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21 February 2019

Re: Summit Ridge Wind Farm – Request for Amendment 4

Dear Chair Beyeler and Members of the Council,

On behalf of Friends of the Columbia Gorge, Oregon Wild, the Oregon Natural Desert Association, Central Oregon LandWatch, the Audubon Society of Portland, and East Cascades Audubon Society, I write to comment on the Request for Amendment 4 for the Summit Ridge Wind Farm, which requests a postponement of construction start and end dates for the project and which proposes an amended Habitat Mitigation Plan (January 2019). I primarily wish to comment on (1) the suitability of the habitat assessment underlying the amended Habitat Mitigation Plan, and (2) the need to update baseline surveys, project impact predictions, mitigation measures, and post-construction monitoring protocols. Updated surveys and analyses are needed in part because over the near-decade that has passed since the primary baseline study (Northwest Wildlife Consultants 2010), science has made vast improvements in field survey methods and in our understanding of wind turbine collision factors, displacement effects, and cumulative impacts related to wind projects. Methodology has vastly improved in preconstruction studies needed to predict project-scale and wind turbine-scale impacts, to measure post-construction impacts, and to assess whether and to what degree specific mitigation measures can be tested for efficacy.

My qualifications for preparing these comments as expert comments are the following. I earned a Ph.D. degree in Ecology from the University of California at Davis in 1990. My research has been on animal density and distribution, habitat selection, habitat restoration, interactions between wildlife and human infrastructure and activities, conservation of rare and endangered species, and on the ecology of invading species. I have performed research and monitoring on renewable energy projects for 20 years, and I have authored many peer-reviewed reports, papers, and book chapters on fatality monitoring, fatality rate estimation, mitigation, micro-siting, and other issues related to biological impacts of wind energy generation. I served for five years on the Alameda County Scientific Review Committee (SRC) that was charged with overseeing the fatality monitoring and mitigation measures in the Altamont Pass Wind Resource Area (APWRA), and I prepared many comment letters on proposed renewable energy projects. I collaborate with colleagues worldwide on the underlying science and policy issues related to renewable energy impacts on wildlife.

Most of my wind energy work has been in the APWRA, which is where much of the research funding has been directed to understanding factors related to wind turbine collisions and to finding solutions. The APWRA is the longest-monitored wind resource area in the world for collision fatalities and relative abundance and behaviors of affected species, and the wind resource area with by far the largest number of documented golden eagle fatalities. There is no other place where more could have been learned about how and why eagles collide with wind turbines and what can be done to mitigate the impacts. In the APWRA I have performed research on behavior, relative abundance (use rates), fatality rates, fatality detection trials, nocturnal activities of bats, owls and other wildlife, and research on spatial patterns of raptor prey species. I am participating with a GPS/GSM telemetry study of golden eagles within and beyond the APWRA. I have manipulated livestock grazing as a mitigation measure, and I have participated with mitigation involving power pole retrofits, hazardous turbine removals, winter shutdowns of wind turbines, and repowering of wind projects based on careful siting. I have also opportunistically documented wildlife responses to wildfires in the APWRA. I have personally discovered too many golden eagle fatalities and one bald eagle fatality in the APWRA, including mortally wounded eagles that were later euthanized. I personally witnessed hundreds of near misses that golden eagles and other raptor species have experienced at wind turbines, transmission lines and electric distribution lines in the APWRA. I have been involved with renewable energy impacts on all fronts – study design, fieldwork on fatalities and use and behavior and ecological relationships, study administration, hypothesis-testing, report writing, presentations at meetings, formulation of mitigation, micro-siting, study review, policy review and decision-making, and public outreach.

I provided expert comments on a project proposed and later built by Babcock & Brown, out of which Pattern Energy emerged as a company soon after. I later contracted with Pattern Energy to assist with the preparation of an Environmental Impact Report of the same project I commented on as an expert. I also developed collision hazard models and provided micro-siting recommendations to minimize raptor impacts at a proposed Pattern Energy project, and I assisted with analysis of fatality monitoring data from one of Pattern Energy's projects. Lastly, as a member of the Alameda County SRC, I oversaw monitoring and mitigation at two Pattern Energy projects in the APWRA. My CV is attached.

HABITAT MITIGATION PLAN

The applicant is required by Oregon Administrative Rule (OAR) 345-021-0010(1)(p)(B) to provide an *"[i]dentification of all fish and wildlife habitat in the analysis area, classified by the general fish and wildlife habitat categories as set forth in OAR 635-415-0025 . . . and a description of the characteristics and condition of that habitat in the analysis area, including a table of the areas of permanent disturbance and temporary disturbance (in acres) in each habitat category and subtype."* In addition, the applicant is required by OAR 345-021-0010(1)(p)(C) to provide "*[a] map showing the locations of the habitat*," is required by OAR 345-021-0010(1)(p)(D) to identify "*all*

State Sensitive Species that might be present in the analysis area," and is required by OAR 345-021-0010(1)(p)(E) to provide "*[a] baseline survey of the use of habitat in the analysis area*" by State Sensitive Species. Finally, the applicant is required by OAR 345-021-0010(1)(p)(F) to describe "*the nature, extent and duration of potential adverse impacts on the habitat identified in (B) and species identified in (D) that could result from construction, operation and retirement of the proposed facility*," and is required by OAR 345-021-0010(1)(p)(G) to provide "*a description of any measures proposed by the applicant to avoid, reduce, or mitigate the potential adverse impacts described in (F) in accordance with the general fish and wildlife habitat mitigation goals and standards described in OAR 635-415-0025 . . . , and a discussion of how the proposed measures would achieve those goals and requirements*."

For its part, the Wasco County Land Use and Development Ordinance (LUDO) at LUDO § 19.030.C.5 requires the Council to "*tak[e] into account mitigation, siting, design, construction, and operation [of] the energy facility*" in order to ultimately ensure that the facility "*will not cause significant adverse impact to important or significant natural resources*," and authorizes the Council to require "*monitoring and mitigation actions that [the Council] determines appropriate*."

Several key premises of the amended Habitat Mitigation Plan are incorrect (see Attachment D of Proposed Order: Draft Habitat Mitigation Plan for the Summit Ridge Wind Project (As Amended), January 2019). The Habitat Mitigation Plan states that Northwest Wildlife Consultants (2010) had mapped habitat, performed a habitat quality assessment, conducted avian use surveys, and inventoried bat species, among other tasks. As I will explain further below, Northwest Wildlife Consultants did not map habitat as defined under OAR 635-415-0005. They did not assess habitat quality because they measured no variables representative of population performance indicative of habitat quality. The use surveys were not designed nor intended for supporting habitat mapping or assessing habitat quality, and were insufficient for the intended purpose, which was for assessing wind turbine collision risk. The bat surveys were grossly insufficient for supporting an "inventory," and because they were performed at ground-level, they never could have informed of collision risk for bats that fly at the heights of wind turbine rotors.

Conclusions in the Habitat Mitigation Plan, and responses to Energy Facility Siting Council (EFSC) standards in the Request for Amendment, rely upon inappropriate studies and unsuitable study methods in the context of a wind energy project. Use surveys originated in early wind energy projects to meet a specific need for predicting wind turbine collision risk (Smallwood 2017b), and were based on the largely unsubstantiated assumption that collision rates correlate positively with relative abundance of flying birds or bats (de Lucas et al. 2008, Ferrer et al. 2012, Hull et al. 2013, Hein et al. 2013, Smallwood 2017a,b). One reason for poor prediction performance has been variation in baseline study methods and poor execution of both use surveys and fatality monitoring (Smallwood 2017a,b, Smallwood et al. 2018). Another reason has been that flight behaviors relate much more strongly to collision risk than does relative abundance (Smallwood et al. 2017b). But whatever the reasons for poor prediction performance, use surveys were not intended for assessing habitat in wind projects.

Use surveys could be adapted to support habitat assessments for some species, though not for habitat quality, by adjusting use rates for large biases (discussed later). So long as data measured from use surveys meet or exceed the spatial resolution of environmental variables measured as potential habitat elements, use survey data could contribute to habitat analysis. Unfortunately, Northwest Wildlife Consultants (2010) measured use rates within plots of 800-m survey radius. These plots each encompassed 201 hectares (unrealistically assuming flat terrain) and included multiple mapped vegetation cover types to which the use survey observations, given the way they were measured, could not be linked. If one of the five within-plot golden eagle observations were in Plot X and the survey radius of Plot X encompassed old field, dryland wheat, pond, riparian, exotic annual grassland, and rabbitbrush, with which of these six cover types should we associate the eagle? Unless the use surveys are tailored for habitat analysis, such surveys are not useful for habitat analysis. In fact, the summary of use survey methods in Northwest Wildlife Consultants (2010) did not include steps for habitat assessment, but instead focused on recording flight attributes at the location where a bird was first seen or where it approached closest to the observer or where it crossed a ridge structure.

Habitat quality is measured by population performance metrics, none of which were measured in Northwest Wildlife Consultants (2010) for any species. Population performance metrics can include productivity, abundance, stability, persistence, and other terms that none of them alone can comprehensively represent habitat quality. Habitat quality is a controversial term in wildlife ecology; it is more conceptual than measurable. Anyhow, it was not measured in any form in Northwest Wildlife Consultants (2010).

The specific metrics quantified from avian use surveys were mean use (mean number of birds seen per 20 min survey), percent composition, and frequency of occurrence among 20-min survey sessions (Northwest Wildlife Consultants 2010:10). None of these metrics were related to mapped habitat in any way, so they contributed nothing to habitat assessment. Apparently independent of the avian use metrics, "habitat" was characterized as a map of vegetation cover types – a map for which no on-site, species-specific data had contributed. The habitat map was delineated from aerial imagery, marking boundaries where Northwest Wildlife Consultants saw clear demarcations in land cover, followed by a bit of ground-truthing. No avian use surveys or acoustic bat surveys, nor any other surveys, had anything to do with the formulation of this "habitat" map.

Habitat Assessment

A potential project impacts analysis is needed that scientifically compares habitat conditions for each species pre- and post-construction, and that considers any interaction effects from extensive wildfires that altered vegetation cover on the project area in 2018. Habitat is defined by the species, and is more than just a desktop analyst's decision on delineating cover types viewable on aerial imagery. Habitat is a product of perceptions of an organism's environment – where opportunities might be found and dangers avoided or minimized. Thus, an important aspect of habitat analysis in the context of a wind project is any perceived threat posed by wind turbines and maintenance traffic that might result in displacement (Leddy et al. 1999, Whitfield and Madders 2006, Pearce-Higgins et al. 2009, Garvin et al. 2011, Langston 2013). Displacement is habitat loss. The mapping of vegetation cover types is irrelevant to an assessment of displacement caused by a species' instinctual avoidance of the wind turbines, wind project infrastructure, or maintenance traffic. Likewise, avian use surveys and bat acoustic surveys are irrelevant to this type of assessment if they collect data that are too crude for comparisons before and after wind project construction.

As examples of displacement effects, white-tailed eagle breeding success declined near a Norwegian wind project because breeding territories within 500 m of wind turbines were vacated (Dahl et al. 2012). Tasmanian wedge-tailed eagles (*Aquila audax fleayi*) and white-bellied sea-eagles (*Haliaeetus leucogaster*) flew through wind projects along flight paths that maximized their distances from wind turbines (Hull and Muir (2013). Telemetered golden eagles were found to increase flight heights while passing over wind projects (Johnston et al. 2014). Nesting birds in grasslands were reduced within 80 m of wind turbines (Leddy et al. 1999). None of these examples relied on vegetation cover maps, but rather measured displacement effects as distances from wind turbines. Measuring and mitigating habitat impacts in a wind project context requires measurements of animals relative to planned and constructed wind turbine locations, which is yet to be accomplished at Summit Ridge.

On the issue of whether the project will be consistent with the general fish and wildlife habitat mitigation goals and standards in OAR 635-415-0025, Tetra Tech (2018:29) offers a 2009 habitat analysis supporting the conclusion that the project meets the standards despite changes to the environment caused by extensive wildfires in 2018 (Tetra Tech 2018:30). Tetra Tech explains that Northwest Wildlife Consultants previously constructed a map of available vegetation categories and then assigned wildlife species to those categories. A desktop analysis followed, concluding that the wildfire degraded habitat quality, but that the wind project would not reduce habitat quality. Tetra Tech's conclusions, however, are based on scientifically incorrect characterizations of habitat, an outdated and insufficient analysis from nearly a decade ago that is not likely to reflect current conditions, an unsubstantiated assumption that burned vegetation negatively affects all wildlife, and absence of any consideration of an interaction effect between vegetation changes and the proposed wind project.

OAR 635-415-0005 defines habitat as "*the physical and biological conditions within the geographic range of occurrence of a species, extending over time, that affect the welfare of the species or any sub-population or members of the species*." This definition is consistent with the scientific definition of the term, which generally is that portion of the environment used by a particular species (Hall et al. 1997, Morrison et al. 1998). Habitat is typically characterized for a species following use-and-availability studies, in which the occurrences of a species are compared to the availability of measured environmental elements, such as soil types, terrain features, vegetation cover types, seasons and times of day. From these comparisons, scientists infer species' habitat affinities (Smallwood 2002), or the assignment of particular portions of the environment where a particular species is typically found in numbers equal to or exceeding the number that would be expected of a random or uniform distribution across a broader space or time period. Under Implementation of Department Habitat Mitigation Recommendations (OAR 635-415-0005), 6 Habitat Categories are described along a continuum of habitat affinity, of which Habitat Category 1 would represent strongest affinity and Habitat Category 6 weakest affinity. But any categorization under these rules is not as simple as a continuum of use versus availability, as a species' use of a portion of the environment could be measured as lower than proportional while still meeting a critically important function. OAR 635-415-0025 appropriately allows for both a quantified use-and-availability approach and a categorization based on expert knowledge in assigning portions of the environment to its 6 Habitat Categories. The critical point here is that the species informs the investigators of its habitat affinities through its expressions of behavior, spatial-temporal distribution, and performance, rather than the investigators' lumping of species into conveniently available, catch-all, vegetation cover types as part of a "desktop analysis."

The Summit Ridge habitat map was not based on use-and-availability analysis, nor did it characterize habitat for any particular species. The approach used by Northwest Wildlife Consultants in 2010 was inconsistent with both the scientific definition of habitat and Oregon's definition in OAR 635-415-0005. Even more inconsistent, however, is the current claim that habitat was degraded as a result of the 2018 wildfires (Tetra Tech 2018:30). Wildlife species vary in their responses to changes in the environment, so vegetation cover changes caused by a wildfire will displace some species while attracting others. I have seen and quantified such variation in response to fires when I performed a 13-year study of wildlife responses to mechanical alteration of the environment as well as the use of controlled burns (Smallwood and Morrison 2013; Smallwood and Morrison paper in prep.).

Early successional vegetation following a fire can increase the numbers and availability of some small mammal species to aerial predators. For example, vegetation-removal treatments in one of my study areas resulted in a 7.4-fold increase in ground squirrel burrow systems and a 4-fold increase in burrowing owl nest sites relative to control sites, and the spatial distributions of both squirrels and burrowing owls shifted following the treatments (Smallwood and Morrison in prep.). In an effort to reduce wind turbine collision fatalities of raptors in the Altamont Pass, I led a study in which we switched grazing regimes from cattle to sheep and we varied the density of animal units to elicit quantifiable responses of raptors to changes in ground cover (Smallwood et al. 2009). We documented substantial responses. Since that study I have continued to document spatial and numerical shifts of small mammals, raptors and other birds to continuing managed variation in sheep grazing intensity (Smallwood unpublished data).

In fact, even without a major change in vegetation cover, wildlife typically shift activity areas every generation or so, as reported for >130 animal species worldwide (Taylor and Taylor 1979) and as found in my own research (Smallwood 2016, Smallwood and Morrison 2018, Smallwood unpublished data). In the Altamont Pass, for example, I began monitoring burrowing owls among 46 large sampling plots in 2011 (Smallwood et al. 2013), and have since found that I cannot predict the burrowing owl distribution several years following any given year (Figure 1; data from 2017 and 2018 further confirm the loss of predictability, but are not shown in this figure). Whereas I obtained a strong correlation between the number of breeding pairs per sampling plot in 2012 relative to the number of breeding pairs in those same plots in 2011, my correlation visibly declines with each succeeding year until the 2016 distribution bears no resemblance to the 2011 distribution, as indicated by the regression slope of 0 in Figure 1. Hypothesized causes for this shifting mosaic pattern of abundance include (1) escape from parasite loads, (2) escape from predator loads, (3) accumulating around more abundant food supplies while allowing food replenishment at vacated sites, (4) natural accumulation of dispersing young while adults in the natal area senesce, or (5) some combination of these causes. Whatever the cause, it is mistaken to regard wildlife distributions as static or habitat as spatially fixed.

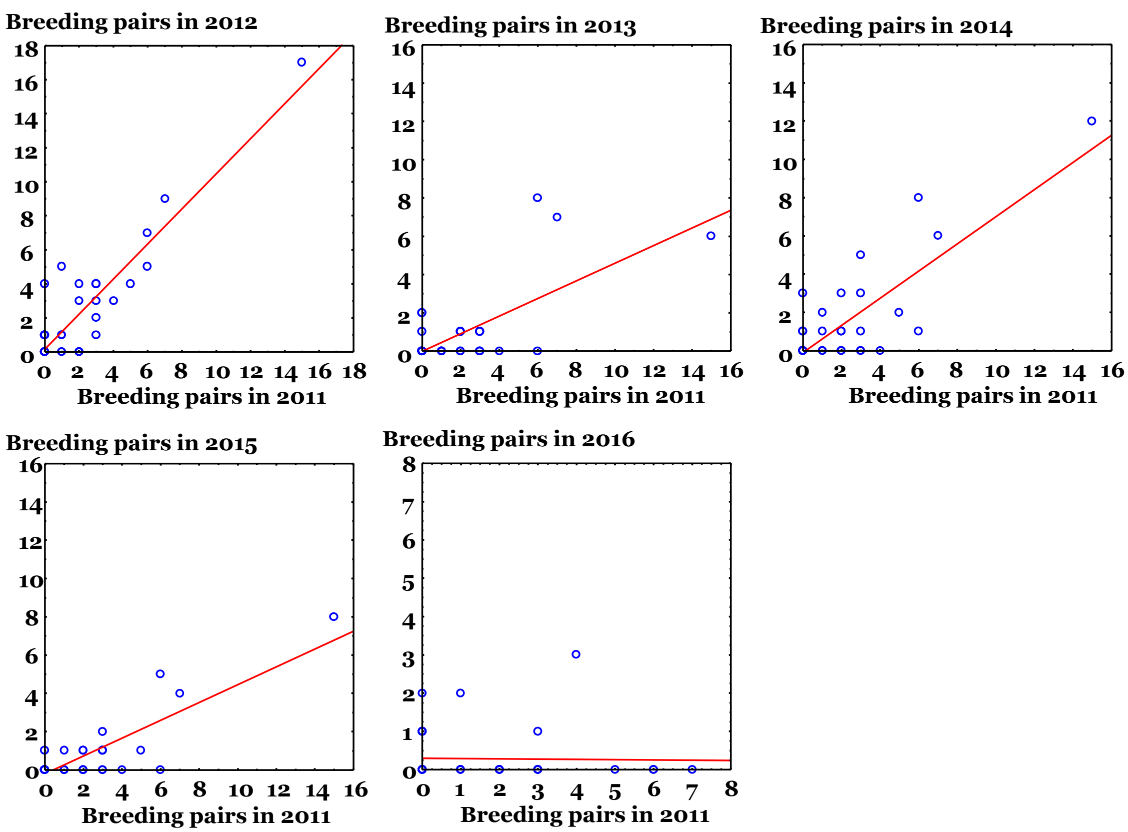


Figure 1. *Breeding pairs of burrowing owls among 46 plots in the APWRA from 2012 through 2016 as functions of breeding pairs in 2011 (Smallwood, unpublished data).*

Another way to answer the question of whether one or two years of preconstruction use surveys can generate representative use rates many years into the future is to test the degree to which one year of use rates can predict use rates in subsequent years. A follow-up question would be how predictive do the preconstruction use rates need to be for predicting a wind project's impacts? In lieu of a scientific deliberation on this follow-up question, let's say the answer is 10% prediction accuracy. With this answer serving as my standard, I should expect to see most of the use rates calculated from 84 APWRA survey stations in any given year falling within the 90% prediction interval that represents use rates of some previous year.

I tried the comparison using golden eagle use survey data from multiple years in the APWRA. One year's use rates predicted subsequent use rates with decreasing accuracy as the number of years separating the use rates increased (Table 1). With one year difference between use rates, the linear regression slope differed significantly from 0 in 4 of 6 years, but r^2 averaged only 0.34 among the 4 years with slopes >0 and root-mean square error (RMSE) averaged 0.48 and the proportion of use rates included within the 90% prediction intervals averaged only 45% of the 19 stations (Table 1, Figure 2). With two years difference between use rates, the linear regression slope differed significantly from 0 in 2 of 5 comparisons, but r^2 averaged only 0.46 between the 2 years with slopes >0 and RMSE averaged 0.45 and the proportion of use rates included within the 90% prediction intervals averaged only 42% of the 19 stations (Table 1, Figure 3). With three years difference between use rates, the linear regression slope differed significantly from 0 in 1 of 4 comparisons, but r^2 was only 0.19 for the comparison with slope >0 and RMSE was 0.45 and the proportion of use rates included within the 90% prediction intervals was only 32% of the 19 stations (Table 1, Figure 4). With four years difference between use rates, the linear regression slope differed significantly from 0 in 1 of 3 comparisons, but r^2 was only 0.19 for this comparison with slope >0 and RMSE was 0.46 and the proportion of use rates included within the 90% prediction intervals was only 26% of the 19 stations (Table 1, Figure 5). With five years difference between use rates, the linear regression slope differed significantly from 0 in neither comparison (Table 1, Figure 5). Even among comparisons for which regression slopes differed significantly from 0, the relationship in golden eagle use rates between years was weak. The relationship further weakened with the number of years between use rates. As was clear for burrowing owls (Figure 1), golden eagle use rates measured over one year in one place cannot be relied upon to predict golden eagle use 3 years hence.

It is also noteworthy that Figures 1 through 5 reveal false-0 use rates, as indicated by data points on the Y-axis. This revelation can be found wherever use rates were 0 for burrowing owls or golden eagles, but later found to be >0. Had the use survey effort stopped after the year with a 0 later found to be >0 at any given site, the result would have been a false determination of absence. False-0 outcomes are important because they cannot be adjusted and can lead to adverse surprises after the project is constructed. The only way to avoid the effects of false-0's is to survey long enough to minimize the likelihood of recording false-0's.

Table 1. *Summary of one year's golden eagle use rates (eagles per hour) regressed on a previous year's use rates among 19 wind projects across the Altamont Pass Wind Resource Area, including a hypothetical result for which use rates in the subsequent year (2010) differed by 10% from use rates in 2009 (orange highlight).*

Pre-year	Post-year	Slope, b	P < 0.05	r^2	RMSE	Proportion within 90% prediction interval
2009	2010	0.99	yes	0.97	0.11	0.95
2006	2007	0.34	no	0.09	0.48	0.42
2007	2008	0.86	yes	0.40	0.35	0.47
2008	2009	0.69	yes	0.36	0.47	0.42
2009	2010	0.56	yes	0.23	0.56	0.37
2010	2011	0.54	yes	0.38	0.53	0.53
2011	2012	0.24	no	0.00	0.59	0.21
2006	2008	0.30	no	0.01	0.50	0.42
2007	2009	0.59	no	0.12	0.42	0.26
2008	2010	0.88	yes	0.56	0.39	0.47
2009	2011	0.56	yes	0.36	0.51	0.37
2010	2012	0.31	no	0.06	0.67	0.32
2006	2009	0.62	yes	0.20	0.45	0.32
2007	2010	0.58	no	0.09	0.43	0.26
2008	2011	0.43	no	0.15	0.54	0.53
2009	2012	0.18	no	0.00	0.66	0.21
2006	2010	0.65	yes	0.19	0.46	0.26
2007	2011	-0.01	no	0.00	0.46	0.32
2008	2012	0.10	no	0.00	0.61	0.16
2006	2011	0.42	no	0.09	0.48	0.26
2007	2012	0.15	no	0.00	0.45	0.21

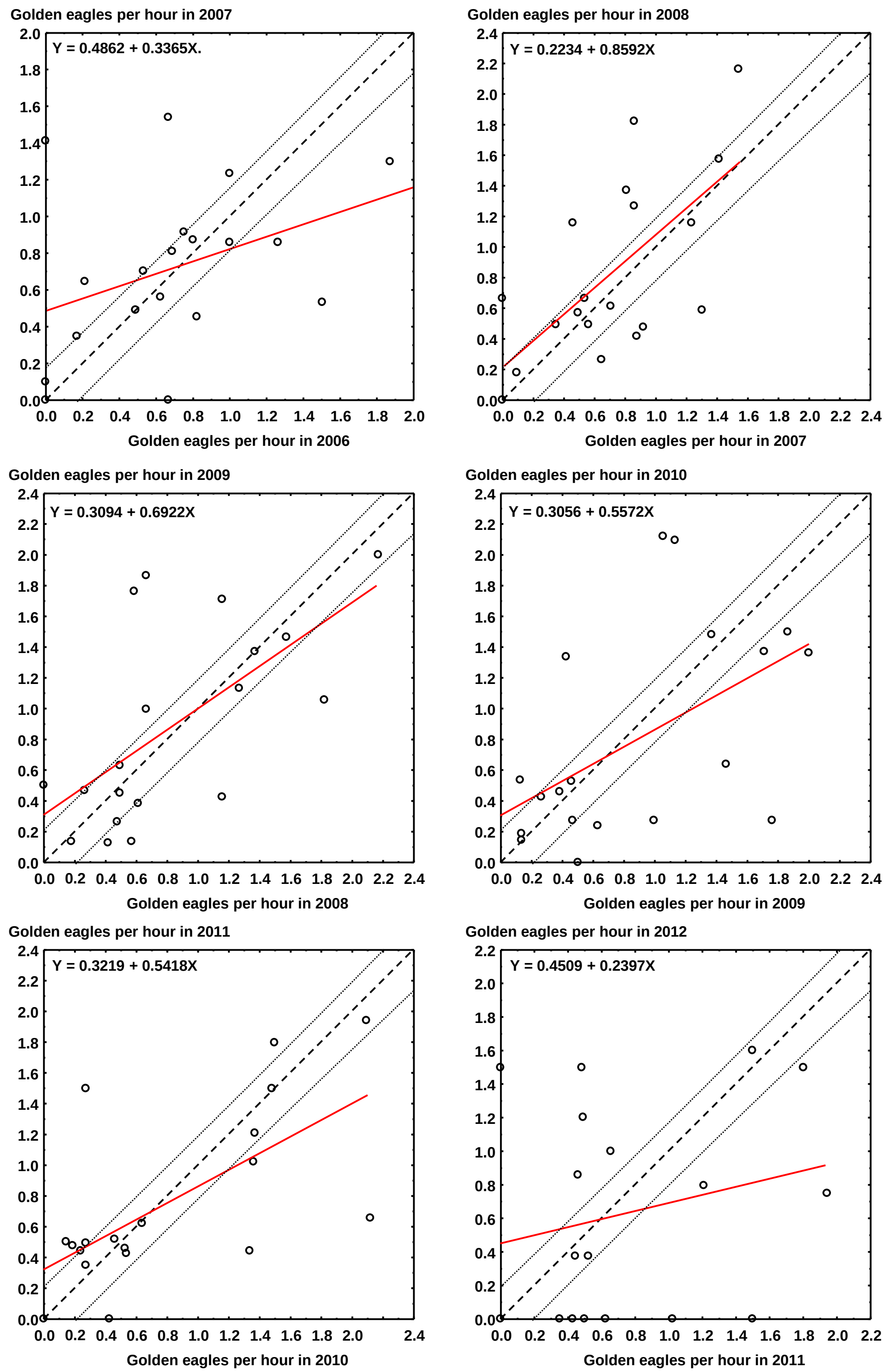


Figure 2. *Golden eagle use rates at 19 APWRA wind projects regressed (red line) on use rates measured the year before and compared to slope of equivalency (dashed line) and 90% prediction interval calculated from hypothetical 2010 use rates differing 10% from 2009 use rates.*

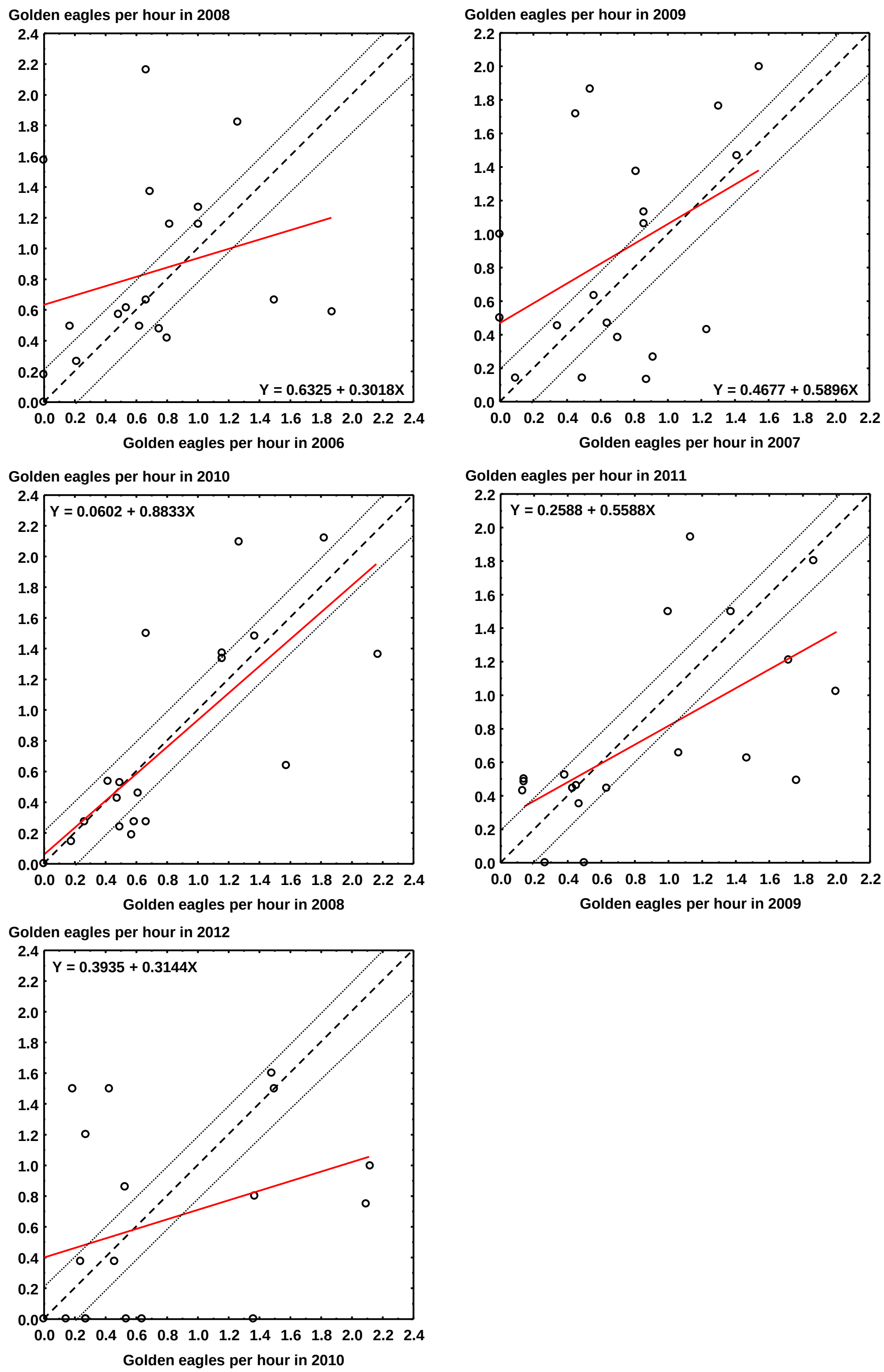


Figure 3. *Golden eagle use rates at 19 APWRA wind projects regressed (red line) on use rates measured two years before and compared to slope of equivalency (dashed line) and 90% prediction interval calculated from hypothetical 2010 use rates differing 10% from 2009 use rates.*

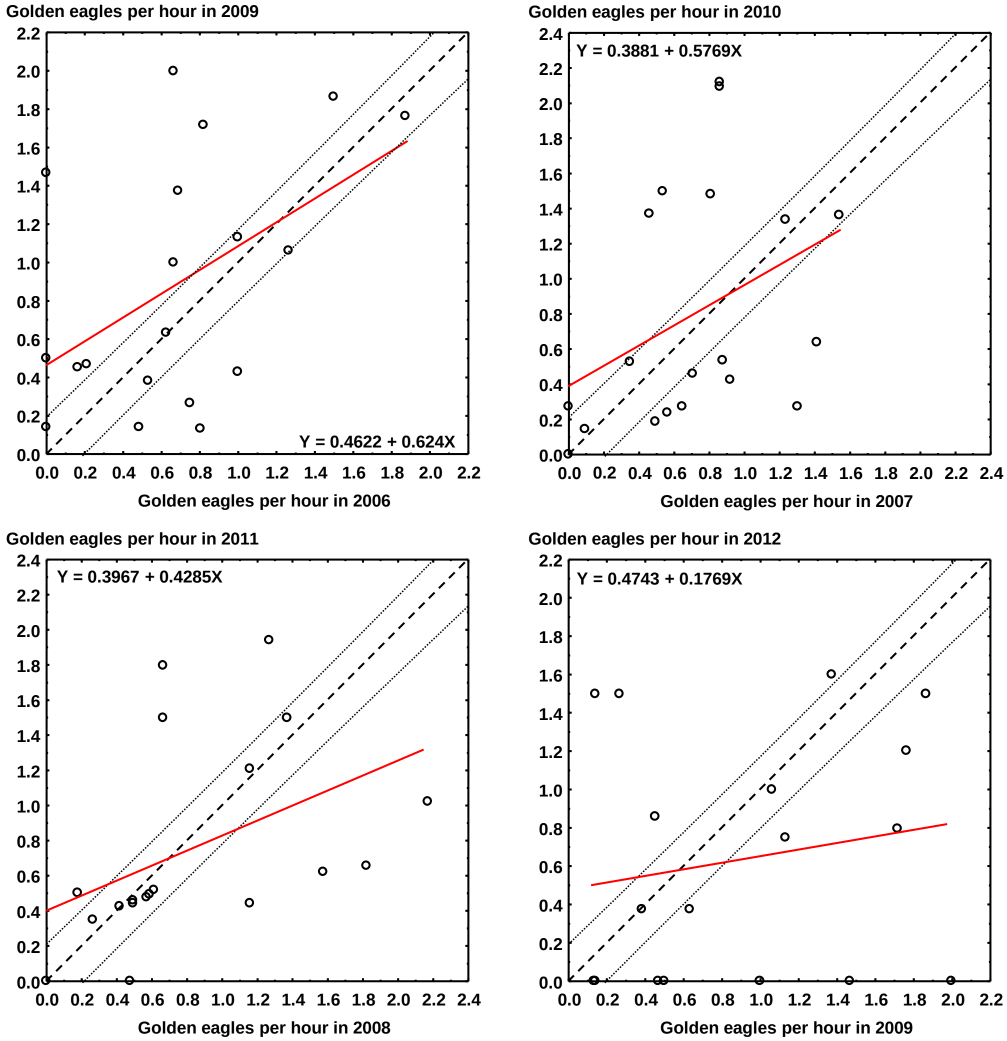


Figure 4. *Golden eagle use rates at 19 APWRA wind projects regressed (red line) on use rates measured three years before and compared to slope of equivalency (dashed line) and 90% prediction interval calculated from hypothetical 2010 use rates differing 10% from 2009 use rates.*

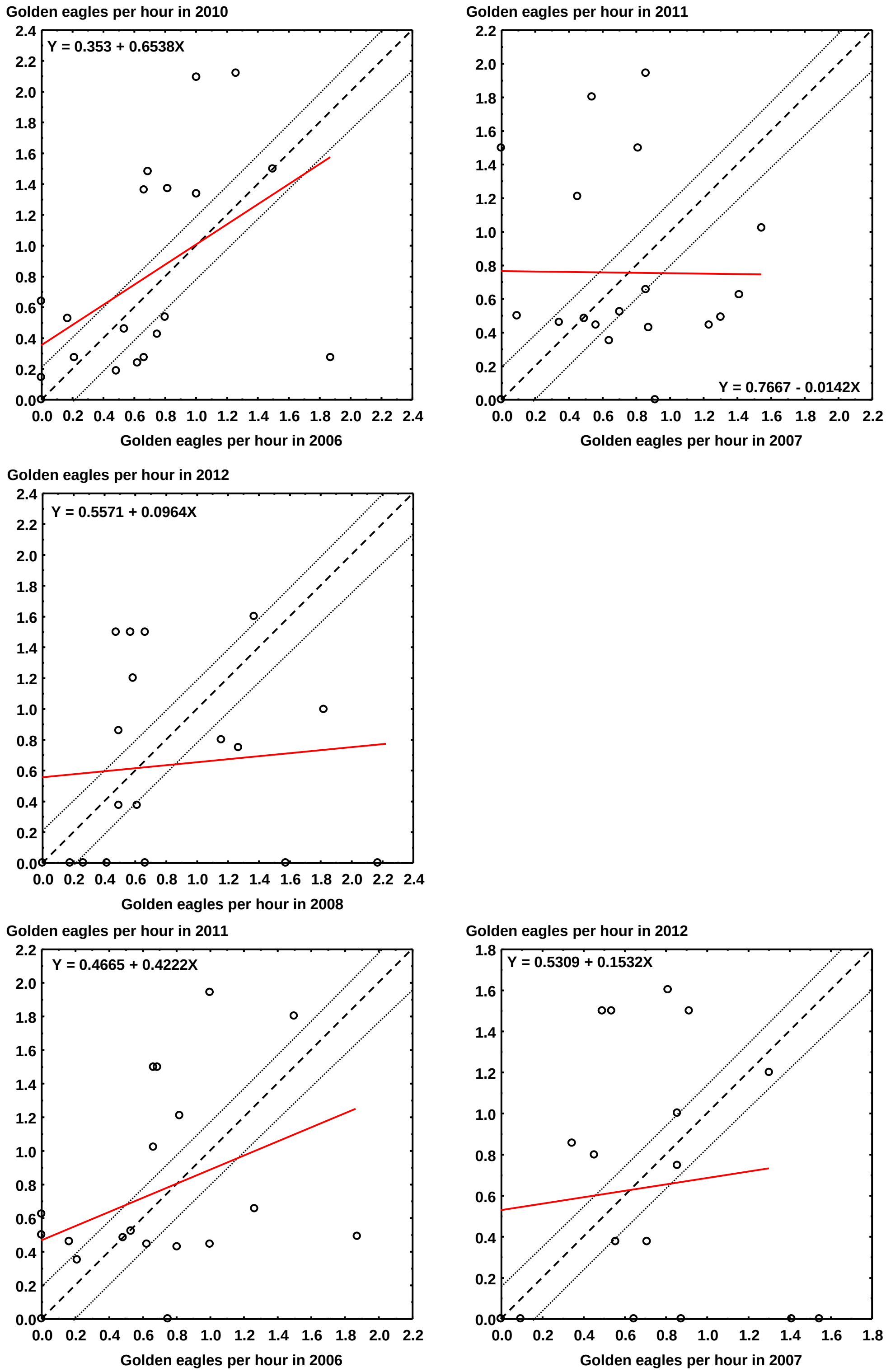


Figure 5. *Golden eagle use rates at 19 APWRA wind projects regressed (red line) on use rates measured four years (top 3 graphs) and five years (bottom 2 graphs) before and compared to slope of equivalency (dashed line) and 90% prediction interval calculated from hypothetical 2010 use rates differing 10% from 2009 use rates.*

Whereas the use surveys performed at Summit Ridge in 2005-2010 can inform the types of environment where a particular species is more likely to be found, assuming the 'use' survey data were mapped and the mapped data subjected to appropriate use-and-availability analysis, I would not agree that raptors in 2023 will occur where they were seen in 2005-2010. A particular species might occur in the same type of environmental setting, but not necessarily in the same places.

UPDATING PROJECT IMPACT PREDICTIONS AND MITIGATION

The applicant is required by OAR 345-021-0010(1)(p) to provide "*information about . . . the fish and wildlife species . . . that could be affected by the proposed facility*" and is required by OAR 345-021-0010(1)(p)(A) to describe the "*biological and botanical surveys performed . . . , including a discussion of the timing and scope of each survey.*" In addition, the Wasco County ordinance at LUDO § 19.030.C.5 requires the applicant to "*[c]onduct biologically appropriate baseline surveys in the areas affected by the proposed energy facility to determine natural resources present and patterns of habitat use*," and to provide "*information pertaining to the energy facility's potential impacts and measures to avoid impacts on . . . all potential species of reasonable concern*," including species identified "*by any jurisdictional wildlife agency resource management plan adopted and in effect on the date the application is submitted*" (which would include bald eagles, golden eagles, federally designated migratory birds, and federal birds of conservation concern). Two such wildlife management plans per the Wasco County ordinance are the US Fish and Wildlife Service's Eagle Take Rule and the USA Eagle Conservation Plan Guidance (US Fish and Wildlife Service 2013).

In the 9 years since Northwest Wildlife Consultants (2010), I have studied baseline studies to assess their contributions to predicting and understanding wind project impacts (Smallwood 2017b, Smallwood and Neher 2017, Smallwood unpublished data). Baseline studies are intended to predict project impacts and formulate mitigation, and to set the stage for measuring project impacts. Baseline studies can predict project impacts by pursuing several objectives: (A) Identifying species present at a site, including species known to be vulnerable to wind turbine collision or displacement; (B) Quantifying abundance of species on site as a next-level assessment of collision risk; (C) Locating breeding sites to assess collision risk; (D) Quantifying behaviors on site, such as flight patterns and inferred objectives, e.g., foraging, mating, staging, stopping-over, migrating; (E) Characterizing spatial distributions of relative abundance and flight patterns to inform micro-siting for minimizing project impacts; and, (F) identifying opportunities for measuring project impacts and mitigation efficacy (Sinclair and DeGeorge 2016). However, baseline studies often suffer major shortfalls toward each of these objectives. Species presence can be difficult to confirm, requiring special survey methods and large time commitments; otherwise, determinations of species' absence are inappropriate and too often followed by documented fatalities at the operational wind project. Whether species are vulnerable to wind turbine collision depends on the likelihood of fatality monitoring methods detecting the species as fatalities in earlier monitoring efforts at other projects (Smallwood 2017). Whether species are vulnerable to displacement has rarely been measured. If behavior data are collected as part of use surveys, the investigators rarely analyze the behavior data to assess collision risk or to inform micro-siting decisions. This latter shortfall is most critical because it goes to the only mitigation measure demonstrated to have minimized or reduced avian collision impacts (Smallwood 2008, 2009; Brown et al. 2016, Smallwood et al. 2017). As for identifying opportunities to measure impacts and mitigation efficacy, baselines studies rarely if ever address the experimental design constraints on testing mitigation efficacy or the statistical constraints associated with fatality estimation. They also never discuss the biological ramifications of fatality estimates in terms of demographic consequences or cumulative impacts. The Summit Ridge baseline study suffered these shortfalls and needs to be updated now that we know better.

