRA. Approved projects total 230.8 MW. With the addition of the proposed Project's 109.5 or 144.5 MW alternatives, and total APWRA-wide MW capacity would increase to either 340.3 or 375.3 MW, respectively. Add to this the proposed Mulqueeny Ranch Project (Potential Future Projects p. 2-22) of 80 MW, and the APWRA-wide capacity 6-3 rises to 420 or 455.3 MW, respectively. If one includes the Diablo Winds Project in Table 2-6 which has been operating under the 1998 EIR, the totals come to 420 or 455.3 MW, respectively. The Diablo Winds project contributes to the cumulative impacts of the APWRA (Smallwood and Karas 2009) and should be included in such analyses. Including the Diablo Winds nameplate capacity brings the APWRA-wide total nameplate capacity to 440.5 or 475.8 MW, respectively. As stated in the DPEIR (pp. 2-21 to 2.22) "…*the County will not approve a project that results in more than 450 MW of production capacity in the APWRA without additional CEQA review to address the cumulative environmental impacts that were not addressed in the PEIR*". Essentially, the current Project is at the limit at which the County cannot approve the Project without additional CEQA review that must take into account cumulative, APWRA-wide impacts. Additional repowering projects are planned in the APWRA that will not only exceed the 450 MW cap (e.g. Clearway Energy p. 2-21), but also include new areas not previously sited with wind turbines. The County needs to develop a new PEIR to account for additive wind projects and associated impacts. 6-3 cont.

6-4

Turbine Micro-Siting (DSEIR 3.4-11-12 and PEIR Mitigation Measure BIO-11b DSEIR 3.4-75)):
Smallwood and Neher (2018) used map-based collision hazard (risk) models to analyze three of five turbine layouts of the Project. The risk models produced for the Sand Hill project were the latest generation models, refined from previous risk models that had been developed for the Tres Vaqueros and Vasco Winds projects in Contra Costa County, and Patterson Pass, Golden Hills and Golden Hill North projects in Alameda County. The risk models incorporated data from thousands of bird flight observations conducted over more than a decade, hundreds of specific golden eagle flight observations across ridgelines with and without the presence of old generation and new generation wind turbines, thousands of telemetry data points from golden eagles outfitted with GPS/GSM satellite transmitters, mapped burrowing owl burrow complexes and location-specific fatality data (including species-specific collision histories) from previous monitoring efforts within the Project footprint. Table 11 of Smallwood and Neher (2018) presents results of the analysis for 3 of the 5 Project's turbine layout schemes. For each proposed turbine location, it presents an updated SRC hazard rating (in principal, the same qualitative approach used by Estep (2019)). includes Fuzzy Logic (FL) hazard classes for the four "focal" species of raptors – golden eagle, red-tailed hawk, American kestrel and burrowing owl (PEIR 2014), nearest old (pre-repowered) turbines, old SRC ratings and collision histories. This information is "translated" to initial siting assessments and recommendations in Table 12 of Smallwood and Neher (2018). It should be noted that the Smallwood and Neher (2018) report does not apply the FL models to turbine locations 27 to 35 because these locations are in the Project area that has been devoid of turbines for decades and thus were assumed to be outside of original repowering plans. It should further be noted that Smallwood intended to follow-up this initial siting report with site-visits and further consultations with sPower (Smallwood 2019). That did not happen. Instead, sPower enlisted Estep Environmental Consulting to perform a follow-up, on-site, qualitative assessment of proposed turbine locations in Layouts 1-5 (Estep 2019). The turbine site assessment by Estep (2019) employed a qualitative hazard rating scale similar to the SRC hazard classes. Table 1 of the report by Estep (2019) summarizes risk determinations and exact siting recommendations for 81 alternative locations for the 40 proposed turbine locations of the Project. Anonymous (2019) attempts to summarize conclusions of both Smallwood and Neher (2018) and Estep (2019), and provides justifications for the Project's final 40 turbine siting locations in layout 5 (see Exhibit 1; Anonymous 2019). However, Smallwood (2019) disagrees with Anonymous' (2019) attributing 8 turbine

relocations to Smallwood and Neher (2018). For a critique of both the Estep (2109) and Anonymous (2019) reports, see Smallwood (2019). 6-4 cont.

Smallwood and Neher (2018) raised concerns about the locations of turbines 4 (we recommend avoiding this site), 10 (uncertain about likely impacts), 16A (we recommend avoiding this site), 16B (we recommend avoiding this site), 17A (we recommend avoiding this site), 20A (we recommend avoiding this site), 20B (relatively unsafe for eagles), 21 (we recommend avoiding this site), 25 (no solution, we recommend avoiding this site), 34 (we recommend avoiding this site), and 40 (no local option to recommend). Table 1 of the Estep (2019) report list the following turbine locations as "High Risk": 4A, 4B, 13A-D, 16A-C, 18A (followed by "None" for recommended locations of 18A-C), 21A, 27A, 28A-B, 29A, 30A-B (followed by "None" for recommended locations), 34A, 37A. According to Exhibit A in Anonymous (2019), (listed as Anon below) the following turbines in Layout 5 were sited *contra* the recommendations of Smallwood and Neher (2018) (SN below) and/or Estep (2019) (Es Below) as noted:

Turbine 3: SN- no better options locally; Es- move N 105'; Anon - moved N 105'
Turbine 4: SN- avoid; Es- move S 225'; Anon- could not move due to wake effects
Turbine 9: SN- shift W, uphill; Es- move NW 280'; Anon- could not move due to wake effects
Turbine 10: SN- uncertain about likely impacts; Es- use site; Anon- site used
Turbine 14: SN- use 14-2; Es-move N 130'; Anon-cannot use 14-2 due to wake effects, moved 14-1 N 130'
Turbine 15: SN-shift N 25m; ES- move NW 140'; Anon- could not move N 25m due to wake effects, moved NW 140'
Turbine 17: SN- move N to ridge crest; Es- move N 250'; Anon- could not move due to wake effects
Turbine 19: SN- maybe safer S 30m; Es- no recommendation: Anon- could not move due to wake effects
Turbine 20: SN- 20-1 move N to crest, 20-2,3 recommend avoid, unsafe for eagles); E- ,move NNE 80'; Anon- - could not move N to crest due to wake effects, moved 80' NNE
Turbine 23: SN- no safer local option; Es- move S 100' to top of hill; Anon- could not move due to setback requirements
Turbine 24: SN- no safer local option; Es- move SW 150'; Anon- moved SW 150'
Turbine 25: SN- recommend avoiding site; Es- no recommendation; Anon- N/A, using site
Turbine 27: SN- move N to peak; Es- move S 200'; Anon- could not move N due to setback, could not move S due to wake effects
Turbine 28-4: SN- location not in array analyzed; Es- move 150' to hill top; Anon- could not move due to wake effects
Turbine 30: SN- no better local options; Es- no recommendation; Anon- move slightly, Estep- use site
Turbine 34: SN- recommend avoiding site; Es- move E 350'; Anon- could not move due to setback
Turbine 36: SN- move NNW away from canyon edge; Es-move NW 200'; Anon- could not move due to wake effect
Turbine 37: SN- move W to higher ground; Es- move SW 140'; Anon- could not move due to wake effect
Turbine 40: SN- location not in array analyzed; Es- move NW 275'; Anon- could not move due to wake effect

Summary: 18 turbine locations seriously conflict with siting recommendations between Smallwood and Neher (2018) and/or Estep (2019). Of these, 11 turbines could not be re-sited due to wake effects or set-back requirements (yellow highlights) according to Anonymous (2019). Anonymous (2019, maintains that decreasing turbine size from 3.8 MW to 2.8 MW, increasing turbine blade height above ground from 13m to 25m, and decreasing in rotor swept area (RSA) mitigate the above siting decisions. The PEIR (2014) recommends minimum turbine blade height above ground of 29 m. Blade heights above ground level of all Project turbines are below this minimum blade height: 13 m (3.8 MW), 25 m (2.8 MW) and 22 m (2.3 MW). These "repowered" turbines bring blade reaches into pre-repowered height domains of the deadly old gen turbines. Thus, any benefits accrued through decreasing RSA may be eliminated through the Project's minimum blade height above ground regardless of RSA. In addition, we have seen a trend in the APWRA where repowering with numerous smaller turbines, e.g. 1.79 MW turbines at Golden Hills (HT Harvey 2018) versus larger turbines can have greater wildlife impacts (except bats) than repowering with large turbines (Brown et al. 2016). The benefits of any careful micro-siting are likely going to be offset by too many turbines in too small an area (see Fig. 1 below). 6-4 cont.

The fact that 11 turbines in layout 5 could not be relocated due mostly to wake effects suggests that they too tightly packed, some less than 300 feet part on neighboring ridgelines. Project proponents maintain both in print and in public meetings that in these cases, economics trump environmental considerations in that purchase power agreements hinge upon the 40 turbine Project layout. However, economics do not require a 40 project turbine layout. The APWRA can and does support projects with markedly reduced nameplate capacities and their associated purchase power agreements (e.g. see other projects in the APWRA operating of far less MW capacity in Table 2-6, DSEIR). Thus, the project could be scaled back. Based on micro-siting analyses alone, at least 11-18 Project turbines, and likely more such as additional turbines listed "of concern" by Smallwood and Neher (2018) and those designated as "High Risk" by Estep (2019), should be considered for elimination from Project scope to reduce significant and unavoidable impacts to wildlife. Additional micro-siting analyses should be conducted to rectify conflicting interpretations of the micro-siting reports (Smallwood and Neher 2018), Estep (2109), Anonymous (2019) and Smallwood (2019) and attendant recommendations. 6-5

Ideally, maco-siting a wind project, that is, deciding whether a project's proposed location is appropriate from a benefit (energy production) versus cost (environmental, economic) analysis, should be employed prior to developing a wind project. This is obviously too late for the APWRA. However, macro-siting can be employed within a Project's footprint to inform micro-siting. For example, satellite telemetry of 29 non-adult (non-territorial) golden eagles using the APWRA indicate extensive use of the Sand Hill project footprint (Fig. 1). Note that these data do not include any use data by territorial golden eagles in the APWRA, nor does it include other, non-telemetered golden eagles using the APWRA. Such extensive use of the Sand Hill Project Footprint by golden eagles suggests that one way to reduce overall risk to eagles is to decrease the scope of the project via decreasing the absolute number and packing of wind turbines to the extent practical. Smallwood et al (2008) found that raptor use was greater in turbine-free areas. Thus, eliminating high-risk turbines or turbines as identified by micro-siting could go a long way towards reducing overall risk to wildlife.

Fig 1 referenced in Comment 6-4

Golden Eagles Telemetry Data within the Altamont Pass Wind Resource Area

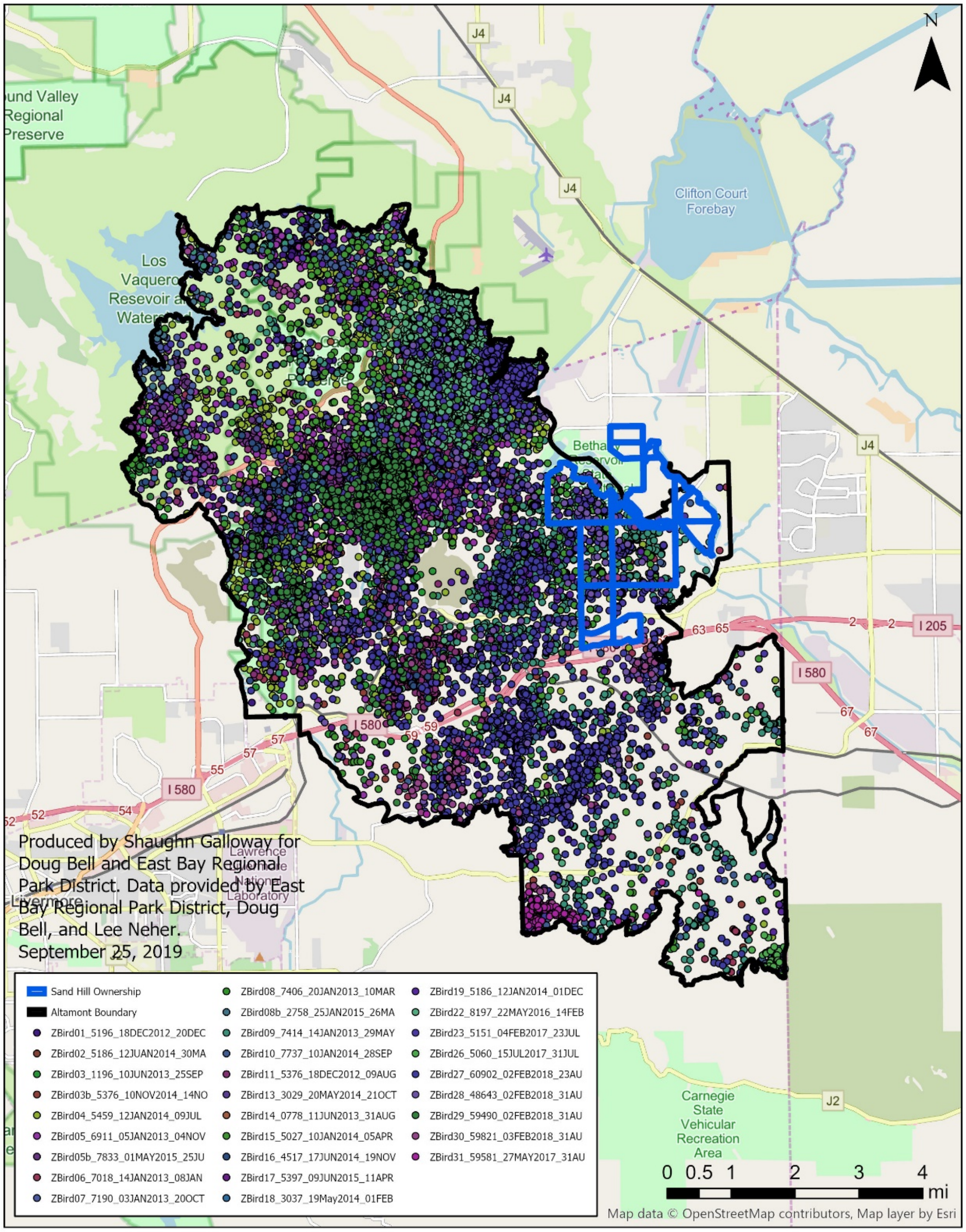


Figure 1. Satellite telemetry locations of 29 non-adult golden eagles using the APWRA, 2012-2018. Dot colors denote different individuals. Location points taken in 15 min intervals from flying eagles (not perched). Sand Hill Project outlined in blue. Note data are lacking in the northern portion of Sand Hill Project because that region lay outside of the boundary of the APWRA (black outline) that was used in this analysis.

<u>Additional Fatality Monitoring Studies (DSEIR 3.4-9-11):</u> Attributing increased second-year golden eagle mortality rates at Golden Hills to bias from increased perching opportunities provided by old gen turbines near the site is pure conjecture, golden eagles spend considerable time perched on the ground and low rocks throughout the APWRA in areas where structures are lacking (personal observations). Likewise, although climate does influence inter-annual variability in environmental parameters, the reported "surge" in golden eagle productivity following a wet year in 2018 (HT Harvey & Associates 2018b:63) did not happen locally (EBRPD, unpublished data; Contra Costa Water District). 6-6

<u>Additional Studies on Golden Eagle (DSEIR 3.4-12-15):</u> "*The findings of the study indicated that the average nearest-neighbor distance of simultaneously occupied territories was approximately 3.2 km…Bell (2017)"* (DSEIR 3.4-13). This citation is wrongly attributed to Bell (2017a,b). "*The applicant notes that those data indicate that between 2014 and 2019, USGS surveys have documented 0-2 eagle nests each year within the APWRA"* (DSEIR 34.13). Contrary to this statement, Kolar and Wiens (2017) documented up to 15 territorial pairs of golden eagles within 3.2 km of wind turbines in the APWRA between 2014-16 with 4, 3 and 6 nesting attempts in those respective years (see also Wiens and Kolar 2018), At least 3 golden eagle nests are present in or very near the Project boundary. Project proponent has access to these nest location data from recent surveys that have been provided by the USGS and/or ICF. "*Furthermore, those data indicate that nest site fidelity is low within the AWPRA*" (DSEIR 34-13). In this area, golden eagles may have one to several alternate nests within their respective territories (EBRPD unpublished data). Thus one of several nests may be used in a given year. A nesting attempt is a nesting attempt, regardless of individual site fidelity. *"It is likely that the current estimate of 718 individuals in BCR 32 currently used by USFWS to estimated cumulative effects on golden eagles is an underestimate"* (DSEIR 34.13) and *"Cumulative impacts on the Altamont LAP are likely to be substantially lower than previously estimated by USFWS*" (DSEIR 34-14). LAP is defined as the "local area population" and is based on the number golden eagles within 109 miles of a project site (US Fish and Wildlife Service 2013). The DSEIR uses the USGS estimate of 280 territorial pairs within the Diablo Range (Wiens et al. 2015) to then estimate the total Sand Hill LAP, including those outside of the Diablo Range, as 840 individuals. This latter number is important in calculating the percentage "take" by a project for assessing mitigation. But this estimate is purely area-based and is not based on any habitat suitability modeling similar to the performed by Wiens et al. (2015). In addition, it does not take into account population-specific movements of individuals. The majority of juvenile, sub-adult and floater adult golden eagles tagged with GSM-GPS satellite transmitters between 2012 and 2017 within 30km of the APWRA remained within the Diablo Range from the Carquinez Strait in the north south to mountains east of Hollister (Bell 2017a,b), suggesting that the Sand Hill LAP is much smaller in area than the estimated LAP and in fact does not include much if any of the areas north of the Carquinez Strait and little of the southern Diablo Range below San Benito Mountain. Thus, cumulative impacts of the APWRA on local golden eagle populations may be more severe than indicated in the DSEIR (see below).

<u>Special Status Wildlife (DSEIR 3.4-19-23) and Impact BIO-8 (DSEIR 3.4-58-61):</u> Recent survey work has documented nesting of golden eagle in isolated trees in the APWRA (EBRPD unpublished data, Kolar and Wiens 2017) and Swainson's hawk at the Mountain House Conservation Bank, which located adjacent to the northern extent of the Project footprint (Joe DiDonato, personal communication) and Vasco Caves Regional Preserve (EBRPD unpublished data). In addition, the United States Geological Survey (USGS) has documented a golden eagle nest in a tree within the Project footprint and on transmission towers either within or near the project footprint (Kolar, unpublished data), and cliff 6-7

6-7 cont.

nesting golden eagles have been documented within the APWRA as recently as 2018 (Kolar, pers. Comm., see also Wiens and Kolar 2019). The PEIR requires surveys for golden eagle nests within 2 miles of the project site for developing site-specific risk analyses in consultation with the US Fish and Wildlife Service (Service). We do not consider removal of suitable nesting habitat (shrubs and trees) during the non-breeding season to be a viable mitigation measure. Tricolored blackbirds have recently been documented nesting at Vasco Caves Regional Preserve (EBRPD unpublished data).

6-8

Impact BIO-11 (DSEIR 3.4-66-74): Regardless of how annual fatalities for the Sand Hill Wind Repowering project are calculated (Table 3.4-8), repowering the APRWA will continue to cause significant and unavoidable impacts related to avian and bat mortality. The first two years of monitoring of the repowered Golden Hills Project (H.T. Harvey & Associates (2018a,b) indicates that mortality rates for the focal species golden eagle and red-tailed hawk, among others, are substantially higher than estimated from the PIER (2014) (see also DSEIR: Table 3.4-8). For golden eagle, total fatalities from years 1 and 2 at Golden Hills are 11 and 15, respectively (Table ES-2, H.T. Harvey & Associates (2018a, b). The PIER (2014) estimated average annual fatalities for a fully repowered 417 MW APWRA (Alternative 1) at 4-17 golden eagles (PEIR: Table 3.4-10), and for a 450 MW APWRA (Alternative 2) at 5-18 golden eagles (PEIR: Table 3.4-12). Thus, the Golden Hills project alone may potentially exceed the PIER (2014) threshold for impacts to golden eagles from the projected repowering of the entire APWRA. Including the cumulative effects from the existing repowered projects (Diablo Winds, Buena Vista, Vasco Winds) pushes the golden eagle fatality rate above the threshold set by the PEIR (2014). In effect, the significant and unavoidable impact of the Project, and permitted projects yet to be built, may be far more severe than previously assumed. Cumulative impacts from further repowering of the APWRA, combined with existing impacts, may likely bring blade strike mortality rates for golden eagle back into the pre-repowered range of 55-65 annual fatalities. Hunt et al. (2017) have estimated that the entire reproductive output of 216-255 breeding pairs of golden eagles would be required to sustain a population in the face of such a mortality rate. Wiens et al. (2014, 2018) detected a total of 199 pairs and estimated a total population of approximately 280 pairs for the northern Diablo Range. In other words, the entire annual reproductive output of golden eagles in the northern Diablo Range may be required to compensate for the loss of eagles in the APWRA. Furthermore, eagle productivity in the northern Diablo Range is severely depressed during drought (Wiens et al. 2018). In effect, a fully repowered APWRA may continue to represent a population sink to golden eagles in the northern Diablo Range unless significant mitigation measures are undertaken (Bell and Smallwood 2010, Wiens et al. 2018) or subsequent projects are downsized in rated capacity to the extent practical.

6-9

2019 Updated PEIR Mitigation Measure BIO-11h (DSEIR 3.4-79-84): For golden eagles and other raptors, the EBRPD supports and encourages the implementation of *Conservation Measures* (DSEIR 3.4-80) above and beyond the USFWS's Eagle Conservation Plan guidelines of retrofitting high risk electrical infrastructure (US Fish and Wildlife Service 2013).

- Contributing to regional conservation of raptor habitat (DSEIR 3.4-83) and Other Conservation Measures Identified in the Future (DSEIR 3.4-82): Compensatory mitigation should be applied broadly and at the landscape level. In the case of golden eagles, take thresholds should be set at the local level commensurate with the sustainability of the local eagle population, and it should include cumulative effects, including the loss of reproductive potential of an eagle based on its age class. Compensatory mitigation should include habitat restoration and enhancement of

6-9 cont.

prey populations that would directly benefit golden eagles. For example, the ground squirrel in California is a major prey item for golden eagles; it is also a keystone species for grasslands. Some landowners adjacent to the APWRA control this species via poisoning which often results in secondary poisoning of eagles and other predators. Mitigation could involve compensating ranchers for economic loss due to ground squirrels if they cease poisoning. Related to this, compensatory mitigation could support programs that create conservation easements or conservation bank credits on private lands that would then be a managed for golden eagles (and other species). For example, an unprecedented opportunity presents itself with the sale of the N3 Ranch, a 50,000 acre property south of the APWRA that spans four counties that no doubt supports habitat for golden eagles and many listed species https://www.californiaoutdoorproperties.com/listing/n3-cattle-company. Compensatory mitigation could be used to reduce other known threats, such as payments for retiring wind rights or wind farms in areas where eagle and other raptor mortality rates are unsustainable. Outright land acquisition or purchase of key parcels that may sustain a local eagle population (e.g. parcels with nests) could also be part of a mitigation strategy.

- <u>Contribute to raptor conservation efforts (DSEIR 34.81)</u>: Project proponents are required to contribute $580/raptor fatality to raptor conservation efforts (PEIR 2104). This amount is based on the average cost to rehabilitate one raptor at the California Raptor Center, U.C. Davis. This number is wholly inadequate and does not take into account transporting a wounded raptor to a veterinary facility, veterinary medical attention, the cost of pharmaceuticals and medical supplies, staff and volunteer time required to treat a wounded raptor or even euthanize a mortally-wounded raptor. The medical treatment of a single raptor prior to entering rehab can costs thousands of dollars and take months. As such, County should consult wildlife hospitals in the region, e.g. Lindsay Wildlife Hospital (Walnut Creek), Sulpher Creek Nature Center (Hayward), and the UC Davis School of Veterinary Medicine to obtain realistic cost estimates for treating injured wildlife, in addition to the costs incurred for rehabbing a raptor at the Davis Raptor Center for release. This being said, only in rare cases are raptors injured by wind projects releasable.

<u>PEIR Mitigation Measure BIO11-i 84 Implement an avian adaptive management program (DSEIR 3.4-83)</u>: 6-10
Such a program should include the options of seasonal shutdowns and turbine removal or relocations. H.T. Harvey & Associates (2018a,b) have identified potential fatality hotspots at specific turbine locations. Removal of turbines identified as such through post-construction monitoring may be the *best and only* option available to substantially reduce impacts to golden eagles and other raptors.

<u>Impact BIO-14.: Turbine-related fatalities of special-status and other bats (significant and unavoidable) (DSEIR 3.4-86-92):</u> Wind turbine related bat fatalities represent a challenging and significant impact. Results from years 1 and 2 of Golden Hills monitoring using scent-detection dogs estimated annual bat mortalities of 549 (425-663) and 500 (326-674) individuals, respectively (H.T. Harvey & Associates 2018a,b). These annual mortality rates are far greater than previously reported for the APWRA, and they belie a trend noted in the Vasco Winds study (Brown et al. 2016), namely, that bat fatalities increase with larger repowered wind turbines relative to the old generation turbines. Smallwood has noted bats being attracted to operating turbine nacelles and foraging in their immediate vicinity (Smallwood et al. *in prep*). Table 3.4-9 (DSEIR 3.4-87) estimates 463-566 annual bat mortalities for the Sand Hill Project. In order to refine this estimate, it is imperative that post-construction bat fatality 6-11

monitoring use scent detection dogs in monitoring trials. For example, Smallwood et al. (in prep) in one monitoring study that compared dog versus human searchers, dogs found 71 bat fatalities in 55 searches compared to humans finding 1 bat in 69 searches of the same site (Smallwood et al. *in prep*). Only by understanding the true bat mortality rate can sufficient mitigation measures be developed and implemented. 6-11 cont.

6-12

Thank you for this opportunity to comment on the Notice of Preparation of Subsequent Environmental Impact Report (SEIR) for the Sand Hill Wind Repowering Project, County Planning Application PLN2017-00201.

Sincerely yours,

signed for

Douglas A. Bell, Ph.D.
Wildlife Program Manager

dbell@ebparks.org

References

Alameda County Community Development Department. 2018. Sand Hill Wind Repowering Project Environmental Analysis. September [ICF 00631.17] Hayward, CA. With technical assistance from ICF, Sacramento, CA.

Bell, D. A. 2017a. GPS Satellite Tracking of Golden Eagles (*Aquila chrysaetos*) in the Altamont Pass Wind Resource Area (APWRA) and the Diablo Range: Final Report for Phases 1 and 2 of the NextEra Energy Settlement Agreement. Active Birds. East Bay Regional Park District, Oakland, California.

Bell, D. A. 2017b. GPS Satellite Tracking of Golden Eagles (*Aquila chrysaetos*) in the Altamont Pass Wind Resource Area (APWRA) and the Diablo Range: Final Report for Phases 1 and 2 of the NextEra Energy Settlement Agreement. Supplement - Inactive Birds. East Bay Regional Park District, Oakland, California.

Bell, D.A. and K.S. Smallwood. 2010. Birds of prey remain at risk. Science 330:912.

Brown, K., Smallwood, K.S., Karas, B., and J.M. Szewczak. 2016. Final Report 2012-2015, Avian and Bat Monitoring Project, Vasco Winds, LLC. Prepared by Ventus Environmental Solutions, Portland, Oregon. Prepared for NextEra Energy Resources, Livermore, CA.

H.T. Harvey & Associates 2018a. Golden Hills Wind Energy Center Postconstruction Fatality Monitoring Report: Year 1. PROJECT 3926. Prepared by H.T. Harvey & Associates, Los Gatos, CA. Prepared for Golden Hills, LLC, Livermore, CA.

H.T. Harvey & Associates 2018b. Golden Hills Wind Energy Center Postconstruction Fatality Monitoring Report: Year 2. PROJECT 3926. Prepared by H.T. Harvey & Associates, Los Gatos, CA. Prepared for Golden Hills, LLC, Livermore, CA.

Hunt, G., Wiens, J.D., Law, P.R. Fuller, M.R., Hunt, T., Driscoll, D.E. Jackman R.E. 2017. Quantifying the demographic cost of human-related mortality of a raptor population. PLoS ONE 12(2): e0172232. https://doi.org/10.1371/journal.pone.0172232

ICF International. 2014a. Draft Altamont Pass Wind Resource Area Bird Fatality Study, Bird Years 2005-2012. SRC Ref No. M101. http://www.altamontsrc.org/alt_doc/m101_apwra_2005_2012_bird_fatality_report.pdf

ICF International. 2014b. Altamont Pass Wind Resource Area Bird Fatality Study, Bird Years 2005-2012. June. Final. M101 . (ICF 00904.08.) Sacramento, CA. Prepared for Alameda County Community Development Agency, Hayward, CA.

ICF 2018a. Biological Resources Evaluation for the Sand Hill Wind Repowering Project. June. 2018. Sacramento, CA. Prepared for Alameda County Community Development Agency, Hayward, CA.

ICF International. 2018b. Sand Hill Wind Repowering Project Environmental Analysis. September 2018. Sacramento, CA. Prepared for Alameda County Community Development Agency, Hayward, CA.

Kolar, P.S., and Wiens, J.D. 2017. Distribution, nesting activities and age-class of territorial pairs of golden eagles at the Altamont pass Wind Resource Area, California, 2014-16: United States Geological Survey Open-File Report 2017-1035, 18 p., https://doi.org/10.3133/ofr20171035.

PIER. 2014. Alameda County Community Development Agency. 2014. Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report. State Clearinghouse #2010082063. Hayward, CA.

Smallwood, K.S. 2018. Addendum to comparison of wind turbine collision hazard model performance: one year post-construction assessment of golden eagle fatalities at Golden Hills. Prepared for NextEra, Livermore, CA.
Smallwood, k. and B. Karas. 2009. Avian and bat fatality rates at old-generation and repowered wind turbines in California. J. Wildlife Management 73:1062-1071.

Smallwood, K. S., and L. Neher. 2009. Map-Based Repowering of the Altamont Pass Wind Resource Area Based on Burrowing Owl Burrows, Raptor Flights, and Collisions with WindTurbines. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. CEC-500-2009-065. Sacramento, California. 63

pp. http://www.energy.ca.gov/2009publications/CEC-500-2009-065/CEC-500-2009- 065.PDF

Smallwood, K.S. and L. Neher. 2017, 2018. Comparison of wind turbine collision hazard model performance prepared for repowering projects in the Altamont Pass Wind Resource Area. Prepared for NextEra, Livermore, CA.

Smallwood, K. S., L. Neher, and D. A. Bell. 2009. Map-based repowering and reorganization of wind resource area to minimize burrowing owl and other bird fatalities. Energies 2009(2):915 943. http://www.mdpi.com/1996-1073/2/4/915

Smallwood, K.S., Bell, D.A., Walther, E.L., Levyas, E., Standish, S., Mount, J., and B. Karas. 2018. Estimating wind turbine fatalities using integrated detection trials. J. Wildlife Management 82:1169-1184.

Smallwood, K.S., Neher, L. and D. A. Bell. 2017. Turbine siting for raptors: an example from repowering of the Altamont Pass Wind Resource Area. Pp. 145-166 *in* Perrow, M.R. (ed) (2017) Wildlife and Wind Farms, Conflicts and Solutions. Volume 2 Onshore: Monitoring and Mitigation. Pelagic Publishing, Exeter, UK.

U.S. Fish and Wildlife Service. 2013. Eagle Conservation Plan Guidance: Module 1 – Land-based Wind Energy V. 2. US. Fish and Wildlife Service. https://www.fws.gov/migratorybirds/pdf/management/eagleconservationplanguidance.pdf

Wiens, J.D. and P.S. Kolar. 2019. Golden eagle population monitoring in the vicinity of the Altamont Pass Wind Resource Area, California, 2014-2018. Administrative report prepared for NextEra Energy. United States Geological Survey, Corvallis OR

Wiens, J.D., Kolar, P.S, Hunt, G.W., Fuller, M.R. Hunt, GW, and T. Hunt. 2015. Estimation of occupancy, breeding success and predicted abundance of golden eagles (*Aquila chrysaetos*) in the Diablo Range, California, 2014. US Geological Survey Open-File Report 2015-1039, 23p. http://dx.doi,org/10.3133/ofr20151039

Wiens, J.D., Kolar, P.S, Hunt, G.W., Hunt, T., Fuller, M.R. and D. A. Bell. 2018. Spatial patterns and reproduction of golden eagles during drought: prospects for conservation in changing environments. The Condor: Ornithological Applications 120: 106-124.

Letter 7

inspiring people to protect
Bay Area birds since 1917

Andrew Young, Planner
Alameda County Planning Department
Community Development Agency
224 W. Winton Avenue, Suite 110
Hayward, CA 49544
andrew.young@acgov.org

Oct 04, 2019

re: Comment in Response to the draft Subsequent Environmental Impact Report (dSEIR) for the Sand Hill Wind Repowering Project, tiered under the Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report (PEIR, State Clearinghouse #2010082063), certified November 12, 2014. County Planning Application PLN2017-00201

Dear Mr, Young,

7-1

On behalf of the Golden Gate Audubon Society (GGAS), thank you for this opportunity to comment on the draft Subsequent Environmental Impact Report (dSEIR) for the Sand Hill Repowering Project, tiered under the Altamont Pass Wind Resource Area (APWRA) Repowering Final Program Environmental Impact Report (PEIR, State Clearinghouse #2010082063), certified November 12, 2014, PLN2017-00201.

GGAS is a 102 year old non-profit organization with over 7,000 members who are dedicated to protecting native bird populations and their habitats. GGAS incorporates by reference comments from GGAS on the Sand Hill Conditional Use Permit, PLN2017-00201 that were submitted to this Lead Agency on Oct 1, 2018 and on the Notice of Preparation of a Subsequent Environmental Impact Report (SEIR) that were submitted on Feb 13, 2019. GGAS also incorporates by reference October 2018 comments on this project from the State Attorney General's office and from the State Department of Fish and Wildlife and additional comments on the Notice of Preparation of an SEIR from the State Attorney General's office dated Feb 13, 2019 and on the Notice of Preparation of an SEIR from the California Department of Fish and Wildlife from February, 2019.

This comment is in response to the Notice of Availability a draft Subsequent EIR (dSEIR) for the Sand Hill Wind Repowering Project (Project) as an application for a Conditional Use Permit (CUP) to redevelop an estimated 671 prior wind turbine sites with up to 40 new turbines with maximum production capacity of 144.5 megawatts (MW) on approximately 2,600 acres within the northeasterly quadrant of the Alameda County portion of the APWRA.

7-1 cont.

As described on page ES-1, "the proposed Project [will install] up to 40 new wind turbines … with generating capacities between 2.3 and 4.0 megawatts (MW) each, all generally similar in size and appearance, to develop up to 144.5 MW of generating capacity." The project site encompasses 15 privately owned discontinuous parcels on approximately 2,600 acres. The dSEIR was evaluated pursuant to Section 15162 of the California Environmental Quality Act (CEQA) Guidelines, and as tiered under the Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report (PEIR, State Clearinghouse #2010082063), certified November 12, 2014.

The dSEIR was reviewed for its thoroughness in identifying and analyzing adverse impacts to birds and bats in particular from the Project that may constitute significant environmental effects as proposed by Sand Hill Wind LLC (Sand Hill). The dSEIR is the basis for determining the adequacy of consideration of specific alternatives to this proposed Project. Mitigation measures for avoiding or minimizing adverse impacts or for compensating for unavoidable significant effects require a detailed evaluation for their adequacy in this dSEIR.[1] For this dSEIR to be legally adequate under CEQA and before the County can issue a final approval, there must be an accurate analysis that is made available to the public of the project's significant effects.[2] The focus of this comment is the analysis of potential adverse impacts to avian and bat populations in the project area.

BASELINE AND EXISTING CONDITIONS

7-2

<u>The Project-level Analysis of the Proposed Scope of the dSEIR Should Describe Two Sets of Existing Conditions That Constitute the Current Baseline for Evaluating Impacts</u>

CEQA Guidelines, Title 14 Article 9. §15125(a)[3] stress that knowledge of the regional setting is critical to an assessment of environmental impacts. The impact assessment should emphasize a thorough description and detailed knowledge of rare and unique species and resources in the project area.

---

1 Pub. Res. Code § 21002. [P]ublic agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects…[T]he procedures required by this division are intended to assist public agencies in systematically identifying both the significant effects of proposed projects and the feasible alternatives or feasible mitigation measures which will avoid or substantially lessen such significant effects."

2 Pub. Res. Code § 21002.1(e) "To provide more meaningful public disclosure, and focus on potentially significant effects on the environment of a proposed project, lead agencies shall…focus … on those potential effects on the environment of a proposed project which the lead agency has determined are or may be significant."

3 An EIR must include a description of the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published… This environmental setting will normally constitute the baseline physical conditions by which a lead agency determines whether an impact is significant.
§ 15125(a) CEQA Guidelines. (Cal. Code Regs., tit. 14, § 15000 et seq
Found at: http://resources.ca.gov/ceqa/guidelines/art9.html

7-2 cont.

The Project area's initial conditions should consider two sets of description because the prior wind farm operation that occupied nearly half of the project site ended over twenty years ago. On page 3.4-6, the Environmental Setting describes, "Much of the Project area is occupied by a previously operating wind farm within a rural, unincorporated portion of northeastern Alameda County." On page 2-2, Existing Conditions, "All of the parcels were previously used for wind energy production, although about half the area has not contained wind turbines for about two decades." Therefore, the detailed description and comprehensive evaluation of initial conditions in the Project area that serve as the baseline for determining impacts that may constitute significant effects need additional consideration as both a repower of a former wind farm and as a new project on an undeveloped area.

A thorough description of both sets of existing conditions will better serve as a baseline for analyzing impacts from temporary and permanent land disturbance and for methods of removal of old turbines and pads. An analysis of dual initial considerations will better inform a detailed report on how this baseline analysis fits criteria for both repowering requirements and for a new wind farm operation.

The environmental setting for this project-site baseline included elements of a required description that were found to be inadequate: 7-3

- Descriptions of old turbines, pads, equipment or locations were vague. See page 2.2 ("The proposed Project may include the removal of old turbine foundations.")
- Except for referencing documents and resource databases, detailed descriptions and evaluations of temporary and permanently disturbed terrain were vague.
- Detailed descriptions of existing roads, operation and maintenance sites and activities, temporary and permanent storage of wind farm equipment were vague. See page 2-2 "

Evaluation of the project's effects depends on detailed descriptions of proposed new physical structures and operations. The project descriptions did not incorporate the following necessary elements. Therefore the basis for measuring the project's effects is inadequate.

The detailed description should include all proposed new construction and associated potential impacts, including road infrastructure upgrades, the proposed new Operations & Maintenance (O&M) facility, and associated physical structures and activities.

The descriptions on pages 2-4 and 2-6 and Table 2-3 on page 2-9 should provide exact locations and adequate detail for measuring effects from temporary or permanent disturbance. While Table 2-3 estimates the acreage that would temporarily or permanently impacted, the exact locations, magnitude, and intensity of impacts are not in evidence:

- "Existing roads would be used where possible, and temporary widening and some new roads would be necessary." 7-3 cont.
- "Use of existing roads to the extent possible….New roads may be needed in areas where existing roads do not provide access to proposed turbine locations." Pages 2.4, 2.6

Use of an existing operations and maintenance (O&M) facility and additional related information on page 2-16 describe "a wide variety of activities" that are conducted "in and around the tower." However, the information is narrative in style and does not identify exact locations, describe disturbances to vegetation, or quantify the duration, magnitude, or intensity of specific activities. Descriptions of these activities should identify methods for assessing disturbances to baseline initial conditions and measuring impacts that can be avoided or minimized.

Installation of three permanent meteorological towers are described in Table 2-3 on page 2-9 as permanently impacting 0.2 acres and temporarily impacting 207.5 acres. However, on page 2.2, "Four [not three] 50-meter (164-foot) meteorological towers are present onsite." No description of the magnitude, intensity, or duration of the installation impacts are included with this information. On page 3.4-76 PEIR Mitigation Measure BIO-11d states: "All permanent meteorological towers will be unlit unless lighting is required by FAA." Details about the type of impacts form a basis for determining whether the impacts constitute a significant effect that should be avoided or mitigated. Without adequate baseline information about the type of disturbance that tower installation is expected to create, a method for measuring impacts, avoidance and minimization measures cannot be analyzed. The same information is repeated in Table 3.4-6 but again, the descriptions for measuring impacts and recommendations for avoiding or minimizing impacts are not available. Table 2-4 on page 2-10 describes the duration of project activities but does not address their magnitude or intensity.

