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Stopover Ecology of Landbirds Migrating Along the Middle Rio Grande in Spring and Fall

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Abstract

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This research represents the first comprehensive summary of our study of stopover ecology of migratory landbirds in riparian habitats along the middle Rio Grande of central New Mexico. We report results from mist-netting operations conducted during spring and fall migration in 1994, 1995, and 1996. A total of 23,800 individuals of 146 species were captured during the study. Of the 146 species, 53 percent were Neotropical migrants, and 32 percent were temperate migrants. The most abundant species were the MacGillivray's Warbler, Wilson's Warbler, and White-crowned Sparrow in spring and the Chipping Sparrow, Pine Siskin, and White-crowned Sparrow in fall. Migrants were most abundant between late April and the first 2 weeks of May in spring and between the last week of August and mid-October. Temperate migrants passed through the sites earlier in spring and later in fall than Neotropical migrants. About 50 percent of the birds had no visible fat stores upon capture. More birds used riparian habitat along the middle Rio Grande for stopover in fall than in spring. Species richness and relative abundance were lower in spring (108 species, 4,673 birds) than in fall (125 species, 19,127 birds). In addition to the influx of hatching-year birds in fall, differential use of migratory routes by landbirds in spring and fall may explain the seasonal difference in capture rate. We recaptured 2,875 birds (12 percent of the total captures) after the day of initial capture. Energetic condition and migratory status affected recapture probability: birds with low fat stores were more likely to stay overnight, and Neotropical species had shorter stopovers than temperate migrants and residents. The average rate of body mass gain across all species was 7.46 ± 0.10 percent/day in spring and was 4.68 ± 0.05 percent/day in fall, suggesting that migrants were not only able to gain energy for regular metabolic needs, but also for accumulating fat stores for migration. The capture rate was highest in willow habitat (288 birds/1,000 net hour) in spring and in agricultural field/edge habitat (718 birds/1,000 net hour) in fall. Cottonwood with Russian olive understory had the highest species richness in spring (80 species) and in fall (94 species). Saltcedar habitat had lowest species richness both in spring (26 species) and in fall (33 species). Detrended correspondence analysis of spring migration data separated species with high abundance in saltcedar from species with high capture rates in cottonwood overstory habitats, and in agriculture and willow habitats. The same analysis for fall data separated species with high capture rates in habitats dominated by agriculture, willow, saltcedar, and cottonwood. Species composition was most similar between agricultural habitat and cottonwood/Russian olive habitat in spring and among habitats with cottonwood as overstory in fall. During fall migration, about 60 percent of the birds captured were immatures. Body masses of adult birds were generally higher than those of immature birds, and young birds were more likely to be fat-depleted when they captured at our sites. The rate of mass gain was similar between immatures and adults. Our study confirms that riparian habitats along the middle Rio Grande of central New Mexico are important stopover sites during spring and fall migration for birds that breed in New Mexico, its adjacent States, and at a much larger geographic scale. Habitat loss and disturbance along the middle Rio Grande could affect not only local breeding landbird populations, but also many Neotropical and temperate migratory individuals that may use the area for only a few days each migration season.

Keywords: Neotropical migrants, Rio Grande, bird migration, riparian, New Mexico, tamarisk

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Cover photos: Top right photo: a Neotropical long-distance migrant, the Wilson's Warbler (*Wilsonia pusilla*). Middle left photo: A temperate, short-distance migrant, the Song Sparrow (*Melospiza melodia*). Bottom right photo: Assistant Mike Means removing a migratory bird from a mist net. Photo credits: RMRS staff.

Stopover Ecology of Landbirds Migrating Along the Middle Rio Grande in Spring and Fall

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Introduction

The Rio Grande, one of the longest rivers in North America (approximately 3,000 km), originates in Southern Rocky Mountains of Colorado, flows the whole length of New Mexico and forms the entire border between Texas and Mexico. It is the second greatest source of permanent water in the desert Southwest, behind the Colorado River, and supports the largest cottonwood (*Populus fremontii*) forest in North America. However, riparian habitats along the Rio Grande are under increasing pressure from human activities. Water management, catastrophic fires, recreation, urban development, and invasion of exotic plant species such as saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) have altered riparian habitats, potentially influencing wildlife use (Finch and others 1995). Knopf (1988) estimated that more than 90 percent of the original desert riparian habitat in the Western United States has been eliminated by flood control and irrigation projects.

