Incidental captures of birds in small-mammal traps: a cautionary note for interdisciplinary studies

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Abstract Although benefits of interdisciplinary studies are numerous, potential exists for data acquisition for some aspects of such studies to impact data acquisition for other aspects. This may be particularly true in studies involving both trapping of small mammals and assessment of bird populations. We summarize the incidence of birds captured during 8 research projects in Massachusetts, Oregon, and Washington that used 5 types of small-mammal traps, and discuss possible impacts of small-mammal trapping on bird surveys and possible mitigation measures. In these studies, 867 birds representing 17 species were captured in 703,138 total trap-nights (TN). The song sparrow (*Melospiza melodia*), spotted towhee (*Pipilo maculatus*), Steller's jay (*Cyanocitta stelleri*), and gray jay (*Perisoreus canadensis*) accounted for 86% of all bird captures; ground-foraging species accounted for 54% of all bird captures. Relatively high capture rates were observed in Sherman (H. B. Sherman Traps, Inc., Tallahassee, Flor.) and Tomahawk traps (Tomahawk Live Trap Co., Tomahawk, Wisc.) (4.1 and 9.8 birds/1,000 TN, respectively) in study 1, whereas pitfall and Ugglan (Grahnab, Ekhaga Marieholm, Hillerstorp, Sweden) traps had negligible captures (<0.1 and 0.0 birds/1,000 TN, respectively) in 4 studies that used them. On 11 occasions capture rates in 1 stand on 1 day in study 1 ranged from 50.0-100.0 birds/1,000 TN. Despite relatively high capture rates of birds in Tomahawk and Sherman traps in 2 studies, the 6 other studies had limited avian captures in both these and all other trap types used. Variability in avian capture rates within trap types across studies makes it difficult to predict the time of year when and habitats where avian captures could occur. Therefore, researchers should be mindful of potential negative impacts of small-mammal trapping on avian aspects of research when designing interdisciplinary studies that include both avian and small-mammal components conducted simultaneously at the same sites.

Key words birds, incidental captures, interdisciplinary studies, mortality, nontarget captures, small-mammal traps, small-mammal trapping

In recent years interdisciplinary studies have been implemented to examine consequences of management and policy on multiple facets of forest ecosystems (e.g., Aubry et al. 1999, Carey et al. 1999, Chambers et al. 1999, Suzuki and Hayes 2003). Research simultaneously conducted on several taxa at a common set of sites offers insight into relationships among taxa that would be difficult to

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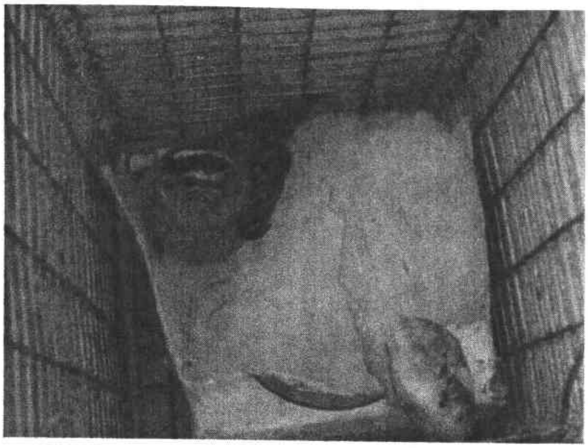
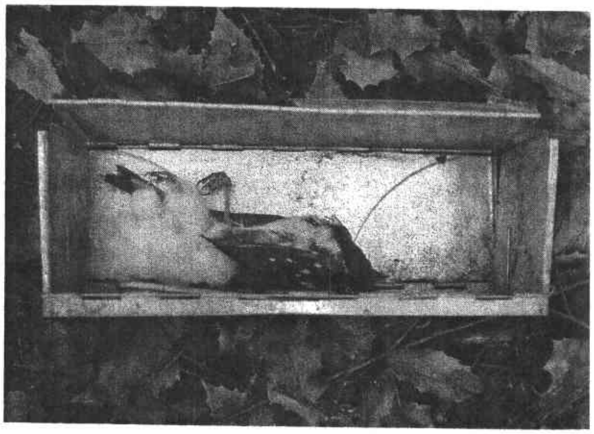


Adult white-crowned sparrow in bedding box in Tomahawk trap.

