TRENDS IN RIPARIAN SONGBIRDS BANDED AT BIG SUR, CENTRAL CALIFORNIA COAST

MIKE M. STAKE and KELLY SORENSON, Ventana Wildlife Society, 19045 Portola Dr., Suite F-1, Salinas, California 93908; mikestake@ventanaws.org

ABSTRACT: We assessed trends in rates of capture of eight riparian songbirds mist-netted over 17 years (1993–2009) at Big Sur, on the central California coast. The Warbling Vireo (*Vireo gilvus*) and Yellow Warbler (*Dendroica petechia*) declined significantly, whereas the Swainson's Thrush (*Catharus ustulatus*) showed a nearly significant increase. Rates of capture of the Willow Flycatcher (*Empidonax traillii*), Wilson's Warbler (*Wilsonia pusilla*), Common Yellowthroat (*Geothlypis trichas*), Yellow-breasted Chat (*Icteria virens*), and Black-headed Grosbeak (*Pheucticus melanocephalus*) were stable. Negative trends for the Warbling Vireo and Yellow Warbler were particularly strong for hatching-year birds, indicating that factors acting in the breeding season were responsible for declines. We captured high ratios of transients to local adults, and at Big Sur trends for some of these species are associated more with populations breeding in other regions. However, in the Swainson's Thrush and Wilson's Warbler, we observed significant increases in local adults and local hatching-year birds, indicating the importance of local riparian habitat for some species at Big Sur.

Destruction of riparian habitat is an important cause of declines of landbirds in western North America (DeSante and George 1994). Ohmart (1994) estimated that 95% of riparian habitats in western North America have been lost or altered in the past 100 years. In California, riparian areas remain vulnerable to continued pressures, especially agriculture and development (Katibah 1984, Kucera and Barrett 1995, Rottenborn 1999). Yong and Finch (1997) suggested that riparian areas are undersampled by bird surveys and that changes in western riparian areas have had a greater effect on biological diversity than is currently known. Because the quality of riparian areas is important for birds, monitoring is fundamental to assessing the condition of riparian habitat and determining conservation priorities (Rich 2002).

Focal species are often used to evaluate the condition of ecosystems and guide habitat restoration and management (Chase and Geupel 2005). California Partners in Flight created a list of 14 riparian focal bird species, based on their associations with elements of riparian ecosystems and special conservation needs (Chase and Geupel 2005). Some of these focal species have declined locally in recent years. Ballard et al. (2003) reported negative trends for the Warbling Vireo (*Vireo gilvus*), Yellow Warbler (*Dendroica petechia*), and Wilson's Warbler (*Wilsonia pusilla*) in coastal California, 1979–1999. The California Department of Fish and Game has listed several riparian species, such as the Willow Flycatcher (*Empidonax traillii*), as threatened or endangered, and others, such as the Yellow Warbler and Yellow-breasted Chat (*Icteria virens*), as species of special concern (Shuford and Gardali 2008). The high conservation concern for many riparian birds, and the importance of these species for evaluating riparian ecosystems, underscore the need for long-term monitoring and information on current trends.

Long-term banding is a useful method of evaluating trends in songbird populations. Bird-capture data can be readily stratified by the birds' age, and for some species, by population (e.g., local breeder versus transient), providing opportunities for better understanding of demographic factors likely affecting trends. We quantified trends in rates of capture of eight riparian species at the Ventana Wildlife Society's banding station at Big Sur, California (formerly the Big Sur Ornithology Lab), over 17 years, 1993–2009. The banding station was situated in riparian habitat along a major corridor of songbird migration, so trends in capture rates might reflect changes in either local breeding populations or populations breeding elsewhere. Our objectives were to determine trends in annual capture rates for eight riparian species at Big Sur and trends associated with demographic categories.

STUDY AREA

Our banding station was along the Big Sur River near its mouth in Andrew Molera State Park (36° 17′ N, 121° 50′ W), along Highway 1 near Big Sur, Monterey County, California. We used 21 nylon mist nets (12 × 2.6 m, 30-mm mesh) in and adjacent to riparian woodland; several nets bordered coastal scrub. Predominant woodland trees included Western Sycamore (*Platanus racemosa*), Black Cottonwood (*Populus trichocarpa*), California Bay Laurel (*Umbellularia californica*), Arroyo Willow (*Salix lasiolepis*), and Red Alder (*Alnus rubra*). The coastal scrub community included Western Poison-oak (*Toxicodendron diversilobum*), Coyote Brush (*Baccharis pilularis*), Coffeeberry (*Rhamnus californica*), and California Sagebrush (*Artemisia californica*). Restoration of riparian trees was undertaken along the Big Sur River from 1995 to 1998, mostly downstream from the area of netting. Although some of the planted trees (19%) survived as of 2007, few of the surviving trees were in the area of netting (Ventana Wildlife Society, unpubl. data).