Species Inventory

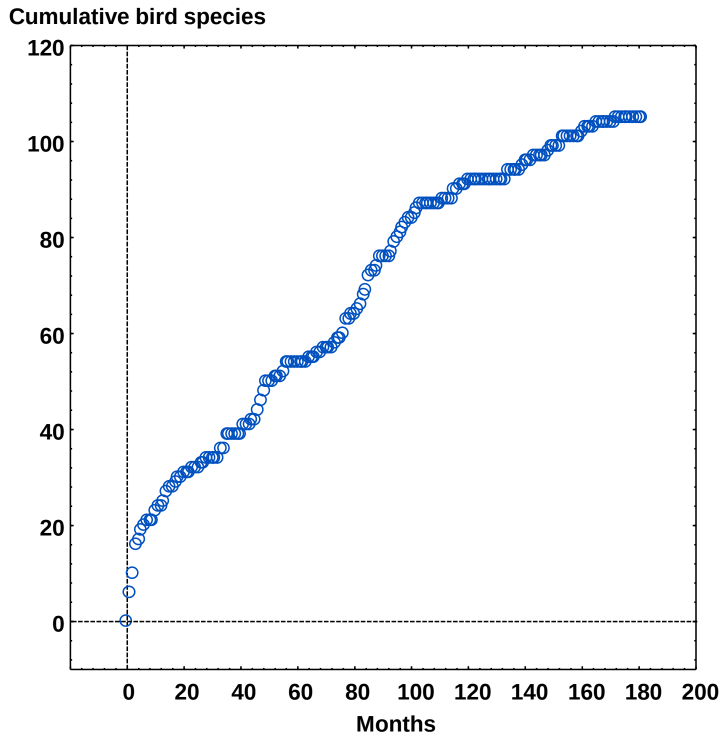
The US Fish and Wildlife Service (2012) recommends implementing survey methods that are appropriate for detecting the species.

Birds

Use surveys of the type performed at Summit Ridge were designed for detecting large birds, specifically large raptors. Additional survey methods are needed for an *inventory* of birds, including point counts for songbirds, focused surveys for burrowing owls, nocturnal surveys for owls, and call-back surveys for cryptic species. These various survey methods to meet the detection challenges of different species is what the US Fish and Wildlife Service (2012) meant by implementing survey methods appropriate to the species.

In my experience, bird species detected by use surveys at a project site increase in a typical pattern with additional survey efforts, so that the number of species yet to be detected can be predicted by a model fit to the cumulative counts of species already detected (Figure 6). It takes a great deal of survey effort to approach an asymptote in the number of species occurring at a site, and even in the case of the APWRA (Figure 6) there are bird species being killed by wind turbines that were never detected during use surveys. At Summit Ridge, because the data were not made available, I have no way of graphing bird detections against survey effort to assess whether the number of species detected was close to the number likely occurring at Summit Ridge. It is noteworthy, however, that Northwest Wildlife Consultants (2010) detected at least 55 species of birds in only 168 hours of survey over portions of two years. The 168 hours of survey at Summit Ridge equals about 7.5 months of survey effort in the APWRA, on average, so the survey effort at Summit Ridge detected nearly 3 times the number of bird species as detected in the APWRA for the same effort level, suggesting that additional survey effort would eventually tally a very large number of bird species. Given that the APWRA is notorious for avian collision fatalities, the larger number of species detected from a much smaller effort at Summit Ridge might portend large impacts. But there is more to collision risk than a simple species inventory.

Figure 6. *Cumulative bird species detected during use surveys at 84 stations approached an asymptote of about 110 species after 180 months of effort in the Altamont Pass Wind Resource Area, California.*



Not inventoried by the use surveys at Summit Ridge were the owls, goatsuckers, nocturnal migrants, or small or cryptic birds unlikely to be detected in use surveys. Due to the relatively small survey effort and the use of only one survey method, the baseline study includes more false-zero detections than it does bird species detections, and is therefore short of any sort of inventory. This is a pervasive problem among baseline studies performed across North American (Beston et al. 2015), and needs to be rectified at Summit Ridge.

Bats

The 2009 bat surveys (which are erroneously referred to by Tetra Tech (2018) as an "inventory" of bats) in the project area were severely limited by survey methodology, totaling 16 detector-nights over 4 nights at 6 stations. Not only were the bat surveys brief, they were constrained to bats that typically forage near the ground. In my experience using acoustic detectors for 4.5 months per year over 3 years, bat species composition differed between ground level and 80 m above ground, where the rotor hubs of modern wind turbines occur. Brown et al. (2016) detected 4 species of bats exclusively at ground level, whereas another 3 species were found at both heights. In other words, placing acoustic detectors near the ground can give the investigator a biased view of foraging or migrating bat species composition within a proposed project area. The surveys need to be repeated by placing acoustic detectors at heights within the planned rotor plane, but also using thermal-imaging cameras to count bats using the airspaces over various topographic settings, and by spanning a larger portion of the year.

After having studied bat activity in the APWRA for 7 years, including 940 hours on a FLIR T620 thermal imaging camera fitted with an 88.9 mm telephoto lens (Smallwood 2016, 2017), 3 years monitoring bat species via ground and wind turbine-based acoustic detectors (Brown et al. 2016), and many years of bat fatality monitoring, I recommend an update to the 2009 bat surveys. Understanding bat ecology is challenging due to bats' nocturnal activity, travel patterns, and cryptic roosting. This past year – my 7th year of monitoring bat migration through the APWRA – there was for the first time in my experience no migration (Smallwood unpublished data). One implication of this year's lack of migration through my APWRA study area is that an entire migration event can be missed by monitoring a site during a single migration season one year. If I had relied solely on 2018 thermal-imaging surveys over the migration season, I would have erroneously concluded that bats do not migrate through my study area. Such an error would have been profound. Similarly, Northwest Wildlife Consultants (2010) could easily have missed entire species of bat using the project area during the brief period of their 2009 surveys.

If, at the Vasco Winds Energy Project (Brown et al. 2016), we had relied on only one of three years of post-construction acoustic monitoring, and had we interpreted no detections as evidence of absence, as Tetra Tech (2018) and Northwest Wildlife Consultants (2010) did by characterizing the 2009 survey as an inventory, then we would have erroneously concluded that big brown bats (*Eptesicus fuscus*) were absent. But we detected this species in other years. Furthermore, preconstruction surveys detected 3 species of bat (*Myotis evotis*, *Myotis thysanodes*, *Lasiurus noctivagans*) that we never detected post-construction (Normandeau Associates Inc. 2011). Acoustic detectors have a range of about 30 m at best, or about 36% of the rotor-swept area of a modern wind turbine, not accounting for any obstructions. Detectors mounted 1.5 m above ground are limited in range to about 18% of the rotor-swept area of a modern wind turbine due to nearness to ground. An investigator relying on such detectors to characterize a bat community has to hope that members of all species of bats in the area will fly low to the ground and within a 30-m vertical ark of one of the detectors. Not only do members of each species have to visit these low-lying detector zones to be detected, but they have to echolocate or vocalize while doing so. Some species do not echolocate or vocalize as often as others, meaning that some species are more likely to be missed in acoustic detector surveys (Sinclair and DeGeorge 2016). Acoustic detection of bats has brought highly valuable data to investigators, but its limitations must be recognized. I would need a very large acoustic detector survey effort involving placements at multiple heights above ground before concluding the bat community had been inventoried.

A biased view of bat species inventory, as well as collision risk, can also emerge from focusing surveys into one season of the year, as did Northwest Wildlife Consultants (2010). It is widely known that bat foraging activity peaks either in summer or fall, depending on location. The largest peak activity period in the APWRA has been during the last week of September and first week of October, which is later than most locations in North America that we know of. But by monitoring year-round, I also documented an activity peak in April, and I continued to see large bats (hoary bats) through spring and summer. Hoary bats also have been found dead at APWRA wind turbines from spring through fall. During preconstruction acoustic detector surveys at Vasco Winds, Normandeau (2011) documented bats year-round, as well as shifting compositions of bat species detected each season. Rather than restricting bat surveys to a narrow portion of a year based on an assumed peak in activity, surveys should be performed year-round to discover unique activity patterns at the project site.

I recommend an expanded survey effort for bats, especially if the objective is to determine an inventory of bat species. Between the Normandeau (2011) and Brown et al. (2016) studies at Vasco Winds, it took 475 detector-nights per detection of western long-eared myotis and 285 detector-nights per detection of fringed myotis. Even for silver-haired bat, we needed 5 times the number of detector-nights (79) than the 16 used at Summit Ridge to detect this species. Sixteen detector-nights is highly unlikely to yield an inventory, especially at ground level.

Based on the average detector-nights per detection of species (Figure 7), had Brown et al. (2016) relied solely on 16 detector-nights, we would have failed to detect 83% of the species that we actually detected. According to the model that best fits the data in Figure 7, we should have detected 12 species of bats after the 1,425 detector-nights used in the studies, so we likely missed two species. Assuming this model would be applicable to Summit Ridge, 16 detector-nights should have detected 2 or 3 species of the 15 or so potentially present, but Northwest Wildlife Consultants detected 7 species, or more than predicted. A possible explanation for the more-than-predicted detections was Northwest Wildlife Consultants' (2010) selection of study locations thought more likely to be used by bats, whereas the studies at my project site location were selected based on met tower availability or wind turbine sites. Nevertheless, Northwest Wildlife Consultants did not truly inventory bat species at Summit Ridge, nor did they identify bat species or quantify their activity levels within the airspaces likely to be swept by wind turbines. A survey effort is needed in the airspaces that will be affected by wind turbines.

Related to the objective of identifying species present at a site, there is the objective of identifying species known to be vulnerable to wind turbine collision or displacement. Northwest Wildlife Consultants (2010) addressed this objective by listing average fatality rates of bat species having been recorded as fatalities at Pacific Northwest wind projects. The problem with this is that we now know how unlikely it was for all bat fatalities to have been found and recorded, especially fatalities of smaller-bodied species of bats. Based on a detection trial integrated into a 7-day fatality search interval out to 105 m from 2.3-MW wind turbines mounted on 80-m towers, carcass detection rates would be 1.6% for small-footed myotis (Figure 8, predictive model from Brown et al. 2016). Given the longer search interval used at Pacific Northwest wind projects cited by Northwest Wildlife Consultants (2010), detection rates would have been even lower, likely requiring hundreds of bat fatalities before a single one was found. Until skilled scent-detection dogs are widely used in bat fatality searches at wind projects and the results shared with the public, it will remain unknown which of the bat species might be more vulnerable to wind turbine collision (see the findings of Mathews et al. 2013 and Smallwood et al 2018 – Attachment 1).

Figure 7*. Cumulative bat species detected in acoustic surveys increased with detector-nights per detection, based on 1,425 detector-nights at Vasco Winds Energy Project, 2010-11 (Normandeau 2011) and 2012-14 (Brown et al. 2016).*

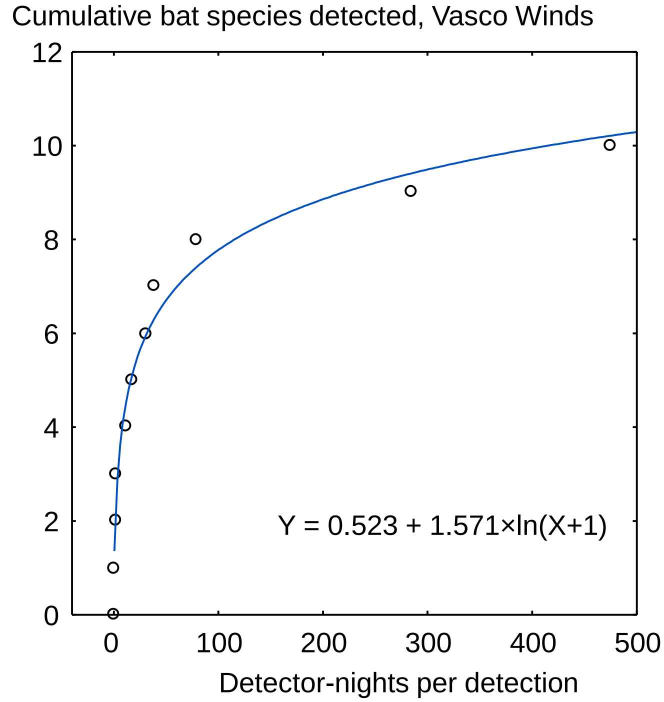
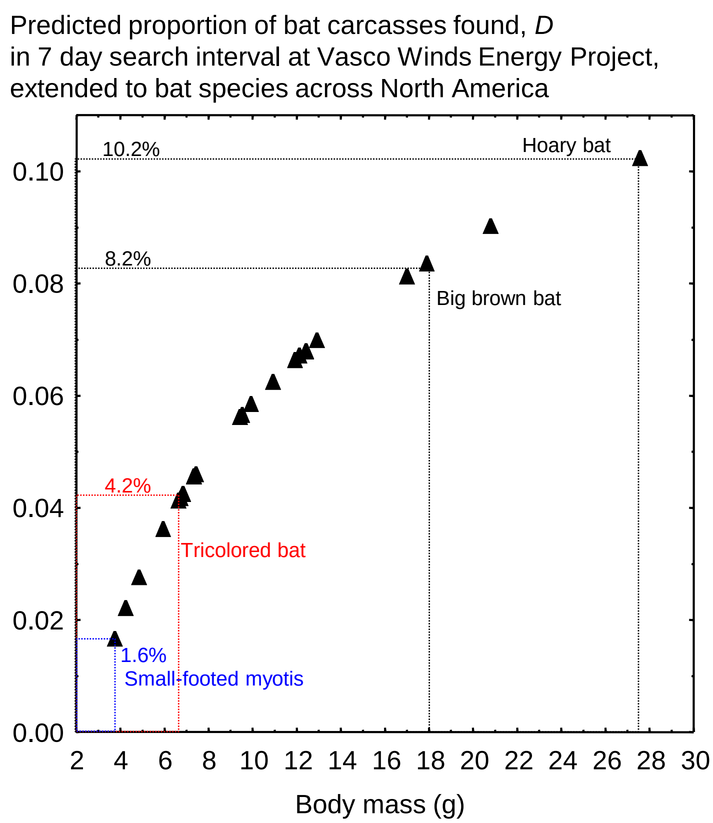


Figure 8*. A model was fit to carcass detection rates, D, regressed on body masses of nearly 200 frozen-fresh bats of multiple species that were thawed and placed over three years in fatality search areas around monitored wind turbines in the Altamont Pass Wind Resource Area. The model was then projected to North American bat species based on body mass typical of each species.*



Relative Abundance

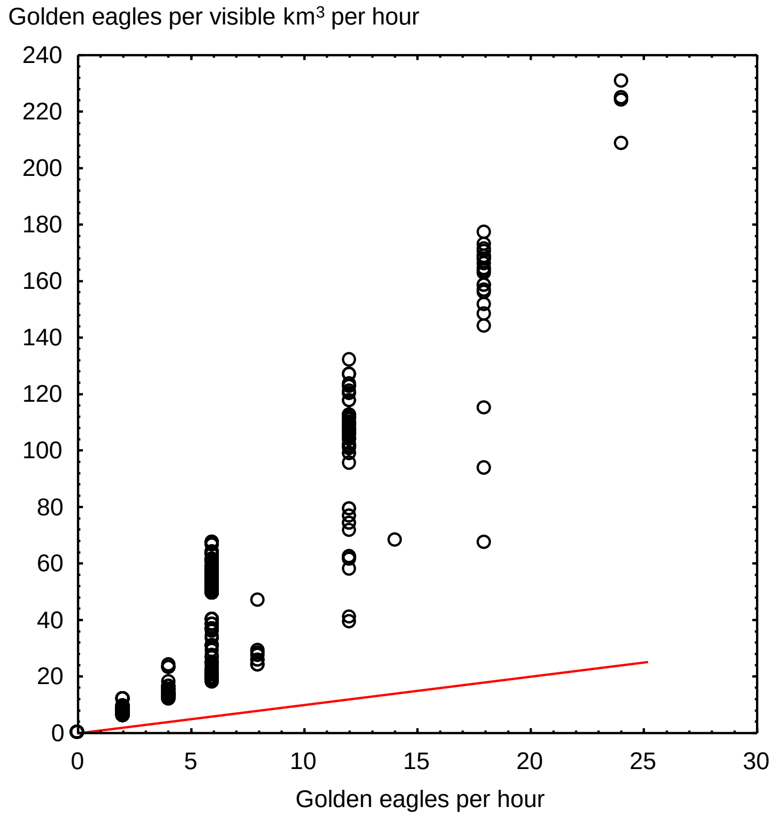
Wasco County LUDO § 19.030.C.5.b requires the applicant to conduct "*biologically appropriate baseline surveys in the areas affected by the proposed energy facility to determine natural resources present and patterns of habitat use*" and LUDO § 19.030.C.5.c requires the applicant to select turbine "*locations to reduce the likelihood of significant adverse impacts on natural resources based on expert analysis of baseline data*."

The USA Eagle Conservation Plan Guidance (US Fish and Wildlife Service 2013) recommends 40 hours of relative abundance or use surveys per station covering at least 30% of the project's footprint. To be consistent with this recommendation, the 10 use-survey stations at Summit Ridge would have needed 400 hours of surveys instead of the 168 hours completed. Based on what has been learned in the APWRA, I contend that more hours are needed than the 400 recommended by US Fish and Wildlife Service (2013). Also based on what has been learned in the APWRA, I contend that more years of surveys are needed than the 2 years recommended by US Fish and Wildlife Service (2013). Species composition and species' activity areas shift inter-annually to a degree that cannot be captured by only 2 years.

As earlier illustrated in Figures 1 through 5, use rates shift spatially and inter-annually, so use rates estimated in one year cannot be expected to represent use rates 14 years hence. As an example of how things change, bald eagles – a species protected under the federal Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act – were not expected by the Alameda County Scientific Review Committee to be at risk of wind turbine collision in the Altamont Pass because use surveys rarely reported bald eagles in the Altamont Pass through 2011. Since 2011, however, bald eagles have been seen in increasing numbers. Last week I saw 3 bald eagles in 2 days in the Altamont Pass. A few years ago I found one dead under a wind turbine. Tetra Tech (2018:36) expects that Summit Ridge will not affect bald eagles, but I suggest that appropriate surveys might lead to an altered expectation. (Tetra Tech also claims in their Table 2 that bald eagles eat carrion in the upland environment, but in my experience they also catch and consume live prey just as golden eagles do.)

The use rates I compared in Figure 2 had been adjusted because we learned since 2010 that use rates are functions of maximum survey radius and they vary according to the proportion of the sky that is visible from any given observation station (Figure 9). As field biologists are asked to survey to greater distances, they miss increasingly larger proportions of the available birds, more so for small-bodied bird species than large-bodied species. As illustrated in Figure 9, these functions are biases if they are not quantified and accounted for in the use-rate metric (Smallwood and Neher 2017, Smallwood 2018). In Figure 9, the highest golden eagle use rates adjusted for occluding terrain were 11 times higher than without the adjustment. Without accounting for these biases, use-rate comparisons are potentially misleading, both between projects and within a project area when using the data to carefully micro-site the turbine layout with the intention of minimizing collision impacts.

Figure 9. *Golden eagles seen flying per visible km³ per hour increased faster than proportionately with increasing golden eagles seen flying per hour among the APWRA's 84 observation stations monitored 2005-2011. The red line depicts theoretical equivalency between the use rates had there been no effect of visual obstruction.*



Two of the three metrics measured by Northwest Wildlife Consultants (2010) were almost entirely functions of the distance bias discussed above. Smaller birds are seen less often than larger birds for the simple reason that many individuals of smaller-bodied species are either not seen or are seen but not identified to species due to being located too far from the observer. Percent composition is deeply confounded by this distance bias, and therefore does not represent the species true contribution to the total number of birds on a 201-hectare survey plot. According to Table 6 of the Baseline Study, common ravens were 21 times more abundant than savannah sparrows and 6.6 times more abundant that American goldfinches. I question these results because I know from experience that common ravens are easy to see (and hear) out to 800 m from the observer, whereas savannah sparrows and American goldfinches, unless accompanied by calls, are much more difficult to detect and identify. Assuming the American goldfinches and savannah sparrows were seen within 50 m of the observer, which is a generous assumption, the relative abundance estimated for these species would need to be extrapolated to the additional 200.175 ha of the survey plot to account for those members of each species too far away to be seen or identified, resulting in relative abundance estimates about 250 times greater than reported. The third metric, percent frequency, suffers the same confounding from plot size as do the other metrics, and is therefore just as misleading without any adjustment for the distance effect.

Use surveys to 800-m boundaries are fraught with species identification errors. McClure et al. (2018) compared human detections of eagles to automated detections out to 1,000 m and found through photo documentation that the biologists misidentified 32% of large birds as eagles. Human misidentification of large birds as eagles increased 26% for every 100 m added distance from the observer, and the median distance of bird detections was <400 m (McClure et al. 2018). Additional errors at long distances include estimation of the bird's height above ground (Stanek 2013) and determining whether the bird is within or outside the maximum search radius. Using maximum survey radii >400 m hurts any micro- or macro-siting model development more than it helps due to the large error rates.

Not only was the maximum survey radius too far for the stated objectives of the use surveys, but the survey stations were too few to encompass many of the then-planned wind turbine sites in the surveyed airspace. If the analysts are not going to use behavior patterns to highlight locations of likely collision impacts, then passage rates through the airspace of planned or potential wind turbine locations could inform of collision risk and help guide micro-siting (Smallwood 2017). Of the then-planned 86 turbine sites, however, only 28 (32%) were within surveyed airspace, only 13 (15%) were within 400 m of the observers, and only 7 (8%) were within 200 m of the observers. Thus, only 8% of the project could be assessed for collision risk to birds the size of American kestrels and only 15% of it could be assessed reliably for birds to the size of eagles. Most of the relative abundance quantified by Northwest Wildlife Consultants (2010) was at locations other than where wind turbines would be constructed.

Also missing from reports of use surveys in the Baseline Study were any of the types of statistics that accompany fatality rate estimates, such as standard error and confidence ranges. In fact, there was no handling of error at all, as if measured use rates represented true use rates. Because there were no error terms accompanying the estimates of mean use rates, there was no carrying of error terms through the calculation of use rates. Without error terms, birds with high use rates were compared to birds with low use rates without acknowledging that as use rates diminished, uncertainty in the accuracy of their use rates likely increased. This is a strange omission because estimated use rates likely carry larger error terms than do fatality estimates. Northwest Wildlife Consultants (2010) compared fatality rates and use rates as if error did not exist for either metric.

Nor was the reader of the Baseline Study informed of potential biases caused by imbalance in start times per observation station, although the reader was informed of imbalance in seasonal representation. No ceiling was specified for inclusion of birds in use rate estimates, as if birds flying 900 m above ground were included along with birds flying 60 m above ground. And as pointed out earlier, there was no adjustment for variation in how much airspace was visible from one station to the next, and no adjustment for the proportion of birds unseen due to the effect of the long survey distance used.

Bats

The Habitat Mitigation Plan has yet to be informed by measured relative abundance of bats, but it should be. The surveys performed in 2009 appeared to be intended for identifying which species of bat occur at the project site, but even for that purpose the survey effort was insufficient (as noted earlier). But a question long in need of an answer is whether relative abundance of bats can predict post-construction fatality rates of bats. A follow-up question has been whether pre-construction activity patterns of bats can be used to guide micro-siting to minimize bat collision impacts.

Hein et al. (2012) tested for a correlation between post-construction fatality rates and pre-construction use rates based on acoustic detectors placed in proposed wind projects, but found no significant correlation. Hein et al.'s (2012) disappointing result might have been influenced by the same type of inter-annual variation in relative abundance as I have noted for birds, or it could have been caused by inadequate research methods; it remains unknown why a significant correlation was not found. My colleagues and I decided to try testing for a correlation by quantifying passage rates through turbine rotors using a thermal-imaging camera and relating these passage rates to the results of fatality searches performed much closer to the time of the passage rate surveys, and we used dogs as the fatality searchers.

We found that bat fatality finds *did* correlate with the previous night's relative abundance (Figure 10), but our model predictions of fresh bat fatality finds were more responsive to higher rates of near misses with wind turbine blades and even more so with observed collisions (Figure 11). But whereas we established that observed risky situations do indeed translate into fatality finds, we still do not know whether we can predict fatality rates at candidate turbine locations based on preconstruction use surveys. A possible reason for potentially being unable to predict fatality rates of bats at the turbine scale is because bats are attracted to wind turbines (Smallwood 2016). I have seen many bats go out of their way to visit wind turbines and often fly through the operating rotors repeatedly. Interestingly, when the turbines are turned off or not operating, bats largely lose interest in them and passage rates decline (Smallwood unpublished data). When turbines are shut down, fatalities of bats ceased (Smallwood and Bell, In prep.). Even if not for predicting impacts at a specific project such as Summit Ridge, the magnitudes of bat impacts are so great that preconstruction bat surveys are warranted for research value. In the meantime, fatality rates at other wind projects likely serve as the best predictors of bat impacts at Summit Ridge, so long as the data from other projects were collected using dogs or search intervals of <10 days.

Figure 10. *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. Data were from Smallwood et al. (In prep.).*

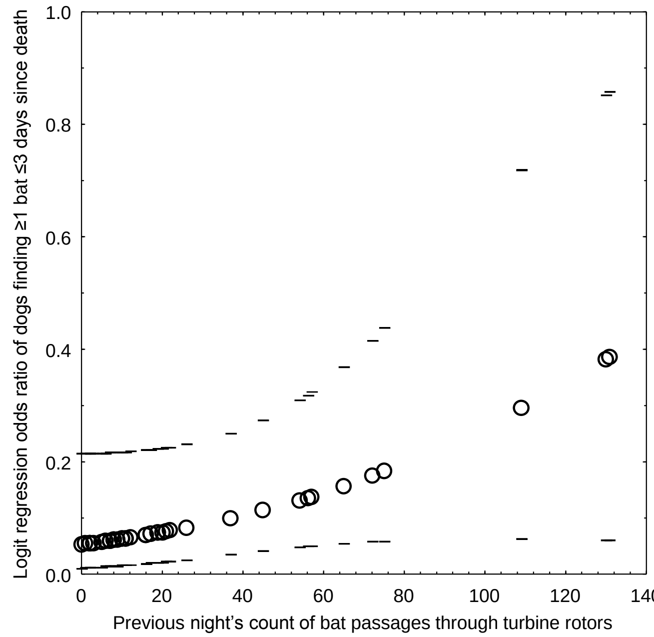
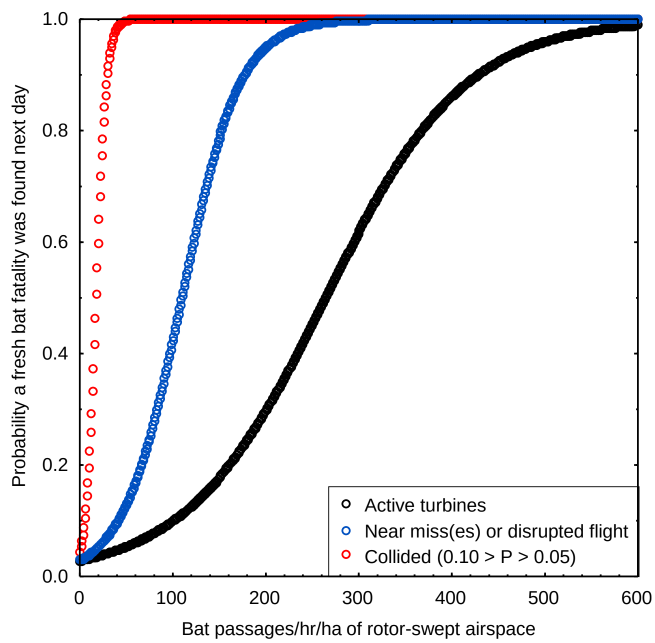


Figure 11. *Logit-regression model predictions of the odds of dogs finding fresh bat fatalities the morning after thermal-imaging survey-counts of bats passing through active turbine rotors (black), bats nearly colliding or experiencing disrupted flights due to pressure waves of passing blades or wake turbulence (blue), and bats seen colliding with a blade (red) in California's Altamont Pass Wind Resource Area, 15 September through 15 November 2017. Data were from Smallwood et al. (In prep.).*



Behavior Data for Micro-siting

Micro-siting to minimize collision impacts has obviously not been attempted for this project, yet such information should have been provided in the application materials pursuant to OAR 345-021-0010(1)(p)(G) and Wasco County LUDO §§ 19.030.C.5.c and 19.030.C.5.h. To assist with micro-siting to minimize collision impacts, the US Fish and Wildlife Service (2003) had prepared guidelines that identified terrain features and environmental settings to avoid. Here, the application materials provide no indication that micro-siting to minimize collision impacts took place. The crude map of 86 turbine locations in the Baseline Study (Northwest Wildlife Consultants 2010) shows regular spacing between turbines along Summit Ridge, as did the partial map attached to a 21 April 2016 email from Arthur Smith to Peter Ostrowski (in Attachment B: Reviewing Agency Comments on Preliminary Request for Amendment 4). In my experience, regular spacing results in some wind turbines installed on ridge saddles, breaks in slope, and other terrain settings that happen to coincide with regular spacing. Wind turbines on these terrain features will result in disproportionate collision rates at those turbine sites – collision rates that could be avoided.

No matter the layout iteration, I have seen no evidence of an effort to avoid landscape features long known to associate with more collision fatalities, including features identified in the original federal guidelines for minimizing wind energy impacts on wildlife (US Fish and Wildlife Service 2003). The map of use survey stations in Northwest Wildlife Consultants (2010) was overlaid on a turbine layout, suggesting that the layout at the time had been decided before any use surveys were performed. Using Google Earth to examine some of the planned sites in the Arthur Smith email of 21 April 2016, it appears to me that some wind turbines are planned for ridge saddles, ravines, and relatively low-lying portions of ridge structures. This is unfortunate because we know that careful micro-siting is the most effective mitigation measure available for minimizing wind project impacts to raptors (Attachments 2 and 3).

A change to the layout was proposed in 2014, increasing tower height to 91 m and turbine size to 2.7 MW, and reducing the number of turbines from 87 to 75 or 72. Rick Gerhardt of Northwest Wildlife Consultants was asked to assess changes to wildlife risk resulting from the change in turbines, which he did by email to Steven Ostrowski and Eric Desmarais on 8 August 2014. Gerhardt replied that it was intuitive that the taller tower and larger rotor would kill more birds and bats, but that the increased collision risk posed at the individual turbine level would be more than offset by decreased collisions with fewer turbines and reduced impacts on habitat. In my experience, intuition has not served biologists well when it comes to impact predictions at wind projects, but the important point here is that no consideration was given to where the larger turbines could be sited to minimize collision risk. With fewer wind turbines needed to meet the project's capacity goal comes the opportunity of more space to carefully micro-site the turbines to avoid terrain features known to associate with more collisions and areas where behavior data suggest are disproportionately trafficked by birds and bats (Smallwood 2017c). By not suggesting micro-siting of the larger turbines to minimize collision risk, Gerhardt's 2014 reply email indicates again that this approach was not part of the baseline study for the project. Because micro-siting to minimize collision impacts was not an objective of Northwest Wildlife Consultant's (2010) baseline study, the data needed for micro-siting were not collected.

Behavior data are needed to inform micro-siting to minimize collision fatalities. Northwest Wildlife Consultants (2010) reportedly recorded behavior data, but only once per flight path. Behaviors need to be mapped at frequent intervals along a flight path (Smallwood 2017b, Smallwood et al. 2017). This type of data can be used to develop collision hazard models useful for micro-siting, or they can be used as empirical support for expert micro-siting decision-making. Ample evidence suggests that this general approach can minimize avian collision mortality (Brown et al. 2016, Smallwood et al. 2017; Attachments 2 and 3; Figures 12 and 13). Figure 12 shows how map-based collision hazard models performed in the APWRA, where Hazard Class 1 included wind turbines on landscape settings predicted safest and Hazard Class 4 included wind turbines on landscape settings predicted most dangerous. Class 1 tended to compose 63% of the landscape, Class 2 about 20%, Class 3 about 12% and Class 4 about 5%. The wind turbines in Hazard Class 4, composing 5% of the landscape, caused fatality rates 4 times higher than wind turbines in Hazard Class 1 for golden eagles, 1.5 times higher for red-tailed hawks, 3.4 times higher for American kestrels, and >6 times higher for burrowing owls. Work still needs to be done to improve collision hazard models for red-tailed hawk, although expert opinion tends to work well for this species. I should also note that the model for golden eagles also made use of telemetry data and landscape attributes associated with wind turbine fatality finds. The burrowing owl model made use of fatality finds as well as landscape attributes associated with breeding sites.

Figure 12. *Mean and 95% CI fatality rates of golden eagle, red-tailed hawk, American kestrel, and burrowing owl in response to model-predicted collision hazard classes 1 through 4, where 1 was least hazard, and 4 greatest hazard in the Altamont Pass Wind Resource Area.*

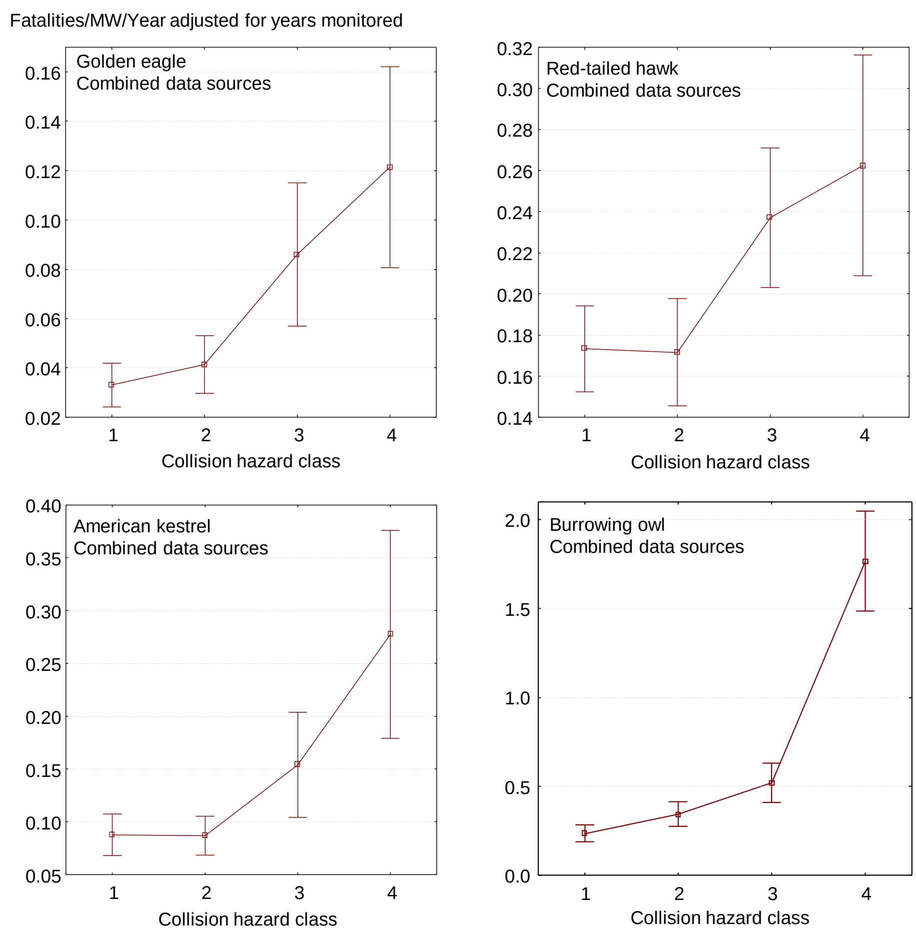


Figure 13. *Golden eagle fatalities per turbine relative to (top) SRC style hazard ratings binned 4 = 3 to 5, 6 = 6 and 6.5, 7 = 7 and 7.5, 8 = 8 and 8.5, and 9 = 9 and 9.5; (middle) Grading within 40 m of the turbine leaving cut slopes or berms of 0 = none, 1 = 1-3 m, and 2 = >3 m; (bottom) Combined indicator of SRC-style hazard rating, grading impact and whether low on declining ridge or within saddle or valley structure. The combined indicator was the sum of the binned SRC rating divided by 9, the binned grading impact weighted by half, 1 for sites low on ridge and 1 for sites within saddle or valley structures, and this sum was binned as 1 = 0 to 1; 2 = 1 to 2; 3 = 2 to 2.8, and 4 = >2.8. I note that I applied SRC-style hazard ratings to 6 turbine addresses post-construction because these turbines had been relocated far from original sites during the planning process. These data were from the first year of fatality monitoring at 48 wind turbines in the Golden Hills project.*

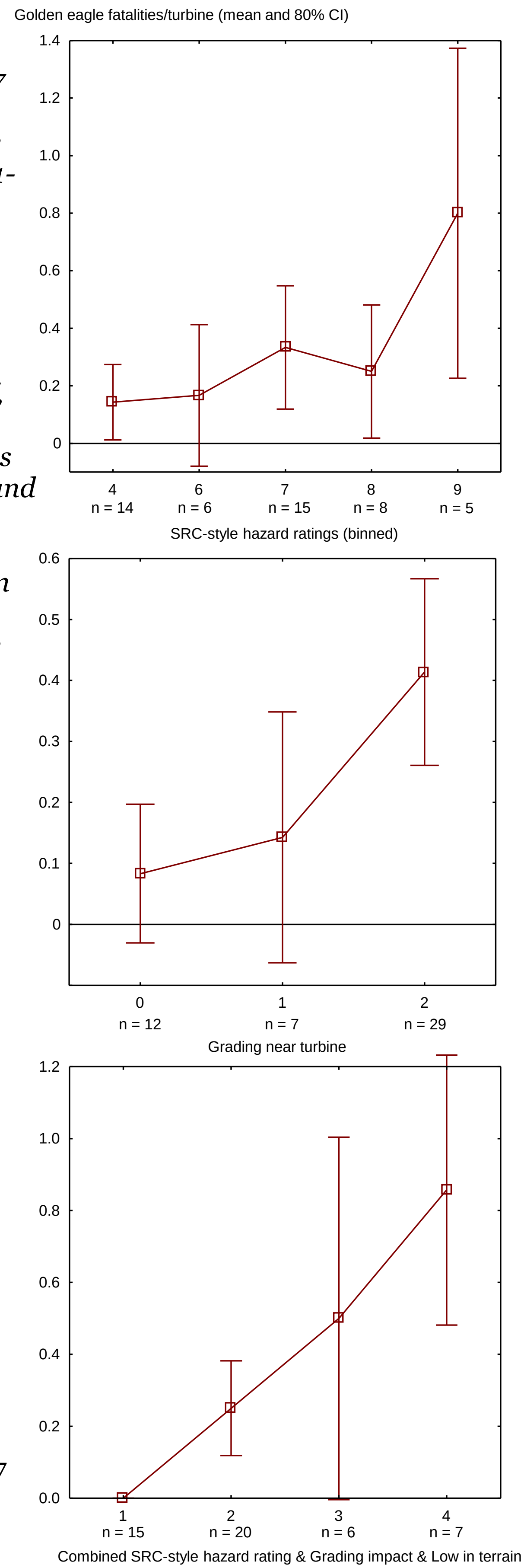


Figure 13 shows how golden eagle fatality rates varied among 48 modern wind turbines rated for landscape contributions to collision threat based on expert opinion (SRC-style ratings), levels of grading for the turbine pad and access roads, and a combination of expert opinion about the landscape setting and degree of grading. An emerging issue is the contribution of grading for turbine pad and access roads to subsequent wind turbine collision risk. Pads cut deeply into slopes can leave berms in the prevailing upwind aspect of turbine rotors, effectively reducing the space between the low-reach of the blades and the height above ground a bird needs to clear above the berm (Figure 14). This grading can also increase turbulence that birds or bats will experience as they fly from air above matrix slope conditions to air above a graded pad (Attachment 3). Wind speeds over such pads can drop radically, and wind directions can change. In addition to micro-siting to minimize collision risk, micro-siting to minimize grading should be an objective.

Figure 14. *This view is toward the prevailing wind (see broad white arrow), so the prevailing upwind slope, the crest of which is only 30 m from the wind turbine, forces any bird or bat passing over it into a vertical gap of only 16 m between the hill crest and the low reach of the blade. The wind turbine's dimension of 29 m height above ground of the low reach of the rotor has lost its meaning due to the effects of grading of a pocket into the slope. I have seen this type of grading across the western USA.*

The application and Habitat Mitigation Plan need to be revised to incorporate the most effective mitigation measures, including wind turbine micro-siting, based on current data, to minimize collision hazards to birds and bats. To this end, appropriate studies need to be performed.

Nest Locations

The applicant is required by OAR 345-021-0010(1)(p), and (1)(p)(A) through (1)(p)(H) to survey the current locations of nests for raptors and sensitive birds in order to ensure the protection of these species and their habitat. In addition, the applicant is required by Wasco County LUDO § 19.030.C.5.h to reduce impacts by "*[a]voiding construction activities near raptor nesting locations during sensitive breeding periods and using appropriate no construction buffers around known nest sites*." In addition, nest locations can often inform about "*patterns of habitat use*" and potential project siting "*locations to reduce the likelihood of significant adverse impacts*," which are required by Wasco County LUDO §§ 19.030.C.5.b and 19.030.C.5.c, respectively.

Northwest Wildlife Consultants (2010) compared raptor nest density at Summit Ridge to raptor nest densities and raptor fatality rates measured at other Pacific Northwest wind projects where both of these metrics had been measured. Lumping species together to measure nest density and fatality rate introduced multiple problems that were ignored by Northwest Wildlife Consultants. Raptor species vary in nest density and in fatality rates. By lumping species for their comparison, Northwest Wildlife Consultants washed out any species-specific relationships between nest density and fatality rates, and they made no effort to manage the error terms associated with each species. If I were to repeat the assessment approach of Northwest Wildlife Consultants (2010) in the Altamont Pass, I would have to combine, among other species, the 2 or 3 golden eagle nests with the 25 to 50 or so red-tailed hawk nests and the 537 (90% CI: 320-753) burrowing owl nests when measuring raptor nest density. My raptor nest density would obviously be dominated by burrowing owl nests, and so would my raptor fatality estimate. Lumping species for this type of assessment is not a good idea.

When investigators appropriately examine relationships of nest location with wind turbine fatalities, they consistently document harmful outcomes (Hunt e al. 1998, Pearce-Higgins et al. 2009, Dahl et al. 2012, Loesch et al. 2012). In my own studies I found that burrowing owl nest location turned out to be a key predictor variable in my burrowing owl collision hazard model in the Altamont Pass. A common thread among these studies is their simultaneous measurement of nesting locations and wind turbine impacts. This simultaneity is important because birds are not as tenacious about nesting in the same place from year to year as some people might believe. Just as shown in my Figure 1, the locations of entire burrowing owl nesting colonies shift inter-annually, and in studies where I have focused on individual nest sites, I found that these also shift use inter-annually (Smallwood and Morrison 2018). Doug Bell and I have been tracking the nest locations of a pair of prairie falcons, which change locations from one year to the next in the APWRA, one year nesting in a rock cave in Vasco Caves Regional Preserve, the next year nesting in a derelict Howden turbine nacelle, then returning to a different rock cave in Vasco Caves, and then nesting in a derelict Micon turbine nacelle on the east side of the Altamont Pass. Nesting sites are not static.

