

NESTING BURROWING OWL DISTRIBUTION AND ABUNDANCE IN THE ALTAMONT PASS WIND RESOURCE AREA, CALIFORNIA

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Wind turbines in the Altamont Pass Wind Resource Area (APWRA) have for thirty years generated renewable electricity for northern California, but they have also been implicated in the deaths of hundreds of burrowing owls (*Athene cunicularia*) per year (Smallwood et al. 2007, 2010; Smallwood and Karas 2009). The large numbers of burrowing owls estimated to be killed in the APWRA are of special concern because the burrowing owl has been declining in California (DeSante et al. 2007), it is a second-priority California Species of Special Concern (Shufard and Gardali 2008). Causes of fatalities have been hypothesized to be collisions with wind turbines and predation that might be facilitated by aerial predators' use of wind turbines and their towers as hides. Regardless of the relative contributions of collisions and predation to the estimated burrowing owl fatality rates, repowering the older small turbines with modern, large turbines has reduced burrowing owl fatalities associated with wind turbines in the APWRA (Smallwood and Karas 2009). For this and other reasons, efforts have begun to repower substantial portions of the APWRA, guided by an agreement between NextEra, the California Office of the Attorney General, Californians for Renewable Energy, and Audubon Society.

Repowering not only reduces the number of hazardous structures on the landscape, but it also shifts much of the rotor-swept area to greater heights above ground, and it reduces the perching opportunities on adjacent broken turbines and vacant towers common amongst the old-generation wind turbines. It also provides the opportunity to carefully site the new wind turbines to avoid or minimize the encounter rate between burrowing owls and wind turbines. For these reasons, the Alameda County Scientific Review Committee (SRC) recommended focused research on burrowing owl distribution and abundance in the Altamont Pass Wind Resource Area (APWRA) (SRC doc P90). Our study's principal objectives were to (1) estimate the size and distribution of the nesting population of burrowing owls in the APWRA, and (2) relate nest locations to slope measurements to develop a predictive model of burrowing owl nest locations. In this report, we only address the first objective, estimating size and distribution of the burrowing owl population in the APWRA. A report to be prepared later will present the results of relating nest burrows to slope attributes and the development of a predictive model.

METHODS

Using GIS, we first delineated watershed boundaries in the ca. 16,760-ha APWRA, then sub-watershed boundaries. We divided sub-watershed polygons by line features representing prominent valley bottoms, which were actually major streambeds. The resulting polygons represented *slopes* bounded by ridge crests and ridge lines and which drained rainfall into a reach of stream between stream intersection nodes. Slope polygons smaller than 1 ha were aggregated with adjacent polygons, as most of these small polygons were GIS slivers resulting from earlier geoprocessing steps.

We intersected slope polygons with wind turbine locations representing conditions in 2002-2006, prior to the removal of wind turbines for repowering and mitigation. From these 952 polygons (mean = 11.3 ha, range 1-90 ha) we defined 19 *turbine field polygons* representing wind turbines of common ownership, model, and geography (Figure 1). We used the old-generation turbine locations to represent the Buena Vista project, which was repowered with many fewer turbines in 2006, because the old-generation turbines covered all of the original project area, including the lower slopes to the east. We aggregated the Diablo Winds project with the Difwind project because the turbines of these projects were interspersed. We also aggregated the turbine field representing the Altech, Viking and TaxVest projects with the turbine field representing the Venture project because both of these fields were very small and we wished to prevent over-sampling in areas represented by small turbine fields. The 19 turbine field polygons covered 10,803 ha. Sampling from the slope polygons within turbine fields ensured that we would gain property access and that the owls we detected were in close proximity to wind turbines.

Within each turbine field polygon, we randomly selected 1 slope polygon using a stratified random number generator in Statistica 10.0 (Stat Soft, Inc. 2011). This polygon was the starting point for building a burrowing owl sampling plot by aggregating adjacent slope polygons until the total area was between 40 and 100 ha in size. We used decision rules to build sampling plots from each randomly selected slope polygon:

- (1) The next and subsequent slope polygons to add must have been located within the boundary of the turbine field polygon;
- (2) If adding an adjacent slope polygon would extend the survey plot across a prominent valley bottom line, then that polygon would be selected next, else the adjacent slope polygon nearest to a prominent valley bottom line would be added next; and,
- (3) If the most recently added slope polygon presented an opportunity to cross a prominent valley bottom line with the next slope polygon addition, then that polygon would be added next, else another slope polygon adjacent to the starting polygon would be added next, so long as it was closer than any other candidate slope polygon to the nearest prominent valley bottom line.