Because of its south-north orientation and abundant, diverse riparian habitats, the Rio Grande may serve as a valuable migratory route for many songbird migrants that breed in North America and winter in more tropical areas in Mexico, Central America, and South America (Keast and Morton 1980), and for species that migrate within the North American biogeographic realm. Because the vegetation along the riverbank is typically narrow and surrounded by arid and harsh environment, the riparian habitat along the Rio Grande in New Mexico may represent a bottleneck during migration. Many North American songbird species and individuals funnel into these limited habitats on their journeys to the breeding grounds in spring or to the wintering ground in fall (Finch and Yong 2000, Yong and Finch 1996, 1997a). The availability of food, water, cover, and suitable north-south routing along the river may be critically important and strongly influential in directing migration of landbirds (Finch and Yong 2000, Ligon 1961, Stevens and others 1977, Wauer 1977, Yong and Finch 1996).

The conservation of Neotropical migratory songbirds has been the subject of considerable interest because some species have declined in recent years (Askins and others 1990, Martin and Finch 1995, Moore 2000). The population status of migratory landbirds in Western North America is less well documented than that in the East. However, recent studies based on Breeding Bird Survey (BBS) (Robbins and others 1986, Sauer and Droege 1992, Peterjohn and Sauer 1993), counts of migrating birds (Pyle and others 1994), and historic data (Marshall 1988, DeSante and George 1994) indicate that populations of some western songbird migrants have also declined. Herkert (1995) found that several grassland bird species exhibited major population declines in the Midwest between 1966 and 1993. DeSante and George (1994) and Yong and Finch (1997b) reported that numerous bird species in the Western United States were extirpated from various States, had experienced contraction of breeding ranges over time, or showed local population reductions.

Declines in populations of migratory songbirds species have been attributed to events associated with both breeding and wintering areas (Sherry and Holmes 1995). The rapid rate of deforestation in tropical areas, for example, has been implicated in population declines of many forest-dwelling landbird migrants (Lovejoy 1983, Rappole and others 1983, Robbins and others 1989a). Other study results point to changes in suitability of breeding habitat (Whitcomb 1977, Hutto 1988). For example, forest-interior migrants are reported to be area-sensitive (Robbins 1980, Robbins and others 1989b), which explains, in part at least, why fragmentation of forested breeding habitat has been implicated in the population declines of migratory birds (Lynch and Whigham 1984, Wilcove 1988). Recently, more researchers have suggested that stopover habitat along migratory routes may play an important role in the population dynamics of migratory songbirds (Finch 1991, Moore and others 1995, Yong and others 1998, Finch and Yong 2000). Because the persistence of migrant populations depends on the bird's ability to find favorable conditions for survival throughout the annual cycle (Morse 1980), analyses of population ecology need to account for factors associated with en route ecology of migrants (Moore and Simons 1992). How well migrants "offset" costs of migration—that is, satisfy their energy demands and meet contingencies that arise en route—may affect the success of an individual's migration as well as the future status of the population itself. As stopover habitats are degraded or lost, the cost of migration increases and the probability of a successful migration decreases.

Anthropogenic modification of riparian stopover habitats may have a greater impact on population dynamics of songbird migrants in Western North America where riparian and deciduous woodlands are limited in availability than in the East (Terborgh 1989). When migrants stopover, they may have to adjust their foraging behavior to unfamiliar habitats, resolve conflicting demands of predator avoidance and food acquisition, compete with other migrants and resident birds for limiting resources, respond to unpredictable and sometimes unfavorable weather, and correct for orientation errors (Moore and Simons 1992). These problems are magnified when songbirds migrate through inhospitable environments such as deserts and arrive at stopover sites with depleted energy stores.

No systematic research has been conducted to study stopover ecology of migratory songbirds along the middle Rio Grande despite its potential importance to landbird migration (Finch and Yong 2000). The objectives of this research were to (1) determine species composition, relative abundance, and timing of spring and fall migration of songbirds along the middle Rio Grande, (2) evaluate the distribution of migrants among habitats, (3) investigate the stopover biology of migrants including stopover length, energetic condition, and amount and rate of mass gain, and (4) investigate the potential effect of habitat differences on the stopover ecology of songbird migrants along the middle Rio Grande of New Mexico.

