ELEVATIONAL RANGES OF BIRDS ALONG CALIFORNIA'S PACIFIC CREST TRAIL

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ABSTRACT: Climate change is predicted to affect the ranges of montane birds differently, depending on their ecological adaptations to regional conditions. Detailed regional data on species' distributions from a systematic survey are crucial for tracking these range shifts and for guiding conservation decisions. We systematically completed 3578 point counts along a 2736-km mega-transect by following the Pacific Crest Trail (PCT) from 2 April to 8 September 2006. On this basis, we describe the elevation ranges of 74 common bird species and their habitats along the PCT by five segments: southern California, southern and northern Sierra Nevada, southern Cascade Range, and Klamath Mountains. We also identify potential sampling bias caused from seasonal variation in the detectability of birds by region. This assessment of bird distributions over a wide range can permit future efforts to gauge the responses of large numbers of common birds to land use and climate change.

California is a state with great topographic relief, dominated by mountain ranges oriented largely north–south, and supports a rich avifauna. The elevational ranges of montane species are determined by many factors, including past and present climate, topography, biological interactions, habitat distribution, and patterns of human disturbance (Lee et al. 2004, Ruggiero and Hawkins 2008, Tingley et al. 2009). Many of these factors vary across California's distinctive mountain regions, so many birds' ranges are determined by intrinsic regional conditions.

Data over the past 100 years show that birds of the California cordillera are particularly sensitive to climate changes (Tingley et al. 2009). Depending on their climate niche, many species have moved upslope or downslope in response to changes in temperature and precipitation, and this response may vary in neighboring regions (Tingley et al. 2012). By the end of the 21st century, the average annual temperature throughout California is expected to increase by 2 to 5 °C (Snyder et al. 2002, Cayan et al. 2012). Additionally, although there is less agreement among climate modelers about the direction of change in precipitation (IPCC 2007), rain is expected to be more frequent than snow, resulting in a reduced snowpack, especially in the Sierra Nevada (Hayhoe et al. 2004, Cayan et al. 2012). This reduction is expected to change vegetation structure and plant-species composition profoundly, a change already underway (Thorne et al. 2008, Dolanc et al. 2013). Hayhoe et al. (2004) predicted a conversion of 50 to 90% of subalpine and alpine habitats by the year 2099.

In addition to climate change, change in human land use can shape the patterns of species' distributions on mountains (Lee et al. 2004, Nogues-Bravo et al. 2008). On the California cordillera, habitat alteration has played a significant role in reducing species richness, particularly at the lower elevations (Forister et al. 2010). As California's population expands from 37.3 million (2010) to a projected 59.3 million in 2050 (Sanstad et al. 2009), continued development of housing, roads, and resources will likely further stress montane birds (Strasser and Heath 2013) already coping with climate change.

These disturbances increase the need for systematically recorded data on bird distributions to inform management (Tingley and Beissinger 2009). As yet, few studies have documented the occurrence of birds in remote mountainous regions systematically (Siegel et al. 2011, 2012). We recorded birds by point counts and assessed habitat along a single, continuous mega-transect and documented their elevational ranges and habitats by five adjoining segments of the Pacific Crest National Scenic Trail (PCT).

METHODS

Study Area

The PCT extends along mountain ranges from Mexico to Canada, traversing California, Oregon, and Washington. It is a recreational and scenic trail reserved for hiking and equestrian use that crosses remote areas. We hiked the California portion of the PCT (2736 km), which served as a mega-transect for a survey of birds every 10 minutes walked. This route spanned nine degrees in latitude (32.58° N to 42.00° N) and elevations from 365 m (San Gorgonio Pass in southern California) to 4020 m (Forester Pass in the southern Sierra Nevada). Varying locally with elevation, precipitation generally increases from south to north along the PCT. The Transverse and Peninsular Ranges of southern California receive the least amount of precipitation, where annual precipitation ranges from 15 to 102 cm. In the Klamath Mountains of northwestern California, annual precipitation ranges from 46 to 305 cm (Miles and Goudey 1997). We used topographic, climatic, and biogeographic features to divide this PCT mega-transect into five segments: southern California mountains (“SoCa”), southern Sierra Nevada (“SoSN”), northern Sierra Nevada (“NoSN”), southern Cascade Range (“Casc”), and Klamath Mountains (“Klam”) (Figure 1). With some modification, this delineation agrees with boundaries of natural regions defined by Schoenherr (1992), Small (1994), and Miles and Goudey (1997). The wide range of habitats along the PCT is due to the trail’s elevation as well as the mountains’ topography. The extent of the elevation gradient sampled differed for each region, so our transect should not be considered representative of the entire range of elevations but only of the habitats along the PCT.

Data Recording

Stopping at 10-minute intervals while walking along the PCT, McGrann counted birds for 5 minutes within a radius of 50 m, estimated visually, and avoided counting any bird that may have been recorded at a previous plot. The distance between plots, ~500–700 m, depending on terrain, was greater than the 250-m minimum recommended by Ralph et al. (1995), reducing the potential for duplicate counts of individuals. We excluded from analysis all birds observed beyond 50 m and those flying above the vegetation canopy, apparently not foraging, displaying, or behaving in a way that

Figure 1. The route of the Pacific Crest Trail (black line) through California, showing the five regions by which the results of point counts are analyzed and their dates of survey in 2006.

suggested use of the habitat below. By visual assessment, Amy McGrann classified the habitat in each plot according to the scheme of the California Wildlife Habitat Relationship System (CWHR; www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp). Additionally, we recorded the time, date, and geographic coordinates of each point count. We did not count in inclement weather, and on one occasion a snow storm forced the observers off the PCT, resulting in a gap of approximately 15–20 km along the transect in southern California. Otherwise, our mega-transect was complete in a single field season, yielding 3578 plots along the PCT in California.

Timing of Surveys

To maximize our data, we followed the recommendations for point counts of Ralph et al. (1995) except for time of day and season. Instead of being restricted to the morning, surveys extended from dawn to dusk. As birds' singing generally declines in the late morning and afternoon, our counting through the day may introduce a source of bias. However, the influence of any such bias on our calculations of species' distributions by region should be minimal because the proportion of counts before 10:30 in each region was similar (SoCa: 30%, SoSN: 31%, NoSN: 31%, Casc: 30%, and Klam: 32%). Furthermore, seasonal variation in vocalizing may have influenced the detectability of species in different regions because we did not restrict counts to the breeding season but instead continued them from 2 April to 8 September. To complete surveys when the PCT was mostly free of snow, we surveyed each region separately: SoCa (2 April–27 May), SoSN (29 May–20 June), NoSN (8 August–8 September), Casc (26 June–20 July), and Klam (20 July–4 August). By reviewing Small (1994) and www.ebird.org, we assessed whether each species' observed distribution along the PCT represented its summer range, or may have been significantly reduced by cryptic post-breeding behaviors, may have represented primarily latitudinal or elevational migrants, or may have represented primarily birds in their winter ranges.

Data Analysis

We used the spatial analyst extension in ArcGIS (version 10, Environmental Systems Research Institute, Redlands, CA) to extract elevation from the National Elevation Dataset (resolution 10 m; U. S. Geological Survey, http://ned.usgs.gov) for each GPS-recorded survey point.

We calculated birds' elevational distribution in each region by methods similar to those of Siegel et al. (2011, 2012). The basis was data from 1126 plots in SoCa (mean elevation of point counts 1495 m, range 363–3195 m), 486 in SoSN (mean 2286 m, range 1164–3661 m), 877 in NoSN (mean 2735 m, range 1904–3662 m), 687 in Casc (mean 1584 m, range 662–2312 m), and 402 in Klam (mean 1771 m, range 428–2331 m).

Next, we categorized each species detected at least 20 times in at least one region as detected or not detected at each plot in that region. We then calculated summary statistics to describe the elevations at which the species was detected in each of the five regions, including the mean elevation of detection as well as the range encompassing 95% of the detections (lowest and highest 2.5% of detections excluded), calculated with the quantile function (Hyndman and Fan 1996) in R version 2.15.1.

