Effects of Selective Logging on Birds in the Sierra de Coalcomán, Sierra Madre del Sur, Michoacán, Western Mexico[1]

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Abstract

In order to determine the effects of selective logging on pine-oak forest's bird communities in central-western Mexico, we gathered information through 10-min point counts in plots without wood extraction and sites logged at different times in the past (1, 4, and 8 years). We did not find evidences to argue for effects of logging on bird communities; the study plots showed very similar diversity values, and similarity index values among them were high. Feeding guild groups showed different patterns after logging, and particular resident species were the most affected. Migrants as a group did not show a negative effect; none showed significant differences among treatments, and some species were detected more frequently in logged sites.

Introduction

Selective logging is one the most frequently applied silvicultural techniques in the world for the extraction of forest resources. "Sustainable forest management" practices are intended to maintain biodiversity as well as the ecosystem functions and ecological processes of the forests. Selective logging is one of the sustainable methods applied, attempting to emulate the dynamics of natural processes such as the establishment of openings and natural ecological succession (Pearce et al. 2003). In Mexico, as in many other Latin American countries, its implementation has not been completely appropriate and has promoted the deterioration of the forest's structure. With the decrease in habitat's quality, it is logical to expect the impoverishment of the native wildlife communities.

Most of the research on the effects of selective logging on animal communities has been carried out in temperate forests of the United States and Canada (e.g. Sallabanks et al. 2000), as well as in tropical areas of the world such as Belize (Whitman et al. 1998), Brazil (Johns 1991, Aleixo 1999), Ghana (Holbech 1992), Uganda (Sekercioglu 2002), Guiana (Thiollay 1992), and areas of the South Pacific like Borneo (Lambert 1992), Indonesia (Wilson and Johns 1982), and Malaysia (Wong 1986, Johns 1996). According to Sekercioglu (2002), even though 3 to 10 percent of the trees in a selectively logged area are removed for commercial use, 40 to 80 percent of the trees are destroyed as a result of the creation of logging roads, trees falling over neighboring trees, and the activity of machinery used in the process. Basal area, canopy cover, and canopy height are reduced while average gap size and distance between trees increase. Changes in vegetation structure modify the microclimatic conditions by altering temperature, humidity, and light. On one hand, soil desiccation increases seed mortality and lowers tree recruitment, and on the other, rapidly growing shrubs frequently become dominant as a result of higher light incidence near the ground. In general, the findings suggest the existence of important changes in the composition of animal communities and the distribution and abundance of food resources (Johns 1988).

Animal groups that have been frequently used as indicators to determine the effects of selective logging are birds (e.g. Thiollay 1997, Sallabanks et al. 2000), small mammal species and primates (e.g. Kasenene 1984, Crome and Richards 1988, Plumptre and Reynolds 1994, Laurance and Laurance 1996, Ochoa 2000), amphibians (e.g. Messere and Ducey 1998, Lemckert 1999), butterflies and other insect groups (e.g. Atlegrim et al. 1997, Willot 1999, Vasconcelos et al. 2000, Wagner 2000, Willot et al. 2000, Lewis 2001, Summerville and Crist 2002), and reptiles (e.g. Lima et al. 2001).

Particularly for bird populations, the results of studies show a variety of responses. Some studies have detected negative effects, such as the collapse of densities in some bird guilds that are more abundant in forests without harvesting (such as large species, frugivores, and terrestrial and understory insectivores); the decrease has been estimated between 20 to 100 percent of the number of individuals in the groups inhabiting the affected area (Wong 1986; Johns 1988, 1991, 1996; Lambert 1992; Thiollay 1999). Another group of studies has found positive effects, such as an increase in the local abundance of those bird species that adapt very fast to the new conditions, such as hummingbirds, upper-canopy frugivores, omnivores, and gap, edge or low second-growth specialists (Johns 1992; Thiollay 1992, 1999). Additionally, another set of investigations

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did not find clear and significant effects on bird communities, but considered that species richness and diversity were similar in places with and without selective logging (Holbech 1992, Johns 1992, Whitman et al. 1998, Aleixo 1999).