<u>The dSEIR Should Provide A Detailed Analysis of Altamont's Carrying Capacity for the Four Focal Species – Golden Eagle, Red-tailed Hawk, American Kestrel, Western Burrowing Owl – and the Tricolored Blackbird, a California Threatened Species</u> 7-4

- Careful consideration of the Altamont's biological carrying capacity for the four focal species – golden eagle, red-tailed hawk, American kestrel, Western burrowing owl - the tricolored blackbird, and Altamont-area bats as an existing condition in the project-site baseline was not included.
- Analysis of tricolored blackbird occupancy and activity within and near the project site - a species listed as Threatened under the California Endangered Species Act.[4]

[4] "[T]he California Fish and Game Commission (Commission), … on April 19, 2018, found pursuant to Fish and Game Code Section 2075.5, that the information contained in the petition to list tricolored blackbird (Agelaius tricolor) … warrants adding tricolored blackbird to the list of threatened species under the California Endangered Species Act (CESA) (Fish & G. Code, § 2050 et seq.). (see also Cal. Code Regs., tit. 14, § 670.1, subsec. (i).)"

<u>Field Studies Did Not Answer the Question: What is the Altamont's biological carrying capacity for the tricolored blackbird, the four focal species, and Altamont bats?</u> 7-4 cont.

The Altamont's biological carrying capacity for the four focal species, the tricolored blackbird, and bats were not carefully considered as an existing condition in the project-site baseline. The Altamont is home to one of the highest concentrations of golden eagles in North America.[5] Fatalities from turbine strikes may exceed the Altamont carrying capacity for golden eagles. The Wiens study found that "any additive mortality posed by an increase in anthropogenic threats is likely to trigger population declines or exacerbate any declines that may be ongoing.[6] Incorporating population studies into the baseline informs the effectiveness of impact avoidance and mitigation measures and should be included in this dSEIR.

<u>The dSEIR Project-Level Analysis Lacks A Thorough Assessment of Direct, Indirect, and Cumulative Impacts That May Adversely Effect Birds, Bats, and Associated Biological Resources, or Detailed Descriptions of Specific Avoidance Measures and Where Unavoidable, A Description of Measures That Minimize Such Impacts</u> 7-5

The PEIR methods of impact analysis were based on professional standards and information cited throughout the section on Biological Resources. PEIR 3.4.2 p. 3.4-20 stating: "The key effects were identified and evaluated based on the environmental characteristics of the program and project areas and the expected magnitude, intensity, and duration of activities related to the construction and operation of the program and the Patterson Pass and Golden Hills projects."

Because the dSEIR is tiered off of the PEIR, new and more severe impacts that were not analyzed in the PEIR were to include detailed descriptions of the intensity and magnitude of expected significant effects and the methods for avoiding or minimizing such effects. However, page 3-3 described annual raptor fatalities per MW at lower rates (0.64 annual raptor fatality/MW) than that described by HTHarvey's Table ES3 at

---

Found at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=161202%20&inline

[5] J. David Wiens, Patrick S. Kolar, W. Grainger Hunt, Teresa Hunt, Mark R. Fuller and Douglas A. Bell"Spatial patterns in occupancy and reproduction of Golden Eagles during drought: Prospects for conservation in changing environments," *The Condor* 120(1), (3 January 2018).https://doi.org/10.1650/CONDOR-17-96.1

The Diablo Range is "a region that supports one of the densest known breeding populations of Golden Eagles in North America (~54 pairs per 1,000 km2; Wiens et al. 2015, Hunt et al. 2017). This region includes the Altamont Pass Wind Resource Area (APWRA), where previous reports have indicated that ~65 Golden Eagles are killed annually by collisions with wind turbines (Smallwood and Thelander 2008)".

[6] "[S]ite quality can be temporally and spatially dynamic as a result of natural or anthropogenic disturbances that influence an area's capacity to consistently support occupancy and reproduction." *Ibid*.

7-5 cont.

p. Xiii (December 2018) (0.79 annual raptor fatality/MW). The dSEIR values in Table 3.4.8 on page 3.4-67 are therefore unsupported and are lower than the HTHarvey projections. Alternatively, on page 3.4-39, "Table 3.4-4 Annual Adjusted Fatality Rates for Nonrepowered and Repowered APWRA Turbines, all raptors annual fatalities/MW were 1.74. If the maximum project capacity is 144.5 MW, then annual raptor fatalities would be 251. (1.74 X 144.5 MW = 251 fatalities/year at Sand Hill). However, there is uncertainty in this information because Table 3.4.8 does include a source for its base rate.

The dSEIR on page 3- 3 states, "[T]he available avian and bat mortality reports on repowered turbines are not indicative of any definitive trend or suited for making different conclusions about repowered turbines in general." However, the dSEIR later states on page 3.4-14, "[T]he monitoring data sources [represent] considerable information on which to base conclusions about the effects of the Sand Hill repowering project." The mortality reports are based on the monitoring data. Therefore, the avian and bat mortality reports in fact do indicate trends and are suited for basing conclusions about the effects of the Sand Hill repowering project.

7-6

Updated Monitoring Reports, New Published Findings, and Update Collision Hazard Models Did Not Adequately Inform Impact Evaluations and Micro-siting

The dSEIR provided a list of monitoring reports, recent research, analysis, and published findings, updated collision hazard models, and post-construction assessments. However, instead of utilizing this new information to update their plans, the project proponents elected to forego altering the magnitude of the project or conform the turbine locations to the recommended micro-siting from Estep and Smallwood.[7]

The dSEIR discussed micrositing methods as well as summary reports from findings and recommendations from the Technical Advisory Committee (TAC) since the 2014 publication of the PEIR. Page 3-4-12 states, "the micrositing approach— and the studies completed to date—are consistent with and support the approach used in the PEIR (Mitigation Measure BIO-11b) that requires micrositing for each subsequent project to "… use the results of previous siting efforts to inform the analysis and siting methods as appropriate such that the science of siting continues to be advanced."… Although the efficacy and benefits of micrositing currently remains speculative, each successive project and its micrositing program is anticipated to benefit the next one.."

---

[7] Smallwood comments on Sand Hill dSEIR 18Sep2019 "With reduced fatality rates, the project can still result in a net increase in fatalities if the project's size is much larger than the project that existed before repowering."; 20August 2018, Smallwood, K. Shawn and Neher, L., **Siting Wind Turbines To Minimize Raptor Collisions At Sand Hill Repowering Project, Altamont Pass Wind Resource Area; March 2019, Sand Hill – Estep Micrositing Appendices A-1 – A-4; March 2019, Estep Environmental Consulting, Assessment of Proposed Wind Turbine Sites to Minimize Raptor Collisions at the Sand Hill Wind Repowering Project in the Altamont Pass Wind Resource Area**

While these publications and monitoring reports should inform the turbine strike fatalities analysis in the dSEIR as well as consideration and proposals for alternatives and mitigation measures, the preferred alternatives and mitigation measures did not reflect the new information. The project ultimately elected to disregard the micro-siting recommendations and Layout 5 was chosen, in spite of the risks of placement of many turbines in high hazard locations. 7-6 cont.

Instead of reducing the number of turbines, a well-supported method for avoiding and minimizing adverse impacts to bats and birds, the project replace 19 turbines with smaller sized turbines, a method that is not well-supported for minimizing adverse impacts. On page 4-14, the dSEIR chose the Smaller Turbine – Pre-Micro-Sited Layout and "relocating 19 of the proposed Project's 40 turbines, reducing overall Project capacity by 24% from 144.5 MW to 109.5 MW, reducing rotor-swept area by 13%, from 568,775 m2 to 496,220 m2, and raising the average clearance of turbine blades by 75%, from 14.1 m to 24.7 m above the ground. Each of these steps is expected to reduce bird and bat mortality based on input obtained from two micro-siting studies. Consequently, this alternative would have less severe impacts on biological resources than the proposed Project. The same mitigation measures as identified for the proposed Project would be required for this alternative."

Monitoring reports show substantially greater mortality of eagles and hawks at the repowered Golden Hills project for Years One and Two of the PEIR's three year monitoring mitigation program than were predicted for this 86 MW wind farm operation. Cumulatively, 25 golden eagles and100 red-tailed hawks were killed by the new repower turbines in just two years of monitoring.[8] These fatalities at this one 86 MW wind farm greatly exceed the PEIR's total estimated golden eagle and red-tailed hawk fatalities for the entire 450 MW APWRA repowering program.[9] Years One and Two monitoring reports for total unadjusted fatalities from the other two focal species were 15 American kestrels and 27 burrowing owls and bat unadjusted total fatalities for Years One and Two were 353. [10]

This level of eagle and hawk mortality at one repowering wind farm constitutes specific environmental effects that raise serious concerns about the adequacy of the PEIR's mitigation measures. Dr. Shawn Smallwood's April 10, 2018 report to the TAC expressed a high level of uncertainty in current collision hazard modeling due the unexamined effects of extreme grading that were not analyzed for their potential to increase the risk of avian and bat turbine strikes. *Without an experimental design, such as*

---

8 *See* H.T. Harvey, *Golden Hills Wind Energy Center Post-Construction Fatality Monitoring Report: Year 1*, Feb. 2018; and, H.T. Harvey, *Golden Hills Wind Energy Center Post-Construction Fatality Monitoring Report: Year 2*, Dec. 2018

9 PEIR at 3.4-120, 123 "[A] fully repowered 450 MW program area would be expected to result in an estimated 5–18 golden eagle fatalities per year." "[T]he repowered 88.4 MW Golden Hills Project would be expected to result in an estimated 9–22 red-tailed hawk fatalities per year."

10 See Footnote 3

the opportune before-after, control-impact (BACI) design that was available for the Vasco Winds repowering project (Brown et al. 2016), it cannot be known whether the collision hazard models were truly effective at Golden Hills [11] The importance of each wind operator to work closely with specialists on micro-siting and on evaluating detailed accounts of each turbine's location and operation warrants emphasis in this dSEIR. The dSEIR tables and descriptions did not provide a full impact analysis that accounts for this most recent mortality. The monitoring reports and associated analyses were listed but the reviewing comments dismissed their value because analysis that they were speculative and therefore not useful. For example, on page 3.4-12, the dSEIR states, "the extent to which these factors [excessive grading for wind turbine pads and new access roads] actually influence potential mortality remains speculative." While certainties remain, the analyses for avoiding high-hazard locations continue to improve and this dSEIR should incorporate new micro-siting guidelines that were recommended by their consultants. 7-6 cont.

<u>Micro-siting Recommendations to Avoid or Minimize Adverse Impacts Were Disregarded</u> 7-7

Detailed descriptions of methods for micro-siting pads and turbines to avoid and reduce impacts to birds and bats refer to three possible layouts as referenced on page 2-3 ("Three conceptual alternative layouts are proposed, each using up to 40 wind turbines. The layouts are substantially similar, mainly varying according to the location of 11 turbines in the center of the Project area, south and west of Bethany Reservoir, and their relative distance from the primary access road for the Project. The final layout would be selected based on site constraints (e.g., avian siting considerations), data obtained from meteorological monitoring of the wind resources, and turbine availability.")

Descriptions of proposed new construction lacks adequate details for examining potential associated adverse impacts. Rather than conforming to the recommendations from both Estep and Smallwood [12] for micro-siting pads and turbines, the project proponent elected to keep all turbine locations as originally micro-sited under their preferred alternative, Layout 5, regardless of their hazard ratings. [13] Without supporting

---

[11] *Addendum to Comparison of Wind Turbine Collision Hazard Model Performance: One-Year Post-Construction Assessment of Golden Eagle Fatalities at Golden Hills*, Apr. 10, 201 "[E]xtreme grading for access roads and turbine pads can interfere with collision hazard model predictions by adding significant risk to turbine sites." p.5

[12] **March 2019, Estep Environmental Consulting, Assessment of Proposed Wind Turbine Sites to Minimize Raptor Collisions at the Sand Hill Wind Repowering Project in the Altamont Pass Wind Resource Area**; 2018, Smallwood, K. Shawn and Neher, L., **Siting Wind Turbines To Minimize Raptor Collisions At Sand Hill Repowering Project, Altamont Pass Wind Resource Area**

[13] "[T]he Smaller Turbine – Pre-Micro-Sited Layout alternative is expected to reduce avian and bat fatalities because the turbines locations would be adjusted based on the results of two micrositing studies and larger turbines would be replaced with smaller turbines with a smaller total rotor-swept area and a greater distance between the ground and the tips of the turbine

evidence, the dSEIR's conclusion that the Smaller Turbine – Pre-Micro-Sited Layout alternative is expected to reduce avian and bat fatalities, this assertion is arguably conclusory. The micro-siting discussion needs to be supported with evidence and by the project proponent's micro-siting consultants. 7-7 cont.

The project proponent presented Layout 5 at the Sept 19, 2019 Technical Advisory Committee meeting. This Layout favors the full suite of 40 turbines (the maximum number of turbines proposed for this project) and reduces the size of 19 of these 40 turbines. Layout 5 relocates 19 of the proposed Project's 40 turbines, reducing overall Project capacity by 24% from 144.5 MW to 109.5 MW, reducing rotor-swept area by 13%, from 568,775 m2 to 496,220 m2, and raising the average clearance of turbine blades by 75%, from 14.1 m to 24.7 m above the ground. Each of these steps is expected to reduce bird and bat mortality based on input obtained from two micro-siting studies. Consequently, this alternative would have less severe impacts on biological resources than the proposed Project. The same mitigation measures as identified for the proposed Project would be required for this alternative." (p4-15) However, the dSEIR cites no supporting research or best available science to substantiate this assertion.

The objective for this layout was to maximize megawatt production and minimize impacts to bats and birds. However, the evidence that this layout will minimize impacts to bats and birds was not supported by the biologists, Estep and Smallwood, micro-siting consultants. In fact, Tara Mueller presented at the same Sep 19, 2019 TAC meeting, a chart showing that the micro-siting locations of virtually all the turbines remained in high-hazard locations. (See Appendix A) When asked why fewer turbines were not considered as a mitigation for avoiding or minimizing adverse impacts, the project proponent indicated that such a proposal was infeasible because the economic costs of reducing the number of turbines to be installed outweighed the benefits of minimizing adverse impacts to bats and birds.

<u>The Alternatives Discussion Preemptively Excludes Important Project Alternatives That Should Be Considered</u> 7-8

CEQA § 21002 states, "public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects, and that the procedures required by this division are intended to assist public agencies in systematically identifying both the significant effects of proposed projects and the feasible alternatives or feasible mitigation measures which will avoid or substantially lessen such significant effects." This dSEIR's consideration of project alternatives should include all reasonable alternatives. The purpose of reviewing project alternatives is to assist public agencies in identifying and avoiding or substantially lessening significant effects. If some alternatives are excluded from consideration, then the public

---

blades." dSEIR p4-14

is not afforded an opportunity to review and comment on such reasonable project alternatives for avoiding, minimizing, or mitigating significant environmental effects from the proposed Project. Therefore, project alternatives, such as the Fewer New Turbines alternative and the Avoid Specific Biologically Sensitive/Constrained Areas alternative should also be considered, analyzed, and discussed in this dSEIR. 7-8 cont.

Some Alternatives Were Not Analyzed to Ensure That Project Alternatives Are Fully Evaluated and Considered

The PEIR considered two program alternatives: Alternative 1, with a maximum capacity of 417 MW and 260 turbines, and Alternative 2, with a maximum capacity of 450 MW and 281 turbines. The two alternatives differ only in nameplate capacity and total estimated turbines. Page ES-8 Chapter 4 of the PEIR screened eight alternatives and compared five alternatives:

- The No Project alternative would have reauthorized existing Conditional Use Permits (CUPs) for old generation turbines and there would be no repowering
- The No Repowering alternative would fully decommission all turbines
- The Fewer New Turbines alternative considered reductions in wind farm operations that would "result in fewer avian and bat fatalities," reduced surface disturbance, and "would have less severe impacts on biological resources than the proposed program. PEIR at p 4-27
- The Avoid Specific Biologically Sensitive/Constrained Areas alternative was expected to reduce impacts on terrestrial species but would not reduce avian and bat impacts because turbine installations would be unchanged.
- The No New Roads alternative would reduce the extent of ground disturbance but would not reduce avian and bat impacts from turbines.

Of the five compared alternatives, the Fewer New Turbines alternative may reduce avian and bat mortality from turbine strikes. Therefore, this alternative should be evaluated and considered in this dSEIR. In particular, this alternative should be tailored to consider the direct effects on bats and birds from the rotor swept area of larger turbines that are between 3 – 4 MW. An impact from turbines of this magnitude was not contemplated in the PEIR and warrants detailed evaluation and impact analysis.

The PEIR held that "Because program Alternative 2 would result in the construction of more turbines, generating more power, that alternative would have a greater impact related to bird and bat mortality, an impact found to be significant and unavoidable under all alternatives with the exception of the No Project alternative." PEIR at p.ES-8 As written, the Sand Hill project is applying to construct "up to 40 new turbines with nameplate production capacity rated between 2.3 and 3.8 megawatts (MW) each (potentially up to 4.0 MW), that together will have a maximum production capacity of

144.5 MW."[14] A project of this magnitude exceeds the PEIR's impact analysis for Alternative 1 at 417 MW and possibly even Alternative 2 at 450 MW and will require detailed evaluation that is based on evidence and scientifically defensible analysis. 7-8 cont.

CEQA PRC § 21081.5; CEQA Guidelines §§ 15091.6(e)(2) require that the SEIR identify the Environmentally Superior Alternative unless under §§ 15126.6(a), (c), (f), such an alternative would not accomplish the basic project objectives and/or is infeasible. Here, reports and collision hazard modeling demonstrate that the basic project objectives of sustainably producing wind energy and protecting the carrying capacity of the four focal species, the tricolored blackbird, and bats may not be achievable even with appropriate oversight and mitigation. Impacts from the proposed Sand Hill project are likely to significantly affect the threshold for sustaining the carrying capacity of the four focal species, the tricolored blackbird, and Altamont bats, and project alternatives and/or new and more stringent mitigation measures must be considered. 7-9

Alternatives may not be rejected merely because they are beyond an agency's authority, would require new legislation, or would be too expensive (CEQA Guidelines § 15126.6(f)(2) 7-10

At the Sep 19, 2019 TAC meeting, project proponents argued that the fewer turbines alternative was infeasible because the economic costs were unacceptably high. However, CEQA precludes this reasoning for rejecting an alternative.
CEQA Guidelines direct that project alternatives that may be beyond the agency's authority, or may be costly, or that would require new legislation should nevertheless be analyzed to ensure they are fully considered and evaluated. If, for example, a proposed alternative appears too costly, then under CEQA § 21061.1, a feasibility study should analyze whether the proposed alternative can be accomplished in a successful manner. Alternatives that may offer scientifically verifiable improvements in design and implementation of wind energy and avoid or minimize bird and bat fatalities and related significant effects should be an ongoing investigation. For example, impact-reduction studies are being undertaken.[15]

The dSEIR Cumulative Impact Analysis Should Incorporate New Information That Reasonably Analyzes Feasible Options for Mitigating and Avoiding Significant Effects 7-11

---

[14] (SEIR) for the Sand Hill Wind Repowering Project, tiered under the APWRA PEIR, State Clearinghouse #2010082063), certified November 12, 2014. County Planning Application PLN2017-00201

[15] Sinclair, K.; DeGeorge, E. (2016). Framework for Testing the Effectiveness of Bat and Eagle Impact-Reduction Strategies at Wind Energy Projects. Report by National Renewable Energy Laboratory (NREL). Available at: http://batsandwind.org/pdf/sinclair-and-degeorge-2016.pdf

Cumulative impacts analysis under CEQA Guidelines, § 15130 for significant effects relating to ongoing bird and bat fatalities from turbine strikes and from habitat disturbance and loss that are likely to be substantially greater than that analyzed in the PEiR failed to adequately describe the magnitude, intensity, or duration that The SEIR should evaluate these fatalities as ongoing effects that cumulatively constitute significant impacts that warrant new and stronger mitigation measures. Similarly, associated significant effects from construction-related impacts and ongoing operation and maintenance activities that result in habitat loss and disturbance to special-status species should be analyzed as substantially greater impacts than were evaluated in the PEIR. Indirect impacts from disturbance to habitat, including permanent and/or temporary loss of roosting, foraging, nesting, and dispersal habitat for birds and bats and evaluations for new mitigation measures should be fully described in the SEIR. 7-11 cont.

In this dSEIR, new information was not sufficiently incorporated into the decisions for avoiding cumulative impacts. The PEIR requires that new information shall be included in ongoing analysis so that new adaptive management measures will be incorporated as new information is gathered and improves the understanding and science of analyzing impacts, including cumulative impacts. Therefore, the dSEIR cumulative impacts analysis warrants additional analysis and review.

The dSEIR on page 5-3 states, “. It is expected that each project implemented under the program would be required to mitigate losses of vegetation and wetlands, resulting in no net loss, and thereby reducing any contribution to cumulative impacts to a less-than significant level.” However, no evidence of this conclusion of no net loss is provided. Therefore, this claim is an assertion that requires supporting evidence under the requirement of applying the best available science.

On page 5-3, the dSEIR states, “With this offset, and with implementation of mitigation measures identified in the PEIR that require restoration of temporarily affected habitat and compensation for the permanent loss of habitat, the program’s contribution to certain cumulative impacts on habitats and terrestrial species would be reduced.” However, habitat restoration does not adequately offset the cumulative impacts of newly installed turbines in high-hazard locations. The dSEIR must adequately discuss the severity of cumulative impacts.

CEQA §15130(b) The discussion of cumulative impacts shall reflect the severity of the impacts and their likelihood of occurrence… The discussion …should focus on the cumulative impact to which the identified other projects contribute … to the cumulative impact. The following elements are necessary to an adequate discussion of significant cumulative impacts:
(1) Either:
(A) A list of past, present, and probable future projects producing related or cumulative impacts, including, if necessary, those projects outside the control of the agency, or

(B) A summary of projections contained in [the] planning document, that describes or evaluates conditions contributing to the cumulative effect. 7-11 cont.

…

(4) A summary of the expected environmental effects to be produced by those projects with specific reference to additional information stating where that information is available; and

(5) A reasonable analysis of the cumulative impacts of the relevant projects. An EIR shall examine reasonable, feasible options for mitigating or avoiding the project's contribution to any significant cumulative effects.

Here, the dSEIR should explain why the project proponents elect to keep the project level at 40 turbines regardless of the cumulative impacts that likely constitute significant and avoidable effects, as asserted by their consultants, Estep and Smallwood. The dSEIR must provide a reasonable analysis and explanation for how the project will avoid cumulative impacts if fewer turbines are not considered.

<u>This dSEIR Should Not Be Approved As Proposed If There Are Feasible Alternatives Or Feasible Mitigation Measures Available Which Would Substantially Lessen The Significant Environmental Effect</u> 7-12

CEQA § 21002 requires that public agencies not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects. Here, the dSEIR should only be approved if significant effects cannot be substantially lessened by reducing the number of turbines in the project area. However, new research indicates that reducing the number of turbines may lessen significant effects. "[O]ur study suggests that for most bird species, more of the collision risk might be in the structure of a wind turbine than in the moving parts, as suggested by collision risk modeling performed before our study began (Richard Podolski, Pers. Comm. with K. S. Smallwood)"[16]

The dSEIR's analysis of mitigation measures was reviewed for its utility as a means to avoid and minimize significant environmental effects that may result from this Project. The dSEIR's recommendations to update and increase mitigations were considered for their adequacy. The adequacy of consideration and evaluation of new and additional compensatory mitigation measures were discussed and but were not fully applied in this dSEIR. The dSEIR's evaluation of environmental effects that resulted from an analysis of all relevant research and findings were referenced. However, the project plans to

---

[16] 17July2019, Unpublished report, Notes on Wind Turbine Curtailment Effects on Bird Bat Fatalities, **Report #3 to the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03)**
K. SHAWN SMALLWOOD,1 *3108 Finch Street, Davis, CA 95616, USA*
DOUGLAS A. BELL, *East Bay Regional Park District, 2950 Peralta Oaks Court, Oakland, CA 94605, USA*

avoid and minimize significant effects were too often determined to be infeasible as presented by the project proponents at the Sep 19, 2019 TAC meeting. 7-12 cont.

The dSEIR references 2019 Updated PEIR Mitigation Measure BIO-8a on p 3.4-59 that requires a qualified biologist to conduct preconstruction nesting bird surveys within 7 days prior to construction activities. However, on page 3. 4-60 , the dSEIR states, "the no-disturbance buffer may be reduced to 0.5 mile if construction activities are not within line-of-sight of the nest." This condition should not take precedence over the recommendations of qualified biologists to avoid disturbing an active eagle nest.

Mitigation for avian and bat mortality that cumulatively constitute significant effects, should be implemented with the goal of no net loss and should demonstrate verifiable impact reductions to a less-than-significant level. The permanent and temporary loss of land cover types should be mitigated or offset by mitigation measures that require restoration of temporarily disturbed habitat and compensation for permanent habitat loss.[17]

<u>The dSEIR Evaluation Of Measures That Avoid Or Minimize Impacts To Sensitive Biological Resources, Including The Four Focal Species Named In The PEIR, The Tricolored Blackbird, And Altamont Bats Are Inadequate</u> 7-13

The PEIR directs the application of a range of adaptive management and mitigation measures that should be made more stringent and responsive in this dSEIR. The PEIR's Impact Analysis includes Mitigation Measures BIO – 11(a) through (i) that should be updated and serve as critical response actions that can be immediately enacted to eliminate or significantly diminish the risk of raptor or bat turbine collisions. However, this dSEIR provided only the updated Raptor Conservation Mitigation Measure on page 2-25, stating, "The County has modified Mitigation Measure BIO-11h so that now, or after any initial 10-year period, projected costs [rehabilitating the typical injured raptor (indicated as $580/raptor fatality] are adjusted for inflation according to the Consumer Price Index. Such adjustment would occur on the tenth anniversary of commercial operation. However, many more mitigations are proposed in new information as well as in the PEIR.

<u>Mitigation Measures BIO-11a Through i Should Be Updated to Reflect All Recent Research, Newest Collision Hazard Models, Behavior and Use Study Findings, and Related Guidance Materials</u> 7-14

The dSEIR should apply all recent research, the most current collision hazard models, behavior and use study findings, and all related guidance materials from the TAC and from field biologists to update and expand Mitigation Measure BIO-11a. The APP should incorporate the most recent scientifically valid findings for siting turbines,

---

17 Adapted from APWRA Repowering Final PEIR, October 2014, 5.4.2 Analysis of Cumulative Impacts p.5-9

thorough documentation for appropriate turbine design, and evidence that supports best avian-safe practices. 7-14 cont.

The PEIR's Mitigation Measure BIO-11b on page 3.4-109 directs the project proponent to use "analyses of landscape features and location-specific bird use and behavior data to identify locations with reduced collision hazard risk", as recommended by Shawn Smallwood, PhD et al. 2009. The use of existing data as well as the requirement to collect new site-specific data is a required "part of the siting analysis." (PEIR p3.4-109) Therefore, the SEIR must analyze existing collision hazard models for their application as well as for their limitations. As previously described. the collision hazard models failed to account for the impacts from extreme grading that alter the terrain studies on which the collision hazard models are based. The SEIR must collect new site-specific data as part of the siting analysis that accounts for terrain alterations such as extreme grading and update site-specific collision hazard models for this project site.

Mitigation Measure BIO-11b directs the project proponents to "use the results of previous siting efforts to inform the analysis and siting methods as appropriate such that the science of siting continues to be advanced. All project proponents will collect field data that identify or confirm the behavior, utilization, and distribution patterns of affected avian and bat species prior to the installation of turbines. Project proponents will collect and utilize available existing information, including but not necessarily limited to: siting reports and monitoring data from previously installed projects; published use and abundance studies and reports; and topographic features known to increase collision risk (trees, riparian areas, water bodies, and wetlands)." Therefore, the SEIR must thoroughly apply the details of Mitigation Measure BIO-11b to collect field data that identify or confirm the behavior, utilization, and distribution patterns of affected avian and bat species at their project-site, especially in light of the new fatality reports at Golden Hills. Furthermore, the SEIR should specifically apply these directives to avoid impacts to the four focal species, the tricolored blackbird, and the Altamont bats.

Mitigation Measure BIO-11b specifies that "Project proponents will also collect and utilize additional field data as necessary to inform the siting analysis for golden eagle. As required in Mitigation Measure BIO-8a, surveys will be conducted to locate golden eagle nests within 2 miles of proposed project areas. Siting of turbines within 2 miles of an active or alternative golden eagle nest or active golden eagle territory will be based on a site-specific analysis of risk based on the estimated eagle territories, conducted in consultation with USFWS." PEIR p3.4-109 Therefore, the SEIR should thoroughly address this requirement for specifically collecting and utilizing additional field data as necessary to inform the siting analysis for golden eagle[s]. The SEIR should specify that surveys of golden eagle nesting will preclude any turbine siting within 2 miles of golden eagle nesting or active golden eagle territory. Such field studies should be conducted by qualified independent neutral third party biologists.

As directed under Mitigation Measure BIO-11b (PEIR p. 3.4-110), "The project proponent will compile the results of the siting analyses for each turbine and document these in the project-level APP, along with the specific location of each turbine." Here, the dSEIR must include this compilation of results of the siting analyses for each turbine and document these in their APP. 7-14 cont.

The PEIR's Mitigation Measure BIO-11c on page 3.4-110 directs the use of turbine designs that reduce avian impacts. However, the PEIR fails to direct the use of compensatory mitigation funds or other alternatives that apply new research to improving the design and siting of wind turbines "such that the science of siting continues to advance." PEIR p.3.4-109

This dSEIR should apply recent research, updated collision hazard modeling, findings from raptor and bat behavior and use studies, and TAC recommendations to improve monitoring and related studies of existing turbine design and siting methods. The improved monitoring and related studies should focus on testing methods for advancing turbine design and siting guidelines that reduce avian and bat fatalities.

The PEIR Should Be Updated to Reflect Current Pricing and Costs in Compensatory Measurement Guidelines 7-15

The dSEIR should update funding contributions for loss of raptors and other avian species, including golden eagles, should be based on the costs of active field research, collision hazard modeling, new turbine design and impact-reduction research, recovery and management of lands for raptors, and methods for increasing and enhancing raptor reproduction, especially of the four focal species and the tricolored blackbird. These funding updates should reflect known costs for the range of compensatory mitigations that would contribute a no-net loss result in the Altamont.

The PEIR ADMM-4, page 3.4-117, permits project proponents to "deploy experimental technologies at their facilities to test their efficacy in reducing turbine related fatalities." At the time of the publication of this PEIR, few technologies demonstrated effectiveness in reducing bird and bat fatalities from turbine strikes. Testing of new research on turbine design and impact-reduction strategies show mixed results. This SEIR should commit funds, via continuing compensatory mitigations, to continuing research and testing of experimental turbine designs, siting, and related impact-reduction strategies.

Update and Implement the PEIR's Adaptive Management Measures (AMMs) With More Stringent Standards That Require A Rapid Response to Confirmed Turbine-caused Fatalities 7-16

Beginning on page 3.4-116, the PEIR directs in Mitigation Measure BIO-11i that, "If fatality monitoring described in Mitigation Measure BIO-11g results in an estimate that exceeds the preconstruction baseline fatality estimates (i.e., estimates at the nonrepowered turbines as described in this PEIR) for any focal species or species group (i.e., individual focal species, all focal species, all raptors, all non-raptors, all birds combined), project proponents will prepare a project-specific adaptive management plan within 2 months following the availability of the fatality monitoring results. These plans will be used to adjust operation and mitigation to the results of monitoring, new technology, and new research to ensure that the best available science is used to minimize impacts to below baseline. Project-specific adaptive management plans will be reviewed by the TAC, revised by project proponents as necessary, and approved by the County." 7-16 cont.

This project-specific adaptive management plan should be updated in this dSEIR to reflect new information that warrants a rapid response to monitoring reports that indicate avian fatalities of the four focal species, the tricolored blackbird, or the Altamont bats that exceed the mortality predictions to levels that constitute significant affects. As soon as monitoring reports are confirmed and approved by the TAC, measures should be immediately enacted to cease operations that are linked to confirmed fatalities. Adaptive measures should include mitigation measures that include but are not limited to:

- Curtailment
- Cut-in speed changes
- Shutdowns
- Real-time curtailment
- Overnight shutdowns during bat migration

The PEIR ADMM-5 states, "If postconstruction monitoring indicates patterns of turbine-caused fatalities—such as seasonal spikes in fatalities, topographic or other environmental features associated with high numbers of fatalities, or other factors that can potentially be manipulated and that suggest that curtailment of a specific turbine's operation would result in reducing future avian fatalities—the project operator can curtail operations of the offending turbine or turbines. PEIR pp 3.4-116,117 However, this measure should be updated to remove uncertainty about the time for implementing this measure. The dSEIR should include specific directives that all measures to avoid continuing fatalities at locations that were confirmed by monitoring reports to be immediately implemented and, as confirmed by monitoring reports, within the first year of operation. Likewise, ADMMs 6 and 7 on page 118 should be updated to require prompt implementation within the first year of operation.

Other measures to be considered in response to reports of higher than expected fatalities should require that the project proponent modify the project with possible changes such as:

- Reduce the number of turbines
- Reduce the size of turbines
- Replace existing turbines with new designs that demonstrate impact reductions
- Remove hotspots or known high-kill turbines that repeatedly kill avian or bat species.

All Research Produced From Next Era (NEER) Mitigation Funds Should Comprise Recent Research and Analysis 7-17

All research produced under Next Era mitigation funds should be reviewed and evaluated in this SEIR. Publications and related findings inform studies about specific environmental effects such as identifying and avoiding high-kill grading sites and practices.

Revised and Updated Collision Hazard Models Should Inform Project-Level Impact Analyses

Recent publications focus on the benefits of applying only the most recently updated collision hazard models and should be reflected in the SEIR. This new data informs and updates collision hazard models and should be incorporated into APPs and AMMs.

Bat Impacts Are Demonstrably Greater Than Were Contemplated in the PEIR and Warrant Stronger Commitments to Research and Mitigation 7-18

The PEIR, on page 3.4-8, states that " "Each phase of repowered turbines is subject to 3 years of postconstruction fatality monitoring, using the focal species identified in the 2007 Settlement Agreement as well as bats as benchmarks for evaluating effectiveness of repowering." Furthermore, the H.T.Harvey reported that, ""[R]epowering with larger, taller turbines also may have increased the fatality rate for bats, as has been demonstrated elsewhere."[18] The SEIR must, therefore, continue to study effects on bats, especially because the design proposes to install the largest turbines ever contemplated for the APWRA. The PEIR identifies in Table 3.4-5 five bat species that may occur within the APWRA. Years One and Two of the Golden Hills monitoring report listed adjusted total fatality estimates of over 500 bats that were killed by turbines. This alarming report warrants stringent mitigation actions to reduce bat fatalities similar to those recommended for raptors and other birds. Furthermore, the PEIR Mitigation Measure 12 on page 3.4-130ff directs that bat roost surveys be conducted and that disturbance of bats or their roosts be avoided. The PEIR further recommends on page 3.4-134 that the TAC include "one biologist with significant expertise in bat research and wind energy impact on bats" to review research and advise the County on measures to protect bats in the APWRA. The County and this SEIR should actively fulfill this PEIR mandate and include a bat specialist on the TAC.

Compensatory Mitigation Should Include Compensation For the Economic and Environmental Costs of Avian and Bat Fatalities 7-19

Bat and Bird Deaths from Turbines Strikes Should Not Be Treated As Externalities 7-20

[18] H.T. Harvey, *Golden Hills Wind Energy Center Post-Construction Fatality Monitoring Report: Year 2*, Dec. 2018, p.xii

CEQA § 21001 (g) requires "governmental agencies at all levels to consider qualitative factors as well as economic and technical factors and long-term benefits and costs, in addition to short-term benefits and costs and to consider alternatives to proposed actions affecting the environment." These costs arguably include environmental costs that should not be excluded from the cost assessment that attaches to this project proponent's proposal to install all 40 turbines regardless of the associate risks of unsustainably high mortality to bats and birds. 7-20 cont.

The County is entrusted by the public to protect the benefits of an intact ecosystem and to weigh as a cost the loss of biological resources that fall below their carrying capacities. Here, the installation of all 40 turbines should be evaluated for its high hazard risk to kill bats and birds at numbers that exceed the Altamont's carrying capacity. Such high kill rates should not be discounted from the overall economic calculus of this project's expected power production as a cost that is external to this projects economic bottom line. Avian and bat mortality are not externalities. They should attach to the cost of power production as a debt that must be paid. They are economic and environmental costs that warrant critical consideration as adverse impacts to be avoided. If they cannot be avoided, then compensatory mitigations in the form of compensation for avian and bat fatalities should be a financial accounting in the mitigation analysis.

<u>The Precautionary Approach Should Be Stringently Applied To This dSEIR For Avoiding Significant Effects</u> 7-21

As attested in this dSEIR, there is uncertainty in the process of avoiding and minimizing adverse impacts to bats and birds. Therefore, the County can instruct the project proponent to take a precautionary approach that requires more stringent action. This action can include multiple precautionary steps such as, reducing the number of total turbines in the project, shutting down turbines overnight, enacting cut-in speeds, curtailing turbine operations near active nests, and decommissioning turbines that demonstrate high kill rates.

CEQA requires a reasonable and good faith attempt to quantify the degree of impact or, at minimum, qualify that impact in light of best available scientific information and develop mitigation measures or such effects, including cumulative effects. See Sierra Club v. County of Fresno, 6 Cal.5th 502, 519 to 521 and CEQA Guidelines § 15130 (b)(5) "A reasonable analysis of the cumulative impacts of the relevant projects. An EIR shall examine reasonable, feasible options for mitigating or avoiding the project's contribution to any significant cumulative effects." As discussed in this comment, project proponents can offer a range of measures to avoid adverse impacts that were not considered in this dSEIR. Thereafter, mitigations and compensatory mitigations should reflect new information and new compensations such as purchasing and retiring wind rights, funds for acquiring mitigation land, funding ongoing field research and monitoring 7-22 programs, funding research on improve turbine designs that avoid adverse bat and bird impacts, and establishing a general fund that is paid from bat and bird fatalities that exceed the Altamont's carrying capacity for those species. 7-22 cont.

Please notify GGAS of all relevant actions and documents pertaining to this Sand Hill Repowering Project. Please do not hesitate to contact us at the information provided. Thank you for considering these comments.

Respectfully,

Pam Young

Pam Young
Executive Director
Golden Gate Audubon Society

pyoung@goldengateaudubon.org

Letter 8

Shawn Smallwood, PhD
3108 Finch Street
Davis, CA 95616

Andrew Young, Senior Planner
Planning Department
Alameda County Community Development Agency
County of Alameda
224 W. Winton Avenue, Room 110
Hayward, CA 94544

4 October 2019

RE: Sand Hill Supplemental EIR

Dear Mr. Young,

8-1

I write to follow-up on my comment letter of 18 September 2019 regarding potential biological impacts of the proposed Sand Hill Wind Energy project (County of Alameda 2019). Herein I comment specifically on the cumulative impacts analysis in the Subsequent EIR, focusing on golden eagles and bats as examples of how the County should assess, as a starting point, cumulative impacts related to all volant wildlife in a fully repowered Altamont Pass Wind Resource Area (APWRA). I also add a comment about the County's burrowing owl impact assessment.