The nest surveys at Summit Ridge support my point that nest distributions are dynamic. Species composition of on-site nesters changed considerable between 2009 and 2016 (Northwest Wildlife Consultants 2010, 2016). Northwest Wildlife Consultants found 5 species of raptor in 2009 but only 1 species of raptor in 2016. They found twice as many red-tailed hawk nests in 2009 as they did in 2016. They reported a map of red-tailed hawk nests in 2009 that looked nothing like the map of nests in 2016; the spatial distribution had changed completely, except perhaps for underlying environmental conditions at the nest sites.

Planning a wind project layout to buffer nest sites previously mapped in one particular year – say in 2009 or 2016 – will do little to minimize impacts when nest sites of those same birds or some future generation of birds nest at different sites. A more effective approach is to map breeding sites over several years and then model nest site selection for use in micro-siting. This was how we developed an effective collision hazard model for burrowing owls in the Altamont Pass. Knowing the types of places where a particular species tends to nest is more useful than relying on a 2009 or 2016 map of nest sites. An appropriate nest site survey is needed at Summit Ridge, and it needs to be interpreted appropriately.

PREDICTING IMPACTS

The applicant is required by OAR 345-021-0010(1)(p) to provide "*information about . . . the fish and wildlife species . . . that could be affected by the proposed facility*" and is required by OAR 345-021-0010(1)(p)(F) to provide "*[a] description of the nature, extent and duration of potential adverse impacts on the [identified habitat] and [identified sensitive species] that could result from construction, operation and retirement of the proposed facility*." In addition, the Wasco County ordinance at LUDO § 19.030.C.5 requires the applicant to provide "*information pertaining to the energy facility's potential impacts and measures to avoid impacts on . . . all potential species of reasonable concern*," and this information must *"[t]ak[e] into account mitigation, siting, design, construction, and operation [of] the energy facility*."

As a first step, the proposed mitigation measures need predictions of collision fatalities per species of bird and bat. Appropriate mitigation cannot possibly be planned effectively without first knowing the potential impacts. Imagine trying to plan mitigation for impacts of a natural disaster on personal property without knowing the value of the personal property or the potential magnitude of damage caused by the disaster. The Habitat Mitigation Plan, as written, poses the same problem for birds and bats at Summit Ridge because it remains unknown how many of each species of bird and bat would be made vulnerable to wind turbine collisions, and it remains unknown how many might be killed by wind turbine collisions, collisions with transmission lines, or other elements of the project. Potential impacts are not entirely unknown, however, because impacts have been measured at other wind projects, providing a starting point for defining a range of possible outcomes.

The Baseline Study did not predict collision fatality impacts, other than to conclude that impacts would be low for every taxonomic group addressed. Northwest Wildlife Consultants (2010) compared reported fatality rates from other Pacific Northwest wind projects, but did not project the mean fatality rates from those projects to Summit Ridge – an easy and obvious step. Or was it? Although Northwest Wildlife Consultants laid out wind project attributes from which the fatality rates were drawn – such as wind turbine size, tower height, blade length and so on – they did not lay out the fatality monitoring attributes that bear on variation in estimated fatality rates. These fatality monitoring attributes can influence fatality estimates more than the true number of fatalities, and include monitoring duration search interval, inter-transect spacing, maximum search radius, carcasses used in detection trials, detection trial duration, the types and condition of trial carcasses used, and whether humans or skilled detection dogs were used as searchers (more on these attributes later, when I comment on post-construction monitoring, but also see Smallwood 2007). So to answer my earlier question, no, extrapolating reported fatality rates from Pacific Northwest wind projects to Summit Ridge is not a simple and obvious step. Reported estimates should be compared at face-value.

I took on the challenge of estimating new fatality rates from every wind project where monitoring results were publicly reported through 2012. The challenge was to obtain comparable fatality rates, using the same suite of assumptions and analytical methods for all of them. There was no way that I could remove all of the unique influences of individual studies, especially those related to carcass detection trials, but my estimates were much more comparable than the originals (Smallwood 2013). Based on wind projects where the average fatality search interval was <10 days, predicted bat fatalities at Summit Ridge is 7,620 with an upper-bound prediction of >11,000 bat fatalities (Table 2). The two sensitive species of bat in the project area for which fatality estimates existed somewhere in North America by 2012 were hoary bat and silver-haired bat, predicted to be killed by the Summit Ridge project at the rates of 527 hoary bats and 342 silver-haired bats per year. If these rates continued through 30 years of operations, the project will have killed about 15,810 hoary bats and 10,254 silver-haired bats.

Applying the 2012 national averages (Smallwood 2013) to the Summit Ridge capacity and assuming no micro-siting to minimize collision impacts, the averages predict at least 2.7 eagles per year, or at least 81 eagles after 30 years of operations. For burrowing owls the averages predict 15.4 fatalities per year, or 462 after 30 years. For all raptors the averages predict 119 per year or 3,579 after 30 years. For all birds as a group, the averages predict 1,454 fatalities per year, or 43,611 after 30 years. Relative to the biology of each taxonomic group, none of these predicted numbers are small, and all should be carefully considered. Any project beginning operations in 2023 should not rely on baseline use surveys conducted in 2009.

Table 2. *Predicted fatality rates of Oregon's and the nation's sensitive species at Summit Ridge, based on estimated mean and 90% CI fatalities/MW/year in 2012 (Smallwood 2013), and assuming 2.7-MW turbines would be installed without any careful micro-siting. I represents search interval.*

	Predicted fatalities/MW/year		
Taxa	**Mean**	**90% LB**	**90% UB**
Bats, *I* < 10 days	7,620.5	4,179.6	11,061.4
All raptors	119.3	15.4	216.5
All birds	1,453.7	24.9	2,401.2
Long-billed curlew	0.2	0.0	0.4
Bald eagle	0.2	0.0	0.0
Golden eagle	2.5	0.7	4.3
Ferruginous hawk	0.4	0.0	0.9
Swainson's hawk	1.0	0.0	1.7
Burrowing owl	15.4	0.9	25.2
Common nighthawk	4.0	0.0	6.0
Lewis's woodpecker	0.2	0.0	0.4
Grasshopper sparrow	0.4	0.0	1.0
Brewer's sparrow	1.5	0.0	2.9
Hoary bat	527.2	90.3	641.1
Silver-haired bat	341.8	41.1	330.2

Cumulative Impacts

In order to successfully analyze and prevent adverse impacts to wildlife species, cumulative impacts must be assessed. For this project, however, the most recent avian use surveys were performed in 2009. I must point out that circumstances have changed substantially since then. One changed circumstance includes USA wind energy's 2.75-fold increase in installed capacity from 35,128 MW in 2009 to 96,488 MW by 2018 (https://www.awea.org/wind-101/basics-of-wind-energy/wind-facts-at-a-glance, last accessed 14 February 2019). This increase in installed capacity has translated into an increase in cumulative effects to bats and birds, including to threatened and endangered species. Regressing installed capacity on the number of years since 2007 (2007 was the beginning of a linear increase in capacity through the present time) results in a model that predicts 131,351 MW by the requested end of project construction in 2023 ($r^2 = 1$, $P < 0.0001$). My 2012 nationwide fatality estimates (Smallwood 2013, Smallwood and Neher 2017) applied to the 2009 installed capacity and also projected to the 2023 installed capacity yields very different cumulative impacts, averaging about 3.74 times greater in 2023 than they did in 2009 (Table 3).

Table 3. *Predicted fatality rates nationwide based on estimated mean and 90% CI fatalities/MW/year in 2012 (Smallwood 2013).*

Taxa	Predicted fatalities/MW/year					
	2009			2023		
	Mean	**90% LB**	**90% UB**	**Mean**	**90% LB**	**90% UB**
All bats, I<10 days	1,377,018	755,252	1,998,783	5,148,959	2,824,047	7,473,872
All raptors	21,562	2,786	39,119	80,623	10,416	146,272
All birds	262,677	4,503	433,894	982,203	16,839	1,622,421
Long-billed curlew	35	0	70	131	0	263
Bald eagle	32	0	0	118	0	0
Golden eagle	457	119	773	1,708	447	2,890
Ferruginous hawk	70	0	162	263	0	604
Swainson's hawk	179	0	316	670	0	1,182
Burrowing owl	2,779	155	4,549	10,390	578	17,010
Common nighthawk	717	0	1,092	2,680	0	4,085
Lewis's woodpecker	28	0	70	105	0	263
Grasshopper sparrow	77	0	190	289	0	709
Brewer's sparrow	270	0	520	1,011	0	1,944
Hoary bat	95,260	16,317	115,838	356,198	61,013	433,143
Silver-haired bat	61,762	7,423	59,675	230,941	27,754	223,139

The small bird predictions in Tables 2 and 3 are probably biased low due to the preponderance of fatality search intervals being longer than what was appropriate for small birds, resulting in too many false-zero estimates (see Smallwood 2018). The bat predictions are also likely biased low for having used human searchers instead of dogs. In a recent study my colleagues and I found 73 bats at wind turbines using dogs where concurrent searches by humans found 1 bat over the same search areas, during the same time period, and at nearly the same search intervals (Attachment 1). This stunning result calls into question most of the bat fatality estimates in the USA, and indicates the very large predictions in Table 2 are too low. Even assuming the predictions are accurate, an annual toll of more than 5 million bats would qualify wind energy as by far the greatest mortality source for bats, begging the question of whether ongoing impacts are sustainable. These are the changed circumstances facing Summit Ridge, given the proposed several years of delay in project startup. The analysis performed in 2010 (based on 2009 data) is obsolete and cannot apply to the situation in 2023.

Much has changed since 2010, including our understanding of the magnitudes of impacts and whether certain mitigation measures are effective. For example, the US Fish and Wildlife Service (2013) projected a 35% reduction in national eagle numbers due to wind energy impacts. Eagles are protected by the federal Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act, as well as the Wasco County Ordinance at LUDO § 19.030.C.5. The US Fish and Wildlife Service's acknowledgement of a highly significant cumulative impact qualifies as an important changed circumstance in which any wind project starting several years hence needs to be considered.

In another example of changed circumstances, when I was a member of the Alameda County Scientific Review Committee (SRC) overseeing fatality monitoring and mitigation strategies in the Altamont Pass Wind Resource Area from 2006 through 2011, the 5 of us on the SRC concurred that bat fatalities were not an issue in the Altamont Pass, because our human searchers monitoring at >40-day intervals were turning up about 1 bat fatality per year. After leaving the SRC in 2011, I initiated fatality monitoring in 2012 with much shorter search intervals at two wind projects in the Altamont Pass, and searchers started finding many more bats per year. When we initiated monitoring using skilled scent-detection dogs as fatality searchers in 2017, discoveries of bat fatalities escalated to the example I cited above – 73 bat fatality discoveries using dogs, versus 1 bat fatality using humans. A startup of Summit Ridge four years hence should not rely on what was known about bat and bird fatalities in 2010.

Related to the above example of how outdated understanding of the issues translate into poorly-founded policy, the Alameda County Programmatic Environmental Impact Report established a threshold bat fatality rate of 1.3 bats/MW/year, exceedance of which would result in mitigation to reduce or offset impacts. This fatality rate had been estimated by dividing the number of bats found during the first year of monitoring at the repowered Vasco Winds Energy Project by national averages for searcher detection and carcass persistence rates of bats placed in detection trials at wind projects across the USA and Canada. I used these national averages (reported in Smallwood 2013) in the first-year monitoring report for Vasco Winds because I lacked results based on sufficient sample sizes from my new integrated detection trials (Smallwood et al. 2018). The new integrated trials avoided the large sources of error and bias that were suspected and increasingly demonstrated in conventional detection trials (Smallwood 2007, Smallwood et al. 2010, 2013, 2018). County of Alameda relied on that first-year result from Vasco Winds as its mitigation threshold going forward, even though I warned the County that my new integrated detection trials were beginning to show that the fatality estimate based on national averages for searcher detection and carcass persistence was biased low. County of Alameda established a threshold that is now grossly exceeded by every wind project repowered in the Altamont Pass. The repowered Golden Hills project is killing bats at 5 times the County's threshold level. Perhaps the outdated information helped justify the County's decision to permit repowering projects in the Altamont Pass, but it did not prevent the impacts we are seeing borne out by the projects today, and it set in place an untenable mitigation threshold. Our understanding of the magnitude of the collision problems and what to do about them has been changing quickly; analysis from 2010 (based on 2009 data) is grossly outdated.

IMPACT AVOIDANCE, REDUCTION, AND MITIGATION

The applicant is required by OAR 345-021-0010(1)(p)(G) to provide "*a description of any measures proposed by the applicant to avoid, reduce, or mitigate the potential* *adverse impacts described [pursuant to OAR 345-021-0010(1)(p)(F)] in accordance with the general fish and wildlife habitat mitigation goals and standards described in OAR 635-415-0025 . . . , and a discussion of how the proposed measures would achieve those goals and requirements*." In addition, the Council is required to evaluate the "*design, construction and operation of the facility, taking into account mitigation*" in determining compliance with OAR 345-022-0060(1) and OAR 345-022-0070(2).

For its part, the Wasco County ordinance at LUDO § 19.030.C.5 requires the Council to "*tak[e] into account mitigation, siting, design, construction, and operation [of] the energy facility*" in order to ultimately ensure that the facility "*will not cause significant adverse impact to important or significant natural resources*," and authorizes the Council to require "*monitoring and mitigation actions that [the Council] determines appropriate*." The applicant is also required by LUDO § 19.030.C.5.a to provide "*information pertaining to the energy facility's potential impacts and measures to avoid impacts*" and is required by LUDO § 19.030.C.5.c to "*[s]elect locations to reduce the likelihood of significant adverse impacts on natural resources based on expert analysis of baseline data*."

The application materials do not update the impact avoidance, reduction, and mitigation proposals to incorporate current baseline data, current science, and current technologies, including the latest micro-siting strategies. Very few projects through 2010 carefully micro-sited wind turbines to minimize collision fatalities. At that time, 'use' survey data, which were actually visual-scan point counts, were never suited for micro-siting without first mapping the positions of birds over the landscape, and then developing and later projecting predictive models of bird flights relative to the terrain (Smallwood 2018). Most use survey efforts were too coarse-grained in spatial resolution to inform how a wind turbine layout might affect birds. An early attempt to micro-site turbines was a project built by Babcock and Brown, from which Pattern Energy emerged as a company. I contracted with Babcock and Brown and later Pattern Energy to first advise on the turbine layout of the Buena Vista repowering project in the Altamont Pass and then to assess performance.

For micro-siting Buena Vista, I relied on behavior data I had been collecting in the Altamont Pass, rather than 'use' data, and I also relied on what I had already learned about fatality patterns relative to wind turbine locations on the landscape. I recommended that wind turbines not be installed on ridge saddles or breaks in slope, and I recommended that two wind turbines on either side of a deep ravine be mounted on towers that were 10 m taller than the rest. These recommendations were documented in the project's Environmental Impact Report (Lamphier-Gregory et al. 2005). The California Attorney General intervened when it concluded that the constructed project differed from the layout that was promised in the EIR by placing some turbines on towers that were too short and by installing some turbines on ridge saddles and breaks in slope. A settlement was negotiated for compensatory mitigation and new threshold fatality rates that would determine whether the company would be permitted to develop another repowered wind project in the Altamont Pass.

Subsequently, following post-construction monitoring, I learned that of the golden eagles and red-tailed hawks that I am aware were killed by the project, all but one red-tailed hawk were killed by wind turbines I had predicted would be more hazardous. Most of these fatalities were at wind turbines on ridge saddles and breaks in slope, and 2 of the golden eagle fatalities were at one of the turbines straddling the deep ravine that concerned me during the planning stage. Micro-siting based on behavior patterns and fatality patterns proved effective at Buena Vista – the proof coming from our ability to measure outcomes at a project that had not fully adhered to the micro-siting strategy.

Following that effort, I developed collision hazard models based on more intensive behavior survey data and more fatality data, and I used these models to recommend the layout of the repowered Vasco Winds Energy Project in 2011. I felt that the company listened well to my recommendations at Vasco Winds. After three years of post-construction monitoring, I had the opportunity to compare fatality rates in a before-after, control-impact (BACI) experimental design. The results included fatality reductions from the earlier wind project on the site by 75% to 82% for golden eagle, 34% to 47% for red-tailed hawk, 48% to 57% for American kestrels and 45% to 59% for burrowing owls (Brown et al. 2016). Annual fatality rates were reduced between 56% and 65% for all raptors combined, and 64% to 66% for all birds combined.

Since the Vasco Winds effort, I collected bird behavior data from 2011 through the present, as well as fatality data and golden eagle telemetry data (with Doug Bell as the lead investigator of the telemetry study). I also learned from earlier micro-siting surprises and mistakes, each one improving our understanding of collision factors and how to address them.

Our basis for micro-siting to minimize collision impacts is not the same in 2019 as it was in 2005 (Buena Vista) or 2010 (Vasco Winds). Instead, it is vastly improved. Any project planned to begin operations in 2023 should not rely on 'use' data collected in 2009, especially without appropriately analyzing those data to predict collision hazards posed by the turbine layout.

Although landscape-based collision hazard models have yet to be developed for bats, we have sufficient information to begin the process. We have sufficient fatality data, and we have 940 hours of behavior data around wind turbines using a thermal-imaging camera fit with a telephoto lens. Research on bat behaviors around wind turbines have added greatly to our understanding of the problem (Kunz et al. 2007, Horn et al. 2008, Cryan et al. 2014), as has the use of skilled detection dogs to find bats around wind turbines (Smallwood et al. unpublished data in preparation).

A micro-siting strategy to minimize bird and bat collision risk is needed at Summit Ridge (and this strategy must be part of the application materials, to be reviewed by the Council as part of its decision on the pending construction extensions). Micro-siting in this case would be additional to the micro-siting for engineering requirements discussed in the proposed order. It would be additional to the certificate holder's obligation "*to satisfy pre-construction survey requirements for fish and wildlife habitat (Condition*

10.7) and potential historic, cultural and archeological resources (Condition 11.3) in areas within the micrositing corridor…" The micro-siting strategy to which I refer is the shifting of wind turbine locations to avoid terrain or environmental conditions (e.g., copses of trees or ponds) that are heavily trafficked by flying birds and bats and that will contribute to disproportionately greater numbers of collision fatalities. This micro-siting strategy has been used at other wind projects. No other mitigation method has proven effective for minimizing or reducing bird collision impacts at wind projects.

For bats, the most effective strategy – the only effective strategy so far – has been operational curtailment. Operational curtailment typically involves a small increase in wind turbine cut-in speed, although it can also be guided by an algorithm that considers season of the year, time of night, and wind speed, among other variables. Generally, studies have documented about a 50% reduction in bat fatalities for a fractional percentage loss of wind generation.

A substantial fund needs to be committed for donation to wildlife rehabilitation facilities. Fatality searchers and wind project neighbors too often encounter injured birds and bats, which are often delivered to wildlife hospitals for treatment. Release rates from rehabilitation facilities tend to be low, partly due to the nature of wind turbine collision injuries and partly due to insufficient funds for maintaining facilities and keeping staff. Any new wind project should donate funds to cover the impacts of injured animals.

<u>Preconstruction surveys</u>

The proposed order's Condition 10.7 requires preconstruction surveys for wildlife within the micro-siting corridor. Elsewhere these types of surveys are referred to as "take-avoidance surveys" and are intended to find and relocate special-status species of animals or plants in jeopardy of being crushed by the heavy machinery of project construction. In her 19 February 2019 email to Luke May, Linnea Fossum of Tetra Tech confirms her understanding of the required survey is that they are indeed preconstruction, take-avoidance surveys. These surveys compose a sensible last-minute effort to salvage the readily salvageable biological resources on a project site, but they are no substitute for detection surveys. Preconstruction surveys are more effective when informed by detection surveys, which are surveys of sufficient rigor that absence determinations can be justified if no members of the target species are found. Species experts have prepared detection survey protocols or guidelines for most special-status species. Using these protocols typically requires more time and effort than is available for preconstruction surveys, but they are helpful to preconstruction surveys by prioritizing where preconstruction surveys can be most productive and by informing appropriate compensatory mitigation.

I recommend revising Condition 10.7 so that it clearly states the purpose and objectives of preconstruction surveys. I also recommend requiring the completion of detection surveys prior to preconstruction surveys, and that these detection surveys extend to the 400-foot boundaries as specified in Condition 10.7. The baseline study included few if any true detection surveys, and by construction startup too much time will have passed since the baseline study. Preconstruction surveys should be informed by detection surveys.

POST-CONSTRUCTION MONITORING

The applicant is required by OAR 345-021-0010(p)(H) to provide "*[a] description of the applicant's proposed monitoring plans to evaluate the success of the measures [for avoiding, reducing, or mitigating wildlife impacts] described*" under OAR 345-021-0010(p)(G)," and is required by OAR 345-021-0010(q)(G) to provide a "*proposed monitoring program . . . for impacts to threatened and endangered species*." Similarly, the Wasco County ordinance at LUDO § 19.030.C.5.k requires the applicant to provide "*a plan for post-construction monitoring of the facility site using appropriate survey protocols to measure the impact of the project on identified natural resources in the area*" (the citation in the Wasco ordinance is LUDO § 19.030.C.5.j(3), but given the grammatical context of this ordinance, this provision was probably intended to be placed at LUDO § 19.030.C.5.k).

Perhaps the strongest contribution that use surveys can bring to wind project impact assessments is in their repetition before and after construction. Use surveys are suited for measuring relative abundance of readily visible diurnal birds, so performing them before and after a wind project is built and operational can inform of changes in relative abundance. Whether any such changes can be attributed to the wind project however, requires the control of variation in an experimental design (Sinclair and DeGeorge 2016). The Habitat Mitigation Plan ought to be revised by informing it with additional use surveys prior to construction, and by informing of impacts by formulating a post-construction use-survey effort. Both the before and after survey efforts should be designed with experimental design tenets in mind.

Northwest Wildlife Consultants (2010) proposed methods for fatality monitoring – methods which surely should not be implemented in 2019, nor in 2023. Since 2010, we have learned a great deal about sources of uncertainty, biases and methodological efficacy related to fatality monitoring used to estimate fatality rates. The Habitat Mitigation Plan needs to be revised accordingly. Below are specific recommendations for improving post-construction fatality monitoring at Summit Ridge:

- Fatality searches need to be performed using skilled detection dogs (see Attachment 1).

- The proposed fatality search interval is too long, at 23 days. It has been well established that search intervals longer than 10 days are too long.

- The proposed monitoring duration is too brief at one year per turbine. A single year of fatality monitoring cannot possibly inform of inter-annual variation in fatality rates. Three years should be the minimum.

- The maximum search radius is too short, at a distance equal to the height above ground of the blade tip in the 12:00 position. Smallwood et al. (2018) established that this distance would be insufficient. The maximum search radius needs to be 160 m.

- The carcass persistence trials will bias the adjustment factor due to use of two body-size categories and placement of carcasses outside the fatality search plots where scavengers will not be searching for them. Integrated carcass detection trials are what is needed going forward. See Smallwood et al. (2018) for specific details.

- The searcher efficiency trials will be biased by placing carcasses in search areas just prior to fatality searches. Fatality searchers need to be tested on bird and bat carcasses that have weathered the environment at the same times and duration as carcasses of wind turbine fatalities. Integrated detection trials are what is needed.

- A searcher's pacing in meters per minute should not be specified in a fatality monitoring protocol. The searchers need to use whatever pace suits the situation, and however much time suits the conditions within the maximum search radius of the turbine.

- The protocol for handling incidental finds also needs to be updated to include all incidental fatality detections in the fatality estimate.

- Injured animals should be counted as fatalities, and if a particular animal cannot be associated with a specific turbine due to mobility of the injured animal, then it should be assigned to the project.

- The proposed use of mean days to carcass removal needs to be replaced with the proportion of carcasses found in integrated detection trials. Mean days to carcass removal is known to bias fatality estimates lower the longer the trial lasts (Smallwood et al. 2013, 2018).

- It should be specified that clearing searches will not be performed, and all found carcasses should be left in the field as found in order to avoid altering scavenger dynamics. The results of fatality monitoring should represent conditions typical of when there will be no fatality monitoring.

- There should be a specified threshold searcher detection rate, below which searchers (dogs or humans) need to be replaced.

- During the year preceding construction, fatality monitoring should commence to quantify background mortality.

- Northwest Wildlife Consultants (2010) proposes fatality rates serving as thresholds of concern, above which mitigation would be implemented. These thresholds need to be species-specific and agreed-upon with state and federal regulators; consultants should not be in the business of deciding which level of mortality is of concern. As is, the thresholds assigned to broad vegetation cover types are vague and unenforceable, as species can be reassigned to some other cover type to prevent threshold exceedance of any particular cover type.

- Data reporting needs to be to public, and not just to ODOE. A critical attribute of the scientific method is transparency, so all results need to be made available to the public.

In addition to the fatality monitoring measures, post-construction monitoring of relative abundance and behaviors is needed. The way to quantify habitat impacts via displacement is to compare use rates and behavior rates before and after wind turbine construction. The same needs to be done for bats using either acoustic detectors or thermal-imaging cameras, or both. These post-construction monitoring methods need to be tied to preconstruction monitoring methods using experimental design tenets, ensuring that objectives can be met (Sinclair and DeGeorge 2016). Also, additional mitigation options need to be identified prior to construction, and these measures need to be tied to threshold outcomes of post-construction monitoring. Such measures might include wind turbine removals or increased operational curtailment, or provision of additional compensatory funds or habitat protections.

SUMMARY OF COMMENTS

Pattern Energy's request for extensions of the construction deadlines for the Summit Ridge Wind Farm was submitted with an amended Habitat Mitigation Plan (January 2019) and Pattern's responses to EFSC standards. I commented on (1) the suitability of the habitat assessment underlying the amended Habitat Mitigation Plan, and (2) the need to update baseline surveys, project impact predictions, mitigation measures, and post-construction monitoring protocols. I found that the habitat assessment was based on a conveniently invented characterization of wildlife habitat that does not find its origin in wildlife ecology and that is inconsistent with the definition of habitat in OAR 635-415-0005. Habitat analysis is needed for each species, separately, and in the context of a wind project it needs to include displacement effects of wind turbines.

The most recent avian use surveys and bat detection surveys at the proposed Summit Ridge site were performed in 2009. In the decade since those surveys, much has been learned about the strengths and weaknesses of methods used in the baseline study (Northwest Wildlife Consultants 2010) and in the proposed post-construction fatality monitoring plan. To be consistent with the applicable law and management guidance, the baseline study needs to be updated. Use surveys are needed at the level of effort recommended by the US Fish and Wildlife Service. Behavior surveys are needed for micro-siting to minimize collision impacts. Bat surveys are needed at many more stations across the project area and at heights above ground that are relevant to wind turbine impacts. All measured variables and metrics need to be reported to scientific standards, including error terms and assessments of potential biases. Impact predictions are needed that are based on careful interpretation of impacts measured at other wind projects, and this interpretation needs to account for the biases and sources of uncertainty that have been quantified since 2010. Of critical importance is the need for a cumulative effects analysis, given the >3-fold increase in USA installed wind energy capacity since this project was initially proposed and the fatality impacts that have accompanied this increase.

I recommended wind turbine micro-siting to minimize collision impacts of birds and bats because, incredibly, no such effort has yet occurred at the Summit Ridge site. Careful micro-siting has been found to substantially reduce raptor fatality rates at repowered wind projects in the APWRA, so we know it works. Besides careful micro-siting to minimize collision impacts of both birds and bats, operational curtailment needs to be formulated as a mitigation measure, and funds need to be committed for wildlife rehabilitation facilities to care for injured wildlife. I also recommended a suite of improvements to the proposed post-construction fatality monitoring, most importantly the use of skilled detection dogs as fatality searchers, a much shorter search interval than proposed, and longer duration.

Thank you for your attention,

____
Shawn Smallwood, Ph.D.

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ERRATA SHEET

The following corrections apply to the comments of Shawn Smallwood, PhD (21 February 2019):

1. On page 32, Table 2, the table heading "Predicted fatalities/MW/year" is corrected to read "Predicted fatalities/year."
2. On page 33, Table 3, the table heading "Predicted fatalities/MW/year" is corrected to read "Predicted fatalities/year."

Kenneth Shawn Smallwood
Curriculum Vitae

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Born May 3, 1963 in
Sacramento, California.
Married, father of two.

Ecologist

Expertise

- Finding solutions to controversial problems related to wildlife interactions with human industry, infrastructure, and activities;
- Wildlife monitoring and field study using GPS, thermal imaging, behavior surveys;
- Using systems analysis and experimental design principles to identify meaningful ecological patterns that inform management decisions.

Education

Ph.D. Ecology, University of California, Davis. September 1990.
M.S. Ecology, University of California, Davis. June 1987.
B.S. Anthropology, University of California, Davis. June 1985.
Corcoran High School, Corcoran, California. June 1981.

Experience

- 480 professional publications, including:
- 83 peer reviewed publications
- 24 in non-reviewed proceedings
- 371 reports, declarations, posters and book reviews
- 8 in mass media outlets
- 87 public presentations of research results

Editing for scientific journals: Guest Editor, *Wildlife Society Bulletin*, 2012-2013, of invited papers representing international views on the impacts of wind energy on wildlife and how to mitigate the impacts. Associate Editor, *Journal of Wildlife Management*, March 2004 to 30 June 2007. Editorial Board Member, *Environmental Management*, 10/1999 to 8/2004. Associate Editor, *Biological Conservation*, 9/1994 to 9/1995.

Member, Alameda County Scientific Review Committee (SRC), August 2006 to April 2011. The five-member committee investigated causes of bird and bat collisions in the Altamont Pass Wind Resource Area, and recommended mitigation and monitoring measures. The SRC reviewed the science underlying the Alameda County Avian Protection Program, and advised the County on how to reduce wildlife fatalities.

Consulting Ecologist, 2004-2007, California Energy Commission (CEC). Provided consulting services as needed to the CEC on renewable energy impacts, monitoring and research, and produced several reports. Also collaborated with Lawrence-Livermore National Lab on research to understand and reduce wind turbine impacts on wildlife.

Consulting Ecologist, 1999-2013, U.S. Navy. Performed endangered species surveys, hazardous waste site monitoring, and habitat restoration for the endangered San Joaquin kangaroo rat, California tiger salamander, California red-legged frog, California clapper rail, western burrowing owl, salt marsh harvest mouse, and other species at Naval Air Station Lemoore; Naval Weapons Station, Seal Beach, Detachment Concord; Naval Security Group Activity, Skaggs Island; National Radio Transmitter Facility, Dixon; and, Naval Outlying Landing Field Imperial Beach.

Part-time Lecturer, 1998-2005, California State University, Sacramento. Instructed Mammalogy, Behavioral Ecology, and Ornithology Lab, Contemporary Environmental Issues, Natural Resources Conservation.

Senior Ecologist, 1999-2005, BioResource Consultants. Designed and implemented research and monitoring studies related to avian fatalities at wind turbines, avian electrocutions on electric distribution poles across California, and avian fatalities at transmission lines.

Chairman, Conservation Affairs Committee, The Wildlife Society--Western Section, 1999-2001. Prepared position statements and led efforts directed toward conservation issues, including travel to Washington, D.C. to lobby Congress for more wildlife conservation funding.

Systems Ecologist, 1995-2000, Institute for Sustainable Development. Headed ISD’s program on integrated resources management. Developed indicators of ecological integrity for large areas, using remotely sensed data, local community involvement and GIS.

Associate, 1997-1998, Department of Agronomy and Range Science, University of California, Davis. Worked with Shu Geng and Mingua Zhang on several studies related to wildlife interactions with agriculture and patterns of fertilizer and pesticide residues in groundwater across a large landscape.

Lead Scientist, 1996-1999, National Endangered Species Network. Informed academic scientists and environmental activists about emerging issues regarding the Endangered Species Act and other environmental laws. Testified at public hearings on endangered species issues.

Ecologist, 1997-1998, Western Foundation of Vertebrate Zoology. Conducted field research to determine the impact of past mercury mining on the status of California red-legged frogs in Santa Clara County, California.

Senior Systems Ecologist, 1994-1995, EIP Associates, Sacramento, California. Provided consulting services in environmental planning, and quantitative assessment of land units for their conservation and restoration opportunities basedon ecological resource requirements of 29 special-status species. Developed ecological indicators for prioritizing areas within Yolo County to receive mitigation funds for habitat easements and restoration.

Post-Graduate Researcher, 1990-1994, Department of Agronomy and Range Science, *U.C. Davis*. Under Dr. Shu Geng's mentorship, studied landscape and management effects on temporal and spatial patterns of abundance among pocket gophers and species of Falconiformes and Carnivora in the Sacramento Valley. Managed and analyzed a data base of energy use in California agriculture. Assisted with landscape (GIS) study of groundwater contamination across Tulare County, California.

Work experience in graduate school: Co-taught Conservation Biology with Dr. Christine Schonewald, 1991 & 1993, UC Davis Graduate Group in Ecology; Reader for Dr. Richard Coss's course on Psychobiology in 1990, UC Davis Department of Psychology; Research Assistant to Dr. Walter E. Howard, 1988-1990, UC Davis Department of Wildlife and Fisheries Biology, testing durable baits for pocket gopher management in forest clearcuts; Research Assistant to Dr. Terrell P. Salmon, 1987-1988, UC Wildlife Extension, Department of Wildlife and Fisheries Biology, developing empirical models of mammal and bird invasions in North America, and a rating system for priority research and control of exotic species based on economic, environmental and human health hazards in California. Student Assistant to Dr. E. Lee Fitzhugh, 1985-1987, UC Cooperative Extension, Department of Wildlife and Fisheries Biology, developing and implementing statewide mountain lion track count for long-term monitoring.

Fulbright Research Fellow, Indonesia, 1988. Tested use of new sampling methods for numerical monitoring of Sumatran tiger and six other species of endemic felids, and evaluated methods used by other researchers.

Projects

Repowering wind energy projects through careful siting of new wind turbines using map-based collision hazard models to minimize impacts to volant wildlife. Funded by wind companies (principally NextEra Renewable Energy, Inc.), California Energy Commission and East Bay Regional Park District, I have collaborated with a GIS analyst and managed a crew of five field biologists performing golden eagle behavior surveys and nocturnal surveys on bats and owls. The goal is to quantify flight patterns for development of predictive models to more carefully site new wind turbines in repowering projects. Focused behavior surveys began May 2012 and continue. Collision hazard models have been prepared for seven wind projects, three of which were built. Planning for additional repowering projects is underway.

Test avian safety of new mixer-ejector wind turbine (MEWT). Designed and implemented a before-after, control-impact experimental design to test the avian safety of a new, shrouded wind turbine developed by Ogin Inc. (formerly known as FloDesign Wind Turbine Corporation). Supported by a $718,000 grant from the California Energy Commission's Public Interest Energy Research program and a 20% match share contribution from Ogin, I managed a crew of seven field biologists who performed periodic fatality searches and behavior surveys, carcass detection trials, nocturnal behavior surveys using a thermal camera, and spatial analyses with the collaboration of a GIS analyst. Field work began 1 April 2012 and ended 30 March 2015 without Ogin installing its MEWTs, but we still achieved multiple important scientific advances.

Reduce avian mortality due to wind turbines at Altamont Pass. Studied wildlife impacts caused by 5,400 wind turbines at the world's most notorious wind resource area. Studied how impacts are perceived by monitoring and how they are affected by terrain, wind patterns, food resources, range management practices, wind turbine operations, seasonal patterns, population cycles, infrastructure management such as electric distribution, animal behavior and social interactions.

Reduce avian mortality on electric distribution poles. Directed research toward reducing bird electrocutions on electric distribution poles, 2000-2007. Oversaw 5 founds of fatality searches at 10,000 poles from Orange County to Glenn County, California, and produced two large reports.

Cook *et al*. v. Rockwell International *et al*., No. 90-K-181 (D. Colorado). Provided expert testimony on the role of burrowing animals in affecting the fate of buried and surface-deposited radioactive and hazardous chemical wastes at the Rocky Flats Plant, Colorado. Provided expert reports based on four site visits and an extensive document review of burrowing animals. Conducted transect surveys for evidence of burrowing animals and other wildlife on and around waste facilities. Discovered substantial intrusion of waste structures by burrowing animals. I testified in federal court in November 2005, and my clients were subsequently awarded a $553,000,000 judgment by a jury. After appeals the award was increased to two billion dollars.

Hanford Nuclear Reservation Litigation. Provided expert testimony on the role of burrowing animals in affecting the fate of buried radioactive wastes at the Hanford Nuclear Reservation, Washington. Provided three expert reports based on three site visits and extensive document review. Predicted and verified a certain population density of pocket gophers on buried waste structures, as well as incidence of radionuclide contamination in body tissue. Conducted transect surveys for evidence of burrowing animals and other wildlife on and around waste facilities. Discovered substantial intrusion of waste structures by burrowing animals.

Expert testimony and declarations on proposed residential and commercial developments, gas-fired power plants, wind, solar and geothermal projects, water transfers and water transfer delivery systems, endangered species recovery plans, Habitat Conservation Plans and Natural Communities Conservation Programs. Testified before multiple government agencies, Tribunals, Boards of Supervisors and City Councils, and participated with press conferences and depositions. Prepared expert witness reports and court declarations, which are summarized under Reports (below).

Protocol-level surveys for special-status species. Used California Department of Fish and Wildlife and US Fish and Wildlife Service protocols to search for California red-legged frog, California tiger salamander, arroyo southwestern toad, blunt-nosed leopard lizard, western pond turtle, giant kangaroo rat, San Joaquin kangaroo rat, San Joaquin kit fox, western burrowing owl, Swainson's hawk, Valley elderberry longhorn beetle and other special-status species.

Conservation of San Joaquin kangaroo rat. Performed research to identify factors responsible for the decline of this endangered species at Lemoore Naval Air Station, 2000-2013, and implemented habitat enhancements designed to reverse the trend and expand the population.

Impact of West Nile Virus on yellow-billed magpies. Funded by Sacramento-Yolo Mosquito and Vector Control District, 2005-2008, compared survey results pre- and post-West Nile Virus epidemic for multiple bird species in the Sacramento Valley, particularly on yellow-billed magpie and American crow due to susceptibility to WNV.

Workshops on HCPs. Assisted Dr. Michael Morrison with organizing and conducting a 2-day workshop on Habitat Conservation Plans, sponsored by Southern California Edison, and another 1-day workshop sponsored by PG&E. These Workshops were attended by academics, attorneys, and consultants with HCP experience. We guest-edited a Proceedings published in Environmental Management.

Mapping of biological resources along Highways 101, 46 and 41. Used GPS and GIS to delineate vegetation complexes and locations of special-status species along 26 miles of highway in San Luis Obispo County, 14 miles of highway and roadway in Monterey County, and in a large area north of Fresno, including within reclaimed gravel mining pits.

GPS mapping and monitoring at restoration sites and at Caltrans mitigation sites. Monitored the success of elderberry shrubs at one location, the success of willows at another location, and the response of wildlife to the succession of vegetation at both sites. Also used GPS to monitor the response of fossorial animals to yellow star-thistle eradication and natural grassland restoration efforts at Bear Valley in Colusa County and at the decommissioned Mather Air Force Base in Sacramento County.

Mercury effects on Red-legged Frog. Assisted Dr. Michael Morrison and US Fish and Wildlife Service in assessing the possible impacts of historical mercury mining on the federally listed California red-legged frog in Santa Clara County. Also measured habitat variables in streams.

Opposition to proposed No Surprises rule. Wrote a white paper and summary letter explaining scientific grounds for opposing the incidental take permit (ITP) rules providing ITP applicants and holders with general assurances they will be free of compliance with the Endangered Species Act once they adhere to the terms of a "properly functioning HCP." Submitted 188 signatures of scientists and environmental professionals concerned about No Surprises rule US Fish and Wildlife Service, National Marine Fisheries Service, all US Senators.

Natomas Basin Habitat Conservation Plan alternative. Designed narrow channel marsh to increase the likelihood of survival and recovery in the wild of giant garter snake, Swainson's hawk and Valley Elderberry Longhorn Beetle. The design included replication and interspersion of treatments for experimental testing of critical habitat elements. I provided a report to Northern Territories, Inc.

Assessments of agricultural production system and environmental technology transfer to China. Twice visited China and interviewed scientists, industrialists, agriculturalists, and the Directors of the Chinese Environmental Protection Agency and the Department of Agriculture to assess the need and possible pathways for environmental clean-up technologies and trade opportunities between the US and China.

Yolo County Habitat Conservation Plan. Conducted landscape ecology study of Yolo County to spatially prioritize allocation of mitigation efforts to improve ecosystem functionality within the

County from the perspective of 29 special-status species of wildlife and plants. Used a hierarchically structured indicators approach to apply principles of landscape and ecosystem ecology, conservation biology, and local values in rating land units. Derived GIS maps to help guide the conservation area design, and then developed implementation strategies.

Mountain lion track count. Developed and conducted a carnivore monitoring program throughout California since 1985. Species counted include mountain lion, bobcat, black bear, coyote, red and gray fox, raccoon, striped skunk, badger, and black-tailed deer. Vegetation and land use are also monitored. Track survey transect was established on dusty, dirt roads within randomly selected quadrats.

Sumatran tiger and other felids. Upon award of Fulbright Research Fellowship, I designed and initiated track counts for seven species of wild cats in Sumatra, including Sumatran tiger, fishing cat, and golden cat. Spent four months on Sumatra and Java in 1988, and learned Bahasa Indonesia, the official Indonesian language.

Wildlife in agriculture. Beginning as post-graduate research, I studied pocket gophers and other wildlife in 40 alfalfa fields throughout the Sacramento Valley, and I surveyed for wildlife along a 200 mile road transect since 1989 with a hiatus of 1996-2004. The data are analyzed using GIS and methods from landscape ecology, and the results published and presented orally to farming groups in California and elsewhere. I also conducted the first study of wildlife in cover crops used on vineyards and orchards.

Agricultural energy use and Tulare County groundwater study. Developed and analyzed a data base of energy use in California agriculture, and collaborated on a landscape (GIS) study of groundwater contamination across Tulare County, California.

Pocket gopher damage in forest clear-cuts. Developed gopher sampling methods and tested various poison baits and baiting regimes in the largest-ever field study of pocket gopher management in forest plantations, involving 68 research plots in 55 clear-cuts among 6 National Forests in northern California.

Risk assessment of exotic species in North America. Developed empirical models of mammal and bird species invasions in North America, as well as a rating system for assigning priority research and control to exotic species in California, based on economic, environmental, and human health hazards.

Peer Reviewed Publications

Smallwood, K. S. and M. L. Morrison. 2018. Nest-site selection in a high-density colony of burrowing owls. Journal of Raptor Research 52:454-470.

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.

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. 2017. 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.

