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MONITORING PRODUCTIVITY WITH MULTIPLE MIST-NET STATIONS

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Abstract. We evaluated data from 22 mist-net capture stations operated over 5 to 13 years in northern California and southern Oregon, to help develop sampling designs for monitoring using mist nets. In summer, 2.6% of individuals were recaptured at other stations within 1 km of the original banding station, and in fall, 1.4% were recaptured nearby. We recommend that stations be established 1–5 km apart to promote independent sampling. Percent of young birds in the total captured was similar among stations, both in summer and fall, indicating that large numbers of stations might not be necessary to sample age structure for an entire region, at least for common species. We examined the percent of young captured in fall and summer to determine whether some stations consistently captured lower proportions of young across all species, and found no consistent pattern. Power analysis indicated that about 10 stations were required to detect a 50% change in percent young between years for the Song Sparrow (*Melospiza melodia*), a common species. To detect a 25% change, 10 stations still sufficed in fall, but about 3× more were required in summer. Summer results were similar for the Yellow-breasted Chat (*Icteria virens*). More stations would be needed to reach similar precision targets for uncommon species, and probably also in regions of more heterogeneous habitat. Although the capture rates at stations in our region increased during the study, the capture rates at individual stations declined significantly after the first year of operation.

Key Words: bird, migration, mist net, monitoring, productivity.

Constant-effort mist netting can be used to estimate population composition, species abundance, and demographic parameters such as survivorship and productivity. Coupled with habitat surveys and trend analyses, demographic monitoring has been suggested as a necessary minimum for meeting the monitoring obligations of various resource-management agencies, and for interpreting differences in bird abundance among habitats and over time (e.g., Butcher 1992, Manley 1993). Central to planning and execution of monitoring with mist netting is knowledge of the number of stations necessary to characterize population parameters for a region or a habitat.

Determining the number of netting stations needed to most efficiently monitor birds in a target region requires a balance between effort and the power of the results. If stations produce relatively uniform results, few stations will be needed, as long as sample size requirements can be met. For example, Bart et al. (1999) found that 7 stations could monitor productivity in Kirtland's Warbler (*Dendroica kirtlandii*), using the proportion of young in the total catch as the index of productivity, but the study took place in uniform habitat, for a single species, and in a small area. By contrast, Peach et al. (*this volume*) found that for 17 of 23 species captured, 40–70 netting stations were required to detect annual changes across England with precision of 5% mean standard error. Number of stations required for monitoring productivity at a target level of precision may also differ between the summer season and fall, when more migrants than summer residents are captured.

In this paper, we examine the number of stations needed to sample productivity in summer and fall, in an area approximately 25–50 km in radius and sampled in reasonably homogenous habitat. We also analyzed data from a dense configuration of stations in a larger region of northwestern California and southern Oregon, most established since 1992 to monitor the birds of the region. Our stations were established in riparian habitats along river and stream corridors, and near mountain meadows. We were interested in monitoring permanent and summer residents, as well as migrants, and in monitoring the very important post-breeding period of late summer and fall.

Specifically, this paper addresses the following questions:

(1) To what degree do nearby stations share the same individuals? If movement rates among stations are relatively high, such that nearby stations capture a high number of the same individuals, then stations must be located farther apart to achieve statistical and biological independence of samples.

(2) How much variation is there in percent of young within and among stations? If stations are similar to each other in their percent young, then fewer stations may be needed to provide a good estimate of annual changes in productivity for the region.

(3) How many stations are needed in a region to detect a specific change in our demographic measure of productivity, percent of young?

(4) Is there a consistent effect of year-of-operation on capture rate, which could affect interpretation of trend results?

METHODS

With several cooperators, we established 34 constant-effort stations in northwestern California and southern Oregon, in what is referred to as the Klamath-Siskiyou bioregion. A sub-set of 22 stations with the most similar operating years, schedules, and effort was selected for the analyses presented here (Table 1, Fig. 1). Stations were located along the Klamath River and its tributaries, the major riparian corridors of northwestern California, as well as some nearby rivers. All stations were located in riparian areas bordered by coniferous forests; on the main stem of a river, on a tributary, or in upper elevation meadow–riparian areas. Two coastal stations were in riparian areas within the coast redwood (*Sequoia sempervirens*) zone, and two were along the riparian margin of a coastal pine (*Pinus contorta*) forest.