METHODS

We operated mist nets 5–7 days per week from 1994 to 2008 and 2–3 days per week in 1993 and 2009. Weather permitting, we opened nets about 15 minutes after sunrise and closed them after about 5 hours (average 94 net-hours per day). We aged captured birds as hatching-year or after-hatching-year by plumage, molt, and degree of skull pneumatization (Pyle et al. 1997). We were unable to determine the age of fewer than 2% of captured birds. We banded all passerines and many other birds. All captured birds were released immediately after being processed.

We assessed trends in capture rates for eight species, the Willow Flycatcher, Warbling Vireo, Swainson's Thrush (*Catharus ustulatus*), Yellow Warbler, Common Yellowthroat (*Geothlypis trichas*), Wilson's Warbler, Yellow-breasted Chat, and Black-headed Grosbeak (*Pheucticus melanocephalus*). Each was categorized as a riparian focal species by California Partners in Flight, Riparian Habitat Joint Venture Project (Chase and Geupel 2005). We excluded five of California Partners in Flight's riparian focal species that do not occur regularly at our site and one, the Song Sparrow (*Melospiza*

melodia), to limit our focus to long-distance migrants. The Warbling Vireo, Swainson's Thrush, Wilson's Warbler, and Black-headed Grosbeak are summer residents at our site, and those captured at Big Sur included both local breeders and transients. We considered all captures of the Willow Flycatcher, Yellow Warbler, Common Yellowthroat, and Yellow-breasted Chat to represent transients. The Willow Flycatcher is listed by the state of California as an endangered species, but it was extirpated as a breeder from Monterey County by the 1970s (Roberson and Tenney 1993). Currently known breeding populations of the Willow Flycatcher in central and northern California are restricted to the Sierra Nevada and Cascade Range (Sedgwick 2000), so all Willow Flycatchers captured at our site were presumably migrants to and from the Pacific Northwest. The Yellow Warbler, Common Yellowthroat, and Yellow-breasted Chat nest locally in Monterey County (Roberson and Tenney 1993) but not regularly at Big Sur. The Yellow Warbler and Yellow-breasted Chat are considered species of special concern by the California Department of Fish and Game (Shuford and Gardali 2008).

To standardize the number of birds captured by year, we calculated the number of birds caught per 1000 net-hours, as did Gardali et al. (2000). We used data from 1 March through 31 October to cover the seasonal occurrence of the eight selected species. We included captures of individuals we had banded in previous years but excluded recaptures within the same year. We calculated annual capture rates for each age class, and for the four summer residents, we calculated capture rates for demographic groups, including local adults, transients, and local hatching-year birds. We categorized the Warbling Vireo, Swainson's Thrush, Wilson's Warbler, and Black-headed Grosbeak by means of recapture data and known dates of migration, based on Roberson (2002). We considered adult birds to be local adults if they were recaptured at least once within a season over a period of at least 7 days, a criterion used by Chase et al. (1997) and Gardali et al. (2000) for defining demographic categories of Wilson's Warbler and Warbling Vireo, respectively. This criterion is based on data reported by Moore and Kerlinger (1987) indicating a stopover of less than 7 days for most migrants. We also categorized adults captured outside of the species' typical migration period as local adults and considered the remaining adults captured during spring migration to be transients. Although some birds might be classified incorrectly on the basis of recaptures (e.g., a local adult might avoid recapture), we consider this method to yield the best available approximation of the actual ratio of transients to local adults at our site. For hatching-year birds, we considered captures before the typical fall period of migration to represent local birds. We did not categorize birds captured during fall migration by demographic group. We used linear regression in SYSTAT 13 to determine trends in annual capture rates of each species, age class, and demographic group from 1993 to 2009. We log-transformed capture rates to improve normality (Zar 1996) and considered a trend statistically significant if $P < 0.05$.