May, R., Gill, A. B., Köppel, J. Langston, R. H.W., Reichenbach, M., Scheidat, M., Smallwood, S., Voigt, C. C., Hüppop, O., and Portman, M. 2017. Future research directions to reconcile wind turbine–wildlife interactions. Pages 255-276 in Köppel, J., Editor, Wind Energy and Wildlife Impacts: Proceedings from the CWW2015 Conference. Springer. Cham, Switzerland.

Smallwood, K. S. 2017. Monitoring birds. M. Perrow, Ed., Wildlife and Wind Farms - Conflicts and Solutions, Volume 2. Pelagic Publishing, Exeter, United Kingdom. www.bit.ly/2v3cR9Q

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Johnson, D. H., S. R. Loss, K. S. Smallwood, W. P. Erickson. 2016. Avian fatalities at wind energy facilities in North America: A comparison of recent approaches. Human–Wildlife Interactions 10(1):7-18.

Sadar, M. J., D. S.-M. Guzman, A. Mete, J. Foley, N. Stephenson, K. H. Rogers, C. Grosset, K. S. Smallwood, J. Shipman, A. Wells, S. D. White, D. A. Bell, and M. G. Hawkins. 2015. Mange Caused by a novel Micnemidocoptes mite in a Golden Eagle (*Aquila chrysaetos*). Journal of Avian Medicine and Surgery 29(3):231-237.

Smallwood, K. S. 2015. Habitat fragmentation and corridors. Pages 84-101 in M. L. Morrison and H. A. Mathewson, Eds., Wildlife habitat conservation: concepts, challenges, and solutions. John Hopkins University Press, Baltimore, Maryland, USA.

Mete, A., N. Stephenson, K. Rogers, M. G. Hawkins, M. Sadar, D. Guzman, D. A. Bell, J. Shipman, A. Wells, K. S. Smallwood, and J. Foley. 2014. Emergence of Knemidocoptic mange in wild Golden Eagles (Aquila chrysaetos) in California. Emerging Infectious Diseases 20(10):1716-1718.

Smallwood, K. S. 2013. Introduction: Wind-energy development and wildlife conservation. Wildlife Society Bulletin 37: 3-4.

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., L. Neher, J. Mount, and R. C. E. Culver. 2013. Nesting Burrowing Owl Abundance in the Altamont Pass Wind Resource Area, California. Wildlife Society Bulletin: 37:787-795.

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.

Bell, D. A., and K. S. Smallwood. 2010. Birds of prey remain at risk. Science 330:913.

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., 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. and B. Nakamoto. 2009. Impacts of West Nile Virus Epizootic on Yellow-Billed Magpie, American Crow, and other Birds in the Sacramento Valley, California. The Condor 111:247-254.

Smallwood, K. S., L. Rugge, and M. L. Morrison. 2009. 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. 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.

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Smallwood, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.

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.

Cain, J. W. III, K. S. Smallwood, M. L. Morrison, and H. L. Loffland. 2005. Influence of mammal activity on nesting success of Passerines. J. Wildlife Management 70:522-531.

Smallwood, K.S. 2002. Habitat models based on numerical comparisons. Pages 83-95 *in* Predicting species occurrences: Issues of scale and accuracy, J. M. Scott, P. J. Heglund, M. Morrison, M. Raphael, J. Haufler, and B. Wall, editors. Island Press, Covello, California.

Morrison, M. L., K. S. Smallwood, and L. S. Hall. 2002. Creating habitat through plant relocation: Lessons from Valley elderberry longhorn beetle mitigation. Ecological Restoration 21: 95-100.

Zhang, M., K. S. Smallwood, and E. Anderson. 2002. Relating indicators of ecological health and integrity to assess risks to sustainable agriculture and native biota. Pages 757-768 *in* D.J. Rapport, W.L. Lasley, D.E. Rolston, N.O. Nielsen, C.O. Qualset, and A.B. Damania (eds.), Managing for Healthy Ecosystems, Lewis Publishers, Boca Raton, Florida USA.

Wilcox, B. A., K. S. Smallwood, and J. A. Kahn. 2002. Toward a forest Capital Index. Pages 285-298 *in* D.J. Rapport, W.L. Lasley, D.E. Rolston, N.O. Nielsen, C.O. Qualset, and A.B. Damania (eds.), Managing for Healthy Ecosystems, Lewis Publishers, Boca Raton, Florida USA.

Smallwood, K.S. 2001. The allometry of density within the space used by populations of Mammalian Carnivores. Canadian Journal of Zoology 79:1634-1640.

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Comments on Environmental Documents

I was retained or commissioned to comment on environmental planning and review documents, including:

- The Villages of Lakeview EIR (2017; 28 pp);
- Notes on Proposed Study Options for Trail Impacts on Northern Spotted Owl (2017; 4 pp);
- San Gorgonio Crossings EIR (2017; 22 pp);
- Replies to responses on Jupiter Project IS and MND (2017; 12 pp);
- MacArthur Transit Village Project Modified 2016 CEQA Analysis (2017; 12 pp);
- Central SoMa Plan DEIR (2017; 14 pp);
- Colony Commerce Center Specific Plan DEIR (2016; 16 pp);
- Fairway Trails Improvements MND (2016; 13 pp);
- Review of Avian-Solar Science Plan (2016; 28 pp);
- Replies to responses on Initial Study for Pyramid Asphalt (2016; 5 pp);
- Initial Study for Pyramid Asphalt (2016; 4 pp);
- Agua Mansa Distribution Warehouse Project Initial Study (2016; 14 pp);
- Santa Anita Warehouse IS and MND (2016; 12 pp);
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- Orange Show Logistics Center Initial Study and MND (2016; 9 pp);
- City of Palmdale Oasis Medical Village Project IS and MND (2016; 7 pp);
- Comments on proposed rule for incidental eagle take (2016, 49 pp);
- Grapevine Specific and Community Plan FEIR (2016; 25 pp);
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- Tri-City Industrial Complex Initial Study (2016; 5 pp);
- Hidden Canyon Industrial Park Plot Plan 16-PP-02 (2016; 12 pp);
- Kimball Business Park DEIR (2016; 10 pp);
- Jupiter Project IS and MND (2016; 9 pp);
- Revised Draft Giant Garter Snake Recovery Plan of 2015 (2016, 18 pp);
- Palo Verde Mesa Solar Project Draft Environmental Impact Report (2016; 27 pp);

- Reply Witness Statement on Fairview Wind Project, Ontario, Canada (2016; 14 pp);
- Fairview Wind Project, Ontario, Canada (2016; 41 pp);
- Supplementary Reply Witness Statement Amherst Island Wind Farm, Ontario (2015, 38 pp);
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- Proposed Section 24 Specific Plan Agua Caliente Band of Cahuilla Indians DEIS (2015, 9 pp);
- Replies to comments 24 Specific Plan Agua Caliente Band of Cahuilla Indians FEIS (2015, 6 pp);
- Willow Springs Solar Photovoltaic Project DEIR (2015; 28 pp);
- Sierra Lakes Commerce Center Project DEIR (2015, 9 pp);
- Columbia Business Center MND (2015; 8 pp);
- West Valley Logistics Center Specific Plan DEIR (2015, 10 pp);
- World Logistic Center Specific Plan FEIR (2015, 12 pp);
- Bay Delta Conservation Plan EIR/EIS (2014, 21 pp);
- Addison Wind Energy Project DEIR (2014, 32 pp);
- Response to Comments on the Addison Wind Energy Project DEIR (2014, 15 pp);
- Addison and Rising Tree Wind Energy Project FEIR (2014, 12 pp);
- Alta East Wind Energy Project FEIS (2013, 23 pp);
- Blythe Solar Power Project Staff Assessment, California Energy Commission (2013, 16 pp);
- Clearwater and Yakima Solar Projects DEIR (2013, 9 pp);
- Cuyama Solar Project DEIR (2014, 19 pp);
- Draft Desert Renewable Energy Conservation Plan (DRECP) EIR/EIS (2015, 49 pp);
- Kingbird Solar Photovoltaic Project EIR (2013, 19 pp);
- Lucerne Valley Solar Project Initial Study & Mitigated Negative Declaration (2013, 12 pp);
- Palen Solar Electric Generating System Final Staff Assessment of California Energy Commission, (2014, 20 pp);
- Rebuttal testimony on Palen Solar Energy Generating System (2014, 9 pp);
- Rising Tree Wind Energy Project DEIR (2014, 32 pp);
- Response to Comments on the Rising Tree Wind Energy Project DEIR (2014, 15 pp);
- Soitec Solar Development Project Draft PEIR (2014, 18 pp);
- Comment on the Biological Opinion (08ESMF-00-2012-F-0387) of Oakland Zoo expansion on Alameda whipsnake and California red-legged frog (2014; 3 pp);
- West Antelope Solar Energy Project Initial Study and Negative Declaration (2013, 18 pp);
- Willow Springs Solar Photovoltaic Project DEIR (2015, 28 pp);
- Alameda Creek Bridge Replacement Project DEIR (2015, 10 pp);
- Declaration on Tule Wind project FEIR/FEIS (2013; 24 pp);
- Sunlight Partners LANDPRO Solar Project Mitigated Negative Declaration (2013; 11 pp);
- Declaration in opposition to BLM fracking (2013; 5 pp);
- Rosamond Solar Project Addendum EIR (2013; 13 pp);
- Pioneer Green Solar Project EIR (2013; 13 pp);
- Reply to Staff Responses to Comments on Soccer Center Solar Project Mitigated Negative

Declaration (2013; 6 pp);
- Soccer Center Solar Project Mitigated Negative Declaration (2013; 10 pp);
- Plainview Solar Works Mitigated Negative Declaration (2013; 10 pp);
- Reply to the County Staff's Responses on comments to Imperial Valley Solar Company 2 Project (2013; 10 pp);
- Imperial Valley Solar Company 2 Project (2013; 13 pp);
- FRV Orion Solar Project DEIR (PP12232) (2013; 9 pp);
- Casa Diablo IV Geothermal Development Project (3013; 6 pp);
- Reply to Staff Responses to Comments on Casa Diablo IV Geothermal Development Project (2013; 8 pp);
- FEIS prepared for Alta East Wind Project (2013; 23 pp);
- Metropolitan Air Park DEIR, City of San Diego (2013;);
- Davidon Homes Tentative Subdivision Map and Rezoning Project DEIR (2013; 9 pp);
- Analysis of Biological Assessment of Oakland Zoo Expansion Impacts on Alameda Whipsnake (2013; 10 pp);
- Declaration on Campo Verde Solar project FEIR (2013; 11pp);
- Neg Dec comments on Davis Sewer Trunk Rehabilitation (2013; 8 pp);
- Declaration on North Steens Transmission Line FEIS (2012; 62 pp);
- City of Lancaster Revised Initial Study for Conditional Use Permits 12-08 and 12-09, Summer Solar and Springtime Solar Projects (2012; 8 pp);
- J&J Ranch, 24 Adobe Lane Environmental Review (2012; 14 pp);
- Reply to the County Staff's Responses on comments to Hudson Ranch Power II Geothermal Project and the Simbol Calipatria Plant II (2012; 8 pp);
- Hudson Ranch Power II Geothermal Project and the Simbol Calipatria Plant II (2012; 9 pp);
- Desert Harvest Solar Project EIS (2012; 15 pp);
- Solar Gen 2 Array Project DEIR (2012; 16 pp);
- Ocotillo Sol Project EIS (2012; 4 pp);
- Beacon Photovoltaic Project DEIR (2012; 5 pp);
- Declaration on Initial Study and Proposed Negative Declaration for the Butte Water District 2012 Water Transfer Program (2012; 11 pp);
- Mount Signal and Calexico Solar Farm Projects DEIR (2011; 16 pp);
- City of Elk Grove Sphere of Influence EIR (2011; 28 pp);
- Comment on Sutter Landing Park Solar Photovoltaic Project MND (2011; 9 pp);
- Statement of Shawn Smallwood, Ph.D. Regarding Proposed Rabik/Gudath Project, 22611 Coleman Valley Road, Bodega Bay (CPN 10-0002) (2011; 4 pp);
- Declaration of K. Shawn Smallwood on Biological Impacts of the Ivanpah Solar Electric Generating System (ISEGS) (2011; 9 pp);
- Comments on Draft Eagle Conservation Plan Guidance (2011; 13 pp);
- Comments on Draft EIR/EA for Niles Canyon Safety Improvement Project (2011; 16 pp);
- Declaration of K. Shawn Smallwood, Ph.D., on Biological Impacts of the Route 84 Safety Improvement Project (2011; 7 pp);
- Rebuttal Testimony of Witness #22, K. Shawn Smallwood, Ph.D, on Behalf of Intervenors Friends of The Columbia Gorge & Save Our Scenic Area (2010; 6 pp);
- Prefiled Direct Testimony of Witness #22, K. Shawn Smallwood, Ph.D, on Behalf of

Intervenors Friends of the Columbia Gorge & Save Our Scenic Area. Comments on Whistling Ridge Wind Energy Power Project DEIS, Skamania County, Washington (2010; 41 pp);

- Evaluation of Klickitat County's Decisions on the Windy Flats West Wind Energy Project (2010; 17 pp);
- St. John's Church Project Draft Environmental Impact Report (2010; 14 pp.);
- Initial Study/Mitigated Negative Declaration for Results Radio Zone File #2009-001 (2010; 20 pp);
- Rio del Oro Specific Plan Project Final Environmental Impact Report (2010;12 pp);
- Answers to Questions on 33% RPS Implementation Analysis Preliminary Results Report (2009: 9 pp);
- SEPA Determination of Non-significance regarding zoning adjustments for Skamania County, Washington. Second Declaration to Friends of the Columbia Gorge, Inc. and Save Our Scenic Area (Dec 2008; 17 pp);
- Comments on Draft 1A Summary Report to CAISO (2008; 10 pp);
- County of Placer's Categorical Exemption of Hilton Manor Project (2009; 9 pp);
- Protest of CARE to Amendment to the Power Purchase and Sale Agreement for Procurement of Eligible Renewable Energy Resources Between Hatchet Ridge Wind LLC and PG&E (2009; 3 pp);
- Tehachapi Renewable Transmission Project EIR/EIS (2009; 142 pp);
- Delta Shores Project EIR, south Sacramento (2009; 11 pp + addendum 2 pp);
- Declaration of Shawn Smallwood in Support of Care's Petition to Modify D.07-09-040 (2008; 3 pp);
- The Public Utility Commission's Implementation Analysis December 16 Workshop for the Governor's Executive Order S-14-08 to implement a 33% Renewable Portfolio Standard by 2020 (2008; 9 pp);
- The Public Utility Commission's Implementation Analysis Draft Work Plan for the Governor's Executive Order S-14-08 to implement a 33% Renewable Portfolio Standard by 2020 (2008; 11 pp);
- Draft 1A Summary Report to California Independent System Operator for Planning Reserve Margins (PRM) Study (2008; 7 pp.);
- SEPA Determination of Non-significance regarding zoning adjustments for Skamania County, Washington. Declaration to Friends of the Columbia Gorge, Inc. and Save Our Scenic Area (Sep 2008; 16 pp);
- California Energy Commission's Preliminary Staff Assessment of the Colusa Generating Station (2007; 24 pp);
- Rio del Oro Specific Plan Project Recirculated Draft Environmental Impact Report (2008: 66 pp);
- Replies to Response to Comments Re: Regional University Specific Plan Environmental Impact Report (2008; 20 pp);
- Regional University Specific Plan Environmental Impact Report (2008: 33 pp.);
- Clark Precast, LLC's "Sugarland" project, Negative Declaration (2008: 15 pp.);
- Cape Wind Project Draft Environmental Impact Statement (2008; 157 pp.);
- Yuba Highlands Specific Plan (or Area Plan) Environmental Impact Report (2006; 37 pp.);
- Replies to responses to comments on Mitigated Negative Declaration of the proposed

Mining Permit (MIN 04-01) and Modification of Use Permit 96-02 at North Table Mountain (2006; 5 pp);

- Mitigated Negative Declaration of the proposed Mining Permit (MIN 04-01) and Modification of Use Permit 96-02 at North Table Mountain (2006; 15 pp);
- Windy Point Wind Farm Environmental Review and EIS (2006; 14 pp and 36 Powerpoint slides in reply to responses to comments);
- Shiloh I Wind Power Project EIR (2005; 18 pp);
- Buena Vista Wind Energy Project Notice of Preparation of EIR (2004; 15 pp);
- Negative Declaration of the proposed Callahan Estates Subdivision (2004; 11 pp);
- Negative Declaration of the proposed Winters Highlands Subdivision (2004; 9 pp);
- Negative Declaration of the proposed Winters Highlands Subdivision (2004; 13 pp);
- Negative Declaration of the proposed Creekside Highlands Project, Tract 7270 (2004; 21 pp);
- On the petition California Fish and Game Commission to list the Burrowing Owl as threatened or endangered (2003; 10 pp);
- Conditional Use Permit renewals from Alameda County for wind turbine operations in the Altamont Pass Wind Resource Area (2003; 41 pp);
- UC Davis Long Range Development Plan of 2003, particularly with regard to the Neighborhood Master Plan (2003; 23 pp);
- Anderson Marketplace Draft Environmental Impact Report (2003: 18 pp + 3 plates of photos);
- Negative Declaration of the proposed expansion of Temple B'nai Tikyah (2003: 6 pp);
- Antonio Mountain Ranch Specific Plan Public Draft EIR (2002: 23 pp);
- Response to testimony of experts at the East Altamont Energy Center evidentiary hearing on biological resources (2002: 9 pp);
- Revised Draft Environmental Impact Report, The Promenade (2002: 7 pp);
- Recirculated Initial Study for Calpine's proposed Pajaro Valley Energy Center (2002: 3 pp);
- UC Merced -- Declaration of Dr. Shawn Smallwood in support of petitioner's application for temporary restraining order and preliminary injunction (2002: 5 pp);
- Replies to response to comments in Final Environmental Impact Report, Atwood Ranch Unit III Subdivision (2003: 22 pp);
- Draft Environmental Impact Report, Atwood Ranch Unit III Subdivision (2002: 19 pp + 8 photos on 4 plates);
- California Energy Commission Staff Report on GWF Tracy Peaker Project (2002: 17 pp + 3 photos; follow-up report of 3 pp);
- Initial Study and Negative Declaration, Silver Bend Apartments, Placer County (2002: 13 pp);
- UC Merced Long-range Development Plan DEIR and UC Merced Community Plan DEIR (2001: 26 pp);
- Initial Study, Colusa County Power Plant (2001: 6 pp);
- Comments on Proposed Dog Park at Catlin Park, Folsom, California (2001: 5 pp + 4 photos);
- Pacific Lumber Co. (Headwaters) Habitat Conservation Plan and Environmental Impact Report (1998: 28 pp);
- Final Environmental Impact Report/Statement for Issuance of Take authorization for listed

species within the MSCP planning area in San Diego County, California (Fed. Reg. 62 (60): 14938, San Diego Multi-Species Conservation Program) (1997: 10 pp);

- Permit (PRT-823773) Amendment for the Natomas Basin Habitat Conservation Plan, Sacramento, CA (Fed. Reg. 63 (101): 29020-29021) (1998);
- Draft Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*). (Fed. Reg. 64(176): 49497-49498) (1999: 8 pp);
- Review of the Draft Recovery Plan for the Arroyo Southwestern Toad (*Bufo microscaphus californicus*) (1998);
- Ballona West Bluffs Project Environmental Impact Report (1999: oral presentation);
- California Board of Forestry's proposed amended Forest Practices Rules (1999);
- Negative Declaration for the Sunset Skyranch Airport Use Permit (1999);
- Calpine and Bechtel Corporations' Biological Resources Implementation and Monitoring Program (BRMIMP) for the Metcalf Energy Center (2000: 10 pp);
- California Energy Commission's Final Staff Assessment of the proposed Metcalf Energy Center (2000);
- US Fish and Wildlife Service Section 7 consultation with the California Energy Commission regarding Calpine and Bechtel Corporations' Metcalf Energy Center (2000: 4 pp);
- California Energy Commission's Preliminary Staff Assessment of the proposed Metcalf Energy Center (2000: 11 pp);
- Site-specific management plans for the Natomas Basin Conservancy's mitigation lands, prepared by Wildlands, Inc. (2000: 7 pp);
- Affidavit of K. Shawn Smallwood in Spirit of the Sage Council, et al. (Plaintiffs) vs. Bruce Babbitt, Secretary, U.S. Department of the Interior, et al. (Defendants), Injuries caused by the No Surprises policy and final rule which codifies that policy (1999: 9 pp).

Comments on other Environmental Review Documents:

- Proposed Regulation for California Fish and Game Code Section 3503.5 (2015: 12 pp);
- Statement of Overriding Considerations related to extending Altamont Winds, Inc.'s Conditional Use Permit PLN2014-00028 (2015; 8 pp);
- Draft Program Level EIR for Covell Village (2005; 19 pp);
- Bureau of Land Management Wind Energy Programmatic EIS Scoping document (2003: 7 pp.);
- NEPA Environmental Analysis for Biosafety Level 4 National Biocontainment Laboratory (NBL) at UC Davis (2003: 7 pp);
- Notice of Preparation of UC Merced Community and Area Plan EIR, on behalf of The Wildlife Society—Western Section (2001: 8 pp.);
- Preliminary Draft Yolo County Habitat Conservation Plan (2001; 2 letters totaling 35 pp.);
- Merced County General Plan Revision, notice of Negative Declaration (2001: 2 pp.);
- Notice of Preparation of Campus Parkway EIR/EIS (2001: 7 pp.);
- Draft Recovery Plan for the bighorn sheep in the Peninsular Range (*Ovis candensis*) (2000);
- Draft Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*), on behalf of The Wildlife Society—Western Section (2000: 10 pp.);
- Sierra Nevada Forest Plan Amendment Draft Environmental Impact Statement, on behalf of The Wildlife Society—Western Section (2000: 7 pp.);

- State Water Project Supplemental Water Purchase Program, Draft Program EIR (1997);
- Davis General Plan Update EIR (2000);
- Turn of the Century EIR (1999: 10 pp);
- Proposed termination of Critical Habitat Designation under the Endangered Species Act (Fed. Reg. 64(113): 31871-31874) (1999);
- NOA Draft Addendum to the Final Handbook for Habitat Conservation Planning and Incidental Take Permitting Process, termed the HCP 5-Point Policy Plan (Fed. Reg. 64(45): 11485 - 11490) (1999; 2 pp + attachments);
- Covell Center Project EIR and EIR Supplement (1997).

Position Statements I prepared the following position statements for the Western Section of The Wildlife Society, and one for nearly 200 scientists:

- Recommended that the California Department of Fish and Game prioritize the extermination of the introduced southern water snake in northern California. The Wildlife Society--Western Section (2001);
- Recommended that The Wildlife Society—Western Section appoint or recommend members of the independent scientific review panel for the UC Merced environmental review process (2001);
- Opposed the siting of the University of California's 10th campus on a sensitive vernal pool/grassland complex east of Merced. The Wildlife Society--Western Section (2000);
- Opposed the legalization of ferret ownership in California. The Wildlife Society--Western Section (2000);
- Opposed the Proposed "No Surprises," "Safe Harbor," and "Candidate Conservation Agreement" rules, including permit-shield protection provisions (Fed. Reg. Vol. 62, No. 103, pp. 29091-29098 and No. 113, pp. 32189-32194). This statement was signed by 188 scientists and went to the responsible federal agencies, as well as to the U.S. Senate and House of Representatives.

Posters at Professional Meetings

Leyvas, E. and K. S. Smallwood. 2015. Rehabilitating injured animals to offset and rectify wind project impacts. Conference on Wind Energy and Wildlife Impacts, Berlin, Germany, 9-12 March 2015.

Smallwood, K. S., J. Mount, S. Standish, E. Leyvas, D. Bell, E. Walther, B. Karas. 2015. Integrated detection trials to improve the accuracy of fatality rate estimates at wind projects. Conference on Wind Energy and Wildlife Impacts, Berlin, Germany, 9-12 March 2015.

Smallwood, K. S. and C. G. Thelander. 2005. Lessons learned from five years of avian mortality research in the Altamont Pass WRA. AWEA conference, Denver, May 2005.

Neher, L., L. Wilder, J. Woo, L. Spiegel, D. Yen-Nakafugi, and K.S. Smallwood. 2005. Bird's eye view on California wind. AWEA conference, Denver, May 2005.

Smallwood, K. S., C. G. Thelander and L. Spiegel. 2003. Toward a predictive model of avian

fatalities in the Altamont Pass Wind Resource Area. Windpower 2003 Conference and Convention, Austin, Texas.

Smallwood, K.S. and Eva Butler. 2002. Pocket Gopher Response to Yellow Star-thistle Eradication as part of Grassland Restoration at Decommissioned Mather Air Force Base, Sacramento County, California. White Mountain Research Station Open House, Barcroft Station.

Smallwood, K.S. and Michael L. Morrison. 2002. Fresno kangaroo rat (*Dipodomys nitratoides*) Conservation Research at Resources Management Area 5, Lemoore Naval Air Station. White Mountain Research Station Open House, Barcroft Station.

Smallwood, K.S. and E.L. Fitzhugh. 1989. Differentiating mountain lion and dog tracks. Third Mountain Lion Workshop, Prescott, AZ.

Smith, T. R. and K. S. Smallwood. 2000. Effects of study area size, location, season, and allometry on reported *Sorex* shrew densities. Annual Meeting of the Western Section of The Wildlife Society.

Presentations at Professional Meetings and Seminars

Repowering the Altamont Pass. Altamont Symposium, The Wildlife Society – Western Section, 5 February 2017.

Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area, 1999-2007. Altamont Symposium, The Wildlife Society – Western Section, 5 February 2017.

Conservation and recovery of burrowing owls in Santa Clara Valley. Santa Clara Valley Habitat Agency, Newark, California, 3 February 2017.

Mitigation of Raptor Fatalities in the Altamont Pass Wind Resource Area. Raptor Research Foundation Meeting, Sacramento, California, 6 November 2015.

From burrows to behavior: Research and management for burrowing owls in a diverse landscape. California Burrowing Owl Consortium meeting, 24 October 2015, San Jose, California.

The Challenges of repowering. Keynote presentation at Conference on Wind Energy and Wildlife Impacts, Berlin, Germany, 10 March 2015.

Research Highlights Altamont Pass 2011-2015. Scientific Review Committee, Oakland, California, 8 July 2015.

Siting wind turbines to minimize raptor collisions: Altamont Pass Wind Resource Area. US Fish and Wildlife Service Golden Eagle Working Group, Sacramento, California, 8 January 2015.

Evaluation of nest boxes as a burrowing owl conservation strategy. Sacramento Chapter of the Western Section, The Wildlife Society. Sacramento, California, 26 August 2013.

Predicting collision hazard zones to guide repowering of the Altamont Pass. Conference on wind power and environmental impacts. Stockholm, Sweden, 5-7 February 2013.

Impacts of Wind Turbines on Wildlife. California Council for Wildlife Rehabilitators, Yosemite, California, 12 November 2012.

Impacts of Wind Turbines on Birds and Bats. Madrone Audubon Society, Santa Rosa, California, 20 February 2012.

Comparing Wind Turbine Impacts across North America. California Energy Commission Staff Workshop: Reducing the Impacts of Energy Infrastructure on Wildlife, 20 July 2011.

Siting Repowered Wind Turbines to Minimize Raptor Collisions. California Energy Commission Staff Workshop: Reducing the Impacts of Energy Infrastructure on Wildlife, 20 July 2011.

Siting Repowered Wind Turbines to Minimize Raptor Collisions. Alameda County Scientific Review Committee meeting, 17 February 2011

Comparing Wind Turbine Impacts across North America. Conference on Wind energy and Wildlife impacts, Trondheim, Norway, 3 May 2011.

Update on Wildlife Impacts in the Altamont Pass Wind Resource Area. Raptor Symposium, The Wildlife Society—Western Section, Riverside, California, February 2011.

Siting Repowered Wind Turbines to Minimize Raptor Collisions. Raptor Symposium, The Wildlife Society - Western Section, Riverside, California, February 2011.

Wildlife mortality caused by wind turbine collisions. Ecological Society of America, Pittsburgh, Pennsylvania, 6 August 2010.

Map-based repowering and reorganization of a wind farm to minimize burrowing owl fatalities. California burrowing Owl Consortium Meeting, Livermore, California, 6 February 2010.

Environmental barriers to wind power. Getting Real About Renewables: Economic and Environmental Barriers to Biofuels and Wind Energy. A symposium sponsored by the Environmental & Energy Law & Policy Journal, University of Houston Law Center, Houston, 23 February 2007.

Lessons learned about bird collisions with wind turbines in the Altamont Pass and other US wind farms. Meeting with Japan Ministry of the Environment and Japan Ministry of the Economy, Wild Bird Society of Japan, and other NGOs Tokyo, Japan, 9 November 2006.

Lessons learned about bird collisions with wind turbines in the Altamont Pass and other US wind farms. Symposium on bird collisions with wind turbines. Wild Bird Society of Japan, Tokyo, Japan, 4 November 2006.

Responses of Fresno kangaroo rats to habitat improvements in an adaptive management framework. California Society for Ecological Restoration (SERCAL) 13th Annual Conference, UC Santa

Barbara, 27 October 2006.

Fatality associations as the basis for predictive models of fatalities in the Altamont Pass Wind Resource Area. EEI/APLIC/PIER Workshop, 2006 Biologist Task Force and Avian Interaction with Electric Facilities Meeting, Pleasanton, California, 28 April 2006.

Burrowing owl burrows and wind turbine collisions in the Altamont Pass Wind Resource Area. The Wildlife Society - Western Section Annual Meeting, Sacramento, California, February 8, 2006.

Mitigation at wind farms. Workshop: Understanding and resolving bird and bat impacts. American Wind Energy Association and Audubon Society. Los Angeles, CA. January 10 and 11, 2006.

Incorporating data from the California Wildlife Habitat Relationships (CWHR) system into an impact assessment tool for birds near wind farms. Shawn Smallwood, Kevin Hunting, Marcus Yee, Linda Spiegel, Monica Parisi. Workshop: Understanding and resolving bird and bat impacts. American Wind Energy Association and Audubon Society. Los Angeles, CA. January 10 and 11, 2006.

Toward indicating threats to birds by California's new wind farms. California Energy Commission, Sacramento, May 26, 2005.

Avian collisions in the Altamont Pass. California Energy Commission, Sacramento, May 26, 2005.

Ecological solutions for avian collisions with wind turbines in the Altamont Pass Wind Resource Area. EPRI Environmental Sector Council, Monterey, California, February 17, 2005.

Ecological solutions for avian collisions with wind turbines in the Altamont Pass Wind Resource Area. The Wildlife Society—Western Section Annual Meeting, Sacramento, California, January 19, 2005.

Associations between avian fatalities and attributes of electric distribution poles in California. The Wildlife Society - Western Section Annual Meeting, Sacramento, California, January 19, 2005.

Minimizing avian mortality in the Altamont Pass Wind Resources Area. UC Davis Wind Energy Collaborative Forum, Palm Springs, California, December 14, 2004.

Selecting electric distribution poles for priority retrofitting to reduce raptor mortality. Raptor Research Foundation Meeting, Bakersfield, California, November 10, 2004.

Responses of Fresno kangaroo rats to habitat improvements in an adaptive management framework. Annual Meeting of the Society for Ecological Restoration, South Lake Tahoe, California, October 16, 2004.

Lessons learned from five years of avian mortality research at the Altamont Pass Wind Resources Area in California. The Wildlife Society Annual Meeting, Calgary, Canada, September 2004.

The ecology and impacts of power generation at Altamont Pass. Sacramento Petroleum Association, Sacramento, California, August 18, 2004.

Burrowing owl mortality in the Altamont Pass Wind Resource Area. California Burrowing Owl Consortium meeting, Hayward, California, February 7, 2004.

Burrowing owl mortality in the Altamont Pass Wind Resource Area. California Burrowing Owl Symposium, Sacramento, November 2, 2003.

Raptor Mortality at the Altamont Pass Wind Resource Area. National Wind Coordinating Committee, Washington, D.C., November 17, 2003.

Raptor Behavior at the Altamont Pass Wind Resource Area. Annual Meeting of the Raptor Research Foundation, Anchorage, Alaska, September, 2003.

Raptor Mortality at the Altamont Pass Wind Resource Area. Annual Meeting of the Raptor Research Foundation, Anchorage, Alaska, September, 2003.

California mountain lions. Ecological & Environmental Issues Seminar, Department of Biology, California State University, Sacramento, November, 2000.

Intra- and inter-turbine string comparison of fatalities to animal burrow densities at Altamont Pass. National Wind Coordinating Committee, Carmel, California, May, 2000.

Using a Geographic Positioning System (GPS) to map wildlife and habitat. Annual Meeting of the Western Section of The Wildlife Society, Riverside, CA, January, 2000.

Suggested standards for science applied to conservation issues. Annual Meeting of the Western Section of The Wildlife Society, Riverside, CA, January, 2000.

The indicators framework applied to ecological restoration in Yolo County, California. Society for Ecological Restoration, September 25, 1999.

Ecological restoration in the context of animal social units and their habitat areas. Society for Ecological Restoration, September 24, 1999.

Relating Indicators of Ecological Health and Integrity to Assess Risks to Sustainable Agriculture and Native Biota. International Conference on Ecosystem Health, August 16, 1999.

A crosswalk from the Endangered Species Act to the HCP Handbook and real HCPs. Southern California Edison, Co. and California Energy Commission, March 4-5, 1999.

Mountain lion track counts in California: Implications for Management. Ecological & Environmental Issues Seminar, Department of Biological Sciences, California State University, Sacramento, November 4, 1998.

“No Surprises” -- Lack of science in the HCP process. California Native Plant Society Annual Conservation Conference, The Presidio, San Francisco, September 7, 1997.

In Your Interest. A half hour weekly show aired on Channel 10 Television, Sacramento. In this episode, I served on a panel of experts discussing problems with the implementation of the Endangered Species Act. Aired August 31, 1997.

Spatial scaling of pocket gopher (*Geomyidae*) density. Southwestern Association of Naturalists 44th Meeting, Fayetteville, Arkansas, April 10, 1997.

Estimating prairie dog and pocket gopher burrow volume. Southwestern Association of Naturalists 44th Meeting, Fayetteville, Arkansas, April 10, 1997.

Ten years of mountain lion track survey. Fifth Mountain Lion Workshop, San Diego, February 27, 1996.

Study and interpretive design effects on mountain lion density estimates. Fifth Mountain Lion Workshop, San Diego, February 27, 1996.

Small animal control. Session moderator and speaker at the California Farm Conference, Sacramento, California, Feb. 28, 1995.

Small animal control. Ecological Farming Conference, Asylomar, California, Jan. 28, 1995.

Habitat associations of the Swainson's Hawk in the Sacramento Valley's agricultural landscape. 1994 Raptor Research Foundation Meeting, Flagstaff, Arizona.

Alfalfa as wildlife habitat. Seed Industry Conference, Woodland, California, May 4, 1994.

Habitats and vertebrate pests: impacts and management. Managing Farmland to Bring Back Game Birds and Wildlife to the Central Valley. Yolo County Resource Conservation District, U.C. Davis, February 19, 1994.

Management of gophers and alfalfa as wildlife habitat. Orland Alfalfa Production Meeting and Sacramento Valley Alfalfa Production Meeting, February 1 and 2, 1994.

Patterns of wildlife movement in a farming landscape. Wildlife and Fisheries Biology Seminar Series: Recent Advances in Wildlife, Fish, and Conservation Biology, U.C. Davis, Dec. 6, 1993.

Alfalfa as wildlife habitat. California Alfalfa Symposium, Fresno, California, Dec. 9, 1993.

Management of pocket gophers in Sacramento Valley alfalfa. California Alfalfa Symposium, Fresno, California, Dec. 8, 1993.

Association analysis of raptors in a farming landscape. Plenary speaker at Raptor Research Foundation Meeting, Charlotte, North Carolina, Nov. 6, 1993.

Landscape strategies for biological control and IPM. Plenary speaker, International Conference on Integrated Resource Management and Sustainable Agriculture, Beijing, China, Sept. 11, 1993.

Landscape Ecology Study of Pocket Gophers in Alfalfa. Alfalfa Field Day, U.C. Davis, July 1993.

Patterns of wildlife movement in a farming landscape. Spatial Data Analysis Colloquium, U.C. Davis, August 6, 1993.

Sound stewardship of wildlife. Veterinary Medicine Seminar: Ethics of Animal Use, U.C. Davis. May 1993.

Landscape ecology study of pocket gophers in alfalfa. Five County Grower's Meeting, Tracy, California. February 1993.

Turbulence and the community organizers: The role of invading species in ordering a turbulent system, and the factors for invasion success. Ecology Graduate Student Association Colloquium, U.C. Davis. May 1990.

Evaluation of exotic vertebrate pests. Fourteenth Vertebrate Pest Conference, Sacramento, California. March 1990.

Analytical methods for predicting success of mammal introductions to North America. The Western Section of the Wildlife Society, Hilo, Hawaii. February 1988.

A state-wide mountain lion track survey. Sacramento County Dept Parks and Recreation. April 1986.

The mountain lion in California. Davis Chapter of the Audubon Society. October 1985.

Ecology Graduate Student Seminars, U.C. Davis, 1985-1990: Social behavior of the mountain lion; Mountain lion control; Political status of the mountain lion in California.

Other forms of Participation at Professional Meetings

- Scientific Committee, Conference on Wind energy and Wildlife impacts, Berlin, Germany, March 2015.
- Scientific Committee, Conference on Wind energy and Wildlife impacts, Stockholm, Sweden, February 2013.
- Workshop co-presenter at Birds & Wind Energy Specialist Group (BAWESG) Information sharing week, Bird specialist studies for proposed wind energy facilities in South Africa, Endangered Wildlife Trust, Darling, South Africa, 3-7 October 2011.
- Scientific Committee, Conference on Wind energy and Wildlife impacts, Trondheim, Norway, 2-5 May 2011.
- Chair of Animal Damage Management Session, The Wildlife Society, Annual Meeting, Reno, Nevada, September 26, 2001.

- Chair of Technical Session: Human communities and ecosystem health: Comparing perspectives and making connection. Managing for Ecosystem Health, International Congress on Ecosystem Health, Sacramento, CA August 15-20, 1999.

- Student Awards Committee, Annual Meeting of the Western Section of The Wildlife Society, Riverside, CA, January, 2000.

- Student Mentor, Annual Meeting of the Western Section of The Wildlife Society, Riverside, CA, January, 2000.

Printed Mass Media

Smallwood, K.S., D. Mooney, and M. McGuinness. 2003. We must stop the UCD biolab now. Op-Ed to the Davis Enterprise.

Smallwood, K.S. 2002. Spring Lake threatens Davis. Op-Ed to the Davis Enterprise.

Smallwood, K.S. Summer, 2001. Mitigation of habitation. The Flatlander, Davis, California.

Entrikan, R.K. and K.S. Smallwood. 2000. Measure O: Flawed law would lock in new taxes. Op-Ed to the Davis Enterprise.

Smallwood, K.S. 2000. Davis delegation lobbies Congress for Wildlife conservation. Op-Ed to the Davis Enterprise.

Smallwood, K.S. 1998. Davis Visions. The Flatlander, Davis, California.

Smallwood, K.S. 1997. Last grab for Yolo's land and water. The Flatlander, Davis, California.

Smallwood, K.S. 1997. The Yolo County HCP. Op-Ed to the Davis Enterprise.

Radio/Television

PBS News Hour,

FOX News, Energy in America: Dead Birds Unintended Consequence of Wind Power Development, August 2011.

KXJZ Capital Public Radio -- Insight (Host Jeffrey Callison). Mountain lion attacks (with guest Professor Richard Coss). 23 April 2009;

KXJZ Capital Public Radio -- Insight (Host Jeffrey Callison). Wind farm Rio Vista Renewable Power. 4 September 2008;

KQED QUEST Episode #111. Bird collisions with wind turbines. 2007;

KDVS Speaking in Tongues (host Ron Glick), Yolo County HCP: 1 hour. December 27, 2001;

KDVS Speaking in Tongues (host Ron Glick), Yolo County HCP: 1 hour. May 3, 2001;

KDVS Speaking in Tongues (host Ron Glick), Yolo County HCP: 1 hour. February 8, 2001;

KDVS Speaking in Tongues (host Ron Glick & Shawn Smallwood), California Energy Crisis: 1 hour. Jan. 25, 2001;

KDVS Speaking in Tongues (host Ron Glick), Headwaters Forest HCP: 1 hour. 1998;

Davis Cable Channel (host Gerald Heffernon), Burrowing owls in Davis: half hour. June, 2000;

Davis Cable Channel (hosted by Davis League of Women Voters), Measure O debate: 1 hour. October, 2000;

KXTV 10, In Your Interest, The Endangered Species Act: half hour. 1997.

Reviews of Journal Papers (Scientific journals for whom I've provided peer review)

Journal	**Journal**
American Naturalist	Journal of Animal Ecology
Journal of Wildlife Management	Western North American Naturalist
Auk	Journal of Raptor Research
Biological Conservation	National Renewable Energy Lab reports
Canadian Journal of Zoology	Oikos
Ecosystem Health	The Prairie Naturalist
Environmental Conservation	Restoration Ecology
Environmental Management	Southwestern Naturalist
Functional Ecology	The Wildlife Society--Western Section Trans.
Journal of Zoology (London)	Proc. Int. Congress on Managing for Ecosystem Health
Journal of Applied Ecology	Transactions in GIS
Ecology	Tropical Ecology
Wildlife Society Bulletin	Peer J
Biological Control	The Condor

Committees

- Scientific Review Committee, Alameda County, Altamont Pass Wind Resource Area
- Ph.D. Thesis Committee, Steve Anderson, University of California, Davis
- MS Thesis Committee, Marcus Yee, California State University, Sacramento

Other Professional Activities or Products

Testified in Federal Court in Denver during 2005 over the fate of radio-nuclides in the soil at Rocky Flats Plant after exposure to burrowing animals. My clients won a judgment of $553,000,000. I have also testified in many other cases of litigation under CEQA, NEPA, the Warren-Alquist Act, and other environmental laws. My clients won most of the cases for which I testified.

Testified before Environmental Review Tribunals in Ontario, Canada regarding proposed White Pines, Amherst Island, and Fairview Wind Energy projects.

Testified in Skamania County Hearing in 2009 on the potential impacts of zoning the County for development of wind farms and hazardous waste facilities.

Testified in deposition in 2007 in the case of O'Dell et al. vs. FPL Energy in Houston, Texas.

Testified in Klickitat County Hearing in 2006 on the potential impacts of the Windy Point Wind Farm.