In the area of the Sierra de Coalcomán, Mexico, selective logging practices have been applied for wood extraction since the 1960s, by "Maderas de Coalcomán" (MADECO) and more recently by "Maderas Preciosas y Derivados" (MAPREyDE), companies that have followed the guidelines of the method known as "Ordenación de Bosques Irregulares". For this method, the volume of wood to be extracted depends on the total number of potentially exploitable trees; the removal of one third of those trees is permitted, and after extraction the plot is allowed to rest for a minimum period of 10 years for the regeneration of the tree cover and the restitution of the forest structure. The criteria of selection for those individual trees to extract are their diameter, age, and general condition (Molina 1997).

Considering the importance of the forest in this section of the Sierra Madre del Sur in Mexico, and that we are not aware of any attempt to determine the effects of selective logging on birds in any forest within Mexico, the objective of this study was to assess the effect of selective logging on the bird communities of a temperate pine-oak forest in central-western Mexico, by determining (1) the diversity of birds in plots without wood extraction and sites logged at different times in the past, (2) the degree of similarity among those plots, and (3) the species richness and abundance of species within the feeding guilds in the plots studied.

Methods

The study area is located in the Sierra de Coalcomán, in the southwestern portion of the state of Michoacán, Mexico, within the municipalities of Coalcomán and Aguililla. The area has a vegetative cover of coniferous forests (pine-oak-fir-juniper) and some cloud forest restricted to protected and more humid areas, at an elevation between 1,700 and 2,500 meters above sea level. To assess the effects of selective logging we selected a control plot that was maintained without extraction at least during the twenty previous years (non-replicated because other non-logged sites were unavailable), and three pairs of plots representing three treatments: (1) one year, (2) four years, and (3) eight years after selective logging. To sample bird communities we performed standard 10-minute point counts (Hutto et al. 1986), in permanent transects in those plots during seven repeated visits, and recorded resident as well as migratory species between December 1999 and December 2000. Bird species were assigned to six foraging guilds according to De Graff (1985): carnivores, granivores, nectarivores, frugivores, insectivores (canopy, understory, aerial, trunk, and terrestrial), and omnivores. Values of diversity were calculated through the Shannon Index [$H'=-\Sigma(p_i*\log_2 p_i)$], and the species abundance distribution by the evenness index

$$[H'/H'_{max} \text{ where } H'_{max} = \log_2 S];$$

similarity among plots was determined by the use of both, the Sorensen qualitative Index and the Morisita quantitative Index (Magurran 1988); significant differences in the abundance of feeding guilds individuals and the most common species among treatments were determined by one-way ANOVA.

Table 1— *Number of bird species and individuals, and mean number of species and individuals per count, diversity (Shannon Index, H') and evenness (e) for each of the treatment sites at Sierra de Coalcomán, Mexico. n=number of counts.*

Treatments: Years after logging (sample size)	Number of species	Number of individuals	Mean number of species per count	Mean number of individuals per count	H'	e
Control (1 site) (n = 69)	77	854	9.8	12.4	3.9	0.90
1 (2 sites) (n = 138)	89	1,929	9.6	14.0	3.7	0.83
4 (2 sites) (n = 157)	91	2,160	8.9	13.8	3.8	0.84
8 (2 sites) (n = 157)	89	1,962	9.4	12.5	3.8	0.85
Totals (7 sites) (n = 521)	110	6,905	9.4	13.2		

Results

We obtained information from a total of 521 counts, in which 6,905 individuals of 110 species were detected (86 residents and 24 migrants). In general, we did not find significant differences in the mean number of species detected per count (mean = 9.4 [8.9 - 9.8], F = 1.27, p = 0.28), nor in the number of individuals per count (mean = 13.2 [12.4 – 14.0], F = 1.87, p = 0.13) among treatments (*table 1*). With regard to the diversity calculated through the Shannon index, the values were very similar (3.7 to 3.9), as well as the evenness values (0.83 to 0.90). See *table 1*.