At each station, 10–12 mist nets were operated during the breeding season, and usually during fall migration as well. Nets were placed in the same locations each year. Except for two stations (HOME and PARK), each station was consistently operated one day during each 10-day period beginning in early May and continuing to the end of August (defined here as the breeding season). During September and October (our definition of the fall migration season), nets were operated once per week. Since 1992, the HOME station has been operated during the breeding season twice every 10 days and in the fall for 3 days a week (usually with at least 1 day between sessions). PARK station was operated during the breeding season once every 10 days, and in the fall for 2 days a week. Regardless of season, nets were opened at all stations from within 15 min of dawn and operated for five hours, weather permitting. Other net operations and processing of birds followed the guidelines in Ralph et al. (1993) and Hussell and Ralph (1998).

Most analyses in this paper included data for the most frequently-captured species; 14 in summer, and 12 in fall (Table 2). The dates defined above for these seasons cover the majority of the breeding and migration seasons of the species involved. However, in many species, at least a proportion of the population does migrate earlier than September. Stations used for each analysis varied (Table 1). Because the effort was similar at all stations, except where otherwise indicated, we did not weight stations in the analyses according to effort.

To determine whether stations close together were sampling the same local population (and therefore not collecting independent samples), we determined the percent of individuals captured between stations as a function of distance. We confined this analysis to eight of the closest stations (analysis A in Table 1).

We used the percent of young of the total of birds captured as an index to productivity. Stations used for this analysis (analysis B in Table 1) represent an area of about 120,000 ha, near the average size of a Forest Service District in the national forests of the Klamath River region. For some of the stations operated for five or more years during the period of 1992–2001, we computed the average annual percent young for each species in summer and fall. To test for differences of the average percent young among stations, we used ANOVA and Duncan's multiple range test (Zar 1984).

To test whether annual percent young was consistently low or high at a given station across species, we calculated an index of productivity for each station. We first calculated the range of percent young for each species over the years of the study period at that station, then calculated an index representing the annual percent young relative to the range of percentages of young of that species captured at that station. For example, if the range for Black-headed Grosbeaks (scientific names of all species are in Table 2) was 25–75% over 10 years at a station, and the percent young in a given year was 65%, 10% lower than maximum value, the relative value for that species at that station was 0.80 (= 1 – (0.10 / (0.75–0.25))). We used a General Linear Model (SAS Institute 1996) to compare the means of these relative percent young by species over all the years when the species was captured (in some years at some stations a species may not have been captured).

We estimated the power of detecting a change in the proportion of young in the total number of birds captured ($\hat{d}$), by species and season (analysis C in Table 1), for two common riparian species, Song Sparrow and Yellow-breasted Chat. We tested for differences in percent young $H_0 : d = 1$ vs. $H_1 : d \neq 1$ (Cochran 1977), for all pairs of years from 1992 to 1995. We estimated the power of detecting a 50% (d = 0.5 or 1.5) or 25% (d = 0.25 or 1.25) decrease or increase, over a range of sample sizes (number of stations) from one to 50.

To determine if capture rate at a station changed according to year of operation, we compared annual capture rates for the first year of operation (1991, 1992, 1993 or 1994) to the three subsequent years for 17 of the stations (analysis D in Table 1). We used a mixed-effects model (Littell et al. 1996) to estimate the structure of capture rates with year of operation (Year 1, Year 2, Year 3 or Year 4) and capture year (1991–1997), testing capture year both as a categorical and as a continuous variable. We used Tukey-Kramer test for multiple pairwise comparisons of capture rates by years and by year of operation. Station was the random effect in the model, and we accounted for potential serial correlation among years assuming an autoregressive correlation structure (SAS Institute 1996).