Juvenile spotted towhee with cere abrasion as a result of attempting to escape from a Tomahawk trap.

obtain if studies of individual taxa were conducted in different areas. However, potential also exists for assessment methods of some taxa to influence results of other components of interdisciplinary studies performed simultaneously at the same sites. For example, pitfall traps effectively capture amphibians (Corn and Bury 1990), but many small mammals trapped in pitfalls (e.g., shrews and voles) succumb to hypothermia or starvation if mitigation measures are not implemented to allow their escape (Karraker 2001). Similarly, birds may be captured and injured or killed in traps set for mammals (Turkowski et al. 1984, Dickman et al. 1994, McClearn et al. 1994, Huggins 1999, Anonymous 2003).

Our experiences in trapping small mammals in Massachusetts, Oregon, and Washington, along with those of others (see Bateman 1979, Barnett and Dutton 1995), suggest that incidental capture of birds and other nontarget species occurs during many small-mammal research projects. Yet, captures of nontarget species rarely are reported in the primary literature. Understanding the prevalence of capture, injury, and mortality of nontarget species seems valuable for the design and implementation of interdisciplinary studies. Here we summarize incidental bird captures in commonly used small-mammal traps across a range of environmental conditions. Additionally, we discuss approaches to minimize avian injuries and deaths in such traps, and potential ramifications of incidental captures on estimates of bird populations made during interdisciplinary studies.



Dead adult spotted towhee in Sherman trap entangled in polyester bedding material.

Methods

We gathered data on incidental bird captures from 6 small-mammal studies in Oregon, 1 in Oregon and Washington, and 1 in Massachusetts (Table 1). Investigators provided information on sampling methodology, site location, vegetation community, season, year of study, and species, numbers, injuries, and mortality of birds captured. All research projects were conducted under the auspices of university Institutional Animal Care and Use Committees (IACUC) or the United States Department of Agriculture, and in accordance with state and federal permits.

In all studies captured birds were identified and released if alive. Definitive evidence of a bird capture was the presence of a live or dead bird (all studies). In study 1, vacant traps tripped by birds were identified by the presence of feathers or an amputated foot in the trap; species identification

Table 1. Eight research studies conducted from 1988–2002 in Massachusetts, Oregon, and Washington, USA, that authors examined to evaluate bird captures in small mammal traps.

Study[a]	Location	Vegetation community	Years	Season	Trap types	Trap-nights
1	Oregon Coast Range	Douglas-fir forest (*Pseudotsuga menziesii*)	1999–2002	Sp, Su, F	Sherman (7.5 × 8.8 × 22.5 cm) Tomahawk 201 (14.5 × 14.5 × 40 cm)	80,400 15,300
2	Oregon Cascades, Washington Cascades, Washington Coast Range	Douglas-fir forest (*Pseudotsuga menziesii*)	1995–2000	F	Pitfall (2 connected #10 cans; 72 × 15 cm) Tomahawk 201 (14.5 × 14.5 × 40 cm)	299,653 88,512
3	Oregon Coast Range	Douglas-fir forest (*Pseudotsuga menziesii*)	1999–2000	Sp, Su	Sherman (7.5 × 8.8 × 22.5 cm)	50,400
4	Oregon Coast Range	red alder forest (*Alnus rubra*)	1988–1991	Su, F	Sherman (7.5 × 8.8 × 22.5 cm) Pitfall (2 connected #10 cans; 72 × 15 cm) Tomahawk 201 (14.5 × 14.5 × 40 cm)	43,344 43,344 6,912
5	Central Oregon	ponderosa pine (*Pinus ponderosa*)	2000–2001	Su, F	Ugglan model 3 (25 × 7.8 × 6.5 cm) Tomahawk 201 (14.5 × 14.5 × 40 cm)	18,240 3,648
6	Willamette Valley, OR	native wet prairie	1996–1999	Su	Sherman (7.5 × 8.8 × 22.5 cm) Pitfall (2 connected #10 cans; 72 × 15 cm)	3,780 1,125
7	Siskiyou Mountains, OR	Douglas-fir forest (*Pseudotsuga menziesii*)	1999–2000	Su	Sherman (7.5 × 8.8 × 22.5 cm)	35,640
8	Central Massachusetts	mixed-wood forest; red oak (*Quercus rubra*), white pine (*Pinus strobus*), red maple (*Acer rubrum*)	1997–1999	Su	Sherman (7.5 × 8.8 × 22.5 cm) Museum Special and small Victor snap traps	6,420 6,420

[a] Additional details on study design can be found in McComb et al. (1994) and Chambers et al. (1999) for study 1, Aubry et al. (1999) for study 2, Larson (2000) and Suzuki and Hayes (2003) for study 3, Cole et al. (1998) for study 4, Smith (2002) for study 5, Manning (2002) for study 7, and DeGraaf et al. (1999) for study 8. Study 6 is unpublished data (J. Faulkner, Department of Fisheries and Wildlife, Oregon State University).