These decision rules treated the randomly selected starting polygons as pivotal for building burrowing owl sampling plots, while also favoring the selection of slopes facing each other across a shared major streambed. Favoring opposite slopes in the selection process helped to equalize the incidence of aspect (i.e., slope orientation) among the sampling plots.

We repeated the process of selecting and building sampling plots in 17 of the 19 wind turbine fields (round 2), omitting two turbine fields on the eastern side of the APWRA because they were too small. Within 10 turbine fields greater than 500 ha in size, we repeated the process again (round 3).

From 11 April to 29 June 2011, we searched for burrowing owl nest sites within 46 sampling plots, starting with plots selected in round 1 and ending with plots selected in round 3. We randomized the sequence of plots visited within a round, though we adjusted the sequence to

accommodate property access. During July 2011, we revisited nest burrows previously recorded to check on nesting status, and we extended our surveys to another 1,176 ha around plots where we had recorded the highest densities of nesting burrowing owls. The extended areas connected plots and formed larger geographic areas from which hypotheses about burrowing owl distribution and abundance could be tested, but they were not used to estimate population size in the APWRA.

We surveyed for burrowing owls using 7× and 10×-15× binoculars from inside a vehicle at multiple vantage points within plots, and we walked over areas not easily seen from vantage points. We used our vehicles as blinds because burrowing owls are less wary of stationary vehicles than they are of ambulating people, but we walked over areas not readily visible from roadside vantage points. Using a combination of vantage surveys and walkover surveys, we surveyed for burrowing owls in each plot until we felt that we had detected all of the nesting burrowing owls. Evidence of nesting included the presence of a male guard, indicated by faded plumage due to long term exposure to the sun, and it included alarm calling, short flights around the burrow, and presence of an adult female. Evidence at the burrow included decorations, such as decapitated lizards and mice, broken cattle dung, sticks, and other items. It also included abundant feathers, whitewash, and pellets. Later in the season, chicks emerging from the burrow would confirm many of the burrows as nesting sites.

Nest burrows were mapped using a Trimble Geo-XT global positioning system (GPS) accurate to <1 m. GPS data also included date and time, vegetation cover, attributes of the burrow, and diagnostics used to classify the burrow as a nesting burrow, satellite burrow, or refuge burrow. GPS data were converted to GIS shapefiles for analysis.

RESULTS

During our surveys at 19 plots in round 1 from 11 April to 27 May, we found 35 pairs of nesting burrowing owls. In surveys at 17 plots in round 2 from 17 May to 20 June, we found another 35 pairs. We found 6 pairs in 10 plots during round 3 from 31 May to 29 June. We found another 7 nest sites at the 36 plots sampled during rounds 1 and 2, but these additional nest sites might have been shifts in locations of nesting pairs recorded earlier. In the extended survey areas surveyed in July, we found another 118 nesting pairs. In between plots and extended areas, we found another 37 nesting pairs incidentally. Minimally, we found 231 nesting pairs of burrowing owls in the APWRA.

Nesting density among 46 plots averaged 3.20 pairs per km², but was higher among the first 36 plots searched during April and May (and some in June), at 3.79 pairs per km² (Table 1). By the time we got to the third round of plot surveys, burrowing owls were experiencing high attrition at nest burrows. Of 120 nest burrows we recorded from 11 April to 20 June, we found 50 (41.7%) of them vacant in July when we revisited them. Limiting our comparison of mean nesting densities to wind turbine field groups with 3 plots each, it appeared that nesting density declined through the spring, from round 1 to round 3 plot surveys (Figure 2). Expanding the mean from the first two rounds of surveys to the estimated 167 km² composing the APWRA, we estimate that there were 635 pairs of burrowing owls in the APWRA (90% CI: 368-903) during spring 2011.