Memberships in Professional Societies

The Wildlife Society
Raptor Research Foundation

Honors and Awards

Fulbright Research Fellowship to Indonesia, 1987
J.G. Boswell Full Academic Scholarship, 1981 college of choice
Certificate of Appreciation, The Wildlife Society—Western Section, 2000, 2001
Northern California Athletic Association Most Valuable Cross Country Runner, 1984
American Legion Award, Corcoran High School, 1981, and John Muir Junior High, 1977
CIF Section Champion, Cross Country in 1978
CIF Section Champion, Track & Field 2 mile run in 1981
National Junior Record, 20 kilometer run, 1982
National Age Group Record, 1500 meter run, 1978

Community Activities

District 64 Little League Umpire, 2003-2007
Dixon Little League Umpire, 2006-07
Davis Little League Chief Umpire and Board member, 2004-2005
Davis Little League Safety Officer, 2004-2005
Davis Little League Certified Umpire, 2002-2004
Davis Little League Scorekeeper, 2002
Davis Visioning Group member
Petitioner for Writ of Mandate under the California Environmental Quality Act against City of Woodland decision to approve the Spring Lake Specific Plan, 2002
Served on campaign committees for City Council candidates

Representative Clients/Funders

Law Offices of Stephan C. Volker	EDF Renewables
Blum Collins, LLP	National Renewable Energy Lab
Eric K. Gillespie Professional Corporation	Altamont Winds LLC
Law Offices of Berger & Montague	Salka Energy
Lozeau | Drury LLP	Comstocks Business (magazine)
Law Offices of Roy Haber	BioResource Consultants
Law Offices of Edward MacDonald	Tierra Data
Law Office of John Gabrielli	Black and Veatch
Law Office of Bill Kopper	Terry Preston, Wildlife Ecology Research Center
Law Office of Donald B. Mooney	EcoStat, Inc.
Law Office of Veneruso & Moncharsh	US Navy
Law Office of Steven Thompson	US Department of Agriculture
Law Office of Brian Gaffney	US Forest Service
California Wildlife Federation	US Fish & Wildlife Service
Defenders of Wildlife	US Department of Justice
Sierra Club	California Energy Commission
National Endangered Species Network	California Office of the Attorney General
Spirit of the Sage Council	California Department of Fish & Wildlife
The Humane Society	California Department of Transportation
Hagens Berman LLP	California Department of Forestry
Environmental Protection Information Center	California Department of Food & Agriculture
Goldberg, Kamin & Garvin, Attorneys at Law	Ventura County Counsel
Californians for Renewable Energy (CARE)	County of Yolo
Seatuck Environmental Association	Tahoe Regional Planning Agency
Friends of the Columbia Gorge, Inc.	Sustainable Agriculture Research & Education Program
Save Our Scenic Area	Sacramento-Yolo Mosquito and Vector Control District
Alliance to Protect Nantucket Sound	East Bay Regional Park District
Friends of the Swainson's Hawk	County of Alameda
Alameda Creek Alliance	Don & LaNelle Silverstien
Center for Biological Diversity	Seventh Day Adventist Church
California Native Plant Society	Escuela de la Raza Unida
Endangered Wildlife Trust	Susan Pelican and Howard Beeman
and BirdLife South Africa	Residents Against Inconsistent Development, Inc.
AquAlliance	Bob Sarvey
Oregon Natural Desert Association	Mike Boyd
Save Our Sound	Hillcroft Neighborhood Fund
G3 Energy and Pattern Energy	Joint Labor Management Committee, Retail Food Industry
Emerald Farms	Lisa Rocca
Pacific Gas & Electric Co.	Kevin Jackson
Southern California Edison Co.	Dawn Stover and Jay Letto
Georgia-Pacific Timber Co.	Nancy Havassy
Northern Territories Inc.	Catherine Portman (for Brenda Cedarblade)
David Magney Environmental Consulting	Ventus Environmental Solutions, Inc.
Wildlife History Foundation	Panorama Environmental, Inc.
NextEra Energy Resources, LLC	Adams Broadwell Professional Corporation
Ogin, Inc.	

Representative special-status species experience

Common name	Species name	Description
Field experience		
California red-legged frog	*Rana aurora draytonii*	Protocol searches; Many detections
Foothill yellow-legged frog	*Rana boylii*	Presence surveys; Many detections
Western spadefoot	*Spea hammondii*	Presence surveys; Few detections
California tiger salamander	*Ambystoma californiense*	Protocol searches; Many detections
Coast range newt	*Taricha torosa torosa*	Searches and multiple detections
Blunt-nosed leopard lizard	*Gambelia sila*	Detected in San Luis Obispo County
California horned lizard	*Phrynosoma coronatum frontale*	Searches; Many detections
Western pond turtle	*Clemmys marmorata*	Searches; Many detections
San Joaquin kit fox	*Vulpes macrotis mutica*	Protocol searches; detections
Sumatran tiger	*Panthera tigris*	Track surveys in Sumatra
Mountain lion	*Puma concolor californicus*	Research and publications
Point Arena mountain beaver	*Aplodontia rufa nigra*	Remote camera operation
Giant kangaroo rat	*Dipodomys ingens*	Detected in Cholame Valley
San Joaquin kangaroo rat	*Dipodomys nitratoides*	Monitoring & habitat restoration
Monterey dusky-footed woodrat	*Neotoma fuscipes luciana*	Non-target captures and mapping of dens
Salt marsh harvest mouse	*Reithrodontomys raviventris*	Habitat assessment, monitoring
Salinas harvest mouse	*Reithrodontomys megalotus distichlus*	Captures; habitat assessment
Bats		Thermal imaging surveys
California clapper rail	*Rallus longirostris*	Surveys and detections
Golden eagle	*Aquila chrysaetos*	Numerical & behavioral surveys
Swainson's hawk	*Buteo swainsoni*	Numerical & behavioral surveys
Northern harrier	*Circus cyaeneus*	Numerical & behavioral surveys
White-tailed kite	*Elanus leucurus*	Numerical & behavioral surveys
Loggerhead shrike	*Lanius ludovicianus*	Large area surveys
Least Bell's vireo	*Vireo bellii pusillus*	Detected in Monterey County
Willow flycatcher	*Empidonax traillii extimus*	Research at Sierra Nevada breeding sites
Burrowing owl	*Athene cunicularia hypugia*	Numerical & behavioral surveys
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	Monitored success of relocation and habitat restoration
Analytical		
Arroyo southwestern toad	*Bufo microscaphus californicus*	Research and report.
Giant garter snake	*Thamnophis gigas*	Research and publication
Northern goshawk	*Accipiter gentilis*	Research and publication
Northern spotted owl	*Strix occidentalis*	Research and reports
Alameda whipsnake	*Masticophis lateralis euryxanthus*	Expert testimony

ATTACHMENT 1

Skilled Dog Detections of Bat and Small Bird Carcasses in Wind Turbine Fatality Monitoring

K. Shawn Smallwood, Doug Bell, Skye Standish

16 February 2018

Jack searches for fatalities in the Altamont Pass, 2017

It is imperative that scientists learn whether preconstruction surveys can generate data and metrics, such as passage rates and accurate fatality rates, that can predict wind turbine impacts on bats and small birds and that can help minimize impacts via micro-siting. Recent research in the Altamont Pass Wind Resource Area (APWRA) revealed high fatality rates of bats (Brown et al. 2016) and small birds (Smallwood 2016a), but these estimated rates carried large uncertainty due to very low carcass detection rates using human searchers. That the mean fatality rate estimates might be realistic was supported by hundreds of hours of nocturnal surveys in the APWRA using a FLIR T620 thermal camera with an 88 mm lens (Smallwood 2016a,b). The nocturnal surveys accumulated hundreds of documented near misses of bats and small birds and at least 8 collisions of bats with wind turbine blades or with the atmospheric pressure waves and wake turbulence created by the blade sweeps. Bats were often seen to tumble through the air and sometimes disappeared around the blade sweeps. Bats were also seen to target wind turbines, often pass through operating wind turbine rotors multiple times each, and to chase blades as they swept through their rotations. Other investigators also noticed these patterns (Kunz et al. 2007, Horn et al. 2008, Cryan et al. 2014). Also, large bats (likely hoary bats, *Lasiurus cinereus*) behaved differently than smaller bats (mostly Mexican free-tailed bats, *Tadarida brasiliensis*), and certain behaviors appeared to associate with the frequencies of near misses.

As higher-than-expected bat fatality rates emerge from fatality monitoring at repowered wind turbines, the question arises whether macro- and micro-siting of wind turbines might help to minimize impacts to bats or small birds. Micro-siting has been shown to reduce raptor fatalities at a repowered wind project (Brown et al. 2016), and offers considerable promise for minimizing specific avian impacts at proposed new wind projects (Smallwood et al. 2017). Still unknown is whether use of acoustic detectors in preconstruction surveys or post-construction monitoring can accurately predict bat collision risks. Also still unknown is whether monitoring bat activity using acoustic detectors can generate collision risk metrics that accurately predict impacts at a spatial resolution fine enough for micro-siting of wind turbines. Fatality rates need to be compared to bat passage rates recorded over overlapping time periods to determine whether there is a relationship.

Hein et al. (2013) failed to obtain a significant positive correlation between bat fatality rates and passage rates through turbine rotors among multiple wind projects in Canada and the USA. Even though there has been considerable interest in this relationship since that time, scientific support for it has not advanced beyond speculation. One constraint in acoustic detectors is their range, which is typically 30 m, or <1/3 of the rotor diameter of a modern wind turbine. In addition, if a detector is directional or if the nacelle blocks incoming bat calls from a portion of the rotor, the detector's effective coverage of the rotor may be much smaller. Using a thermal camera, one of us (KSS) has recorded bats passing through all parts of the rotor, disproportionately at the edge of the rotor plane where nacelle-mounted acoustic detectors would fail to detect bat passages. Therefore, acoustic detectors might not serve as the technology best suited for obtaining bat passage rates to be compared to fatality rates.

Another possible explanation for Hein et al.'s lack of correlation could be that an attraction of bats to wind turbines might prevent discernment of any meaningful pattern between passage rates and fatality rates. If bats are strongly attracted to wind turbines, as some have posited (Kunz et al. 2007, Horn et al. 2008, Cryan et al. 2014, Smallwood 2016b), then it might be that preconstruction surveys simply cannot predict fatality rates because once new wind turbines are installed bats will shift their preconstruction flight paths to visit the new turbines. Nevertheless, in certain landscapes bat passage rates might provide useful patterns for guiding micro-siting. Furthermore, rather than passage rates being predictive of fatalities, what might be more predictive are certain behavior rates – e.g., hovering, interacting with other bats, making foraging runs, chasing blades, passing through the rotor parallel rather than perpendicular to the rotor plane, approaching portions of the rotor emitting disproportionately greater heat – and one or more of these behavior rates might very well relate to landscape settings.

Yet another possible explanation for Hein et al.'s lack of correlation could be high uncertainty in fatality rate estimates. Fatality rate estimates have been vulnerable to large biases and error caused by unrealistic field trials and weak fatality monitoring methods (Smallwood 2007, Smallwood et al. 2010, 2013). Accuracy in fatality rate estimates would increase by detecting more of the fatalities, and in more effectively addressing biases such as use of inadequate maximum search radii. Matthews et al. (2013) argued that use of skilled dogs would increase carcass detection rates, a method that we employed here. Other approaches would be to decrease the time interval between searches and to increase the maximum search radius around wind turbines.

The scientific basis for deciding on a maximum search radius has been scarce. Hull and Muir (2010) proposed a method based on ballistics, and Smallwood (2013) proposed a method based on modeling the pattern of carcass deposition within previously searched areas. 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, 2017) 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. Given the types of detection trials we deployed in this study, and our use of dogs to improve carcass detection, we had the opportunity to more closely examine searcher detection and carcass distributions around wind turbines.

It needs to be known whether preconstruction surveys can generate useful passage rate metrics of bats and small birds, and whether post-construction fatality rates of bats and small birds can be estimated with sufficient accuracy to discover meaningful patterns with passage rates. The primary objectives of this study were to test the efficacy of using skilled dogs relative to human searchers to find available fatalities and 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. We needed this close comparison because fatality monitoring is a contest between investigators and scavengers over who might find the fatalities first. The longer the time interval between searches, the more likely scavengers will remove evidence of fatalities from the search area before investigators can detect them. A key element to this close comparison is the use of carcass detection trials, in which we place bat and small bird carcasses into the search areas without the searchers being aware of placement details such as location, species or number of carcasses. However, this report is interim to a final report that will make use of the nocturnal survey data to measure bat passage rates with fatality rates. The objectives of this interim report are to (1) test whether carcass detection rates are higher using dogs than humans as fatality searchers, (2) examine patterns of carcass deposition around wind turbines in an effort to assess the suitability of earlier and ongoing maximum search radii, (3) test for an effect on fatalities caused by a serendipitous, project-wide wind turbine shutdown in the midst of the bat migration season.

METHODS

To achieve our ultimate goal of comparing bat passage rates to fatality rates, we sought to maximize our detection of bat fatalities by conducting fieldwork through the peak period of bat activity and documented fatalities in the APWRA. This period includes the last week in September and the first week of October, which also happens to generally coincide with a peak in small bird flights through the APWRA at night. We surveyed for bats and small birds 4 September through 15 November 2018. Nocturnal surveys lasted 3 hours per night, and fatality surveys were performed at the same turbines the following morning, 5 days per week. Nocturnal surveys included at least 1 round of 5-10 minute scans per turbine per hour. Each night nocturnal surveys covered 2 to 5 wind turbines, which were searched for fatalities the following morning.

Nocturnal surveys were performed between dusk and 3 hours after dusk, which is the time period corresponding with most bat activity. We recorded temperature, wind direction, and wind speed each hour using a Kestrel wind meter. Using the thermal camera we also recorded temperatures of ground cover and the vents at the rear of wind turbine nacelles. In 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. Each timed scan was also video-recorded so that observations could be verified and any missed bat or bird passages recorded upon later viewing of the video.

Our fatality searches were performed by our dog team consisting of Collette Yee, a trained dog handler, who worked with one of two trained dogs at a time, Captain and Jack, and was accompanied by Skye Standish. Captain and Jack were trained by Conservation Canines with the Center of Conservation Biology, University of Washington. Our dog team searched 5 days per week, 15 September through 15 November. Searches were performed in the morning, when conditions were optimal for searching with dogs. Each dog was given turns at 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. 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 2016a, Brown et al. 2016). 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 unit, and identified carcasses to species. Found carcasses were left in place for possible repeat discovery.

At Golden Hills our dog team searched for fatalities at 32 wind turbines that were also searched by the onsite fatality monitor (H.T. Harvey and Associates 2017) at 28-day intervals. On 19 September the fatality monitor switched from using dogs to using human searchers at the 32 turbines we searched. Human searchers and the dog team were blind to each other's fatality finds, but the dog team informed the human searchers of our trial carcass placements (described below). Also, the human searchers removed found fatalities, except for our trial carcasses. Over the same time period the dog team performed 55 searches at the same 32 turbines where the human searchers performed 69 searches. We later compared the fatality finds between the dog team and human searchers.

Within the intensively searched areas downwind of wind turbines at Golden Hills and Buena Vista, Smallwood deposited fresh carcasses of bats and small birds the day prior to each fatality search (Table 1). Placements were to randomized locations within the fatality search areas. Smallwood weighed trial carcasses prior to placements, and he clipped the tips of flight feathers of birds and removed one foot from bats. These carcasses served as fatality detection trials that are typically used to adjust fatality finds to fatality rates (Brown et al. 2016, Smallwood 2017, Smallwood et al. unpublished). The fatality searchers were blind to the trials, and reported them in the same manner as turbine-caused fatalities, except that searchers also reported whether bird carcasses had clipped flight feathers or bat carcasses lacked one foot. Smallwood followed-up on trial carcass placements with status-checks. Carcasses were left in the field indefinitely at Buena Vista. At Golden Hills, we were required to remove bat carcasses following the dog team's search, and we removed bird carcasses after obtaining persistence rates via carcass status checks.

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, Smallwood 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 first search attempt, 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).

Using only the fresh carcasses and carcass status checks using both the trial administrator and our dog team searches, we estimated daily mean carcass persistence rates, R_c, defined as the mean proportion of carcasses remaining following the average time interval (days) between searches:

$$R_c = \frac{\sum_{i=1}^{I} R_i}{I} ,$$

where R_i was the predicted proportion of carcasses remaining at the *i*th day into the trial, based on nonlinear regression used to fit a predictive model to the data, and *I* was the number of days into the trial which corresponded with the average interval between the fatality searches. The number of found fatalities would be divided by R_c to derive a fatality estimate adjusted for the proportion of fatalities not found due to scavenger removal.

Patterns of Found Fatalities around Wind Turbines

Fatality rates are less comparable between wind projects unless one accounts for variation in combinations of tower heights and maximum fatality search radius (Smallwood 2009, 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. The adjustment factor, *d*, represents the proportion of carcasses likely to be found within the maximum search radius around wind turbines of given tower heights. To obtain *d* in fatality rate equation 1, Smallwood (2013) reviewed tables and appendices in available reports to obtain distances of fatalities from wind turbines. Fatality finds were summed within 1-m intervals of distance from the turbines for each group of tower heights and each group of maximum search radii, and least-squares regression analysis was used to fit logistic functions to the cumulative sum fatalities with increasing distance from the turbine. The regressions were restricted to the distance of the maximum search radius plus 5 m to account for the area likely searched as the searcher reached the search boundary. In all cases, a logistic function was fit to the data, 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 wind turbine where nearest fatality remains were located, and *a* and *b* were fitted coefficients.

The regression models were used to predict cumulative sum fatalities as functions of distance from the turbine, which were then extended to distances beyond the maximum search radii that were reported at wind-energy projects (Smallwood 2013). These model predictions were extended to greater distances to identify asymptotic values, which were then divided into predicted values at each 1-m interval to represent the predicted value as a proportion of the asymptotic value. The result was a predicted cumulative proportion of fatalities relative to the predicted maximum (1.0) that would have been found had the searches extended well beyond the search boundary. New models were developed from data collected during our study.

Impact of Turbine Shutdown on Volant Wildlife

Before our study began, we learned that the Buena Vista project was scheduled for shutdown 2 October through 10 November to repair a circuit. This shutdown provided an opportunity to test whether wind project curtailment reduces bat and bird fatalities. To compare impacts of a project-wide turbine shutdown, we measured the change in fatality finds per search before and after the Buena Vista shutdown. The Golden Hills turbines served as the control group, because they continued to operate before and after the Buena Vista shutdown. We took the ratio of post-shutdown fatality rates to pre-shutdown fatality rates in the control group and multiplied it by the pre-shutdown fatality rate at Buena Vista to obtain an expected value. We took the difference between the expected value and the average fatality rate after the Buena Vista shutdown and divided this difference by the expected value to calculate the change in fatalities due to the shutdown:

$$E[I_A] = (C_B - C_A) \times I_B,$$
$$IMPACT = \frac{(E[I_A] - I_A)}{E[I_A]} \times 100\%,$$

where C_B and C_A were fatalities/search at the control site (Golden Hills) before and after the Buena Vista shutdown, I_B and I_A were fatalities/search at the impact site (Buena Vista) before and after the shutdown, $E[I_A]$ was the expected post-shutdown fatalities/search at Buena Vista, and IMPACT was the effect of the shutdown on fatalities/search, which could also be translated to the number of fatalities by multiplying IMPACT and the number of post-shutdown searches.

RESULTS

Fatality Searches

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. Skye Standish searched 20 turbines once each from 4 through 13 September 2017. Captain and Jack – our trained dogs – 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 32 turbines that were being searched every 28 days by human searchers after 19 September. Of these turbines, our dog team searched 12 turbines once, 17 turbines twice, and 3 turbines three times for a project total of 55 turbine searches. At Buena Vista, our dog team searched 3 turbines once, 15 turbines twice, 9 turbines three times, and 4 turbines four times for a project total of 76 turbine searches.

Buena Vista experienced a planned project-wide shutdown beginning 06:00 hours on 2nd October. This shutdown extended through the remainder of the study period. 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 searched 14 turbines at Golden Hills prior to the Buena Vista shutdown, and performed 41 turbine searches (31 turbines) afterwards. Results from these searches were examined in a before-after, control-impact experimental design to test the degree to which operating turbines contribute to fatalities found at wind turbines.

Between both projects, we found carcasses of 9 bats and 43 birds that we believe had died prior to the start of our study. Also between both projects, our human searches performed in early September detected 2 bats that had died after the start of our study and 10 birds that died prior to the study. The human-found bats included a western red bat and hoary bat at Buena Vista. The human-found birds included 1 turkey vulture, 1 golden eagle, 2 red-tailed hawks, 1 American kestrel, 2 burrowing owls, 1 mourning dove, 1 horned lark, and 1 unidentified large bird. The human-found searches will not factor into the remainder of our results. Species found by our dog team are listed in Table 2.

We found 8 of the 21 birds reported to have been found and removed by human searchers at Golden Hills, meaning that either we found 8 birds prior the human searchers' removal of them or we detected residual evidence after the removals, i.e., incomplete removals. We found 3 of the 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 their 3 burrowing owls, the one mallard they found, and 1 of 2 horned larks. We did not find the 1 Mexican free-tailed bat found by human searchers, or the 1 golden eagle, 1 ferruginous hawk, and other birds. Except for large birds, the human searchers' practice of removing found carcasses probably had little impact on our study results.

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 2). Whereas our dog team failed to detect the one bat found by human searchers, likely because it had been removed by the human searchers after discovery, the human searchers found none of the 71 bats that our dogs found and which we left in the field to be potentially found by human searchers (some of these bats would have been removed by scavengers between our detections of them and the next human search).

Detection Trials

Of 278 trial placements, 214 were available to be found by dogs during at least one search. Most of the remainder had been removed by scavengers prior to the first search following placement, and a few were mistakenly placed outside the search areas.

Of the trial carcasses placed for the first time and shortly before the next fatality search, and hence confirmed available to searchers, our dogs detected 96% of bats and 90% of birds between both projects. Our dogs found 100% of 41 bats placed at Golden Hills and 93% of 54 bats placed at Buena Vista. They found 84% of 56 birds placed at Golden Hills and 91% of 32 birds placed at Buena Vista. For comparison, at Golden Hills the dog search team of H.T. Harvey (2017) found 77% of 35 placed bats and 53% of 26 placed small birds that were confirmed available to be found the previous fall, 2016.

We also quantified detection rates of all searcher exposures to carcasses, whether just placed or those persisting through multiple searches and subjected to trial testing each time. Of these, our dogs found 95% of 132 bat trials and 91% of 101 bird trials between both projects. Our dogs found 100% of 44 bat trials at Golden Hills and 92% of 88 bat trials at Buena Vista. They found 88% of 57 bird trials at Golden Hills and 95% of 44 bird trials at Buena Vista.

Because we were required to remove bats soon after trial completion at Golden Hills, we relocated these bat carcasses to Buena Vista as special trials to test dogs on older carcasses (Table 1). All of these bats had persisted 1 to 4 days of trial placements at Golden Hills prior to relocation. Our dogs detected 87.5% of 24 relocated bats confirmed to be available for detection.

We also placed 36 bird carcasses on randomized days at Buena Vista to vary the days since placement by up to two weeks (Table 1). Our 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 already been removed by scavengers.

For our dog team, mean distance to carcass occlusion did not differ significantly between trial carcasses that were detected versus missed for bats, birds, and bats and birds pooled together (t-tests, $P > 0.05$). Nor did mean $\log_{10}$ body mass differ significantly between trial carcasses that were detected versus those missed for bats, birds, and bats and birds pooled together (t-tests, $P > 0.05$). That body mass was not a factor was especially interesting for bats, of which the smallest was a dried out carcass of 1 g, and many of which consisted of immature bats that had fallen out of a nest box. Among birds, the dogs had no problem finding hummingbirds and many chicks of various songbird species. The mean number of fatality (and trial) finds on a particular day did not differ significantly between trial carcasses that were detected versus missed for bats, birds, and bats and birds pooled together (t-tests, $P > 0.05$).

Of the 7 bats that were 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 having 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. Three bats were missed on the same day – 31 October 2017. One missed bat was on a gravel pad, 1 on a gravel road, 1 on restored grassland, and 4 on 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.

Our dogs missed 8 birds ranging in size from a 3.7 g Bewick's wren to an 87.6 g Eurasian collared-dove. Three birds were missed on the same day – 13 November 2017, and 2 more were missed on the same day – 23 October 2017. Two of the missed birds were on the non-gravel portions of turbine pads, 3 were on reclaimed grassland, and 3 were 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 were missed on 8 search days when the dog team was either accompanied by Heath Smith (4 carcasses missed during 3 days) or photographed by Shawn Smallwood (6 carcasses missed during 5 days). That is, 67% of the misses occurred on 18% of the search days when the dog team might have been distracted. The misses occurred on days of distraction nearly 4× other than expected. Another bat trial carcass was missed during the first day the dog team searched. Twelve of the 15 trial carcass misses occurred among only 3 groups of turbines typically searched on a single day. Golden Hills turbines 4, 5 and 6, searched on the same day, included 5 missed trial carcasses. Buena Vista turbines C11 and C12, which were searched with C13 as a group, included 4 missed carcasses. Buena Vista turbines A14, A15, and A16, which were searched with A13 as a group, included 3 missed carcasses. Thus, 80% of missed trial carcasses occurred at 3 of 21 (14%) turbine search groups, or nearly 6× other than expected at these turbine groups. Common features of these turbine search groups were steep slopes and highest elevation peaks in the local area.

Searcher Detection and Distance from the Turbine

Searcher detection of trial carcasses was higher for dogs than for humans, more so for bat carcasses than bird carcasses (Figure 1 and below). Our dog searcher detection rates, S, did not change significantly with increasing distance from the turbine, whereas human searcher detection rates tended to decline with increasing distance ($P<0.10$):

Bat carcasses placed for dogs (Statistics unnecessary): $S = 1.000 - 0.0000X$
Bat carcasses placed for humans ($r^2 = 0.16$, SE = 0.08, $P>0.05$): $S = 0.174 - 0.0015X$
Bird carcasses placed for dogs ($r^2 = 0.04$, SE = 0.16, $P>0.05$): $S = 0.970 - 0.0020X$
Bird carcasses placed for humans ($r^2 = 0.21$, SE = 0.15, $P>0.05$): $S = 0.612 - 0.0031X$

Carcass Persistence

Within 10 days of placements, 75% of bats and 67% of small birds disappeared from placements sites (Figure 2). One month since placement, persistence rates were about 5% for bats and 11% for small birds (Figure 2). Broken down by body mass, smaller and larger bats persisted at nearly the same rates until two weeks elapsed, after which the smaller bats persisted longer

(Figure 3). Examined by carcass freshness at time of placement, the freshest carcasses might have persisted longer through about two weeks, after which persistence did not differ by freshness at placement time (Figure 3). Daily mean carcass persistence rates were similar between bats and small birds (Figure 4):

Bats $R_i = 1.01855 \times 0.89976^i$, $r^2 = 0.98$, RMSE = 0.11
Birds $R_i = 1 - 3.07322 \times \left(1 - exp\left(-0.09959 \times log(i+1)\right)\right)$, $r^2 = 0.99$, RMSE = 0.04

Daily mean search interval, *I*, at Buena Vista and Golden Hills was 22 and 27 days, respectively, so the fatality adjustment for carcass persistence would be 0.40 and 0.35 for bats and 0.39 and 0.35 for small birds. These adjustments translate to fatality estimates of 60 bats and 67 small birds at 31 wind turbines at Buena Vista, and 203 bats and 180 small birds at 32 wind turbines at Golden Hills during the time of our study (these estimates serve only as examples of fatality adjustments and are not intended for comparison to other wind projects).

Our carcass persistence rates generally compared well to those estimated at Vasco Winds (Brown et al. 2016) and previously at Golden Hills (H.T. Harvey and Associates 2017), although there were some notable differences (Table 3). Bat carcass persistence rates were very low at Vasco Winds in 2013, and the H.T. Harvey and Associates' (2017) estimates for both bats and small birds were higher than ours at 28 days.

Patterns of Found Fatalities around Wind Turbines

Here we begin with a human searcher basis for comparison. In the Vasco Winds monitoring effort of 2012-2015, human searchers revealed that fatalities/ha decreased rapidly with distance from the turbine (Figure 5, left graph), and in the same manner as reported by Huso et al. (2014, 2017). However, they also found that, examined another way, the number of small and large birds were represented in relatively constant numbers among increasing 10-m distance intervals from the tower base to the maximum search radius (Figure 5, right graph). The number of bats found by humans declined significantly with increasing distance from the turbine, but not as rapidly as when expressed in a density metric (Figure 5). The density plot exaggerates the concentration of carcasses near the turbine because the area is smaller; and not necessarily because there are more carcasses. The Huso et al. assumption of higher carcass density near the turbine can bias fatality estimates if searcher efficiency varies with distance from the turbine or if more fatalities actually deposit farther from the turbine.

The best-fit logistic model of cumulative fatality finds regressed on 10-m distance increments (Figure 6) was the following (Bats: $r^2 = 0.96$, RMSE = 90.76; Small birds: $r^2 = 0.99$, RMSE = 42.77; Large birds: $r^2 = 0.97$, RMSE = 75.27):

$$Y_{Bats} = \frac{1}{\frac{1}{45.39} + 0.29 \times (0.937^X)},$$

$$Y_{Small\ birds} = \frac{1}{\frac{1}{84.58} + 0.15 \times (0.957^X)},$$

$$Y_{Large\ birds} = \frac{1}{\frac{1}{60.43} + 0.12 \times (0.966^X)},$$

where *X* represented 10-m distance increments from the wind turbine's tower base. To come within 1 fatality of each asymptote, μ, maximum search radii would need to be 99, 159 and 173 m for bats, small birds, and large birds, respectively.

Over the time period for which we were provided data at Golden Hills, the human searcher results can provide for only weak examinations of spatial patterns of carcass deposition around wind turbines. Only a single bat was found, negating any spatial comparison, and only 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 of cumulative bird fatality finds regressed on 10-m distance increments (Figure 7) was the following ($r^2 = 0.98$, RMSE = 11.15):

$$Y_{Birds} = \frac{1}{\frac{1}{21.90} + 0.607 \times (0.953^X)}.$$

To come within 1 fatality of the asymptote, μ, the maximum search radius would need to be 119 m for birds, according to the findings of human searchers at Golden Hills. This maximum search radius was predicted to be shorter at Golden Hills than it was for both small and large birds at Vasco Winds.

Based on our dog searches at Golden Hills, the best-fit logistic model of cumulative fatality finds regressed on 10-m distance increments (Figure 7) was the following (Bats: $r^2 = 0.98$, RMSE = 109.14; Small birds: $r^2 = 0.99$, RMSE = 24.77; Large birds: $r^2 = 0.98$, RMSE = 6.02; All birds: $r^2 = 0.99$, RMSE = 29.71):

$$Y_{Bats} = \frac{1}{\frac{1}{78.86} + 0.16 \times (0.962^X)},$$

$$Y_{Small\ birds} = \frac{1}{\frac{1}{52.15} + 0.58 \times (0.954^X)},$$

$$Y_{large\ birds} = \frac{1}{\frac{1}{17.83} + 9.18 \times (0.942^X)},$$

$$Y_{Birds} = \frac{1}{\frac{1}{73.889} + 0.48 \times (0.956^X)},$$

Site	Taxa	Model coefficients			r^2	RMSE	Model-predicted asymptote of cumulative fatalities	
		a	b	c			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

where X represented 10-m distance increments from the wind turbine's tower base. To come within 1 fatality of each asymptote, μ, maximum search radii would need to be 177, 156, 120 and 173 m for bats, small birds, large birds, and all birds, respectively.

Using dogs, the number of bats that were found increased with increasing distance from the turbine at both Buena Vista and Golden Hills (upper graphs, Figure 8), but these increases were proportional to the search areas within radial bands at increasingly greater distances from the turbine (lower graphs, Figure 8). At Buena Vista, the number of birds found by dogs spiked between 40 and 50 m from the turbines, whereas the number of birds/ha decreased greatly with distance from the turbine at both projects (Figure 8).

Impact of Turbine Shutdown on Volant Wildlife

Our expected values, $E[I_A]$, were 0.1958, 0.1220, 0.0061, and 0.1166 fatalities/search for bats, small birds, large birds, and all birds, respectively. Our observed fatalities/search at Buena Vista following the shutdown were 0, 0.0833, 0, and 0.0833 for bats, small birds, large birds, and all birds, respectively. The IMPACTs of the shutdown were 100% fatality reductions for bats and large birds, and a 32% reduction for small birds. The fatality finds examined in our BACI design would predict that 9.4 bats would have been found as fatalities at Buena Vista had the turbines continued operating. That 22 bats had been found at Buena Vista prior to the shutdown, and that 37 (58%) of 64 bats had been found at Golden Hills prior to the Buena Vista shutdown, indicates that the bat migration was winding down by the time the Buena Vista project was shut down. Nevertheless, the effect of the shutdown was substantial for bats. For large birds, the effect was ambiguous because the number of predicted large bird fatalities in the shutdown period was <1.

DISCUSSION

Despite the trial administrator's (Smallwood's) deliberate use of immature bats and birds, a preponderance of small-bodied species, and old carcasses along with the fresh ones, and despite the administrator's placement of some carcasses beyond the dog search radius, our dogs still found 100% of bat trial carcasses at Golden Hills and the vast majority of all other bird and bat carcass placements between the two wind projects. Adding to the findings of Mathews et al. (2013), our study further verifies the very large differences between human and dog searchers in bat and small bird carcass detection rates. Compared to the 71 bat fatalities our dog team found at Golden Hills, human searchers found 1 bat among the same turbines searched and the same time period. Making this 71-fold difference even greater was the fact that the human searchers performed 69 turbine searches to our 55. Additionally, human searchers found 11 small birds whereas our dogs found 47 (4 were found by both teams), a greater than four-fold difference in small bird detection. A smaller, though substantial, difference in detection rates was associated with large birds, of which human searchers found 10 and our dogs found 16 (4 were found by both teams).

The bat carcass detection rate derived from human searches was 0.014 (1 human-found bat divided by 72 found by both human searchers and our dog team), whereas our rate derived from dog searches and detection trials was 1.000 (or 100%). For comparison, the human searches at Vasco Winds achieved a bat carcass detection rate of 0.052 for 134 bat trial carcasses that were integrated into routine fatality monitoring at turbines searched weekly (Brown et al. 2016). More precisely, among 82 bat trial carcasses known to be available to human searchers at Vasco Winds, the detection rate increased to 0.085. Among 42 bat trial carcasses placed in one-day trials at Vasco Winds, and therefore more comparable to the trials we performed at Golden Hills, the detection rate using humans was 0.143. Even the Vasco Winds rate based on a more comparable method was much lower than the rate we achieved at Golden Hills using dogs. Mathews et al. (2013) had found bat trial carcass detection rates of 0.73 using dogs and 0.20 using humans.

Consistent with Brown et al.'s (2016) conclusion that bat detection rates at Vasco Winds were too low for determining whether some wind turbines kill disproportionate numbers of bats, the basis for the same conclusion is even stronger at Golden Hills among the 32 turbines that were searched using humans without dogs. Human searchers cannot find enough of the available bats to test hypotheses related to spatial distributions of bat fatalities deposited around each wind turbine, let alone among wind turbines across a project. Only trained dogs and dog handlers can find enough of the available bats and small birds to test for patterns that can lead to more efficient fatality monitoring. Only dog searchers can inform whether activity patterns seen before construction can predict post-construction impacts. And only dogs can find enough of the available bats to develop micro-siting strategies and test operational curtailment strategies.

One of the implications of our study results is that fatality rates are being underestimated because too often investigators and permitting agencies have assumed that disproportionate numbers of fatalities fall straight down or near the wind turbine. This common assumption has justified maximum search radii that fall far short of the area needed to adequately detect available carcasses of birds and bats. Even at the recent wind projects in the APWRA, the search radius of 105 m appears to be too short. Rather than finding fewer bats with increasing distance from the turbine, as Huso et al. (2014, 2017) posited, we found the opposite. We found the number of bats to increase with distance from the turbine, consistent with Smallwood's (2016, and unpublished data) eyewitness observations of wind turbine casualties sometimes drifting far downwind of the turbine. Compounding this search radius bias, we also found that human searchers at Vasco Winds tended to find decreasing proportions of available bat and small bird carcass trials with increasing distance from the turbine. Not only did we learn that bat fatalities are deposited in greater numbers farther from the wind turbine, but humans are able to find fewer of the available fatalities farther from the turbine.

Additional research is needed to determine just how far searches need to extend from turbines to potentially detect all of the available fatalities. Alternatively, additional research is needed to determine the proportion of fatalities that are not being detected due to insufficient search radius. Just 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 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.

Other than the search radius bias, using trained dogs for fatality monitoring requires only one substantial adjustment to fatality estimates, and that would be for carcass persistence. Many of the placed bats and small birds are gone from placement sites within one week of placement. If carcass placement schedules are integrated into the fatality monitoring schedule (Smallwood 2017), then the average daily availability of carcasses will reduce the size of the adjustments from what might be implied in Figure 4. Such integrated detection trials would also provide for the small adjustments needed for dog searcher detection. Regardless, body mass would no longer be required for deriving fatality adjustments (Smallwood 2017).

Searching with dogs revealed a substantial error associated with carcass removals. 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 (KSS), 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 (2017) left carcasses where found and relied on fatality photos and on tracking when and where remains were found to prevent double counting.

We concur with Mathews et al. (2013) that fatality monitoring at wind turbines should be performed using trained dogs and dog handlers, and we further concur that dogs should be carefully selected for the task. 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 trained dogs and their handlers can collect at wind turbine projects.

Finally, our test of whether operational curtailment can reduce bat fatalities was convincing, and compelling. We found that where wind turbines are shut down during a bat migration, bat fatalities cease. For bats to collide with wind turbines, the rotors of the turbines must spin. Because the migration season is relatively brief, a seasonal curtailment strategy would drastically reduce bat fatalities while not giving up a large proportion of the annual energy generation. However, operational curtailment appears to be less effective at reducing fatalities of small birds, consistent with the findings of Smallwood (2016a).

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Captain celebrates after finding a fatality in the Altamont Pass, 2017

ATTACHMENT 2

Comparison of Wind Turbine Collision Hazard Model Performance Prepared for Repowering Projects in the Altamont Pass Wind Resources Area

K. Shawn Smallwood and Lee Neher

7 January 2017 (Updated 5 April 2018)

Photo by Shawn Smallwood

A repowered 2.3 MW Siemens wind turbine neighboring 1 MW Mitsubishi turbines in the background and 120 KW Bonus "old-generation" turbines in the foreground.

Update: This report was updated to include a revised burrowing owl collision hazard model, developed for a repowering project that is in progress. The new model relies on relationships between fatality rates at old-generation wind turbines and terrain. The new model performed much better than did any of the previous models. Everything else in this update is unchanged from the 7 January 2017 report. Because the first year report of fatality monitoring at Golden Hills became available in February 2018, an addendum to this report was prepared to address golden eagle model performance at Golden Hills.

Wind turbines were installed in the Altamont Pass Wind Resource Area (APWRA) in Alameda and Contra Costa Counties, California, beginning in the early 1980s. These original wind turbines, herein referred to as "old-generation wind turbines," ranged in rated capacity from 40 KW to 400 KW, some of which were installed on vertical axis towers and the rest were installed on horizontal axes mounted on towers ranging from 14 m to 43 m high. These old-generation wind turbines were usually arranged in rows, which were not sited with avian or bat collision risk in mind. By the mid to late 1980s the issue of raptor collisions emerged, and with subsequent monitoring efforts collision mortality was recognized as problems for raptors, other birds and even bats (Orloff and Flannery 1992, Smallwood and Thelander 2004, ICF International 2016). Orloff and Flannery (1992, 1996) and Smallwood and Thelander (2004, 2005) examined patterns of fatalities in efforts to identify candidate causal factors and to recommend mitigation solutions. Both studies recognized topography as important, as wind turbines located on particular terrain features were associated disproportionately with fatalities. Such terrain features included ridge saddles, breaks in slope, steep slopes, and valley features such as canyons and ravines. Given the deterioration of many old-generation wind turbines by the time the Smallwood and Thelander (2004) study was completed, Smallwood and Thelander recommended repowering of the wind projects as soon as possible.

Smallwood and Thelander's (2004) strongest recommendation was to begin repowering by replacing the old-generation wind turbines with modern turbines that are sited to minimize bird collisions. This recommendation was reiterated in Smallwood (2006), Smallwood and Neher (2005, 2009), Smallwood and Thelander (2005, 2008), Lamphier-Gregory et al. (2005), Smallwood and Karas (2009), and Smallwood et al. (2009a, c). The Alameda County Scientific Review Committee also recommended careful repowering as the highest priority measure for reducing raptor fatalities in the APWRA. Following the Smallwood and Thelander (2004, 2005) study, additional studies were performed and reports and papers written in support of developing collision hazard models to help guide repowering (Smallwood 2017a; Smallwood et al. 2009b,c; Smallwood et al. 2010, Smallwood et al. 2017). Some challenges and opportunities related to measuring the effects of repowering on birds and bats were summarized in Smallwood (2017b). Beginning in 2009 Smallwood and Neher began developing map-based collision hazard models, the first of which were prepared as demonstration studies focused on burrowing owl (Smallwood and Neher 2009, Smallwood et al. 2009a). Tres Vaqueros was the first repowering project for which we prepared map-based collision hazard models to reduce raptor fatalities (Smallwood and Neher 2010a, 2011). New models followed for the Vasco Winds repowering project (Smallwood and Neher 2010b), the Golden Hills project (Smallwood and Neher 2015a), the Patterson Pass project (Smallwood and Neher 2015b), Golden Hills North (Smallwood and Neher 2015c), Sand Hill (Smallwood and Neher 2016a), and Summit Winds (Smallwood and Neher 2016b).

Map-based collision hazard models of each successive repowering project benefitted from lessons learned from past efforts on repowering projects, but mostly from the Vasco Winds repowering project. For example, we learned from the Vasco Winds project that terrain needs to be weighted for collision hazard in anticipation of changes to terrain caused by grading for the new turbine pads and access roads. Another lesson learned was that most golden eagle fatalities are caused by wind turbines located on ridge structures that are generally oriented east-west. The models also benefitted from a transition from reliance on use rates to behavior rates and from the accumulation of additional use and behavior data collected over longer time periods and larger areas in the APWRA. As the sample sizes of use and behavior data increased, additional predictor variables became available, such as rates of ridge crossings and wind turbine interaction events, i.e., near-misses. Newer collision hazard models also benefitted from the emergence of golden eagle telemetry data, and more expansive and more carefully interpreted fatality rates from both old and new wind turbines across the entire APWRA. The burrowing owl models benefitted from the expansion from the Vasco Caves Regional Preserve study of 2006-2007 used in the earliest models to the APWRA-wide burrowing owl density and distribution study begun in 2011 and used for later models. Furthermore, the latest model was prepared for the entire APWRA instead of tailored for individual project locations as had been done earlier. In summary, collision hazard models likely improved through time due to expanded and improved data used to inform the models, expanded and improved terrain measures used to develop the models, lessons learned from previous projects, and finally the shift from tailoring models for project sites to developing models APWRA-wide. However, these improvements were assumed rather than measured.

The primary objective of this study was to assess the predictive performance (defined explicitly in Methods section) of collision hazard models developed through the succession of repowering projects in the APWRA. Another objective was to assess whether the latest version of collision hazard models is the top-performer in terms of predicting collision risk based on spatial locations of wind turbines. A third objective was to assess whether and to what degree any of our collision hazard models developed for particular species might serve as umbrella predictors of collision hazard to all raptors as a group or to all birds as a group. A fourth objective was to further explore the data to determine why model predictions might have turned out to be lower than expected.