was attempted based on feather size and color and foot morphology. Additionally, in study 1, injuries, general physical condition, and capture stress of birds were recorded during the last 3 years of the 4-year project. Independent of injuries, the physical condition of live birds was based on the proportion of the body covered with feces, moisture, and bait (good condition: <5% covered in moisture, feces, or bait; moderate condition: 5–50% covered; poor condition: >50% covered). Stress associated with capture was based on release behavior (minor stress: the bird flew away with no apparent difficulty; major stress: the bird was lethargic and had difficulty flying).

Specific injuries were used to indirectly identify recaptured birds in study 1. Birds captured in Tomahawk traps (Tomahawk Live Trap Co., Tomahawk, Wisc.) occasionally had an abrasion above their bill (hereafter "cere abrasion") that apparently was caused by birds attempting to escape through the wire mesh of these traps. This type of injury was not possible in the Sherman traps (H. B. Sherman Traps, Inc., Tallahassee, Flor.) used in study 1 because they were constructed of solid sheet metal. Consequently, capture of a bird with a cere abrasion in a Sherman trap was evidence that the bird had been previously captured in a Tomahawk trap. A low-level banding effort was made in study 1 during fall 2000 to gain insight into recaptures beyond that provided by specific injuries; 1 adult and 1 juvenile spotted towhee (*Pipilo maculatus*) and 1 adult song sparrow (*Melospiza melodia*) were banded.

In this paper, we present general patterns of bird captures in small-mammal traps. We did not conduct formal statistical analyses on the data sets included in this paper, because of inconsistencies in study design among studies.

Table 2. Number of birds captured and capture rates (per 1,000 trap-nights) by species (with at least 5 captures) in 5 types of small mammal traps during 8 research projects conducted from 1988–2002 Massachusetts, Oregon, and Washingtion, USA. See Table 1 for information on number of trap-nights by trap type for each study.

	Sherman						Tomahawk				Pitfall			Snap[a]	Ugglan	Total
Species	Study 1	Study 3	Study 4	Study 6	Study 7	Study 8[c]	Study 1	Study 2	Study 4	Study 5	Study 2	Study 4	Study 6	Study 8	Study 5	captures
dark-eyed junco[b] (*Junco hyemalis*)	4 (<0.1)	19 (0.4)	0 (0.0)	0 (0.0)	30 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	53
gray jay (*Perisoreus canadensis*)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	267 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	267
song sparrow[b] (*Melospiza melodia*)	138 (1.7)	0 (0.0)	3 (0.1)	5 (1.3)	0 (0.0)	0 (0.0)	22 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	168
spotted towhee[b] (*Pipilo maculatus*)	136 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.1)	0 (0.0)	85 (5.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	223
Stellar's jay (*Cyanocitta stelleri*)	2 (<0.1)	2 (<0.1)	0 (0.0)	0 (0.0)	17 (0.5)	0 (0.0)	34 (2.2)	33 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	88
white-breasted nuthatch (*Sitta carolinensis*)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	7 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	7
white-crowned sparrow[b] (*Zonotrichia leucophrys*)	9 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	13
winter wren[b] (*Troglodytes troglodytes*)	3 (<0.1)	0 (0.0)	1 (<0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (<0.1)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	6
other[d]	4 (<0.1)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.1)	0 (0.0)	5 (0.3)	0 (0.0)	1 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.8)	0 (0.0)	19
species not recorded	16 (0.2)	0 (0.0)	1 (<0.1)	0 (0.0)	2 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.3)	0 (0.0)	23
sprung traps[e]	18 (0.2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18
Total	330 (4.1)	21 (0.4)	5 (0.1)	5 (1.3)	61 (1.7)	0 (0.0)	150 (9.8)	300 (3.4)	1 (0.1)	3 (0.8)	1 (<0.1)	0 (0.0)	0 (0.0)	8 (1.2)	0 (0.0)	885
Total dead	66 (0.8)	12 (0.2)	1 (<0.1)	0 (0.0)	9 (0.3)	0 (0.0)	10 (0.7)	37 (0.4)	0 (0.0)	0 (0.0)	1 (<0.1)	0 (0.0)	0 (0.0)	7 (1.1)	0 (0.0)	143
% dead	20	57	20	0	15	0	7	12	0	0	100	0	0	88	0	16

[a] Museum Special Victor snap traps and small Victor snap traps of equal number; the larger Museum Specials captured and killed six of eight birds.