8-2

County of Alameda's (2019) two-sentence cumulative impacts analysis related to bird and bat collision mortality was grossly deficient. Although fatality rates have been estimated for repowered wind projects in the APWRA, County of Alameda (2019) made no use of them for predicting APWRA-level cumulative impacts. In Table 1, I present available monitoring counts of golden eagle fatalities F and subsequent fatality estimates $\hat{F}$, which were derived from F adjusted for variation in fatality search radius and search interval, including searcher detection and carcass persistence rates:

$$\hat{F} = \frac{F}{R_C \times S \times d} \text{ or } \hat{F} = \frac{F}{D \times d} \text{ ,}$$

,

where F was number of fatalities found, R_C was mean daily proportion of trial carcasses persisting at a time interval corresponding with the average search interval in days, S was searcher detection or proportion of trial carcasses detected upon the next search following carcass placement, d was proportion of fatalities detected within the maximum search radius, and D was overall detection of trial carcasses integrated randomly into routine fatality monitoring, where "integrated" means the trial carcasses were indefinitely left where placed and treated like actual fatalities. Table 1 also presents weighted mean fatality rates among specific projects listed in Table 1, and it projects those means to County of Alameda's maximum allowable capacity of 450 MW.[1] For an APWRA-wide cumulative impact assessment, I added the fatality rates reported

[1] This maximum capacity was taken from the Programmatic EIR.

in Brown et al. (2016) for Vasco Winds Smallwood (2011) for Buena Vista (Attachment 1) as ongoing fatality rates in Contra Costa County.[2] 8-2 cont.

Golden eagles 8-3

Table 1 presents a stark contrast in APWRA-level cumulative impacts for golden eagle, depending on whether the remainder of Alameda County's allowable capacity is built like Vasco Winds or like Golden Hills. At Vasco Winds, wind turbines were sited to avoid model-predicted hazard classes 3 and 4, where 4 was the most hazardous class predicted by the model (Smallwood and Neher 2011). None of the final turbine sites caused me disproportionate concern except for a few sites where, after construction, it was clear that grading substantially altered the terrain setting of the turbine. Learning from the grading impacts at Vasco Winds, I since recommended to all of my clients in the APWRA that turbine sites should be avoided if grading was to leave substantial berms or cut-slopes in the prevailing upwind directions from the wind turbine, thereby reducing the ground clearance a flying animal would need to negotiate in the short distance between the upwind terrain and the low reach of the turbine's rotor. Also, since Vasco Winds I provided SRC-style hazard ratings for each proposed turbine site, which added learned experience that could not yet be captured in the model. Based on my SRC-style ratings, I sometimes over-rule model-predicted hazard classes of 3 or 4 (4 being the highest hazard class), but otherwise any site developed on or next to model-predicted hazard classes 3 or 4, or at sites I rated 8 to 10 on the SRC-style scale, or that left substantial berms or cut slopes upwind of the turbine will deviate from the PEIR's standard of using "*the best information available to site turbines to reduce avian collision risk*" (ICF 2014:3.4-104).

As shown in Table 1, if the remainder of the APWRA's capacity were to be built at the same turbine density as Vasco Winds, and with optimized siting with respect to micro-siting recommendations, then the APWRA-level impact could be a third of the impact resulting from development consistent with Golden Hills. However, Golden Hills North has already been built, and Summit Winds is under construction, so the choice in outcomes remains for projects yet to be permitted and composing about half of Alameda County's maximum allowable capacity of 450 MW. The SEIR needs to honestly inform the public and decision-makers of the consequences of how wind energy development proceeds in terms of cumulative impacts. Careful micro-siting to minimize impacts to golden eagle can only be achieved through scientific micro-siting and wind company sacrifice of optimal wind energy generation.

[2] Treating these reported fatality rates as ongoing fatality rates assumes that the reported rates have not changed since fatality monitoring ended at Buena Vista and Vasco Winds, but in fact it remains unknown whether fatality rates remain unchanged. Fatality rates at those projects could have since decreased or increased.

8-3 cont.

Table 1. *Existing golden eagle fatality rate estimates $\hat{F}$ and their projections to Alameda County's maximum allowable capacity of 450 MW and to the entire Altamont Pass Wind Resource Area (APWRA).*

Project	MW	Monitoring		$\hat{F}$/MW/Yr	$\hat{F}$/Yr	Projected $\hat{F}$/Yr	
		Years	*F*			Alameda	APWRA
Diablo Winds (DW)[a]	20.46	5	3	0.0326	0.670		
Buena Vista (BV)[a]	38.00	3	5	0.0673	2.546		
Vasco Winds (VW)	78.20	3	7	0.0440	3.440	19.8	25.8
Golden Hills (GH)	85.92	2	23	0.1500	12.890	67.5	73.5
Weighted $\bar{x}$, all projects	202.12			0.0878	19.546	39.5	45.5
Weighted $\bar{x}$, sans DW[b]				0.0934	18.878	42.0	48.0
Weighted $\bar{x}$, BV & VW				0.0515	5.984	23.2	29.2

[a] I independently calculated the estimates presented here, in order to comparatively adjust for factors contributing to the proportion of fatalities likely not found during monitoring (Attachment 1).
[b] Diablo Winds is of questionable suitability as a comparably modern wind project, as its turbines are rated at only 0.66 MW. This project's contribution to golden eagle fatalities has been relatively low, possibly because the turbines were constructed on relatively safer terrain features (I would have recommended most of the sites, had I been involved).

I understand that hope has been placed in deployment of IdentiFlight as a mitigation strategy to reduce golden eagle fatalities. I hope this technology proves effective, but I also need to remind the County that hope was earlier placed in multiple other mitigation strategies that proved ineffective or insufficiently effective. I have yet to see any evidence of IdentiFlight's efficacy other than its ability to accurately distinguish eagles from other large birds McClure et al. 2018). If it is going to yield evidence of efficacy in the APWRA, then it needs to be deployed in an appropriate experimental design (Sinclair and DeGeorge 2016) and with a monitoring effort that is supported by statistical power analysis. Without considering potential confounding factors or anticipated effect size, deployment of IdentiFlight might not yield the definitive results hoped for. And until IdentiFlight is proven effective, there exists no mitigation measure, other than careful siting, that has minimized golden eagle fatalities at wind turbines.

In my assessment – based on the available data, if wind companies developing in Alameda County are allowed to decide on project size and layout in order to maximize energy generation, then nearly 50 additional golden eagles will be killed annually over the number that would have resulted otherwise (73.5 minus 25.8 in the rightmost column of Table 1). The resulting annual toll will be no lower than the toll from thousands of old-generation wind turbines operating in the APWRA for longer than 30 years.

Bats 8-4

In addition, it is highly likely the repowered APWRA will kill thousands of bats annually, or until local bats and the migratory bats using the APWRA are extirpated. Bat fatality estimates have been evolving in the APWRA since fatality monitoring transitioned from searches at old-generation turbines to searches at repowered turbines. The older searches at old-generation wind turbines involved human searchers searching at intervals much too long for finding more than a tiny fraction of bat fatalities. The use of human searchers continued at Buena Vista post-repowering, but at this project the average search interval was shortened to two weeks, thereby giving searchers many more opportunities to find available bat fatalities. Vasco Winds also made use of human searchers, but by integrating actual bat carcasses (instead of some surrogate species of bird) into routine fatality monitoring, the Vasco Winds effort documented low bat carcass detection rates using human searchers, at <6%, which means the adjustment factor needed for the fatality estimate was >17-fold. Such a large factor invites large instability in the estimate, where any hidden biases could greatly affect the estimate. It also invites omissions of entire species from the fatality estimates. Nevertheless, bat fatalities were estimated using large adjustment factors to account for the undetected fatalities. Following the Vasco Winds effort, detection dogs were put to work searching for fatalities at Golden Hills, and Doug Bell and I used scent-detection dogs in fatality monitoring at Golden Hills and Buena Vista in fall 2017 as a research study (see attached reports, including Report 1, Report 2, and Report 3). 8-4 cont.

The scent-detection dogs that Bell and I deployed at Buena Vista found in 3 weeks nearly twice the number of bat fatalities that human searchers found over 3 years (see Report 1, attached). We found this many more bats despite using the same search interval and maximum search radius as did the earlier human searchers. Because our dog study also overlapped ongoing fatality monitoring at Golden Hills, I was able to use the seasonal distribution of fatality finds by the Golden Hills' monitor (dogs only) to estimate annual fatalities at Buena Vista (see App. C in H. T. Harvey et al. 2017). I estimated annual fatalities $\hat{F}$ of bats using the following estimator:

$$\hat{F} = \frac{F}{R_C \times S \times d \times p \times \frac{F'_{60\ days}}{F'_{365\ days}}} ,$$

where most of the terms were defined earlier, *F'* was the number of bat fatalities found by H.T. Harvey & Associates' (2018) dogs who searched at weekly at 14 Golden Hills turbines, and $\frac{F'_{60\ days}}{F'_{365\ days}}$ was the ratio of those fatalities found during the 60-day portion of the year concurrent with our study to those found throughout 2017.

As a check on this estimator, I compared our estimated bat fatalities at Golden Hills to the estimate made by the project's monitor (H. T. Harvey & Associates 2018). Based on our dog searches, we estimated 227.5 bat fatalities in 60 days in Fall 2017 at Golden Hills. Over this same period, the dogs of H.T. Harvey & Associates (2018) found 47.5% of the bat fatalities in 2017 among the 14 Golden Hills turbines they searched weekly. Applying the above estimator, our fatality estimate adjusted for this percentage (converted to the proportion 0.475) yields an annual estimate of 479 bats (5.58 bat fatalities/MW/yr), which was nearly equal to H.T. Harvey & Associates' (2018) two-year mean of 484 bat fatalities. Satisfied with the performance of our estimator, which differed from the monitor's estimate by only 1%, I applied the same approach to our bat fatality findings at Buena Vista to estimate an annual toll of 262 bat fatalities, or 6.89 bat fatalities/MW/yr. This estimate was almost 14 times greater than the 3-year average based on human searches at two-week intervals during 2008-2011 at the same project (Insignia 2011). 8-4 cont.

Table 2 includes available bat fatality estimates at repowered wind projects in the APWRA, including alternative estimates for Buena Vista (as discussed above). Table 2 also includes projections of estimated fatality rates to Alameda County and APWRA-wide for use in assessing cumulative impacts. For projecting Buena Vista fatality rates, I only used the estimate derived from dog searches in 2017 (KSS instead of Insignia). The result is an empirically founded, cumulative annual fatality rate of 2,733 bats in the APWRA.

Table 2. *Existing bat fatality rate estimates $\hat{F}$ and their projections to Alameda County's maximum allowable capacity of 450 MW and to the entire Altamont Pass Wind Resource Area (APWRA).*

Project	MW	Monitoring		$\hat{F}$/MW/Yr	$\hat{F}$/Yr	Projected $\hat{F}$/Yr	
		Years	F			Alameda	APWRA
Buena Vista (BV) Insignia	38.00	3	13	1.553	59		
Buena Vista (BV) KSS	38.00	0.06	24	6.890	262		
Vasco Winds (VW)	78.20	3	56	3.205	251		
Golden Hills (GH)	85.92	2	321	5.635	484		
Weighted $\bar{x}$, all projects	202.12			4.933	997	2,220	2,733

The SEIR needs to address cumulative impacts on bats. Bats, due to their long lifespans and low productivity, are vulnerable to new sources of mortality. Hoary bat, as an example, is experiencing a regional decline (Rodhouse et al. 2019). Bats are particularly vulnerable to wind turbines because they are attracted to them and behave dangerously around them (Kunz et al. 2007, Horn et al. 2008, Cryan and Barclay 2009, Smallwood 2016). The SEIR needs to be revised in order to analyze the findings of Normandeau (2011) and Brown et al. (2016) at Vasco Winds, among other data sources.

Note on Burrowing Owls 8-5

I noticed on page 3.4-22 of County of Alameda (2019) that only 1 burrowing owl nest was confirmed on the project site in 2017. I have monitored burrowing owls on 4 sampling plots within the project boundary since 2011 (I originally monitored 6 plots, but 2 of these were inaccessible to me in 2017). In 2017 there were 5 burrowing owl nest sites on my sampling plots alone, or 5 on 24% of the project area. Therefore, there were likely 20 burrowing owl nest sites on the project area, or 20 times the number purported by County of Alameda (2019). The SEIR needs to be revised to present the public and decision-makers with better information about a species that is rapidly declining across California (DeSante et al. 2007, Wilkerson and Siegel 2010), in the Bay Area, specifically (Conway 2018), and in the APWRA (Smallwood, unpublished data).

REFERENCES CITED

Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas. 2016. Final 2012-2015 Report Avian and Bat Monitoring Project Vasco Winds, LLC. Prepared for NextEra Energy Resources, Livermore, California.

Conway, C. J. 2018. Spatial and temporal patterns in population trends and burrow usage of burrowing owls in North America. Journal of Raptor Research 52:120-142.

County of Alameda. 2019. Sand Hill Wind Project Draft Subsequent Environmental Impact Report. Prepared by ICF International. Hayward, CA.

Cryan, P. N. and R. M. R. Barcaly. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. Journal of Mammalogy 90:1330-1341.

Desante, D. F., E. D. Ruhlen, and R. Scalf. 2007. The distribution and relative abundance of Burrowing Owls in California during 1991–1993: evidence for a declining population and thoughts on its conservation. In Proceedings of the California Burrowing Owl Symposium, November 2003 (J. H. Barclay, K. W. Hunting, J. L. Lincer, J. Linthicum, and T. A. Roberts, Editors). Bird Populations Monographs No. 1. The Institute for Bird Populations and Albion Environmental, Point Reyes Station, CA, USA. pp. 1–41.

Horn, J. W., E. B. Arnett, and T. H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72:123-132.

H.T. Harvey & Associates. 2017. Golden Hills Wind Energy Center Post-construction Fatality Monitoring Report: Year 1. Prepared for Golden Hills Wind, LLC, Livermore, California.

H.T. Harvey & Associates. 2018. Golden Hills Wind Energy Center Post-construction Fatality Monitoring Report: Year 2. Prepared for Golden Hills Wind, LLC, Livermore, California.

Insignia Environmental. 2011**.** Draft Final Report for the Buena Vista Avian and Bat Monitoring Project. Report to County of Contra Costa, Martinez, California.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5:315-324.

McClure, C. J. W., L. Martinson, and T. D. Allison. 2018. Automated monitoring for birds inflight: Proof of concept with eagles at a wind power facility. Biological Conservation 224:26-33.

Normandeau Associates, Inc. 2011. Pre-Construction Acoustic Bat Monitoring for the Vasco Winds Repower Area, Final Report, Contra Costa County, California. Prepared for NextEra Energy Resources, Juno Beach, Florida.

Rodhouse, T. J., R. M. Rodriguez, K. M. Banner, P. C. Ormsbee, J. Barnett, K. M. Irvine. 2019. Evidence of regionwide bat population decline from long‐term monitoring and Bayesian occupancy models with empirically informed priors. Ecology and Evolution 2019;00:1–11. https ://doi.org/10.1002/ece3.5612

Sinclair, K. and E. DeGeorge. 2016. Framework for Testing the Effectiveness of Bat and Eagle Impact-Reduction Strategies at Wind Energy Projects. S. Smallwood, M. Schirmacher, and M. Morrison, eds., Technical Report NREL/TP-5000-65624, National Renewable Energy Laboratory, Golden, Colorado.

Smallwood, K. S. 2016. Report of Altamont Pass research as Vasco Winds mitigation. Report to NextEra Energy Resources, Inc., Office of the California Attorney General, Audubon Society, East Bay Regional Park District.

Smallwood, K. S. and L. Neher. 2010. Siting repowered wind turbines to minimize raptor collisions at Vasco Winds. Report to NextEra Energy Resources, LLC, Livermore, California.

Wilkerson, R. L., and R. B. Siegel. 2010. Assessing changes in the distribution and abundance of Burrowing Owls in California, 1993–2007. Bird Populations 10:1-36.

Attachment 1: Report of Fatality Rates at Buena Vista

8-6

Avian Fatality Rates at Buena Vista Wind Energy Project, 2008-2011

K. Shawn Smallwood

15 February 2011

The Buena Vista Wind Energy Project (hereafter BV) was repowered from old-generation turbines rated at 40.6 MW of capacity with modern turbines rated at 38 MW. The project replaced 179 turbines manufactured by Windmaster (5 at 75 kW, 129 at 200 kW, 30 at 250 kW, and 15 at 300 kW) with 38 1-MW turbines manufactured by Mitsubishi Corporation. The new turbines began generating power in December 2006. Now, the developer of the BV project proposes to repower the 86 Howden turbines (85 rated at 300 kW and 1 rated 750 kW) in the Tres Vaqueros portion of the Altamont Pass Wind Resource Area (APWRA), and has initiated environmental review under the California Environmental Quality Act (CEQA). This repowering would replace 28.7 MW of old-generation capacity with 42 MW of modern turbines.

Wind power generation at Tres Vaqueros is partly contingent on a settlement agreement between the former owner of BV and the California Office of the Attorney General (AG). The AG intervened in the repowering of BV, because the AG thought that the installation of the BV turbines differed from the project's Environmental Impact Report (EIR). Following a successful negotiation, the parties agreed that the continued operation of Tres Vaqueros would depend on the repowered BV project causing fewer fatalities than threshold levels that were established for golden eagle, red-tailed hawk, American kestrel, and burrowing owl (focal raptors). The thresholds were to be assessed at the end of the three year fatality monitoring program at BV, and that program just ended in January 2011.

Lamphier-Gregory (2005) projected that 80 raptors were killed annually by BV before repowering, including 54.6 focal raptors. Their projection was based on estimates of APWRA-wide fatality rates (Smallwood and Thelander 2004). Using frequency distributions of reported flight heights of raptors in the APWRA, I then adjusted the predicted fatality rates that would be caused by the BV project as described in the EIR (see Lamphier-Gregory 2005). I predicted that repowering, as outlined in the EIR, would reduce the combined fatality rate of focal raptors by 78% (Table 1). My point estimate of the pre-repowering focal raptor fatality rate was used as the basis from which to establish threshold levels of fatality reductions which were tied to required mitigation measures in the Final EIR (Table 2) and the settlement agreement with the AG's office (Table 3).

Insignia Environmental was contracted by Contra Costa County to perform the fatality monitoring at BV. However, Pattern Energy, the developer of BV and the owner of Tres Vaqueros, requested that I also estimate fatality rates over the three year monitoring period at BV. My objectives in this report are to estimate fatality rates and to compare them to the thresholds agreed upon as part of the settlement agreement with the AG. My report does not represent or replace the report that will be produced by Insignia.

8-6 cont.

METHODS

I used the same general methodology and assumptions for estimating fatality rates as used in Smallwood and Karas (2009). Because Insignia searched for fatalities at monthly intervals from February through August 2008, and then twice per month through January 2011, for 2008 I took a weighted average of fatality rates adjusted for proportions of carcasses not removed by scavengers after 30 days and 15 days, respectively, and for 2009-2010 I adjusted fatality rates using the proportion of carcasses remaining after 15 days (Smallwood 2007). Furthermore, I used national averages of scavenger removal rates and searcher detection rates (Smallwood 2007) instead of the rates estimated by Insignia's on-site trials. I did this because Insignia relied on a methodological protocol which was a revised version (Anonymous 2007) of the original protocol prepared by Erickson and Smallwood (2005). Unknown to Insignia at the start of their monitoring effort, their revised protocol might have introduced substantial biases to their estimates of scavenger removal rates; that is, the removal trials might have swamped scavengers by placing too many dead birds in the field at once, and they utilized carcasses of rock pigeons and domestic quail, which inappropriately represented wild birds (Smallwood 2007). For example, golden eagle carcasses are unlikely to be removed as quickly as rock pigeon carcasses. I would have used the scavenger removal rates from Vasco Caves Regional Preserve (Smallwood et al. 2010), but those rates were derived using a different methodology than were the removal rates used to adjust fatality rates for the 1998-2003 monitoring period, so they would have been incomparable unless I applied them to the APWRA-wide estimates over 1998-2003.

RESULTS

After 3 years of post-construction monitoring, Insignia found 14 bat fatalities and 57 bird fatalities, including 25 raptors (Table 4). I estimated that the repowered BV project caused average annual fatalities of 1.8 golden eagles, 4.5 red-tailed hawks, 4.9 American kestrels, and 0 burrowing owls, or 11.2 focal raptors as a group (Table 5). These fatality rates were lower than my predicted rates in all cases except for American kestrel (Table 5). The all birds and all bats fatality rates were about 25% of the predicted rates.

Overall, repowering appears to have reduced mean annual fatality rates by 79% for focal raptors as a group and 89% for all birds as a group (Table 6). No burrowing owl fatalities were recorded at BV since repowering (Table 6). Post-repowering fatality rates did not breach threshold fatality rates that would have triggered additional mitigation actions (Lamphier-Gregory et al. 2005) or that would have affected the Tres Vaqueros project (AG agreement).

DISCUSSION

The BV repowering project reduced fatality rates of focal raptors much more than any other action taken in the APWRA over its 30-year history. It reduced fatality rates to levels that do not require additional mitigation according to the EIR and the settlement agreement with the AG’s office. In my assessment, BV reduced avian fatalities more so than did the Diablo Winds Energy repowering project. BV's superior performance might have been due to its larger wind turbines and more careful siting efforts, which were intended to minimize impacts.

Uncertainties remain in the comparison of pre- and post-repowering fatality rates. For example, the comparison could be influenced by differences in tower heights and maximum fatality search radii. Larger turbines could throw carcasses farther, but perhaps these carcasses would have been detected using the 25-m longer search radius. Methods should soon be available to account for these types of differences, but for now I assume that the estimates were comparable. Another source of uncertainty is crippling bias, or the proportion of birds mortally wounded by turbine collisions, but which moved away from the project under their own power. However, I have no reason to expect that crippling bias would have differed before and after repowering. 8-6 cont.

Most of the golden eagle fatalities occurred during the first year of monitoring, which was the second year of new turbine operations. Thus, although BV did not reduce golden eagle fatalities in its first year of monitoring, only two fatalities were detected over the last two years. Still, an average of 1.8 golden eagles per year remains 1.8 golden eagles more than I would prefer to see killed by the project. Through improved siting methods (Smallwood and Neher 2010), and by using even larger wind turbines in the future, I expect to achieve even greater fatality reductions through additional repowering. Fatalities will not be eliminated, but perhaps the unavoidable impacts will have been reduced to levels that can be reasonably mitigated.

REFERENCES

Anonymous. 2007. Avian and bat monitoring plan for the Buena Vista Wind Energy Project, Contra Costa County, California. Unpublished document. Contra Costa County.

Erickson, W. and S. Smallwood. 2005. Avian and Bat Monitoring Plan for the Buena Vista Wind Energy Project Contra Costa County, California. Unpubl. report to Contra Costa County, Antioch, California. 22 pp.

Lamphier-Gregory, West Inc., Shawn Smallwood, Jones & Stokes Associates, Illingworth & Rodkin Inc. and Environmental Vision. 2005. Environmental Impact Report for the Buena Vista Wind Energy Project, LP# 022005. County of Contra Costa Community Development Department, Martinez, California.

Smallwood, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.

Smallwood, K. S. and C. Thelander. 2004. Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. 500-01-019. Sacramento, California. 531 pp.

Smallwood, K. S. and B. Karas. 2009. Avian and Bat Fatality Rates at Old-Generation and Repowered Wind Turbines in California. Journal of Wildlife Management 73:1062-1071.

Smallwood, K. S. and L. Neher. 2010. Siting Repowered Wind Turbines to Minimize Raptor Collisions at the Tres Vaqueros Wind Project, Contra Costa County, California. Draft Report to the East Bay Regional Park District, Oakland, California. 39 pp.

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management 74: 1089-1097 + Online Supplemental Material.

8-7

Table 1. Predictions of fatality rates before and after repowering the Buena Vista Wind Energy Project in Contra Costa County, California.

Species or group	Predicted annual fatality rates based on APWRA-wide estimates, 1998-2003		Predicted fatality reduction
	Assuming no change in tower heights	**Assuming increased tower heights [a]**	
Golden eagle	5-8	2.5-4	50%
Red-tailed hawk	14.4-20.7	5.3-7.7	63%
American kestrel	5-23	0.7-3.2	86%
Burrowing owl	6.8-26.2	0	100%
Focal raptors	31.2-77.9 (54.6)	8.5-14.9 (11.9)	78%
All birds [b]		100-300	
All bats [b]		40-125	

[a] I compared frequency distributions of flight heights (Smallwood and Thelander 2004) to the heights above ground of the rotor planes of the proposed new turbines, and assumed that encounter frequencies of flying birds with operating wind turbines would correspond to the shift in the proportion of flight heights within the height domain of the new rotor planes.

[b] Estimates provided by Wally Erickson, based on his comparison of fatality rates among wind resource areas throughout the western USA.

8-8

Table 2. Mitigation measures tied to threshold fatality rates in the Final Draft Environmental Impact Report for the Buena Vista Wind Energy Project. For example, an average annual fatality reduction of more than 50% would result in an estimated fatality rate of fewer than 27.3 fatalities per year for focal raptors (Measure 0), and no mitigation would be required.

Repowering reduces focal raptor fatality rates by:	**Threshold focal raptor fatality rates:**	**Project owner shall implement the following measures:**
≥50%	≤27.3/year	0. No additional conservation strategies
38% to 50%	27.3–33.9/year	1. Add restrictions to grazing management
25% to 38%	33.9–41.0/year	2. Measure 1 and install end-of-row pylons as bird flight diverters
13% to 25%	41.0–47.5/year	3. Measure 2 and implement experimental blade painting
<13%	>47.5/year	4. Measure 3 and seasonally shut down turbines killing disproportionate numbers of birds
<0%	>54.6/year	5. County shall impose any or all of Measure 4, and owner shall double annual compensatory mitigation fee from $500/MW to $1,000/MW of installed capacity

8-9

Table 3. Mitigation measures tied to threshold fatality rates in the settlement agreement between the AG's office and the owners of the Buena Vista Wind Energy Project.

Repowering reduces focal raptor fatality rates by:	**Threshold focal raptor fatality rates:**	**Project owner shall implement the following measures:**
<35%	>35.5/year	Shut down turbines that kill disproportionately more focal raptor fatalities from 15 November through 28 February up to a maximum of 10% of BV's installed capacity, and continue fatality monitoring another 3 years
≤50%	≥27.3/year	Tres Vaqueros Wind Farms LLC will begin decommissioning the existing wind turbines at Tres Vaqueros by 1 September 2012, and will complete decommissioning without unreasonable delay
0%	≥54.6/year	Shut down all turbines from 15 November through 28 February, and continue fatality monitoring another 3 years

8-10

Table 4. Number of fatalities detected at the 38 MW Buena Vista Wind Energy project during three years of fatality monitoring, February 2008 to January 2011.

Species or group	**Species name**	**Number of fatalities detected**
Hoary bat	*Lasiurus cinereus*	9
Mexican free-tailed bat	*Tadarida brasiliensis muscula*	4
California myotis	*Myotis californicus*	1
Great blue heron	*Ardea herodius*	1
California gull	*Larus californicus*	1
Golden eagle	*Aquila chrysaetos*	5
Red-tailed hawk	*Buteo jamaicensis*	13
American kestrel	*Falco sparverius*	5
Prairie falcon	*Falco mexicanus*	1
Barn owl	*Tyto alba*	1
Burrowing owl	*Athene cunicularia*	0
Common raven	*Corvus corax*	1
American crow	*Corvus brachyrhynchos*	1
Rock pigeon	*Columba livia*	2
Mourning dove	*Zenaida macroura*	1
Western tanager	*Piranga ludoviciana*	1
Horned lark	*Eremophila alpestris*	7
Ruby-crowned kinglet	*Regulus calendula*	1
Vireo		1
Black-throated gray warbler	*Dendroica nigrescens*	1
Townsend's warbler	*Dendroica townsendi*	1
Yellow warbler	*Dendroica petechia*	1
Golden-crowned sparrow	*Zonotrichia leucophrys*	1
Sparrow		1
Brewer's blackbird	*Euphagus cyanocephalus*	3
Western meadowlark	*Sturnella neglecta*	4
Lesser goldfinch	*Carduelis psaltria*	1
Passerine		2
All focal raptors		23
All raptors		25
All birds		57
All bats		14

8-11

Table 5. Estimates of annual fatalities caused by the 38 MW Buena Vista Wind Energy project during three years of fatality monitoring, February 2008 to January 2011.

Species or group	**Annual fatalities (80% CI)**			**Predicted annual fatalities (mean)**
	Mean	**LCL**	**UCL**	
Hoary bat	12.8	2.0	23.6	
Mexican free-tailed bat	5.4	0.1	10.8	
California myotis	1.4	0.0	3.2	
Great blue heron	0.6	0.0	1.5	
California gull	0.6	0.0	1.5	
Golden eagle	1.8	0.0	3.5	2.5-4.0 (3.3)
Red-tailed hawk	4.5	1.4	7.7	5.3-7.7 (6.5)
American kestrel	4.9	0.0	9.8	0.7-3.2 (2.0)
Prairie falcon	0.4	0.0	0.8	
Barn owl	0.3	0.0	0.8	
Burrowing owl	0.0	0.0	0.0	0
Common raven	0.6	0.0	1.5	
American crow	0.6	0.0	1.5	
Rock pigeon	1.0	0.0	2.3	
Mourning dove	1.4	0.0	3.2	
Western tanager	1.9	0.0	4.6	
Horned lark	10.1	0.0	20.5	
Ruby-crowned kinglet	1.4	0.0	3.2	
Vireo	1.9	0.0	4.6	
Black-throated gray warbler	1.9	0.0	4.6	
Townsend's warbler	1.4	0.0	3.2	
Yellow warbler	1.9	0.0	4.6	
Golden-crowned sparrow	1.4	0.0	3.2	
Sparrow	1.9	0.0	4.6	
Brewer's blackbird	4.1	1.0	9.6	
Western meadowlark	5.4	0.1	10.8	
Lesser goldfinch	1.9	0.0	4.6	
Passerine	2.7	0.0	5.4	
Focal raptors	11.2	1.4	21.0	8.5-14.9 (11.9)
All raptors	11.9	1.2	22.6	
All birds*	54.8	0.0	117.7	100-300 (200)
All bats*	19.6	1.6	37.7	40-125 (82.5)

* Predictions made by Wally Erickson, who relied on mean fatality rates reported at wind resource areas throughout western USA (Lamphier-Gregory 2005).

8-12

Table 6. Predicted versus measured reductions in mean annual fatality rates before and after repowering at the Buena Vista Wind Energy project.

Species or group	Predicted fatality reduction	Measured fatality reduction
Golden eagle	50%	72%
Red-tailed hawk	63%	74%
American kestrel	86%	65%
Burrowing owl	100%	100%
Focal raptors	78%	79%
Total birds	60%	89%

Skilled Dog Detections of Bat and Small Bird Carcasses in Wind Turbine Fatality Monitoring

Report #1 to the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03)

17 July 2019

K. SHAWN SMALLWOOD,[1] *3108 Finch Street, Davis, CA 95616, USA*
DOUGLAS A. BELL, *East Bay Regional Park District, 2950 Peralta Oaks Court, Oakland, CA 94605, USA*
SKYE STANDISH, *Standish Ecological Services, 156 Franklin Street, Santa Cruz, CA 95060, USA*

Collette Yee (Conservation Canines), Skye Standish and "Captain" engaged in carcass search, Buena Vista Wind Farm, Contra Costa County, California, 3 November 2017 (Photo: Shawn Smallwood).

[1] *Email: puma@dcn.org*

Skilled Dog Detections of Bat and Small Bird Carcasses in Wind Turbine Fatality Monitoring

ABSTRACT - As wind turbine-caused mortality of birds and bats increases with increasing wind energy capacity, accurate fatality estimates are needed to assess impacts, identify collision factors, and formulate mitigation. Finding a larger proportion of wind turbine collision victims would improve fatality estimates, so we tested skilled detection dogs in trials involving randomly placed bat and small bird carcasses in routine fatality monitoring at the Buena Vista and Golden Hills Wind Energy projects, California. Of carcasses placed before next-day fatality searches and confirmed available, dogs detected 96% of bats and 90% of birds. At one project dogs found 71 bat fatalities in 55 searches compared to 1 found by humans in 69 searches within the same turbine search plots over the same season. Dog detection rates remained unchanged with distance from the turbine, but dogs found more fatalities at greater distances from the turbine. Patterns of fatalities indicated we missed 20% of birds and 14% of bats beyond our 105-m search radius at 1.79-MW turbines on 80-m towers and 20% of birds and 4% of bats beyond our 75-m search radius at 1-MW turbines on 55-m towers. Dogs also increased estimates of carcass persistence by finding carcasses that the detection trial administrator concluded had been removed. Whereas our bat fatality estimate equaled that of the monitor's at Golden Hills, our small bird fatality estimate was 3 times higher and both our bat and small bird fatality estimates far exceeded those based on earlier human searches at Buena Vista. Accuracy and precision of fatality estimates at wind projects would greatly improve by using scent-detection dogs guided by trained handlers.

INTRODUCTION

A potential bat mortality crisis lurks behind available estimates of wind turbine collision fatality rates (Kunz et al. 2007). Estimated annual wind turbine-caused bat fatalities in the USA was 888,036 (90% CI: 384,643 to 1,391,428) across 51,630 MW of installed wind energy capacity in 2012 (Smallwood 2013), but installed capacity increased to 96,488 MW by 2018 (https://www.awea.org/wind-101/basics-of-wind-energy/wind-facts-at-a-glance, last accessed 27 February 2019). If vulnerability of bats to wind turbine collision increased linearly with this increased wind energy capacity, and if we restrict mean fatality rates to those estimated from fatality search intervals <10 days (Smallwood and Neher 2017), then estimated annual fatalities in 2018 would have increased to 3,782,330 bats (90% CI: 2,074,492 to 5,490,167), or more than the estimated mortality caused by white nose syndrome (Hopkins and Soileau 2018). However, the Smallwood (2013) estimate was based on human searches for birds and bats around wind turbines – an approach prone to large biases and sources of uncertainty due to wide variation in fatality monitoring methods and poor detection of bats by human searchers (Smallwood 2007, Smallwood et al. 2010, 2013). Given the potential magnitude of wind turbine impacts on bats, and given the need to formulate mitigation measures based on inferences drawn from seasonal and spatial patterns of fatalities, it is imperative that fatality rates are accurately estimated.

Whether a crisis lurks behind wind turbine-caused small bird mortality remains less clear, partly due to high uncertainty in estimates based on human searchers and widely varying fatality monitoring methods (Smallwood 2007, 2013). Smallwood (2013) did not specifically estimate "small bird" fatalities in the USA, but had he done so, his estimate would have numbered more than the 214,000 to 368,000 estimated by Erickson et al. (2014) for North America's installed capacity of 63,023 MW in 2014. Projecting Erickson et al.'s 2014) estimate to the 96,488 MW of capacity in 2018 and the annual toll of small birds would have been 327,633 to 563,406. Whether this range of fatalities qualifies as a crisis depends on whether Erickson et al.'s (2014) estimate was accurate, and whether it threatens particular species or contributes cumulatively with other mortality factors to cause significant impacts. Of particular concern to us was low detection rates of human searchers compounded by relatively long search intervals typical of older studies serving as sources used by Smallwood (2013) and Erickson et al. (2014). In a study of overlapping fatality monitoring by two teams that differed in method only in one team averaging 5 days and the other 39 days between searches, the team with the shorter search interval contributed to a small bird fatality estimate numbering 2.3 times higher than the other team (Smallwood 2017). Considering the effect of long search interval alone, the true small bird fatality rate could be double the rate estimated by Erickson et al. (2014).

The accuracy of fatality estimates depends largely on (1) detecting as many of the available fatalities as possible, and (2) accurately adjusting for the proportion of fatalities not found (Smallwood et al. 2018). Finding more of the actual fatalities decreases the proportion of unfound fatalities, thereby minimizing inaccuracy caused by biases and error in the adjustment. Multiple steps can be taken to detect more of the available fatalities, including searching to a maximum radius around wind turbines that includes all deposited carcasses, searching along transects spaced closer together, searching more frequently, and searching with skilled detection dogs instead of only humans. Homan et al. (2001), Arnett (2006), Paula et al. (2011), and Matthews et al. (2013) found that using skilled dogs greatly increased carcass detection rates over human searchers, and Reyes et al. (2016) found that dogs improved searcher efficiency and were more likely to detect fatalities of rarely-represented species.

The scientific basis for deciding on a maximum search radius has been scarce. Hull and Muir (2010) proposed a method based on ballistics. However, ballistics cannot account for the collider's pre-mortem contribution to deposition distance, including staying aloft until farther from the turbine or continued movement on the ground post-deposition. An injured mobile bat can defy predictions of deposition patterns based on ballistics. Another approach is to observe the pattern of outcomes – where bat carcasses finally wind up within the wind project. Smallwood (2013) proposed such an outcomes method based on modeling the pattern of carcass deposition within previously searched areas, but the pattern could shift with increasing maximum search radius. Huso et al. (2014, 2017) also proposed modeling the pattern of carcass deposition, but the proposed metric consisted of the density of carcasses (carcasses/m^2) as opposed to Smallwood's (2013) cumulative number of carcasses with increasing distance from the turbine. Huso et al. (2014, 2016) further proposed that monitoring can be more efficient by concentrating efforts near the turbine tower where carcass densities were higher at one cited project site. Both the Smallwood (2013) and Huso (2014, 2016) approaches are also vulnerable to a potential bias caused by human searchers finding fewer fatalities farther from the wind turbines, a pattern that can result from decreasing ground visibility, searchers struggling to remain on the intended transect, and searchers shifting attention to navigating more difficult terrain farther from the turbine. If use of dogs greatly improves carcass detection (Arnett 2006, Mathews et al. 2013), then dogs might reveal truer patterns of carcass deposition around wind turbines.

Our primary study objectives were to (1) quantify detection rates of skilled dogs on volitionally placed bats and small birds within wind turbine fatality search plots; (2) compare detection rates of dogs by carcass time in the field, relative occlusion by vegetation, and size; (3) quantify bias in maximum search radii to adjust for proportion of bat fatalities that are undetected because they are outside the maximum search radius; (4) test the efficacy of using skilled dogs relative to human searchers to find available fatalities, (and (5) roughly estimate fatality rates. We note that our reference to dogs includes human handlers as part of a dog-human fatality detection team.

STUDY AREA

Our study involving dogs included 2 wind projects 8 km apart in the Altamont Pass Wind Resource Area (APWRA), California. The Buena Vista Wind Energy project (Buena Vista) consisted of 38 1-MW Mitsubishi wind turbines, 31 of which were accessible to us on land owned by East Bay Regional Park District, Contra Costa County. Two Mitsubishi turbines were on 45-m towers, 2 on 65-m towers, and 27 on 55 m towers. The Golden Hills Wind Energy project (Golden Hills) consisted of 48 1.79-MW General Electric (GE) wind turbines, 32 of which were accessible to us on privately held land in Alameda County. All GE turbines were on 80-m towers. Relying on data from Brown et al. (2016), we compared the pattern of fatalities found by human searchers with distance from the wind turbine at Vasco Winds Energy Project (Vasco Winds) to the pattern found by dogs at Buena Vista and Golden Hills. Vasco Winds consisted of 34 2.3-MW Siemens turbines on 80-m towers, located immediately west and south of Buena Vista in Contra Costa County. All 3 projects were on steeply rolling hills covered by cattle-grazed annual grasses. Elevations ranged 41 - 280 m at Buena Vista, 115 - 477 m at Golden Hills, and 54 - 402 m at Vasco Winds.

METHODS

Dog searches

We sought to maximize bat and small bird fatality finds by performing fatality searches through fall migration from 4 September through 15 November 2017 – a period of peak activity in our study area identified by nocturnal surveys using a thermal-imaging camera since 2012 (Smallwood 2016; Smallwood unpublished data). During daylight morning hours 5 days per week, we searched within 105 m of 2-3 turbines/day at Golden Hills, and within 75 m of 3-5 turbines/day at Buena Vista, achieving about a two week search interval at both projects. The maximum search radii were the same as those used by fatality monitors at the projects (Insignia 2011, H. T. Harvey & Associates 2018).

Our search team included two trained scent detection dogs, worked one at a time by a trained handler and accompanied by a data collector. We led dogs by leash along transects oriented perpendicular to the wind and separated by 10 m over most of each search area. The exception was within a 90° arc between 210° and 300° from the turbine, which corresponds with prevailing upwind directions in the APWRA. Within this 90° arc we allowed dogs off leash for a more cursory search, because in our experience few bat and small bird fatalities are found upwind of wind turbines (Smallwood 2016, Brown et al. 2016). Within the intensive, on-leash search areas we navigated transects using GPS and a Locus Map application on a phone along with visible flagging as needed. We also tracked dogs using a Keychain Finder Transystem 860e GPS data logger to ensure complete search coverage. We mapped and photographed fatality finds using a Trimble GeoExplorer 6000 GPS unit, and identified carcasses to species. We left found carcasses in place for possible repeat discovery.