RESULTS

INDEPENDENCE OF STATIONS

For the stations less than 1 km apart, 2.6% of individual birds were recaptured at another station in the summer, and 1.4% in fall (Table 3). At stations more than 1 km from the original capture stations, in both

TABLE 1. MIST-NET CAPTURE STATIONS, THE ANALYSES IN WHICH THE STATION'S DATA WERE USED, NUMBER OF NETS, THE YEARS OPERATED, AND SEASONS OF OPERATION (S = SUMMER, F = FALL).

Station	Operator	Analyses[a]	N nets	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aiken's Creek (AKEN)	Redwood Sciences Laboratory	A	10	S	–	–	–	–	–	–	–	–	–
Antelope Creek (ANT1)	Klamath National Forest	D	10	–	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	–
Big Bar (BBAR)	Trinity National Forest	B	12	S,F	S	S,F	S	S,F	S	–	–	–	–
Bondo Mine (BOND)	Redwood Sciences Laboratory	A, B, C, D	10	<u>S</u>	<u>S</u>	<u>S</u>	<u>S</u>	S	–	–	–	–	–
Camp Creek (CAMP)	Redwood Sciences Laboratory	A, B, C, D	10	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F	S,F	S,F
Red Cap Creek D (CAPD)	Redwood Sciences Laboratory	A, B, C, D	13	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F	S,F	S,F
Carberry Creek (CARB)	Rogue River National Forest	D	10	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S	–	–	–	–
Emmy's Place (EMMY)	Redwood Sciences Laboratory	D	10	–	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	–	–	–	–
Grayback Creek (GBCR)[b]	Siskiyou National Forest	D	8	<u>S</u>	<u>S</u>	<u>S</u>	S	S	S	S	S	S	–
Grove's Prairie (GROV)	Redwood Sciences Laboratory	D	10	–	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F
HBBO HQ (HOME)	Humboldt Bay Bird Observatory	A	17.5	S,F	S,F	S,F	S,F	S,F	S,F	S,F	S,F	S,F	–
Indian Valley (INVA)	Redwood Sciences Laboratory	D	10	–	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F
Delaney Farm (LADY)	Redwood Sciences Laboratory	A, B, C, D	10	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F	S,F	S,F
Long Ridge (LORI)	Siskiyou National Forest	D	10	<u>S</u>	<u>S</u>	<u>S</u>	<u>S</u>	S	S	–	–	–	–
Molier (MOLI)	Redwood Sciences Laboratory	A, B, C, D	12	<u>S</u>	<u>S</u>	<u>S</u>	<u>S</u>	S	–	–	–	–	–
DeMello pasture (PARK)	Humboldt Bay Bird Observatory	A	14	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F	S,F	–
Pacific Coast Trail 1 (PCT1)	Klamath National Forest	B, D	13	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	–	–
Redwood Creek (RECR)	Redwood Sciences Laboratory	D	11	–	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	S,F	S,F	S,F
Red Cap Creek 2 (RED2)	Redwood Sciences Laboratory	A, B, C, D	13	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	S,F	–	–	–	–	–
Whitmore Creek (WHIT)	Redwood Sciences Laboratory	A	10	S	–	–	–	–	–	–	–	–	–
Wright Refuge (WREF)	Humboldt State University	D	10	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>	S	–	–	–	–
Yager Creek (YACR)	Pacific Lumber Company	D	12	–	–	<u>S</u>,F	<u>S</u>,F	<u>S</u>,F	<u>S</u>	S	S	S	S

Notes: "–" denotes no data were taken.

[a] Stations used in each analysis: A = Independence between stations from movement among stations (includes all years); B = Variation in percent young among stations and years (1992–1995); C = Number of stations needed to detect declines in productivity (includes years 1992–1995); D = Effect of running nets on capture rate (includes summer data from first four years of operation – years used indicated with underline).

[b] This station was also operated in the summer of 1991.