Using the "beanplot" package in R (Kampstra 2008), we graphed the distributions of survey plots with and without detections for common species (at least 20 detections in at least one region) to ensure a sample large enough for a beanplot to be built (Siegel et al. 2011, 2012). Beanplots employ a density trace and depict a species' distribution along an elevational gradient. The density trace illustrates the relative difference in the density of detections or non-detections along the elevation gradient. The width of the density trace (the *x* axis) is determined by the sample size, the spread of data points along the gradient, and a bandwidth parameter, whose value we determined by the method of Sheather and Jones (1991). The asymmetrical beanplots display the distribution of plots with detections next to the distribution of plots without detections. The differing shapes of the density traces on either side of the beanplot's *y* axis are not complementary and thus do not represent the ratio of detections to non-detections. Rather, they represent the proportion of detection or non-detections with respect to entire distribution of locations (of detection or non-detection pooled) along the elevation gradient (Siegel et al. 2011).

We employed an identical procedure to illustrate the distributions of the habitats noted at each plot. Again, the only habitats analyzed are those recorded at least 20 times in one region.

RESULTS

Bird Distributions

Many California birds commonly move upslope after breeding (Grinnell 1908, Siegel et al. 2011). We made no attempt to locate nests and could not verify whether birds detected on point counts were local breeders. Thus our results should be interpreted as birds' summer ranges rather than strictly breeding ranges. Figure 2 depicts the densities of detection and non-detection by elevation for each species meeting our criterion of 20 plots with detections in at least one region. Seventy-four species met this criterion, including 69 in SoCa, 65 in SoSN, 47 in NoSN, 59 in Casc, and 49 in Klam (see Table 1 for mean elevations and ranges). The observed distributions of 12 species may have been influenced by the timing of the survey, detections of migrants, or detections of birds still in their winter ranges (Figure 2). These species excluded, 30 species occurred in all regions, and of these 30 species, the elevational means of 24 (80%) were higher across all three southern regions (SoCa, SoSN, NoSN) than in either of the two northern regions (Casc and Klam). In part, these differences are due to regional variation in the elevations sampled and may also reflect the distributions of forest habitats optimal for these birds (see Habitat Distributions below).

The ranges of several lower-elevation species lay primarily below the mean elevation of all point counts along the PCT (1954 m), while several higher-elevation species occurred primarily above this elevation. These included eight low-elevation species detected only in the two most southern regions (SoCa and SoSN): the California Quail, Costa's Hummingbird, California Thrasher, California Towhee, Black-chinned Sparrow, Lark Sparrow, Black-throated Sparrow, and Bell's Sparrow (see Figure 2 for scientific names); their ranges tended to correspond with distributions of desert scrub and chaparral (Figure 3). Additionally, we detected the Horned Lark only in SoCa at low elevations, in association with annual grassland—none in the Sierra Nevada along the PCT, perhaps reflecting the species' negative trend in Sierra Nevada according to data from the Breeding Bird Survey over 45 years (Sauer et al. 2012). Bewick's Wren and Wrentit, common in chaparral in SoCA, were also confined to lower elevations but occurred across a wider latitudinal range along the PCT, being noted in regions SoCa, SoSN, and Casc. The ranges of the Acorn Woodpecker and Oak Titmouse, also restricted to lower elevations in these regions, corresponded with montane hardwood–conifer and montane hardwood habitats. Three species were restricted to high elevations; the range of Clark's Nutcracker corresponded with subalpine conifers, particularly in SoCa, and the Gray-crowned Rosy-Finch and American Pipit (*Anthus rubescens alticola*) were confined almost entirely to the alpine dwarf-shrub and barren habitats at the highest elevations of regions SoSN and NoSN. The American Pipit was detected on just 14 plots so is not included in Figure 2.

Habitat Distributions

Twenty-one CWHR habitats met our criterion of occurring on 20 survey plots in at least one region (Figure 3). The xeric grass and shrub habitats (annual grassland, desert scrub, chamise–redshank chaparral, mixed chaparral, and sagebrush) occurred most frequently below 1954 m (the mean elevation of all points) in the two southernmost regions (SoCa and SoSN), whereas woodland and more mesic habitats (montane hardwood, montane hardwood–conifer, and Douglas-fir) occurred more frequently below 1954 m in the two northernmost regions (Casc and Klam). Montane riparian forest was frequent along streams and at springs below 1954 m in the SoCa region and sporadic elsewhere along the PCT. Where the PCT traversed drier and east-facing slopes, frequent woodland habitats were juniper, pinyon–juniper, and Joshua tree. At middle to upper elevations of all five regions, montane chaparral and several forest habitats were common (Jeffrey pine, mixed conifer, white fir, red fir, lodgepole pine, and subalpine conifer); their mean elevations in the two northernmost regions were lower than in the three southernmost regions. The alpine dwarf-shrub and barren (i.e., devoid of vegetation) habitats were found only at the highest elevations along the PCT, predominantly in regions SoSN and NoSN, to a lesser extent in Klam.

DISCUSSION

Systematic surveys of California's mountains, including Grinnell's historic transects (e.g., Grinnell 1908, Grinnell and Storer 1924) and the recent efforts of Siegel et al. (2011, 2012), have proven invaluable to avian ecology and conservation. Our mega-transect represents the first systematic survey of bird diversity along the entire PCT in California. In the five regions we defined, species' distributions differed notably. Furthermore, certain species had narrow elevational ranges at both extremes of the gradient. Elevational range is an important predictor of montane species' risk of extinction (Sekercioglu et al. 2008, La Sorte and Jetz 2010). Low-elevation species with limited ranges may be more susceptible to land-use change (Lee et al. 2004, Forister et al. 2010) but may have an opportunity to disperse to higher elevations in response to climate change. Of particular conservation concern are species confined to high elevations, generally much smaller in extent than low-elevation zones (McCain 2007). Species restricted to these areas may have limited opportunities to disperse laterally to neighboring alpine habitats (La Sorte and Jetz 2010). Because of their narrow and isolated ranges, two