Our carcass detection trials varied slightly from the integrated detection trials of Smallwood et al. (2018). Within intensively searched areas downwind of wind turbines, our detection trial administrator (KSS) deposited carcasses of bats and small birds at randomized locations the day prior to each fatality search (Table 1). All carcasses had been frozen immediately post-mortem, but we deliberately placed older carcasses in some trials (described below). We weighed trial carcasses prior to placements, removed one foot from bats and clipped off tips of flight feathers of birds. Fatality searchers, who were blind to trials, reported found trial carcasses in the same manner as turbine-caused fatalities except for additionally reporting carcasses that were marked by removed foot or clipped flight feathers. At Buena Vista KSS checked on trial carcass status as long as carcasses persisted. At Golden Hills, KSS removed carcasses of bats but not birds following the dog team's next search, as required by the wind company.

We implemented two additional types of detection trial to test whether time since death and time in the field might affect detection rates. At Buena Vista, we placed fresh frozen bird carcasses on randomized days up to two weeks prior to the next fatality search to test whether carcasses persisting in the field longer than a day were detected at the same rates as those placed one day prior to the search. Because we were required to remove bat trial carcasses from Golden Hills after our next search following placement, we relocated persisting carcasses to Buena Vista to test whether carcasses thawed an extra 1 to 4 days prior to placement affected detection rates (Table 1). We also deliberately placed baby bats and flightless bird chicks to test whether detection dogs would detect them at lower rates than adult animals.

We also tested whether dog detection rates of trial carcasses varied by $\log_{10}$ mass of carcass, where carcasses were weighed at time of placement. We tested whether daily trial carcass detection rates might have increased or decreased with more finds of both trial carcasses and fatalities. Also, upon trial carcass placement we counted paces in 3 standard directions from each carcass until the carcass was no longer visible, and we related detection outcomes to mean number of paces to carcass occlusion. One direction for pacing was directly away from the turbine, and the other two directions were perpendicular to the first direction.

Human searches at Golden Hills

The 32 Golden Hills wind turbines searched by our dog team at 27-day intervals were also searched by humans (H.T. Harvey & Associates 2018) at 28-day intervals within the same maximum search radius of 105 m and the same transect spacing of 10 m. Human searchers and the dog team were blind to each other's fatality finds until the end of our study, but we informed the human searchers of our trial carcass placements. Human searchers removed carcasses they found, except for our trial carcasses. Over our study period we performed 55 searches with dogs at the same 32 turbines where human searchers performed 69 searches. We later compared fatality finds and fatality estimates between human searchers and our dog team.

Patterns of Searcher Detection and Fatalities around Wind Turbines

Humans also searched for fatalities at 34 turbines at Vasco Winds from May 2012 through May 2015, using the same maximum search radius and transect spacing as at Golden Hills, and using a similar detection trial protocol. We used Vasco Winds data to compare searcher detection rates by distance from the turbine between human and dog searchers. We also used Vasco Winds data to compare the pattern of found fatalities with distance from the turbine, where the pattern was derived from human searchers at Vasco Winds and dog searchers at Golden Hills.

Fatality rates are less comparable between wind projects unless one accounts for variation in combinations of tower heights, rotor diameters, and maximum search radii (Smallwood 2013, Hull and Muir 2010, Kitano and Shiraki 2013, Loss et al. 2013). These combinations partly determine the proportion of fatalities that are found, because some proportion of birds and bats end up outside the search area and are never discovered. To derive an adjustment factor, *d*, for the proportion of undetected fatalities among wind projects, Smallwood (2013) reviewed tables and appendices in available reports to obtain distances of fatalities from wind turbines. He summed fatality finds within 1-m intervals of distance from the turbines for each group of tower heights and each group of maximum search radii, and used least-squares regression analysis to fit logistic functions to the cumulative sum fatalities with increasing distance from the turbine, iteratively changing the upper bound value of the dependent variable in the model until the minimum root mean square error (RMSE) was obtained:

$$Y = \frac{1}{\left(\frac{1}{u} + a \times b^{X}\right)},$$

where *u* was the upper bound value of the cumulative proportion of found fatalities Y, X was meters from the wind turbine where the nearest fatality remains were located, and *a* and *b* were fitted coefficients.

Smallwood (2013) then used the models to predict cumulative sum fatalities at 1-m intervals from the turbine, including at distances extended beyond the maximum search radii to predict asymptotic search radii including all fatalities. He divided predicted values at each 1-m interval into the model's asymptotic value to represent the proportion of fatalities found within the maximum search radius, *d*. A potential bias resulting from this approach would be any shift in fatality detection as distance from the turbine increases. Because dog detection rates might differ from humans, we applied Smallwood's (2013) approach to fatalities found by humans at Vasco Winds (Brown et al. 2016) and dogs at Golden Hills.

Fatality Estimation

We estimated fatalities $\hat{F}$ of bats and small birds by dividing the number of carcasses found F by carcass persistence rate R_C, searcher detection rate S, maximum search radius bias d, proportion of wind turbines in the project searched, and concurrent with our study period the proportion of fatalities found in 2017 by H.T. Harvey & Associates' (2018) dogs searching 14 Golden Hills turbines at 7-day intervals. We used 28-day R_C values to represent first visits, and R_C representing our average search interval for later visits. We did not attempt to estimate confidence intervals, which we felt were inappropriate for such a brief survey effort. Our intention was to roughly compare our point estimates to those of H. T. Harvey & Associates (2018) for Golden Hills and Insignia (2011) for Buena Vista, and to the predicted fatalities of Lamphier-Gregory et al. (2005) for Buena Vista prior to construction.

RESULTS

We performed 151 fatality searches at 63 wind turbines from 4 September through 15 November 2017, including 20 searches by humans through 13 September, and 131 searches by dogs thereafter. Our dog team searched 15 turbines once each and another 48 turbines twice to four times per turbine, averaging 25-day intervals between searches (range 2 to 53 day intervals). At Golden Hills, our dog team searched 12 turbines once, 17 twice, and 3 thrice, totaling 55 turbine searches. At Buena Vista, our dog team searched 3 turbines once, 15 twice, 9 thrice, and 4 four times, totaling 76 turbine searches. During the period of our fatality searches using dogs, we found 24 bats and 26 birds at Buena Vista and 71 bats and 63 birds at Golden Hills (Table 1). Based on carcass decay, we estimated that 9 bats and 43 birds had died prior to our study (Table 1).

Trial Carcass Detection Rates

Of 278 trial carcass placements, 214 were available to be found by dogs during at least one search. Of the remainder, 54 had been removed by scavengers prior to the first search, 7 were placed at turbines not subsequently searched as the study ended, and 3 were mistakenly placed outside search areas. Of carcasses placed before next-day fatality searches and confirmed available, dogs detected 96% of bats and 90% of birds between both projects. Dogs found 100% of 41 bats placed at Golden Hills and 93% of 54 bats placed at Buena Vista. They found 84% of 56 small birds placed at Golden Hills and 91% of 32 small birds placed at Buena Vista.

Of all searcher exposures to placed carcasses, whether just placed or persisting through multiple searches, dogs found 95% of 132 bat trials and 91% of 101 bird trials between both projects. Dogs found 100% of 44 bat trials at Golden Hills and 92% of 88 bat trials at Buena Vista. They found 88% of 57 small bird trials at Golden Hills and 95% of 44 small bird trials at Buena Vista.

Because we were required to remove bats soon after trial completion at Golden Hills, we relocated bats to Buena Vista to perform older-carcass trials, since they had already persisted 1 to 4 days at Golden Hills (Table 2). Dogs detected 87.5% of 24 relocated bats confirmed to be available for detection, or 5.5% lower than the fresh bat detection rate at Buena Vista.

We placed 36 bird carcasses on randomized days at Buena Vista to vary the days since placement by up to two weeks (Table 2). Dogs detected 36% of these carcasses, but they found 100% of 13 that had persisted through the next fatality search. The 64% that were undetected had not persisted until the next search, likely because scavengers removed them.

For bats, birds, and bats and birds pooled together, dog detection trial outcomes did not differ significantly by mean distance to carcass occlusion (t-tests, $P > 0.05$), by mean $\log_{10}$ body mass (t-tests, $P > 0.05$), nor by mean number of carcass (fatalities and trials) finds on a particular day (t-tests, $P > 0.05$).

Of the 7 bats missed by dogs, 3 had been relocated from Golden Hills to Buena Vista (they had been found at Golden Hills, but relocated to test dogs on bats that had been in the field >1 day). Missed relocated bats included 2 adult little brown bats and one adult Mexican free-tailed bat that had persisted at Golden Hills 2-4 days prior to relocation. Dogs missed 3 bats on the same day – 31 October 2017. Dogs missed 1 bat on a gravel turbine pad, 1 on a gravel access road, 1 in restored grassland, and 4 in established grassland. Only one of the missed bats was partially occluded by vegetation. Two of the missed bats were near the edge of the maximum search radius.

Dogs missed 8 birds ranging in size from a 3.7 g Bewick's wren to an 87.6 g Eurasian collared-dove. Dogs missed 2 birds on the same day – 23 October 2017, and 3 more on 13 November 2017. Dogs missed 2 birds on the non-gravel portions of turbine pads, 3 in reclaimed grassland, and 3 in established grassland. Three were partially occluded by vegetation, and 4 were on very steep slopes. Two of the missed birds were at the edge of the maximum search radius.

Of the 15 missed bat and bird trial carcasses, 4 bats and 6 birds (67% of misses) were missed on 8 (18%) search days when the dog team was accompanied by the dog handler's supervisor or a photographer. The misses occurred on such days of distraction nearly 4 times more often other than expected. Dogs missed another bat trial carcass during its first study day. Twelve (80%) of 15 trial carcass misses occurred at 3 of 21 (14%) same-day turbine search groups, or nearly 6 times more often other than expected at these turbine groups. Dogs missed 5 trial carcasses at Golden Hills turbines 4, 5 and 6 grouped for same-day searches, 4 at Buena Vista turbines C11 and C12, which were searched with C13 as a group, and 3 at Buena Vista turbines A14, A15, and A16, which were searched with A13 as a group. Common features of these turbine search groups were steep slopes and highest elevation peaks in the local area.

Searcher Detection by Distance from Turbine

Regardless of distance from the turbine, searcher detection of trial carcasses was higher for dogs than for humans, more so for bat carcasses than bird carcasses (Fig. 1, Table 3). Neither dog nor human searcher detection rates, *S*, changed significantly with increasing distance from the turbine, but human searcher detection rates tended to decline with increasing distance.

Carcass Persistence

Trial carcass persistence rates for bats were 87% at 1 day, 27% at 10 days, and 5% at 30 days, and for small birds they were 84% at 1 day, 34% at 10 days, and 11% at 30 days (Fig. 2A). When assuming constant daily fatality rates and averaging persistence rates by day, dog searches usually increased carcass persistence over trial administrator status checks at the search intervals typically used at wind projects (Fig. 2B, Table 4). The exception was daily searches for birds, where the mean daily persistence was equal. Dogs increased measured carcass persistence by 0.06 to 0.07 for bats and by 0.10 to 0.11 for birds at intervals longer than daily (Table 4).

Bats smaller and larger than 8 g persisted at nearly equal proportions through 14 days, after which a larger proportion of smaller bats persisted (Fig. 3). Higher proportions of the freshest bat carcasses persisted through 14 days, after which proportions persisting did not differ by freshness at placement time (Fig. 3). Our best-fit models for daily carcass persistence were $R[Bats] = 1.0186 \times 0.8998^{I}$ ($r^2 = 0.98$, RMSE = 0.11), and $R[Small\ birds] = 1 - 3.0732 \times \left(1 - e^{-0.0996 \times \log(I+1)}\right)$ ($r^2 = 0.99$, RMSE = 0.04). Predicted daily mean carcass persistence rates, R_C, were similar between bats and small birds (Fig. 4). Because our daily mean search interval, I, was 22 days at Buena Vista and 27 days at Golden Hills, our fatality adjustment for carcass persistence would be 0.40 and 0.35 for bats and 0.39 and 0.35 for small birds at Buena Vista and Golden Hills, respectively.

Patterns of Found Fatalities around Wind Turbines

With increasing distance from the turbine at Vasco Winds, human searchers found increasingly fewer bird and bat fatalities/ha (Fig. 5), but this density relationship reflected more of the change in search area than it did change in fatality finds with distance from the turbine at Vasco Winds (Fig. 5 inset). The cumulative number of human-found bats and birds increased with increasing distance from the turbine (Figure 5). Logistic models fit to found fatalities in 10-m distance intervals from the turbine indicated that all bats were likely found within the maximum search radius, but not all birds (Table 5).

Over the time period for which we were provided data at Golden Hills, human searchers found 1 bat and 21 birds. The single bat was found only 10 m from a turbine tower base, so the cumulative fatality count through 110 m was 1 for every 10-m increment. The best-fit logistic model fit to the human-found birds within 10-m distance increments indicated that the maximum search radius likely did not include all bird fatalities at Golden Hills (Table 5).

Fatality searches by dogs yielded patterns suggesting substantially more bats and birds would have been found beyond the maximum search radius at Golden Hills and Buena Vista (Fig. 6, Table 6). The pattern of dog-found fatalities at Golden Hills relative to human-found fatalities at Vasco Winds suggested that bats were deposited to nearly twice the distance from the turbine, 177 m (Table 5) versus 99 m (Table 6), respectively. The pattern of bird fatalities was similar between Vasco Winds and Golden Hills.

Using dogs, the number of bats that were found increased with increasing distance from the turbine at both Buena Vista and Golden Hills (Fig. 7). At Buena Vista, the number of birds found by dogs spiked between 40 and 50 m from the turbines (Fig. 7).

Comparing Found Fatalities of Dog Team with Human Searchers at Golden Hills

Our dog team found 8 (38%) of 21 birds reported to have been found and removed by human searchers at Golden Hills, half of which we found as whole carcasses and half as partial carcasses or feather piles. For example, we found 3 of 7 red-tailed hawks found by human searchers, 2 of which were found on the same day by our dog team and the monitor's human searcher. We found 2 of 3 burrowing owls found by human searchers, the one mallard, an American pipit, and 1 of 2 horned larks. We did not find the 1 golden eagle and 1 ferruginous hawk found and removed by human searchers. Of the 63 bird fatalities we found using dogs, the human searchers found 11 (17%). Bird fatality finds were skewed towards larger birds among human searchers, whereas dogs discovered most of the small birds (Fig. 8).

Our dog team failed to detect the one bat found by human searchers, because it had been found and removed by the human searchers 39 days before we searched that turbine. The human searchers found none of 71 bats found by our dogs and which we left in place to be potentially found by human searchers. Some of these bats were likely removed by scavengers in the time between our dogs finding them and the next human search.

Fatality Estimates

Based on our surveys we estimated 227.5 bat fatalities in 61 days in Fall 2017 at Golden Hills (Table 7). Over this same period, the dogs of H.T. Harvey & Associates (2018) found 47.5% of the bat fatalities in 2017 among the 14 Golden Hills turbines they searched weekly. Our fatality estimate adjusted for this percentage (converted to the proportion 0.475) yields an annual estimate of 479 bats (5.58 bat fatalities/MW/yr), which was midway between H.T. Harvey & Associates' (2018) year 1 and year 2 mean estimates of 468 and 500, respectively.

Applying the same adjustment approach to our estimated 86.7 bat fatalities at Buena Vista, but restricting it to the operable period preceding the shutdown, we estimate an annual fatality total of 262 bat fatalities at Buena Vista, or 6.89 bat fatalities/MW/yr. Our estimate was almost 14 times greater than the 3-year average based on human searches at 15-day intervals during 2008-2011 at the same project (Insignia 2011). It was also twice the upper-end and 6.5 times the lower end of the predicted range of annual fatalities for the project (Lamphier-Gregory et al. 2005).

Based on our surveys we estimated 243 small bird fatalities in 61 days in Fall 2017 at Golden Hills (Table 7). Over this same period, the dogs of H.T. Harvey & Associates (2018) found 18.5% of the small bird fatalities in 2017 among the 14 Golden Hills turbines they searched weekly. Our fatality estimate adjusted for this percentage yields an annual estimate of 1,314 small birds (15.29 small bird fatalities/MW/yr), which was >3 times more than H.T. Harvey & Associates' (2018) 2-year mean estimate of 421.

Applying this same adjustment approach to our estimated 54.3 small bird fatalities at Buena Vista, we estimate an annual fatality total of 295 small bird fatalities at Buena Vista, or 7.72 small bird fatalities/MW/yr. Our estimate was almost 6 times greater than the 3-year average based on human searches at 15-day intervals during 2008-2011 at the same project (Insignia 2011), although the Insignia estimate was for all birds other than raptors. Our estimate nearly equaled the upper-end of the predicted range of annual all-bird fatalities (Lamphier-Gregory et al. 2005).

DISCUSSION

Skilled scent-detection dogs found 95% of placed bats and 91% of placed birds, despite our deliberate placements of carcasses of immature bats and birds, mostly small-bodied species, and some old carcasses, and despite inadvertent placement of some carcasses beyond the search radius. Dogs found 22 of 23 available immature bats averaging 3.46 g, and a desiccated bat carcass of only 1 g. Dogs found most of the relocated bats that had already decayed in the field for up to 4 days, and they found bats that disappeared into tall grass when dropped from shoulder-height – bats that no human could possibly have found. Among birds, dogs found hummingbirds and many chicks of various songbird species. Dogs found all available birds placed up to 2 weeks prior to their next search. Overall, dogs found the majority of trial carcasses, giving us confidence that they can find the majority of available carcasses representing wind turbine fatalities.

Our results were consistent with others who have used scent-detection dogs for fatality searches. At two wind projects, dogs found 71% and 81% of trial bat carcasses, whereas humans found 42% and 14%, respectively (Arnett 2006). At other wind projects, dogs found 96% of trial *Coturnix coturnix* carcasses compared to 9% found by humans (Paula et al. 2011), and 73% of trial bat carcasses compared to 20% found by humans (Mathews et al. 2013). In another study using untrained dogs, dogs found 92% of trial *Passer domesticus* carcasses compared to 45% found by humans (Homan et al. 2001). Our findings were similar to earlier comparisons between dogs and humans, although we note the disparity between dog and human detection rates increased with smaller-bodied animals. Where 55 of our dog searches overlapped 69 human searches at the same wind turbines, our dogs found 71 bat fatalities whereas human searchers found 1, our dogs found 47 small birds whereas human searchers found 11, and our dogs found 16 large birds whereas humans found 10 (4 were found by both dogs and humans). The 71-fold difference in found bats and 4-fold difference in found small birds represented substantial differences in searcher detection between dogs and humans – differences that were measured in actual concurrent fatality monitoring rather than in separate trials.

Our findings also differed largely from human searches performed at 15-day intervals 6 to 9 years earlier at Buena Vista. Over only 17 days of surveys at operable turbines, our dogs found more bat fatalities than Insignia's (2011) human searchers found in 3 years. Our fatality estimates were 14 times greater for bats and 6 times greater for small birds than estimated by Insignia (2011), and they exceeded predictions made prior to construction (Lamphier-Gregory et al. 2005). Using humans as searchers for bats and small birds leaves much to be understood about wind turbine impacts on small volant animals in the Altamont Pass.

Although our dog searches at Golden Hills translated into the same annual bat fatality estimate as reported by H.T. Harvey & Associates (2018), we found 3.7 times as many small birds per search over the same time period as did H.T. Harvey & Associates' dogs. This difference translated into an annual small bird fatality estimate that was more than 3 times larger than that produced by the other dog team. We posit that H. T. Harvey & Associates would find more of the available small bird carcasses by working dogs on leash and spending more time per search plot (H. T. Harvey & Associates established a 1-hour limit for searching each plot).

Searcher detection error was much lower for scent-detection dogs than for humans. Using skilled dogs, accounting for the undetected portion of fatalities narrows down to crippling bias (Smallwood 2007), carcass persistence, areas unsearched beyond the maximum search radius, and unsearchable areas within the maximum search radius, e.g., cliffs, impenetrable vegetation, tidal zone, and deep water. Crippling bias remains unquantified without detecting collisions in some way other than searches within plots, but the other contributing factors to the undetected portion of fatalities can be measured via integrated detection trials (Smallwood et al. 2018). Because so many of the available carcasses are found by dogs, fewer can persist undetected beyond the search interval, meaning carcass persistence adjustment is smaller and less prone to bias. And because dogs detect carcasses regardless of body mass, integrated detection trials using dogs no longer require body mass as an axis of similitude between trial carcasses and species represented by fatalities (Smallwood et al. 2018). Dogs also facilitate the search radius adjustment by providing truer characterizations of the pattern of fatalities between the wind turbine and the maximum search radius. Logistic models fit to these patterns can more accurately predict the portion of fatalities located beyond the maximum search radius.

Confident of no distance-from-turbine effect on dogs' detection of fatalities, our logistic models fit to the pattern of fatality disposition indicates our maximum search radius of 105 m was too short for encountering all fatalities of wind turbines on 80-m towers. Our models predicted that we did not find 14% of bats and small birds beyond 105 m, nor did we find 21% of large birds. Additional research is needed to determine just how far searches need to extend from turbines to potentially detect all of the available fatalities, and alternatively, to determine the proportion of fatalities undetected due to insufficient search radius. As argued in Smallwood (2013), the fitting of logistic functions to cumulative numbers of fatalities with increasing distance is an interim measure to the more exact approach of actually searching farther. Fitting a model to fatalities collected within a maximum search radius will yield different patterns and different distances associated with asymptotic cumulative fatality finds depending on the search effort, including duration of monitoring and the maximum search radius used. What is needed is a research effort that uses dogs to continue searching outward from turbines until no more fatalities are found.

Scent-detection dogs are needed for finding sufficient numbers of available bat and small bird fatalities to test hypotheses related to spatial distributions of fatalities deposited around and among wind turbines. Dogs are needed for finding enough of the available bats and small birds to reveal patterns that can improve fatality monitoring. Dogs are needed to reveal whether preconstruction bat activity patterns can predict post-construction impacts. Dogs are needed to find enough of the available bats for developing micro-siting strategies consistent with those developed for raptors (Smallwood et al. 2017) and for testing operational curtailment strategies in appropriate experimental designs (Sinclair and DeGeorge 2016).

Searching with dogs further revealed a substantial error associated with carcass persistence trials – an error first reported by Smallwood et al. (2018). Discounting two red-tailed hawks found by both the dog team and human searchers on the same search days, our dog team found 32% of the bird carcasses reported to have been removed by the human search team at Golden Hills. Similarly, our dog team revealed that our trial administrator, even knowing exactly where he placed carcasses, nevertheless falsely determined removals of 8.9% (11 of 123) of bird trial carcasses and 2.9% (3 of 105) of bat trial carcasses. This type of error is difficult to avoid because carcass remains often spread over large areas and some of the remains will be small and hidden in vegetation. Finding feathers and bones a month or two after the carcass was reported to have been removed can result in double-counting a fatality if it was falsely assumed to have been removed. Acknowledging the potential error associated with incomplete removals and false removal determinations, Brown et al. (2016) and Smallwood et al. (2018) left carcasses where found and relied on fatality photos and on tracking when and where remains were found to prevent double counting. Dogs, however, find almost all remains, including small pieces of bat wing or a few feathers of a small bird, and thus nearly eliminate detection trial administration error.

We concur with Paola et al. (2011) and Mathews et al. (2013) that fatality monitoring at wind turbines should be performed using scent-detection dogs and trained handlers, and we further concur that dogs should be carefully selected for the task (Beebe et al. 2016). Unlike humans, skilled dogs find almost all of the available carcasses. Some of our findings suggest that a skilled dog team might find even more of the available carcasses if the dog team is left undisturbed by colleagues. The much more accurate fatality estimates generated from dog searches can lead to more cost-effective monitoring and to insight about causal factors of collisions as well as reasonable solutions. Monitoring and mitigation solutions can be arrived at much more rapidly with the vastly superior data that dogs and their handlers can collect at wind turbine projects.

MANAGEMENT IMPLICATIONS

Many of the available fatality monitoring reports likely underestimated bat and small bird fatalities in North America because they relied on human searchers. Older reports likely underestimated fatalities even more so as fatality search intervals tended to be longer. The accuracy and precision of fatality estimates at wind projects would greatly improve by using scent-detection dogs guided by trained handlers and applied to shorter search intervals than typically used. Dog search teams should consider using leashed dogs for greater precision of areal searches, and should minimize distractions to the dogs. Dog searches can reveal spatial and temporal patterns of fatalities that can better support hypothesis-testing of causal factors and wind turbine micro-siting strategies.

ACKNOWLEDGMENTS

This research was funded in part by the Gordon and Betty Moore Foundation. We are grateful to the Gordon and Betty Moore Foundation for its financial support which was administered through the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03). We also thank the East Bay Regional Park District for additional funding and for assistance with access to the Buena Vista Wind Energy project located on its property. We thank Bryan Maddock and Leeward Renewable Energy LLC for access and assistance at the Buena Vista Wind Energy project, and Renee Culver and NextEra Energy Resources for access and assistance at Golden Hills Wind Energy project. We thank Heath Smith and Collette Yee of Conservation Canines, Center of Conservation Biology, University of Washington, for their highly skilled dog handling. We also thank Jeff Smith and H. T. Harvey & Associates for assistance at Golden Hills. Our study would not have been possible without the generous donations of bird carcasses by Native Songbird Care and bat carcasses by Dr. Deborah Cottrell at West End Animal Hospital. Use of animal carcasses was authorized under permits from the U.S. Fish and Wildlife Service (MB135520-0) and the California Department of Fish and Wildlife (SC-00737). We thank Jennifer Brown of the former agency and Carie Battistone, Esther Burkett, Justin Garcia and Scott Osborn of the latter agency, for assistance with permitting. We are indebted to Debbie Woollett for working with us to train a dog we ended up not using, but this effort was important to our development. We are also greatly indebted to Karen Swaim for her generous donation of living space for our dog handler and detection dogs throughout this study. Lastly, we are grateful to the spirited efforts given us by Captain and Jack.

REFERENCES CITED

Arnett, E. 2006. A Preliminary Evaluation on the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Society Bulletin 34:1440-1445.

Beebe, S. C., T. J. Howell, and P. C. Bennett. 2016. Using scent detection dogs in conservation settings: a review of scientific literature regarding their selection. Frontiers in Veterinary Science 3(96):1-13.

Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas. 2016. Final 2012-2015 Report Avian and Bat Monitoring Project Vasco Winds, LLC. Prepared for NextEra Energy Resources, Livermore, California.

Erickson, W. P., M. M. Wolfe, K. J. Bay, D. H. Johnson, and J. L. Gehring. 2014. A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. PLoS One 9(9): e107491. doi:10.1371/journal.pone.0107491.

Homan, H. J., G. M. Linz, and B. D. Peer. 2001. Dogs increase recovery of passerine carcasses in dense vegetation. Wildlife Society Bulletin 29:292–296.

Hopkins, M. C., and Soileau, S. C. 2018. U.S. Geological Survey response to white-nose syndrome in bats: U.S. Geological Survey Fact Sheet 2018–3020, 4 p., https://doi.org/10.3133/fs20183020.

H.T. Harvey & Associates. 2017. Golden Hills Wind Energy Center Post-construction Fatality Monitoring Report: Year 1. Prepared for Golden Hills Wind, LLC, Livermore, California.

Hull, C. L., and S. Muir. 2010. Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Australian Journal of Environmental Management 17:77-87.

Huso, M. M. P. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics 22:318-329.

Huso. M. M. P. and D. Dalthorp. 2014. Accounting for unsearched areas in estimating wind turbine-caused fatality. Journal of Wildlife Management 78:347-358.

Huso. M. M. P., D. Dalthorp, T. J. Miller, and D. Bruns. 2016. Wind energy development: methods to assess bird and bat fatality rates post-construction. Human–Wildlife Interactions 10:62–70.

Insignia Environmental. 2011**.** Draft Final Report for the Buena Vista Avian and Bat Monitoring Project. Report to County of Contra Costa, Martinez, California.

Paula, J., M. C. Leal, M. J. Silva, R. Mascarenhas, H. Costa, M. Mascarenhas. 2011. Dogs as a tool to improve bird-strike mortality estimates at wind farms. Journal for Nature Conservation 19:202-208.

Kitano, M. and S. Shiraki. 2013. Estimation of bird fatalities at wind farms with complex topography and vegetation in Hokkaido, Japan. Wildlife Society Bulletin 37:41-48.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5:315-324.

Lamphier-Gregory, West Inc., Shawn Smallwood, Jones & Stokes Associates, Illingworth & Rodkin Inc. and Environmental Vision. 2005. Environmental Impact Report for the Buena Vista Wind Energy Project, LP# 022005. County of Contra Costa Community Development Department, Martinez, California.

Loss, S. R., T. Will, and P. P. Marra. 2013. Estimates of bird collision mortality at wind facilities in the contiguous United States. Biological Conservation 168:201–209.

Mathews, F., M. Swindells, R. Goodhead, T. A. August, P. Hardman, D. M. Linton, and D. J. Hosken. 2013. Effectiveness of search dogs compared with human observers in locating bat carcasses at wind-turbine sites: A blinded randomized trial. Wildlife Society Bulletin 37:34-40.

Reyes, G.A., M. J. Rodriguez, K. T. Lindke, K. L. Ayres, M. D. Halterman, B. R. Boroski, and D. S. Johnston. 2016. Searcher efficiency and survey coverage affect precision of fatality estimates. Journal of Wildlife Management 80:1488-1496.

Sinclair, K. and E. DeGeorge. 2016. Framework for Testing the Effectiveness of Bat and Eagle Impact-Reduction Strategies at Wind Energy Projects. S. Smallwood, M. Schirmacher, and M. Morrison, eds., Technical Report NREL/TP-5000-65624, National Renewable Energy Laboratory, Golden, Colorado.

Smallwood, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.

Smallwood, K. S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37:19-33. + Online Supplemental Material.

Smallwood, K. S. 2016. Bird and bat impacts and behaviors at old wind turbines at Forebay, Altamont Pass Wind Resource Area. Report CEC-500-2016-066, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2016publications/CEC-500-2016-066/CEC-500-2016-066.pdf

Smallwood, K. S. 2017. Long search intervals under-estimate bird and bat fatalities caused by wind turbines. Wildlife Society Bulletin 41:224-230.

Smallwood, K. S., and L. Neher. 2017. Comparing bird and bat use data for siting new wind power generation. Report CEC-500-2017-019, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2017publications/ CEC-500-2017-019/CEC-500-2017-019.pdf and http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019-APA-F.pdf

Smallwood, K. S., L. Neher, and D. A. Bell. 2017. Siting to Minimize Raptor Collisions: an example from the Repowering Altamont Pass Wind Resource Area. M. Perrow, Ed., Wildlife and Wind Farms - Conflicts and Solutions, Volume 2. Pelagic Publishing, Exeter, United Kingdom. www.bit.ly/2v3cR9Q

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management 74: 1089-1097 + Online Supplemental Material.

Smallwood, K. S., D. A. Bell, B. Karas, and S. A. Snyder. 2013. Response to Huso and Erickson Comments on Novel Scavenger Removal Trials. Journal of Wildlife Management 77: 216-225.

Smallwood, K. S., D. A. Bell, E. L. Walther, E. Leyvas, S. Standish, J. Mount, B. Karas. 2018. Estimating wind turbine fatalities using integrated detection trials. Journal of Wildlife Management 82:1169-1184.

Table 1. Fatalities found by dogs at Buena Vista (BV) and Golden Hills (GH) Wind Energy Projects, Alameda and Contra Costa Counties, California, fall 2017.

Species name	Scientific name	Old fatalities	New fatalities	
			BV	GH
Western red bat	*Lasiurus blossevillii*	0	4	1
Myotis spp.	*Myotis*	0	0	1
Mexican free-tailed bat	*Tadarida brasiliensis*	3	6	29
Hoary bat	*Lasiurus cinereus*	1	2	13
Bat spp.		5	12	27
Mallard	*Anas platyrhynchos*	0	0	1
Grebe	Podicipedidae	1	0	1
Turkey vulture	*Cathartes aura*	2	0	2
Northern harrier	*Circus cyaneus*	1	1	0
White-tailed kite	*Elanus leucurus*	1	1	0
Red-tailed hawk	*Buteo jamaicensis*	0	0	3
Large raptor		1	0	1
American kestrel	*Falco sparverius*	2	4	1
Prairie falcon	*Falco mexicanus*	1	1	0
Rock pigeon	*Columba livia*	1	1	0
Barn owl	*Tyto alba*	0	1	0
Burrowing owl	*Athene cunicularia*	1	0	4
White-throated swift	*Aeronautes saxatalis*	1	1	0
Pacific-slope flycatcher	*Empidonax difficilis*	0	1	0
Horned lark	*Eremophila alpestris*	10	2	10
Northern rough-winged swallow	*Stelgidopteryx serripennis*	0	0	2
Bewick's wren	*Thryomanes bewickii*	0	0	1
House wren	*Troglodytes aedon*	0	0	1
Ruby-crowned kinglet	*Regulus calendula*	0	0	2
American pipit	*Anthus rubescens*	1	0	2
Warbler	Parulidae	0	0	1
Black-throated gray warbler	*Dendroica nigrescens*	1	0	1
Townsend's warbler	*Dendroica townsendi*	0	1	0
Lincoln's sparrow	*Melospiza lincolnii*	0	0	1
Dark-eyed junco	*Junco hyemalis*	0	0	1
Blackbird	Icteridae	1	0	1
Western meadowlark	*Sturnella neglecta*	6	7	7
Brown-headed cowbird	*Molothrus ater*	1	0	1
Large bird		8	2	8
Small bird		3	3	11
All bats		9	24	71

Species name	Scientific name	Old fatalities	New fatalities	
			BV	GH
All small birds		27	19	47
All large birds		16	7	16
All birds		43	26	63

Table 2. Carcasses placed in detection trials at Golden Hills and Buena Vista Wind Projects, 5 September through 15 November 2017, Alameda and Contra Costa Counties, California. Bat species are listed in order of number placed, then birds. Sample sizes were N_1 for placements of fresh frozen carcasses the day before the search, N_2 for placements on randomized days within two weeks of the search, and N_3 for relocations of carcasses from Golden Hills to Buena Vista the day before the search.

Species	Placed			Body mass (g)		
	N_1	N_2	N_3	Mean	Low	High
Mexican free-tailed bat, *Tadarida brasiliensis*	71		17	7.5	1.9	15.6
Evening bat, *Nycticeius humeralis*	25		11	6.0	1.7	11.4
Little brown bat, *Myotis lucifugus*	6		5	2.2	1.0	3.5
Seminole bat, *Lasiurus seminolus*	3		1	15.1	9.1	19.8
Eastern pipistrelle, *Pipistrellus subvlafus*	2			5.2	4.6	5.8
Cliff swallow, *Hirundo pyrrhonota*	12	1		15.1	10.7	19.0
Oak titmouse, *Parus inornatus*	8	1		12.0	6.9	15.6
House finch, *Carpodacus mexicanus*	5	4		19.9	15.6	23.9
Anna's hummingbird, *Calypte anna*	5	3		3.6	2.5	5.7
Northern mockingbird, *Mimus polyglottos*	4	3		38.0	32.2	47.0
Bushtit, *Psaltriparus minimus*	4	3		4.3	3.7	5.0
Vaux's swift, *Chaetura vauxi*	4	2		12.5	11.1	14.9
Wilson's warbler, *Wilsonia pusilla*	3	2		5.9	4.9	7.7
Bewick's wren, *Thryomanes bewickii*	5			7.4	3.7	8.6
Swainson's thrush, *Catharus ustulatus*	3	2		54.0	38.1	69.0
Western bluebird, *Sialia mexicana*	3	1		20.6	17.8	25.5
Black-headed grosbeak, *Pheucticus melanocephalus*	3	1		39.7	34.2	50.8
Violet-green swallow, *Tachycineta thalassina*	2	2		14.2	11.6	18.0
Barn swallow, *Hirundo rustica*	2	2		16.4	14.4	18.3
Western scrub-jay, *Aphelocoma coerulescens*	2	1		59.2	55.5	64.9
American robin, *Turdus migratorius*	2	1		61.0	49.6	70.3
Black phoebe, *Sayornis nigricans*	1	2		15.8	14.5	17.9
Eurasian collared-dove, *Streptopelia decaocto*	3	1		73.3	44.3	90.0
Cedar waxwing, *Bombycilla cedrorum*	3			24.6	23.7	26.3
White-breasted nuthatch, *Sitta carolinensis*	2			14.0	13.6	14.3
Hooded Oriole, *Icterus cucullatus*	2			16.4	15.5	17.2
Golden-crowned sparrow, *Zonotrichia atricapilla*	2			14.9	7.7	22.0
California towhee, *Piplio fuscus*	2			35.8	28.0	43.6
Acorn woodpecker, *Melanerpes formicivorus*	2			69.3	57.6	81.0
Say's phoebe, *Sayornis saya*	2			25.3	4.9	45.6

Chestnut-backed chickadee, *Parus rufescens*	2			5.4	5.4	5.4
Prairie falcon, *Falco mexicanus*	1			57.4	57.4	57.4
Budgerigar, *Melopsittacus undulatus*	0	1		20.3	20.3	20.3
American goldfinch, *Carduelis tristis*	0	1		9.4	9.4	9.4
Mountain bluebird, *Sialia currucoides*	0	1		26.0	26.0	26.0
Western flycatcher, *Empidonax difficilis*	1			9.7	9.7	9.7
Hermit thrush, *Catharus guttatus*	0	1		17.4	17.4	17.4
American crow, *Corvus brachyrhynchos*	1			179.8	179.8	179.8
Mourning dove, *Zenaida macroura*	1			107.9	107.9	107.9
White-crowned sparrow, *Zonotrichia leucophrys*	1			20.4	20.4	20.4
California quail, *Callipepla californica*	1			184.5	184.5	184.5
Northern rough-winged swallow, *Stelgidopteryx serripennis*	1			13.9	13.9	13.9
Spotted towhee, *Piplio erythrophthalmus*	1			27.8	27.8	27.8
Brewer's blackbird, *Euphagus cyanocephalus*	1					

Table 3. Searcher detection rate, *S*, regressed on increasing 10-m distance increments from wind turbine.

Searcher	Trials	a	b	r^2	SE	P
Dog team	Bats	1.000	-0.0000	0.00	0.00	
Dog team	Birds	0.970	-0.0020	0.04	0.16	
Humans	Bats	0.174	-0.0015	0.16	0.08	<0.10
Humans	Birds	0.612	-0.0031	0.21	0.15	<0.10

Table 4. Proportion of trial carcasses remaining and mean daily proportion of carcasses remaining when measured by trial administrator carcass checks only and by combined carcass checks and dog search detections at the Golden Hills and Buena Vista Wind Energy Projects, Altamont Pass Wind Resource Area, California, Fall 2017.

Taxa	Search interval (*I*, days)	Proportion carcasses remaining (R_i)		Mean daily proportion carcasses remaining (R_C)	
		Carcass checks	Carcass checks and dog searches	Carcass checks	Carcass checks and dog searches
Bats	1	0.86	0.90	0.88	0.94
Bats	7	0.39	0.40	0.68	0.74
Bats	14	0.18	0.19	0.48	0.55
Bats	28	0.03	0.04	0.36	0.43
Birds	1	0.76	0.80	0.87	0.87
Birds	7	0.35	0.41	0.58	0.68
Birds	14	0.21	0.27	0.43	0.54
Birds	28	0.07	0.12	0.34	0.45

Table 5. Logistic models of cumulative human-found fatalities in 10-m distance increments from wind turbines to the maximum search radius at Vasco Winds (VW) and Golden Hills (GH) Energy Projects, Altamont Pass Wind Resource Area, California, 2012-2015.

Site	Taxa	Model coefficients			r^2	RMSE	Model-predicted asymptote of cumulative fatalities	
		µ	a	b			Distance from turbine (m)	Proportion within max search radius
VW	Bats	45.39	0.29	0.937	0.96	90.76	99	1.00
VW	Small birds	84.58	0.15	0.957	0.99	42.77	159	0.89
VW	Large birds	60.43	0.12	0.966	0.97	75.27	173	0.84
GH	All birds	21.90	0.61	0.953	0.98	11.15	119	0.92

Table 6. Logistic models of cumulative dog-found fatalities in 10-m distance increments from wind turbines to the maximum search radius at Golden Hills (GH) and Buena Vista (BV) Energy Projects, Altamont Pass Wind Resource Area, California, fall 2017.