RESULTS

Among the eight species we evaluated, we found a significant negative trend in annual capture rates for two, the Warbling Vireo and Yellow Warbler

(Figure 1). A positive trend for the Swainson's Thrush was nearly significant (Figure 2). We did not find significant trends for the remaining five, the Willow Flycatcher, Common Yellowthroat, Wilson's Warbler, Yellow-breasted Chat, and Black-headed Grosbeak (Table 1). Considering the two age classes separately, we did not find significant trends among after-hatching-year birds of any of the eight species (Table 2). Among hatching-year birds, the Warbling Vireo and Yellow Warbler declined (Figure 1), and the Wilson's Warbler increased (Figure 2). Trends for hatching-year birds of the remaining five species were stable or not significant (Table 3).

For the Warbling Vireo, Yellow Warbler, and Swainson's Thrush, we observed a notable peak in capture rates in 1998 (Figures 1, 2), coinciding with El Niño in the winter of 1997–1998. To evaluate the effect of these apparent outlier values on our results, we repeated regressions for these species with 1998 captures removed from the data. As before, we observed a significant decline in capture rates for both the Warbling Vireo ($\beta = -0.045$, $r^2 = 0.581$, $P = 0.001$) and Yellow Warbler ($\beta = -0.057$, $r^2 = 0.312$, $P = 0.025$). Removal of 1998 captures from the data improved the significance

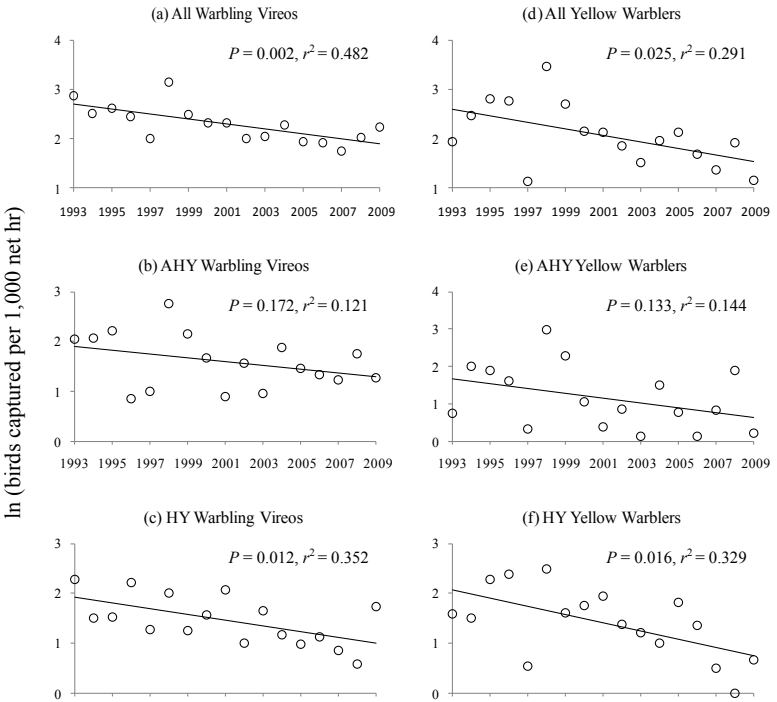

Figure 1. Trends in capture rates for age classes of the Warbling Vireo and Yellow Warbler at Big Sur, California, 1993–2009; (a) all Warbling Vireos, (b) after-hatching-year Warbling Vireos, (c) hatching-year Warbling Vireos, (d) all Yellow Warblers, (e) after-hatching-year Yellow Warblers, and (f) hatching-year Yellow Warblers.