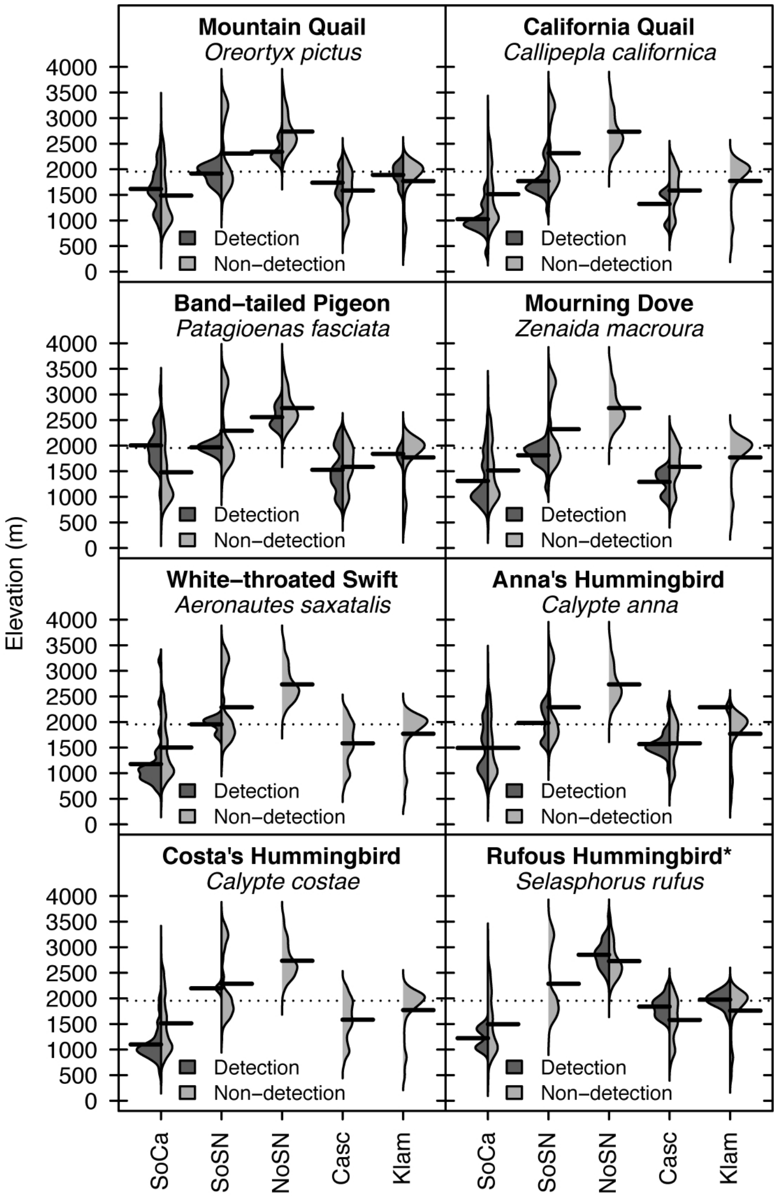
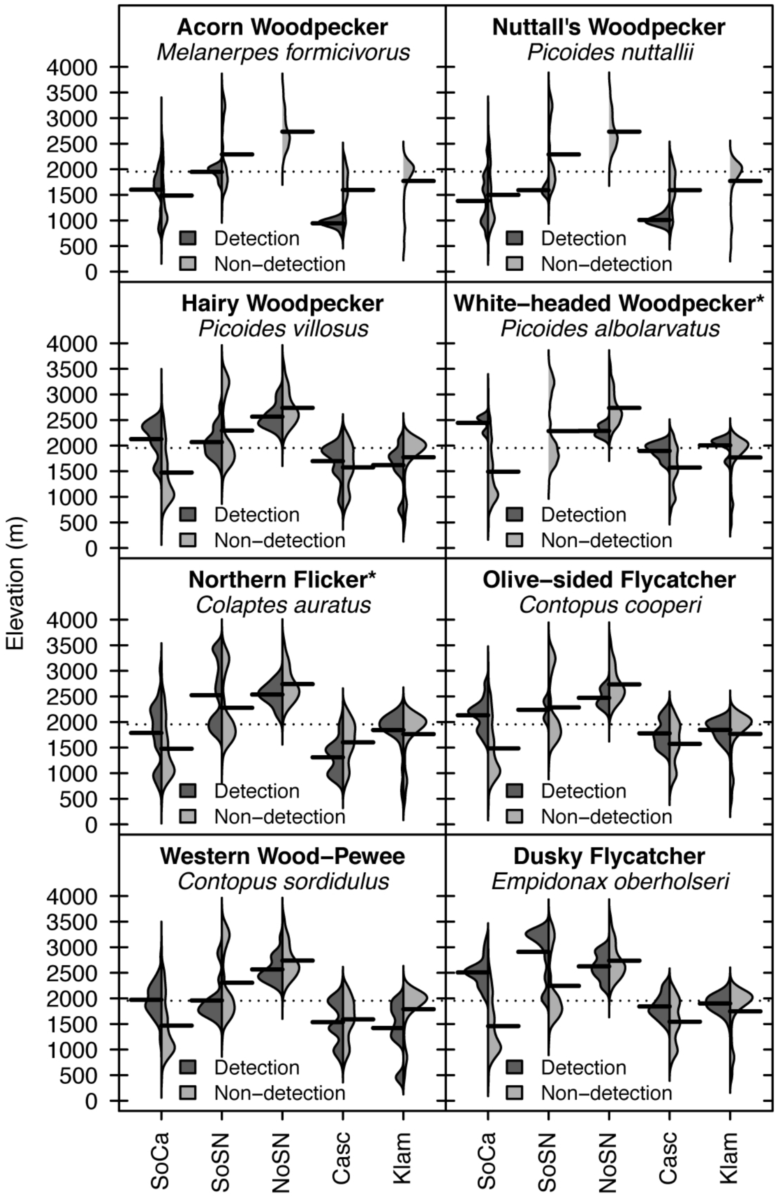
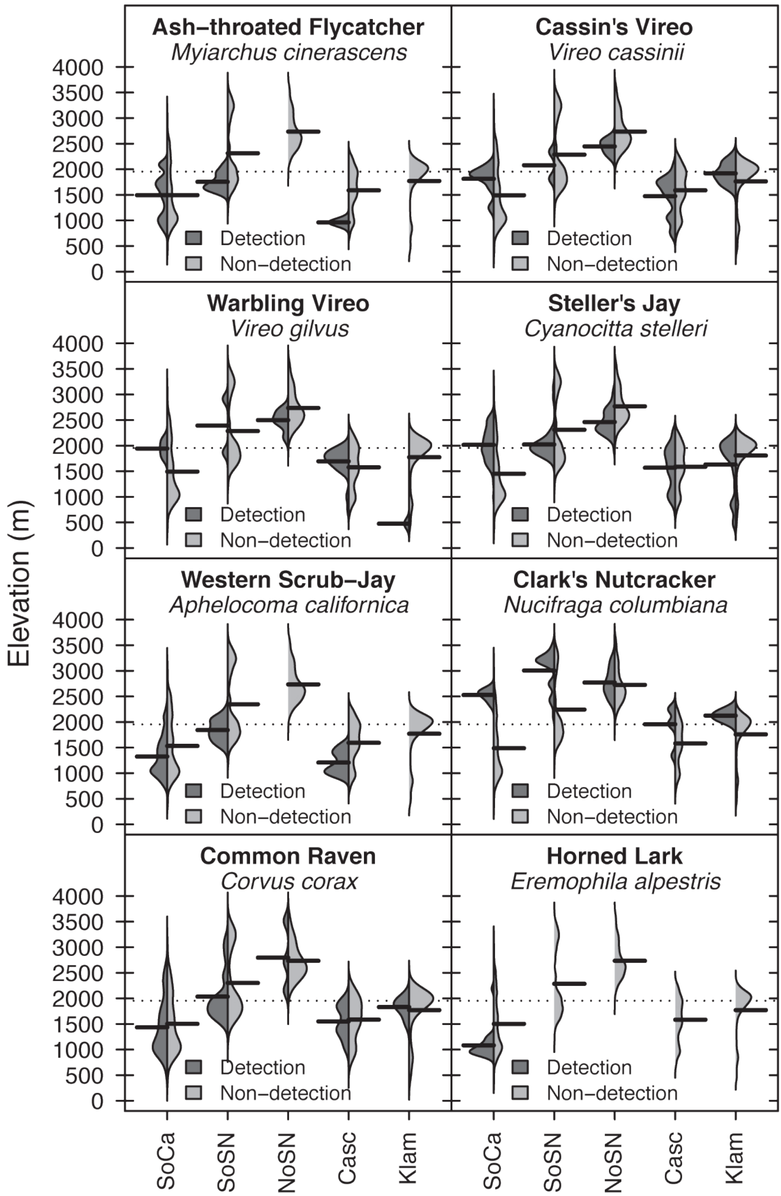


Figure 2. The elevational distribution of plots with and without detections of 74 species detected on at least 20 plots along the Pacific Crest Trail. Dark gray regions to the left of the center line represent density traces of detections; light gray regions to the right of the center line represent density traces of points without detections. Black horizontal lines show mean elevations of points where a species was detected



(left of center) and not detected (right of center). The dashed line indicates the mean elevation of all points, all five regions pooled. An asterisk after a species' English name indicates that at least one form of seasonal detection bias may have influenced the range observed; see text for details. See Figure 1 for definitions and dates of survey of the five segments of the trail.



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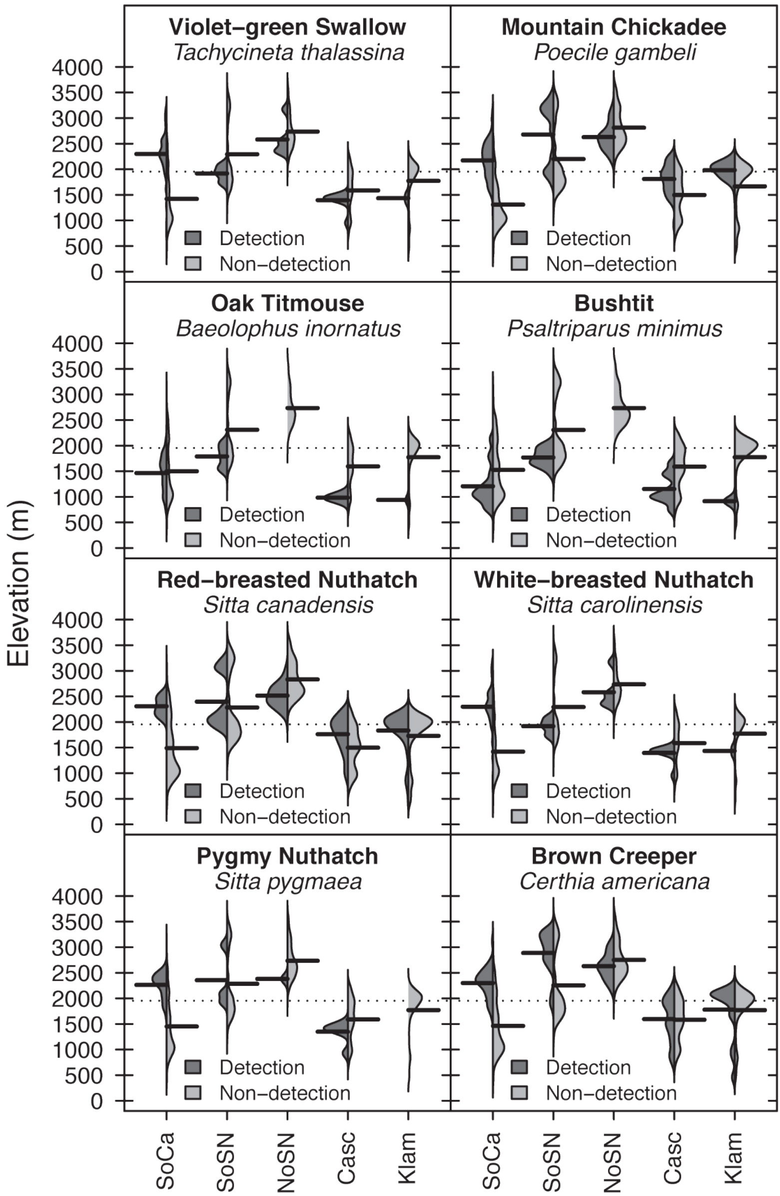