		Model coefficients					Model-predicted asymptote of cumulative fatalities	
Site	Taxa	μ	a	b	r^2	RMSE	Distance from turbine (m)	Proportion within max search radius
GH	Bats	78.86	0.16	0.962	0.98	109.14	177	0.86
GH	Small birds	52.15	0.58	0.954	0.99	24.77	156	0.86
GH	Large birds	17.93	9.18	0.942	0.98	6.02	120	0.79
GH	All birds	73.89	0.48	0.956	0.99	29.71	173	0.80
BV	Bats	25.96	1.22	0.915	0.99	5.16	76	0.96
BV	Small birds	21.63	3.36	0.936	1.00	0.61	110	0.74
BV	Large birds	7.91	18.74	0.917	0.98	1.12	80	0.89
BV	All birds	28.79	3.13	0.929	1.00	2.55	108	0.80

Table 7. Estimated fatalities $\hat{F}$ of bats and small birds killed by wind turbines during our Fall 2017 study at operational wind turbines in the Buena Vista (BV) and Golden Hills (GH) projects in the Altamont Pass Wind Resource Area, California, where the number of carcasses found F was divided by carcass persistence rate R_C, searcher detection rate S, maximum search radius bias d, and proportion of wind turbines in the project searched. We used 28-day R_C values to represent first visits, and R_C representing average search interval for later visits.

Taxa	Project	Search	No. found, F	Adjustments			Sampled portion of project	Point estimate, $\hat{F}$
				R_C	S	d		
Bats	BV	1st	17	0.43	0.93	0.96	0.658	67.3
Bats	BV	2nd	1	0.55	0.93	0.96	0.105	19.4
Bats	GH	1st	39	0.43	1.00	0.86	0.667	158.1
Bats	GH	2nd	13	0.55	1.00	0.86	0.396	69.4
Small birds	BV	1st	10	0.45	0.84	0.74	0.658	54.3
Small birds	BV	2nd-3rd	0	0.54	0.84	0.74	0.105	0
Small birds	GH	1st	22	0.45	0.91	0.86	0.667	93.7
Small birds	GH	2nd-3rd	25	0.54	0.91	0.86	0.396	149.4

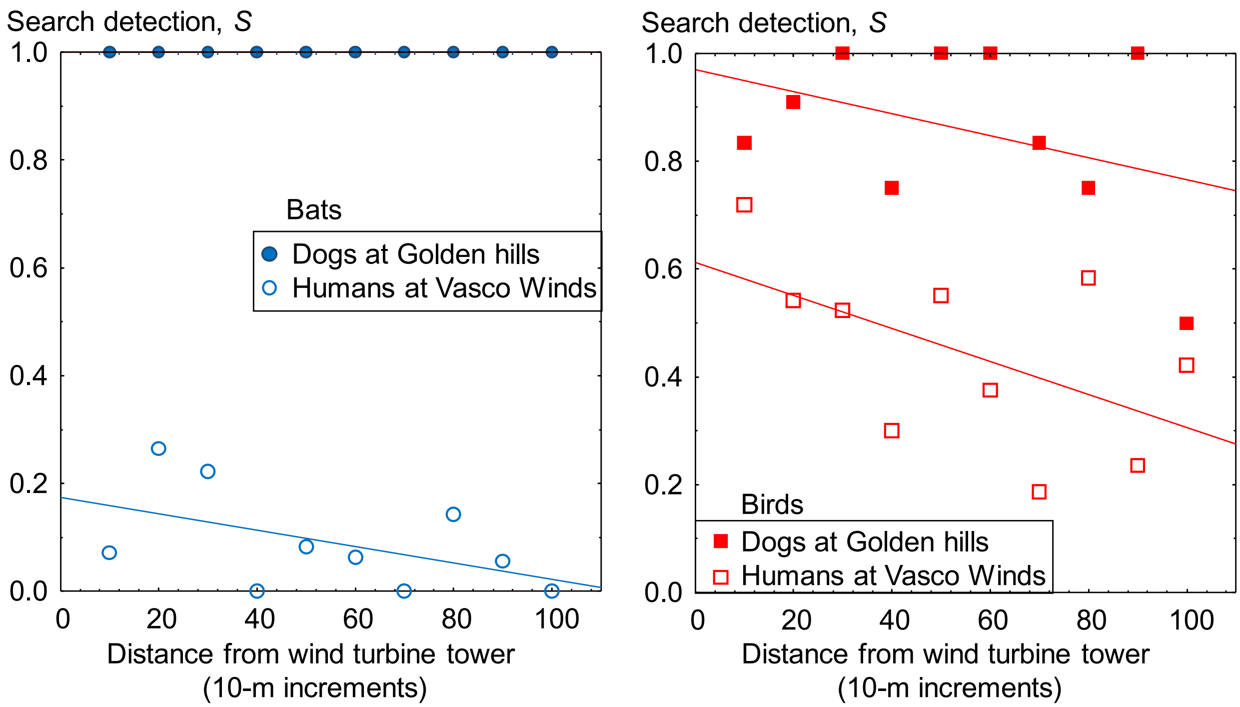


Figure 1. Searcher detection rates of bats (left) and birds (right) did not change significantly with increasing distance from the wind turbine at Vasco Winds, where humans were the searchers, and Golden Hills, where dog teams were the searchers. However, searcher detection using dogs was higher for trial bird carcasses and much higher for trial bat carcasses.

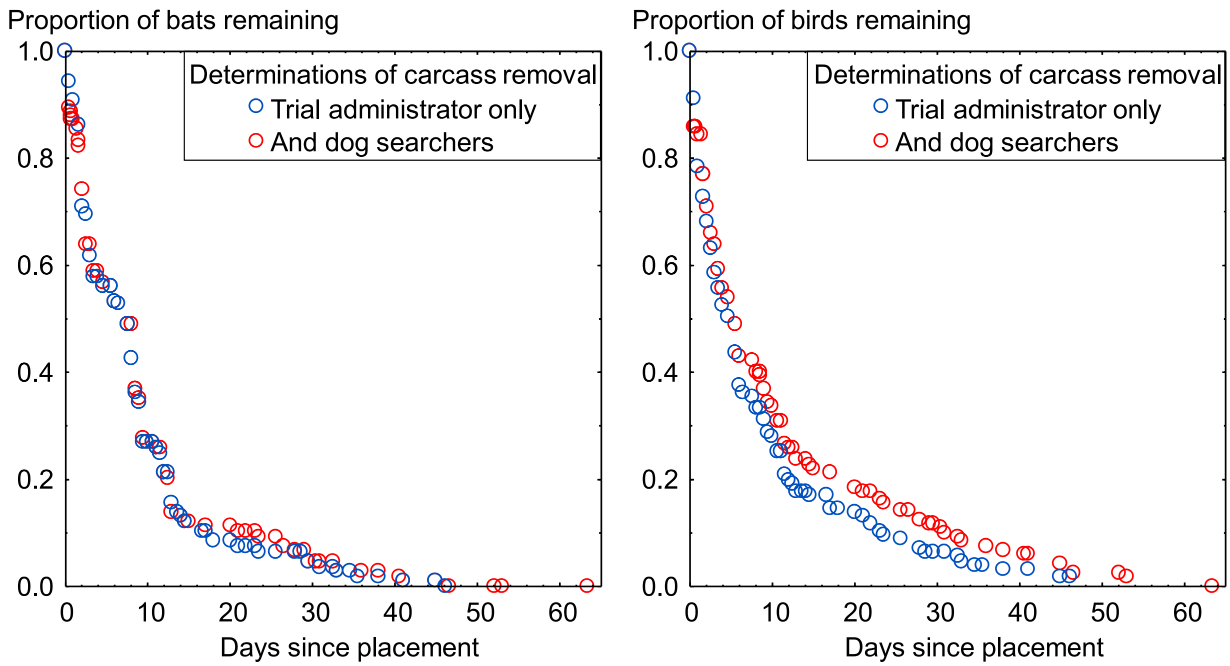


Figure 2. Carcass persistence by day since placement for bats (left) and small birds (right) and as determined by the trial administrator's carcass checks (blue) and both the trial administrator's carcass checks and fatality searches using dogs (red) at Golden Hills and Buena Vista Wind Projects, 2017.

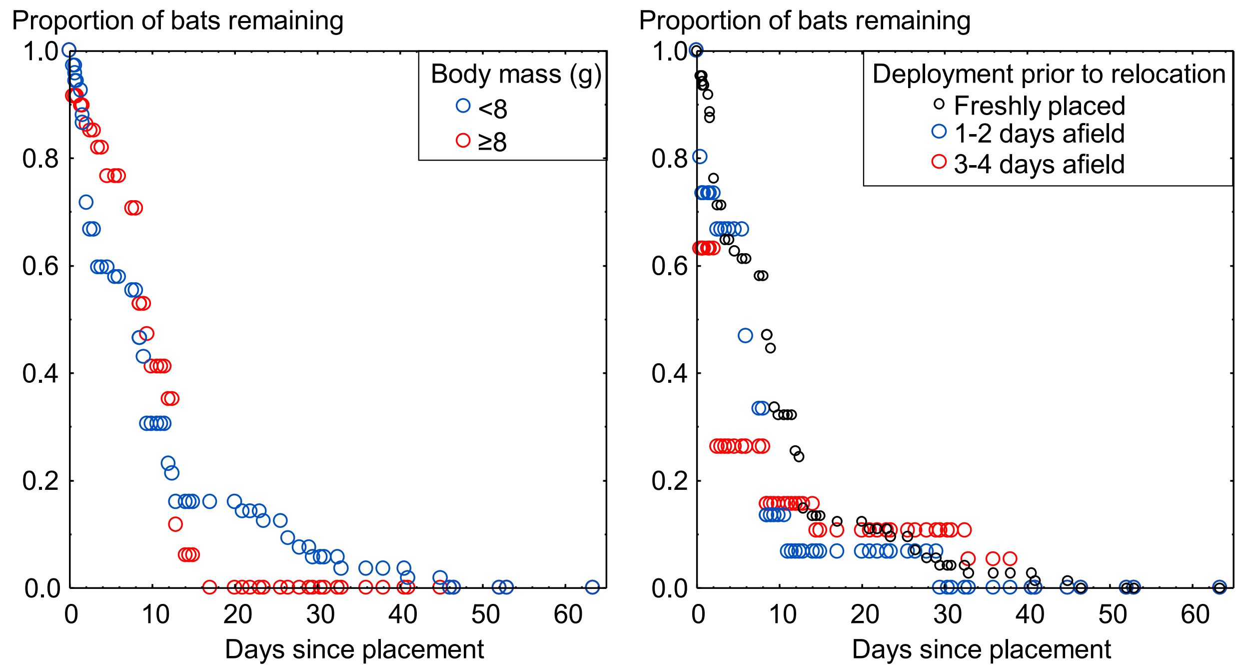


Figure 3. Bat carcass persistence by body mass (left graph) and freshness when placed (right graph) at Golden Hills and Buena Vista Wind Projects, 2017, as status-checked by both a trial administrator and the dog team fatality searches.

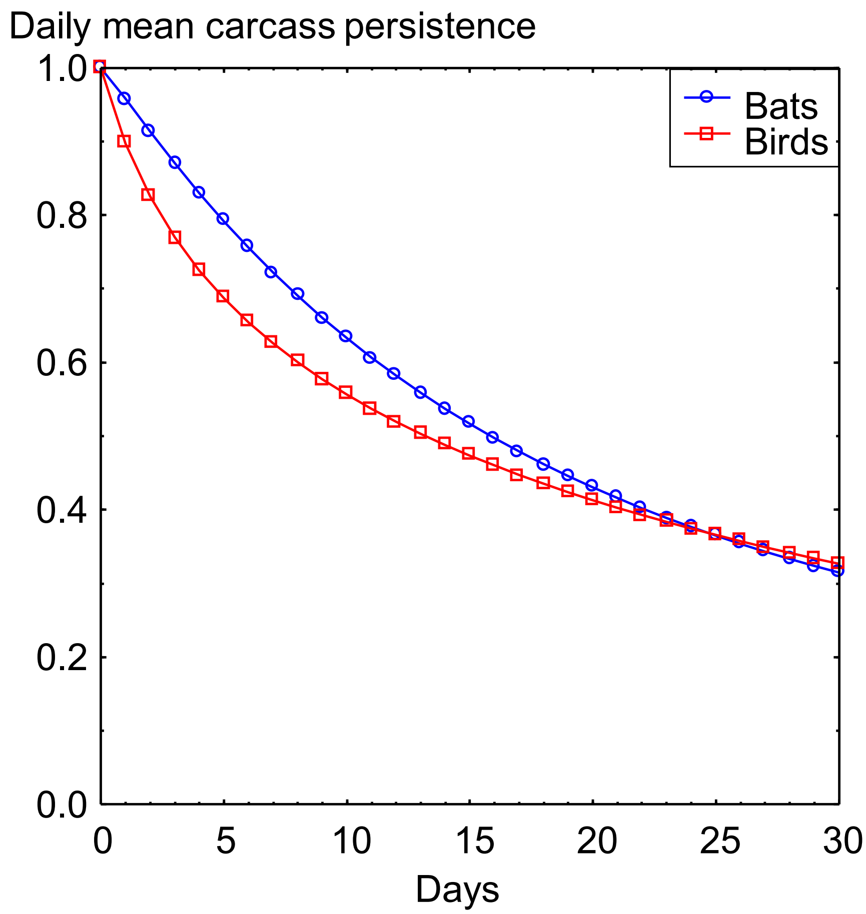


Figure 4. Daily mean carcass persistence rates, R_C, of bats and small birds placed in detection trials and status checked by both a trial administrator and the dog team fatality searches. Only freshly thawed bat carcasses were used for this graph.

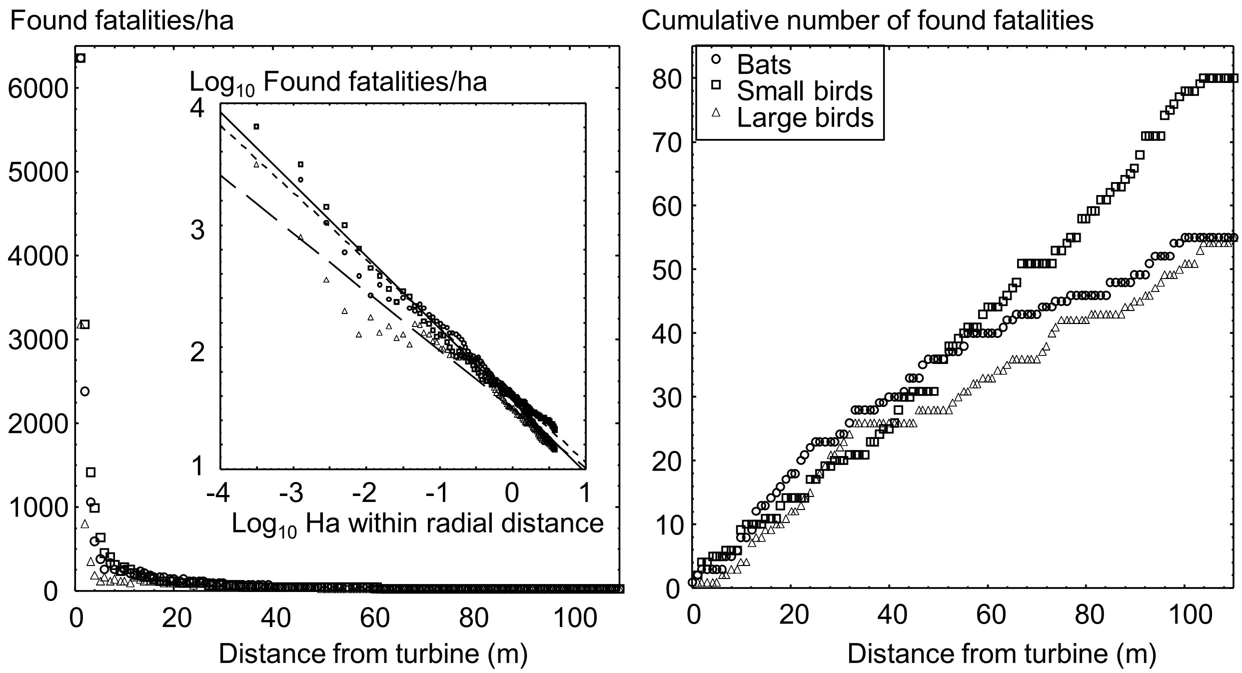


Figure 5. Found fatalities/ha found by human searchers at Vasco Winds declined rapidly with increasing distance from the turbine for bats and birds (left graph), consistent with characterizations by Huso (2010) and Huso et al. (2014, 2016). However, the density metric – fatalities/ha – was a function of the area within incrementally larger radial distances from the turbine (inset, left graph; solid line fit to bats, short dashed line fit to small birds, long dashed line fit to large birds). Cumulative numbers of found fatalities increased nearly linearly with increasing distance from the turbine (right graph).

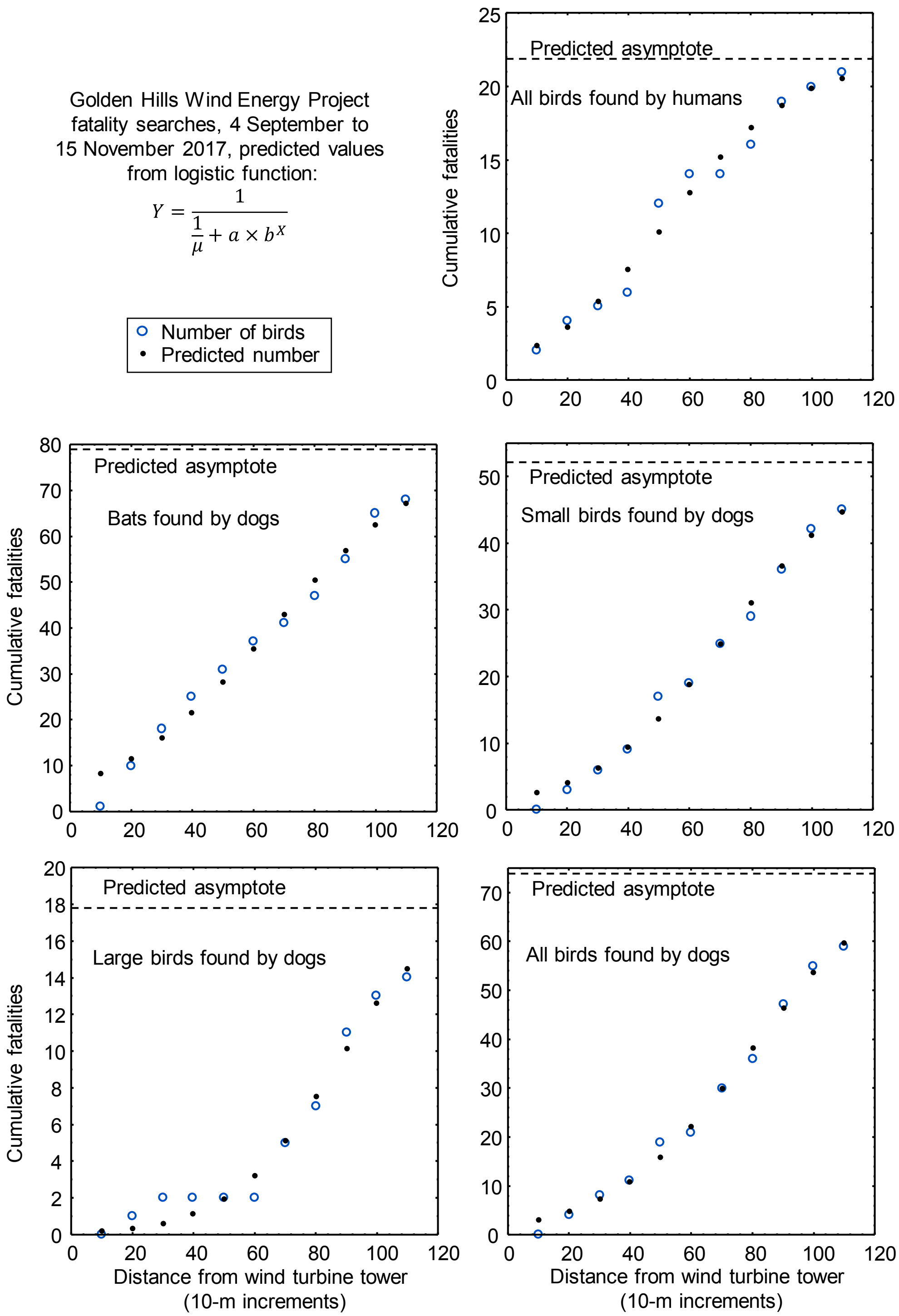


Figure 6. Cumulative numbers of fatalities found at Golden Hills based on human searchers (top right graph) and dog teams (other graphs).

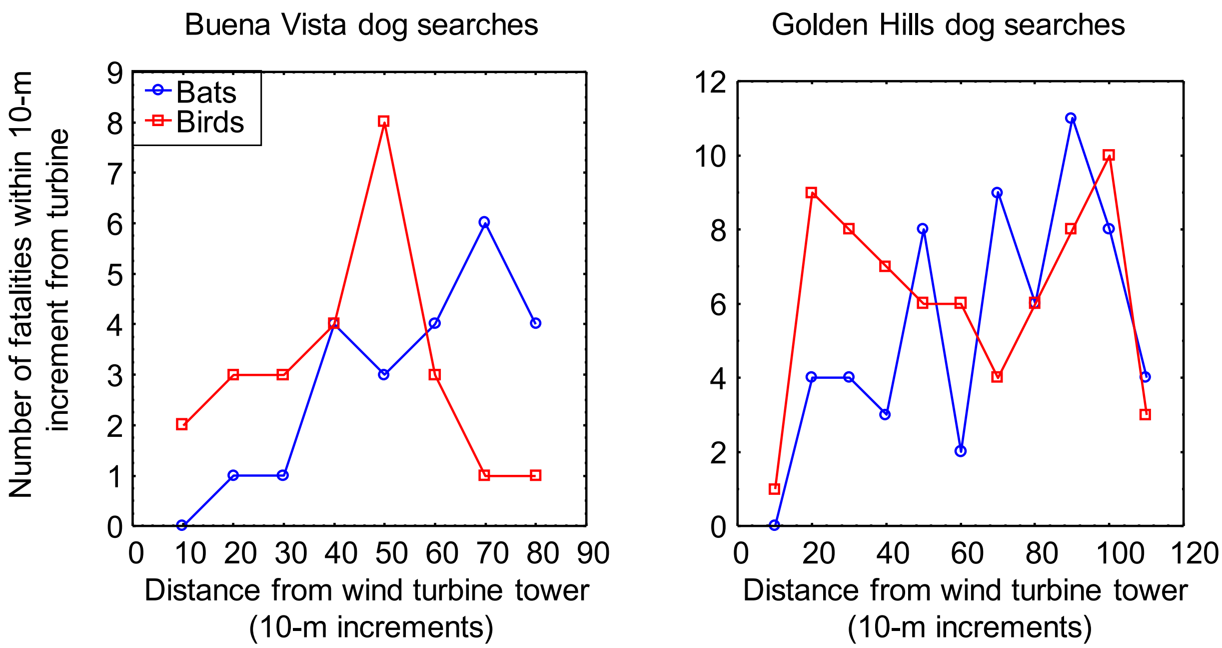


Figure 7. Comparisons of dog team fatality finds by distance from the turbine between Buena Vista (left graph) and Golden Hills (right graph).

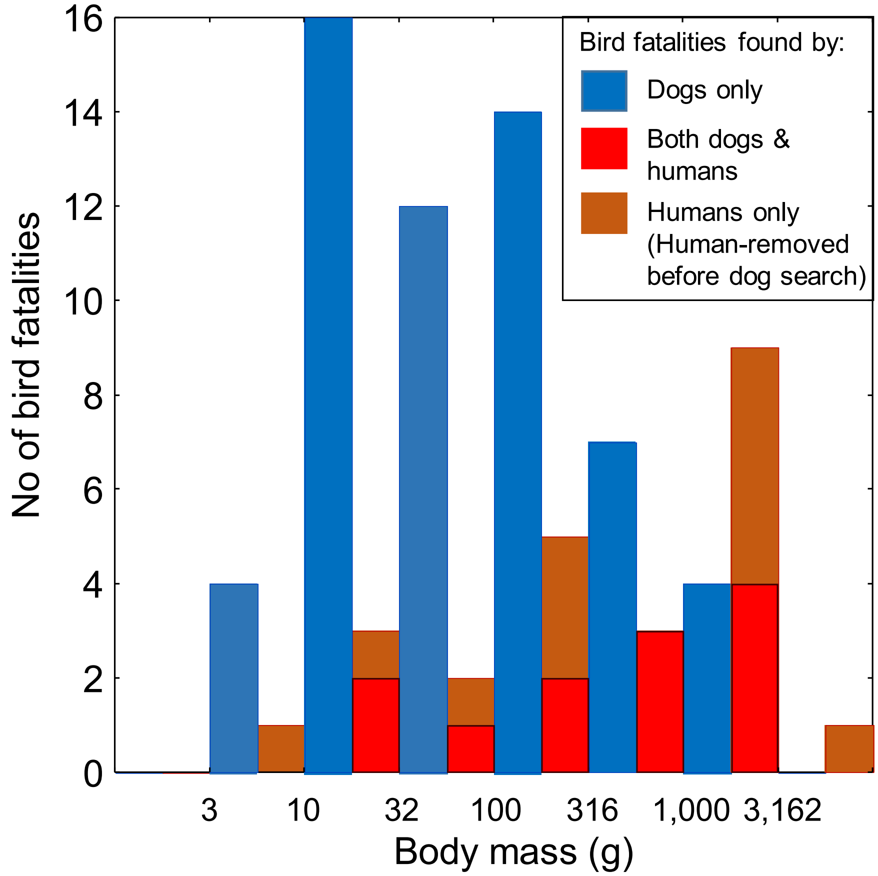


Figure 8. Bird fatality finds by human searchers were skewed toward larger birds, whereas dogs found increasingly larger proportions of small birds with decreasing body mass at Golden Hills during overlapping monitoring efforts between the human searchers and dog team.

Relating Bat and Bird Passage Rates to Wind Turbine Collision Fatalities

Report #2 to the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03)

17 July 2019

K. SHAWN SMALLWOOD,[1] *3108 Finch Street, Davis, CA 95616, USA*
DOUGLAS A. BELL, *East Bay Regional Park District, 2950 Peralta Oaks Court, Oakland, CA 94605, USA*

Screen-shot from video taken with thermal-imaging camera of bat after passing through rotor plane of non-operative 1-MW Mitsubishi wind turbine at Buena Vista Wind Farm, Contra Costa County, California (Image: Shawn Smallwood).

[1] *Email: puma@dcn.org*

Relating Bat and Bird Passage Rates to Wind Turbine Collision Fatalities

ABSTRACT - As wind energy expands, the need grows for macro- and micro-siting of wind turbines to minimize impacts to nocturnal birds and bats. It remains unknown, however, whether activity patterns observed in preconstruction surveys can predict fatality rates. We related wind turbine passage rates of birds and bats observed via thermal-imaging camera to next-day fatality searches by detection dogs to test whether passage rates and rates of near misses, flights disrupted by blade sweeps or rotor wake turbulence, and dangerous behaviors can predict fatalities. Nocturnal bird and bat activity peaked together around the full moon and a shift in winds to more westerly origin. Nightly bat passes through operable wind turbine rotors correlated significantly with next-day counts of fatalities/ha of bats ≤3 days since death ($r = 0.44$, $P<0.05$) and of bats ≤7 days since death ($r = 0.35$, $P<0.05$), but not for bats >7 days since death or for birds. Logit regression revealed that the odds of dogs finding one or more freshly-killed bats were 4 times greater on mornings following nightly thermal imaging surveys when we counted 130 bat passes through the rotors as compared to nights when we counted 0 bat passes. The odds of next-day fatality finds increased with observed near-misses and disrupted flights, and more of these were recorded early during the migration season. Our rates of observed bat collisions would predict 4 times the fatalities that we found using dogs with a measured detection rate of 96%, and consistent with this prediction, our dogs found only 1 of 4 bats seen colliding with turbine blades. The possibility exists that our best estimates of bat fatalities are biased low by crippling bias.

INTRODUCTION

Based on different methods and data sources, USA wind turbines in 2012 were estimated to have killed 600,000 (Hayes 2013) to 888,000 (Smallwood 2013) bats, 214,000 to 368,000 small birds (Erickson et al. 2014), and 234,000 (Loss et al. 2013) to 573,000 (Smallwood 2013) birds of all sizes. Annual fatality numbers undoubtedly increased with the near doubling of installed wind energy capacity by 2018 (https://www.awea.org/wind-101/basics-of-wind-energy/wind-facts-at-a-glance, last accessed 27 February 2019). As wind energy continues to expand, it is imperative that scientists learn whether preconstruction surveys can predict wind turbine impacts on bats and migratory small birds (Kunz et al. 2007). It needs to be known whether preconstruction activity levels or passage rates through planned rotor-swept airspace correlate with post-construction fatality rates. Accurate fatality rate predictions are needed for deciding whether particular wind project sites would cause unreasonable impacts, and for informing micro-siting decisions (Smallwood and Neher 2017, Smallwood et al 2017) or operational curtailment strategies (Arnett et al. 2011, 2013; Behr et al. 2017) to minimize impacts.

Measured across multiple wind projects in Canada and the USA, bat fatality rates did not correlate significantly with preconstruction activity levels measured by bat acoustic detectors (Hein et al. 2013). No similar test has been reported for nocturnally active small birds, e.g., neotropical migrants, nor has a test been reported specific to passage rates through planned rotor-swept airspace for either bats or small birds. Preconstruction activity levels and passage rates could also be measured using radar or thermal-imaging cameras, but no matter how derived, preconstruction activity rates carrying error and potential biases would have to be related, one or more years later, to fatality rates carrying their own suites of error and biases (Smallwood 2007, 2013, 2017; Smallwood et al. 2013, 2018).

Adding to the frustrating result of Hein et al. (2013), fatality rates of bats and small birds measured from daily searches at 48 wind turbines in the Solano Wind Resource Area did not correlate significantly with the previous night's nocturnal activity rates measured by marine radar, acoustic bat detectors, and thermal-imaging goggles (Johnston et al. 2013). Activity rates and fatality rates measured more closely in time, as they were by Johnston et al. (2013), stood a better chance of revealing a correlation than would preconstruction activity levels and post-construction fatalities. Nevertheless, substantial biases and potentially large sources of error loom large when relating fatality rates to activity rates. Activity rates can be biased by placement of acoustic detectors due to limited range caused by sound attenuation (Adams 2013) and by variation in activities by height above ground among bat species (Weller and Baldwind 2011, Roemer et al. 2017). Ground-mounted detectors will miss bats flying at rotor height and nacelle-mounted detectors will miss bats flying through the outer two-thirds of modern turbine's rotor-swept airspace (or preconstruction equivalent) (Adams 2013). Detector range also varies by model, atmospheric conditions, and inter-specific variation in call frequencies (Adams 2013), and the same is true for thermal-imaging cameras. For both radar and thermal imaging, identifying targets to bats, birds, and insects requires accurate assumptions about size, flight speed and behavior. Exemplifying bias related to fatality rates, Johnston et al.'s (2013) fatality searches extended only to 60 m from each turbine, which would have missed many bat fatalities falling beyond 60 m from modern wind turbines (Smallwood 2013, Smallwood et al. in review).

Accurately predicting fatality rates from preconstruction activity levels or passage rates would require accurate fatality estimates, accurate identification of nocturnally observed subjects as bats, birds, or insects, appropriate sampling of the affected airspace, and confirmation that either activity levels and passage behavior would remain unchanged after wind turbines are installed and operative or the changes are predictable. Accuracy in fatality rate estimates increase by detecting more of the available fatalities (Smallwood 2017, Smallwood et al. 2018). Arnett (2006) and Matthews et al. (2013) argued that use of scent-detection dogs would increase carcass detection rates, a method that we employed to great effect by detecting nearly all volitionally-placed bats and small birds (Smallwood et al. in review). Another approach would be to decrease the time interval between searches to find more of the fatalities before vertebrate scavengers find and remove them (Smallwood et al. 2010, Smallwood 2017).

Using a thermal-imaging camera since 2012, Smallwood (2016) recorded bats passing through all parts of the rotor, more so at the edge of the rotor plane where nacelle-mounted acoustic detectors would fail to detect bat passages. Thermal-imaging enables the observer to see heat-distribution across the body, wing-flaps, and dangling legs of some insects – additional attributes useful for identifying subjects as bats, birds or insects. Thermal imaging can reveal behavior patterns that can be inferred as reactions to wind turbines, to prey, and to other bats or birds. Certain behaviors observable through thermal imaging might be more predictive of collision fatalities than simple passage rates, such as hovering near operative rotors, interacting with other bats or birds, chasing blades, repeatedly diving through the rotor plane, passing through the rotor parallel rather than perpendicular to the rotor plane, or approaching portions of the rotor emitting more heat (Kunz et al. 2007, Horn et al. 2008, Cryan et al. 2014). Whereas these types of behaviors are observable post-construction, their topographic and environmental contexts might help interpret preconstruction survey results.

As higher-than-expected bat fatality rates emerged from monitoring at the APWRA's repowered wind turbines, the question arose whether macro- and micro-siting of wind turbines might help minimize impacts on bats and small birds. Micro-siting reduced raptor fatalities at a repowered wind project (Brown et al. 2016), and could minimize impacts at proposed new wind projects (Smallwood et al. 2017). Micro-siting for bats and migratory small birds requires flight behavior data more closely tied to fatality finds than was necessary for raptors because carcasses of bats and small birds do not persist long. As a first step toward macro- and micro-siting, fatality finds need to be compared to bat and small bird passage rates recorded over overlapping time periods to determine if a relationship exists.

We focused on whether post-construction fatality rates of bats and small birds can be estimated with sufficient accuracy to discover meaningful relationships with passage rates. Our primary objective was to relate fatality finds to patterns of bat and small bird activity at wind turbines during the night preceding fatality searches. We aimed to more closely compare wind turbine fatalities to passage rates or behavior rates, near-misses, or angles of entry to the rotor plane observed the night before each fatality search. To meet our objective, we followed each night's observations at specific wind turbines with next-morning fatality searches using scent-detection dogs.

STUDY AREA

Our study included 2 wind projects 8 km apart in the Altamont Pass Wind Resource Area (APWRA), California. The Buena Vista Wind Energy project (Buena Vista) consisted of 38 1-MW Mitsubishi wind turbines, 31 of which were accessible to us on land owned by East Bay Regional Park District, Contra Costa County. The Golden Hills Wind Energy project (Golden Hills) consisted of 48 1.79-MW General Electric (GE) wind turbines, 32 or which were accessible to us on privately held land in Alameda County. Two Mitsubishi turbines were on 45-m towers, 27 on 55-m towers, and 2 on 65-m towers. All GE turbines were on 80-m towers. Both projects were on steeply rolling hills covered by cattle-grazed annual grasses. Elevations ranged 41 - 280 m at Buena Vista and 115 - 477 m at Golden Hills.

METHODS

To achieve our goal of comparing bat passage rates to fatality rates, we sought to maximize our variation in bat fatality finds by conducting fieldwork before, during, and after the seasonal peak of bat activity and previously documented fatalities in the APWRA. Bat activity peaks during the last week of September and first week of October, which also happens to generally coincide with a peak in nocturnal flights of small birds through the APWRA (Smallwood 2016). We surveyed for bats and small birds 15 September through 15 November 2018, 5 days per week. Nocturnal surveys lasted 3 hours per night, including at least 1 round of 5- to10-minute passage-rate scans per turbine per hour, covering 2 to 5 wind turbines per round. We searched for fatalities at the same turbines the following morning.

We performed nocturnal surveys between dusk and 3 hours after dusk, which is the time period corresponding with most bat activity (Limpens et al. 2013). Hourly we recorded each wind turbine's operational status, and air temperature, wind direction, and wind speed using a Kestrel wind meter. Using the thermal camera we also recorded temperatures of ground cover and the hottest portions of wind turbine nacelles, which were vents among Mitsubishi turbines and upper-rear flanks of nacelles among GE turbines. At intervals between timed passage rate surveys, we surveyed for individual bats and birds, which upon detection were tracked by panning the thermal camera to keep pace with the bat or bird to determine whether it targeted one or more wind turbines. We also video-recorded each timed passage rate survey to verify observations, assess degree of confidence in observed collisions, and to capture any missed bat or bird passages upon later viewing of the video.

A skilled dog handler – Collette Yee – and handler-in-training Skye Standish searched for fatalities using one of two scent-detection dogs at a time. The dogs – Captain and Jack – were trained by Conservation Canines with the Center of Conservation Biology, University of Washington. We searched in morning when conditions were optimal for scent detection. Each dog was given turns searching, then rested as the other dog took a turn. Search areas extended to 75 m from 31 1-MW Mitsubishi wind turbines in the Buena Vista Wind Energy project and to 105 m from 32 1.79-MW wind turbines in the Golden Hills Wind Energy project. Daily searches covered 2 to 3 turbines at Golden Hills or 3 to 5 turbines at Buena Vista. Dogs were led by leash along transects oriented perpendicular to the wind and separated by 10 m over most of the search area. Because few bat and small bird fatalities are found upwind of wind turbines (Smallwood 2016a, Brown et al. 2016), we allowed dogs off leash for a more cursory search within a 90° arc between 210° and 300° from the turbine, which corresponds to prevailing upwind directions in the APWRA. Within the intensive search areas we navigated transects using GPS and a Locus Map application on a phone along with visible flagging as needed. We tracked dogs using a Keychain Finder Transystem 860e GPS data logger. Standish mapped and photographed fatality finds using a Trimble GeoExplorer 6000 GPS, and identified carcasses to species. Found carcasses were left in place for possible repeat discovery.

We performed 151 fatality searches at 63 wind turbines from 4 September through 15 November 2017, 20 searches using only a human searcher through 13 September, and 131 searches using dogs thereafter. Standish searched 20 turbines once each from 4 through 13 September 2017. Our dogs searched 15 turbines once each and another 48 turbines twice to four times per turbine, averaging 25 days between searches (range 2 to 53 day intervals). At Golden Hills, we searched 12 turbines once, 17 turbines twice, and 3 turbines three times for a project total of 55 turbine searches. At Buena Vista, we searched 3 turbines once, 15 turbines twice, 9 turbines three times, and 4 turbines four times for a project total 76 turbine searches.

Buena Vista underwent a project-wide maintenance shutdown from 06:00 hours, 2nd October, through the end of our study. At Buena Vista we performed 28 turbine searches (26 turbines) and

48 turbine searches (31 turbines) before and after the shutdown, respectively, while at Golden Hills we performed 14 and 41 turbine searches (31 turbines) over the same time periods.

We related bat and bird fatality counts to the previous night's passages through the rotor plane of wind turbines, having also noted the wind turbine's operational status at the time of each passage. We defined passage as either a flight through the rotor plane or within 1 m of the rotor plane while flying parallel to the rotor axis, and we defined passage rate as the number of passages per hour per ha of rotor plane. We also related fatality counts to passage rates consisting of passages for which birds or bats nearly collided with a blade ("near misses") or were displaced or jostled by a blade sweep ("disrupted flights") or additionally exhibited "dangerous behaviors" such as chasing blades, investigating blades, interacting with other volant animals, fleeing, chasing or foraging for prey items, or other distracted behaviors. We also related fatality counts to observed collisions. After reviewing video of each animal passing through a rotor plane, we judged our accuracy of taxonomic identification on a percentage basis, and subsequently restricted most hypothesis-tests to birds and bats assigned ≥70% confidence.

RESULTS

Using dogs, we found 24 bat and 26 bird fatalities at Buena Vista and 71 bat and 63 bird fatalities at Golden Hills (Table 1). We estimated 59 bats (63%) and 20 birds (22%) died between 7 and 30 days of discovery, 14 bats (15%) and 4 birds (4%) died between 3 and 7 days, and 6 bats (6%) and 2 birds (2%) died within 3 days. Of the bird fatalities found by dogs, 74% were small (<280 g), but small birds composed 90% of birds estimated to have died between 7 and 30 days and 100% of birds estimated to have died both between 3 and 7 days and within 3 days of discovery.

Nightly counts of birds and bats peaked together around the time of a full moon and a shift in winds to more westerly origin (Fig. 1). Bat passage rates through operative wind turbine rotors correlated strongly between ≥70% and ≥90% confidence in subject identification as bats, but passage rates based on ≥90% confidence averaged 18% lower than those based on ≥70% confidence (Fig. 2).