[b] Ground-foraging species

[c] Sherman and modified Sherman traps combined.

[d] Ground-foraging species included: 1 chipping sparrow (*Spizella passerina*), 1 golden-crowned sparrow (*Zonotrichia atricapilla*), 4 ovenbirds (*Seiurus aurocapillus*); Species using other foraging strateges included: 2 Bewick's wrens (*Thryomanes bewickii*), 3 black-headed grosbeaks (*Pheucticus melanocephalus*), 4 western scrub-jays (*Aphelocoma californica*), 2 Swainson's thrushes (*Catharus ustulatus*), 1 turkey vulture (*Cathartes aura*), and 1 wood thrush (*Hylocichla mustelina*).

e Traps where no birds were captured but were sprung by birds. This represents 2 song sparrows, 9 spotted towhees, and 7 traps where the species was not recorded.

Results

We identified 867 captures of 17 species of birds (Table 2) with an additional 18 vacant traps in study 1 sprung by birds based on physical evidence in traps. Song sparrows, spotted towhees, Steller's jays (*Cyanocitta stelleri*), and gray jays (*Perisoreus canadensis*) accounted for 86% of all bird captures; 54% of the captures were ground-foraging species. Capture rates and bird species differed greatly among studies. Studies 1 and 2 documented extensive captures of birds, with capture rates up to 9.8 captures/1,000 trap-nights (TN) in Tomahawk traps (study 1), whereas studies 2–6 and 8 had capture rates <1.0 bird captured/1,000 TN for some trap types (e.g., pitfall, and Ugglan traps; Grahnab, Ekhaga Marieholm, Hillerstorp, Sweden). Although relatively few birds (<2) generally were captured on any given day during most studies, on 11 occasions in study 1, single-day captures resulted in 5–9 birds trapped in a single stand with a trap grid encompassing 0.63 ha (50.0–100.0 birds/1,000 TN).

Species captured and capture rates differed among trap types (Table 2). Generally, birds were captured most frequently in Tomahawk traps, followed by Sherman, snap, pitfall, and Ugglan traps (Table 2). Highest capture rates were in Sherman and Tomahawk traps (4.1 and 9.8 birds/1,000 TN, respectively) (study 1). However, some studies that used these trap types had relatively few avian captures or low capture rates (studies 3–6 and 8). Probability of capture in a given trap type appeared to differ among bird species. For example, capture rates for spotted towhees and Steller's jays were higher in Tomahawk traps (5.6 and 2.2 birds/1,000 TN, respectively) than in Sherman traps (1.7 and <0.1 birds/1,000 TN, respectively), whereas capture rates of song sparrows were similar in Sherman and Tomahawk traps (1.7 and 1.4 birds/1,000 TN, respectively) in study 1.

Avian deaths occurred in 6 of the 8 studies (Table 2), and those studies with the most TN (studies 1 and 2) accounted for 80% of the total deaths (n= 143 deaths). Mortality rates were similar between Sherman (0.8 deaths/1,000 TN) and Tomahawk traps (0.7 deaths/1,000 TN) in study 1, but were lower in other studies that used either trap type. Excluding the single bird captured in pitfall traps, the percentage of captures that resulted in bird mortality was highest for snap traps, specifically Museum Specials (Woodstream Corp., Lititz, Penn.), although the overall capture rate for snap traps was relatively low (1.2 birds/1,000 TN) (Table 2, study 8).

Cere abrasions were the most common injury of entrapped birds in study 1 (76 abrasions from 351 captures in 2000–2002). Other injuries included feather loss and severed legs in 3 spotted towhees from the spring-loaded doors of Sherman traps. Most birds released were in good physical condition (74% of captures), although 19% were in moderate condition and 7% were in poor condition; 29% were classified as significantly stressed.

In study 1, 35 recaptures were documented for song sparrows, spotted towhees, and white-crowned sparrows (*Zonotrichia leucophrys*). Of the 3 birds banded, the adult song sparrow was found dead in a trap the following day, the adult spotted towhee was recaptured once 4 days later, and the juvenile spotted towhee was recaptured for 4 consecutive days following banding. The 2 banded birds alive at the end of the week of trapping in fall 2000 were not recaptured during 6 subsequent trapping sessions in the spring, summer, or fall, 2001–2002. Additionally, 2 of the 3 spotted towhees with amputated legs were recaptured within 4 days of losing a leg in Sherman traps, but were never recaptured in subsequent trap sessions.