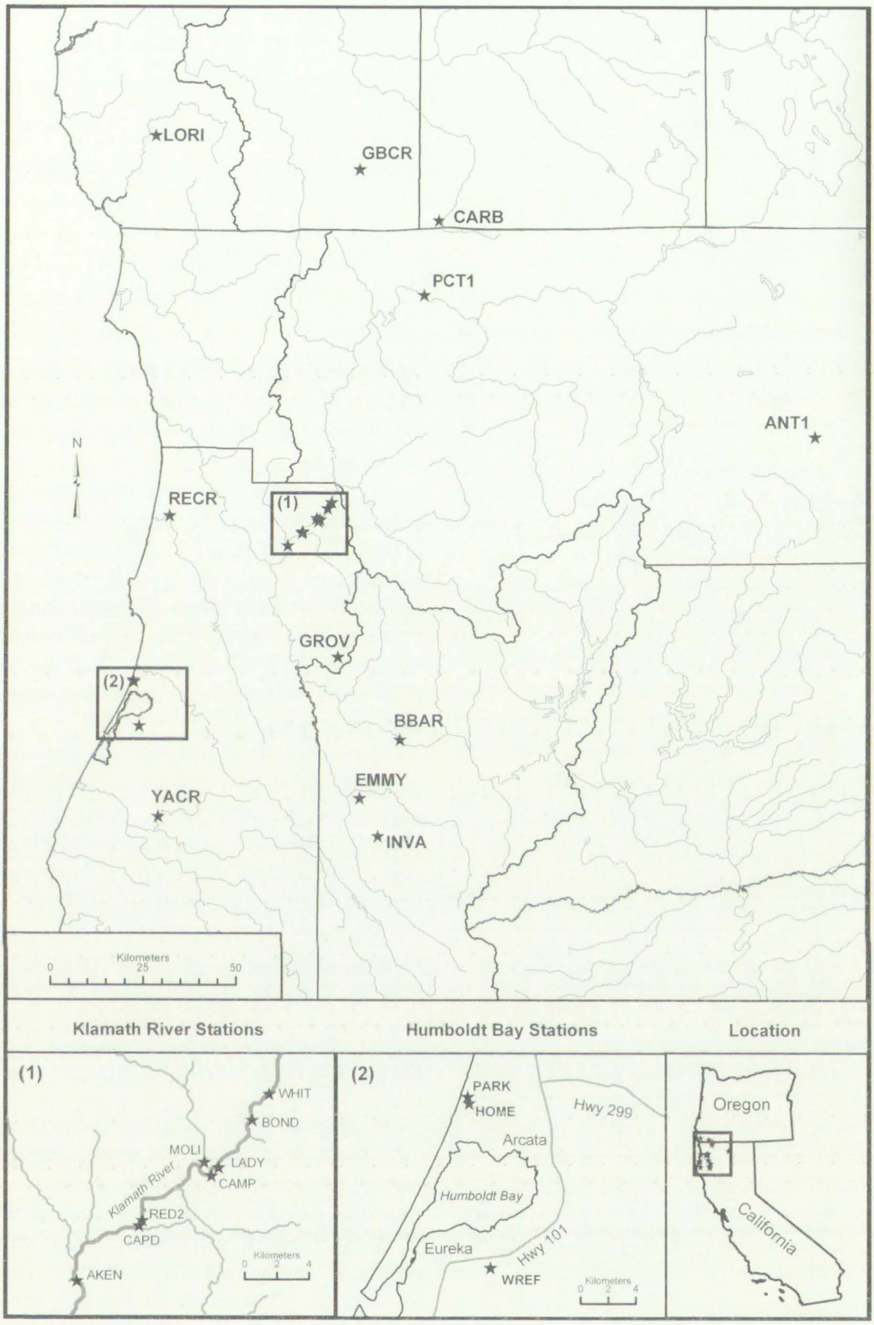

FIGURE 1. Locations and four-letter code names of each of the 22 stations used in this study, with county and state borders (black lines) and river systems (gray lines). Insets show details of the Klamath River and Humboldt Bay intensive study areas.