Daily comparison of passage rates and fatality finds

Relating thermal imaging surveys to next-day fatality searches, nightly bat passes through operable wind turbine rotors correlated significantly with next-day counts of fatalities/ha of bats ≤3 days since death ($r = 0.44$, $P<0.05$) and of bats ≤7 days since death ($r = 0.35$, $P<0.05$), but we found no correlation for bats ≥7 days since death. For those surveys more closely covering the fall bat migration, from 20 September through 26 October, logit regression revealed that the odds of dogs finding one or more freshly-killed bats were 4 times greater on mornings following nightly thermal imaging surveys when we counted 130 bat passes through the rotors as compared to nights when we counted 0 bat passes (Figure 3). We found no significant correlations for small birds.

Daily comparison of passage rates and fatality finds by wind turbine

Throughout the study we found bird and bat fatalities judged to have died ≤7 days earlier (Figs. 4 and 5). During the same portion of the study period when we were seeing most of the near-misses and turbine-disrupted passage flights of bats, we found bat fatalities ≤7 days since death (Fig. 4). However, we did not find fresh bird fatalities until weeks after we saw most bird passages, including near-misses and disrupted flights through operative rotors. Most passages through operative rotors, including most of the near misses and disrupted flights, spanned the early portion of the bat and small bird migration peak when the waxing moon was <50% visible and winds were shifted to more westerly origin.

Our discovery of a bat fatality ≤3 days since death at a given wind turbine on a given day could be predicted from the previous night's bat passage rates through the rotor-swept airspaces of operative wind turbines (Table 2, Fig. 6), but not of inoperative wind turbines (Table 2). Our logit-regression models were not significant when restricting passages to observed collisions, likely due to insufficient sample size. Our best-fit logit regression included bat passages associated with ≥1 near miss or flight disruption (impact) caused by a passing blade's pressure wave or trailing vortex (Table 2). Logit regression models were either weak or not significant when relying on bat fatalities estimated as >3 days since death, or when relating bird fatalities to bird passage rates.

Fatality estimates from observed collisions

We sampled 0.36% of the 3,763 rotor-swept ha-hours between the 28 nights at Golden Hills and 10 nights pre-curtailment at Buena Vista totaling 114 hours of survey time (first 3 hours of darkness per night). The 4 bat collisions with wind turbines that we witnessed translated to 0.2939 collisions per rotor-swept ha-hours. This rate applied to the available 3,763 rotor-swept ha-hours, and assuming the first 3 hours of the night was when most bat collisions occurred, would predict 1,106 bat fatalities. The 1 observed collision at Buena Vista would predict 146 fatalities in 10 session-nights and the 3 observed collisions at Golden Hills would predict 910 fatalities in 28 session-nights, or 14.6/night at Buena Vista and 32.5/night at Golden Hills. Adjusting for project, size, observed collisions predict 0.384 fatalities/MW/night at Buena Vista and 0.378 fatalities/MW/night at Golden Hills. These rates multiplied by the number of turbine searches (26 at Buena Vista and 31 at Golden Hills during operable periods), the proportion of casualties deposited within the search radius (0.96 at Buena Vista and 0.86 at Golden Hills), and the first-night proportion of carcasses persisting (0.9) predict that we should have found 8.6 fresh bat fatalities at Buena Vista and 16.2 at Golden Hills. We found 2 fresh bat fatalities at Buena Vista and 4 at Golden Hills, where fresh included fatalities we judged having died within 3 days. Based on eye-witnessed collisions, we found 25% of the fresh bat fatalities that we should have found at both projects.

DISCUSSION

We were unable to predict small bird collision fatalities from previous-night's passage rates through wind turbines, but we were able to do so for recently-killed bats. Even with all bat species lumped together and a small number of bats found as fresh fatalities, bat fatality rates related significantly to the previous night's passage rates. Passage rates can be used to predict next-day bat fatalities, and predictions increase in accuracy when passage rates are defined by near-misses and turbine-disrupted flights. Wind direction and moon phase were also potentially predictive of fatalities. It remains to be determined, however, whether preconstruction passage rates through planned windswept airspace can also predict post-construction fatalities. It also remains to be determined whether passage rates can be used to predict collision risk based on wind turbine locations. Confounding these determinations is the fact that bats appear to target wind turbines by altering flight trajectories to pass through or near operating wind turbine rotors, likely on foraging runs (Foo et al. 2017).

Our inability to predict small bird fatalities from previous night's passage rates might have resulted from low accuracy in estimating time since death of found bird fatalities (Smallwood et al. 2018). Another likely contributing factor was frequent avoidance of operating wind turbines. Most incoming birds veered wide of, or ascended over, operating wind turbines. However, we confirmed what we earlier suspected -- that nocturnal migrants pass through the APWRA in a seasonal peak of abundance, and this peak generally corresponds with many small bird fatalities.

A question that emerged from our study was whether observed bat collisions serve as evidence that fatality monitoring might be underestimating bat impacts. Although our comparison of fatality estimates between dog searches and witnessed collisions lack confidence intervals, the difference was large enough to justify the question. Further justifying the question, of the 4 bat collisions we witnessed, next-morning dog searches found only 1 of them. Immediately following the standard search for one of the observed collision victims, Smallwood directed the dog team to the area where he saw the bat fall, and a second intensive search was performed without detecting the bat. That bat was either scavenged during the hours between its collision and the morning's fatality search, or it found refuge in one of the many available fossorial mammal burrows or left the site on its own volition. According to our detection trials using dogs, only 6% of bats are removed by scavengers within 1 day, so it was unlikely that scavengers removed all 3 carcasses of the witnessed collisions not found by next-morning dog searches. At the same time, if the bats were not removed, then our dogs likely would have found them because dogs found nearly all trial carcasses, including baby bats (Smallwood et al. In review). We found a live, injured Mexican free-tailed bat under the lip of a concrete pad supporting an electrical transformer box and a dead bat within a soil crack, and the dogs strongly indicated on a ground squirrel burrow, which we believe included a bat. Bats might often survive wind turbine injuries long enough to find cover within or outside the area searched by dogs. Bats struck by wind turbine blades sometimes dismember, and in high winds dismembered parts can drift far from the impact site, especially when the impact site is at the blade's 12:00 position (Smallwood unpublished data). We conclude that crippling bias (Smallwood 2007) and maximum search radius bias might often result in underestimated bat fatalities.

MANAGEMENT IMPLICATIONS

Although measured preconstruction activity levels of bats and small birds might facilitate decisions over the appropriateness of a proposed wind turbine project, they might never support micro-siting decisions. What might prove more instructive for micro-siting is discernment of spatial and temporal patterns of passage rates, near misses, and disrupted flights through existing wind turbine rotors. To this end, thermal imaging enables investigators to see bird and bat interactions with the entirely of wind turbine rotors, as well as flight behaviors and reactions. Thermal imaging also enables counts of insect passages. Combined with nacelle-mounted bat acoustic detectors, some of the bats observed via thermal-imaging camera could be identified to species, which would further elucidate the roles of terrain and location in passage rates, near misses and disrupted flights. Lastly, our observed collisions extrapolated from the sampled hr-ha of rotor-swept airspace during thermal-imaging surveys to the project-level operations over the surveyed periods predicted 4 times the number of bat fatalities than found by our dogs, and in fact our dogs found only 1 of 4 witnessed collision victims. The possibility exists that our best estimates of bat fatalities are biased low by crippling bias – either through the volitional departure of searchable areas by injured bats or their seeking refuge when grounded.

ACKNOWLEDGMENTS

This research was funded in part by the Gordon and Betty Moore Foundation. We are grateful to the Gordon and Betty Moore Foundation for its financial support which was administered through the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03). We also thank the East Bay Regional Park District for additional funding and for assistance with access to the Buena Vista Wind Energy project located on its property. We thank Bryan Maddock and Leeward Renewable Energy LLC for access and assistance at the Buena Vista Wind Energy project, and Renee Culver and NextEra Energy Resources for access and assistance at Golden Hills Wind Energy project. We thank Heath Smith, Collette Yee and Skye Standish of Conservation Canines, Center of Conservation Biology, University of Washington, for their highly skilled dog handling. We also thank Jeff Smith and H. T. Harvey & Associates for assistance at Golden Hills. Our study would not have been possible without the generous donations of bird carcasses by Native Songbird Care and bat carcasses by Dr. Deborah Cottrell at West End Animal Hospital. Use of animal carcasses was authorized under permits from the U.S. Fish and Wildlife Service (MB135520-0) and the California Department of Fish and Wildlife (SC-00737). We thank Jennifer Brown of the former agency and Carie Battistone, Esther Burkett, Justin Garcia and Scott Osborn of the latter agency, for assistance with permitting. We are indebted to Debbie Woollett for working with us to train a dog we ended up not using, but this effort was important to our development. We are also greatly indebted to Karen Swaim for her generous donation of living space for our dog handler and detection dogs throughout this study. Lastly, we are grateful to the spirited efforts given us by Captain and Jack in the face of high temperatures, rugged terrain, and rattlesnakes.

REFERENCES CITED

Adams, A. 2013. Assessing and analyzing bat activity with acoustic monitoring: challenges and interpretations. PhD Thesis, The University of Western Ontario.

Arnett, E. 2006. A Preliminary Evaluation on the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Society Bulletin 34:1440-1445.

Arnett, E. B., M. M. P. Huso, M. R. Schirmacher, and J. P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 9:209-214. DOI:10.1890/100103

Arnett, E. B., G. D. Johnson, W. P. Erickson, and C. D. Hein. 2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. Report to The National Renewable Energy Laboratory, Golden, Colorado.

Behr, O., R. Brinkmann, K. Hochradel, J. Mages, F. Korner-Nievergelt, I. Niermann, M. Reich, R. Simon, N. Weber and M. Nagy. 2017. Mitigating Bat Mortality with Turbine-Specific Curtailment Algorithms: A Model Based Approach. Pages 135-160 in Köppel, J., Editor, Wind Energy and Wildlife Impacts: Proceedings from the CWW2015 Conference. Springer. Cham, Switzerland.

Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas. 2016. Final 2012-2015 Report Avian and Bat Monitoring Project Vasco Winds, LLC. Prepared for NextEra Energy Resources, Livermore, California.

Cryan, P. M., P. M. Gorresen, C. D. Hein, M. R. Schirmacher, R. H. Diehl, M. H. Huso, D. T. S. Hayman, P. D. Fricker, F. J. Bonaccorso, D. H. Johnson, K. Heist, and D. C. Dalton. 2014. Behavior of bats at wind turbines. Proceedings National Academy of Science 111:15126-15131.

Erickson, W. P., M. M. Wolfe, K. J. Bay, D. H. Johnson, and J. L. Gehring. 2014. A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. PLoS One 9(9): e107491. doi:10.1371/journal.pone.0107491.

Foo, C. F., V. J. Bennett, A. M. Hale, J. M. Korstian, A. J. Schildt, and D. A. Williams. 2017. Increasing evidence that bats actively forage at wind turbines. PeerJ5:e3985;DOI 10.7717/peerj.3985

Hayes, M. A. 2013. Bats Killed in Large Numbers at United States Wind Energy Facilities. BioScience 63:975-979.

Hein, C., W. Erickson, J. Gruver, K. Bay, and E. B. Arnett. 2012. Relating pre-construction bat activity and post-construction fatality to predict risk at wind energy facilities. PNWWRM IX. 2013. Proceedings of the Wind-Wildlife Research Meeting IX. Broomfield, CO. November 28-30, 2012. Prepared for the Wildlife Workgroup of the National Wind

Coordinating Collaborative by the American Wind Wildlife Institute, Washington, DC, Susan Savitt Schwartz, ed.

Horn, J. W., E. B. Arnett, and T. H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72:123-132.

Johnston, D. S., J. A. Howell, S. B. Terrill, N. Thorngate, J. Castle, J. P. Smith, Todd J. Mabee, J. H. Plissner, N. A. Schwab, P. M. Sanzenbacher, and C. M. Grinnell. 2013. Bird and bat movement patterns and mortality at the Montezuma Hills Wind Resource Area. California Energy Commission Publication Number CEC-500- 2013- 015 .

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5:315-324.

Limpens, H. J. G. A., M. Boonman, F. Korner-Nievergelt, E. A. Jansen, M. van der Valk, M. J. J. La Haye, S. Dirksen and S. J. Vreugdenhil. 2013. Wind turbines and bats in the Netherlands - Measuring and predicting. Report 2013.12, Zoogdiervereniging & Bureau Waardenburg.

Loss, S. R., T. Will, and P. P. Marra. 2013. Estimates of bird collision mortality at wind facilities in the contiguous United States. Biological Conservation 168:201–209.

Mathews, F., M. Swindells, R. Goodhead, T. A. August, P. Hardman, D. M. Linton, and D. J. Hosken. 2013. Effectiveness of search dogs compared with human observers in locating bat carcasses at wind-turbine sites: A blinded randomized trial. Wildlife Society Bulletin 37:34-40.

Roemer, C., T. Disca, A. Coulon, and Y. Bas. 2017. Bat flight height monitored from wind masts predicts mortality risk at wind farms. Biological Conservation215:116-122.

Smallwood, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.

Smallwood, K. S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37:19-33. + Online Supplemental Material.

Smallwood, K. S. 2016. Bird and bat impacts and behaviors at old wind turbines at Forebay, Altamont Pass Wind Resource Area. Report CEC-500-2016-066, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2016publications/CEC-500-2016-066/CEC-500-2016-066.pdf

Smallwood, K. S. 2017. Long search intervals under-estimate bird and bat fatalities caused by wind turbines. Wildlife Society Bulletin 41:224-230.

Smallwood, K. S., and L. Neher. 2017. Comparing bird and bat use data for siting new wind power generation. Report CEC-500-2017-019, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2017publications/ CEC-500-2017-019/CEC-500-2017-019.pdf and http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019-APA-F.pdf

Smallwood, K. S., L. Neher, and D. A. Bell. 2017. Siting to Minimize Raptor Collisions: an example from the Repowering Altamont Pass Wind Resource Area. M. Perrow, Ed., Wildlife and Wind Farms - Conflicts and Solutions, Volume 2. Pelagic Publishing, Exeter, United Kingdom. www.bit.ly/2v3cR9Q

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management 74: 1089-1097 + Online Supplemental Material.

Smallwood, K. S., D. A. Bell, B. Karas, and S. A. Snyder. 2013. Response to Huso and Erickson Comments on Novel Scavenger Removal Trials. Journal of Wildlife Management 77: 216-225.

Smallwood, K. S., D. A. Bell, E. L. Walther, E. Leyvas, S. Standish, J. Mount, B. Karas. 2018. Estimating wind turbine fatalities using integrated detection trials. Journal of Wildlife Management 82:1169-1184.

Weller, T. J. and J. A. Baldwin. 2011. Using echolocation monitoring to model bat occupancy and inform mitigations at wind energy facilities. Journal of Wildlife Management 76:619-631.

Table 1. Summary of fatalities found by Conservation Canines' dog teams at Buena Vista (BV) and Golden Hills (GH) during fall 2017, and fatalities per search before and after the Buena Vista wind turbines were shut down on 2 October 2017.

Species		Fatalities found			Fatalities/search			
					Buena Vista		Golden Hills	
		Old	BV	GH	Before	After	Before	After
Western red bat	*Lasiurus blossevillii*	0	4	1	0.143	0.000	0.071	0.000
Myotis spp.	*Myotis*	0	0	1	0.000	0.000	0.071	0.000
Mexican free-tailed bat	*Tadarida brasiliensis*	3	6	29	0.214	0.000	1.214	0.220
Hoary bat	*Lasiurus cinereus*	1	2	13	0.071	0.000	0.429	0.146
Bat spp.		5	12	27	0.357	0.000	0.857	0.293
Grebe sp.	Podicipedidae	1	0	1	0.000	0.000	0.000	0.000
Mallard	*Anas platyrhynchos*	0	0	1	0.000	0.000	0.071	0.000
Turkey vulture	*Cathartes aura*	2	0	2	0.000	0.000	0.000	0.000
Northern harrier	*Circus cyaneus*	1	1	0	0.000	0.000	0.000	0.000
White-tailed kite	*Elanus leucurus*	1	1	0	0.000	0.000	0.000	0.000
Red-tailed hawk	Buteo jamaicensis	0	0	3	0.000	0.000	0.143	0.024
Large raptor		1	0	1	0.000	0.000	0.000	0.000
American kestrel	*Falco sparverius*	2	4	1	0.071	0.000	0.071	0.000
Prairie falcon	*Falco mexicanus*	1	1	0	0.000	0.000	0.000	0.000
Rock pigeon	*Columba livia*	1	1	0	0.000	0.000	0.000	0.000
Barn owl	*Tyto alba*	0	1	0	0.036	0.000	0.000	0.000
Burrowing owl	*Athene cunicularia*	1	0	4	0.000	0.000	0.214	0.000
White-throated swift	*Aeronautes saxatalis*	1	1	0	0.000	0.000	0.000	0.000
Pacific-slope flycatcher	*Empidonax difficilis*	0	1	0	0.036	0.000	0.000	0.000
Horned lark	*Eremophila alpestris*	10	2	10	0.000	0.000	0.071	0.024
Northern rough-winged swallow	*Stelgidopteryx serripennis*	0	0	2	0.000	0.000	0.000	0.049
Bewick's wren	*Thryomanes bewickii*	0	0	1	0.000	0.000	0.071	0.000
House wren	*Troglodytes aedon*	0	0	1	0.000	0.000	0.071	0.000
Ruby-crowned kinglet	*Regulus calendula*	0	0	2	0.000	0.000	0.000	0.049
American pipet	*Anthus rubescens*	1	0	2	0.000	0.000	0.000	0.024
Warbler sp.	Parulidae	0	0	1	0.000	0.000	0.071	0.000
Black-throated gray warbler	*Dendroica nigrescens*	1	0	1	0.000	0.000	0.000	0.000
Townsend's warbler	*Dendroica townsendi*	0	1	0	0.036	0.000	0.000	0.000
Lincoln's sparrow	*Melospiza lincolnii*	0	0	1	0.000	0.000	0.000	0.024
Dark-eyed junco	*Junco hyemalis*	0	0	1	0.000	0.000	0.000	0.024
Blackbird sp.	Icteridae	1	0	1	0.000	0.000	0.000	0.000
Brown-headed cowbird	*Sturnella neglecta*	1	0	1	0.000	0.000	0.000	0.000
Western meadowlark	*Molothrus ater*	6	7	7	0.107	0.063	0.000	0.049
Large bird		8	2	7	0.000	0.000	0.000	0.024
Medium bird		0	0	1	0.000	0.000	0.071	0.000
Small bird		3	3	11	0.036	0.021	0.286	0.122
All bats		9	24	71	0.786	0.000	2.643	0.659

Species		Fatalities found			Fatalities/search			
					Buena Vista		Golden Hills	
		Old	BV	GH	Before	After	Before	After
All small birds		27	19	47	0.286	0.083	0.857	0.366
All large birds		16	7	16	0.036	0.000	0.286	0.049
All birds		43	26	63	0.321	0.083	1.143	0.415

Table 2. Six fatalities of bats ≤3 days since death logit-regressed on the previous night's counts of bats with ≥70% or ≥90% confidence in taxonomic assignment passing through the rotor-swept airspace of operative, inoperative or any (all) wind turbines and also observed colliding with a blade or displaced or jostled by blade's pressure wave or trailing vortex (flight impact) or otherwise experiencing ≥1 near miss or displaying distracted behavior such as approaching wind turbine parts in an investigative manner or interacting with another volant animals such as mobbing, harassing, following, approaching, fleeing, or pursuing prey. Under Logit regression, *a* and *b* represent model parameter estimates, final loss value was derived from a maximum likelihood function, and χ^2 measured the goodness of fit with 1 DF and t indicated 0.05 < P < 0.10 and * indicated P < 0.05.

Minimum confidence in bat ID (%)	Wind turbine status	Additional observation on passage hazard	Logit regression			
			a	b	Final loss	χ^2
70	Operative	None	-3.5491	0.0134	21.73	5.44*
90	Operative	None	-3.5621	0.0176	21.69	5.52*
70	All	None				NS
90	All	None				NS
70 or 90	Inoperative	None				NS
70	All	Collided	-3.2424	0.1818	22.67	3.57^t
90	All	Collided	-3.2424	0.1818	22.67	3.57^t
70	Operative	Flight impact or ≥1 near miss	-3.4827	0.0234	21.22	6.47*
90	Operative	Flight impact or ≥1 near miss	-3.5383	0.0323	20.94	7.02*
70	Operative	Flight impact or ≥1 near miss or distracting behavior	-3.4119	0.0132	22.53	3.86*
90	Operative	Flight impact or ≥1 near miss or distracted behavior				NS

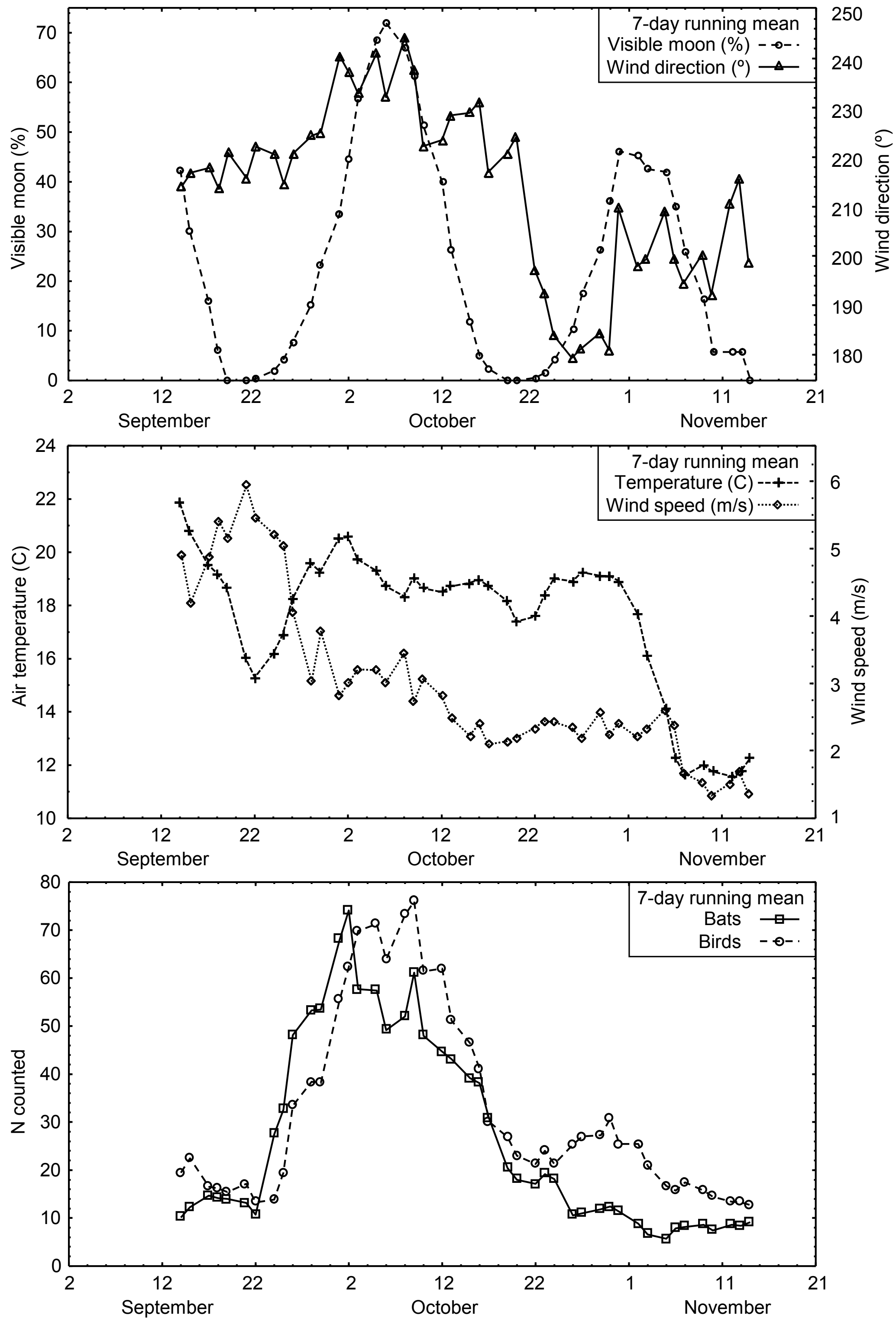


Figure 1. Running means (7-days) of visible moon and wind direction (top graph), air temperature (C) and wind speed (m/s) at ground level (middle graph), and nightly counts of all bats and birds observed flying (bottom graph) during surveys in the Altamont Pass Wind Resource Area, California, 4 September through 14 November 2017.

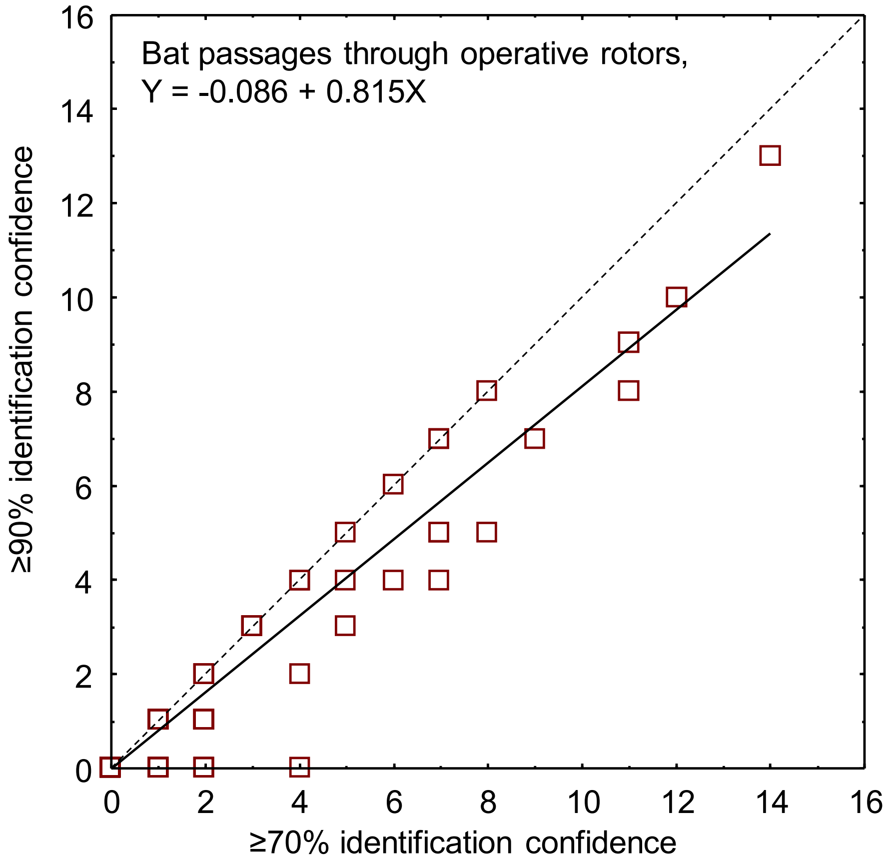


Figure 2. Bat passage rates through operative wind turbine rotors correlated strongly between volant animals having been assigned ≥90% and ≥70% confidence in correct identification as bats in the Buena Vista and Golden Hills Wind Energy Projects, Altamont Pass Wind Resource Area, California, Fall 2017.

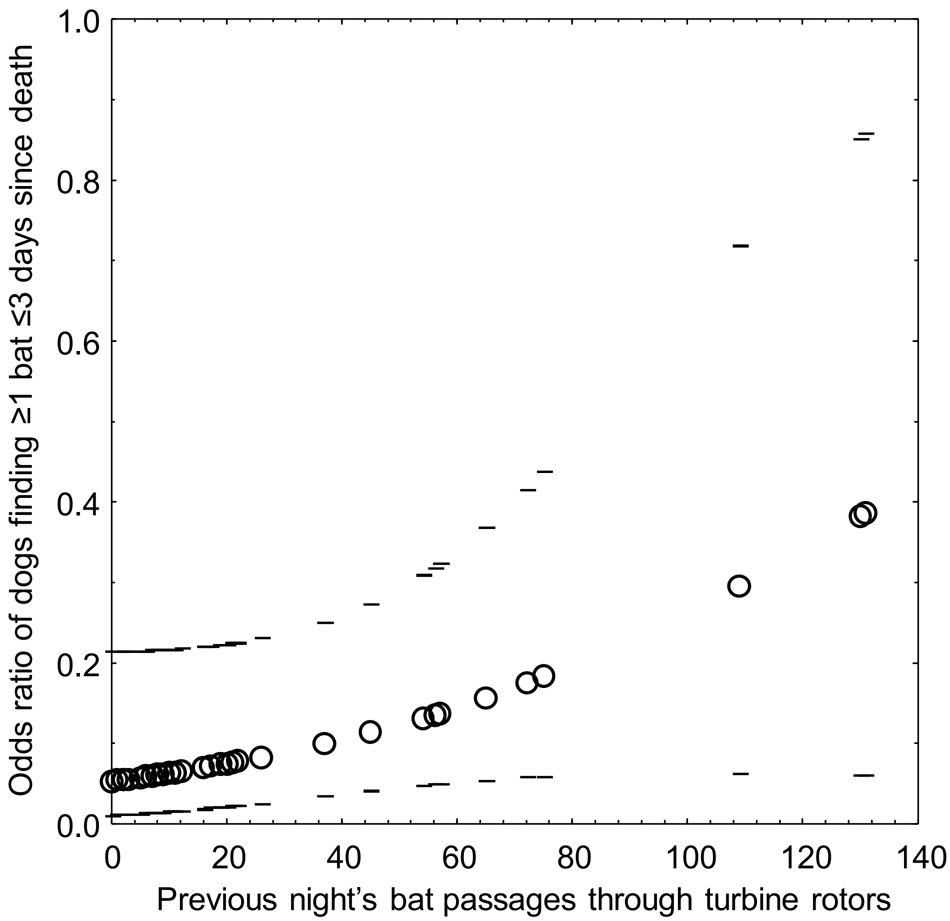


Figure 3. Odds ratio (95% CI) of finding at least 1 bat dead ≤3 days logit-regressed on the number of previous-night bat passes through rotors of the same wind turbines searched by dogs for fatalities at Golden Hills and Buena Vista Wind Energy projects, 20 September through 26 October, 2017.

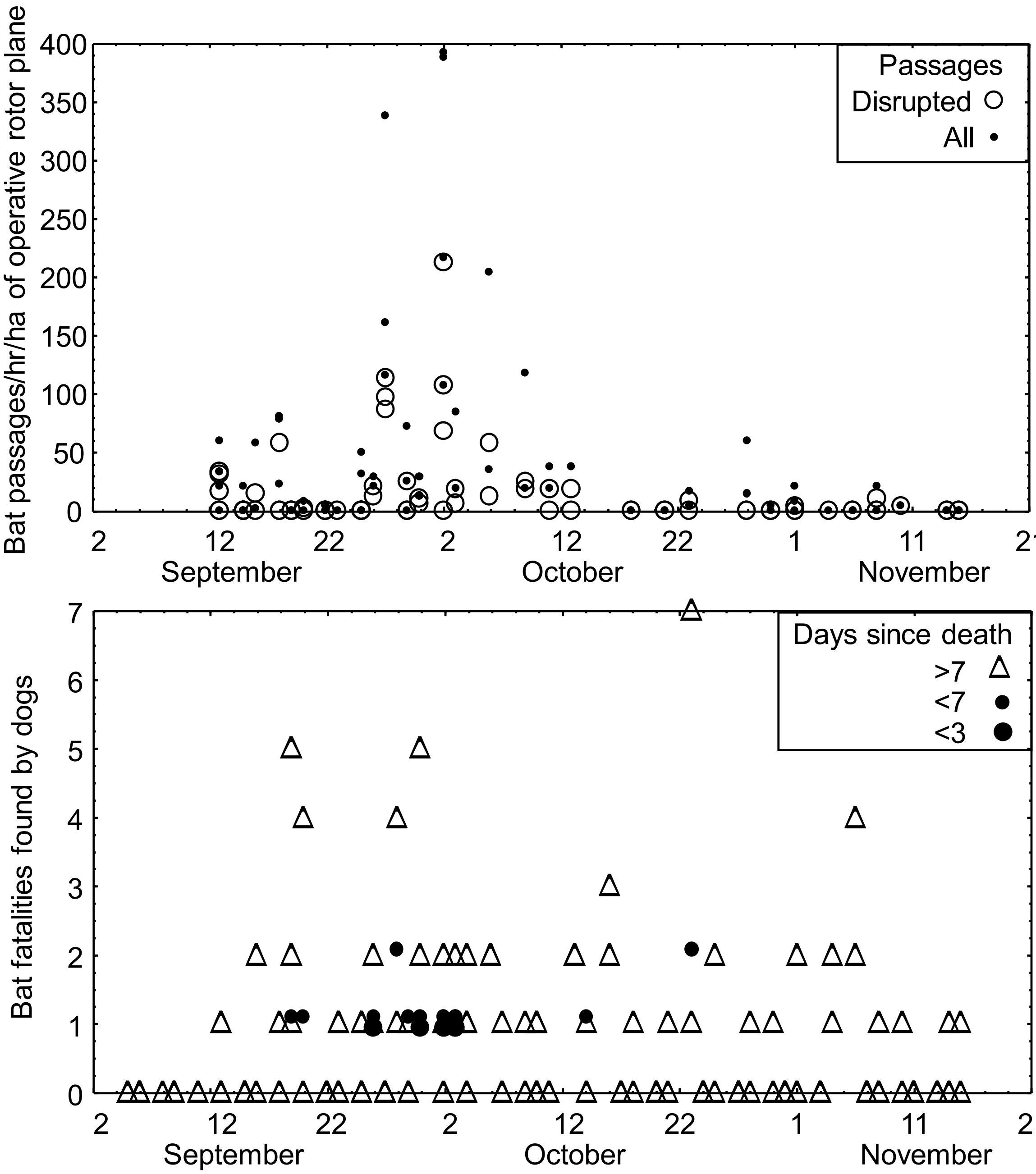


Figure 4. Bat passage rates through operative wind turbine rotors (top) corresponded with next-day fatalities of bats estimated to have died within a week (bottom) in 2017 in the Golden Hills and Buena Vista Wind Projects, Contra Costa and Alameda Counties, California.

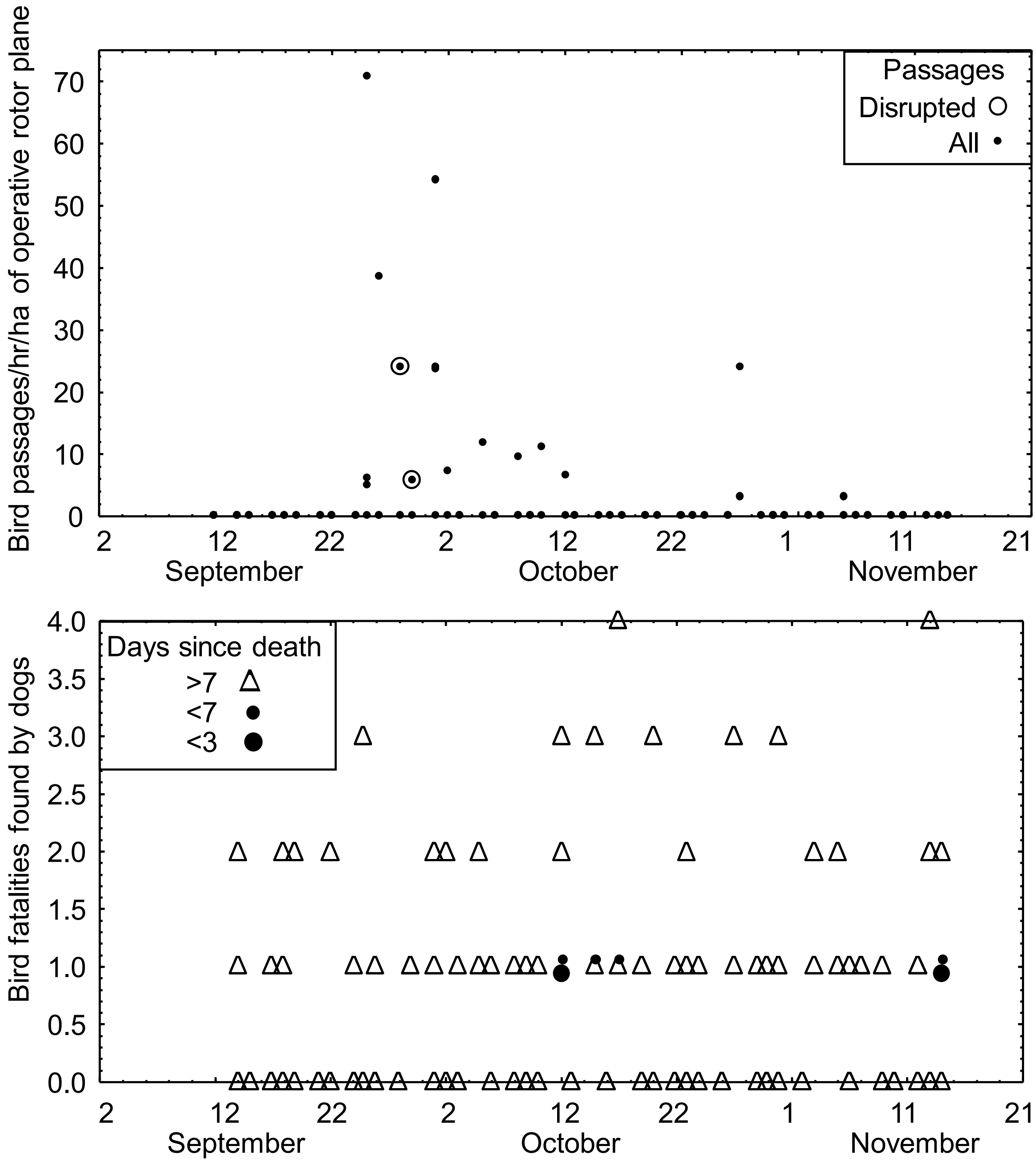


Figure 5. Bird passage rates through operative wind turbine rotors (top) did not correspond with next-day fatalities of birds estimated to have died within a week (bottom) in 2017 in the Golden Hills and Buena Vista Wind Projects, Contra Costa and Alameda Counties, California.

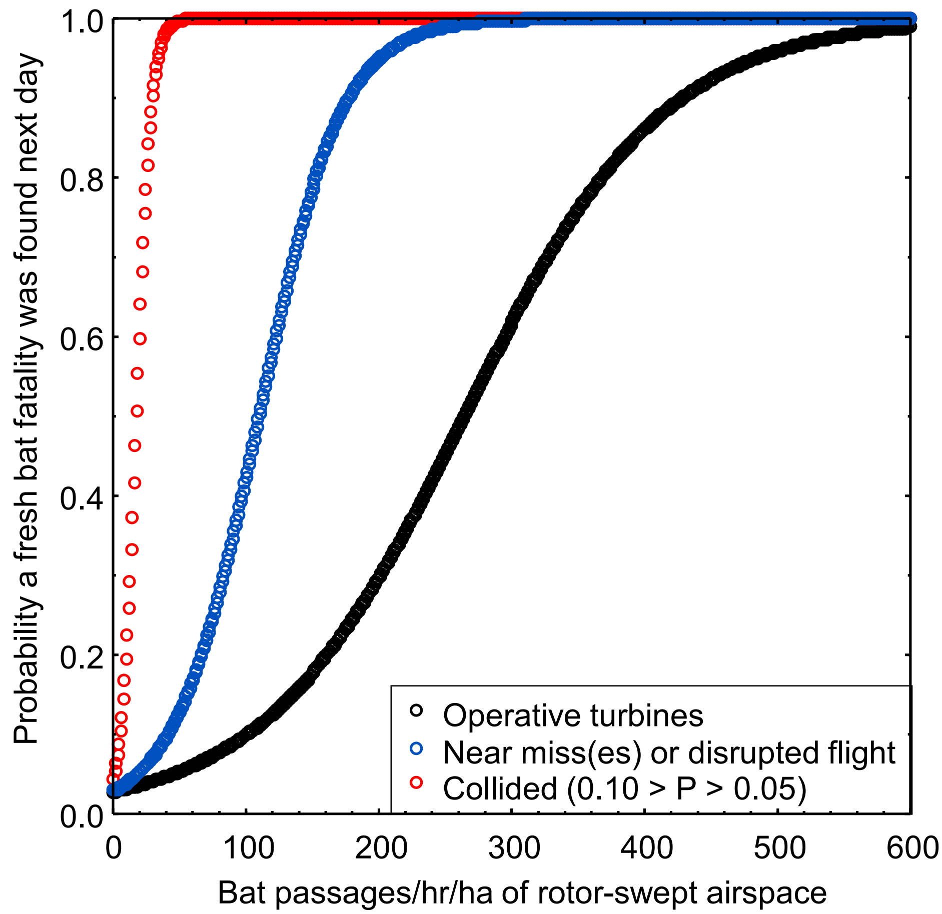


Figure 6. Logit-regression model predictions of the odds of dogs finding fresh bat fatalities the morning after thermal-imaging survey-counts of bats passing through operative turbine rotors (black), bats nearly colliding or experiencing disrupted flights due to pressure waves of passing blades or wake turbulence (blue), and bats seen colliding with a blade (red) in California's Altamont Pass Wind Resource Area, 15 September through 15 November 2017.