When comparing how similar the bird communities were within the treatment plots, it is remarkable that all comparisons resulted in very high coefficients, with a lowest value of 78 percent similarity between the most dissimilar sites (*table 2*). If we consider only information on presence/absence data, the most similar sites are those with one and four years after logging, and the most different being surprisingly the control site and the eight years site. When applying the Morisita Quantitative Index, the sites after one year and after eight years are the most similar, while the control site and the one-year site are the most dissimilar (*table 2*). However, the differences are too small to argue for strong effects.

Table 2— *Comparison between the study sites according to qualitative and quantitative community indexes in the Sierra de Coalcomán, Mexico.*

Treatments	4 year	8 year	Control
Qualitative Index: Sorensen			
1 year	0.91	0.88	0.80
4 year		0.86	0.83
8 year			0.78
Quantitative Index: Morisita			
1 year	0.88	0.94	0.79
4 year		0.93	0.81
8 year			0.87

With respect to the feeding guilds, the insectivores were the most abundant guild, including 53 species, followed by the omnivores (21), frugivores (12), granivores (10), nectarivores (9), and carnivores (5). The non-insectivorous guilds comprised 52 percent of all species, and 41.5 percent of all individuals recorded. Insectivores comprised 48 percent of the species, and 58.5 percent of the individuals recorded. Understory insectivores were the most abundant group with 1,359 individuals, followed by canopy (977), aerial (931), trunk (689), and terrestrial insectivores (83).

With regard to the treatments, guilds showed different responses to harvesting (*fig. 1*). Nectarivores and omnivores increased after opening of the forest and decreased in subsequent years. The carnivores' guild diminished with the logging activities and increased subsequently in the four and eight years after treatment. Frugivores showed a response to the productivity of the forest plants, and had an initial increase that diminishes with time after logging. Seed-eating species showed an initial increase, diminishing in subsequent phases and increasing in the eight years after treatment.

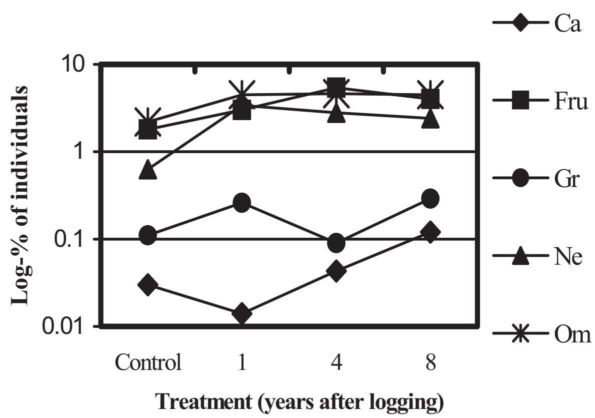

Figure 1— Log-percentage of the number of bird individuals recorded per feeding guild in each treatment, in the Sierra de Coalcomán, Mexico. Feeding guilds: Ca= Carnivores, Fru=Frugivores, Gr= Granivores, Ne= Nectarivores, Om=Omnivores.

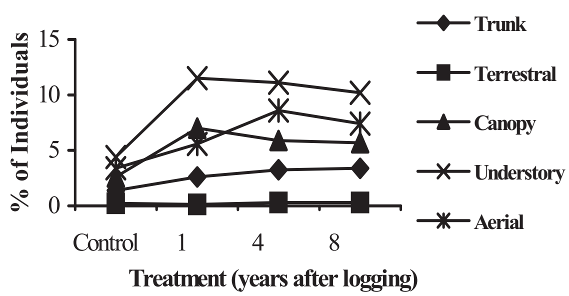

Figure 2— Percentage of the number of insectivore individuals recorded in each treatment at Sierra de Coalcomán, Mexico.