To compare nesting densities between plots, or to characterize the spatial distribution of burrowing owls in the APWRA, we adjusted the density estimates in the 10 plots selected in round 3 and surveyed in late June, because nest abandonment increased rapidly in late June, hence nesting density had declined (Figure 3). We multiplied density estimates in round-3 plots by 3.2, which was the mean density from the same 10 turbine field groups sampled in rounds 1 and 2 and divided by the mean density in round 3. Of the 46 plots searched, we detected 0 burrowing owls in 24 (52%) plots, low densities of nesting burrowing owls in 8 plots, moderate densities in 7 plots, high densities in 4 plots and very high densities in another 3 plots (Figure 3). Nesting densities tended to be higher towards the northwest-southeast axis of the APWRA, and lower along the outer edges of the APWRA.

Burrowing owl nesting density was also high in extended search areas around high-density sampling plots and around plots in the north-central aspect of the APWRA (Figure 4).

DISCUSSION

The Altamont Pass Wind Resource Area supports a large nesting population of burrowing owls, perhaps one of the most significant populations in California. With an estimated 635 nesting pairs (90% CI: 368-903) in spring 2011, the APWRA hosts enough burrowing owls to explain the large fatality estimates associated with the wind turbines (Smallwood et al. 2007, Smallwood and Karas 2009, Smallwood 2010). We used the population estimate based on only the first two rounds of plot surveys, involving 36 plots and 2,056 ha, because nesting pairs declined substantially after mid-June. Had we relied solely on the round 3 plot surveys, involving 10 plots and 507 ha, our APWRA-wide estimate would have been 180 nesting pairs (90% CI: 11-350), which were fewer than the 231 pairs we detected, and which can serve as the absolute minimum number of nesting pairs in the APWRA.

In Vasco Caves Regional Preserve, where surveys were performed in 2006-2007 using the same methodology over the same season and the same survey time per hectare (Smallwood et al. 2010), burrowing owl nests declined substantially between 2006-2007 and 2011. On the areas we searched in 2011 (including extended areas outside our sampling plots), 20 nesting pairs were found in 2006 and 14 were found in 2007, but in 2011 we detected 3 nesting pairs. A switch from cattle to sheep grazing since 2005 might help explain the decline of the nesting owls in Vasco Caves, but the decline might have been caused by other reasons, such as a need to escape parasite loads or predator loads (Taylor and Taylor 1979).

Outside our study area, the abundance of nesting burrowing owls exhibited considerable inter-annual variability, though some of that variability amounted to declining trends. Declines in breeding pairs included 44 to 1 pairs over 11 years in Davis, California (Johnson 1997), and 23 to 2 pairs over 10 years in the Hanna survey area of Alberta, Canada (Shyry et al. 2001). Non-declining variability in breeding pairs included ranges of 4 to 30 pairs over 8 years in New Mexico (Arrowood et al. 2001), and 2 to 14 pairs over 8 years in the Brooks survey area of Alberta, Canada (Shyry et al. 2001). It is premature to determine whether the changes in breeding pairs we observed in Vasco Caves Regional Preserve represented declines or inter-annual variability typical of variability observed elsewhere.

Evidently, burrowing owl distribution is dynamic in the APWRA, and it is also clustered. Burrowing owl nests were absent on many slopes covered by short-stature grassland and abundant ground squirrel burrows. However, most burrowing owl nests occurred in similar, predictable conditions, usually low on slopes. They tended to be most abundant in the interior of the APWRA, especially along the major canyon passes oriented east-west.

Survey methodology had to change through the study as vegetation and owl behaviors altered visibility. At the beginning of the study, we enjoyed high visibility of burrowing owls and their burrows from vantage points, so a greater proportion of the survey effort was performed from automobiles. By late April, the grass had grown tall enough that a greater proportion of our survey effort had to be performed by walking transects. Also, during this time, nesting owls hid in their burrows more often, so they often had to be approached before we could detect the owls. Furthermore, no chicks had yet emerged, so detections were possible only by observing either one or more parents or by seeing the sign around burrows. During late April and early May, our surveys benefitted from extra searchers provided by monitoring team members from ICF.