Effects of Wind Turbine Curtailment on Bird and Bat Fatalities

Report #3 to the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03)

17 July 2019

K. SHAWN SMALLWOOD,[1] *3108 Finch Street, Davis, CA 95616, USA*
DOUGLAS A. BELL, *East Bay Regional Park District, 2950 Peralta Oaks Court, Oakland, CA 94605, USA*

Mexican free-tailed bat (Tadarida brasiliensis) fatality, Golden Hills Wind Farm, Alameda County, California, 3 October 2017 (Photo: K. Shawn Smallwood).

[1] *Email: puma@dcn.org*

Effects of Wind Turbine Curtailment on Bird and Bat Fatalities

ABSTRACT - With the expansion of wind energy, bird and bat fatalities have also increased. Once wind turbines are installed, the only effective impact-reduction measure consists of operational curtailment – documented for bats but not for birds. We measured curtailment effects in an opportune before-after, control-impact (BACI) experimental design involving two wind projects monitored for fatalities using scent detection dogs and for nocturnal passage rates using thermal imaging during fall migration, where one project continued operating and the other shut down from the peak of migration to the study's end. We also compared bird fatality rates based on humans averaging 5-day search intervals among wind turbines of varying operable status, including operable, inoperable, vacant tower, and empty pad. Wind turbine curtailment in the BACI study had no significant effect on bird passage rates or fatality rates, whereas it significantly reduced bat passage rates and reduced bat fatality finds to 0. In the study of variable operable status among wind turbines, birds estimated to have died within 15 days of discovery averaged 35% more fatalities/MW at inoperable than at operable wind turbines, and fatalities declined substantially at vacant towers and empty pads. Of species represented by bird fatalities, 79% were found at inoperable wind turbines, including all 6 red-tailed hawk (*Buteo jamaicensis*) fatalities. Because the migration season is relatively brief, a seasonal curtailment strategy would greatly reduce bat fatalities while losing only a small fraction of a wind project's annual energy generation, but it might not benefit many species of birds.

INTRODUCTION

Wind energy development expanded rapidly over the last three decades while wildlife ecologists pursued mitigation strategies to minimize and reduce bird and bat fatalities caused by collisions with wind turbine blades. Based on different methods and averages drawn from different suites of source studies, annual estimates of fatalities across the USA were 600,000 (Hayes) and 888,000 bats (Smallwood 2013), 214,000 to 368,000 small birds (Erickson et al. 2014), and 234,000 (Loss et al. 2013) to 573,000 (Smallwood 2013) birds of all sizes. Since these estimates representing 2012, the installed capacity of wind energy nearly doubled by 2018. Whereas multiple mitigation measures were proposed, promised or required in conditional use permits in earlier wind projects, efficacy was either poor or unquantified due to lack of appropriate experimental design (Lovich and Ennen 2013, Sinclair and DeGeorge 2016), incomplete implementation, permit noncompliance, or fatality monitoring at search intervals that were too long for measuring mitigation treatment effects (Smallwood 2008). Careful micro-siting contributed to reduced fatality rates in repowered wind projects for select raptor species, but possibly at the expense of other birds and bats (Brown et al. 2016, Smallwood et al. 2017). Operational curtailment showed promise for bats (Arnett et al. 2011, 2013; Behr et al. 2017), whereas evidence has been lacking for birds despite years of seasonal curtailment in the Altamont Pass Wind Resource Area (APWRA) (Smallwood and Neher 2017). It would help to know whether operational curtailment can reduce bat fatalities in the APWRA where bat fatalities emerged as a substantial issue with repowering from old-generation wind turbines to modern wind turbines, and where the strategy had yet to be implemented. It would also help to know whether operational curtailment could reduce bird collision fatalities.

Bats appear to be attracted to wind turbines (Cryan et al. 2014), where they forage near and within the rotor plane (Horn et al. 2008, Foo et al. 2017). A curtailment strategy makes sense for reducing bat impacts, and the evidence indicates it works (Arnett et al. 2013). Evidence is lacking for any attraction to turbines by flying birds, but Tomé et al. (2017) reported no griffon vulture (*Gyps fulvus*) fatalities following implementation of a detect-and-curtail strategy based on radar detections. However, finding no fatalities might mean that none occurred or that fatalities occurred but none were found; the only reported detail of the fatality monitoring used to assess the detect-and-curtail strategy was search intervals of 2 weeks for half the year and monthly for the other half year (Tomé et al. (2017). Outside the context of an experimental design, and not knowing how many animals are normally killed absent an impact-reduction strategy, a finding of zero fatalities is difficult to interpret as an effect of the strategy (Sinclair and DeGeorge 2016). Measuring a treatment effect for small birds and bats is made even more difficult by low fatality detection rates due to quick scavenger removal (Smallwood et al. 2010) and low searcher detection of available carcasses (Smallwood 2017, Smallwood et al. 2018). Fortunately, shorter search intervals (Smallwood et al. 2018) and use of scent-detection dogs (Arnett 2006, Mathews et al. 2013) have vastly improved fatality detection.

Two studies, one using human searchers averaging 5-day intervals between searches (Smallwood et al. 2018) and the other using scent-detection dogs (Smallwood et al. in review), provided sufficient fatality detection rates for testing the effects of operational curtailment on volant wildlife. In the first, a 3-year study involving 187 old-generation wind turbines, 6% of the capacity never worked, 16% always worked in windy conditions, and 78% varied in operability due to mechanical and circuit failures – often remaining inoperable for months at a time. In the second study involving two wind projects composed of modern turbines, a project-wide shutdown to repair the circuit provided an opportune before-after, control-impact (BACI) paired-site experimental design. We were certain that wind turbines were inoperative during inoperable periods, but uncertain about how long wind turbines operated during operable periods. Operable wind turbines operate only when wind speeds exceed the turbine's cut-in speed, which varies by turbine model and season of the year. Fatalities attributed to inoperable periods could be assumed to have collided with the stationary structure of a wind turbine, whereas fatalities attributed to operable periods could have collided with either a stationary portion of the turbine or with the moving blades of the turbine's rotor. Limited as we were in our capacity to draw inference, our primary objective was to test whether and to what degree operational curtailment reduced bird and bat fatalities.

In our BACI study we also used a thermal-imaging camera to perform nocturnal bird and bat passage rate surveys, where passage rates were measured as the number of subjects passing through or within 1 m of the rotor plane. During passage rate surveys we could see whether wind turbines operated, giving us certainty over turbine operations concurrent with measurement of our passage rate metric. Our first objective was to compare passage rates through the rotor planes of both operative and inoperative wind turbines of a control group throughout the study and of an impact group before its shutdown. Our second objective was to test whether birds and bats altered their passage rates through the rotor planes of wind turbines after one project was shut down, and our third objective was to test whether passage rates were sensitive to the immediate operational status of a turbine. Our fourth objective was to test whether bird and bat passage rates composed of near-misses with wind turbine blades changed with operational status of the turbine.

STUDY AREA

Our studies included 5 wind projects averaging 4.2 km apart in the APWRA, Contra Costa and Alameda Counties, California (Table 1). The Buena Vista Wind Energy project (Buena Vista) consisted of 38 1-MW Mitsubishi wind turbines, 31 of which were accessible to us on land owned by East Bay Regional Park District, Contra Costa County. The Golden Hills Wind Energy project (Golden Hills) consisted of 48 1.79-MW General Electric (GE) wind turbines, 32 or which were accessible to us on privately held land in Alameda County. The Sand Hill project consisted of 403 wind turbines (23.123 MW) consolidated from 5 original projects, including 144 40-KW Enertech turbines in the original Altech I project, 12 65-KW Micon turbines in the original Swamp project, 183 65-KW Micon turbines in the original Taxvest project, 26 65-KW Micon turbines in the original Viking project, 26 65-KW Windmatic turbines in the original Venture Winds project, and 12 109-KW Polenko turbines at Venture Winds. The Santa Clara project included 200 0.95-MW Vestas turbines, 36 of which we monitored for one year. All 4 projects were on rolling hills covered by cattle-grazed annual grasses. Elevations ranged 41-280 m at Buena Vista, 115-477 m at Golden Hills, 61-179 m at Sandhill, and 226-351 m at Santa Clara.

METHODS

We performed two studies to test whether wind turbine curtailment affected birds and bats. One study, from 15 September through 15 November 2017, involved all of the wind turbines available to us in the Buena Vista and Golden Hills projects (Table 1). Because the entire Buena Vista project needed to be shut down for circuit repair from 06:00 hours on 2 October 2017 through the remainder of our study, we capitalized on the opportune BACI design, using Golden Hills as our experimental control. We measured treatment effects as (1) nocturnal passage rates through the rotor planes of wind turbines using a FLIR T620 thermal-imaging camera each night preceding fatality searches at the same turbines, and as (2) counts of found fatalities using scent-detection dogs in both instances.

Our other study, from April 2012 through March 2015, involved 151 Sand Hill turbines we selected for their documented histories of fatalities averaging 4.5× higher fatality rates than the others, and 36 Santa Clara turbines chosen to replace 17 turbines we lost to attrition at Sand Hill during the final year of monitoring (Smallwood et al. 2018). Besides undergoing project-wide shutdowns for 10 weeks each winter as mitigation for raptor fatalities, mechanical and circuit failures at these old turbines resulted in frequent forced shutdowns lasting up to all 1,086 days of our study, and for all but 16% of the turbines. We documented 570 wind turbine shutdowns, averaging 146 days per shutdown, and we documented 474 periods of operability, averaging 170 days per operable period. Amidst the periods of operability and inoperability interspersed among turbines, we performed 16,188 (46.4%) wind turbine searches over 474 periods of turbine operability, 17,392 (49.9%) turbine searches over 570 periods of inoperability, 882 (2.5%) turbine searches over 9 periods of vacant towers, and 363 (1.0%) searches over 4 periods of empty pads. Of the searches at inoperable turbines, 60.7% coincided with winter shutdowns as mitigation to reduce raptor fatalities and the rest coincided with mechanical or circuit malfunctions. Eight of the vacant towers were vacant through the study, and another supported a turbine between two periods of vacancy. Two empty pads were empty through the study, and a third supported a turbine between empty periods. We compared fatality estimates derived from fatality searches using experienced human searchers at turbines during periods of operability, inoperability, vacant towers, and empty pads, where vacant towers were towers lacking turbines and empty pads were spaces no longer hosting wind turbines or towers.

Passage rate surveys at Buena Vista and Golden Hills

Using a FLIR T620 thermal imaging camera, we performed 3-hour nocturnal surveys at turbines searched for fatalities the next morning, 14 September through 14 November 2017. Nocturnal surveys began at dusk, and included at least 1 round of 5-10 minute scans per turbine per hour, covering 2 to 3 wind turbines per night at Golden Hills and 3 to 5 turbines per night at Buena Vista. We video-recorded each timed scan to verify the classification accuracy of each subject as a bat or bird, but we could not identify bats or birds to species. Subjects identified as birds or bats with ≥70% confidence in identification accuracy were divided by hours of scan time and by rotor-swept ha of visible airspace within the camera's image-frame. Subjects passing through the rotor plane or ≤1 m parallel to the rotor plane contributed to passage rates. We summed passage rates by wind turbine by night, and averaged nightly turbine passage rates by project before and after the Buena Vista shutdown, which began 2 October 2017 and lasted through 15 November 2017 (Table 2).

In our BACI experiment we also compared passage rates defined by near misses, wind turbine-disrupted flights, and distracted flights inferred from interactions with other volant animals. Near misses were passages judged by the observer to have nearly collided with a blade. Disrupted flights included those resulting in possible, probable or certain collision, or displacements or jostling caused by pressure waves or vortices of passing blades. Certain collisions involved observations of animal-turbine contact, animal dismemberment, or animals falling without flight control all the way to the ground. Probable collisions involved blade sweeps very close to the animal, which subsequently disappeared from view. Possible collisions involved animals seen falling toward the ground after having missed the interaction between animal and wind turbine. Distracted flights included interactions with volant animals such as prey, or mobbing, harassing, chasing, following or fleeing other volant animals, or hovering ≤1 m from rotor sweeps or diving into airspace ahead of blade sweeps, or chasing or approaching or following along blades. Some distracted flights were also classified as disrupted flights, near misses or collisions, and some disrupted flights were also near misses, but no collisions were classified as near misses or disrupted flights.

Dog searches for fatalities at Buena Vista and Golden Hills

Using scent-detection dogs, we searched for bat and bird fatalities 5 days per week, 15 September through 15 November 2017. Our dog team consisted of a trained handler, an orienteer/data collector, and one dog at a time led by leash along transects oriented perpendicular to the wind and 10 m apart over search areas within the 270° arc between 210° and 300° from each turbine, which corresponds with the APWRA's prevailing upwind directions. We allowed dogs off leash for a more cursory search within the prevailing upwind 90° arc, because few bat and small bird fatalities are found upwind of wind turbines (Smallwood 2016, Brown et al. 2016). Maximum search radii were 75 m at Buena Vista and 105 m at Golden Hills. We left found carcasses in place for possible repeat discovery. We also tested the dog team by randomly placing fresh-frozen and thawed bird and bat carcasses within search areas, where carcasses were marked by clipping flight feathers or in the case of bats, removing one foot (Smallwood et al. 2018). These carcasses served as fatality detection trials used to adjust fatality finds for the proportion of fatalities not detected (Smallwood 2017, Smallwood et al. 2018). Fatality searchers were blind to the trials, and reported them in the same manner as turbine-caused fatalities, except that searchers also reported whether carcasses had been marked. To quantify carcass persistence, we checked trial carcasses until scavengers removed them or until the study ended.

Our dog team performed 28 turbine searches (26 turbines) at Buena Vista on or before the shutdown date, and 48 turbine searches (31 turbines) afterwards. They performed 14 turbines searches (14 turbines) at Golden Hills prior to the Buena Vista shutdown, and 41 turbine searches (31 turbines) afterwards.

Human searches for fatalities at Sand Hill and Santa Clara

Experienced fatality searchers walked parallel transects at 4-6 m intervals to a maximum search radius of 50 m, averaging 5 days between searches. They mapped and recorded attributes of fatalities, and left found fatalities in place for repeat detections. They also recorded detection trial carcasses that we integrated into routine fatality monitoring via trial carcass placements randomized by day and location. For estimating fatality rates, we logit-regressed detection trial outcomes on measured body mass of placed carcasses to derive a predictive model which we applied to typical body masses of species represented by found fatalities (Smallwood et al. 2018).

Over 3 years of monitoring in this study we completed 34,863 turbine searches, upon each of which we recorded the operational status of the turbine. We also conferred with the wind company regarding wind turbine operability. An operable wind turbine was one that was intact and able to generate electricity from wind, whereas an inoperable wind turbine was one that could not generate electricity because ≥1 blade was broken or missing, or some other broken part or bad circuit prevented energy generation. Rotors of inoperable wind turbines were often prevented from spinning by rope or cable tie-downs. From our recording of turbine operability, we defined 1,057 periods of contiguous status as operable ($n = 474$), inoperable ($n = 570$), vacant tower ($n = 9$), or empty pad ($n = 4$), where each period was specific to a single turbine's status.

We calculated point estimates and confidence intervals of fatality rates from periods of operational status.

Analytical methods

We compared mean passage rates of bats and birds through wind turbine rotors in a BACI paired-site experimental design using a 2-factor ANOVA with interest only in the significance of the interaction effect between time period and project site. To help interpret the results we also calculated measures of effect specific to the Buena Vista shutdown:

$$E[I_A] = \frac{C_A}{C_B} \times I_B,$$

$$IMPACT = \frac{(E[I_A] - I_A)}{E[I_A]} \times 100\%,$$

where $E[I_A]$ was the expected post-shutdown passage rate at the Buena Vista impact site, C_B and C_A were before and after passage rates at the Golden Hills control site, IMPACT was the percentage effect of the shutdown on passage rate.

Because treatment periods in the BACI design were too brief for calculating >1 fatality rate per period, we used χ^2 test for homogeneity. Our fatality rate metrics were fatality counts and fatalities/search. We also interpreted the results using the same measures of effect described above, but replaced passage rates with fatality counts or fatalities/search. We note that $E[I_A]$ is the expected value specific to treatment impact in the BACI design and not the same expected value in the χ^2 test for homogeneity.

For comparing fatality rates between wind turbine operational status and vacant towers, we estimated fatality rates $\hat{F}$ adjusted for the proportion of fatalities not found:

$$\hat{F} = \frac{F}{D},$$

where *F* was the unadjusted fatality rate, and *D* was trial carcass detection rate estimated from carcass detection trials that were integrated into routine monitoring (Smallwood et al. 2018). We estimated $\hat{F}$ and 95% confidence intervals from turbine-periods of operational status. A fully functional wind turbine monitored for 3 years would have 3 inoperable periods and 4 operable periods around the required winter shutdown, and some had ≥1 additional inoperable periods for malfunctions. The 6% of turbines that never operated were represented by 1 period of operational status. We compared fatality rate estimates derived from all found carcasses, from carcasses estimated ≤30 days since death, and from those estimated ≤15 days since death.

RESULTS

Buena Vista and Golden Hills BACI Experiment

Bat passage rates through Buena Vista wind turbine rotors decreased significantly after the shutdown (Table 3). The observed bat passage rate through shutdown Buena Vista turbines averaged 32.7 passes/hr/ha of rotor plane, which was 67% lower than the expected $E[I_A]$ rate of 97.9. The reduction was greater when restricting the analysis to passage rates through operable wind turbines at Golden Hills and pre-shutdown Buena Vista, resulting in 0 passes/hr/ha through shutdown Buena Vista turbines instead of the expected $E[I_A]$ of 86.1 (Table 3). Restricting the analysis of passage rates to include only passages involving near-miss collisions, we counted 0 near-miss passages through shutdown Buena Vista turbine rotors instead of the expected $E[I_A]$ 30.8 near-miss passes/hr/ha. The shutdown had no significant effect on bat passage rates through inoperative wind turbine rotors (Table 3), but the observed rate of 32.7 passes/hr/ha was twice that of the expected $E[I_A]$ passage rate of 16.3. There was no significant shutdown effect on bird passage rates (Table 3).

Bat fatalities found before and after the Buena Vista shutdown numbered 37 and 27 at Golden Hills, and 22 and 0 at Buena Vista (Table 4; $\chi^2 = 13.53$, d.f. = 1, $P<0.05$). Our BACI expected value, $E[I_A]$, was 16.0, which was substantially greater than the 0 we found.

Bird fatalities found before and after the Buena Vista shutdown numbered 16 and 17 at Golden Hills, and 8 and 5 at Buena Vista (Table 4; $\chi^2 = 0.64$, d.f. = 1, $P>0.05$). Our expected value, $E[I_A]$, was 8.5 bird fatalities, which numbered more than the 5 we found, although the χ^2 test was not significant. Nearly all of the birds in the test were small birds, so the test outcome was the same for small birds. The IMPACTs of the Buena Vista shutdown were 100% fatality reductions for bats and 41% reduction for birds, but factoring in search effort (fatalities/search) reduced the IMPACT to 0% for birds.

The birds we found as fatalities at Buena Vista after the shutdown were 4 western meadowlarks and 1 unidentified small bird (Table 4). After the Buena Vista shutdown, we continued to find western meadowlarks and red-tailed hawks at Golden Hills, where we also found fatalities of horned lark, northern rough-winged swallow, ruby-crowned kinglet, American pipit, Lincoln's sparrow, and dark-eyed junco. Fatality counts of individual species were too few for chi-square tests.

Sand Hill and Santa Clara

We found too few bat fatalities for reliable comparison of bat fatality rates by wind turbine operability at Sand Hill and Santa Clara. We note, however, that we found a Mexican free-tailed bat fatality at an inoperable wind turbine.

Birds estimated to have died within 15 days of discovery averaged 35% more fatalities/MW at inoperable than at operable wind turbines, but 95% confidence intervals largely overlapped (Table 5). Bird fatalities/MW at vacant towers averaged only 5% of those at operable wind turbines and 4% of those at inoperable wind turbines. We found only 1 European starling at an empty pad.

Fatalities/MW compared similarly when including birds estimated to have died within 30 days and earlier. Fatalities/MW including deaths within 30 days of discovery averaged 28.9 (95% CI:

1.5-46.4) at operable turbines, 36.1 (95% CI: 1.6-56.3) at inoperable turbines, 1.7 (95% CI: 1.3-4.6) at vacant towers, and the 1 European starling at empty pads.

Fatalities/MW including all birds averaged 39.3 (95% CI: 1.8-60.8) at operable turbines, 46.2 (95% CI: 1.8-70.1) at inoperable turbines, 2.0 (95% CI: 1.4-5.3) at vacant towers, and 0.2 (95% CI: 0.0-0.5) at empty pads.

Seventy-nine percent of species represented by bird fatalities in this study were found at inoperable wind turbines. All 6 red-tailed hawk fatalities were found at inoperable wind turbines. We found one of these red-tailed hawks directly under an inoperable wind turbine with its bill dislocated into its face. Burrowing owls, great-horned owls, mourning doves, and western meadowlarks died at inoperable turbines at twice the rate as at operable turbines. Notable exceptions included American kestrels, which we found dead at operable turbines at twice the rate as at inoperable turbines, and northern flickers and 3 species of flycatcher which we found dead only at operable wind turbines.

DISCUSSION

The Buena Vista shutdown strongly affected bat passage rates, but not bird passage rates. After the shutdown, bats passed through inoperative turbine rotors at twice the rate other than expected, but this difference between 32.7 and 16.3 passes/hr/ha was not significant. Even more substantial, and significant, was the shutdown effect on bat passages through turbine rotors when the comparison was between operative Golden Hills turbines and shutdown Buena Vista turbines, resulting in 0 passages through shutdown turbine rotors instead of the expected 86. Comparing the expected 86 passages/hr/ha through operative wind turbines to the observed 32.7 passages/hr/ha through inoperative wind turbines suggests bats are 2.6 times more likely to pass through the turbines of operative versus inoperative wind turbine rotors.

The one bat fatality we found at an inoperable wind turbine in the Sand Hill project might have been killed by either of the neighboring wind turbines, which were operable at the time and only 40 m to either side of the inoperable turbine. Alternatively, it might have collided with a nonmoving turbine part. However, results from our BACI experiment at Buena Vista and Golden Hills indicate that shutting down wind turbines during bat migration also curtails bat fatalities. It appears that turbine rotors must spin for bats to collide with wind turbines. Therefore, for bat species vulnerable to population-level impacts caused by wind turbines, such as hoary bat (Frick et al. 2017), a seasonal curtailment strategy should substantially improve population viability.

On the other hand, operational curtailment appears to be ineffective at reducing fatalities of most bird species in our study. The winter shutdown, which was proposed as a mitigation measure by the wind companies and endorsed by Smallwood in 2005 (Smallwood 2008), and then implemented at most of the APWRA's old-generation wind turbines 2006-2014, was probably ineffective for reducing fatalities of most bird species (but see below). Few bats are active over winter, so the shutdown likely failed to reduce bat fatalities. It remains unknown whether the winter shutdown reduced golden eagle fatalities, though we note that historically fewer golden eagles have been found as fresh fatalities over the winter months (Nov-Feb) in the APWRA.

Because we found only 1 golden eagle fatality, and because it collided with a wind turbine unselected for this study, our study results cannot inform of curtailment effects on golden eagles. However, we note that we found this mortally wounded eagle at an operable turbine. Of the hundreds of eagle fatalities documented in the APWRA, we cannot recall any having been associated with an inoperable wind turbine. We suggest it is likely that some species, such as golden eagle, American kestrel, and flycatchers, are more vulnerable to a wind turbine's moving blades. It remains unknown, however, whether a curtailment strategy would minimize or reduce fatalities of these species.

Otherwise, our study suggests that for most bird species, more of the collision risk might be in the structure of a wind turbine than in the moving parts, as suggested by collision risk modeling performed before our study began (Richard Podolski, Pers. Comm. with K. S. Smallwood). Furthermore, our results suggest that vacant towers pose much lower collision risk than do inoperable turbines mounted on towers. We suspect that most of the risk of a mounted turbine is in the blades regardless of whether blades are moving. Although admittedly not birds, we have often found blades difficult to see due to low contrast against a sky backdrop or blending in against certain terrain backgrounds. At night the blades are even more difficult to see, especially when motionless. Operating wind turbines produce considerable noise, which might alert birds to potential hazard. The motion of operating turbines can also enhance blade visibility at night by periodically disrupting artificial background lighting of rural homes and distant cities (Fig. 2), or even the rising or setting of lit moon. Also, a quarter of the turbines flash aviation hazard lights at night. Whether birds perceive these hazard cues remains unknown, but could explain our lack of effect of turbine shutdown.

Our finding of only 2 bat fatalities after 34,863 turbine searches at Sand Hill and Santa Clara suggests that the old-generation wind turbines killed many fewer bats than the repowered modern turbines at Buena Vista and Golden Hills. Confounding the comparison, however, was the use of human searchers at Sand Hill and Santa Clara versus scent detection dogs at Buena Vista and Golden Hills. At Vasco Winds, which was another repowered project consisting of modern wind turbines adjacent to Buena Vista, humans searched half the 2.3-MW turbines on 80-m towers at 7-day intervals (Brown et al. 2016), which was 2 days longer than the average search interval achieved at Sand Hill and Santa Clara, and they searched along transects spaced at twice the distance. Despite these methodological disadvantages for detecting bats at Vasco Winds relative to Sand Hill and Santa Clara, human searchers found 31 bats after 2,652 turbine searches at Vasco Winds, or 204 times the number of bat fatalities per search. Modern turbines appear much more dangerous to bats compared to old-generation wind turbines, but it remains unknown whether the greater danger arose from the small difference in location or in increased tower height, lower RPM, or greater operability.

One implication of our findings is that fatality estimates based on proportion of the time wind turbines operate should work well for bats, so long as investigators have the means to carefully track wind turbine operations, but this approach will not work well for birds. ICF International (2016) defined their fatality rate metric as fatalities/MW/year of operable status, and they used it to conclude that winter shutdowns and the removals of a small number of designated high-risk turbines reduced fatality rates of 4 raptor species – golden eagle, red-tailed hawk, American kestrel, and burrowing owl – by 50%. Our results indicate that ICF International's (2016) conclusion was spurious because fatality rates of most bird species in the APWRA were unrelated to turbine operability.

Another implication of our findings relates to estimates of background mortality in wind projects. ICF International (2015) estimated surprisingly high background mortality over the winter months of 2014-2015, but most of their fatality searches overlapped shutdown wind turbines waiting for removal. Based on our findings, ICF International (2015) erroneously assumed that wind turbines must be operative to kill birds. They also assumed that all birds they found as fatalities at the derelict wind turbines had been consumed by raptors perching on the turbines, but this hypothesis was not supported by the much lower fatality rates we observed at vacant towers. The safest approach for estimating background mortality is to search areas that are empty of wind turbines, operable or not.

MANAGEMENT IMPLICATIONS

Because the migration season is relatively brief, a seasonal curtailment strategy would greatly reduce bat fatalities while not giving up a large proportion of a wind project's annual energy generation. The efficiency of such a migration-specific curtailment could improve by narrowing it to the first few hours following dusk. But for most bird species there does not seem to be a curtailment solution. For birds the most likely effective mitigation is careful macro- and micro-siting to avoid landscape settings where birds will more often encounter obstacles erected in their flight space. Unfortunately, micro-siting might not be as effective for bats because our results indicate bats are attracted to operative wind turbines.

ACKNOWLEDGMENTS

This research was funded in part by the Gordon and Betty Moore Foundation. We are grateful to the Gordon and Betty Moore Foundation for its financial support which was administered through the East Contra Costa County Habitat Conservancy Science and Research Grant Program (Conservancy Contract 2016-03). We also thank the East Bay Regional Park District for additional funding and for assistance with access to the Buena Vista Wind Energy project located on its property. We thank the California Energy Commission for funding of our work at Sand Hill and Santa Clara Wind Energy projects. We thank Bryan Maddock and Leeward Renewable Energy LLC for access and assistance at the Buena Vista Wind Energy project, and Renee Culver and NextEra Energy Resources for access and assistance at Golden Hills Wind Energy project, and John Howe and Ogin Inc. for access, assistance and funding at Sand Hill and Santa Clara. We thank Heath Smith, Collette Yee, and Skye Standish of Conservation Canines, Center of Conservation Biology, University of Washington, for their highly skilled dog handling. We also thank Joanne Mount, Elizabeth Leyvas, and Skye Standish for fatality monitoring, and Erika Walther for administering carcass detection trials, at Sand Hill and Santa Clara. We appreciate the generous donations of bird carcasses by Native Songbird Care and bat carcasses by Dr. Deborah Cottrell at West End Animal Hospital. Use of animal carcasses was authorized under permits from the U.S. Fish and Wildlife Service (MB135520-0) and the California

Department of Fish and Wildlife (SC-00737). We thank Jennifer Brown of the former agency and Carie Battistone, Esther Burkett, Justin Garcia and Scott Osborn of the latter agency, for assistance with permitting. We thank Debbie Woollett for working with us to train a dog we ended up not using, but this effort was important to our development. We are also indebted to Karen Swaim for her generous donation of living space for our dog handler and detection dogs throughout this study. Lastly, we are grateful to the spirited efforts given us by Captain and Jack.

REFERENCES CITED

Arnett, E. 2006. A Preliminary Evaluation on the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Society Bulletin 34:1440-1445.

Arnett, E. B., M. M. P. Huso, M. R. Schirmacher, and J. P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 9:209-214. DOI:10.1890/100103

Arnett, E. B., G. D. Johnson, W. P. Erickson, and C. D. Hein. 2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. Report to The National Renewable Energy Laboratory, Golden, Colorado.

Behr, O., R. Brinkmann, K. Hochradel, J. Mages, F. Korner-Nievergelt, I. Niermann, M. Reich, R. Simon, N. Weber and M. Nagy. 2017. Mitigating Bat Mortality with Turbine-Specific Curtailment Algorithms: A Model Based Approach. Pages 135-160 in Köppel, J., Editor, Wind Energy and Wildlife Impacts: Proceedings from the CWW2015 Conference. Springer. Cham, Switzerland.

Brown, K., K. S. Smallwood, J. Szewczak, and B. Karas. 2016. Final 2012-2015 Report Avian and Bat Monitoring Project Vasco Winds, LLC. Prepared for NextEra Energy Resources, Livermore, California.

Cryan, P. M., P. M. Gorresen, C. D. Hein, M. R. Schirmacher, R. H. Diehl, M. H. Huso, D. T. S. Hayman, P. D. Fricker, F. J. Bonaccorso, D. H. Johnson, K. Heist, and D. C. Dalton. 2014. Behavior of bats at wind turbines. Proceedings National Academy of Science 111:15126-15131.

Erickson, W. P., M. M. Wolfe, K. J. Bay, D. H. Johnson, and J. L. Gehring. 2014. A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. PLoS One 9(9): e107491. doi:10.1371/journal.pone.0107491.

Foo, C. F., V. J. Bennett, A. M. Hale, J. M. Korstian, A. J. Schildt, and D. A. Williams. 2017. Increasing evidence that bats actively forage at wind turbines. PeerJ5:e3985;DOI 10.7717/peerj.3985

Frick, W. F., E. F. Baerwald, J. F. Pollock, R. M. R. Barclay, J. A. Szymanski, T. J. Weller, A. L. Russell, S. C. Loeb, R. A. Medellin, and L. P. McGuire. 2017. Fatalities at wind turbines may threaten population viability of a migratory bat. Biological Conservation 209:172-177.

Hayes, M. A. 2013. Bats Killed in Large Numbers at United States Wind Energy Facilities. BioScience 63:975-979.

Horn, J. W., E. B. Arnett, and T. H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72:123-132.

ICF International. 2015. A study to evaluate the potential contribution of predation and other mortality factors on birds during the winter in the Altamont Pass Wind Resource Area, California. Report M-110 to Alameda County Scientific Review Committee, Hayward, California.

Loss, S. R., T. Will, and P. P. Marra. 2013. Estimates of bird collision mortality at wind facilities in the contiguous United States. Biological Conservation 168:201–209.

Lovich, J. E. and J. R. Ennen. 2013. Assessing the state of knowledge of utility-scale wind energy development and operation on non-volant terrestrial and marine wildlife. Applied Energy 103:52–60.

Mathews, F., M. Swindells, R. Goodhead, T. A. August, P. Hardman, D. M. Linton, and D. J. Hosken. 2013. Effectiveness of search dogs compared with human observers in locating bat carcasses at wind-turbine sites: A blinded randomized trial. Wildlife Society Bulletin 37:34-40.

Sinclair, K. and E. DeGeorge. 2016. Framework for Testing the Effectiveness of Bat and Eagle Impact-Reduction Strategies at Wind Energy Projects. S. Smallwood, M. Schirmacher, and M. Morrison, eds., Technical Report NREL/TP-5000-65624, National Renewable Energy Laboratory, Golden, Colorado.

Smallwood, K. S. 2008. Wind power company compliance with mitigation plans in the Altamont Pass Wind Resource Area. Environmental & Energy Law Policy Journal 2(2):229-285.

Smallwood, K. S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37:19-33. + Online Supplemental Material.

Smallwood, K. S. 2016. Bird and bat impacts and behaviors at old wind turbines at Forebay, Altamont Pass Wind Resource Area. Report CEC-500-2016-066, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2016publications/CEC-500-2016-066/CEC-500-2016-066.pdf

Smallwood, K. S. 2017. Long search intervals under-estimate bird and bat fatalities caused by wind turbines. Wildlife Society Bulletin 41:224-230.

Smallwood, K. S., and L. Neher. 2017. Comparing bird and bat use data for siting new wind power generation. Report CEC-500-2017-019, California Energy Commission Public Interest Energy Research program, Sacramento, California. http://www.energy.ca.gov/2017publications/ CEC-500-2017-019/CEC-500-2017-019.pdf and http://www.energy.ca.gov/2017publications/CEC-500-2017-019/CEC-500-2017-019-APA-F.pdf

Smallwood, K. S., L. Neher, and D. A. Bell. 2017. Siting to Minimize Raptor Collisions: an example from the Repowering Altamont Pass Wind Resource Area. M. Perrow, Ed., Wildlife and Wind Farms - Conflicts and Solutions, Volume 2. Pelagic Publishing, Exeter, United Kingdom. www.bit.ly/2v3cR9Q

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management 74: 1089-1097 + Online Supplemental Material.

Smallwood, K. S., D. A. Bell, E. L. Walther, E. Leyvas, S. Standish, J. Mount, B. Karas. 2018. Estimating wind turbine fatalities using integrated detection trials. Journal of Wildlife Management 82:1169-1184.

Tomé, R., F. Canário, A. H. Leitão, N. Pires and M. Repas. Radar Assisted Shutdown on Demand Ensures Zero Soaring Bird Mortality at a Wind Farm Located in a Migratory Flyway. Pages 119-134 in J. Köppel (ed.), Wind Energy and Wildlife Interactions: Proceedings from the CWW2015 Conference. Springer. Cham, Switzerland. DOI 10.1007/978-3-319-51272-3_7.

Table 1. Wind turbines in project (N) and selected/used in study of relationship between collision fatalities and turbine operational status during intervals preceding fatality searches at Golden Hills, Buena Vista, Sand Hill and Santa Clara Wind Energy Projects, Alameda and Contra Costa Counties, California, 2012-2015 and Fall 2017.

Project	Turbine model	MW	Hub height (m)	N		Monitoring		Searches	
				All	Selected /used	Duration (years)	Searcher	Total	At operable turbines (%)
Golden Hills	GE	1.790	80.0	48	32	0.17	Dogs	55	100.0
Buena Vista	Mitsubishi	1.000	45-65	38	31	0.17	Dogs	76	36.8
Altech I	Enertech	0.040	18.5	144	47/63	3.00	Humans	11,857	40.6
Swamp	Micon	0.065	24.6	12	5	3.00	Humans	1085	41.5
Taxvest	Micon	0.065	24.6	183	56/73	3.00	Humans	13,098	53.5
Viking	Micon	0.065	24.6	26	5/7	3.00	Humans	1519	53.3
Venture	Windmatic	0.065	18.5	26	15/16	3.00	Humans	2936	35.7
Venture	Polenko	0.109	24.4	12	11	3.00	Humans	1985	34.9
Santa Clara	Vestas	0.095	24.6	200	36	1.00	Humans	2345	58.3

Table 2. Nocturnal survey effort using a FLIR T620 thermal-imaging camera for measuring passage rates through rotor-swept airspace in a before-after, control-impact paired-site experimental design at Golden Hills and Buena Vista Wind Energy Projects, Alameda and Contra Costa Counties, California, Fall 2017.

	Golden Hills		Buena Vista		Both projects	
Survey effort	Before	After	Before	After	Before	After
Total survey hours	11.25	34.14	15.58	23.36	26.83	57.50
Survey hours at operative turbine	10.84	26.57	11.34	0.00	22.18	26.57
Survey hours at inoperative turbine	0.41	7.57	4.24	23.36	4.65	30.93
Sum rotor plane viewable (ha)	3.85	10.39	3.85	6.03	7.70	16.42

Table 3. Mean and 95% CI nocturnal passes/hour/ha of rotor plane in before-after, control-impact paired-site experimental design at Golden Hills (GH) and Buena Vista (BV) Wind Energy Projects, Alameda and Contra Costa Counties, California, Fall 2017. F represents the F-ratio specific to the interaction term in 2-factor ANOVA (D.F. = 1,142), where t denotes 0.10>P>0.05, * denotes P < 0.05 and ** denotes P < 0.001. Disrupted flights included those flights resulting in possible, probable or certain collision, or displacements or jostling caused by pressure waves or vortices of passing blades. Distracting flights included interactions with volant animals such as prey, or mobbing, harassing, chasing, following or fleeing other volant animals, or hovering ≤1 m from rotor sweeps or diving into airspace ahead of blade sweeps, or chasing or approaching or following along blades.

Taxa/Passage type	Passes/hour/ha of rotor plane								F
	GH before		GH after		BV before		BV after		
Bats	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	F
All turbine rotors	9.2	1.5–16.9	16.0	8.1–24.0	56.4	29.8–82.9	32.7	2.2–63.1	3.52^{t}
Operative rotor	8.9	1.3–16.5	14.4	6.9–22.0	53.0	27.0–78.9	0.0		24.19**
Inoperative rotor	0.3	0.0–1.0	1.6	0.2–2.9	3.4	0.0–7.6	32.7	2.2–63.1	0.91
Collided	0.0		0.8	0.0–1.8	0.5	0.0–1.5	0.0		3.75^{t}
Near miss or disrupted flight	4.2	1.0–7.5	5.3	2.6–8.0	24.5	8.4–40.6	0.0		14.57**
Near miss, disrupted flight, or distracted	6.5	0.6–12.3	6.4	3.4–9.4	34.8	14.9–54.7	8.1	0.0–18.2	8.10*
Birds									
All turbine rotors	4.9	0.0–13.1	2.2	0.0–4.5	5.5	0.9–10.2	1.9	0.0–5.3	0.72
Operative rotor	4.9	0.0–13.1	1.7	0.3–3.0	5.0	0.4–9.5	0.0		1.46
Inoperative rotor	0.0		0.5	0.0–1.6	0.6	0.0–1.7	1.9	0.0–5.3	0.01
Near miss or disrupted flight	4.9	0.0–12.9	0.3	0.0–0.8	1.4	0.0–3.5	0.0		0.55
Near miss, disrupted flight, or distracted	4.6	0.0–12.9	0.3	0.0–0.8	1.4	0.0–3.5	0.3	0.0–0.8	0.68

Table 4. Summary of fatalities found by Conservation Canines' scent-detection dog teams at Buena Vista (BV) and Golden Hills (GH) during fall 2017, and fatalities per search before and after the Buena Vista wind turbines were shut down on 2 October 2017.