TABLE 2. SPECIES USED IN THE ANALYSES FOR EACH SEASON

Code	Species	Summer	Fall
WIFL	Willow Flycatcher (*Empidonax trailii*)	X	X
PSFL	Pacific-slope Flycatcher (*E. difficilis*)	X	
BUSH	Common Bushtit (*Psaltriparus minimus*)	X	
RCKI	Ruby-crowned Kinglet (*Regulus calendula*)		X
SWTH	Swainson's Thrush (*Catharus ustulatus*)	X	X
HETH	Hermit Thrush (*C. guttatus*)		X
AMRO	American Robin (*Turdus migratorius*)		X
VATH	Varied Thrush (*Ixoreus naevius*)		X
WREN	Wrentit (*Chamaea fasciata*)	X	X
OCWA	Orange-crowned Warbler (*Vermivora celata*)	X	
YWAR	Yellow Warbler (*Dendroica petechia*)	X	
MYWA	Myrtle Warbler (*D. coronata*)		X
MGWA	MacGillivray's Warbler (*Oporornis tolmiei*)	X	
WIWA	Wilson's Warbler (*Wilsonia pusilla*)	X	
YBCH	Yellow-breasted Chat (*Icteria virens*)	X	
WETA	Western Tanager (*Piranga ludoviciana*)	X	
SPTO	Spotted Towhee (*Pipilo maculatus*)	X	X
FOSP	Fox Sparrow (*Passerella iliaca*)		X
SOSP	Song Sparrow (*Melospiza melodia*)	X	X
GCSP	Golden-crowned Sparrow (*Zonotrichia atricapilla*)		X
BHGR	Black-headed Grosbeak (*Pheucticus melanocephalus*)	X	

seasons, the number of birds recaptured was $\leq 0.5\%$, indicating that stations more than 1 km apart were collecting largely independent samples.

CONSISTENCY IN PERCENT OF YOUNG AMONG STATIONS

Percent of young differed little among stations for most species in summer (Table 4). Six of the stations were quite close together, in similar riverine–riparian habitat, and had statistically indistinguishable percents of young. Two more distant stations (BBAR and PCT1) appeared to have lower percents of young for some species (Table 4). However, each of these stations also had the highest percent young for at least one species. Two resident species, Wrentit and Song Sparrow, tended to have more variable percents of young among stations than did the other species, most of which are migratory.

In the fall, percent young was more consistent

TABLE 3. PERCENT OF INDIVIDUALS CAPTURED AT A STATION LOCATION OTHER THAN WHERE PREVIOUSLY CAPTURED, 1992–2001

Distance between capture and recapture locations	Summer		Fall	
	Total captures	Percent recaptured	Total captures	Percent recaptured
< 1.0 km	5646	2.65	5243	1.39
≥ 1.0 ≤ 5.0 km	4326	0.46	1924	0.10
≥ 5.1 ≤ 10.0 km	3719	0.22	1142	0.09
≥ 10.1 ≤ 17.5 km	1483	0.20	0	–

among stations than during the summer (Table 5). However, for five species, the BBAR station had significantly different percent young than the other stations.

We did not find a pattern in standardized percent young that would indicate consistently low or high productivity across years at some stations (all target species combined; Table 6). BBAR was consistently lowest in percent young in summer across all years, although the difference was significant in only one year. In the fall, CAPD usually had the highest percent young, but this was significantly higher in only one of the years.

A station with the highest percent young in one year did not necessarily have the highest in other years. The percent young was indistinguishable across all stations in the summers of 1992 and 1995, and in the falls of 1993 and 1995. However, in the summer of 1993, three stations had fewer young than the other stations. In summer 1994, stations were evenly divided, with some stations having higher percents of young and others having lower percents.