Except for the terrestrial insectivores that showed a decrease in abundance, all other insectivores apparently showed at least a slight increase after selective logging; detections of understory and canopy insectivores went up more than twice one year after logging and decreased gradually afterwards. Trunk insectivores increased slowly to reach the highest numbers at the eight-year treatment, to decrease once again in the nonlogged site (control). Aerial insectivores reached the highest values at the four-year treatment and decreased afterwards (*fig. 2*).

When considering individual species, out of the 54 species with more than 20 detections, 27 (50 percent) showed significant differences in their abundances among treatments (*appendix 1*): among the resident species, 18 decreased and 11 increased; among the neotropical migrant species, none showed significant decreases, and 5 increased their abundances ($\chi^2 = 8.52$, df = 1, P = 0.0035). These figures suggest that there are important differential effects of selective logging on resident and migrant species. Among those affected by selective logging we can include the following species (see *appendix 1* for scientific names): West Mexican Chachalaca, Elegant Trogon, Acorn woodpecker, Happy Wren, Greater Pewee, Grace's Warbler, and Black-headed Oriole. Among the species being favored by logging activities are the White-eared Hummingbird, Broad-tailed Hummingbird*, Western Flycatcher, Cedar Waxwing*, Nashville Warbler*, Townsend's Warbler*, and Hermit Warbler* [* = migrant species].

Discussion

In places where logging activities have been practiced for a considerable period of time in the past, we have different forest successional stages currently represented. Our results did not show evidence of clear trends in any of the diversity and evenness values for the study sites. They were, however, slightly greater in the control site without recent forest extraction, as found by Thiollay (1999) in a tropical rain forest of French Guiana, where the overall effect of selective logging caused only a difference of 6 percent in the diversity and evenness values.

The variation in the composition of the communities, although small, may be caused by changes in the dynamics of the productivity of the forest; the opening of the vegetation could promote the temporary appearance of resources used by different sets of species, and the establishment of different interactions between bird species. The different patterns resulting from selective logging could be the result of various factors involved at different scales. On the other hand, the migratory species as a group did not show evidence of negative effects caused by logging in the forests where they winter, similar to previous studies in western Mexico (Hutto 1992, Hutto 1995, Villaseñor and Hutto 1995). However, individual species were apparently affected. This implies that each species reacts differently to habitat changes caused by logging activities, and those effects are not necessarily detected at the level of guilds. We should devote special attention to those species that are more sensitive to forest modification.

Clear general effects of selective logging on the bird communities of the Sierra de Coalcomán could also be lacking because of confounding effects such as (1) high environmental heterogeneity in the study area, (2) the history of logging in the study sites is complex and not clearly known, and (3) uncertainty of the intensity of the extraction during the previous logging activities.

Marzluff et al. (2000) indicate that two of the main problems of most studies are their limited temporal and spatial scales, as well as the lack of rigorous experimental design. In this sense, very often research is limited by the extant conditions of the study sites and logistical problems, mostly when funding is limited in time, and the design has to take the form of short-term pseudo experimental studies; our study is not an exception to the general picture. Because of these kinds of problems, dispersal and metapopulation effects could be involved making it hard to determine the population dynamics and the real responses of given species. This is stressed in an interesting review of timber harvest effects on bird populations in North America presented by Sallabanks et al. (2000).

Given that selective logging is practiced widely in the world, what are the aspects that we should consider in future research?

- Studies should consider the environmental heterogeneity of the areas,
- Long-term research would help us understand the recovery dynamics of the forests,
- Studies should monitor variables which may be closely related to population demographics, especially for species which are relatively easy to age and sex,
- Studies should identify metapopulation processes occurring in these fragmented, timber harvest landscapes.