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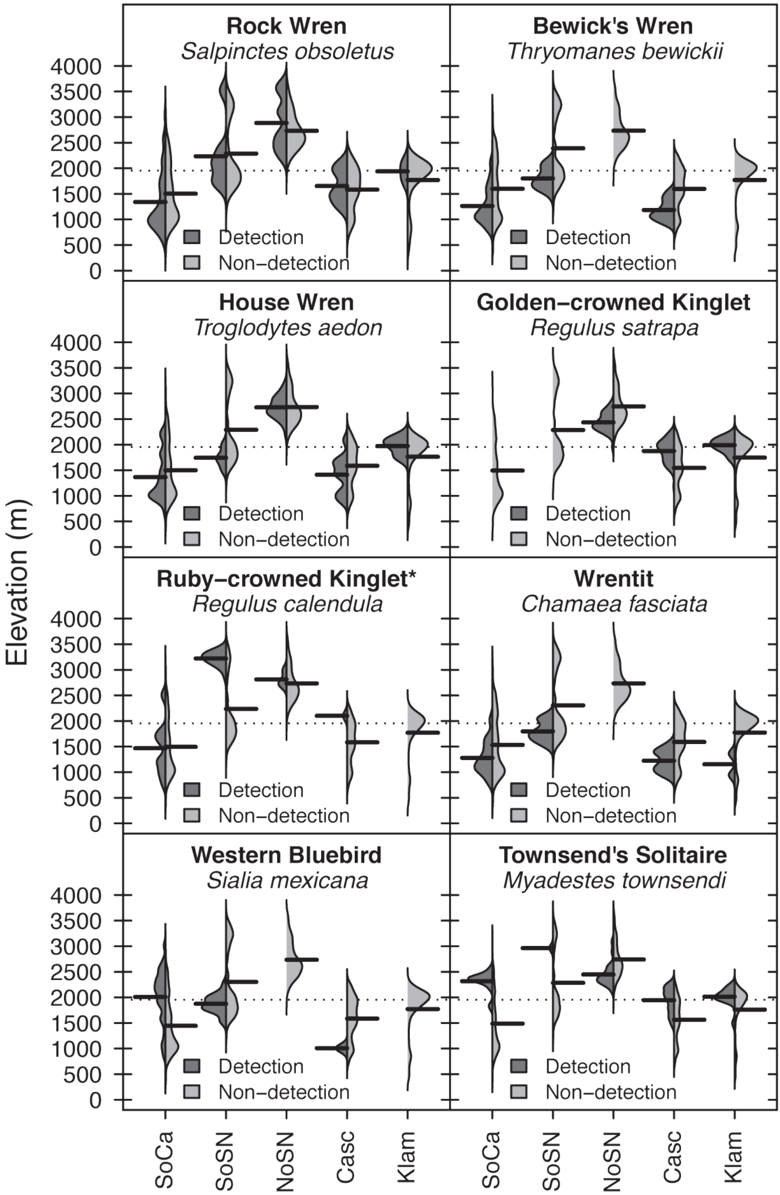

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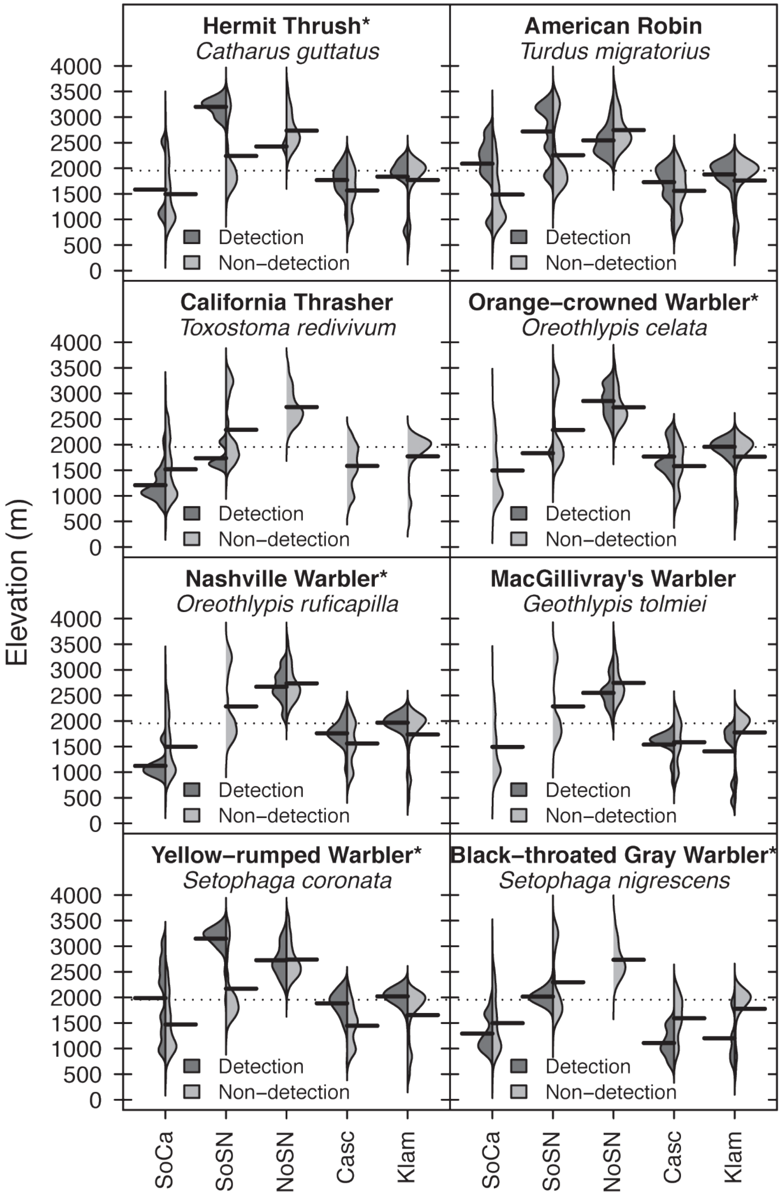