NUMBER OF STATIONS NEEDED TO DETECT ANNUAL CHANGES IN PRODUCTIVITY

Power analysis showed that for the Song Sparrow, 10 stations were required in summer to detect a 50% change in percent young between years with a 0.95 probability and a significance level of 0.05 (Table 7). The number of stations required to detect a 25% change at the same level of probability is three times as large, at 32 stations. In the fall, when percent young was more consistent among stations, only four stations were needed to detect a 50% change, and 10 to detect a 25% change. Summer data for the much-less common Yellow-breasted Chat gave similar results (Table 7; this species is not captured in fall). With 10 stations, the probability of detecting a 50% change in percent young between years was

TABLE 4. PERCENT OF YOUNG (SUMMER) AVERAGED OVER 10 YEARS (1992–2001)

	Station							
Species code	BBAR	BOND	CAMP	CAPD	LADY	MOLI	RED2	PCT1
PSFL	88.8	76.4	49.6	73.0	70.2	66.3	72.8	47.6
	A[a]	AB	B	AB	AB	AB	AB	AB
WIFL	93.3	85.3	84.0	80.7	77.6	94.7	78.7	46.1
	A	A	A	A	A	A	A	B
BUSH	50.9	79.2	0	94.5	100	–	60.0	65.8
	AB	AB	B	A	A	–	AB	AB
WREN	100.0	71.8	58.9	76.1	65.2	64.6	73.1	79.2
	A	BC	C	BC	C	C	BC	AB
SWTH	58.3	44.5	37.3	31.2	18.2	21.8	32.8	23.8
	A	AB	B	B	B	B	B	B
OCWA	21.3	30.6	33.2	48.5	51.0	74.0	59.7	19.5
	B	B	B	AB	AB	A	AB	B
MGWA	3.9	39.7	31.0	42.9	40.2	39.5	35.9	35.6
	B	A	AB	A	A	A	AB	AB
WIWA	1.8	53.6	32.1	61.4	59.3	67.5	60.9	2.9
	B	A	AB	A	A	A	A	B
YWAR	16.6	55.0	17.6	56.5	36.2	38.3	33.3	32.6
	A	A	A	A	A	A	A	A
YBCH	25.8	39.4	49.2	44.1	30.4	34.2	28.2	44.5
	A	A	A	A	A	A	A	A
WETA	52.6	63.7	54.9	75.5	61.8	54.2	68.3	77.8
	A	A	A	A	A	A	A	A
BHGR	13.3	75.2	58.8	69.6	62.2	69.8	68.4	60.3
	B	A	A	A	A	A	A	A
SPTO	67.6	70.1	61.8	74.2	66.9	70.1	81.0	72.6
	A	A	A	A	A	A	A	A
SOSP	61.5	68.9	54.0	70.7	35.9	50.2	56.9	68.0
	ABC	A	ABC	AB	C	BC	ABC	AB

Note: Species codes are explained in Table 2.

[a]Stations with the same letter are not significantly different in average percent young (ANOVA, Duncan's multiple range test, $P > 0.05$).

0.97, and 29 stations were needed to detect a 25% change with 0.95 probability.

CHANGE IN CAPTURE RATE ACCORDING TO YEAR OF OPERATION

We compared capture rates in the first and subsequent three years of station operation to test the assumption that there is no effect of year of operation on capture rates. When capture rate was calculated by the year of operation (i.e., Year 1, Year 2, Year 3 and Year 4) for all 17 stations combined, there was a noticeable (>20%) decline after Year 1 (Table 8). However, many stations were established in the same years, so the decline could have been related to differences in bird abundance among years. To determine if the decline was significant, and related to initiation of the mist-net station or simply a difference in bird abundance, we examined two models: year of operation and capture year as categorical variables and then as continuous variables. Both year of operation and capture year had significant effects on capture rates, in both models (year of operation: categorical, $F = 6.81$, $P = 0.002$, continuous, $F = 11.65$, $P = 0.003$; capture year: categorical, $F = 2.52$, $P = 0.043$, continuous, $F = 6.63$, $P = 0.021$). The predictability of the alternate models, as measured by the estimated variance of a single prediction, was similar. The AIC_c value was considerably lower for the categorical model, 760.4 vs. 845.3, indicating the categorical model was a better fit to the data.