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Appendix 1— *Bird species recorded in the Sierra de Coalcomán, Michoacán, Mexico. Total of individuals detected (n), mean of number of individuals per count for each treatment (T1, T4, T8, Control), and the derived significance value from One-way ANOVA (p)*

			Years after treatment				
Species	**English Name**	**n**	**T1**	**T4**	**T8**	**Control**	**p**
Ortalis poliocephala	West Mexican Chachalaca	38	0.107	0.026	0.026	0.232	0.002
Accipiter striatus	Sharp-shinned Hawk	6	0.000	0.000	0.038	0.000	ns
Buteo jamaicensis	Red-tailed Hawk	5	0.007	0.013	0.006	0.015	ns
Falco sparverius	American Kestrel	1	0.000	0.006	0.000	0.000	ns
Patagioenas fasciata	Band-tailed Pigeon	13	0.065	0.000	0.026	0.000	ns
Zenaida asiatica	White-winged Dove	11	0.015	0.013	0.045	0.000	ns
Columbina inca	Inca Dove	1	0.000	0.000	0.006	0.000	ns
Leptotila verreauxi	White-tipped Dove	19	0.029	0.019	0.051	0.058	ns
Piaya cayana	Squirrel Cuckoo	3	0.000	0.000	0.000	0.044	0.000
Geococcyx velox	Lesser Roadrunner	1	0.000	0.000	0.006	0.000	ns
Glaucidium brasilianum	Ferruginous Pygmy-Owl	1	0.000	0.000	0.000	0.015	ns
Colibri thalassinus	Green Violet-ear	9	0.007	0.045	0.006	0.000	0.042
Hylocharis leucotis	White-eared Hummingbird	400	0.966	0.809	0.771	0.290	0.003
Amazilia beryllina	Berylline Hummingbird	11	0.044	0.006	0.000	0.058	0.040
Lampornis amethystinus	Amethyst-throated Hummingbird	141	0.449	0.261	0.185	0.130	0.001
Eugenes fulgens	Magnificent Hummingbird	14	0.022	0.026	0.045	0.000	ns
Atthis heloisa	Bumblebee Hummingbird	5	0.000	0.000	0.000	0.073	ns
Selasphorus platycercus	Broad-tailed Hummingbird	33	0.101	0.070	0.013	0.087	0.027
Selasphorus rufus	Rufous Hummingbird	14	0.087	0.006	0.006	0.000	0.005
Trogon mexicanus	Mountain Trogon	144	0.384	0.210	0.338	0.073	0.000
Trogon elegans	Elegant Trogon	26	0.015	0.032	0.038	0.188	0.000
Euptilotis neoxenus	Eared Quetzal	2	0.000	0.000	0.013	0.000	ns
Melanerpes formicivorus	Acorn Woodpecker	64	0.217	0.115	0.083	0.435	0.000
Sphyrapicus varius	Yellow-bellied Sapsucker	4	0.007	0.013	0.006	0.000	ns
Picoides scalaris	Ladder-backed Woodpecker	18	0.007	0.032	0.057	0.044	ns
Picoides stricklandi	Strickland's Woodpecker	55	0.080	0.121	0.115	0.101	ns
Veniliornis fumigatus	Smoky-brown Woodpecker	5	0.015	0.006	0.006	0.015	ns
Colaptes auratus	Northern Flicker	50	0.087	0.115	0.057	0.159	ns
Campephilus guatemalensis	Pale-billed Woodpecker	1	0.007	0.000	0.000	0.000	ns
Sittasomus griseicapillus	Olivaceous Woodcreeper	6	0.000	0.000	0.038	0.000	3.553
Lepidocolaptes leucogaster	White-striped Woodcreeper	234	0.522	0.529	0.395	0.246	0.002
Camptostoma imberbe	Northern Beardless-Tyrannulet	3	0.015	0.006	0.000	0.000	ns
Myiopagis viridicata	Greenish Elaenia	8	0.022	0.022	0.006	0.029	ns
Mitrephanes phaeocercus	Tufted Flycatcher	322	0.464	0.605	0.745	0.667	0.011
Contopus pertinax	Greater Pewee	132	0.116	0.172	0.344	0.507	0.000