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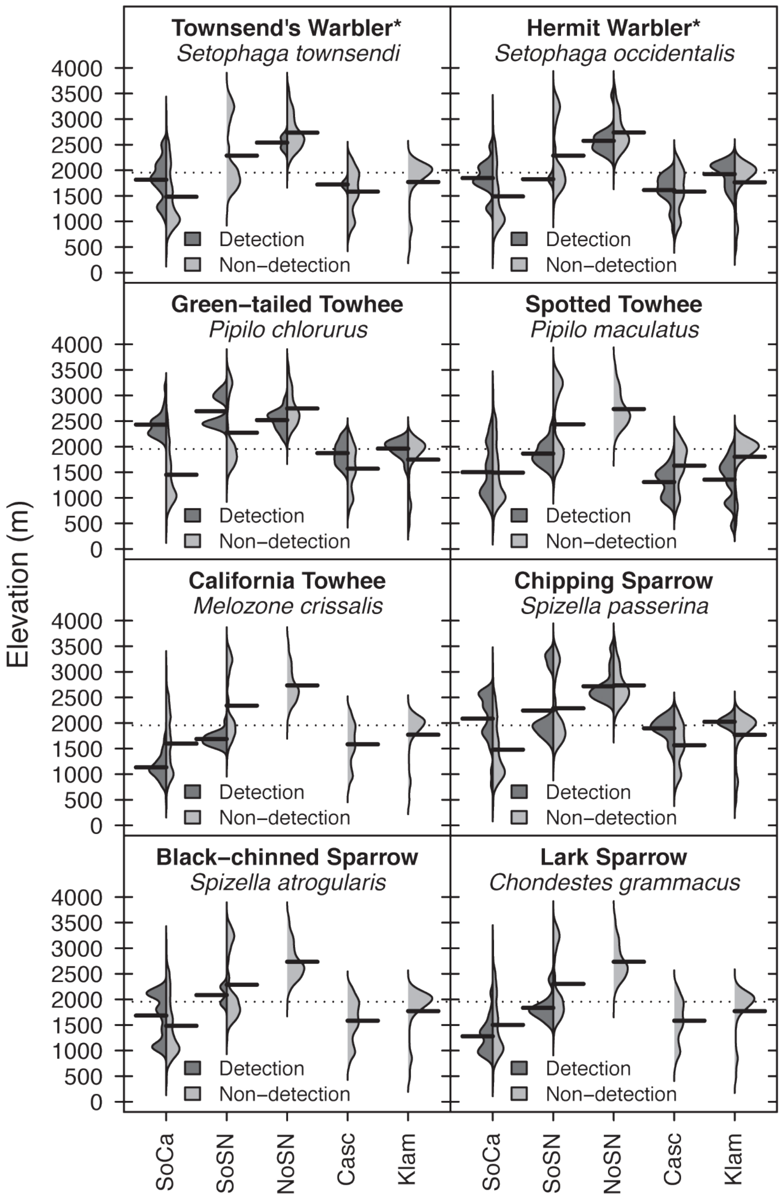

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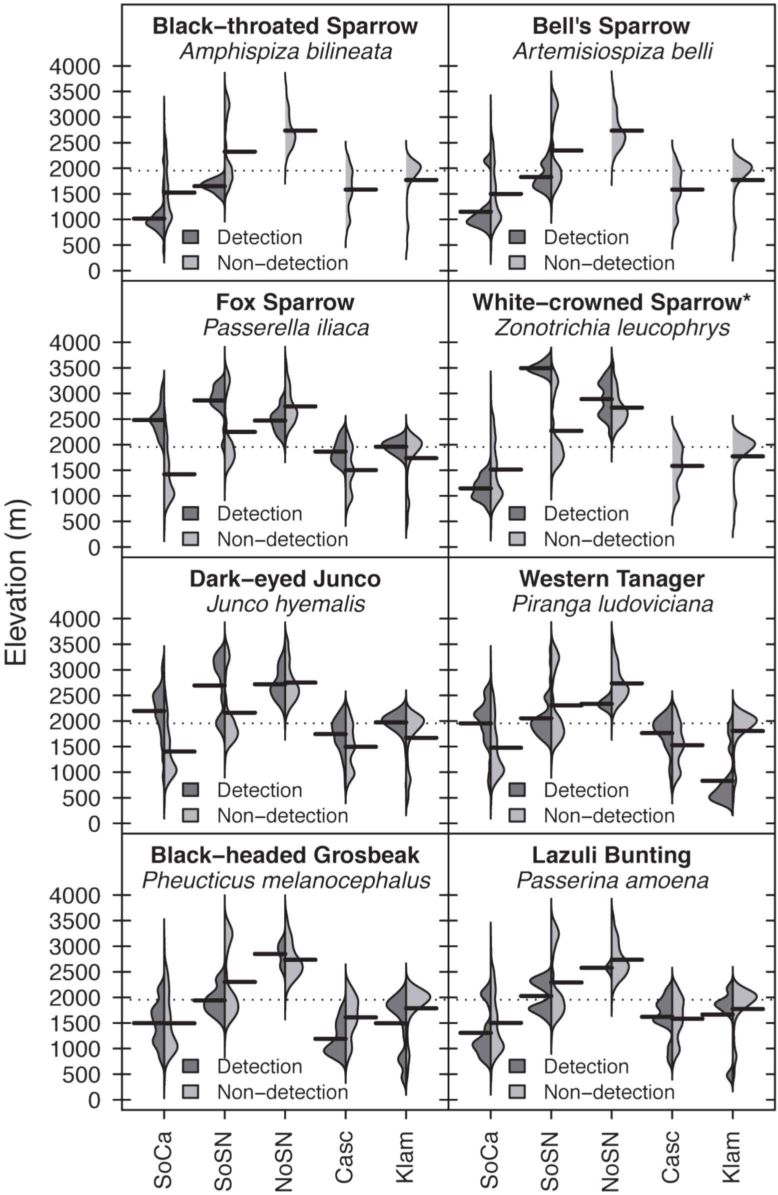

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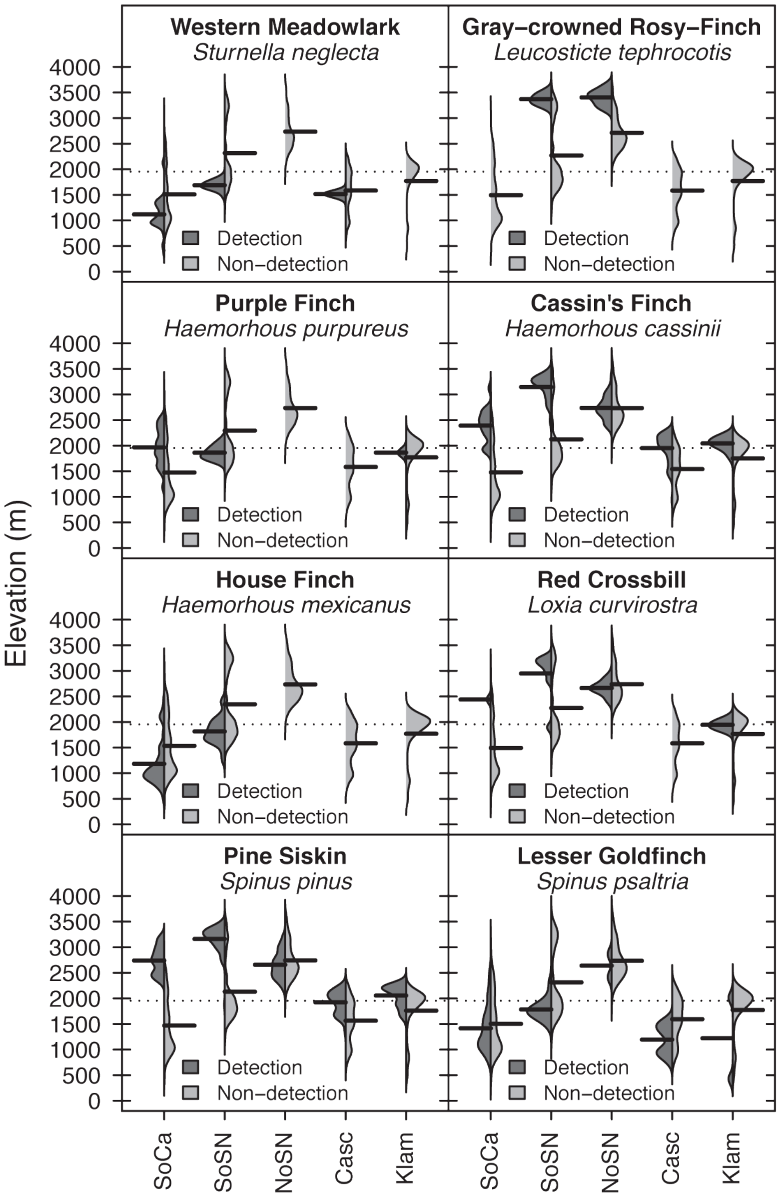