Capture rate at the 17 stations generally increased from 1991 to 1997, with stations that began operation later in the period tending to have higher captures rates. At each individual station, however, capture rates declined after the first year. The mean capture rate averaged over all 17 stations for the first

TABLE 5. PERCENT YOUNG (FALL) OF THE MOST COMMON SPECIES CAPTURED OVER 10 YEARS (1992–2001)

	Station					
Species codes	BBAR	CAMP	CAPD	LADY	RED2	PCT1
WIFL	100.0	97.1	96.7	89.1	96.0	100.0
	A[a]	A	A	A	A	A
RCKI	0.0	35.8	60.7	54.2	20.0	54.8
	A	A	A	A	A	A
SWTH	100.0	67.9	76.5	69.4	74.9	79.9
	A	B	B	B	B	B
HETH	22.9	71.4	78.2	70.8	78.2	78.6
	B	A	A	A	A	A
AMRO	50.0	50.0	75.9	44.1	44.4	49.0
	A	A	A	A	A	A
VATH	0.0	60.6	45.8	66.8	40.0	60.0
	A	A	A	A	A	A
WREN	–	97.5	96.0	94.9	80.6	96.0
	–	A	AB	AB	B	AB
MYWA	–	82.3	94.1	94.0	85.2	86.2
	–	A	A	A	A	A
SPTO	13.9	87.6	86.8	81.4	92.7	85.4
	B	A	A	A	A	A
FOSP	22.9	53.2	69.2	60.8	60.2	72.6
	B	A	A	A	A	A
SOSP	57.8	79.6	71.4	76.6	72.8	82.0
	A	A	A	A	A	A
GCSP	21.4	59.0	57.6	45.6	62.0	62.1
	B	A	A	A	A	A

Note: Species codes are explained in Table 2.

[a]Stations with the same letter are not significantly different in average percent young (ANOVA, Duncan's multiple range test, $P > 0.05$).

year of operation was significantly higher than the capture rate in years 2, 3, and 4.

DISCUSSION

INDEPENDENCE OF STATIONS

Recapture rate between stations >1 km apart was very low. We make the conservative recommendation that stations be established a minimum of 1–5 km apart to approach independence of sampling, while still allowing multiple samples to be collected within an area of relatively homogeneous habitat.

CONSISTENCY IN PERCENT OF YOUNG AMONG STATIONS

If stations in an area are similar in percent of young, then relatively few stations should be needed to sample regional productivity at target levels of precision. The few differences we found between stations in percent young captured in summer seemed to reflect distance from other stations, rather than differences in habitat. Six of the stations used in this analysis (Table 4) were in similar, riverine–riparian habitat, in close proximity on a 12-km section of the main stem Klamath River near Orleans (Fig. 1). The two more distant stations appeared to have, in general, lower productivity. The BBAR station on the Trinity River, a tributary of the Klamath, and PCT1 (109 km upstream along the Klamath River) had the lowest percent young for five of the 14 species analyzed. Together, these two stations accounted for most of the significant differences in percent young among stations. Percents were not consistently low, however, as each of these stations also had the highest percent young for at least one species.

Some resident species had more variable annual percent young than migratory species (Table 4; Wrentit and Song Sparrow), suggesting that there might be real spatial differences in local productivity. It is possible that residents are better able to fine tune their productivity to local conditions, whereas productivity of migrant species might be more affected by wintering ground conditions and factors operating on a broader scale. Variability among stations in percent young for resident species may