Captures differed among vegetative conditions in studies 1 and 2 although both were conducted in Douglas-fir (*Pseudotsuga menziesii*) forests (Table 3). In study 1 capture rates were greatest in two-story stands where dispersed overstory trees were retained (14.1 birds/1,000 TN; 10–12 years post-harvest). Of the remaining conditions, capture rates were higher in clearcut stands (5.9 birds/1,000 TN) than in patch-cut stands (2.0 birds/1,000 TN) and relatively rare in uncut control stands (0.4 birds/1,000 TN). Conversely, in study 2 capture rates of birds were lowest in open units with dispersed green-tree retention (1.6 birds/1,000 TN) 1–2 years post-harvest. Additionally, aggregated retention harvest units had the highest capture rates (6.1 birds/1,000 TN), with relatively lower capture rates in uncut units (3.4 birds/1,000 TN).

Discussion

Incidental capture of birds in small-mammal traps during interdisciplinary studies in which birds and small mammals are studied simultaneously on the same sites could affect estimates of some populations of birds, particularly on days with relatively high levels of captures. Estimates of avian populations frequently are based on point-count surveys of singing males (Ralph et al. 1995), and

Table 3. Bird species captured and capture rates (birds/1,000 TN) by silviculture treatment (study 1)[a] and pre- (Uncut) and post-harvest (Aggregated and Dispersed green tree retention) (study 2)[b]. See Table 2 for scientific names.

Species	Study 1[c]				Study 2[c]		
	Control	Patch-cut	Two-story	Clearcut	Uncut	Aggregated	Dispersed
gray jay	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	183 (3.1)	61 (5.0)	23 (1.3)
song sparrow	0 (0.0)	30 (0.9)	68 (4.9)	62 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)
spotted towhee	0 (0.0)	14 (0.4)	99 (7.2)	108 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)
Stellar's jay	3 (0.2)	18 (0.6)	1 (0.1)	14 (0.4)	14 (0.2)	13 (1.1)	6 (0.3)
white-crowned sparrow	0 (0.0)	0 (0.0)	0 (0.0)	13 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)
other[d]	3 (0.2)	0 (0.0)	6 (0.4)	7 (0.2)	1 (<0.1)	0 (0.0)	0 (0.0)
species not recorded	0 (0.0)	0 (0.0)	10 (0.7)	6 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)
sprung traps[e]	0 (0.0)	2 (0.1)	11 (0.8)	5 (0.1)	-	-	-
Total	6 (0.4)	64 (2.0)	195 (14.1)	215 (5.9)	198 (3.4)	74 (6.1)	29 (1.6)

[a] See McComb et al. (1994) and Chambers et al. (1999) for details on study design. Control stands were uncut, patch-cut stands had 33% of the volume removed in 0.2 ha clearcuts, two-story stands had 75% of the volume removed with retained trees scattered throughout the stand, and clearcuts retained 1.2 trees per hectare.

[b] See Aubry et al. 1999 for details on study design. Uncut stands includes data from stands prior to harvest and control stands, aggregated stands includes data from stands with 75%, 40%, and 15% of the volume retained in groups post-harvest, and dispersed stands includes data from stands with 40% and 15% of volume retained scattered throughout the unit post-harvest.

[c] Total captures and capture rates are calculated from the combination of Sherman and Tomahawk traps in study 1 and Tomahawk and pitfall traps in study 2.

[d] Study 1. Ground-foraging species: 4 dark-eyed juncos (*Junco hyemalis*), 1 golden-crowned sparrow (*Zonotrichia atricapilla*), and 3 winter wrens (*Troglodytes troglodytes*); other foraging strategy: 2 Bewick's wrens (*Thryomanes bewickii*), 4 western scrub-jays (*Aphelocoma californica*), and 2 Swainson's thrushes (*Catharus ustulatus*). Study 2. Ground-foraging species: 1 winter wren.

[e] Traps where no birds were captured but were sprung by birds. This represents 2 song sparrows, 9 spotted towhees, and 7 traps where the species was not recorded.

mortality or temporary entrapment of males could result in lower estimates of abundance. Conversely, temporary (<2 hours) removal of a female from the population prompts increased singing by its mate (Krebs et al. 1981, Cuthill and Hindmarsh 1985) and could result in elevated estimates of abundance. Because avian capture rates varied across vegetative conditions and among silviculture treatments within a study, influence of captures on population estimates of some avian species will not be proportionally distributed across study sites and silviculture treatments. The influence of avian captures on small-mammal population estimates is probably negligible because even the highest capture level observed on any given day in a single stand (9 birds) in study 1 left approximately 90% of the traps available for the capture of small mammals.