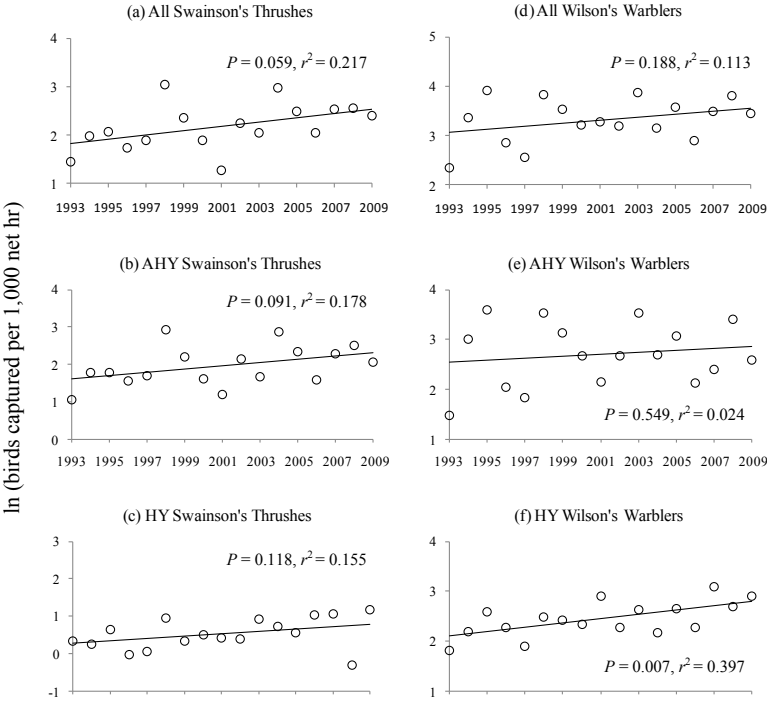

Figure 2. Trends in capture rates for age classes of Swainson's Thrush and Wilson's Warbler at Big Sur, California, 1993–2009; (a) all Swainson's Thrushes, (b) after-hatching-year Swainson's Thrushes, (c) hatching-year Swainson's Thrushes, (d) all Wilson's Warblers, (e) after-hatching-year Wilson's Warblers, and (f) hatching-year Wilson's Warblers.

Table 1 Regression Statistics for the Relationship between Rate of Capture[a] and Year for Eight Species of Riparian Birds at Big Sur, California 1993–2009[b]

Species	No. captured	Coefficient	SE	r^2	*P*
Willow Flycatcher	205	–0.027	0.032	0.044	0.417
Warbling Vireo	**2778**	**–0.050**	**0.013**	**0.482**	**0.002**
Swainson's Thrush	2516	0.044	0.022	0.217	0.059
Yellow Warbler	**2747**	**–0.067**	**0.027**	**0.291**	**0.025**
Common Yellowthroat	601	0.000	0.032	0.000	0.994
Wilson's Warbler	7923	0.030	0.022	0.113	0.188
Yellow-breasted Chat	477	0.045	0.034	0.108	0.197
Black-headed Grosbeak	1563	–0.047	0.027	0.164	0.106

[a]Birds caught per 1000 net-hours.

[b]Significant relationships highlighted in **bold**.

Table 2 Regression Statistics for the Relationship between Rate of Capture[a] of After-Hatching-Year Adults and Year for Eight Species of Riparian Birds at Big Sur, California, 1993–2009

Species	No. captured	Coefficient	SE	r^2	P
Willow Flycatcher	153	–0.018	0.051	0.008	0.735
Warbling Vireo	1479	–0.038	0.026	0.121	0.172
Swainson's Thrush	2027	0.044	0.024	0.178	0.091
Yellow Warbler	1271	–0.064	0.040	0.144	0.133
Common Yellowthroat	529	–0.001	0.041	0.000	0.982
Wilson's Warbler	4706	0.020	0.032	0.024	0.549
Yellow-breasted Chat	459	0.046	0.036	0.101	0.214
Black-headed Grosbeak	639	–0.035	0.022	0.145	0.132

[a]Birds caught per 1000 net-hours.

of the positive trend in the rate of capture of Swainson's Thrush ($\beta = 0.052$, $r^2 = 0.382$, $P = 0.011$).

We captured more transients than local adults of summer resident species, the Warbling Vireo (ratio of transients to local adults 5:1), Swainson's Thrush (10:1), Wilson's Warbler (7:1), and Black-headed Grosbeak (2:1). For the Warbling Vireo, trend coefficients were negative but not significant for all demographic groups (Table 4). For the Swainson's Thrush and Wilson's Warbler, we found significant increases in rates of capture of local adults and local hatching-year birds but no significant increase in transients (Table 4). For the Black-headed Grosbeak, we found a nearly significant negative trend in capture rates of local adults but no significant trend in local hatching-year or transient birds (Table 4).

DISCUSSION

From 1993 to 2009, we did not observe a consistent decline among the eight selected riparian species at Big Sur, but rates of capture of two species,

Table 3 Regression Statistics for the Relationship between Rate of Capture[a] of Hatching-Year Immatures and Year for Eight Species of Riparian Birds at Big Sur, California, 1993–2009[b]

Species	No. captured	Coefficient	SE	r^2	P
Willow Flycatcher	50	–0.006	0.036	0.002	0.870
Warbling Vireo	**1263**	**–0.058**	**0.020**	**0.352**	**0.012**
Swainson's Thrush	450	0.032	0.019	0.155	0.118
Yellow Warbler	**1415**	**–0.116**	**0.043**	**0.329**	**0.016**
Common Yellowthroat	68	–0.028	0.036	0.039	0.463
Wilson's Warbler	**3151**	**0.044**	**0.014**	**0.397**	**0.007**
Yellow-breasted Chat	17	0.102	0.060	0.164	0.107
Black-headed Grosbeak	910	–0.073	0.073	0.154	0.120

[a]Birds caught per 1000 net-hours.