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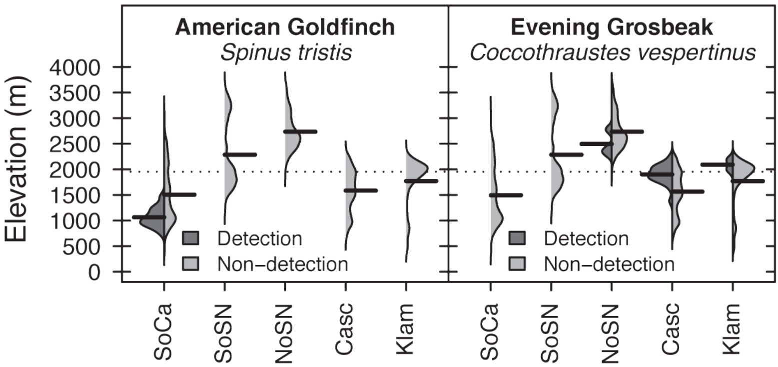

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high-elevation specialists, the American Pipit and Gray-crowned Rosy-Finch in the Sierra Nevada, may be especially at risk of extirpation. The pipit may have vanished from the Sierra Nevada in the past, about 5000–2900 years ago, as a result of warming of the climate that dried its mesic tundra habitat. It recolonized the Sierra Nevada only recently, perhaps about 45 years ago (Miller and Green 1987)

Detections of Migrants

Some species' distributions, in certain regions, were likely influenced heavily by detections of migrants (Figure 2). Surveys in SoCa were completed early in the season, and many or all of the Hermit Thrushes and Nashville, Black-throated Gray, Townsend's, and Hermit warblers seen were likely spring migrants. Furthermore, the Northern Flicker, Ruby-crowned Kinglet, Yellow-rumped Warbler, and White-crowned Sparrow all have complex patterns of seasonal movement within California (Small 1994); detections of these species, especially at low elevations in SoCa, could be of either wintering individuals or migrants. The White-crowned Sparrows in SoCa were likely of subspecies *gambelii* and had not yet departed for their breeding range in Alaska and Canada, while the high-elevation detections of this species in the Sierra Nevada were of subspecies *oriantha* on their breeding territories (Small 1994). Rufous Hummingbirds were detected at low elevations in SoCa, as they were migrating north, and at high elevations in regions NoSN, Casc, and Klam, as they were migrating south. Orange-crowned Warblers were detected mostly at upper elevations in regions NoSN, Casc, and Klam, largely reflecting upslope movements after breeding. Surveys of NoSN and Klam were completed rather late in the season, and because of more cryptic behavior after breeding, the number of detections of the White-headed Woodpecker appeared to be relatively low, given the amount of suitable habitat available. The number of plots with detections of the Ruby-crowned Kinglet was particularly low in NoSN (3 plots) and Casc (1 plot). In addition, we detected no Horned Larks in either Sierra Nevada region, perhaps reflecting the long-term, negative trend for these two species. Both

Table 1 Elevational Distributions of the 74 Species Most Frequently Detected[a] on Point Counts by 5 Regions of the Pacific Crest Trail, 2006

	Region[b]														
	SoCa			SoSN			NoSN			Casc			Klam		
Species[c]	*n*[d]	Mean	Range[e]	*n*	Mean	Range	*n*	Mean	Range	*n*	Mean	Range	*n*	Mean	Range
Mountain Quail	76	1616	901–2385	26	1917	1625–2124	4	2341	2171–2608	4	1738	1474–2068	5	1890	1620–2085
California Quail	40	1025	379–1644	26	1769	1342–2373	0			3	1322	939–1550	0		
Band-tailed Pigeon	33	2004	1438–2692	6	1966	1870–2017	5	2556	2371–2825	10	1529	920–2191	2	1839	1754–1925
Mourning Dove	119	1311	737–2338	34	1812	1200–2102	0			6	1292	965–1530	0		
White-throated Swift	27	1179	697–2661	4	1955	1766–2050	0			0			0		
Anna's Hummingbird	88	1494	748–2448	6	1982	1590–2383	0			19	1568	1225–2098	1	2288	2288–2288
Costa's Hummingbird	51	1100	664–1920	1	2197	2197–2197	0			0			0		
Rufous Hummingbird	6	1222	1021–1459	0			46	2854	2433–3304	14	1840	1570–2186	21	1976	1670–2203
Acorn Woodpecker	75	1601	785–2154	7	1949	1741–2048	0			13	944	789–1016	0		
Nuttall's Woodpecker	41	1381	724–2333	3	1592	1523–1679	0			10	1009	939–1170	0		
Hairy Woodpecker	34	2127	1482–2509	20	2069	1682–2625	21	2566	2275–3039	42	1697	884–2193	7	1620	862–2059
White-headed Woodpecker	3	2445	2263–2546	0			5	2287	2170–2418	24	1897	1624–2088	5	2006	1721–2135
Northern Flicker	58	1786	762–2845	15	2524	1786–3459	27	2537	2144–2863	43	1311	882–1947	34	1844	720–2210
Olive-sided Flycatcher	15	2132	1667–2680	2	2239	2082–2396	5	2472	2283–2692	37	1779	1415–2248	11	1846	1537–2058
Western Wood-Pewee	58	1972	1362–2518	28	1960	1582–2908	20	2566	2261–3054	76	1536	843–2095	20	1421	444–1997
Dusky Flycatcher	38	2507	2040–3074	30	2909	1957–3370	21	2625	2219–2985	91	1843	1451–2288	62	1901	1566–2177
Ash-throated Flycatcher	52	1494	821–2116	24	1755	1535–2090	0			4	963	947–996	0		
Cassin's Vireo	8	1813	1319–2070	2	2078	1828–2329	5	2446	2270–2583	25	1475	742–1968	20	1920	1633–2235
Warbling Vireo	3	1944	1781–2107	2	2392	1894–2889	6	2499	2201–2706	42	1694	982–1992	1	475	475–475
Steller's Jay	86	2016	1477–2557	42	2023	1746–2917	96	2461	2132–2997	136	1569	885–2267	84	1632	477–2195
Western Scrub-Jay	210	1326	783–2154	59	1843	1506–2208	0			17	1209	936–1556	0		
Clark's Nutcracker	6	2528	2365–2621	27	3006	2273–3448	165	2772	2306–3314	5	1957	1403–2275	14	2125	1977–2274
Common Raven	137	1435	716–2554	29	2035	1557–3105	3	2797	2187–3477	7	1550	1108–1937	5	1830	1572–2007
Horned Lark	21	1082	879–1727	0			0			0			0		
Violet-green Swallow	94	2299	1062–3104	10	1918	1721–2089	10	2582	2340–3188	10	1396	1055–1478	2	1436	1368–1503
Mountain Chickadee	242	2173	1504–2952	87	2679	1732–3453	372	2629	2167–3212	192	1810	1328–2265	133	1983	1680–2223