Appendix 1, *continued*

Species	English Name	n	Years after treatment			Control	p
			T1	T4	T8		
Empidonax hammondii	Hammond's Flycatcher	10	0.145	0.026	0.013	0.029	ns
Empidonax occidentalis	Cordilleran Flycatcher	199	0.493	0.369	0.360	0.246	0.041
Empidonax fulvifrons	Buff-breasted Flycatcher	8	0.051	0.006	0.000	0.000	ns
Attila spadieus	Bright-rumped Attila	21	0.007	0.019	0.076	0.073	0.008
Myiarchus tuberculifer	Dusky-capped Flycatcher	222	0.515	0.446	0.357	0.362	ns
Pachyramphus major	Gray-collared Becard	6	0.007	0.013	0.006	0.029	ns
Pachyramphus aglaiae	Rose-throated Becard	3	0.015	0.006	0.000	0.000	ns
Vireo plumbeus	Plumbeous Vireo	11	0.015	0.013	0.032	0.029	ns
Vireo huttoni	Hutton's Vireo	106	0.217	0.239	0.140	0.142	0.025
Vireo gilvus	Warbling Vireo	67	0.130	0.134	0.083	0.217	ns
Vireolanius melitophrys	Chestnut-sided Shrike-Vireo	8	0.044	0.006	0.000	0.015	0.039
Cyanocitta stelleri	Steller's Jay	159	0.413	0.248	0.299	0.232	ns
Corvus corax	Common Raven	2	0.000	0.006	0.006	0.000	ns
Poecile sclateri	Mexican Chickadee	9	0.000	0.019	0.038	0.000	ns
Psaltriparus minimus	Bushtit	177	0.275	0.459	0.369	0.130	ns
Sitta carolinensis	White-breasted Nuthatch	43	0.029	0.096	0.153	0.000	0.000
Sitta pygmaea	Pygmy Nuthatch	82	0.232	0.089	0.159	0.159	ns
Certhia americana	Brown Creeper	169	0.283	0.312	0.414	0.232	ns
Campylorhynchus megalopterus	Gray-barred Wren	155	0.370	0.293	0.306	0.145	ns
Catherpes mexicanus	Canyon Wren	1	0.000	0.000	0.000	0.015	ns
Thryothorus felix	Happy Wren	32	0.029	0.032	0.028	0.246	0.043
Troglodytes aedon brunneicollis	House Wren	231	0.754	0.261	0.369	0.406	0.000
Henicorhina leucophrys	Gray-breasted Wood-Wren	23	0.029	0.446	0.038	0.087	ns
Sialia sialis	Eastern Bluebird	32	0.036	0.076	0.064	0.073	ns
Myadestes occidentalis	Brown-backed Solitaire	323	0.601	0.599	0.713	0.493	ns
Catharus aurantiirostris	Orange-billed Nightingale-Thrush	5	0.007	0.006	0.006	0.029	ns
Catharus occidentalis	Russet Nightingale-Thrush	127	0.210	0.248	0.191	0.420	0.018
Catharus franzii	Ruddy-capped Nightingale-Thrush	2	0.000	0.013	0.000	0.000	ns
Catharus guttatus	Hermit Thrush	9	0.007	0.026	0.026	0.000	ns
Turdus assimilis	White-throated Robin	56	0.029	0.104	0.159	0.145	ns
Turdus migratorius	American Robin	88	0.219	0.198	0.121	0.116	ns
Ridgwayia pinicola	Aztec Thrush	95	0.007	0.535	0.051	0.029	ns
Melanotis caerulescens	Blue Mockingbird	58	0.145	0.076	0.076	0.203	0.043
Bombycilla cedrorum	Cedar Waxwing	86	0.000	0.535	0.000	0.029	0.017
Ptilogonys cinereus	Gray Silky-flycatcher	225	0.159	0.707	0.414	0.391	0.011
Peucedramus taeniatus	Olive Warbler	323	0.688	0.701	0.490	0.594	ns