[b]Significant relationships highlighted in **bold**.

Table 4 Regression Statistics for the Relationship between Rate of Capture[a] of Local Adults, Local Hatching-Year Immatures, and Transients for Four Species of Riparian Summer Residents at Big Sur, California, 1993–2009

	Local adults		Local hatching-year		Transients	
Species	Coefficient	*P*	Coefficient	*P*	Coefficient	*P*
Warbling Vireo	–0.035	0.204	–0.080	0.127	–0.041	0.210
Swainson's Thrush	0.067	0.014	0.080	0.010	0.039	0.190
Wilson's Warbler	0.042	0.003	0.044	0.005	0.019	0.647
Black-headed Grosbeak	–0.066	0.075	0.043	0.425	0.005	0.817

[a]Birds caught per 1000 net-hours.

the Warbling Vireo and Yellow Warbler, declined significantly. The trend for the Yellow Warbler indicates a change in the number of transients. The trend for the Warbling Vireo might indicate a change for both transients and local adults, but the decline was not significant for either category considered separately. DeSante and George (1994) reported population increases for the Warbling Vireo and decreases for the Yellow Warbler in several regions of the West over the 100 years preceding our study. These regions coincide with those where birds migrating through Big Sur likely breed, including Washington and Oregon for the Warbling Vireo and Oregon and California for the Yellow Warbler. Kessel and Gibson (1994) reported a decline of Yellow Warblers breeding in central Alaska from 1977 to 1992. Although DeSante and George (1994) reported a long-term increase of the Warbling Vireo, both species may have declined widely in more recent years. Ballard et al. (2003) found considerable declines in rates of capture of both the Warbling Vireo and Yellow Warbler at Point Reyes, Marin County, California, from 1979 to 1999. Gardali et al. (2000) found that the decline of the Warbling Vireo at Point Reyes was consistent among demographic groups, suggesting declines over a larger area. This conclusion was supported by a decline in fall migrant Warbling Vireos at another site of banding in central California, at Alviso, Santa Clara County (Gardali and Jaramillo 2001). Our results indicate continued declines of both species in the subsequent decade, but for the Warbling Vireo, the association of a decline with local or nonlocal populations is unclear. Results of the Breeding Bird Survey from 1993 to 2009, based on the regional analytical tool provided by Sauer et al. (2011), imply decline of the Yellow Warbler in both the California and Northwestern Interior Forest regions but no significant decline of the Warbling Vireo in California and other northwestern regions.

Negative trends for the Warbling Vireo and Yellow Warbler were particularly strong for hatching-year birds, indicating that factors operating during the breeding season were responsible for the declines. Nest parasitism by the Brown-headed Cowbird (*Molothrus ater*) has been linked to low productivity of some riparian birds, including several western populations of the Warbling Vireo (Ward and Smith 2000, Ortega and Ortega 2003). Western populations of the Warbling Vireo are particularly vulnerable to nest parasitism because they do not reject cowbird eggs, as do eastern populations (Sealy

1996, Sealy et al. 2000). Destruction of breeding habitat might also affect populations, reducing the number of hatching-year birds. The Warbling Vireo occupies a range of habitats, including deciduous riparian woodlands (Gardali and Ballard 2000) and upland coniferous forests (Purcell 2007). The Yellow Warbler occupies deciduous thickets, especially with willows, along streams and in wet meadows (Lowther et al. 1999). Lowther et al. (1999) suggested that intense grazing of willows has affected populations of the Yellow Warbler in the western United States. Taylor and Littlefield (1986) linked a reduction in cattle grazing at one Oregon site with dramatic increases in populations of the Yellow Warbler and Willow Flycatcher. Conversion of riparian areas to agriculture, urban development, and alteration of hydrology are among the processes that could further reduce the amount or suitability of riparian habitat for breeding birds in the West. Reduction of riparian habitat could be manifested through negative trends in hatching-year birds at banding stations along the migration route, such as those we found for the Warbling Vireo and Yellow Warbler.