	Region[b]														
	SoCa			SoSN			NoSN			Casc			Klam		
Species[c]	n^d	Mean	Range[e]	n	Mean	Range	n	Mean	Range	n	Mean	Range	n	Mean	Range
Oak Titmouse	157	1465	814–2091	23	1789	1501–2089	0			12	984	914–1070	1	939	939–939
Bushtit	112	1207	742–2142	19	1769	1482–2039	0			9	1153	789–1612	2	915	887–943
Red-breasted Nuthatch	5	2308	2100–2529	9	2398	1888–3179	271	2515	2134–2989	223	1762	963–2250	158	1835	749–2211
White-breasted Nuthatch	65	1785	832–2571	35	2073	1660–3462	51	2553	2249–2960	24	1104	904–1671	2	1989	1880–2098
Pygmy Nuthatch	59	2263	1787–2599	6	2356	1911–3074	2	2382	2347–2416	13	1349	924–1531	0		
Brown Creeper	44	2299	1773–2724	24	2887	1909–3338	125	2630	2151–3104	80	1595	749–2240	16	1780	614–2174
Rock Wren	57	1340	663–2597	13	2235	1631–3549	15	2885	2224–3634	17	1653	1223–2104	3	1940	1746–2129
Bewick's Wren	352	1264	767–2135	86	1801	1471–2174	0			21	1185	926–1555	0		
House Wren	37	1364	826–2253	4	1743	1535–1969	39	2729	2337–3122	12	1413	915–1986	15	1973	1738–2184
Golden-crowned Kinglet	0			0			36	2436	2144–2773	79	1876	1487–2235	41	1990	1709–2196
Ruby-crowned Kinglet	18	1467	786–2515	24	3222	2955–3383	3	2814	2717–2974	1	2102	2102–2102	0		
Wrentit	168	1280	781–2029	20	1798	1516–2105	0			11	1223	937–1523	2	1154	955–1354
Western Bluebird	99	2009	911–2887	18	1875	1541–2201	0			2	1008	998–1017	0		
Townsend's Solitaire	10	2316	1912–2508	1	2963	2963–2963	19	2447	2181–2997	37	1945	1466–2254	15	2014	1646–2225
Hermit Thrush	3	1583	1066–2453	23	3200	2951–3405	1	2426	2426–2426	63	1769	1088–2227	8	1836	955–2178
American Robin	16	2090	936–2744	31	2719	1814–3356	49	2544	2176–3168	101	1729	867–2198	38	1880	1173–2199
California Thrasher	86	1208	783–2052	4	1735	1599–2025	0			0			0		
Orange-crowned Warbler	0			1	1833	1833–1833	36	2852	2334–3270	14	1767	1360–2287	13	1959	1711–2141
Nashville Warbler	8	1124	940–1562	0			18	2668	2108–3159	81	1760	1076–2176	59	1968	1614–2208
MacGillivray's Warbler	0			0			49	2550	2028–3124	18	1539	918–1763	7	1408	478–1857
Yellow-rumped Warbler	51	1987	916–3109	57	3149	2494–3466	343	2727	2209–3332	217	1885	1381–2251	127	2021	1676–2265
Black-throated Gray Warbler	16	1293	935–1863	20	2016	1846–2239	0			12	1109	721–1494	4	1202	763–1837
Townsend's Warbler	40	1816	1142–2539	0			2	2540	2439–2640	1	1721	1721–1721	0		
Hermit Warbler	15	1848	1253–2363	1	1826	1826–1826	20	2575	2282–3148	29	1614	983–1985	15	1926	1504–2203
Green-tailed Towhee	50	2431	2137–3079	14	2692	2414–3127	44	2519	2141–2914	34	1873	1500–2251	47	1962	1552–2156
Spotted Towhee	360	1501	781–2431	129	1865	1511–2388	0			96	1308	885–1794	28	1356	461–1973
California Towhee	250	1134	739–1708	41	1688	1527–2028	0			0			0		
Chipping Sparrow	27	2086	970–2626	19	2243	1655–3353	14	2719	2434–3371	38	1897	1472–2181	4	2025	1979–2104
Black-chinned Sparrow	62	1684	1000–2229	2	2085	1934–2236	0			0			0		

(continued)

Table 1 (*continued*)

	Region[b]														
	SoCa			SoSN			NoSN			Casc			Klam		
Species[c]	*n*[d]	Mean	Range[e]	*n*	Mean	Range	*n*	Mean	Range	*n*	Mean	Range	*n*	Mean	Range
Lark Sparrow	38	1279	863–2093	18	1835	1531–2393	0			0			0		
Black-throated Sparrow	66	1017	597–1910	28	1650	1446–1805	0			0			0		
Bell's Sparrow	15	1150	812–2151	57	1829	1482–2306	0			0			0		
Fox Sparrow	78	2482	1990–3127	29	2864	1992–3228	44	2471	2135–2915	155	1865	1546–2282	62	1960	1721–2149
White-crowned Sparrow	59	1145	767–1521	6	3495	3375–3645	63	2889	2241–3420	0			0		
Dark-eyed Junco	129	2197	964–3062	112	2694	1799–3393	436	2719	2206–3317	246	1744	956–2237	132	1975	1545–2263
Western Tanager	39	1955	823–2621	40	2054	1599–3152	3	2335	2287–2412	166	1764	885–2228	14	832	428–1877
Black-headed Grosbeak	51	1497	785–2169	21	1942	1577–2401	3	2849	2615–3052	41	1190	821–1797	22	1495	432–2098
Lazuli Bunting	40	1307	755–2143	10	2027	1637–2392	1	2578	2578–2578	42	1621	759–2173	6	1666	630–2140
Western Meadowlark	44	1118	506–2053	24	1688	1512–1836	0			6	1515	1465–1551	0		
Gray-crowned Rosy-Finch	0			7	3369	3233–3521	27	3404	3166–3647	0			0		
Purple Finch	44	1968	1228–2538	10	1863	1721–2080	0			0			2	1864	1840–1887
Cassin's Finch	19	2391	1895–2944	77	3146	2521–3464	58	2737	2382–3174	71	1952	1414–2277	27	2044	1771–2221
House Finch	129	1184	641–2246	56	1816	1300–2401	0			0			0		
Red Crossbill	1	2440	2440–2440	8	2948	2055–3253	56	2665	2396–2909	0			9	1946	1838–2077
Pine Siskin	23	2740	2364–3186	73	3162	2740–3433	83	2657	2230–3206	39	1923	1579–2222	14	2056	1670–2265
Lesser Goldfinch	112	1416	788–2452	26	1784	1486–2263	2	2640	2426–2854	17	1195	796–1549	2	1221	468–1974
American Goldfinch	27	1063	777–1460	0			0			0			0		
Evening Grosbeak	0			0			3	2495	2307–2761	41	1901	1382–2235	2	2092	2002–2181

[a]≥20 detection in at least one region.

[b]SoCA: the southern California (2 April–27 May), SoSN: southern Sierra Nevada (29 May –20 June), NoSN: northern Sierra Nevada (8 August–8 September), Casc: southern Cascade Range (26 June–20 July), and Klam: Klamath Mountains (20 July–4 August).

[c]See Figure 2 for scientific names.

[d]Numbers of point count stations at which we detected the species in each region.

[e]Range encompassing 95% of the detections.

were once numerous throughout Sierra Nevada according to the Breeding Bird Survey and the Grinnell Resurvey Project (Moritz 2007, Sauer et al. 2012, Beedy and Pandolfino 2013).

Conclusion

The stereotypic perception of the PCT is of a scenic route along rugged mountain ridgelines. While this is true in some places, the PCT is a trail of extremes, and the route actually crosses a wide range of landscapes, including desert, plateaus, broad valleys, and deep canyons. Habitats range from sparsely vegetated deserts scrub to dense forests. Over the decades the trail took to construct, the planners and field crews who scouted out the route considered many factors in addition to scenic value (Schifrin et al. 2003), including property ownership, water access, proximity to human development, and topography. Furthermore, the trail was often built on gentle grades to facilitate equestrian use, and some sections follow contours or ascend through river valleys to mountain passes. For this reason, a significant proportion of our count points were not only along riparian corridors but also in a diversity of upland habitats. The ownership of lands crossed by the PCT is also diverse, including private lands, state and federal parks, national forests, and wilderness areas. Similarly, the range of human land uses, including recreation, housing, logging, and energy production, is also wide.

Habitat alteration on the cordillera will likely continue as California's human population continues to grow, but the extent and magnitude of land-use change will vary with local policies (Beardsley et al. 2009). Furthermore, climate change will affect species' distributions on the California cordillera differently depending on regional conditions and a species' climate niche (Tingley et al. 2012). Thus region-specific knowledge of montane birds' distributions is needed to inform prudent conservation decisions. This mega-transect may serve as a benchmark for future assessments of shifts in species' ranges in response to changes in climate and land use.