By June, however, most of the grass had either been consumed by livestock or had lain down due to wind, so our surveys transitioned back to vantage points and automobiles, though we always walked over areas not readily visible from vantage points. Burrowing owls were also more detectable during June and July because chicks emerged, providing more owls per nest that could be detected. However, by July our detections were complicated by possible brood sharing and the ability of chicks to fly between burrows. Determining which young owls belonged to which burrows arose as a new challenge in July. To meet this challenge, we spent more time in automobiles watching the owls and determining their relationships to nest burrows and other types of burrow use before we exited the vehicles to map burrow locations.

With so many owls nesting in the APWRA, and with burrowing owls declining statewide, the Altamont Pass should be considered for directed conservation efforts. Repowering existing wind turbines in the APWRA should substantially improve the conservation of this species in California, as burrowing owl mortality associated with wind turbines should be reduced as a result (Smallwood et al. 2007, Smallwood and Karas 2009). Also, because the presence of ground squirrel burrows was a limiting factor for burrowing owl nesting in the APWRA, conserving ground squirrels would contribute to burrowing owl conservation.

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Table 1. Density and population size estimates of burrowing owl nests within the Altamont Pass Wind Resource Area during spring 2011.

Round	Dates	No. plots	Ha	Nests/km ²		Nests in APWRA		
				Mean	SE	Mean	LCL	UCL
1	11 APR - 27 MAY	19	1,091	3.577	1.589	600	161	1038
2	17 MAY - 20 JUN	17	965	4.032	1.089	676	375	976
3	31 MAY - 29 JUN	10	507	1.075	0.615	180	11	350
Total	11 APR - 29 JUN	46	2,563	3.201	0.786	537	320	753
1-2	11 APR - 20 JUN	36	2,056	3.792	0.971	635	368	903