Separate analysis of local adults and transients clarified overall trends that were not significant, or nearly significant, in the Swainson's Thrush, Wilson's Warbler, and Black-headed Grosbeak. In the Swainson's Thrush and Wilson's Warbler, we observed increases of local adult and local hatching-year birds and no trend for transients. Our results contrast with the Breeding Bird Surveys for 1993–2009, which suggests a decline of Swainson's Thrush for the Coastal California and Northern Pacific Rainforest regions and of Wilson's Warbler for the California, Northern Pacific Rainforest, and Northwestern Interior Forest regions (Sauer et al. 2011). Increases in rates of capture of local birds and stable rates of capture of transients of these species at Big Sur, while regional populations declined, indicate the importance of local riparian habitat for preserving regional populations. The effort to restore riparian woodland along the Big Sur River in the 1990s probably improved habitat for riparian songbirds. Although little of the restoration occurred where we netted, an increase in tree density and subsequent plant growth elsewhere along the river might have contributed to increasing local populations. For Swainson's Thrushes and Wilson's Warblers, a negative regional trend based on the Breeding Bird Survey and a positive trend in rates of capture of local adults at Big Sur were preceded by relatively stable trends for summer residents of these species at Point Reyes (Johnson and Geupel 1996, Chase et al. 1997). Although habitat at Big Sur might be important for local breeding populations of the Swainson's Thrush, Wilson's Warbler, and some other riparian birds, it might be inferior for species associated with large trees, such as the Black-headed Grosbeak (Ortega and Hill 2010), for which the decline of local adults was nearly significant.

Annual rates of capture of the Willow Flycatcher, Common Yellowthroat, and Yellow-breasted Chat at Big Sur varied and provided relatively little information on the current status of populations in California or elsewhere. The habitat in which Willow Flycatchers stopping at Big Sur eventually breed in the Pacific Northwest is unclear. Although the Willow Flycatcher generally breeds in moist, shrubby areas with running or standing water, in the Pacific Northwest it also occurs in nonriparian woodlands and clearcut forest early in regeneration (Sedgwick 2000). The Breeding Bird Survey from

1993 to 2009 indicates a decreasing population of the Willow Flycatcher in the Northern Pacific Rainforest region and an increasing population in the Northwestern Interior Forest region, though the credible interval for the latter region includes zero (Sauer et al. 2011). Therefore, despite the endangered status of the Willow Flycatcher in the state of California, the lack of trend we observed was not associated with California populations and not necessarily with declining riparian populations in other regions. A trend of the Yellow-breasted Chat at Big Sur is more likely to reflect breeding populations in California, where the species is considered of special concern, because of the closer proximity of breeding populations in central California. Trends based on the Breeding Bird Survey from 1993 to 2009 are positive for the Yellow-breasted Chat in the California, Northern Pacific Rainforest, and Northwestern Interior Forest regions, although for each region the credible interval includes zero (Sauer et al. 2011).

Annual variation in weather can affect trends in songbirds' numbers, and one or more weather events might have affected our rates of capture of some species. DeSante and Geupel (1987) found a positive relationship between the number of hatching-year birds captured at Point Reyes and the amount of rainfall during the previous winter. Faaborg et al. (1984) correlated low rates of capture in Puerto Rico with drought. Following several relatively wet years during the first half of our study, California experienced drought in the last few years of the study (2007–2009). Relatively low precipitation might have limited numbers near the end of our study, although the Warbling Vireo and Yellow Warbler were the only species with significant declines. A strong El Niño in the winter of 1997–1998, and frequent storms along the California coast in spring of 1998, were likely responsible for remarkable numbers of migrating Warbling Vireos, Yellow Warblers, and Swainson's Thrushes that stopped over at Big Sur that year. For example, on the mornings of 20 and 21 May 1998, we captured a combined 569 birds, including 130 Yellow Warblers, 125 Swainson's Thrushes, and 63 Warbling Vireos. Nevertheless, these exceptional totals did not greatly affect the trends for 1993 through 2009, except for moderating a positive trend for Swainson's Thrush.

Numerous factors likely affect trends in bird numbers, including weather, loss of breeding habitat, predation, parasitism, mortality during migration, and loss of wintering habitat. It can be profitable to determine which factors explain population changes, but general patterns might not apply to an entire suite of species. We did not find the same trends for all selected riparian birds, and we did not find the same trends among demographic groups within the same species. Nonlocal factors might have influenced trends of some species, such as the Warbling Vireo and Yellow Warbler, whereas local factors might have had more influence on others, such as the Swainson's Thrush and Wilson's Warbler. Understanding the importance of these factors at multiple spatial scales is important for evaluating the current status of individual species and habitat associations.

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