The most effective way to assess model performance is to monitor for fatalities at projects that were micro-sited according to model predictions. Vasco Winds was micro-sited according to one version of the collision hazard models, and because fatality monitoring was ongoing throughout the AWPRA while fatality monitoring was performed for three years following construction, we could assess the performance of the models by comparing project-level fatalities at Vasco Winds to fatalities elsewhere in a before-after, control-impact (BACI) experimental design (Brown et al. 2016). However, a BACI design is no longer feasible for comparing the performance of collision hazard models used to micro-site other repowering projects in the APWRA because APWRA-wide fatality monitoring was discontinued in fall 2014. The only comparisons possible going forward would be before-and-after repowering. Such comparisons are prone to confounding effects from unmeasured factors and would not be possible until post-construction fatality monitoring is completed at repowering projects. Fatality monitoring at Golden Hills began in fall 2016, so results there are becoming available one annual fatality monitoring report at a time. For the sake of minimizing collision risk as part of the micro-siting of new or ongoing repowering projects, we assessed post-construction fatality monitoring results at Golden Hills in an addendum report. In this report, we needed to assess progress of the collision hazard models based on fatality rates at old-generation wind turbines.

This study compared estimates of fatality rates among >4,100 APWRA wind turbines that were monitored for at least one year, 1998-2015, across four hazard classes that were predicted by each version of the models we developed. Collision hazard classes ranged 1 through 4, representing lowest (1) to highest (4) collision risk. Among all 6 versions of the models, Hazard Class 1 typically covered about 63% of the APWRA landscape, Hazard Class 2 covered about 20%, Hazard Class 3 covered about 12%, and Hazard Class 4 covered about 5%. For each of the collision hazard models we identified which of the monitored wind turbines belonged to each of these Hazard Classes. We judged a model to perform well if the estimated mean fatality rate increased substantially from Class 1 to Class 4, or alternatively from Classes 1 and 2 to Classes 3 and 4. Another indicator of superior performance was whether mean fatality rates increased continuously from one Hazard Class to the next in succession. Another indicator included precision (confidence interval) of mean fatality rate estimates, but this indicator was complex and is discussed in more detail later. Our approach assumed that collision hazard is influenced more by spatial location than by wind turbine size or type. This assumption may not be entirely true, but there is little evidence available to either refute or verify it, and it is an assumption that also applied to all of the micro-siting implemented to date in the APWRA.

METHODS

Each version of the collision hazard models required detailed technical explanations resulting in relatively large reports. Because the primary objective of this study is simply to compare the performance of collision hazard models prepared for repowering projects in the APWRA, we report a methodological overview as well as methods that pertain directly to the objectives of this report. Detailed explanations of methods used to develop collision hazard models can be found in the original reports, cited earlier.

Comparing collision hazard models among repowering projects is complicated by variation in data sources (Table 1) and in wind project locations. Models were developed from those portions of the APWRA where data were collected. For example, the earliest models were based on data collected from Vasco Caves Regional Preserve, including the entirety of Vasco Caves for burrowing owl data and the surveyed airspace around 15 observation stations for volant raptor use data. Later models were based on data collected APWRA-wide, including from 46 sampling plots for burrowing owl data and the surveyed airspace around many observation stations for volant raptor use and behavior data. Later models were also based on fatality data collected from wind turbines monitored for at least one year, but the terrain represented by monitored turbines shifted through time as more turbines were included in monitoring. These models, which varied in data sources, were then extended to various project locations. The project locations varied in terrain conditions, with some projects on large hills and deep valleys and others on shallower terrain. We had tailored the models to fit the terrain of each project, leaving a comparison of model performance less than straightforward. For example, some models for specific focal species might apply to ranges of elevation that are missing from other project areas. Adding to the difficulty of comparing model performance is the fact that most of the projects involved have yet to be repowered and monitored for fatalities. Yet to be constructed are Tres Vaqueros, Patterson Pass, Golden Hills North, Sand Hill and Summit Winds. Golden Hills was constructed, but fatality monitoring began in fall 2016, and fatality rate estimates were unavailable until February 2018 (an addendum report has been prepared to address the golden eagle fatalities). The only constructed and monitored repowering project for which collision hazard models were prepared includes the Vasco Winds project.

For each focal species we typically built a collision hazard model combined from models that were built from specific types of data. For a particular species, we might have constructed a model based on behavior patterns, another based on GPS/GSM telemetry positions, and another based on fatality rates. Each of these data sources introduced unique sources of error and bias even though we attempted to reduce error and the effects of bias to the degrees feasible. For example, use rates are prone to error and bias in detection rates of flying birds due to variation in airspace that is visible from the observation station. We therefore adjusted use rates by calculating visible volumes of airspace surveyed at each station and dividing the number of birds detected per survey hour by the visible volume of airspace. In another example, fatality rates vary due to variation in searcher detection rates of carcasses, carcass persistence time, and proportion of carcasses found within the maximum fatality search radius, which also varied in the APWRA. Fatality rates also vary due to variation in the denominators in the fatality ratio metric, including wind turbine capacity in MW and the duration of monitoring in years. We therefore adjusted fatality rates for all these sources of variation. In yet another example, GPS/GSM telemetry positions of golden eagles are referenced to the Geoid, so we mounted telemetry units to Smallwood's truck while driving around the APWRA as a basis for adjusting eagle heights above ground relative to a digital elevation model of the APWRA. Telemetry positions were also processed to identify those within certain height domains above ground and those attributed to perching versus flying. All of these adjustments, and others, are detailed in the reports we prepared on collision hazard models. Adjustments specific to use rates are also detailed in Smallwood (2017a). Adjustments specific to fatality rates are also detailed in Smallwood (2007, 2013).

We integrated the data-specific models to derive composite models in the hope that the collision hazard models would be more robust. The latest iteration of the golden eagle model was a composite of a model developed from flight behaviors, a model developed from GPS/GSM telemetry, and a model developed from fatality rates at monitored wind turbines. The composite collision hazard models that could be compared for golden eagle, red-tailed hawk, American kestrel and burrowing owl include those in Table 1. For burrowing owl, we did not develop a composite model early on, but we developed one later as we acquired data on fatality rates as well as burrow locations.

To assess model performance among species and projects, we compared fatality rate estimates to collision hazard predictions made from the composite models. We did not compare the models developed for Patterson Pass because we were unable to secure permission from the owner of the project, EDF (emails and phone calls were not answered). However, the models developed for Patterson Pass were similar to those developed for Golden Hills North. For the latest version of collision hazard models – those prepared for Summit Winds, we also compared model performance prepared from specific data sources. For all of these comparisons we extended model predictions across the entirety of the APWRA while maintaining the original model structures including collision hazard scores bounding lowest to highest collision hazard classes 1 through 4. All of the models predicted only four collision hazard classes resulting in about 63% of the APWRA in the lowest collision hazard class of 1, about 20% of the APWRA in the second lowest collision hazard class of 2, about 12% of the APWRA in the second highest collision hazard class of 3, and about 5% of the APWRA in the highest collision hazard class of 4.

Table 1. *Summary of data sources used to develop collision hazard models for repowering projects in the Altamont Pass Wind Resources Area, California*.

Model version	**Wind project**	**MW**	**Year**	**Data sources[1] linked to terrain measurements**	
				Golden eagle, red-tailed hawk, American kestrel	**Burrowing owl**
1	Tres Vaqueros	28.800	2010	Use in Vasco Caves 2005-2007	Burrow locations in Vasco Caves 2005-2007
1	Vasco Winds	78.100	2010	Use in Vasco Caves 2005-2007	Burrow locations in Vasco Caves 2005-2007
2	Golden Hills	87.400	2015	Use from Vasco Caves 2005-2007, Buena Vista 2008-2009, and Alameda County monitor 2005-2011; Behavior in APWRA 2012-2014; Fatality rates in APRWRA 1998-2010 (golden eagles only)	No model was developed
3	Patterson Pass	21.960	2015	Behavior in APWRA 2012-2014; Fatality rates in APWRA 1998-2010 (golden eagles only)	No model was developed
4	Golden Hills North	39.250	2015	Behavior in APWRA 2012-2014; Fatality rates in APWRA 1998-2010 (except for American kestrels)	Burrow locations in 46 APWRA plots 2011-2012; Fatality rates in APWRA 1998-2010
5	Sand Hill	24.146	2016	GSM/GPS telemetry (golden eagles only) 2012-2015; Behavior in APWRA 2012-2015; Fatality rates in APWRA 1998-2010 (except for American kestrels)	Burrow locations in 46 APWRA plots 2011-2015; Fatality rates in APWRA 1998-2010
6	Summit Winds	54.000	2016	GSM/GPS telemetry (golden eagles only) 2012-2015; Behavior in APWRA 2012-2015; Fatality rates in APWRA 1998-2015	Burrow locations in 46 APWRA plots 2011-2015; Fatality rates in APWRA 1998-2015

[1] For consistency and comparability, all fatality rates were adjusted consistency by Smallwood , regardless of the source.

Diagnostics indicating superior model performance include (1) increasing mean fatality rates with each higher collision hazard class from 1 through 4, (2) large magnitude increases in mean fatality rates at hazard classes 3 and 4 compared to classes 1 and 2, and (3) smaller 90% confidence intervals (CI). The third diagnostic is less reliable, however, because the majority of monitored wind turbines will not have caused a fatality during the period of monitoring, especially among wind turbines monitored over relatively short periods (monitoring duration varied greatly among APWRA turbines, ranging 1 to 10 years). Fatality rates at wind turbines where fatalities were found will have been adjusted for the portion of fatalities not found among the turbines monitored, meaning the found fatalities are adjusted for the failure to find fatalities that actually happened at other wind turbines. Adjustments for searcher detection error and carcass persistence can result in one burrowing owl fatality found at a turbine being adjusted to more burrowing owl fatalities attributed to that turbine, ranging 7 to 17 burrowing owl fatalities depending on the fatality search interval used in monitoring. Building from this example, what this means is that up to 16 burrowing owl fatalities that occurred at up to 16 other wind turbines were attributed to the single turbine where the one fatality was found while the other turbines were attributed with false zero fatality finds. This loading of unfound burrowing owl fatalities onto the one turbine where a fatality was found artificially inflates the confidence ranges. Therefore, diagnostics (1) and (2) are most reliable, and were weighted accordingly:

Sequential increase of mean fatalities/year in hazard class (S) High score = 3
Y = Mean fatalities/year in hazard class as multiple of mean in lower hazard class

$Y \leq 0.9$	-1
$0.9 < Y < 1.1$	0
$Y \geq 1.1$	1

Magnitude of increase between Classes (M) High score = 8
Y = Mean fatalities/year in hazard class 3 or 4 as multiple of mean in class 1

$Y \leq 0.9$	-1
$0.9 < Y < 1.1$	0
$1.1 \leq Y < 2$	1
$2 \leq Y < 3$	2
$3 \leq Y < 4$	3
$Y \geq 4$	4

Precision of mean fatalities/year in hazard class (P) High score = 8
Y = 90% CI (1.645 × SE) in hazard class as multiple of overall mean fatalities/year

$Y \leq 1$	2
$1 < Y \leq 2$	1
$2 < Y \leq 3$	0
$3 < Y \leq 4$	-1
$Y > 4$	-2

$$Model\ performance = \frac{\left(\left(\frac{S}{3} \times 2\right) + \left(\frac{M}{8} \times 2\right) + \left(\frac{P}{8}\right)\right)}{5}$$

We also plotted mean fatality rate estimates by collision hazard class for all raptors as a group and all birds as a group, and where the collision hazard classes were originally predicted for golden eagle, red-tailed hawk, American kestrel, or burrowing owl. The only models used were combined models for each species. One purpose of this comparison was to determine whether and to what degree species-specific collision hazard models could serve as umbrella models for raptors or all birds. Another was to determine whether any versions of the models can serve as superior umbrellas for predicting raptor or all bird collision hazard.

Each version of the combined collision hazard models were mapped over the same area to illustrate spatial differences. The area selected roughly covered the project area proposed for Golden Hills North. However, we intentionally omitted proposed wind turbine locations related to Golden Hills North because at the outset of this study we agreed not to map proposed turbine locations due to ongoing micro-siting.

RESULTS

The most recent collision hazard models developed for Summit Winds performed best among all monitored wind turbines across the APWRA (Table 2, Figures 1-4). Our indicator of model performance was highest in model version 6 for golden eagle, red-tailed hawk and American kestrel, and in version 7 for burrowing owl (Table 2). Hazard class 4 was highest among all the golden eagle models, but the overall response (magnitude of increase in fatality rates) was best in model version 6 prepared for Summit Winds (Figure 1). Hazard class 4 was also highest among all the red-tailed hawk models, but the overall response was best in model version 6 prepared for Summit Winds (Figure 2). Compared to estimated golden eagle fatality rates at wind turbines in hazard class 1 of model version 6, the estimated fatality rates in hazard class 3 averaged 2.6× higher and the estimated fatality rates in hazard class 4 averaged 3.67× higher. Whereas golden eagle fatality rates in model version 2 increased continuously from one hazard class to the next in succession, compared to estimated golden eagle fatality rates at wind turbines in hazard class 1 of model version 2, the estimated fatality rates in hazard class 3 averaged only 1.9 × higher and the estimated fatality rates in hazard class 4 averaged only 2.3× higher.

For red-tailed hawk, compared to estimated fatality rates at wind turbines in hazard class 1 of model version 6, the estimated fatality rates in hazard class 3 averaged only 1.4 × higher and the estimated fatality rates in hazard class 4 averaged only 1.5× higher (Figure 2). Whereas the magnitude of the fatality rate change between hazard classes 1 and 4 was similar between model version 6 and versions 1 and 2, mean fatality rates did not change much if at all between hazard classes 1 and 3 for any of the models except version 6. Overall, model version 6 performed better at predicting golden eagle fatality rates than red-tailed hawk fatality rates (Table 2).

Until model version 6, the collision hazard models performed miserably for American kestrel (Table 2, Figure 3). Our breakthrough performance with version 6 of the American kestrel model was due to our increased focus on terrain lower on the slopes and farther from ridge crests, which includes wind turbine locations where about 75% of American kestrel fatalities have been found. Model version 6 was the only version for which American kestrel fatality rates increased with successively higher collision hazard class. Compared to estimated American kestrel fatality rates at wind turbines in hazard class 1 of model version 6, the estimated fatality rates in hazard class 3 averaged 1.75× higher and the estimated fatality rates in hazard class 4 averaged 3.16× higher.

Burrowing owl collision hazard models trended in the right direction, but version 7 performed best (Figure 4). Compared to estimated burrowing owl fatality rates at wind turbines in hazard class 1 of model version 1, the estimated fatality rates in hazard class 3 averaged 3.5× higher and the estimated fatality rates in hazard class 4 averaged 6.9× higher. Compared to estimated burrowing owl fatality rates at wind turbines in hazard class 1 of model version 6, the estimated fatality rates in hazard class 3 averaged 2.5× higher and the estimated fatality rates in hazard class 4 averaged 2.3× higher. Compared to estimated burrowing owl fatality rates at wind turbines in hazard class 1 of model version 7, the estimated fatality rates in hazard class 3 averaged 2.2× higher and the estimated fatality rates in hazard class 4 averaged 7.5× higher.

Table 2. *Performance (see indicators of performance, Methods section) of combined collision hazard models developed for each species and each repowering project in the Altamont Pass Wind Resource Area.*

Model version	Wind project	Model performance			
		Golden eagle	Red-tailed hawk	American kestrel	Burrowing owl
1	Vasco Winds	0.233	0.392	0.208	0.775
2	Golden Hills	0.575	0.308	-0.025	---
4	Golden Hills North	0.442	0.467	-0.333	0.333
5	Sand Hill	0.342	0.467	-0.050	0.333
6	Summit Winds	0.725	0.492	0.567	0.333
7	In progress	0.725	0.492	0.567	0.900

Version 6 of the golden eagle collision hazard models appeared to perform best when combined from all data sources, but also performed well when based on any of the three data sources (Figure 5). Version 6 of the red-tailed hawk collision hazard models appeared to perform best when based on the fatality data (Figure 6). Version 6 of the American kestrel collision hazard models also appeared to perform best when based on the fatality data (Figure 7). Version 7 of the burrowing owl collision hazard models appeared to perform best when based on fatality data conditioned on terrain attributes 3 (Figure 8).

The collision hazard models are depicted in map-form for each species and each model version in Figures 9 through 26, including a model for golden eagle collision risk based solely on GPS/GSM telemetry positions as a data source. These models were all extended to an area overlapping the Golden Hills North project. As a reminder, some of the hazard classes in some maps will appear out of balance from the distribution of hazard classes where the models were tailored for specific projects, because the landscape of Golden Hills North differs from the landscapes where models were originally developed, except for model versions 4 (the Golden Hills North model) and 6 (developed APWRA-wide).

Using the latest collision hazard models developed, version 6, we tested how well each species-specific combined model could serve as an umbrella model for all raptors as a group and all birds as a group (Figure 27). The collision hazard model developed for burrowing owl was the only model that performed well at predicting the collision hazard of all raptors as a group and all birds as a group. Compared to estimated all-raptor fatality rates at wind turbines in hazard class 1 of burrowing owl model version 6, the estimated all-raptor fatality rates in hazard class 3 averaged 1.36× higher and the estimated all-raptor fatality rates in hazard class 4 averaged 1.75× higher. Compared to estimated all-bird fatality rates at wind turbines in hazard class 1 of burrowing owl model version 6, the estimated all-bird fatality rates in hazard class 3 averaged 1.4× higher and the estimated all-bird fatality rates in hazard class 4 averaged 1.78× higher. The golden eagle collision hazard model predicted increasing hazard classes with decreasing fatality rates of all birds (top right graph of Figure 27). This relationship demonstrates the trade-off of prioritizing wind turbine siting to maximize golden eagle protection; optimizing siting for eagles increases the likelihood of killing more birds of other species.

CONCLUSIONS

Our collision hazard models improved throughout the repowering process from the first version of the models to the last, and model version 6 was superior to other collision hazard models at predicting fatality rates at previously monitored wind turbines. For version 6 of the burrowing owl model, however, some wind turbines with high fatality rates were located outside areas predicted as hazard class 4. These misclassifications associated with a few specific types of terrain that could be readily accommodated with a change or two to the conditional statement linking terrain with high fatality rates to terrain with burrowing owl burrows. With this small change collision hazard model version 6 would also serve as the superior model for burrowing owls.

The latest version of the collision hazard models performed best for golden eagle, red-tailed hawk and American kestrel. The American kestrel model improved a great deal between versions 5 and 6 due to a shift in emphasis from ridge crests to lower on the slopes. In fact, model version 6 is the only version that accurately predicts collision hazard of American kestrel. The golden eagle model also improved a great deal between versions 5 and 6, probably for the same reason that the American kestrel model improved and also because the fatality rate data were improved and we added a new explanatory terrain measurement expressing ridge features located lower than nearby larger ridge features.

Whereas we are pleased with the improved model performance for 3 of the 4 focal species, we are confident that model performance can be improved further. The models of the other species can be improved by adding the latest telemetry and behavior data and by quantifying one or more terrain features that we hypothesize would relate to collision hazard. These additional terrain features would include ridge slope (slope of ridgeline from ridge crest to valley bottom), and polygons representing breaks in slope (locations along a ridgeline where slope suddenly changes). More could also be done with ridge orientation by specifying whether the ridge structure is declining and to which direction it is declining.

Our assessment of species-specific models for use as umbrella models for predicting collision hazards of all raptors and all birds highlights the tradeoffs often made when micro-siting turbines to minimize collision risk for one species. Prioritizing fatality minimization of golden eagles can result in micro-sited turbines putting many other species of bird at greater collision risk. The burrowing owl model was the only model showing utility as an umbrella predictor of all bird and all raptor fatalities, so prioritizing both the golden eagle and burrowing owl collision hazard models would cover both eagles and most other species of birds.

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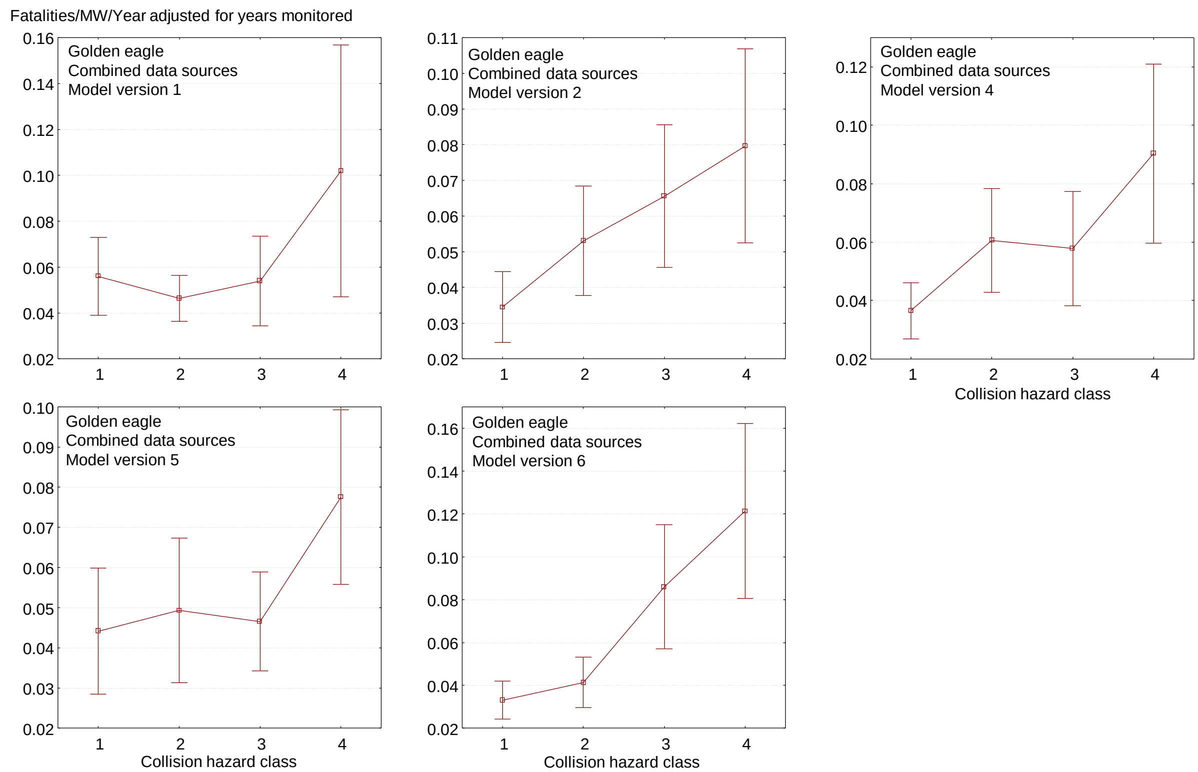


Figure 1. Responses of mean (90% CI) fatalities/MW/year to collision hazard class for golden eagle by collision hazard model versions 1 (Tres Vaqueros project), 2 (Golden Hills project), 4 (Golden Hills North project, 5 (Sand Hill project), and 6 (Summit Winds project).

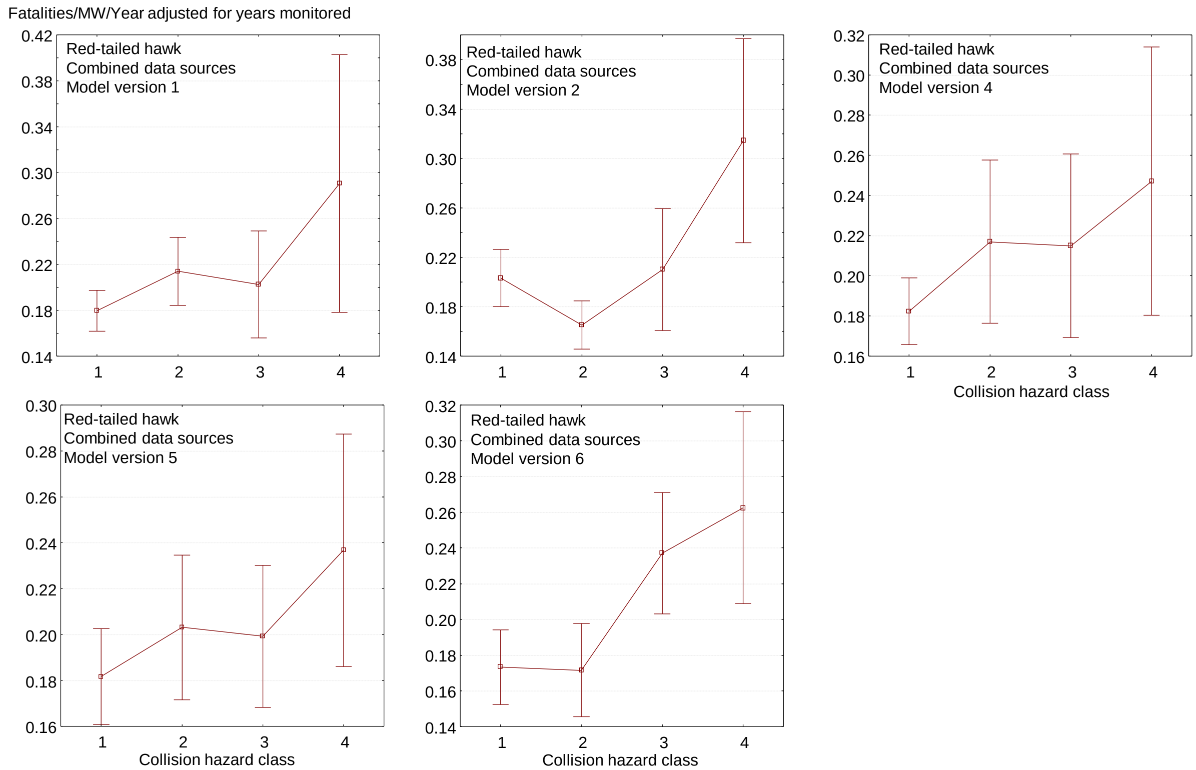


Figure 2. Responses of mean (90% CI) fatalities/MW/year to collision hazard class for red-tailed hawk by collision hazard model versions 1 (Tres Vaqueros project), 2 (Golden Hills project), 4 (Golden Hills North project, 5 (Sand Hill project), and 6 (Summit Winds project).

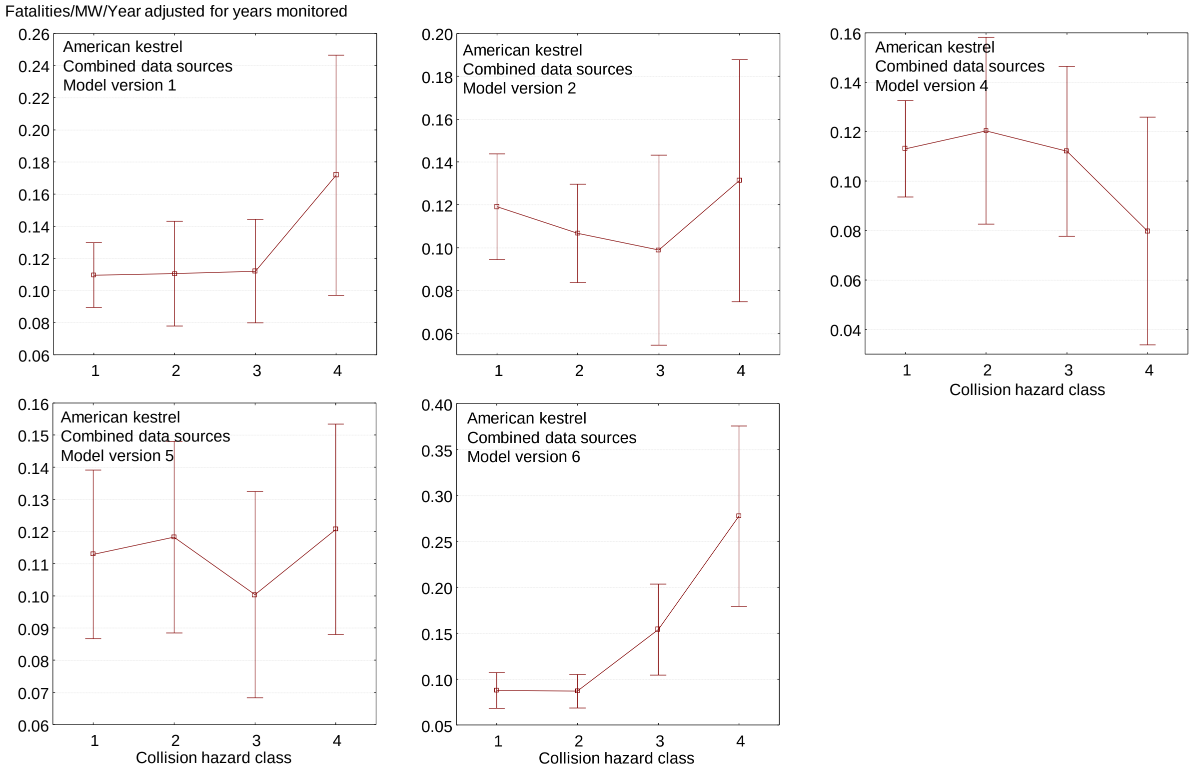


Figure 3. Responses of mean (90% CI) fatalities/MW/year to collision hazard class for American kestrel by collision hazard model versions 1 (Tres Vaqueros project), 2 (Golden Hills project), 4 (Golden Hills North project, 5 (Sand Hill project), and 6 (Summit Winds project).

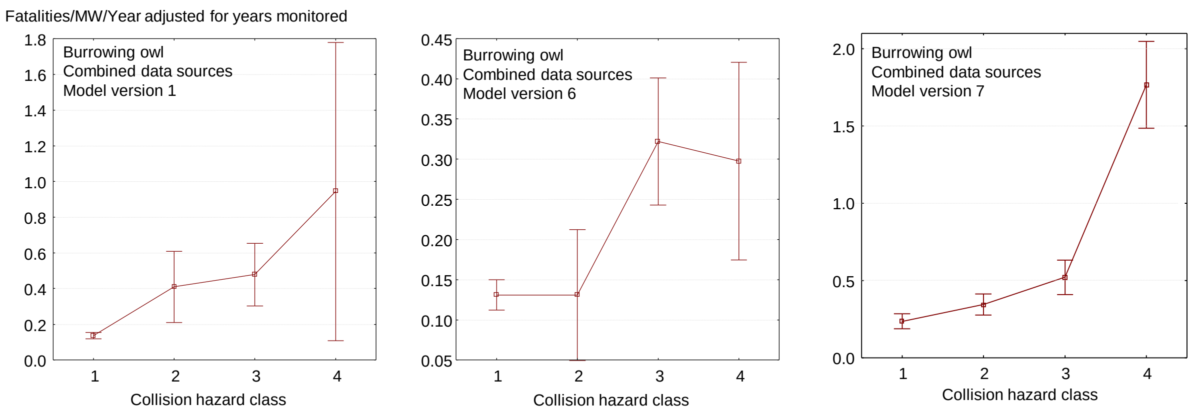


Figure 4. Responses of mean (90% CI) fatalities/MW/year to collision hazard class for burrowing owl by collision hazard model versions 1 (Tres Vaqueros project), 6 (Summit Winds project), and 7 (unnamed project in progress).

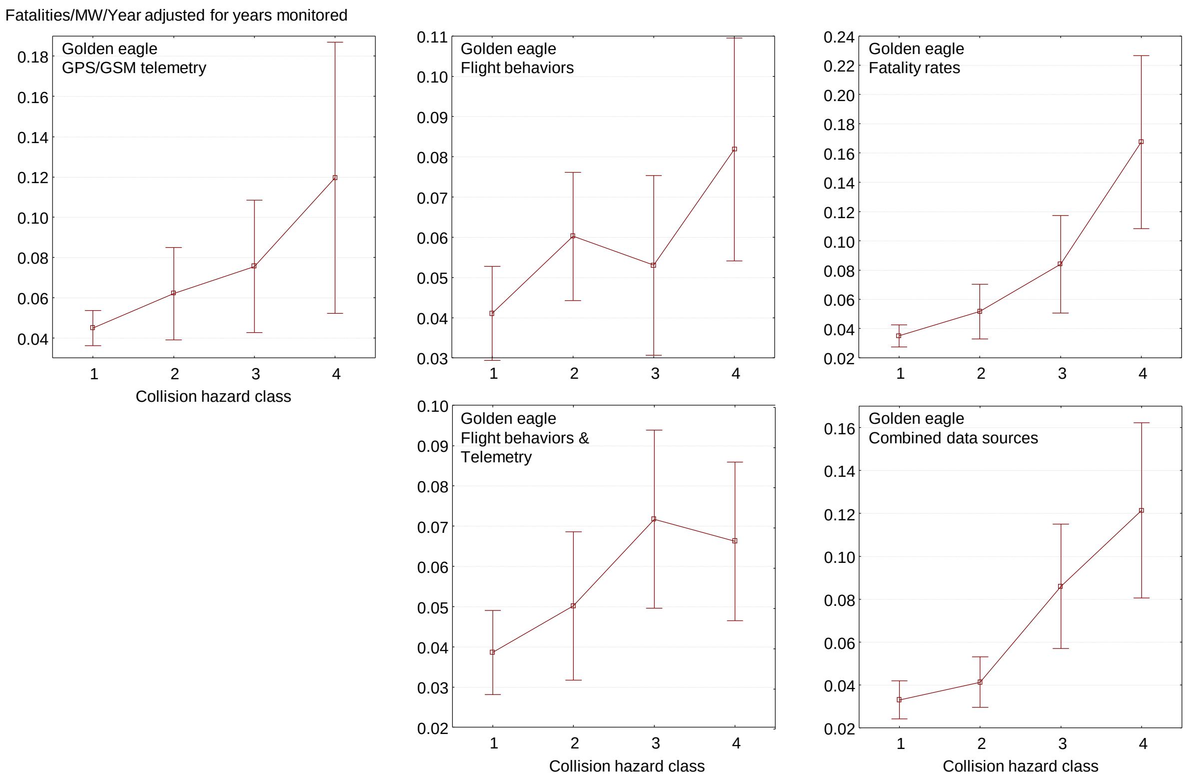


Figure 5. Responses of mean (90% CI) fatalities/MW/year to collision hazard class predicted by version 6 of the models developed for golden eagles based on GPS/GSM telemetry positions (top left), flight behaviors (top middle), fatality rates (top right), combined flight behaviors and telemetry positions (bottom left) and combined all data sources (bottom right).

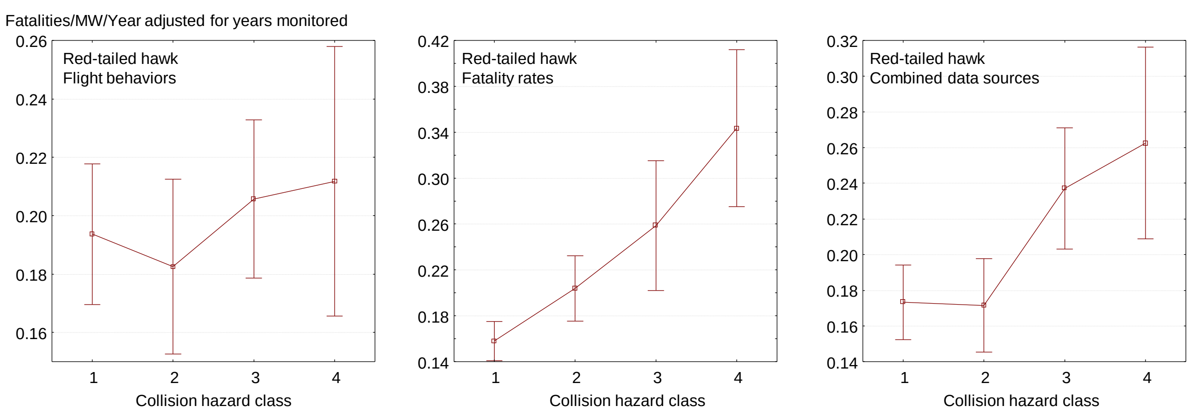


Figure 6. Responses of mean (90% CI) fatalities/MW/year to collision hazard class predicted by version 6 of the models developed for red-tailed hawks based on flight behaviors (left), fatality rates (middle), and combined flight behaviors and fatality rates (right).

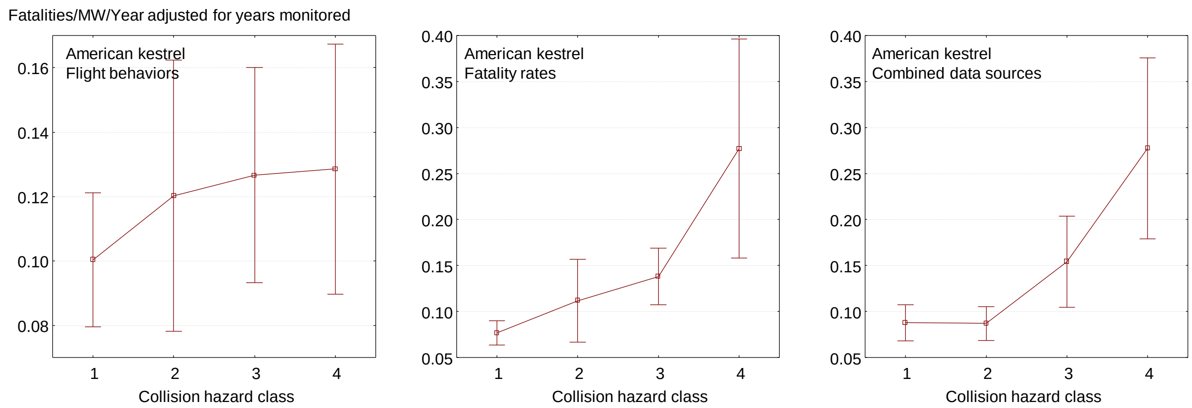


Figure 7. Responses of mean (90% CI) fatalities/MW/year to collision hazard class predicted by version 6 of the models developed for American kestrels based on flight behaviors (left), fatality rates (middle), and combined flight behaviors and fatality rates (right).

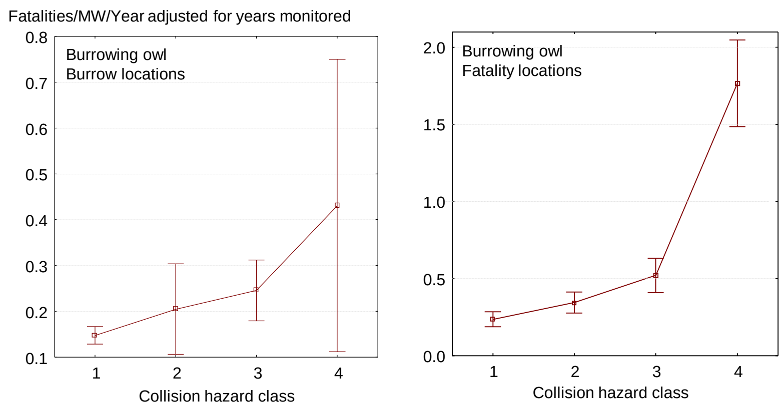


Figure 8. Responses of mean (90% CI) fatalities/MW/year to collision hazard class predicted by versions 6 and 7 of the models developed for burrowing owls based on burrow locations (left, version 6) and fatality rates (right, version 7).