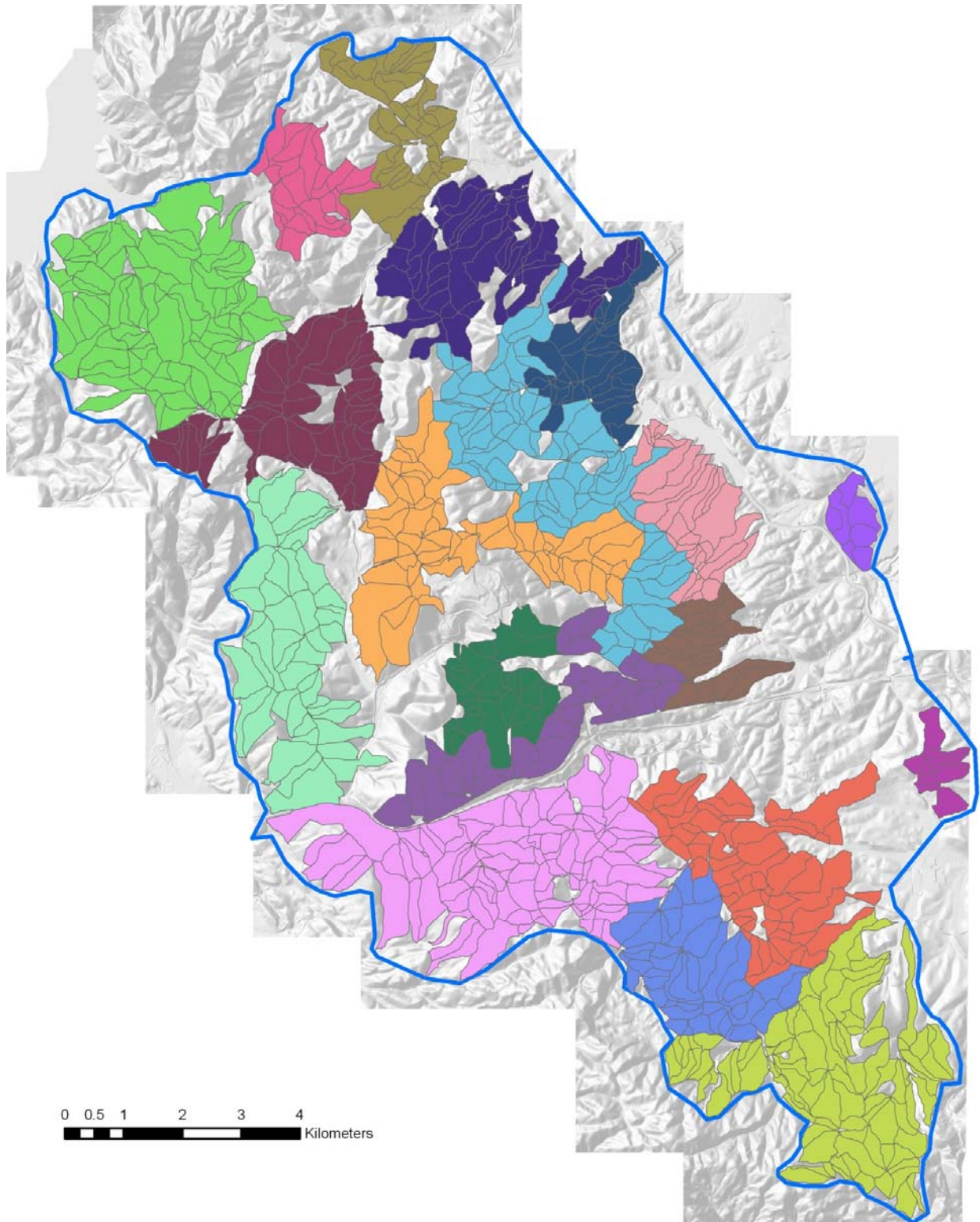


Figure 1. Nineteen wind turbine field groups, represented by colors other than gray, composed 10,803 ha (64.5%) of the 16,760 ha Altamont Pass Wind Resource Area, bounded by the blue line. Faint lines within turbine field groups represented boundaries of 952 slope polygons.

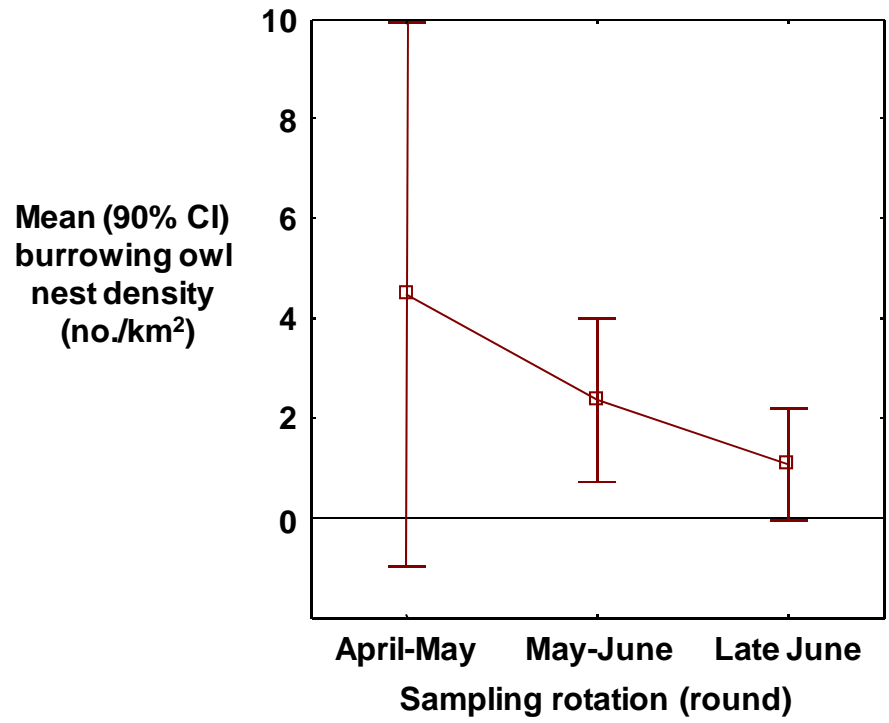


Figure 2. Among the 10 wind turbine field groups with 3 plots each, burrowing owl nesting density declined with later survey rounds.