Confinement of birds in small-mammal traps also has numerous implications for the health, fitness, and survival of entrapped birds. Trapping can result in the immediate death of birds by the trap itself or eventual death through heatstroke, hypothermia, stress, starvation, injury, or predation while in traps. Birds captured in traps may develop wing strain (capture myopathy) or lose flight feathers during attempts to escape. Wing strain is a condition wherein intense wing muscle exertion associated with restraint occurs; it may progress into acute muscle degeneration that will limit a bird's ability to fly for a period of time after release (Cox and Afton 1998, North American Banding Council 2000*a*). Both wing strain and feather loss and their negative impacts on flight may make affected individuals more susceptible to predation once released. Finally, entrapped males may have their attempts to attract mates and establish and defend territories disrupted by capture. When males are unable to sing or physically display, they are more likely to resort to more energy-demanding behaviors upon release, such as chasing and fighting to maintain territories, and are more susceptible to losing territories to "floater" males (Peek 1972, Krebs et al. 1981). For example, nonterritorial song sparrows selectively intrude on territories of other males based on the apparent condition of territory holders (Arcese 1987).

The prevalence of captures of a given avian species likely is associated with its foraging behavior, habitat associations, and local population size. For example, sparrows that forage on or near the ground and jays were captured most often in the studies we summarized. This observation was consistent with patterns of avian captures in Washington (T. Wilson, Olympia Forestry Sciences Laboratory, Pacific Northwest Research Station, unpublished data) and Namibia (Dickman et al. 1994). Similarly, white-tipped doves (*Leptotila verreauxi*) were caught more often in traps set on the ground near a lakeshore where the species was known to forage (Ridgely and Gwynne 1989) than in traps set in forest canopy in Panama (McClearn et al. 1994). However, it should be noted that birds also might be captured in small-mammal traps set in trees (McClearn et al. 1994, Huggins and Gee 1995). Further, birds abundant within a study area or within a particular stand condition, such as song sparrows and spotted towhees in two-story and clearcut stands in study 1 (M. Stoddard, Department of Forest Science, Oregon State University, unpublished data), were strongly represented in trap samples. This likely reflected a relationship between the abundance of ground-foraging sparrows in a habitat and the availability of shrubs and other low-growing vegetation in those stands that resulted from timber harvest.

Temporal variability in avian captures likely is due to fluctuations in environmental conditions that impact bird behavior. Dickman et al. (1994) hypothesized that the prevalence of birds captured in traps at certain times was related to periodic increases in local bird abundance associated with increases of key resources such as river water and insects. It also is possible for autumnal migrants to inundate certain habitats during stopovers, which in turn may lead to increased captures of some migrant species (e.g., swamp sparrow [*Melospiza georgiana*]; T. Maier and K. Doyle, Department of Biology, University of Massachusetts-Amherst, unpublished data).

Results of our study lead us to recommend that whenever possible, measures be undertaken to reduce bird captures in small-mammal traps, both for ethical reasons and to minimize impact to avian components of interdisciplinary studies. When jays or ground-foraging birds are abundant, some will likely be captured inadvertently in certain types of commonly used small-mammal traps. To mitigate potential impacts of trapping on individual birds and population estimates, we advise researchers to temporally separate research components, ideally with avian surveys occurring prior to small-mammal trapping; this should minimize potential influences of capture, injury, or mortality on objectives of the avian research. Because bird encounters with small-mammal traps generally are diurnal, avian captures may be minimized if traps are rendered inoperative during the day, although this may be unacceptable for the goals of the small-mammal research in some cases. Checking traps more than once per day may minimize stress and injury to a captured bird, though even temporary removal from the population may have ramifications on avian research.

Researchers also should consider using traps that are less efficient at trapping birds and have lower mortality associated with entrapment. Traps with relatively small openings (e.g., Longworth; Penlon Ltd., Abing, Oxfordshire, United Kingdom, or Ugglan traps) generally will reduce bird captures due to restricted access, and traps that remain open (e.g., pitfall traps) allow birds to escape. Only 1 bird was captured in over 340,000 trap-nights of effort with pitfall traps in 3 studies, and no birds were captured in over 18,000 trap-nights of effort with Ugglan traps in 1 study. Similarly, no bird captures were reported from pitfall traps used in Namibia (Dickman et al. 1994). Use of exposed snap traps, especially Museum Specials, over broad areas should be evaluated critically in study design because of the high percentage of small birds killed when captured in such traps. Although the snap traps used in study 8 had a relatively low avian capture rate, the rate was higher than for paired Sherman traps in the same study. Thus, in situations where Sherman traps may capture relatively high numbers of birds (e.g., study 1), snap traps have the potential for even higher capture and mortality rates than Sherman traps unless steps are taken to reduce bird captures (e.g., covering traps; Barnett and Dutton 1995).