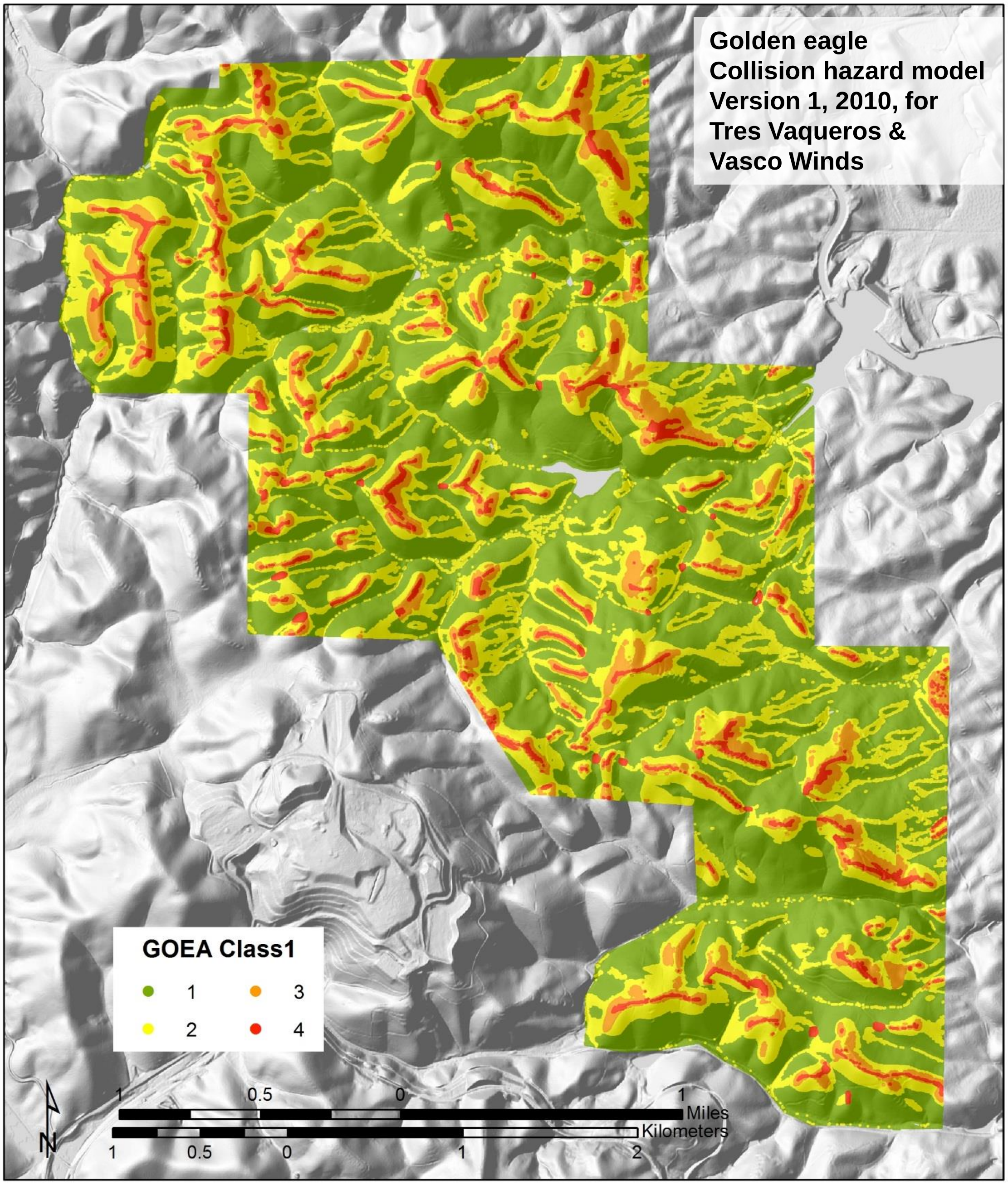


Figure 9. Version 1 of the golden eagle collision hazard classes composed of models developed from use data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

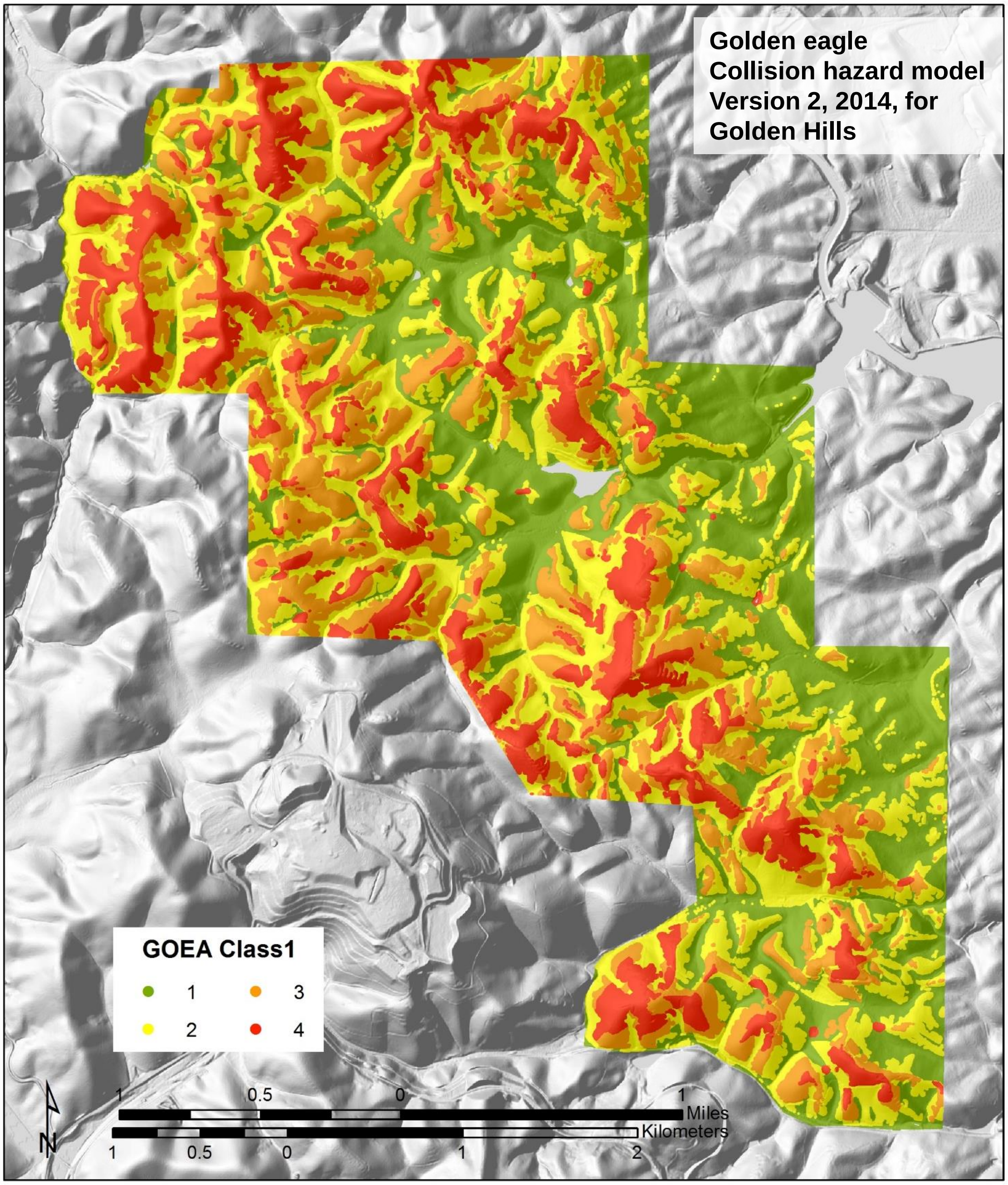


Figure 10. Version 2 of the golden eagle collision hazard classes composed of models developed from behavior data and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

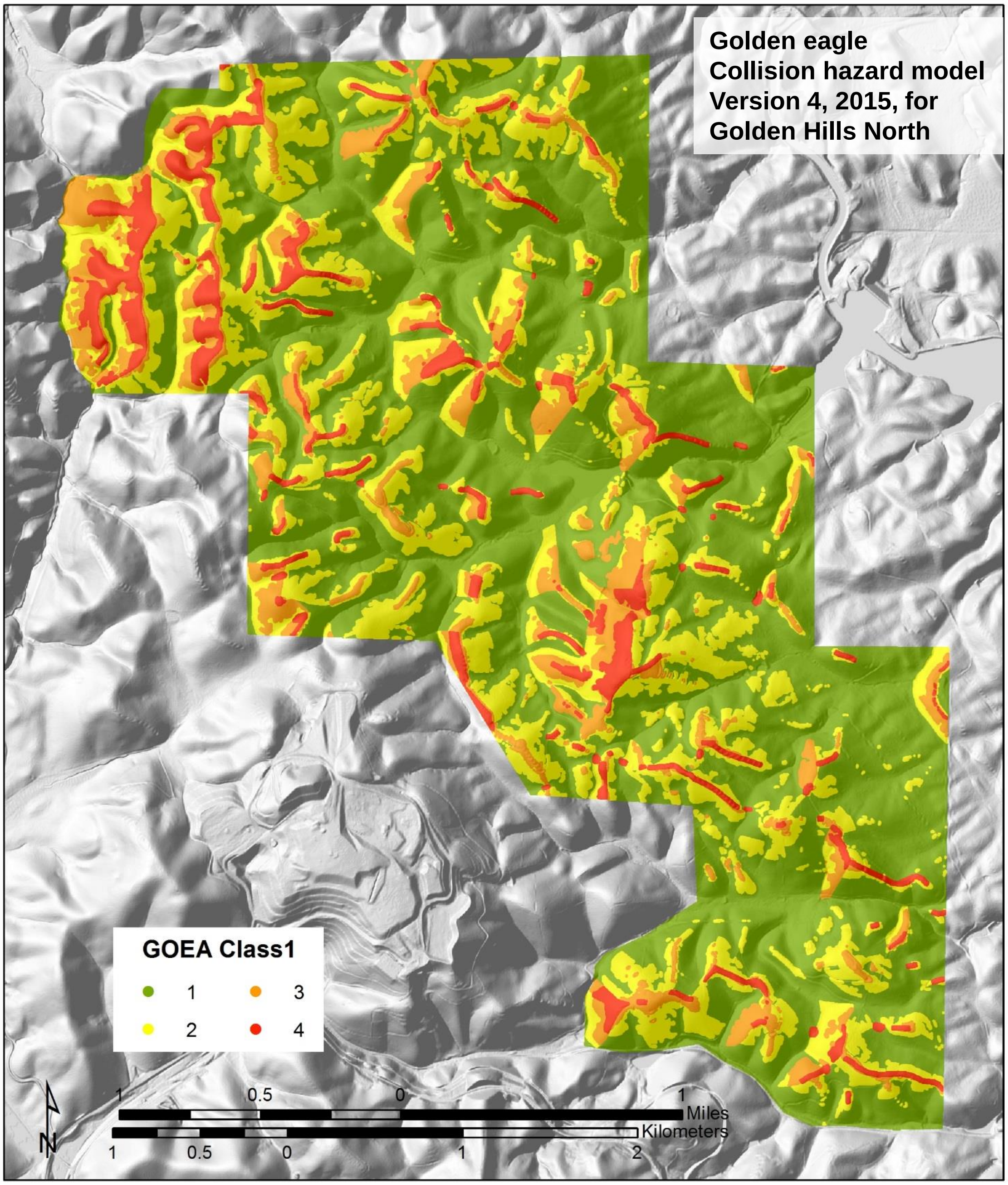


Figure 11. Version 4 of the golden eagle collision hazard classes composed of models developed from behavior data and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

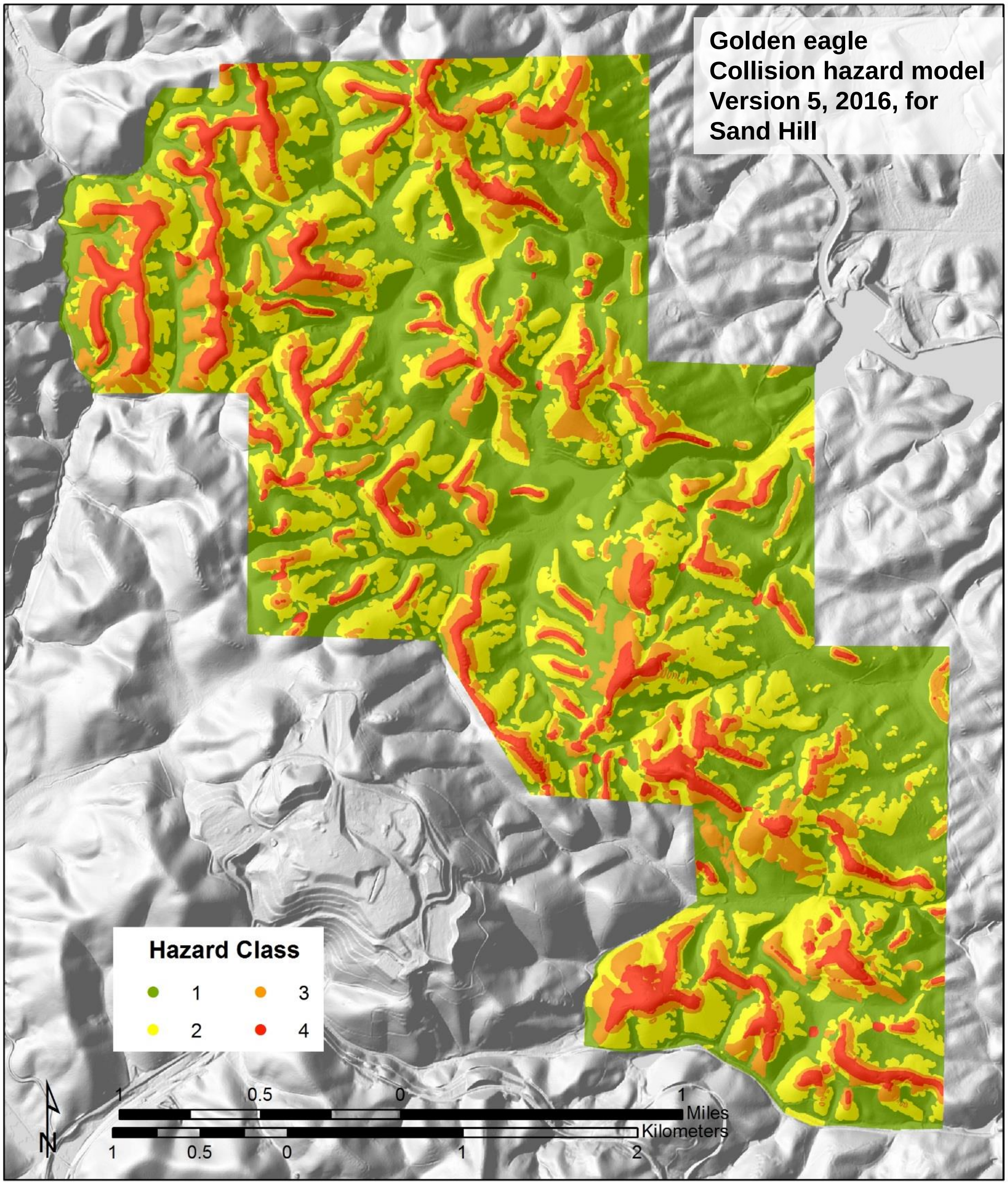


Figure 12. Version 5 of the golden eagle collision hazard classes composed of models developed from GPS/GSM telemetry positions, behavior data, and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

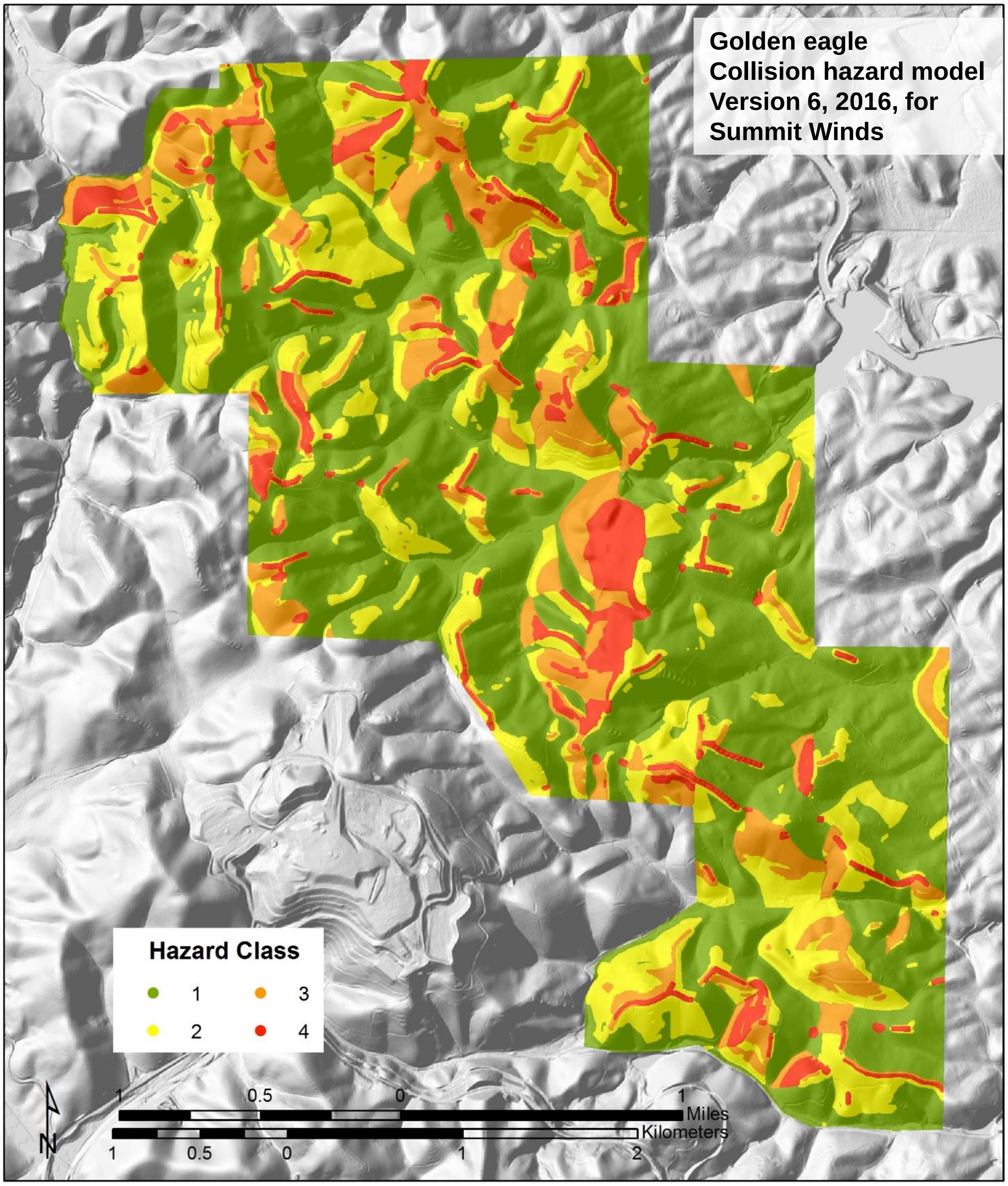


Figure 13. Version 6 of the golden eagle collision hazard classes composed of models developed from GPS/GSM telemetry positions, behavior data, and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

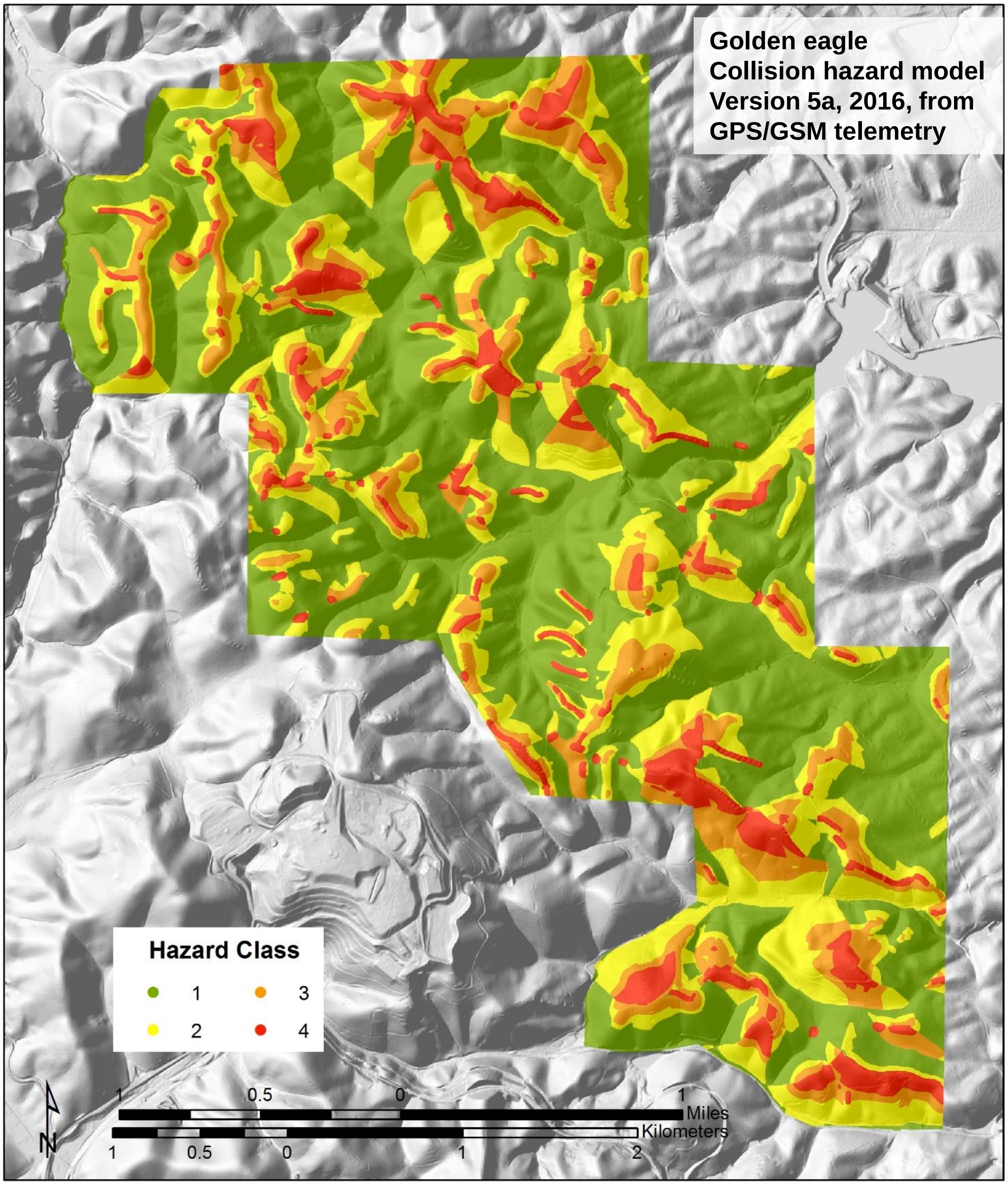


Figure 14. Only that portion of versions 5 and 6 of the golden eagle collision hazard classes composed of a model developed from GPS/GSM telemetry positions and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

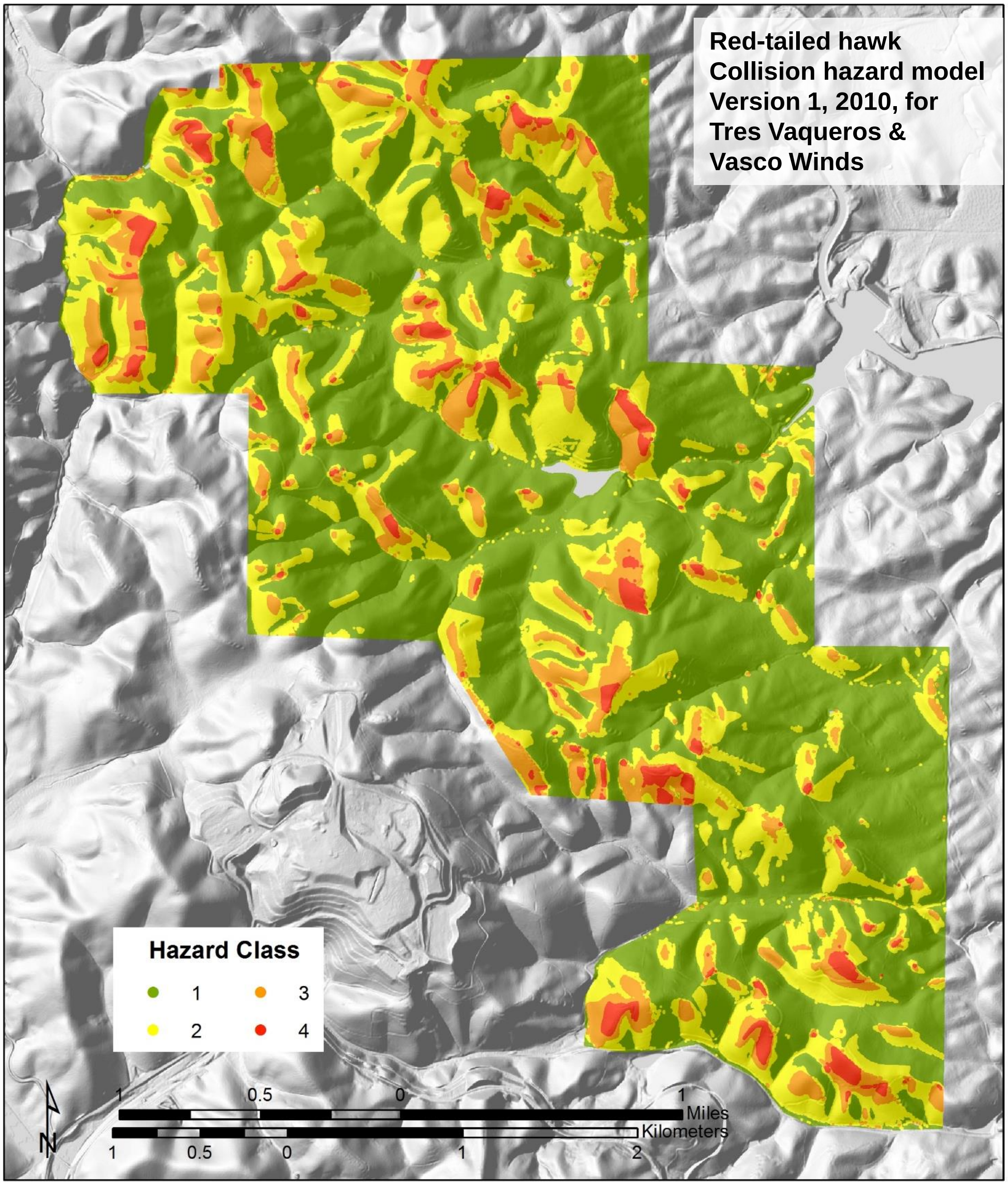


Figure 15. Version 1 of the re-tailed hawk collision hazard classes composed of models developed from behavior data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

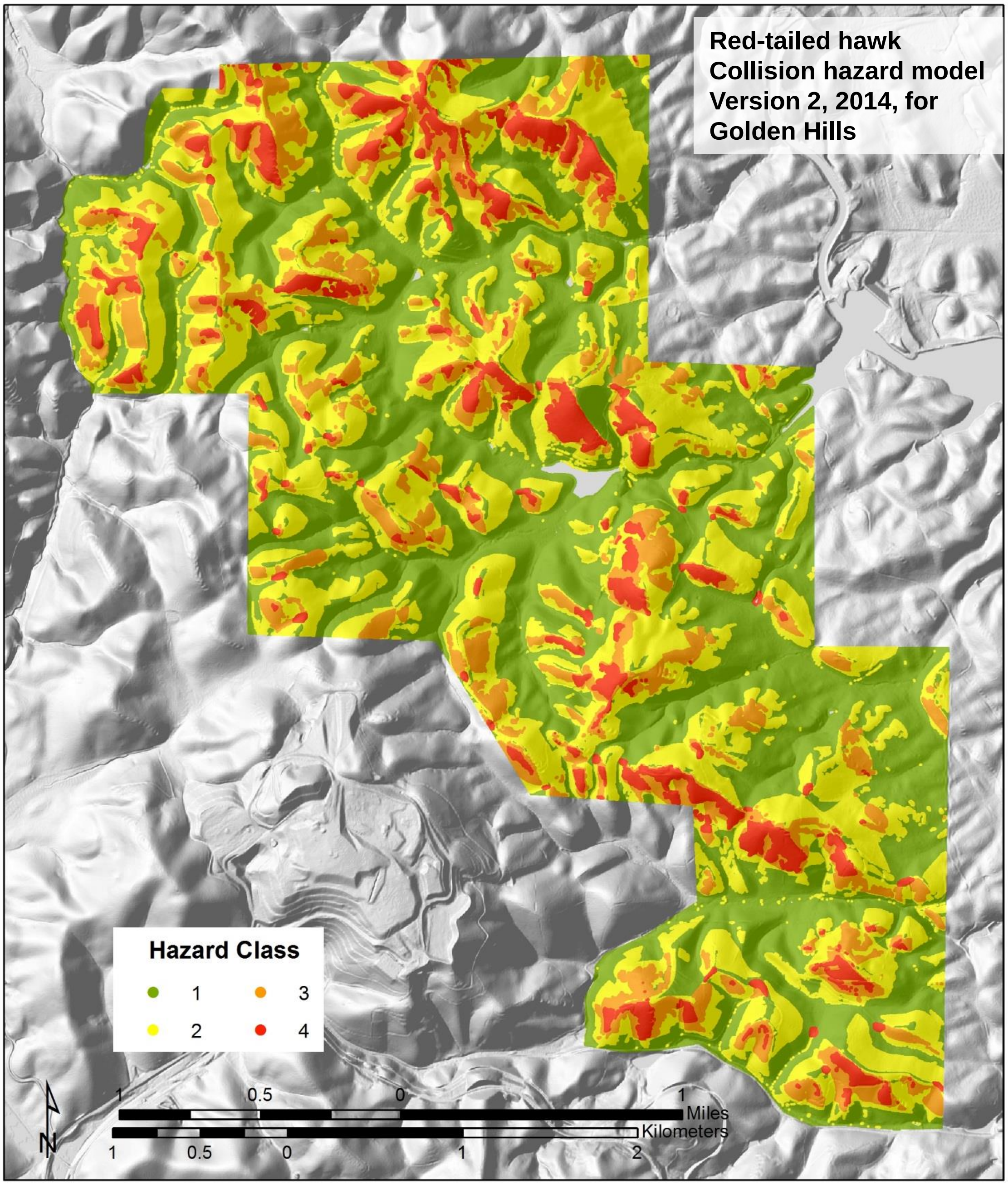


Figure 16. Version 2 of the re-tailed hawk collision hazard classes composed of models developed from behavior data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

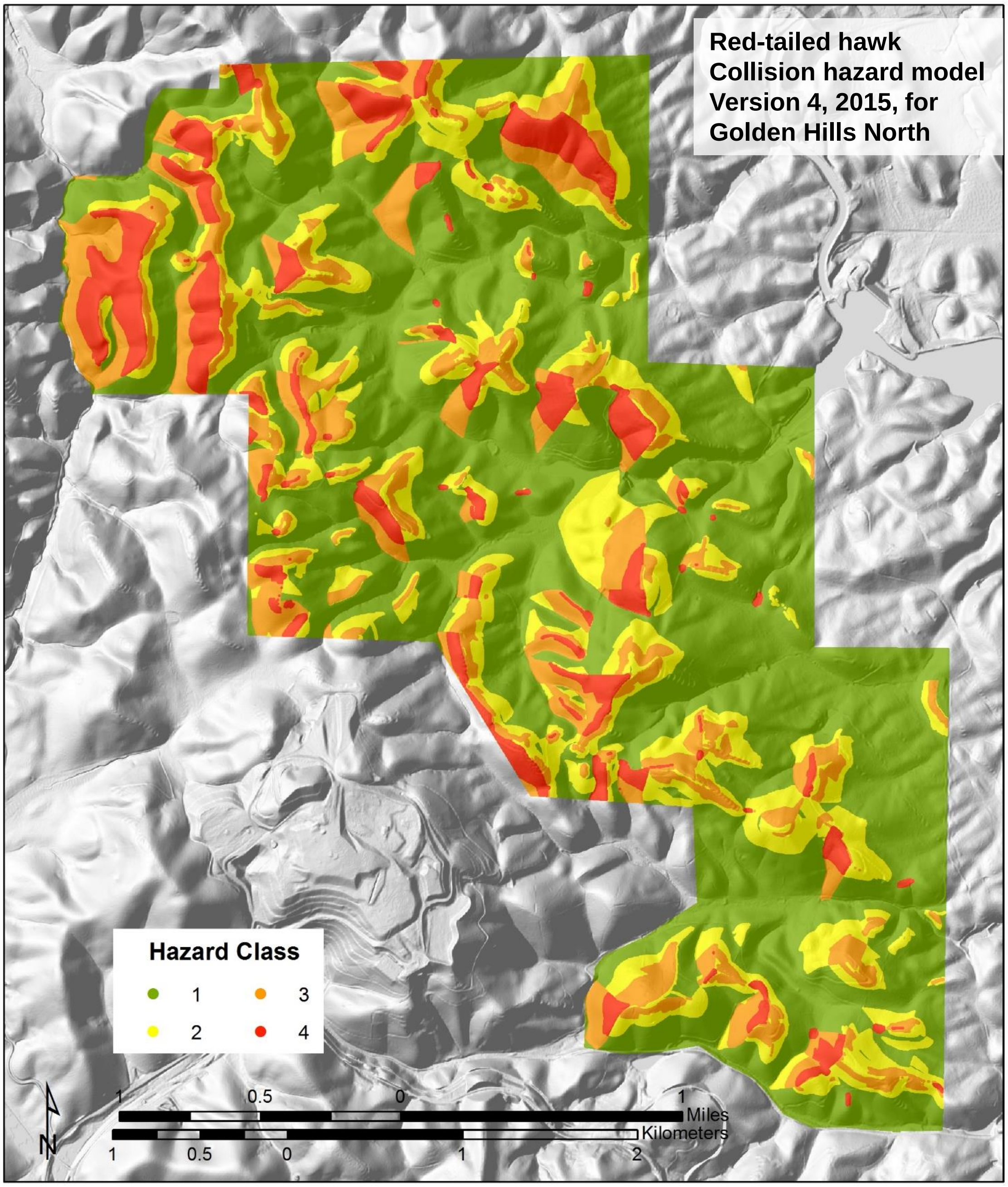


Figure 17. Version 4 of the re-tailed hawk collision hazard classes composed of models developed from behavior data and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

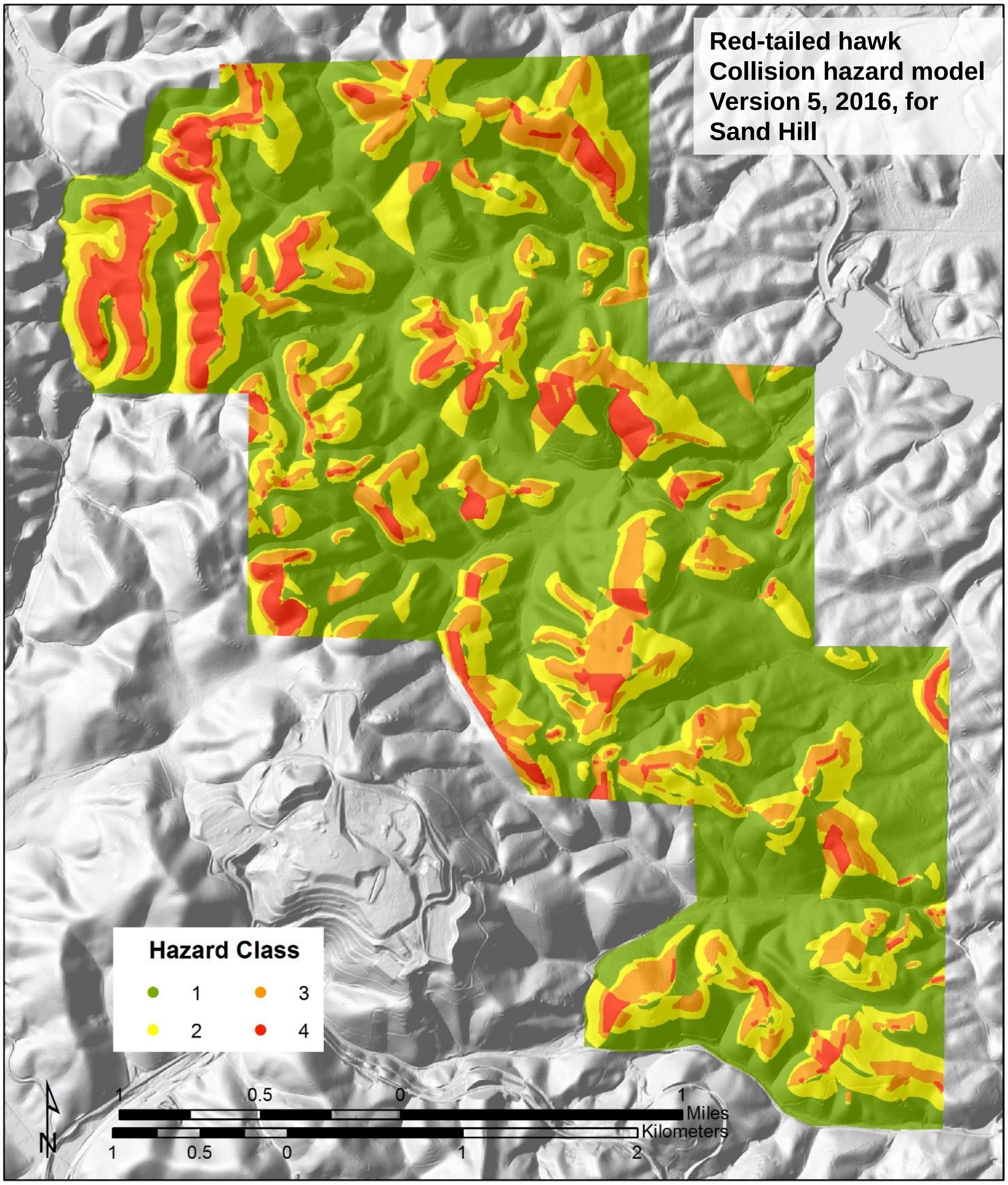


Figure 18. Version 5 of the re-tailed hawk collision hazard classes composed of models developed from behavior data and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

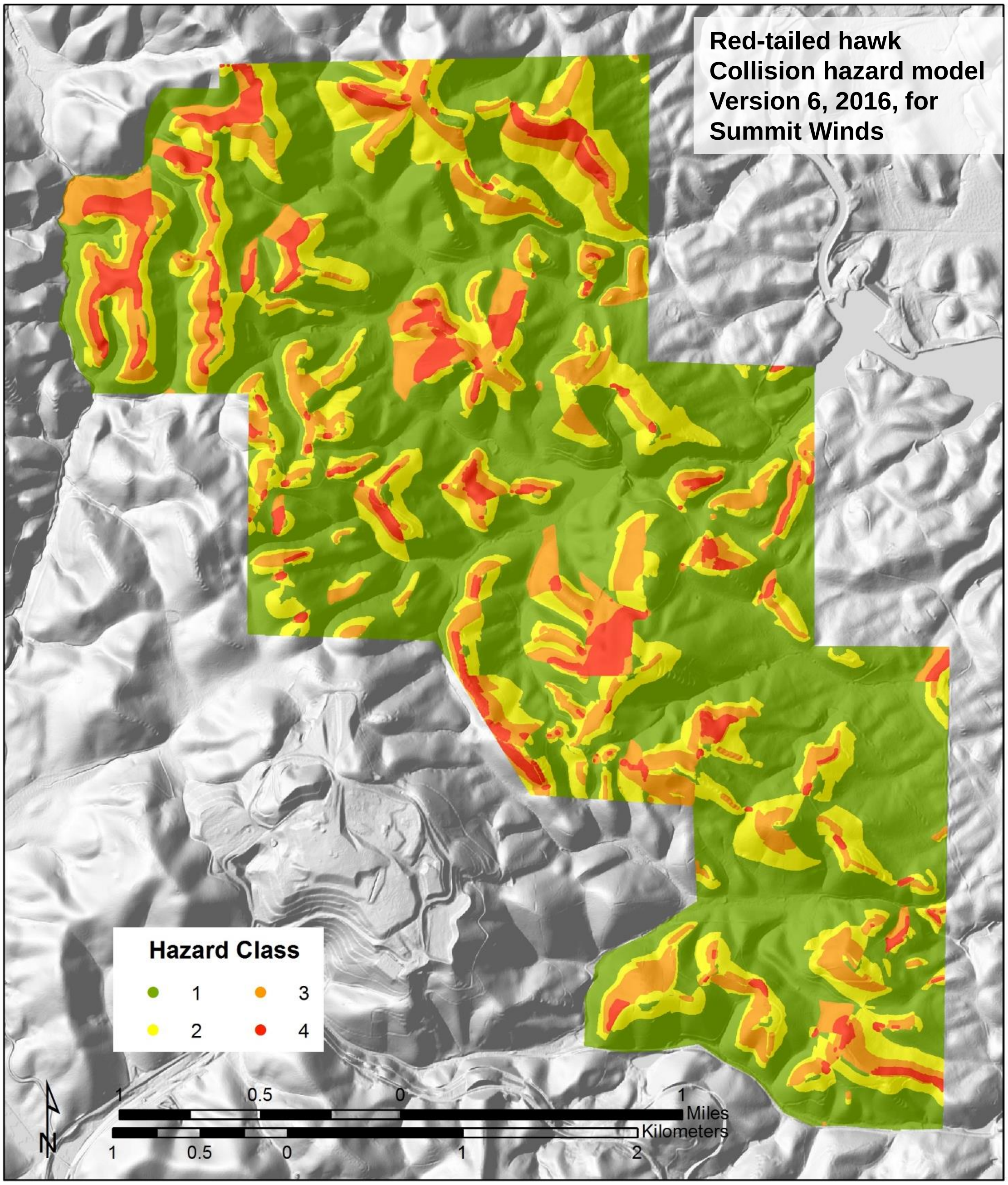


Figure 19. Version 6 of the re-tailed hawk collision hazard classes composed of models developed from behavior data and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

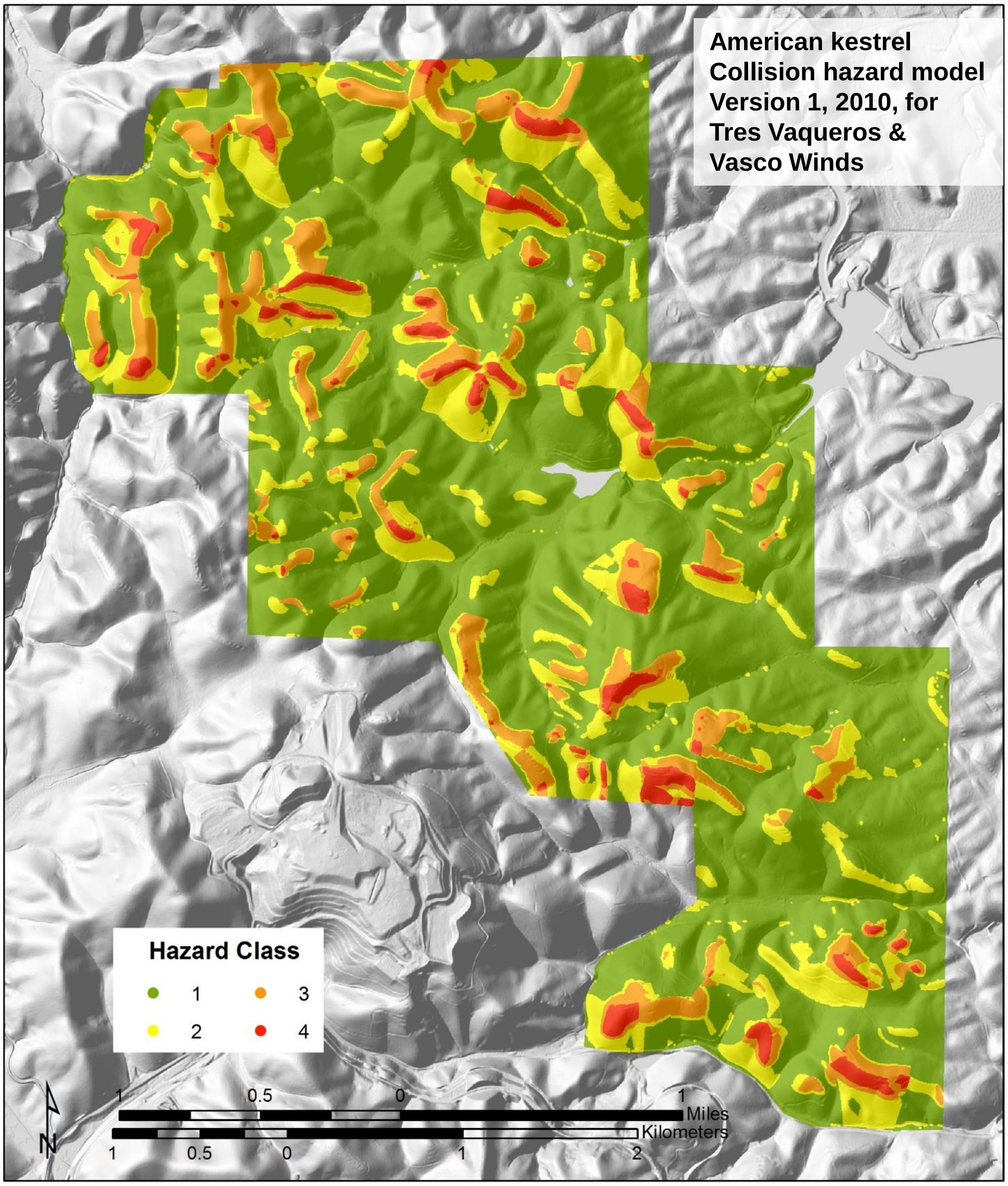


Figure 20. Version 1 of the American kestrel collision hazard classes composed of models developed from behavior data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