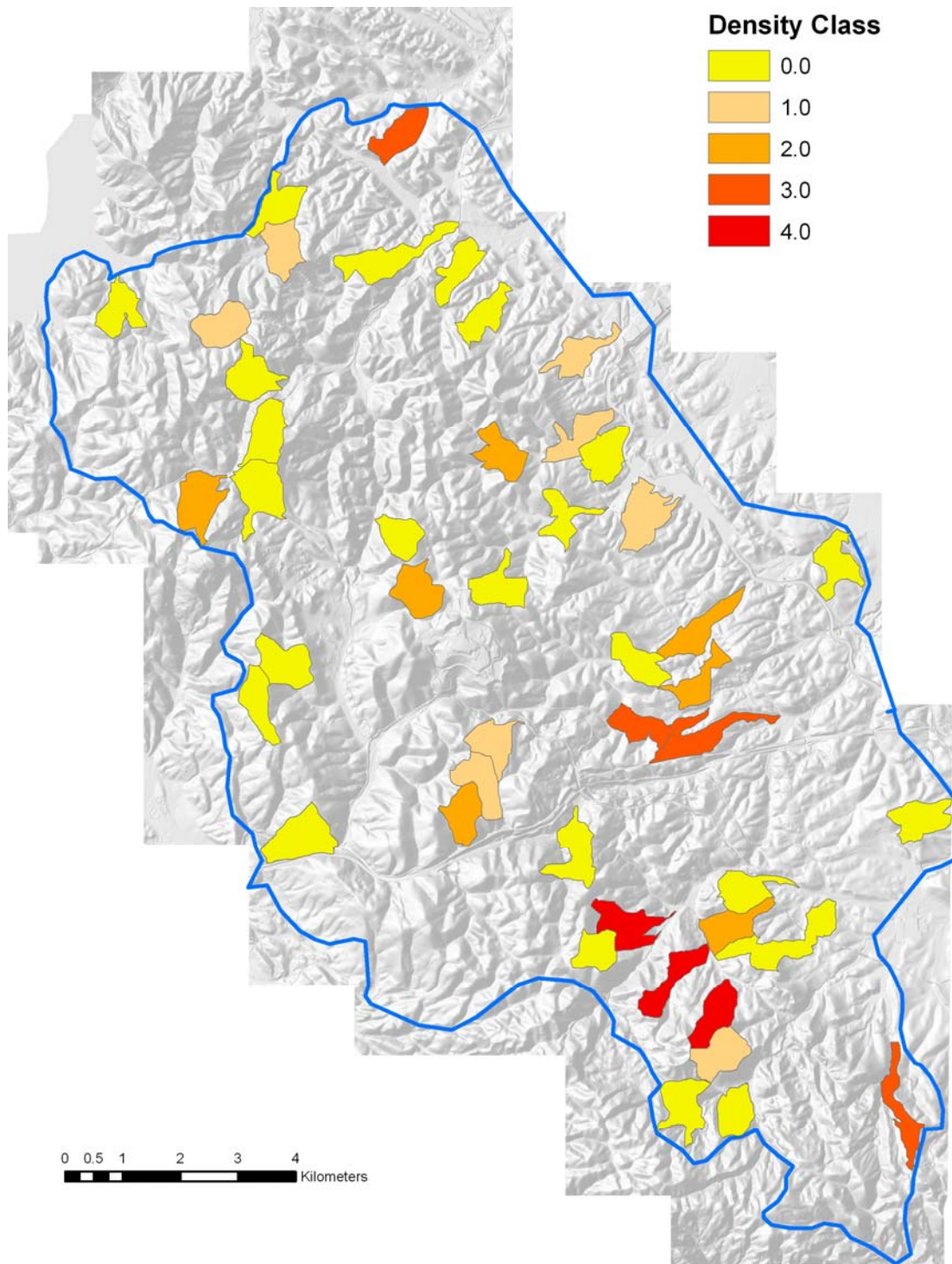


Figure 3. Distribution of nesting burrowing owls in 2011 in the Altamont Pass Wind Resource Area, Alameda and Contra Costa Counties, California. Nesting density in sampling plots was colored yellow for 0 nests/km², beige for 1.7-4.2 nests/km², orange for 5.0-7.5 nests/km², light red for 10.0-13.6 nests/km², and dark red for >15 nests/km², where nest density in 10 plots surveyed in late June was adjusted for densities measured in other plots in early spring.