The efficiency of certain types of live (cage) traps to capture birds has long been recognized (Bub 1991). However, wire-cage units such as Tomahawk traps may be adjusted or modified to reduce bird captures, injuries, or predation. Adjustment of the tension of the treadle to require greater force to trigger traps will reduce captures of smaller birds. However, this also could limit capture of smaller target small mammals (e.g., chipmunks [*Tamias* sp.]). Reduction in the size of the wire mesh and elimination of sharp edges and points on traps will help reduce injuries, and plastic coating applied to the wire mesh of cage-style traps should minimize cere abrasions (North American Banding Council 2000*b*). Locking doors on traps should reduce predation of birds and small mammals by predators that are able to push into cage traps without such mechanisms. Predation of birds and small mammals in cage traps also could be reduced by attaching blocking material around the edge of doors to prevent entry of small predators (e.g., ermine [*Mustela erminea*]) through gaps around closed trap doors.

Consideration also should be given to the type and application of bait used in small-mammal traps. Visible cereal grains often lead birds and other non-target species into traps (see Bateman 1979, Bub 1991, Huggins 1999), and commonly used peanut-butter bait mixtures may attract birds directly or indirectly because insects are attracted to the bait (Dickman et al. 1994). Schemnitz (1994) and Barnett and Dutton (1995) list various anti-insect additives and bait alternatives.

Our findings indicate that small-mammal trapping projects have the potential to alter avian research results in interdisciplinary studies. Therefore, we recommend that interdisciplinary studies consider the issue during the design phase. Long-term implications of small-mammal trapping on local bird populations likely are limited in most situations because of limited captures of birds and natural mortality rates of species that are most often captured. Nonetheless, impacts on individual birds could be an issue if sensitive, threatened, or endangered species that are susceptible to capture in small-mammal traps are present. Increased reporting on the incidence of avian captures in small-mammal traps in different vegetative communities, susceptibility of different species to capture among trap types, and extent of injuries and mortality incurred as a consequence of entrapment will be necessary to clarify ramifications of these phenomena to avian populations.

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Literature Cited

ANONYMOUS. 2003. Rabbits: use of cage-trapping to prevent agricultural damage. Department for Environment, Food & Rural Affairs Technical Advisory Note RDS WM17.

ARCESE, P. 1987. Age, intrusion pressure and defense against floaters by territorial male song sparrows. Animal Behaviour 35: 773-784.

AUBRY, K. B., M. P. AMARANTHUS, C. B. HALPERN, J. D. WHITE, B. L. WOODARD, C. E. PETERSON, C. A. LAGOUDAKIS, AND A. J. HORTON. 1999. Evaluating the effects of varying levels and patterns of green-tree retention: experimental design of the DEMO study. Northwest Science 73 (Special Issue): 12-26.

BARNETT, A., AND J. DUTTON. 1995. Expedition field techniques. Small mammals. Second edition. Expedition Advising Centre, Royal Geographic Society, London, England.

BATEMAN, J. A. 1979. Trapping: a practical guide. Stackpole, Harrisburg, Pennsylvannia, USA.

BUB, H. 1991. Bird trapping and bird banding. Cornell University, Ithica, New York, USA.

CAREY, A. B., D. R. THYSELL, AND A. W. BRODIE. 1999. The forest ecosystem study. United States Department of Agriculture Forest Service General Technical Report PNW-GTR-457. Pacific Northwest Research Station, Portland, Oregon, USA.

CHAMBERS, C. L., W. C. MCCOMB, J. C. TAPPEINER, II, L. D. KELLOGG, R. L. JOHNSON, AND G. SPYCHER. 1999. CFIRP: what we learned in the first ten years. The Forestry Chronicle 75: 431-434.

COLE, E. C., W. C. MCCOMB, M. NEWTON, J. P. LEEMING, AND C. L. CHAMBERS. 1998. Response of small mammals to clearcutting, burning, and glyphosate application in the Oregon Coast Range. Journal of Wildlife Management 62: 1207-1216.