Species	Scientific name	Fatalities/search			
		Buena Vista		Golden Hills	
		Before	After	Before	After
Western red bat	*Lasiurus blossevillii*	0.143	0.000	0.071	0.000
Myotis	*Myotis*	0.000	0.000	0.071	0.000
Mexican free-tailed bat	*Tadarida brasiliensis*	0.214	0.000	1.214	0.220
Hoary bat	*Lasiurus cinereus*	0.071	0.000	0.429	0.146
Bat		0.357	0.000	0.857	0.293
Mallard	*Anas platyrhynchos*	0.000	0.000	0.071	0.000
Grebe	Podicipedidae	0.000	0.000	0.000	0.000
Turkey vulture	*Cathartes aura*	0.000	0.000	0.000	0.000
Northern harrier	*Circus cyaneus*	0.000	0.000	0.000	0.000
White-tailed kite	*Elanus leucurus*	0.000	0.000	0.000	0.000
Red-tailed hawk	*Buteo jamaicensis*	0.000	0.000	0.143	0.024
Large raptor		0.000	0.000	0.000	0.000
American kestrel	*Falco sparverius*	0.071	0.000	0.071	0.000
Prairie falcon	*Falco mexicanus*	0.000	0.000	0.000	0.000
Rock pigeon	*Columba livia*	0.000	0.000	0.000	0.000
Barn owl	*Tyto alba*	0.036	0.000	0.000	0.000
Burrowing owl	*Athene cunicularia*	0.000	0.000	0.214	0.000
White-throated swift	*Aeronautes saxatalis*	0.000	0.000	0.000	0.000
Pacific-slope flycatcher	*Empidonax difficilis*	0.036	0.000	0.000	0.000
Horned lark	*Eremophila alpestris*	0.000	0.000	0.071	0.024
Northern rough-winged swallow	*Stelgidopteryx serripennis*	0.000	0.000	0.000	0.049
Bewick's wren	*Thryomanes bewickii*	0.000	0.000	0.071	0.000
House wren	*Troglodytes aedon*	0.000	0.000	0.071	0.000
Ruby-crowned kinglet	*Regulus calendula*	0.000	0.000	0.000	0.049
American pipit	*Anthus rubescens*	0.000	0.000	0.000	0.024
Warbler	Parulidae	0.000	0.000	0.071	0.000
Black-throated gray warbler	*Dendroica nigrescens*	0.000	0.000	0.000	0.000
Townsend's warbler	*Dendroica townsendi*	0.036	0.000	0.000	0.000
Lincoln's sparrow	*Melospiza lincolnii*	0.000	0.000	0.000	0.024
Dark-eyed junco	*Junco hyemalis*	0.000	0.000	0.000	0.024
Blackbird	Icteridae	0.000	0.000	0.000	0.000
Western meadowlark	*Sturnella neglecta*	0.071	0.083	0.000	0.049
Brown-headed cowbird	*Molothrus ater*	0.000	0.000	0.000	0.000
Large bird		0.000	0.000	0.071	0.024
Small bird		0.036	0.021	0.286	0.122
All bats		0.786	0.000	2.643	0.659

Species	Scientific name	Fatalities/search			
		Buena Vista		Golden Hills	
		Before	After	Before	After
All small birds		0.250	0.104	0.857	0.366
All large birds		0.036	0.000	0.286	0.049
All birds		0.286	0.104	1.143	0.415

Table 5. Comparison of fatalities/MW among operable and inoperable wind turbines and vacant towers from April 2012 through March 2015 in the Sand Hill and Santa Clara Wind Energy Projects, Alameda County, California. Inoperability was either volitional during project-wide winter shutdowns as mitigation intended to reduce raptor fatalities or forced by mechanical or circuit failures, totaling 50% of turbine searches across 570 turbine-shutdown periods. Fatality estimates were adjusted for overall detection rates, *D* (Smallwood et al. 2018).

Common name	Species name	Estimated fatalities/MW by wind turbine operational status					
		Operable		Inoperable		Vacant tower	
		$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Mexican free-tailed bat	*Tadarida brasiliensis*	0.000		0.231	0.035–0.685	0.000	
Bat		0.561	0.056–1.661	0.000		0.000	
Grebe	Podicipedidae	0.000		0.080	0.022–0.235	0.000	
American coot	*Fulicra Americana*	0.000		0.262	0.037–0.625	0.000	
Killdeer	*Charadrius vociferus*	0.107	0.027–0.317	0.107	0.025–0.317	0.000	
Spotted sandpiper	*Actitis macularis*	0.135	0.030–0.400	0.000		0.000	
Glaucous-winged gull	*Larus glaucescens*	0.078	0.024–0.230	0.000		0.000	
Herring gull	*Larus argentatus*	0.000		0.078	0.022–0.231	0.000	
Thayer's gull	*Larus thayeri*	0.000		0.174	0.031–0.515	0.000	
Gull	Laridae	0.159	0.033–0.380	0.195	0.033–0.469	0.000	
Ferruginous hawk	*Buteo regalis*	0.000		0.124	0.027–0.367	0.000	
Red-tailed hawk	*Buteo jamaicensis*	0.000		0.183	0.032–0.541	0.000	
American kestrel	*Falco sparverius*	0.557	0.056–1.050	0.268	0.037–0.651	0.102	0.147–0.303
Barn owl	*Tyto alba*	0.268	0.041–0.664	0.238	0.035–0.508	0.000	
Burrowing owl	*Athene cunicularia*	1.210	0.079–2.100	2.105	0.091–3.207	0.000	
Great-horned owl	*Bubo virginianus*	0.076	0.024–0.224	0.152	0.029–0.362	0.000	
Mourning dove	*Zenaida macroura*	0.911	0.070–1.553	2.497	0.098–3.806	0.000	
Rock pigeon	*Columba livia*	10.937	0.204–13.596	10.768	0.185–13.397	0.392	0.253–0.921
Dove	Columbidae	0.346	0.046–0.744	0.308	0.040–0.737	0.000	
Common poorwill	*Phalanoptilus nuttallii*	0.000		0.193	0.032–0.571	0.000	
White-throated swift	*Aeronautes saxatalis*	0.000		0.151	0.029–0.448	0.000	
Northern flicker	*Colaptes auratus*	0.100	0.027–0.296	0.000		0.000	
Ash-throated flycatcher	*Myiarchus cinerascens*	0.156	0.032–0.462	0.000		0.000	

Common name	Species name	Estimated fatalities/MW by wind turbine operational status					
		Operable		Inoperable		Vacant tower	
		$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Pacific-slope flycatcher	*Empidonax difficilis*	0.411	0.049–1.218	0.000		0.000	
Say's phoebe	*Sayornis saya*	0.288	0.042–0.853	0.000		0.000	
Horned lark	*Eremophila alpestris*	0.000		0.142	0.028–0.421	0.000	
Common raven	*Corvus corax*	0.077	0.024–0.229	0.112	0.026–0.331	0.000	
American robin	*Turdus migratorius*	0.000		0.363	0.043–0.900	0.000	
European starling	*Sturnus vulgaris*	2.326	0.104–3.455	1.809	0.085–2.831	0.165	0.178–0.488
Yellow-rumped warbler	*Setophaga coronata*	0.000		0.656	0.055–1.565	0.000	
Lincoln's sparrow	*Mellospiza lincolnii*	0.000		0.165	0.030–0.489	0.000	
Song sparrow	*Melospiza melodia*	0.000		0.150	0.029–0.445	0.000	
Sparrow	Emberizidae	0.000		0.293	0.039–0.869	0.000	
Red-winged blackbird	*Agelaius phoeniceus*	0.000		0.204	0.033–0.605	0.000	
Tricolored blackbird	*Aegolaius tricolor*	0.000		0.126	0.027–0.373	0.000	
Western meadowlark	*Sturnella neglecta*	0.662	0.061–1.213	1.256	0.073–2.151	0.000	
Blackbird	Icteridae	0.203	0.036–0.602	0.125	0.027–0.371	0.000	
House finch	*Haemorhous mexicanus*	0.241	0.039–0.714	0.310	0.040–0.742	0.241	0.206–0.714
Lesser goldfinch	*Spinus psaltria*	0.208	0.037–0.616	0.000		0.000	
Large bird		0.000		0.000		0.173	0.181–0.512
Medium bird		0.347	0.046–0.763	0.260	0.037–0.554	0.000	
Small bird		0.478	0.053–1.176	4.221	0.123–6.170	0.000	
All birds		20.842	1.239–34.517	28.075	1.500–45.802	1.073	0.964–2.937

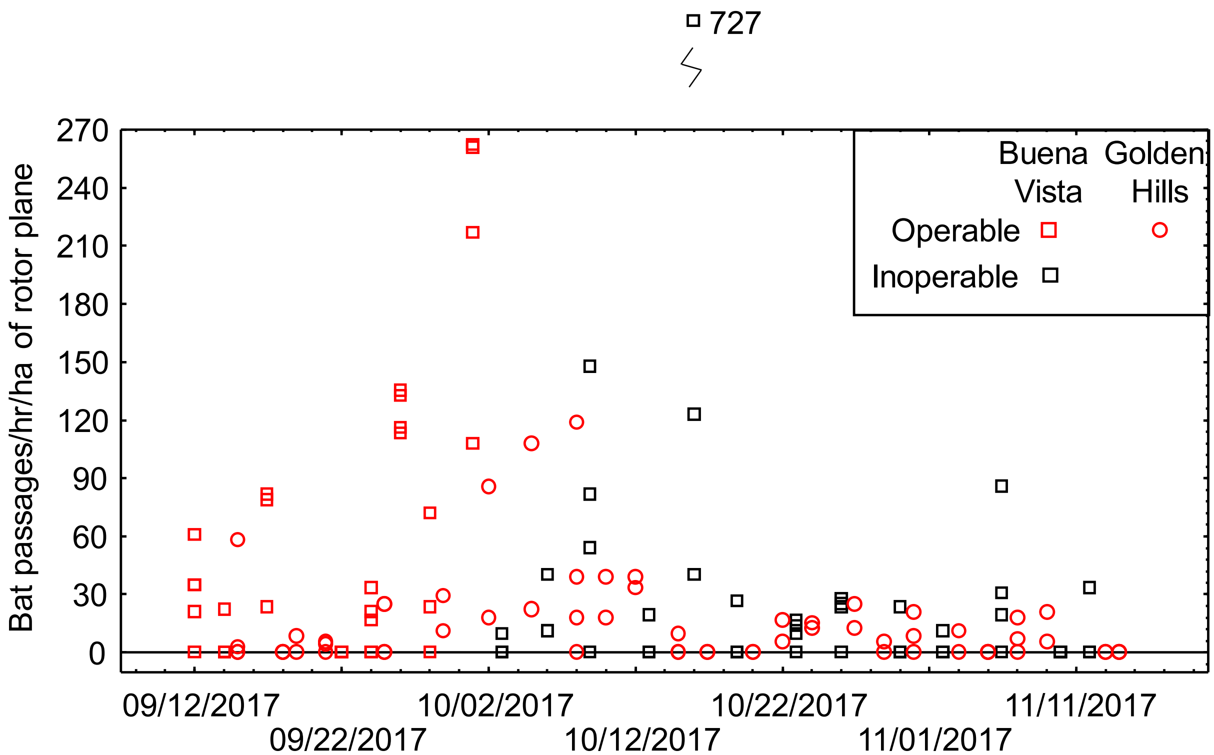


Figure 1. Bat passes/hr/ha of rotor plane at the Golden Hills and Buena Vista wind projects before and after the Buena Vista shutdown on 2 October 2017, Alameda and Contra Costa Counties, California, where passages were those with ≥70% confidence the subjects were bats.

Figure 2A. Blocked background artificial light viewed eastward at rotor-height through the Altamont Pass Wind Resource Area, between the flashing of FAA hazard lights.

Figure 2B. Blocked background artificial light viewed eastward at rotor-height through the Altamont Pass Wind Resource Area, coinciding with the flashing of FAA hazard lights.

Letter 9

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Southwest Region
Migratory Bird Permit Office
2800 Cottage Way, Suite W-1916
Sacramento, California 95825

In Response Reply To:
FWS/R8/MB

October 9, 2019

Mr. Andrew Young
County of Alameda
244 W. Winton Avenue, Room 111
Hayward, CA 94544

Dear Mr. Young,

9-1

The U.S. Fish and Wildlife Service (Service) is providing comments on the Sand Hill Wind Project Draft Subsequent Environmental Impact Report (SEIR). The mission of Service is to work with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of our mission, we are charged with implementing various statutes, including the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d; Eagle Act) and the Migratory Bird Treaty Act (16 U.S.C. § 703 *et seq*.; MBTA). Our review and comments focus on our legal mandate and trust responsibility to maintain healthy bird populations for the benefit of the American public pursuant to the Eagle Act and MBTA. Our comments are consistent with Alameda County's (County) request that the Service provide technical assistance as a member of the Alameda County Altamont Pass Wind Resource Area (APWRA) Technical Assistance Committee (TAC), helping the County to address wind turbine impacts to eagles, birds, and bats.

The draft SEIR analyzes the anticipated approval by the County of a new Conditional Use Permit (CUP) to allow the proposed wind facility to construct and operate wind generation turbines in the APWRA. Your applicant (Sand Hill Wind, LLC) has has also applied for an Eagle Act incidental take permit for golden eagles in association with the Sand Hills Wind Project (Project).

The Service appreciates the County's inclusion of the Conservation Measure which provides the applicant with an option that, should the Project obtain an eagle incidental take permit, that permit's avoidance, minimization, and compensatory mitigation measures may also serve to meet the County's CUP's needs for eagles, as well as a Bird and Bat Conservation Strategy submitted and found acceptable by the Service as we process the eagle incidental take permit request. Therefore our review and comments are attentive to elements of the draft SEIR relative to our Eagle Act take permit regulations, guidance, population assessments and related analyses.

We acknowledge that the County's regulatory authorities and requirements under the California Environmental Quality Act (CEQA) differ from our eagle permit regulations and National Environmental Quality Act (NEPA), even so, CEQA and NEPA are similar, both in intent and in

9-1 cont.

the review process[1]. The County and the Service also share similar goals when working with wind proponents and operators in the APWRA; to minimize impacts to eagles, birds and bats. Our intent is to provide technical assistance such that your analysis is as consistent with our policy, process and our forthcoming National Environmental Protection Act (NEPA) analysis of Sand Hill Wind, LLC's eagle incidental take permit application as is practicable.

Below are the draft SEIR topics for which we are providing comments. Please see the attachment to this letter for our detailed comments and recommendations:

- Bald eagle distribution, habitat and occurrence in the Project Area
- Golden eagle distribution, habitat and occurrence in the Project Area
- Estimated annual avian fatalities
- Additional Studies on Golden Eagle
- Avian impact avoidance and minimization measures

After the County has had the opportunity to review our comments and recommendations, we would like to schedule an in person meeting with the County and the applicant to further discuss options to avoid and minimize impacts to eagles from the proposed project.

We look forward to working with your Planning Department on the Project. If you have any questions regarding this letter, the Service's Eagle Act permitting regulations or processes, please contact Heather Beeler, Eagle Permits Coordinator, at heather_beeler@fws.gov or by phone at 916-414-6651. Ms. Beeler is available to provide technical assistance to the County as needed.

Sincerely,

Thomas Leeman
Deputy Chief, Migratory Birds

cc: Sandra Rivera, Alameda County Planning Department

Attachment

---

1 http://opr.ca.gov/docs/NEPA_CEQA_Handbook_Feb2014.pdf

Attachment 1: U.S. Fish and Wildlife Service Draft SEIR Comments

9-2

1. Bald eagle distribution, habitat and occurrence in the Project Area
   The draft SEIR Table 3.4-3 (Page 3.4-28) describes bald eagle geographic distribution, habitat requirements and likelihood to occur in the Project area. The summary of bald eagle geographic distribution is inaccurate and out dated. In addition, we recommend the description of bald eagle habitat requirements be updated to include oak and other deciduous trees as bald eagle nesting and roosting is not limited to coniferous trees. Please refer to the California Department of Fish and Wildlife's Bald Eagle webpage for the most current data and information about bald eagles in California: https://www.wildlife.ca.gov/Conservation/Birds/Bald-Eagle

   We disagree with the determination for bald eagles summarized under "Likelihood to Occur in the Project Area" which states:

   > *High- species winters in the APWRA and may forage adjacent to the Project area at Bethany Reservoir; however, no suitable nesting or foraging habitat (large lakes, reservoirs, or rivers) is present in the Project area.*

   Bald eagles occur year round throughout most of California, with the possible exception of a few southern California counties. Bald eagles nest in Alameda County and in neighboring Contra Costa County, and could nest near or within the APWRA. Bald eagles have the potential to nest in suitable trees or transmission towers located within the project area. Bethany Reservoir is surrounded on three sides by the proposed project's turbines. As your draft SEIR states, bald eagles are regularly observed at Bethany Reservoir. Bald eagles also frequently perch and roost in the transmission towers late in the day, communally with golden eagles (P. Kolar, written communication). These towers are located along Christensen Road within the proposed project footprint, approximately ¼ miles from the project's proposed turbine locations. It is therefore the Service's opinion that bald eagle foraging, roosting, and nesting habitat exists within and immediately adjacent to the project area.

9-3

2. Golden eagle distribution, habitat and occurrence in the Project Area
   The draft SEIR Table 3.4-3 (Page 3.4-28) describes golden eagle geographic distribution, habitat requirements and likelihood to occur in the Project area. We recommend updating the "Habitat Requirements" description to include mention of small mammals as prey items ground squirrels are known to be an important food source for golden eagles in these habitats.

   The Service disagrees with the County's determination in the "Likelihood to Occur in Project Area" summary which states "*…no suitable nesting habitat is present in the Project area.".* The U.S. Geological Survey (USGS) is conducting a cooperative broad-scale study to estimate site occupancy, reproduction, and abundance of golden eagles in the APWRA and northern Diablo Range. Early in the summer of 2019, at the request of the applicant, Dave Wiens of the USGS provided SPower/Sand Hills Wind, LLC with golden eagle nest locations in the Rooney Ranch and Sand Hill Wind project areas, along with the associated metadata record. Two golden eagle territorial pairs' activity centers are located within the project area: the Christensen Pair and the Jess Ranch pair (Wiens 2018, Wiens written communications, P. Kolar, verbal communication). The Christensen Pair has nested in four out of five of the years this site has been monitored. In addition to providing nesting habitat, the Project area appears to be highly utilized golden eagle foraging habitat (P. Kolar, verbal communication to

Alameda County TAC September 19, 2019). The Service recommends the final SEIR be updated to include a map illustrating the known nest locations in the project area, and within two miles of the project area. We also recommend the analyses in Table 3.4-3 and throughout the draft SEIS be updated to summarize our understanding about the territorial eagle pairs within the project area, and the overall quality of habitat to more accurately reflect the available information 9-3 cont.

3. <u>Estimated annual avian fatalities</u> 9-4

Estimated annual avian fatalities are discussed on pages 3.4-37 to 3.4-40. Draft SEIR Table 3.4-4 presents projected estimates for annual avian fatalities at the Sand Hill Wind Project using average mortality rates from four repowered projects in the APWRA. We recommend refining this analysis so the final estimate is derived from data from the most recently repowered projects, Vasco Wind and Golden Hills, for the following reasons:

- These newer repower project turbines are more similar in size to the proposed Sand Hill Wind Project, although the Sand Hill Wind project proposes even larger turbines.
- The Diablo Wind and Buena Vista turbines are substantially smaller compared to the modern repower (Vasco, Golden Hills, and proposed Sand Hill Wind) projects.
- Vasco Wind and Golden Hills monitoring studies are similar in their design, making their results comparable to each other.
- Vasco Wind and Golden Hills monitoring study results provide more precise and statistically robust impact assessments compared to the Diablo Wind and Buena Vista studies.
  - Project-specific bias trials were not conducted for Diablo Winds.
  - The Buena Vista's study's bias trials utilized species not representative of eagles (pigeon and Japanese quail), skewing the results of anticipated impacts to eagles and large raptors. The final report acknowledged that there was a high level of uncertainty in the final impact estimates.

In addition, the proposed Sand Hill Wind Project turbine blade length is longer, and the per-turbine capacity is greater, than the Vasco or Golden Hills wind project's turbines. As a result, the proposed Project's associated rotor swept area is greater than the four projects the draft SEIR used to estimate impacts. The Alameda County Final Report-Altamont Pass WRA Bird Fatality Study, monitoring Years 2005-2013 concluded that fatality rates increased with increasing rotor swept area (ICF 2016). This finding is consistent with the Service's assessment that risk is associated with a wind project's total rotor swept area (Service 2014). Those results indicate the impacts from the proposed project's larger turbines is likely to be greater than the per megawatt (MW) impacts of the previously repowered projects with smaller turbines. Therefore, it is our recommendation the Final SEIR focus the quantitative impact analysis using the most comparable data from the Vasco Winds and Golden Hills impact studies.

Our comments above also apply to the discussion on page 3.4-15 under the subheading of *Additional Avian Fatality Monitoring Studies,* which states,

> *Evidence collected to date from the four sites in the APWRA that have been repowered (Buena Vista, Diablo Winds, Golden Hills and Vasco Wind) suggests that the larger modern turbines cause substantially fewer turbine-related avian fatalities than the older generation turbines (Brown et al. 2013; ICF International 2013b; Alameda County Community Development Agency 2014; Brown et al. 2016; H. T. Harvey & Associates 2018a, 2018b).*

Of note, this section, as well as others in the Draft SEIR reference an older version of the APWRA Bird Fatality Study, Bird Years 2005-2011 (ICF 2013). The Service recommends the draft SEIR be updated to draw from the Final Report APWRA Bird Fatality Study, Monitoring Years 2005–2013 (April 2016) as it is the most up to date analyses and some conclusions changed compared to earlier reports. 9-4 cont.

Additional Eagle Risk Factors
As previously mentioned, there are two golden eagle territorial pair activity centers located on the project site (Wiens 2018, and written communications); the Christensen Pair have been highly productive breeders, successfully fledging young in four out of the five monitoring years of the USGS lead cooperative study (Wiens 2018). In addition, this pair is the only territorial pair monitored within the Altamont with low turnover of individual pair members. This pair has consisted of two adult golden eagles for the duration of the USGS-lead monitoring study. All other pairs in the APWRA have consisted of at least one subadult member, with evidence of high turnover rates within pairs, which may indicate that much of the APWRA is an ecological sink for golden eagles. In an ecological sink, eagles are continually attracted to high quality nesting and foraging habitat, but survivorship of individual pair members, and likely their offspring, is low. Here, low survivorship is due to risk of collision with the nearby operating wind turbines. The stability of the Christensen pair likely indicates that these eagles have not yet been affected by wind turbine operations, however, construction of the proposed project would likely cause recurring mortality of breeding eagles occupying this site.

4. <u>Additional Studies on Golden Eagle (Pages 3.4-12 through 3.4-14)</u> 9-5
Section 3.4 of the draft SEIR includes a discussion about the Service's National Eagle Permit Program's methods for developing population estimates and our cumulative effects analysis methods. The draft SEIR comments on the Service's golden eagle population estimates and our recent local area population cumulative effects analyses we conduct as required by our Eagle Act regulations (81 FR 91494) in consideration of our eagle take permit decisions. In particular, our 2014 cumulative effects analysis for the incidental take permit to the Shiloh IV Wind Project located within 30 miles of the APWRA (USFWS 2014) which concluded that 12% of the local area population is taken annually in this area. We would like to provide Alameda County (County) with some insight into how we calculate our estimates and our process for considering new information.

U.S. Fish and Wildlife Service Golden Eagle Population Estimates:
In support of our PEIS (USFWS 2016a) for the 2016 Eagle Rule Revision (81 FR 91494), we prepared a report summarizing the status, trends, and sustainable take rates in the United States for bald and golden eagles (USFWS 2016b). In the report, we used data from banding records, satellite telemetry, west-wide golden eagle surveys, and other survey data to develop range-wide golden eagle population estimates and survival rates. We also took into account information about reduced productivity from disturbance, and nest loss. Our estimates are conservative in favor of protecting eagle populations.

As described in our PEIS for the Eagle Rule Revision (Service 2016a) the Service plans to conduct reassessments and updates of population status every 6 years. Currently, modeling efforts and publications are under development for golden eagles in the western States, including those in California. The Service is utilizing information from the United States Geological Survey (USGS) lead cooperative studies (Wiens et al. 2017, 2018) mentioned in your SEIR, as well as other available data to estimate potential available breeding habitat within California's oak woodland savannah habitats. A

9-5 cont.

potential future step could be a validation study to estimate how many pairs of golden eagles may occupy the modeled habitats, as density likely varies across the California landscape.

In 2016, the Service prepared *Questions and Answers -Implementation of the Revised Eagle Incidental Take Permit Regulations* (Q&A) to address common questions, including considerations of locally available eagle data, when we announced the 2016 Eagle Act regulations (81 FR 91494). The Q&A is available on our national Eagle Management webpage[1]. Among other things, the Q&A explains that the Cumulative Effects Tool uses eagle densities calculated from updated population estimates. It also explains why local eagle density data, when available, cannot be used instead of the average Eagle Management Unit density estimate for the Local Area Population analysis; using local data in one location but not another confounds the analysis of cumulative effects.

Draft SEIR discussion of Cumulative Effects to Golden Eagle Populations

Local area population

Regarding the ongoing population level impacts to golden eagles in the Altamont Pass WRA vicinity, the SEIR draws conclusions that are inconsistent with the methods that will be used when considering an Eagle Take Permit. The SEIR calculations do not align with the Service's method for conducting our local area population cumulative effects analysis as described in our Eagle Conservation Plan Guidance (Service 2013). In addition, information from publications and calculations over the years indicate that the APWRA's golden eagle populations cannot be sustained by local breeders alone (Hunt et al.1998, Hunt 2002, Hunt and Hunt 2006, Hunt et al. 2017, Wiens et al. 2017, Wiens et al. 2018, Wiens and Kolar 2019)

Our range-wide analysis of golden eagle populations indicates that, on average, 10% of the population is lost each year from unauthorized human-caused mortality (Service 2016b). Multiple lines of evidence indicate the average unauthorized human-caused mortality rate of golden eagles in the APWRA area is much greater than our range-wide estimate. Hunt et al. (2019) conservatively concluded that anthropogenic caused mortality in the APWRA area was responsible for at least 67% of the fatalities of the telemetered eagles (257 radio tagged eagles, 88 total mortalities) in their study. The majority, 40.9%, of radio-tagged eagle deaths were caused by wind turbine blade strikes.

Breeding pairs with a subadult member

Hunt et al. (1998) investigated the effects to the breeding golden eagle population from wind turbine blade strike in the APWRA. The authors state that if floaters (adult eagles without a breeding territory) immigrating from other subpopulations are available, they may buffer the local breeding population against decline. During the 1990's, the authors observed 100% annual territorial re-occupancy rate and at that time, a low incidence (3%) of subadults as members of breeding pairs. The authors conclude this was an indication that a reserve of adult floaters continued to exist. Hunt and Hunt (2006) reported no apparent upward trend in the proportion of subadult eagles as pair members from a sample of 58 territories monitored in 2000 and again in 2005. Hunt et al. (2017) updated and expanded upon their previous analyses with the addition of the 2013 monitoring year's data. In 2013, the authors reported the proportion of breeding pairs with a subadult member as 3.6%.

In contrast, the USGS publications (Wiens et al. 2017, Kolar and Wiens 2017, Wiens and Kolar 2019) and more recent data (USGS 2019 unpublished data), presents evidence of population impacts when

[1] https://www.fws.gov/migratorybirds/pdf/management/eagleregsQandA.pdf

9-5 cont.

considering the overall proportion of breeding territories that have a subadult member. Wiens et al. (2017) observed a subadult pair member at least once at 5 of the 15 territories identified near the APWRA during their study period. The authors also report that between 2014-2016, the proportion of territories that contained one subadult member increased each year (23%, 27%, 36% respectively). In 2018, 35% of the pairs within 1.3 km of the APWRA contained a subadult member (Wiens et al. 2018, Wiens and Kolar 2019).

It should be noted that the historical surveys completed by Hunt et al. did not include monitoring of pairs within APWRA as the Wiens et al. surveys did. This makes some comparisons difficult because the Hunt et al. survey areas specifically excluded land within the APWRA and surveyed areas surrounding the APWRA, within 30 km. The Wiens et al. study design also monitored pairs within the same 30 km Diablo Range area, but in addition, they included monitoring of pairs within APWRA. Some of the USGS reports focused on territorial pairs within 1.3 km of the APWRA (Wiens 2017, Kolar and Wiens 2017, Wiens 2019). Areas inside of the APWRA, and within 1.3 km of the APWRA or the Pacheco Pass WRA are where the Wiens et al. study identified and monitored pairs with subadult members (Wiens et al. 2018, and unpublished data). Wiens et al. estimates of the proportion of pairs with a subadult member would still be greater than the Hunt et al. studies if they included all pairs within 30 km of the APWRA (Dave Wiens, written communication). In addition, the pairs monitored by Wiens et al. have documented a high rate of pair member turnover amongst most breeding territories in the APWRA area (e.g., an adult male and subadult female one year, followed by a subadult male and adult female the next year) (Kolar and Wiens 2017, USGS unpublished data). The high incidence of subadults as territorial breeding pair members, and high turnover rates of individual pair members, indicates the APWRA is an ecological sink, continually attracting golden eagles into prime foraging and nesting habitat that is of high risk to eagles, and for which survivorship is low.

Productivity

Below we summarize the annual and average productivity of golden eagles in the larger study area (30 km around the APWRA) as reported in Hunt et al. 2017 (Table 1) and the more recent Wiens et al. 2018 study (Table 2).

Table 1. Productivity per monitoring year, and average over five year study.

Hunt et al. 2017						
	1996	1997	1998	1999	2000	average
Study Area	0.66	0.59	0.58	0.9	0.46	0.64

Table 2. Productivity per monitoring year, and average over four year study.

Wieins et al. 2018					
	2014	2015	2016	2018	average
Study Area	0.25	0.21	0.34	0.48	0.32
APWRA	0.23	0	0.08	0.15	0.13

9-5 cont.

Golden eagle productivity (average number of young fledged per breeding territories) was much higher, twice as high on average, during the Hunt et al. monitoring period compared to the recent Wiens et al. 2018 results (Tables 1 and 2). Severe drought conditions during 2014 – 2016 had a strong, negative effect on reproductive success (Wiens et al. 2018), especially compared to the relief from drought conditions in 2018. The Wiens USGS-lead study was not funded during 2017, and so data is not available from that year. While the USGS monitoring results from the 2019 season are not yet available, early analysis suggests productivity was also low, in part due to heavy rains late in the breeding season (P. Kolar personal communication, unpublished data). In conclusion, due to drought and other abnormal weather patterns possibly related to climate change, recent average annual golden eagle productivity is lower in the local area population than previously estimated.

The draft SEIR contains an estimation of the Project area's local area population, drawing from recent scientific literature. The County's discussion references Hunt et al.'s 2017 estimation that the annual reproductive output of 216–255 breeding pairs would be necessary to support published estimates of 55–65 turbine blade-strike fatalities per year. Considering that annual average productivity in recent years (Table 2) is half of that reported in Hunt et al.'s 2017 estimations (Table 1), it is likely that twice as many pairs (432-510) would be needed to sustain the same level of ongoing take from wind turbines collisions. The draft SEIR also cites Wiens et al.'s 2015 estimation that there could be as many as 280 territorial pairs of golden eagles in their larger Diablo Range study area. Next, the SEIR conducts a coarse estimation of the possible golden eagle population in the Bird Conservation Region (BCR) and the Sand Hill Wind Projects local area population utilizing the Wiens et al. 2015 estimations. The draft SEIR discussion implies there are no population level impacts from take of eagles at the APWRA.

Conclusion

As we explained here, the Service has determined there are multiple lines of evidence indicating take of golden eagles from wind turbine collisions is having an ongoing negative effect to the APWRA local area population of golden eagles.

As discussed, the Service has protocols for updating our range-wide population estimates, and regulatory requirements for conducting our cumulative effects analyses. We will take all applicable data and information into consideration as we process the Sand Hill Wind Project's eagle incidental take permit.

9-6

5. Avian impact avoidance and minimization measures

Adjacent Conservation Lands

California Department of Fish and Wildlife (CDFW) recently informed us that the proposed Sand Hills Wind Project area is located adjacent to conservation lands. The Mountain House Conservation Bank is located to the northwest of the Project area (north of Christensen Rd) and CDFW has a conservation easement directly to the west (south of Christensen Rd) of the Project area. The Mountain House Conservation Bank has Swainson's hawk nesting credits and burrowing owl credits. The CDFW conservation easement is for burrowing owl. Swainson's hawk has been documented nesting in the area. Siting the project turbines in close proximity to lands managed for burrowing owl and Swainson's hawk may negate the intended purpose of the mitigation lands, and could result in higher than anticipated impacts to these species, and potentially other raptors, including golden eagles.

Project Layout and Design Features

A transmission line, and multiple lattice towers supporting the line, are located within the proposed Project footprint. Constructing turbines proximate to lattice towers, which provide hunting perches and nesting substrate, increases the risk of collision with wind turbines for eagles and other raptors (ICF 2016). The service recommends that any permanent meteorological towers be of a monopole design rather than a lattice tower. Doing so could be considered as impact avoidance and minimization measures in the project's turbine micrositing considerations. 9-6 cont.

The Project's range of proposed turbine layouts (draft SEIR Figures 3.4-1a, 3.4-1b and 3.4-1c) each site turbines within a quarter mile of the Christensen golden eagle pair's 2015 and 2019 nest site locations. The 2015 nest site was located on a transmission tower; the 2019 site was in a tree. We acknowledge that predicting where golden eagle pairs may nest year to year is difficult. Even so, we recommend that turbine micrositing considerations include appropriate buffers between turbine locations and nesting substrate. The Service also advises the wind operators to survey for golden eagle nests annually within 2 miles of turbine locations to inform appropriate eagle take avoidance and minimization measures, such as curtailment of turbines in close proximity to nesting eagles. We recommend nesting surveys begin in December when pairs are most active and detectable, following the protocol employed by recent USGS studies (Wiens et al. 2015, 2017, 2018).

We offer a technical correction to page 3.4-81, in the Conservation Measure entitled, *Measures outlined in an approved Eagle Conservation Plan and Bird and Bat Conservation Strategy.* Per our 2016 Eagle Rule, long term eagle take permits are no longer called programmatic. Instead, please change the term to "eagle incidental take permit." The Service appreciates the County's inclusion of this measure, which provides the applicant with an option that, should they obtain an eagle incidental take permit under the Eagle Act, requirements under the permit may also serve to meet the County CUP's needs for eagles, birds and bats. 9-7

Micrositing 9-8

We recognize that the County has included the applicant's range of project layout and micrositing reports aimed primarily at minimizing the proposed Project's risk to golden eagles. Our Eagle Permit Coordinator, Heather Beeler, will continue to review these reports and coordinate with the County as a member of your APWRA Technical Advisory Committee (TAC).

References:

Alameda County Community Development Agency. 2014. *Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report*. State Clearinghouse #2010082063. October. (ICF 00323.08.) Hayward, CA. With technical assistance from ICF International, Sacramento, CA.

Bell, A. B. 2017. GPS Satellite Tracking of Golden Eagles (*Aquila chrysaetos*) in the Altamont Pass Wind Resource Area (APWRA) and the Diablo Range: Final Report for Phases 1 and 2 of the NextEra Energy Settlement Agreement. East Bay Regional Park District, Oakland, California.

Brown, K., K. S. Smallwood, B. Karas, and J. M. Szewczak. 2016. *Vasco Avian and Bat Monitoring Project 2012–2015 Final Report*. June. Prepared by Ventus Environmental Solutions, Portland, OR. Prepared for NextEra Energy Resources, Livermore, CA.

H. T. Harvey & Associates. 2018a. *Golden Hills Wind Energy Center Postconstruction Fatality Monitoring Report: Year 1*. February 28. Prepared for Golden Hills Wind, LLC, Livermore, CA.

H. T. Harvey & Associates 2018b. *Golden Hills Wind Energy Center Postconstruction Fatality Monitoring Report: Year 2*. December 17. Draft Report. Prepared for Golden Hills Wind, LLC, Livermore, CA.

Hunt, W.G., R.E. Jackman, T.L. Hunt,.D.E. Driscoll and L. Culp. 1998. A population study of golden eagles in the Altamont Pass Wind Resource Area: population trend analysis 1997. Report to National Renewable Energy laboratory, Subcontract XAT-6-16459-01. Predatory Bird Research Group, University of California, Santa Cruz.

Hunt, W. G. 2002. Golden eagles in a perilous landscape: Predicting the effects of mitigation for energy-related mortality. California Energy Commission Report P500-02-043F.Hunt, W. G. and T. L. Hunt. 2006. The Trend Of Golden Eagle Territory Occupancy In The Vicinity Of The Altamont Pass Wind Resource Area: 2005 Survey. California Energy Commission Report. CEC-500-2006-056.

Hunt, G. W., D. J., Wiens, P. R. Law, M. R. Fuller, T. L. Hunt, and D. E. Driscoll. 2017. Quantifying the demographic cost of human-related mortality to a raptor population. PLos ONE 12(2): e0172232. Doi:10.1371/journal.pone.0172232.

ICF International. 2016. *Final Report Altamont Pass Wind Resource Area Bird Fatality Study, Monitoring Years 2005–2013.* April. M107. (ICF 00904.08.) Sacramento, CA. Prepared for Alameda County Community Development Agency, Hayward, CA.

Insignia Environmental. 2012. Final Report for the Buena Vista Avian and Bat Monitoring Project: February 2008 to January 2011. September. Palo Alto, CA. Prepared for Contra Costa County, Martinez, CA.

Kolar, P. S., and J. D. Wiens. 2017. Distribution, nesting activities, and age-class of territorial pairs of golden eagles at the Altamont Pass Wind Resource Area, California, 2014-2016: U.S. Geological Survey Open-File Report 2017-1035, 18 p., https://doi.org/10.3133/ofr20171035.

U.S. Fish and Wildlife Service. 2012. Land-Based Wind Energy Guidelines. OMB Control No, 1018-0148. Available: https://www.fws.gov/ecological-services/es-library/pdfs/weg_final.pdf.

U.S. Fish and Wildlife Service. 2014. Final Environmental Assessment, Shiloh IV Wind Project Eagle Conservation Plan, California. Prepared by Division of Migratory Bird Management, Sacramento, CA.

U.S. Fish and Wildlife Service. 2016a. Programmatic Environmental Impact Statement for the Eagle Rule Revision. Final. December.

U.S. Fish and Wildlife Service. 2016b. Bald and Golden Eagles: Population demographics and estimation of sustainable take in the United States, 2016 update. Division of Migratory Bird Management, Washington D.C.,USA.

Wiens, J. D., P. S. Kolar, M. R. Fuller, W. G. Hunt, and T. Hunt. 2015. Estimation of occupancy, breeding success, and predicted abundance of Golden Eagles (Aquila chrysaetos) in the Diablo Range, California, 2014: U.S. Geological Survey Open-File Report 2015-1039, 23p http://dx.doi.org/10.3133/ofr20151039.

Wiens, J. D., N. H. Schumaker, R. D. Inman, T. C. Esque, K. M. Longshore, and K. E. Nussear. 2017. Spatial Demographic Models to Inform Conservation Planning of Golden Eagles in Renewable Energy Landscapes. Journal of Raptor Research 51 (3):234-257.

Wiens, J. D., P. S. Kolar, W. G. Hunt, and T. Hunt, M. R. Fuller, and D. A. Bell. 2018. Spatial patterns in occupancy and reproduction of Golden Eagles during drought: Prospects for conservation in changing environments. The Condor, 120(1):106-124.

Wiens, J. D., P. S. Kolar. 2019. Golden Eagle Population Monitoring in the Vicinity of the Altamont Pass Wind Resource Area, California, 2014 – 2018. U.S. Geological Survey Administrative Report prepared for NextEra Energy. July 2019.