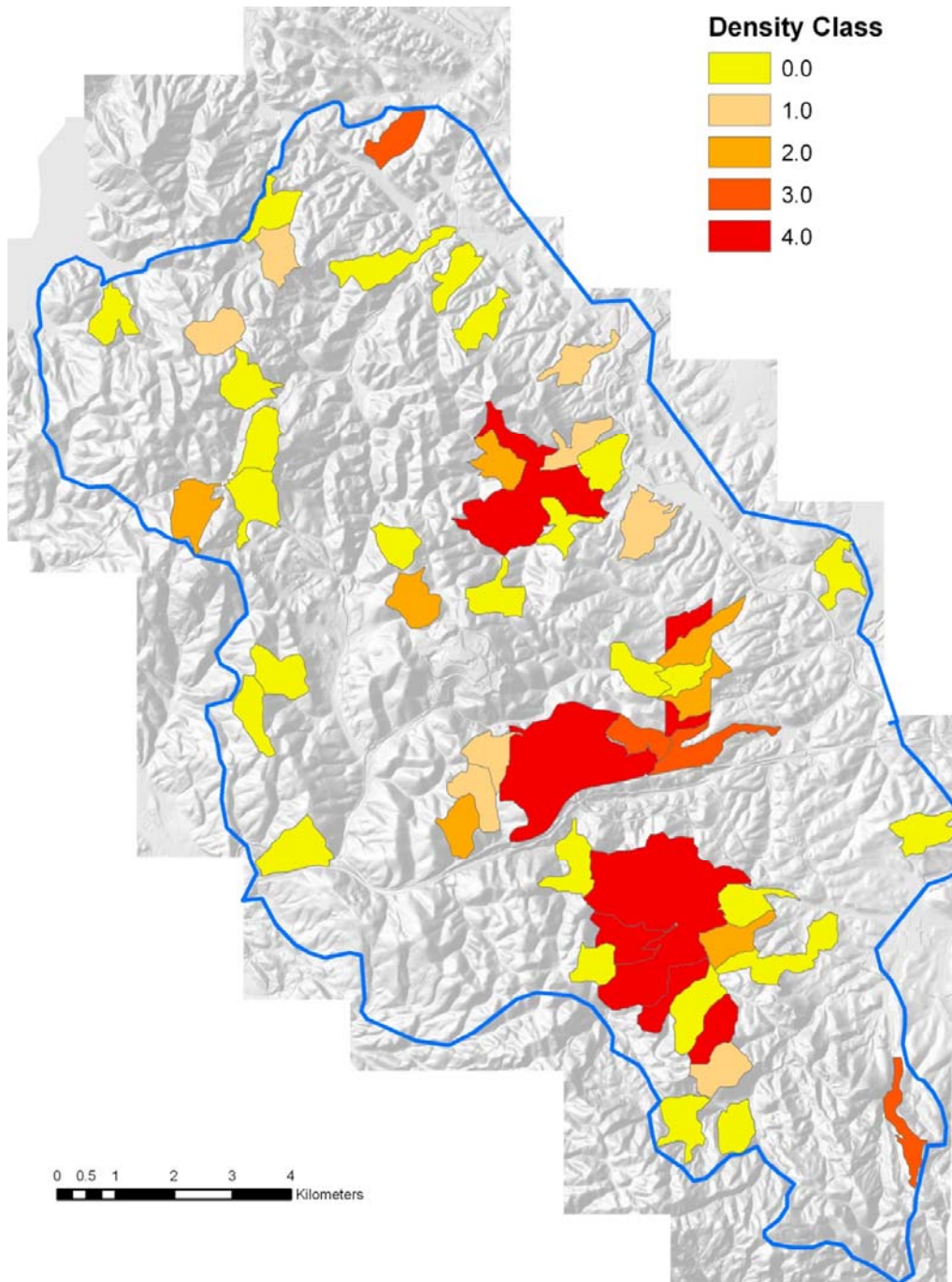


Figure 4. Distribution of nesting burrowing owls in 2011 in the Altamont Pass Wind Resource Area, Alameda and Contra Costa Counties, California, including within extended search areas between sampling plots. Nesting density in sampling plots was colored yellow for 0 nests/km², beige for 1.7-4.2 nests/km², orange for 5.0-7.5 nests/km², light red for 10.0-13.6 nests/km², and dark red for >15 nests/km², where nest density in 10 plots surveyed in late June was adjusted for densities measured in other plots in early spring.