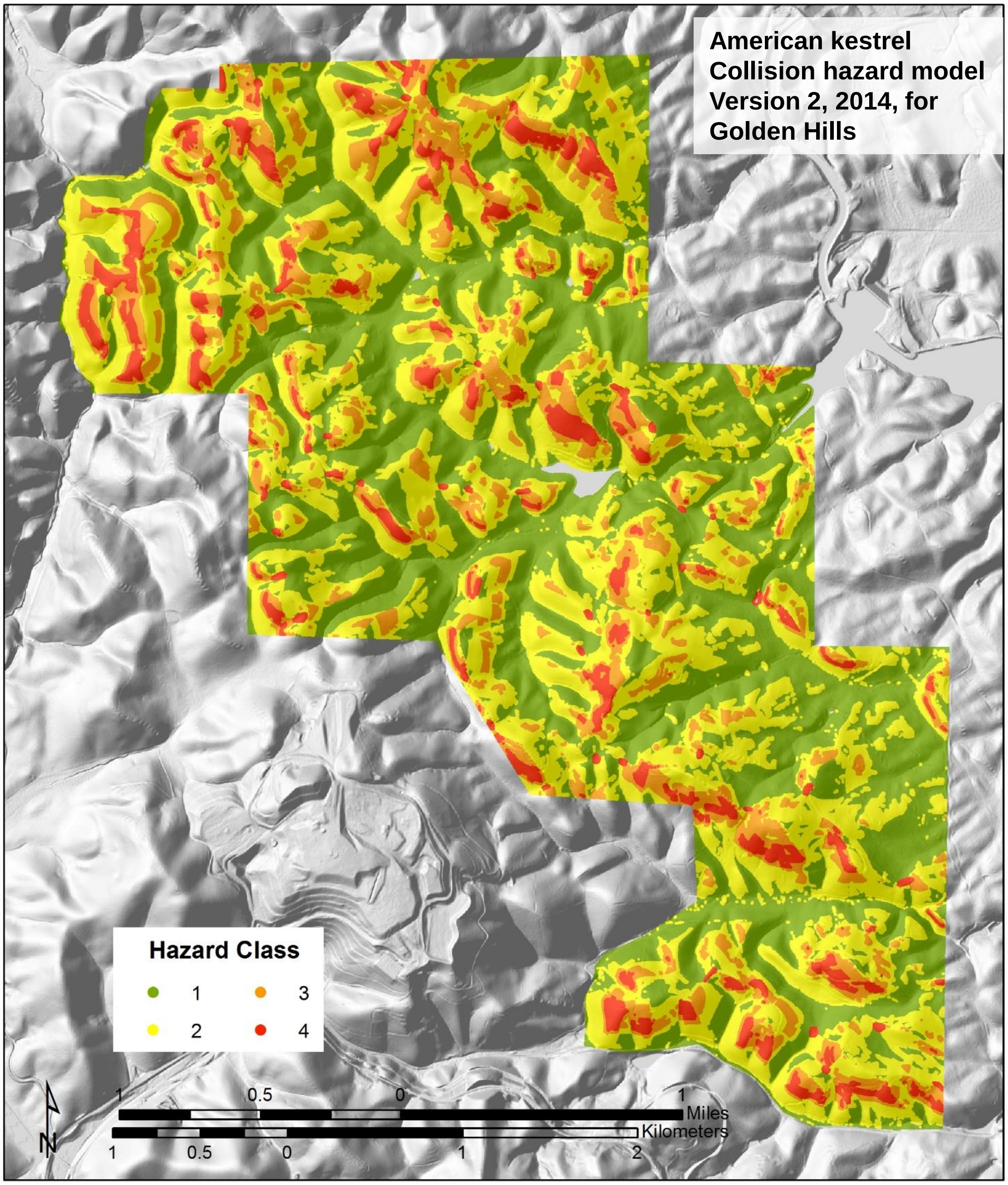


Figure 21. Version 2 of the American kestrel collision hazard classes composed of models developed from behavior data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

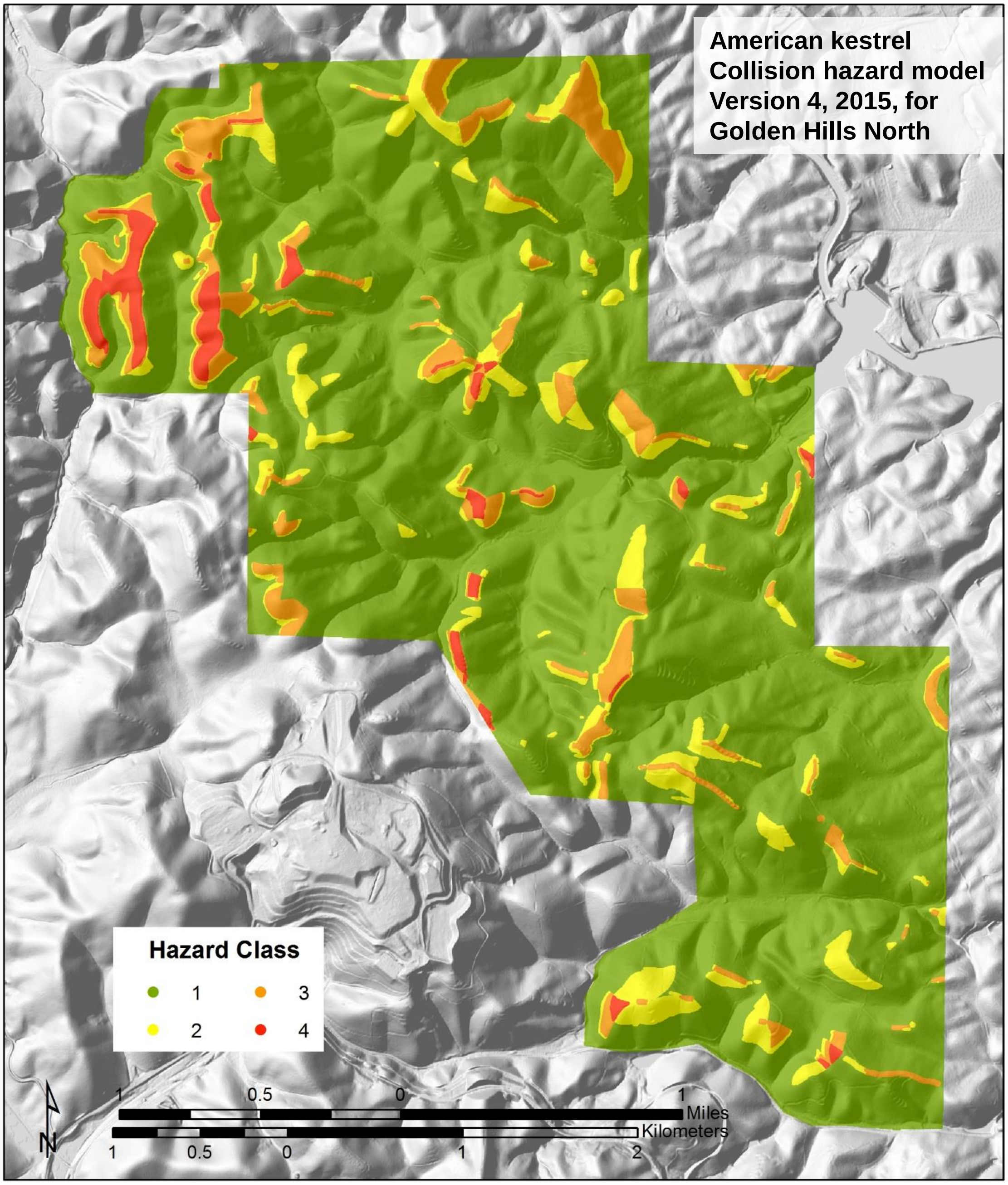


Figure 22. Version 4 of the American kestrel collision hazard classes composed of models developed from behavior data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

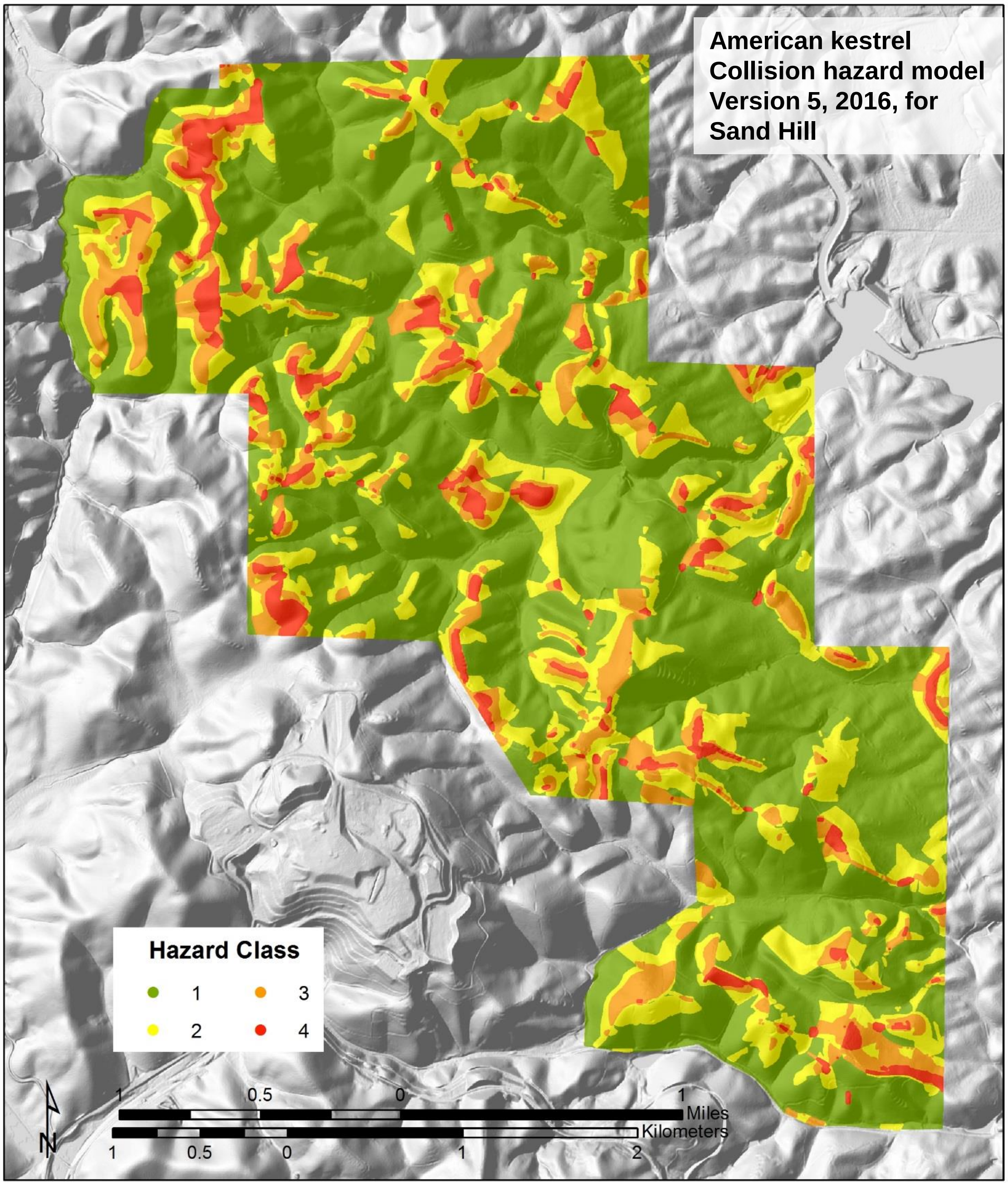


Figure 23. Version 5 of the American kestrel collision hazard classes composed of models developed from behavior data and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

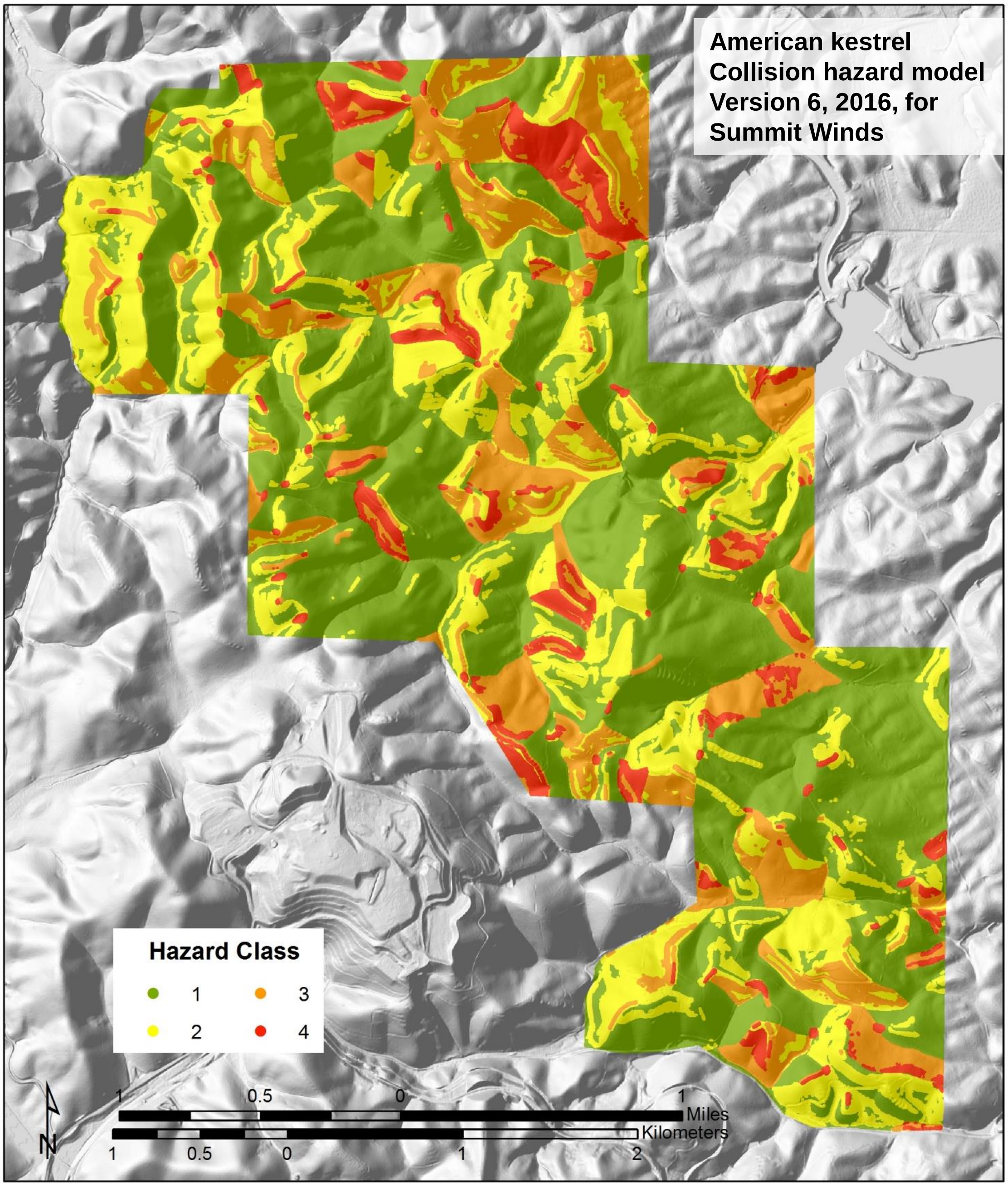


Figure 24. Version 6 of the American kestrel collision hazard classes composed of models developed from behavior data and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

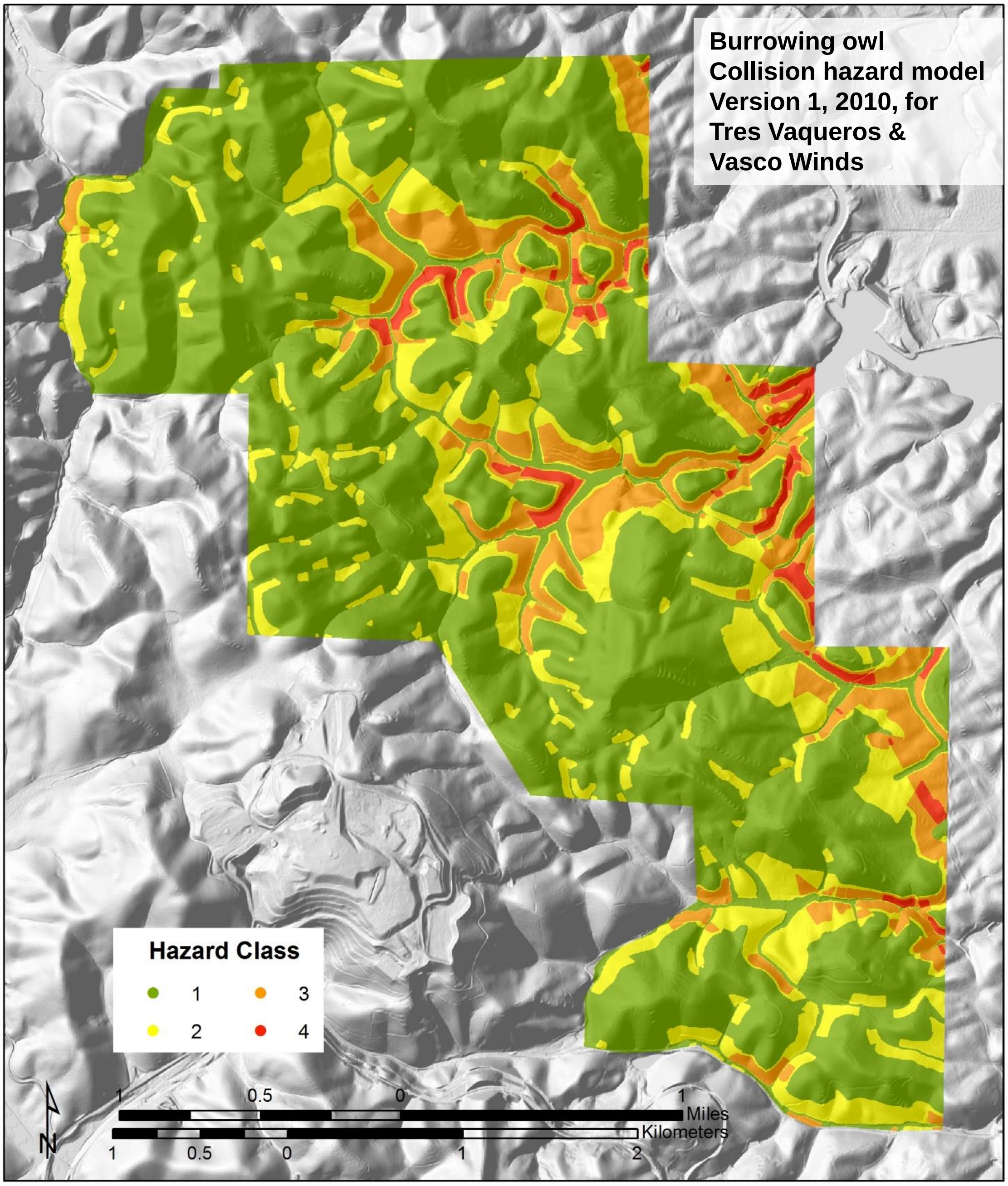


Figure 25. The earliest version of the burrowing owl collision hazard classes composed only of a model developed from burrowing owl locations and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

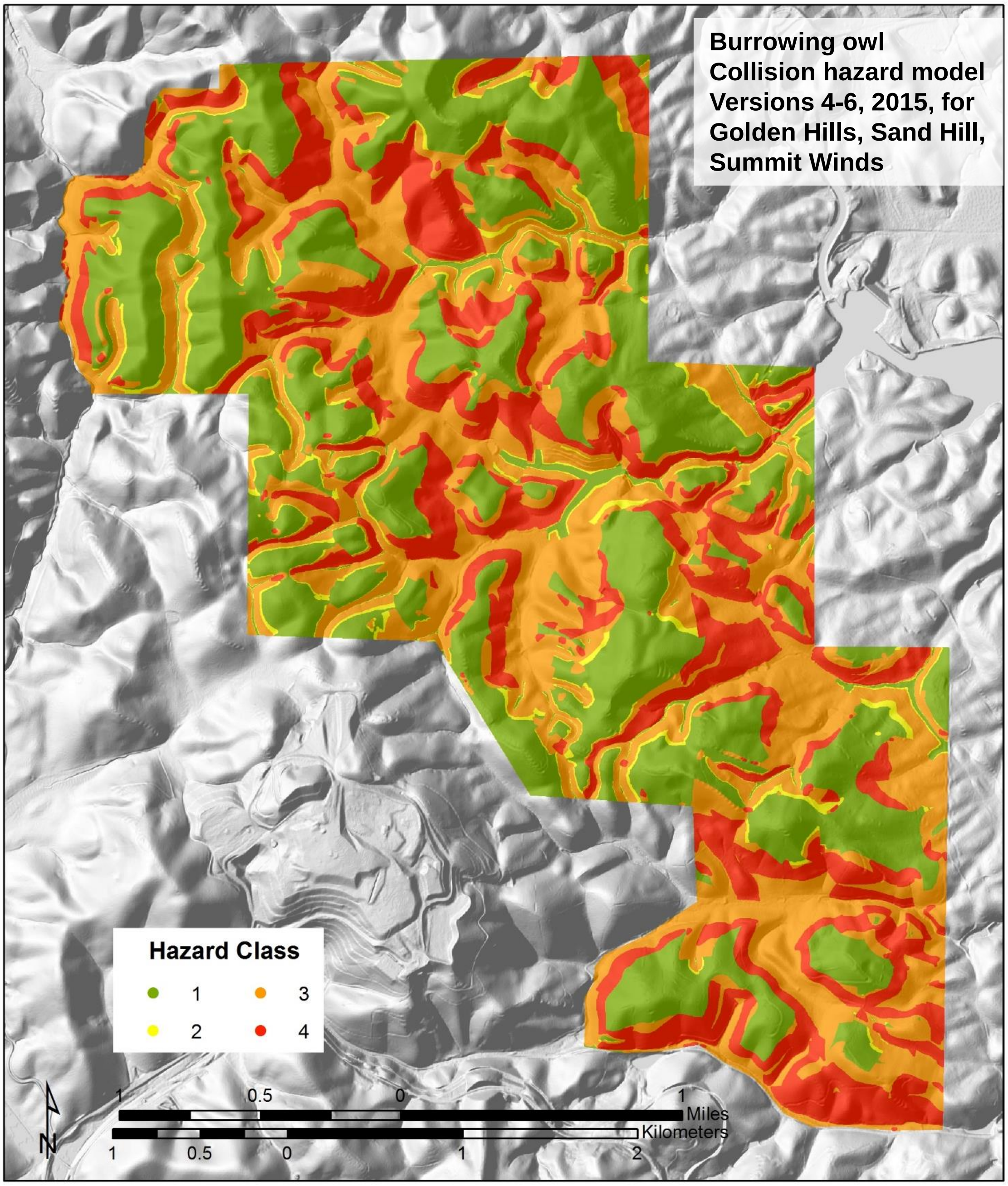


Figure 26. Later versions of the burrowing owl collision hazard classes composed of models developed from burrowing owl locations and fatality rates and extended roughly over the area proposed for the Golden Hills North repowering project in the Altamont Pass Wind Resource Area.

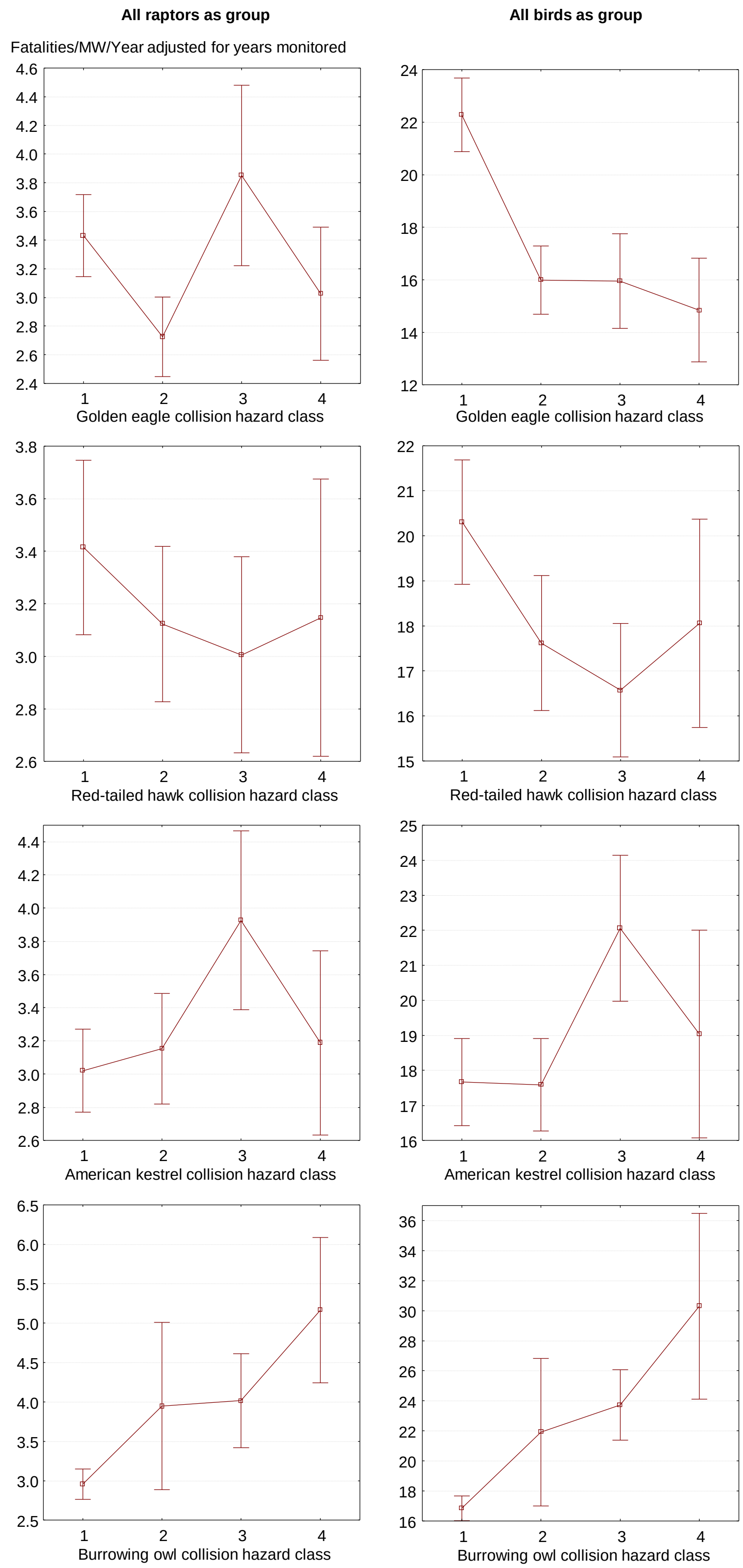


Figure 27. Responses of mean (90% CI) fatalities/MW/year of all raptors as a group (left column) and all birds as a group (right column) to collision hazard classes predicted for golden eagle, red-tailed hawk, American kestrel and burrowing owl.

ATTACHMENT 3

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

10 April 2018

At the time of this addendum to a report Lee Neher and I prepared last year (Smallwood and Neher 2017a), I was aware of 14 golden eagle fatalities at Golden Hills, including 12 found by the monitor during the first year of fatality monitoring, 1 found a month after the first year of monitoring, and 1 found by me prior to the commencement of monitoring. This number of golden eagle fatalities totaled twice as many as found during three years of fatality monitoring at the similar-sized repowered Vasco Winds project (Brown et al. 2016). 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 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.

Without an experimental design, such as 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. 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 exists. Based on fatality finds alone, there is no telling whether the first year of monitoring at Golden Hills reflected a peak in relative abundance as part of a multi-annual cycle (see Smallwood 2017a,b). Without use surveys, no use rates could be estimated for comparing relative abundance to fatality rates (Smallwood and Neher 2017b). However, relative abundance data are available. While performing behavior surveys I counted golden eagles from October 2012 through the present. I observed no annual peak in golden eagles corresponding with the first year of fatality monitoring at Golden Hills, nor was there much of a difference in inter-annual eagle counts outside versus inside Golden Hills (Figures 1 and 2). Intriguingly, however, APWRA-wide use rates of golden eagle averaged 1.63× higher during 2013-2017 than compared to 2006-2011 (see Figure 87 in Smallwood and Neher 2017b).

***Figure 1.** Monthly relative abundance of golden eagles among 28 behavior observation stations (Smallwood 2016) located throughout the Altamont Pass Wind Resource Area but outside Golden Hills.*

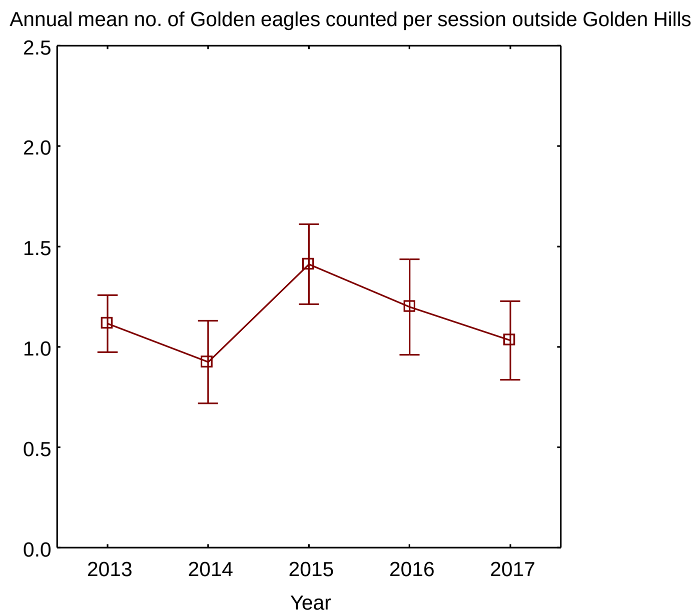
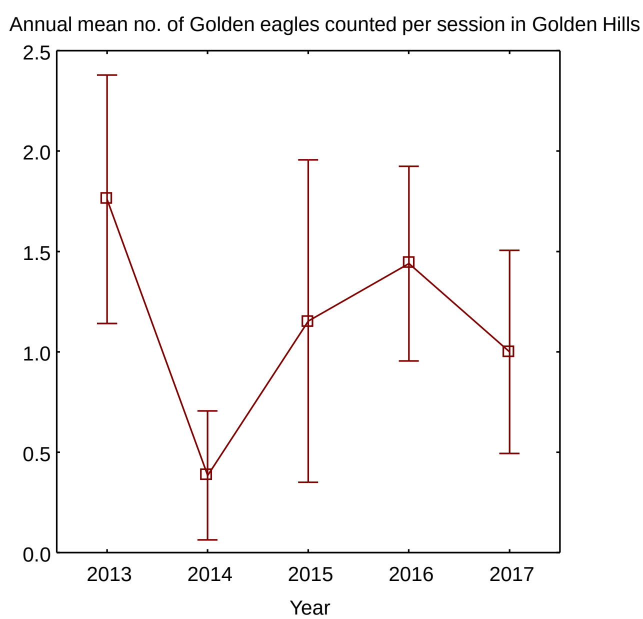


***Figure 2.** Annual relative abundance of golden eagle among 5 behavior observation stations located within the Golden Hills project boundary. The year 2017 would largely correspond with the first year of fatality monitoring at Golden Hills, although operations began in January 2016.* Note: All of the 2015 surveys were in April just before construction began, so representation of 2015 was not as balanced as for other years.



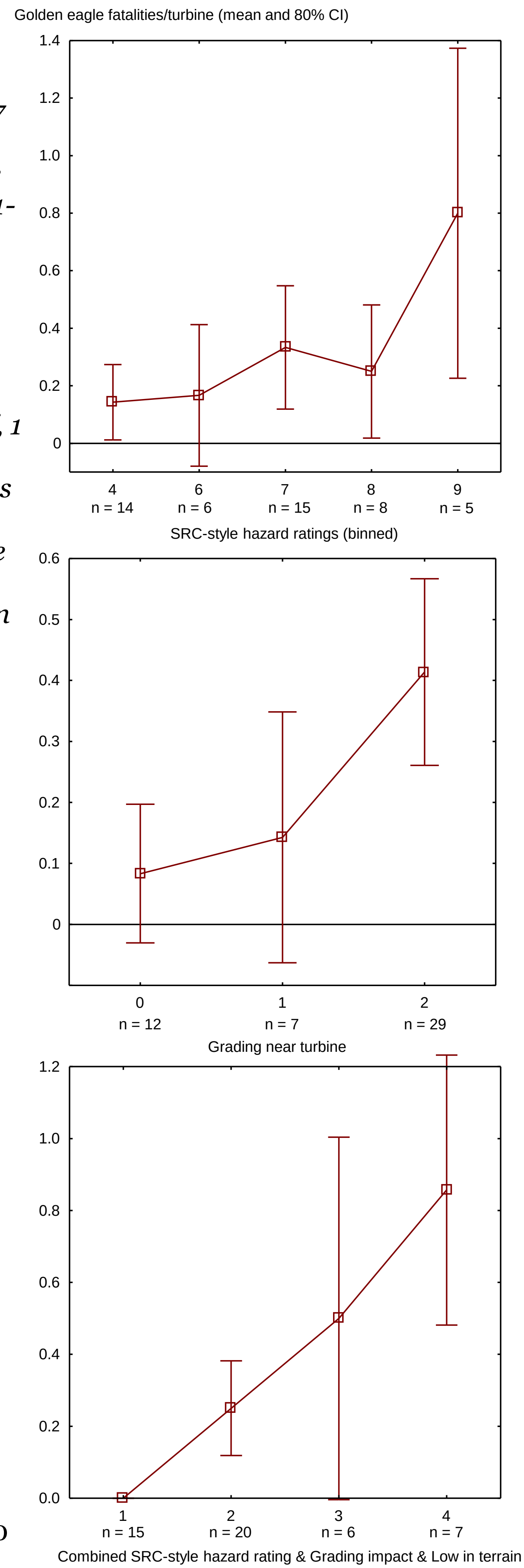
Based on the patterns in Figures 1 and 2, it does not appear that golden eagles were any more abundant during the first year of Golden Hills fatality monitoring than during the few preceding years, although they were 46% more abundant that during 2006-2011 (Smallwood and Neher 2017b). Regardless, without an experimental design, there is no way to know whether the number of collision fatalities would have been any different had the wind turbines been sited without regard to collision hazard posed by the terrain. 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. After all, estimates of golden eagle fatalities at the 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.

Although it is impossible to assess the effectiveness of the collision hazard models for the project on the whole, the effectiveness of micro-siting can be assessed among the wind turbines within the project. Micro-siting was not restricted to the use of map-based collision hazard models, but also included my recommendations based on SRC-style hazard ratings and grading concerns. 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 we had found golden eagle and red-tailed hawk fatalities where grading had altered the terrain around the associated turbines (Smallwood and Neher 2015). 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 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.

Based on the 14 golden eagle fatalities of which I am aware, fatalities per turbine generally increased at Golden Hills with my SRC-style hazard ratings (Figure 3). Wind turbines rated 9 or 9.5 were associated with a mean golden eagle fatality rate that was 5.7× higher than the mean fatality rate at wind turbines I had rated 4 or 5. Wind turbines rated in the 7 or 8 ranges were associated with mean fatality rates that were 1.8× and 2.4× higher than the mean fatality rate of wind turbines I had rated 4 or 5. However, some of my ratings were likely confounded by grading during construction.

Golden eagle fatalities per turbine were highest where grading left berms or cut slopes >3 m within 40 m of the turbine (Figure 3). At these turbines with substantial nearby berms or cut slopes, golden eagle fatalities per turbine numbered 5× higher than at turbines without berms or cut slopes. Berms and cut slopes reduce the effective height above ground that low-flying eagles have to negotiate between the ground and the low reach of the turbine rotor, and the effect increases the closer the distance between turbine tower and the berm or cut slope.

Figure 3. *Golden eagle fatalities per turbine relative to (top) SRC style hazard ratings binned 4 = 3 to 5, 6 = 6 and 6.5, 7 = 7 and 7.5, 8 = 8 and 8.5, and 9 = 9 and 9.5; (middle) Grading within 40 m of the turbine leaving cut slopes or berms of 0 = none, 1 = 1-3 m, and 2 = >3 m; (bottom) Combined indicator of SRC-style hazard rating, grading impact and whether low on declining ridge or within saddle or valley structure. The combined indicator was the sum of the binned SRC rating divided by 9, the binned grading impact weighted by half, 1 for sites low on ridge and 1 for sites within saddle or valley structures, and this sum was binned as 1 = 0 to 1; 2 = 1 to 2; 3 = 2 to 2.8, and 4 = >2.8. I note that I applied SRC-style hazard ratings to 6 turbine addresses post-construction because these turbines had been relocated far from original sites during the planning process.*



Two other terrain factors emerged from an examination of the fatality data, and those were the turbine's position on declining ridgelines and within ridge saddles. My SRC-style ratings would have accounted for these terrain settings at most but not all proposed turbine locations, so these terrain settings warrant additional examination. Golden eagle fatalities at wind turbines located low on declining ridge structures averaged 2.5× other than expected (observed fatalities = 8, expected fatalities = 14 total fatalities × 11/48 wind turbines low on ridge structures = 3.2, so 8 ÷ 3.2 = 2.5). Those found at wind turbines located within a ridge saddle averaged 2.9× more often other than expected. Golden eagle fatalities at wind turbines located both within a ridge saddle and low on declining ridge structures or slopes (n=4) averaged 4.6× other than expected.

Combining my SRC-style ratings, level of grading, and whether the turbine address was low on a declining ridge or slope or within a ridge saddle, golden eagle fatalities among 7 wind turbines averaged 0.857 per turbine (0.5 fatalities/MW), whereas 0 fatalities were found at wind turbines located high on ridge or hill structures, lacking berms or cut slopes, and for which I rated low to moderate hazard (Figure 3). Mean fatality rates increased linearly with this indicator integrating multiple factors (Figure 3).

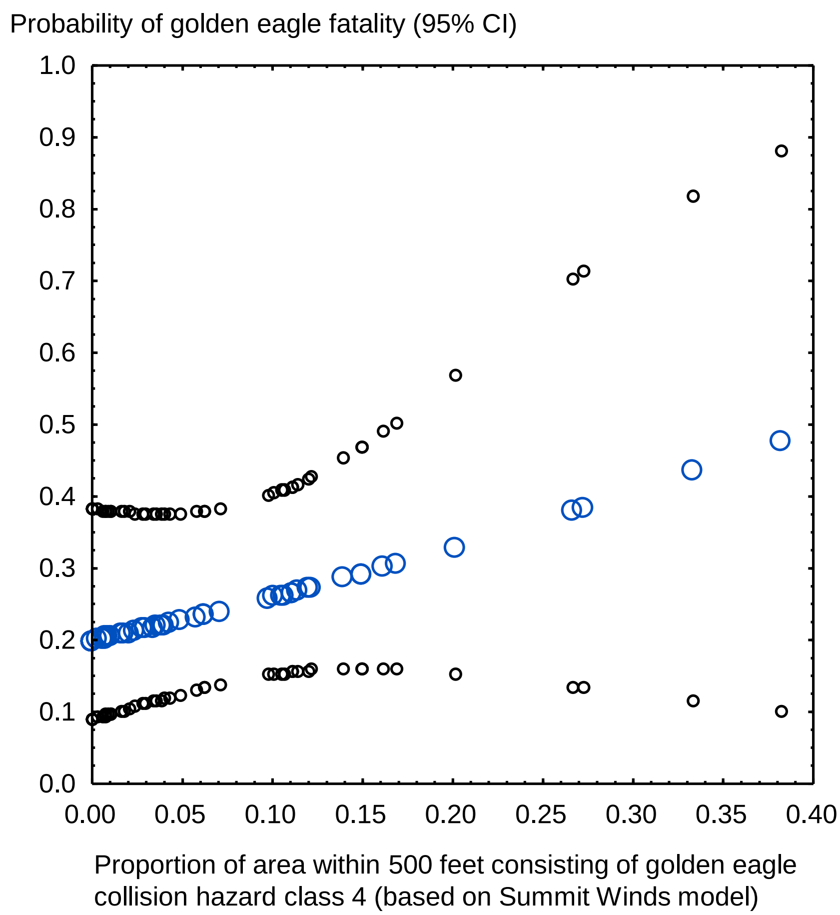
Figure 3 indicates that the process used to derive collision hazard models was fruitful for understanding factors related to golden eagle collisions with wind turbines. The hazard maps were derived from study of hundreds of golden eagle fatalities among old-generation wind turbines located on a landscape that was digitized and measured for dozens of terrain attributes. They were derived from hundreds of hours of behavior surveys, the data from which were also related to terrain attributes. Though not ready for use at the time of micro-siting at Golden Hills, later hazard maps were additionally derived from tens of thousands of GPS telemetry of nearly 30 golden eagles. From all of these data, and from observing the outcomes of repowering at Diablo Winds, Buena Vista, Vasco Winds and Golden Hills, I have learned that extreme grading for access roads and turbine pads can interfere with collision hazard model predictions by adding significant risk to turbine sites. I have also learned that turbines located low on ridge structures or within ridge saddles can be hazardous, even if the turbines are modern and large. These low-lying turbine sites are generally also where grading tends to be more extreme, exacerbating the hazard at these sites. My SRC-style hazard ratings anticipated most of this risk, but turbine sites 3 and 15 at Golden Hills exemplify sites where my ratings were too conservative.

The collision hazard models have advanced since Golden Hills. The most recent model advance was completed in support of the Summit Winds project (Smallwood and Neher 2016). To check whether the latest golden eagle collision hazard model would have predicted fatality locations at Golden Hills, I asked Lee Neher to count the 10x10-foot analytical grid cells within 500 feet of each turbine address that belonged to collision hazard classes 1, 2, 3 and 4, with 1 being the lowest hazard class and 4 the highest hazard class in these models. I converted the counts to areas and divided each by the area of the 500-foot count radius to obtain the proportion of the area consisting of each hazard class. I then logit-regressed whether wind turbines killed one or more golden eagles on the proportion of the 500-foot radius consisting of collision hazard class 4:

$$\hat{F} = \frac{e^{-1.3846+3.3838\times\log_{10}H4}}{1+e^{-1.3846+3.3838\times\log_{10}H4}},$$

where $\hat{F}$ represents the predicted fatality outcome, and H4 represents collision hazard class 4 as a proportion of a 500-foot count radius (Figure 4). According to the Summit Winds model predictions, Golden Hills turbines with 39% of the surrounding area consisting of hazard class 4 were 2.4× more likely to kill golden eagles than turbines with no class 4 within 500 feet. The confidence intervals widen with increasing area in hazard class 4, however, probably due to confounding influence of grading. Even with these increasing confidence intervals, the prediction accuracy of the latest collision hazard model looks good, though still not as good as the expertise developed from iteratively checking field experience against collision hazard models.

Figure 4. *Logit regression model predictions of the probability of Golden Hills wind turbines causing a golden eagle fatality.*



Returning to the obvious question asked as early in this report, the collision hazard models were likely effective at minimizing golden eagle fatalities in the absence of grading, and the modeling process far more effective. However, grading for wind turbine pads and access roads was extensive. It also bears noting that minimizing golden eagle collision hazard was only one of multiple factors contributing to the layout. The wind company decides what wind turbine size to use and how many wind turbines to install in a project, subject of course to County permitting. After deciding on project size and turbine size, the layout is constrained by available land, suitable soils, wind turbine manufacturer's minimum spacing requirements, opportunity for construction of suitable access roads, sufficient wind, locations of cultural resources, locations of endangered terrestrial species, potential for stream and pond sediment loading, and by setback requirements for residences, property lines, public roads, electric transmission lines, buried pipelines, and microwave transmission. Given all these constraints, the range of optional micro-siting recommendations for bird safety diminishes with increasing wind turbine density in the project area.

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 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. 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.

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.

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