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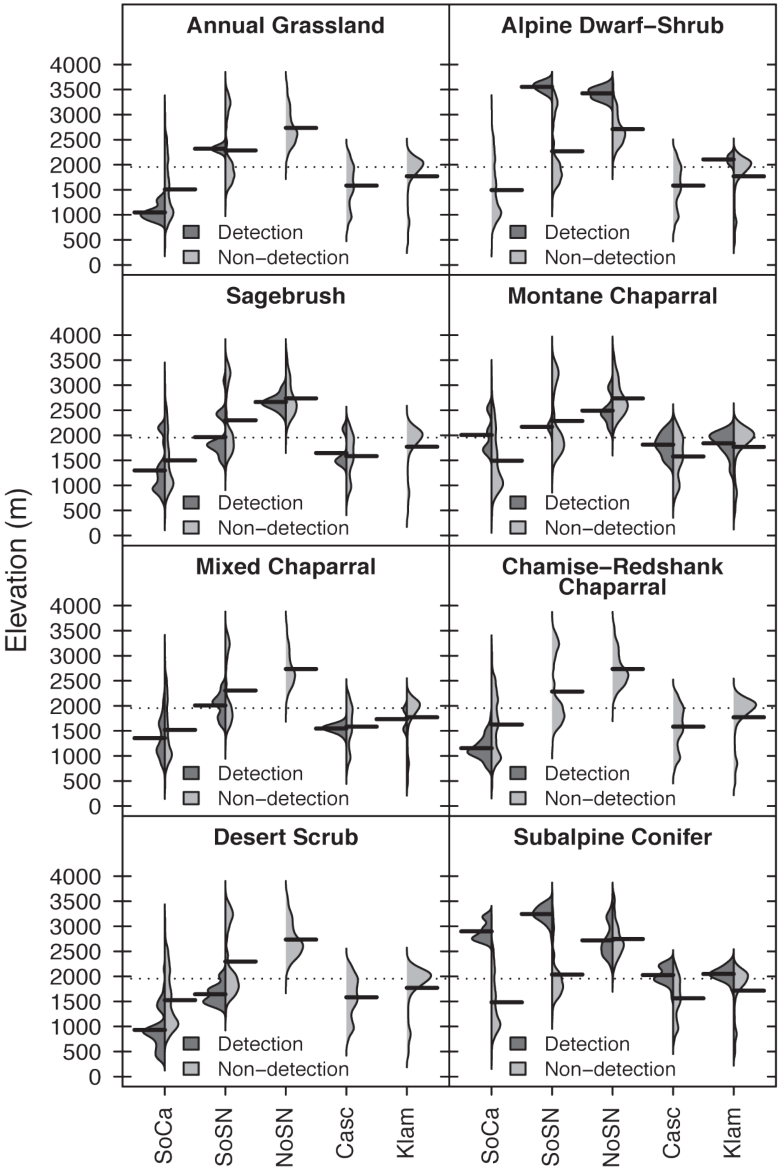
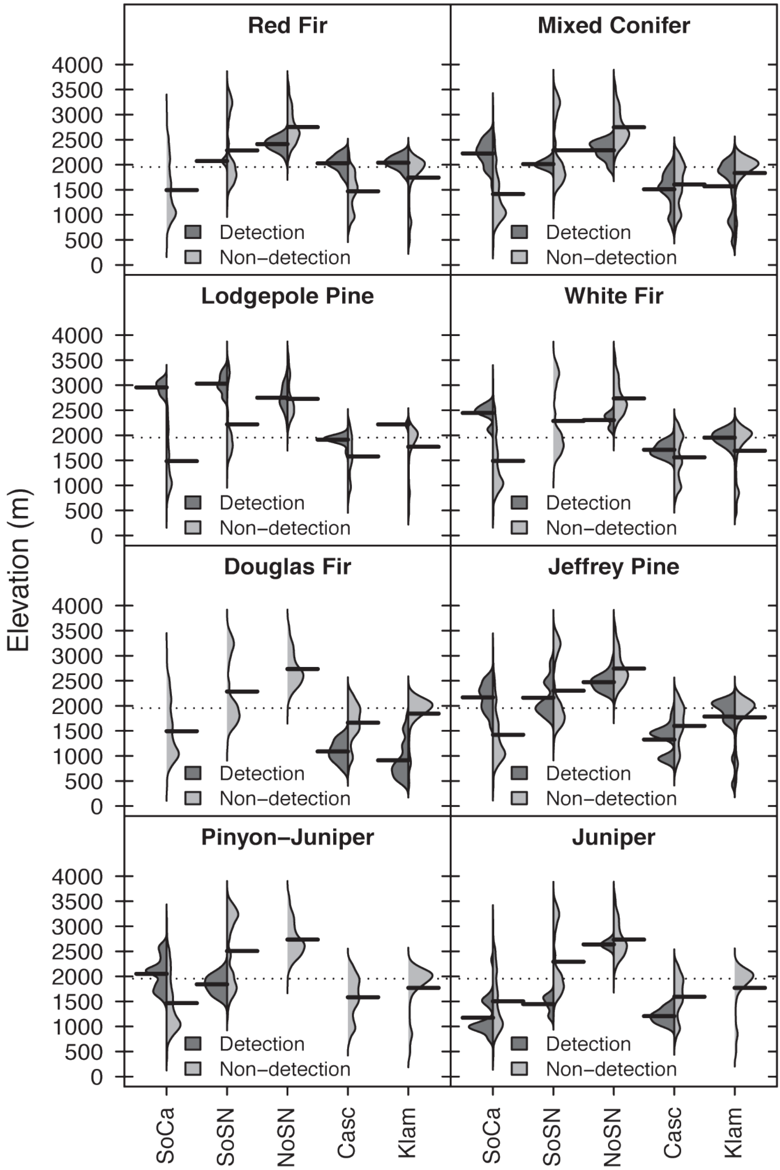
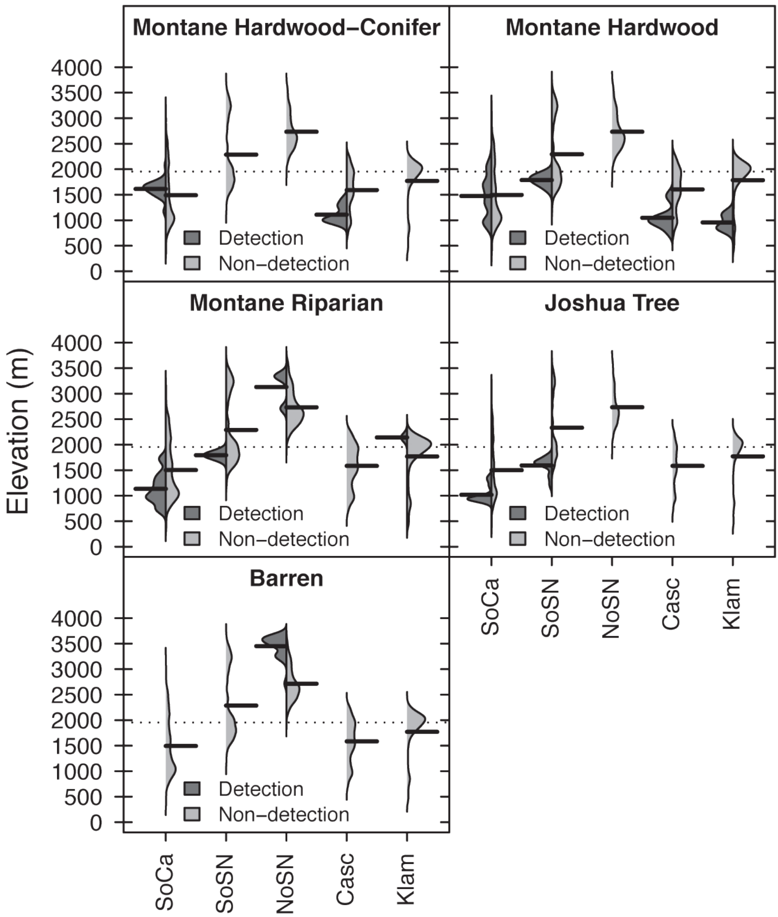


Figure 3. The elevational distribution of plots with and without 21 habitat types defined by the California Wildlife Habitat Relationships System and recorded on at least 20 plots along the Pacific Crest Trail. Dark gray regions to the left of the center line represent density traces of points with the habitat; light gray regions to the right of the



center line represent density traces of points without the habitat. Black horizontal lines show mean elevations of points with the habitat (left of center) and without it (right of center). The dashed line indicates the mean elevation of all points, all five regions pooled. See Figure 1 for definitions and dates of survey of the five segments of the trail.



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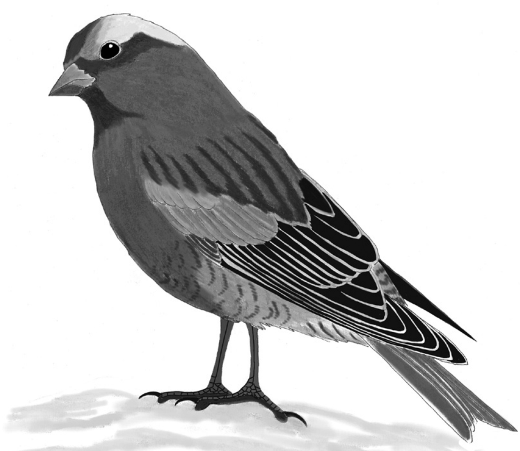

Gray-crowned Rosy-Finch

Sketch by George C. West