CORN, P. S., AND R. B. BURY. 1990. Sampling methods for terrestrial amphibians and reptiles. United States Department of Agriculture Forest Service General Technical Report PNW-GTR-256. Pacific Northwest Research Station, Portland, Oregon, USA.

COX, R. R., AND A. D. AFTON. 1998. Effects of capture and handling on survival of female northern pintail. Journal of Field Ornithology 69: 276-287.

CUTHILL, I., AND A. HINDMARSH. 1985. Increase in starling song activity with removal of a mate. Animal Behaviour 33: 326-335.

DEGRAAF, R. M., T. J. MAIER, AND T. K. FULLER. 1999. Predation of small eggs in artificial nests: effects of nest position, edge, and potential predator abundance in extensive forest. Wilson Bulletin 111: 236-242.

Dickman, C. R., T. M. Glasby, P. A. Higgs, A. Curtin, R. L. Drury, and M. A. J. Honywood. 1994. Captures of birds in mammal traps: chance or opportunism? Ostrich 65: 345-348.

Huggins, J. G. 1999. Gray and fox squirrel trapping: a review. Pages 117-129 *in* G. Proulx, editor. Mammal trapping. Alpha Wildlife Research & Management, Sherwood Park, Alberta, Canada.

Huggins, J. G., and K. L. Gee. 1995. Efficiency and selectivity of cage traps set for gray and fox squirrels. Wildlife Society Bulletin 23: 204-207.

Karraker, N. E. 2001. String theory: reducing mortality of mammals in pitfall traps. Wildlife Society Bulletin 29: 1158-1162.

Krebs, J. R., M. Avery, and R. J. Cowie. 1981. Effect of removal of a mate on the singing behavior of great tits. Animal Behaviour 29: 635-637.

Larson, D. J. 2000. The effects of thinning on forest-floor small mammals in the Coast Range of Oregon. Thesis, Oregon State University, Corvallis, USA.

Manning, J. A. 2002. Small mammal response to silvicultural fuels treatments in southwest Oregon. Thesis, Oregon State University, Corvallis, USA.

McClearn, D., J. Kohler, K. J. McGowan, E. Cedeño, L. G. Carbone, and D. Miller. 1994. Arboreal and terrestrial mammal trapping on Gigante Peninsula, Barro Colorado Nature Monument, Panama. Biotropica 26: 208-213.

McComb, W., J. Tappeiner, L. Kellogg, C. Chambers, and R. Johnson. 1994. Stand management alternatives for multiple resources: integrated management experiments. Pages 71-86 *in* M. H. Huff, L. K. Norris, J. Brian, and N. L. Wilkin coordinators. Expanding horizons of forest ecosystem management: proceedings of the third habitat futures workshop. United States Department of Agriculture Forest Service General Technical Report PNW-GTR-336. Pacific Northwest Research Station, Portland, Oregon, USA.

North American Banding Council. 2000*a*. The bander's study guide. North American Banding Council, Point Reyes, California, USA.

North American Banding Council. 2000*b*. The North American bander's manual for passerines and near passerines (excluding hummingbirds and owls). North American Banding Council, Point Reyes, California, USA.

Peek, F. W. 1972. An experimental study of the territorial function of vocal and visual display in the male red-winged blackbird. Animal Behaviour 20: 112-118.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. Managing and monitoring birds using point counts: standards and applications. Pages 161-168 *in* C. J. Ralph, J. R. Sauer, and S. Droege, technical editors. Monitoring bird populations. United States Department of Agriculture Forest Service, General Technical Report PSW-GTR-149. Pacific Southwest Research Station, Albany, California, USA.

Ridgely, R. S., and J. A. Gwynne, Jr. 1989. A guide to the birds of Panama: with Costa Rica, Nicaragua, and Honduras. Second edition. Princeton University, Princeton, New Jersey, USA.

Schemnitz, S. D. 1994. Capturing and handling wild animals. Pages 106-124 *in* T. A. Bookhout, editor. Research and management techniques for wildlife and habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland, USA.

Smith, T. G. 2002. Small mammal relationships with downed wood and antelope bitterbrush in ponderosa pine forests of central Oregon. Thesis, Oregon State University, Corvallis, USA.

Suzuki, N., and J. P. Hayes. 2003. Effects of thinning on small mammals in Oregon coastal forests. Journal of Wildlife Management 67: 352-371.

Turkowski, F. J., A. R. Armistead, and S. B. Linhart. 1984. Selectivity and effectiveness of pan tension devices for coyote foothold traps. Journal of Wildlife Management 48: 700-708.

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