Appendix 1, *continued*

Species	English Name	n	Years after treatment			Control	p
			T1	T4	T8		
Vermivora celata	Orange-crowned Warbler	6	0.007	0.019	0.006	0.015	ns
Vermivora ruficapilla	Nashville Warbler	21	0.022	0.064	0.045	0.015	ns
Vermivora crissalis	Colima Warbler	1	0.000	0.000	0.006	0.000	ns
Parula superciliosa	Crescent-chested Warbler	216	0.558	0.497	0.331	0.130	0.004
Dendroica coronata	Yellow-rumped Warbler	16	0.015	0.045	0.045	0.000	ns
Dendroica nigrescens	Black-throated Gray Warbler	2	0.000	0.000	0.000	0.029	0.004
Dendroica townsendi	Townsend's Warbler	126	0.384	0.166	0.204	0.217	0.041
Dendroica occidentalis	Hermit Warbler	73	0.268	0.083	0.121	0.058	0.030
Dendroica graciae	Grace's Warbler	64	0.022	0.096	0.172	0.275	0.001
Mniotilta varia	Black-and-white Warbler	8	0.007	0.000	0.019	0.058	0.009
Oporornis tolmiei	MacGillivray's Warbler	8	0.051	0.000	0.006	0.000	ns
Wilsonia pusilla	Wilson's Warbler	159	0.268	0.363	0.306	0.246	ns
Cardellina rubrifrons	Red-faced Warbler	43	0.051	0.089	0.089	0.116	ns
Ergaticus ruber	Red Warbler	15	0.015	0.057	0.026	0.000	ns
Myioborus pictus	Painted Redstart	5	0.000	0.006	0.006	0.044	0.018
Myioborus miniatus	Slate-throated Redstart	419	0.841	0.822	0.822	0.652	ns
Basileuterus rufifrons	Rufous-capped Warbler	14	0.000	0.038	0.000	0.116	0.001
Basileuterus belli	Golden-browed Warbler	149	0.457	0.185	0.344	0.044	0.000
Piranga flava	Hepatic Tanager	134	0.297	0.293	0.217	0.188	ns
Piranga rubra	Summer Tanager	9	0.000	0.026	0.032	0.000	ns
Piranga ludoviciana	Western Tanager	3	0.007	0.006	0.000	0.015	ns
Piranga bidentata	Flame-colored Tanager	99	0.261	0.102	0.172	0.290	0.008
Piranga erythrocephala	Red-headed Tanager	10	0.022	0.000	0.019	0.058	ns
Diglossa baritula	Cinnamon-bellied Flowerpiercer	6	0.015	0.013	0.013	0.000	ns
Atlapetes pileatus	Rufous-capped Brush-Finch	46	0.138	0.108	0.064	0.000	ns
Buarremon virenticeps	Green-striped Brush-Finch	74	0.297	0.057	0.147	0.015	0.000
Pipilo ocai	Collared Towhee	31	0.065	0.070	0.064	0.015	ns
Aimophila ruficeps	Rufous-crowned Sparrow	6	0.007	0.006	0.000	0.058	0.001
Chondestes grammacus	Lark Sparrow	2	0.015	0.000	0.000	0.000	ns
Junco phaeonotus	Yellow-eyed Junco	6	0.015	0.026	0.000	0.000	ns
Pheucticus melanocephalus	Black-headed Grosbeak	23	0.065	0.064	0.026	0.000	ns
Passerina versicolor	Varied Bunting	2	0.007	0.000	0.006	0.000	ns
Icterus graduacauda	Audubon's Oriole	18	0.000	0.006	0.019	0.203	0.000
Icterus galbula	Baltimore Oriole	24	0.015	0.076	0.045	0.044	ns
Icterus parisorum	Scott's Oriole	7	0.007	0.026	0.013	0.000	ns
Euphonia elegantissima	Elegant Euphonia	18	0.015	0.032	0.000	0.159	0.012

Appendix 1, *continued*

			Years after treatment				
Species	**English Name**	**n**	**T1**	**T4**	**T8**	**Control**	**p**
Loxia curvirostra	Red Crossbill	4	0.000	0.000	0.000	0.058	0.001
Carduelis pinus	Pine Siskin	32	0.065	0.019	0.051	0.174	0.026
Carduelis notata	Black-headed Siskin	33	0.029	0.022	0.026	0.333	0.000