TABLE 6. STANDARDIZED PERCENT YOUNG FOR ALL TARGET SPECIES COMBINED, BY STATION AND SEASON, FOR 1992–1995

	Summer				Fall			
Station	1992	1993	1994	1995	1992	1993	1994	1995
BBAR	38.3	17.6	33.2	29.6	63.9	–	20.0	–
	A[a]	D	B	A	AB		C	
BOND	50.1	78.2	47.4	57.7	–	–	–	–
	A	A	B	A				
CAMP	59.4	41.5	38.2	52.8	61.1	37.4	70.0	39.4
	A	DC	B	A	AB	A	AB	A
CAPD	61.2	60.5	86.6	48.6	82.9	61.2	81.2	71.2
	A	AB	A	A	A	A	A	A
LADY	63.3	28.0	50.0	58.4	58.7	58.0	69.4	37.8
	A	DC	B	A	AB	A	AB	A
MOLI	45.7	66.9	64.2	56.2	–	–	–	–
	A	AB	AB	A				
RED2	43.6	68.7	60.1	54.6	32.1	49.4	49.9	43.7
	A	A	AB	A	B	A	B	A
PCT1	–	52.8	39.0	56.7	–	40.0	85.8	70.7
		ABC	B	A		A	A	A

Notes: See Methods for means of standardization. Species codes are explained in Table 2.

[a]Stations with the same letter are not significantly different in average percent young (ANOVA, Duncan's multiple range test, P > 0.05).

TABLE 7. PROBABILITY OF DETECTING ANNUAL CHANGE (DECLINE OR INCREASE) IN THE PERCENT OF YOUNG CAPTURED, WITH A SIGNIFICANCE LEVEL OF 0.05, AMONG KLAMATH RIVER STATIONS

			Probability of detecting	
Species	Season	Number of stations	50% change	25% change
Song Sparrow	Summer	4	0.78	0.37
		6	0.86	0.49
		8	0.91	0.58
		10	0.95	0.65
		32	>0.99	0.95
	Fall	2	0.92	0.58
		4	0.98	0.75
		6	>0.99	0.86
		8	>0.99	0.92
		10	>0.99	0.95
Yellow-breasted Chat	Summer	6	0.72	0.26
		8	0.79	0.33
		10	0.97	0.60
		29	>0.99	0.95

reflect differences in the quality of the immediate and nearby habitats, allowing us to identify source and sink areas. However, Nur and Geupel (1993b) showed that summer mist-net captures reflected local productivity in Song Sparrows, but not Wrentits. In many species, percent young in summer and fall, when dispersers and migrants are being captured, may represent average productivity across the region rather than local productivity at each netting station. In the Klamath network, many species use the riparian habitats during migration, and variability in percent young is low among stations. That fewer stations are needed in fall than in summer to detect annual changes in percent young is an indication that young and adults are distributed among stations in more even proportions during the fall.

TABLE 8. SUMMER CAPTURE RATES OVER THE FIRST FOUR YEARS OF MIST-NET OPERATIONS (17 STATIONS). YEAR 1 RANGED FROM 1991 TO 1994

Year	Mean annual capture rate	SE
1	567.77	29.40
2	440.07	20.72
3	448.99	25.27
4	412.97	23.06

NUMBER OF STATIONS NEEDED TO DETECT ANNUAL CHANGES IN PRODUCTIVITY

For two species in our region, 10 stations were needed to detect a 50% annual change in regional productivity at target precision levels, and about 30 to detect a 25% change (at least in summer). If detecting changes smaller than 25% is of interest, or for detecting similar changes in less common species, a larger number of samples may be required. More stations may also be needed if habitat is more heterogeneous than in our study area.

Here we examined changes in productivity between adjacent years of sampling, both consecutive and non-consecutive years. When additional years of sampling are available, we will examine our power for detecting multi-year trends in productivity.

CHANGE IN CAPTURE RATE IN FIRST AND SUBSEQUENT YEARS

The decline in capture rates following the first year of operation is perplexing. The drop could be due to several causes, including net shyness. The presence of investigators even for as little as one morning in 10 could result in birds avoiding the study area, or, alternatively, learning the location of nets and avoiding them in subsequent years. Net avoidance resulting from long-term memory would result in capture rates suggesting a decline in abundance when none actually occurred. If net shyness was the cause, then decline of captures should be greater in adults than young of the year, so percent young should increase after the first year of operation. This will be tested in future work. It is crucial to that we continue to investigate patterns in capture rate at mist-netting stations that may affect interpretation of monitoring efforts using this technique.

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