Methods

Study Site

The middle Rio Grande riparian forest, locally known as the "bosque," represents one of the largest cottonwood (*Populus* spp.) gallery forests in the Southwestern United States. This wooded reach of the Rio Grande extends from Cochiti Dam, Sandoval, NM, downstream 260 km to San Marcial, NM (Howe and Knopf 1991). We established netting sites at the Rio Grande Nature Center (RGNC) (N 35°07' and W 106°41'), Bernalillo County, and at the Bosque del Apache National Wildlife Refuge (BNWR) (N33°48' and W106°52'), Socorro County, New Mexico. The floodplain at these sites is typically level and broad, varying from 2 to 10 km. Riparian forest habitat lies within or immediately adjacent to the levees paralleling the river. The remainder of the floodplain has largely been converted to agriculture or residential areas. The netting locations were classified into cottonwood/native understory (including willows, mesquite, and New Mexico olive), cottonwood/Russian olive, cottonwood/saltcedar, saltcedar, willow, or agriculture field/edge based on a riparian/wetland vegetation community classification developed by Durkin and others (1996). The first three habitat types are dominated by Rio Grande cottonwood (*Populus fremontii var. wislizeni*) in association with a variety of understory shrubs and small trees, chiefly willows (*Salix spp*), screwbean mesquite (*Prosopis pubescens*), New Mexico olive (*Forestiera neomexicana*), false indigo (*Amorpha fruticosa*), seepwillow (*Baccharis glutinosa*), Russian olive (*Elaeagnus angustiflia*), and saltcedar (*Tamarix spp*.). Cottonwood trees generally reach 10 to 15 m in height and the foliage volume varies depending on the age of the forest stands. The shrub layer is best developed in more open areas of these habitats. Cottonwood/Russian olive habitat is characterized by a nearly monotypic understory of dense to moderately dense Russian olive; herbaceous growth is sparse to absent. The saltcedar habitat is essentially dense monotypic saltcedar shrub stands with widely scattered wolfberry (*Lycium andersonii*) shrubs or patches of arrowweed (*Tessaria sericea*). The willow habitat is composed of dense shrubs between 2 to 4 m tall located immediately along the banks of irrigation water channels. The agricultural habitat is composed primarily of alfalfa (*Medicago stiva*) and corn (*Zea mays*) with heights not exceeding 3 m.

Capture and Recapture

We collected data in spring from 4 April to 15 June 1994, 3 April to 9 June 1995, and from 8 April to 7 June 1996, and in fall from 1 August to 13 November 1994, from 31 July to 12 November 1995, and from 3 August to 10 November 1996. Forty standard mist-nets (12 x 2.6 m) were used to capture birds (20 nets/site), except in 1996 when 20 additional nests were added in BNWR, 14 of which were located at willow stands along an irrigation channel and other six in a saltcedar stands. The netting area for the first 20 nests at each site was about 30 ha (net density approximately 1.5 nets/ha). The nets were placed approximately in proportion to availability of habitats and opportunistically within each habitat, such as in brushy portions of wooded areas, forest edges or breaks, or near water, where birds could be captured most efficiently (Ralph and others 1993). The nets were maintained at the same, or approximately the same, locations from year to year.

To avoid sampling bias, nets were operated simultaneously throughout the seasons and across habitat types, and were checked regularly at 20 to 30 minute intervals. Weather permitting, nets were opened 15 minutes before sunrise and remained open for about 6 hours every morning. For each bird captured, we measured body mass (± 0.1 g using an electronic balance), unflattened wing chord (± 0.5 mm), tail length (± 0.5 mm), and tarsus length (± 0.1 mm). Each bird was banded with a numbered aluminum leg band. Recaptured birds were reweighed without reference to previous records. Age and sex identification was based on Pyle and others (1987) and the North American Bird Banding Manual (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1991).

We estimated the amount of fat stores by observing the visible subcutaneous fat in the interclavicular fossa and on the abdomen following a 6-point scale (Helms and Drury 1960). Fat scores provide a fairly precise index of fat stores as long as the variability between observers is controlled (Krementz and Pendleton 1990). Field assistants were trained so that observational variation among individuals was minimized. Because the proportion of birds identified as fat class ≥ 4 was small in this study, we combined birds that had fat class ≥ 3 into a single group for fat class analysis.

We estimated length of stay (stopover length) of recaptured birds by subtracting the date of first capture from the date of last capture. This method yielded a conservative estimate because we assumed that birds arrived on the day of initial banding and departed on the day of last recapture (Cherry 1982). Individuals that were not recaptured were assumed to have left the study sites the same day they were banded and were assigned a length of stay of zero. We referred to the birds captured after the day of initial capture as recaptures and all other birds as nonrecaptures. We analyzed recapture data for all species that had five or more individuals that were recaptured. We were aware that this method overestimated the stopover length of species and individuals that bred locally and interpreted results with caution.

Body mass and fat class changes during stopover were estimated based on recaptured birds by using the difference between the mass and fat class at initial capture and that at last capture, respectively. Because the majority of birds encountered in the study contributed a single data point of body mass (no recapture data), we performed a linear regression analysis between the time and body mass at initial capture based on all individuals captured for each species (Winker and others 1992a). Recapture data were not used in this analysis. We used the slope of the regression equation as the hourly rate of body mass change. We estimated daily percentage mass based on two methods:

1. body mass change during stopover of recaptured birds:
(% body mass change = mass change $*$ initial body mass^{-1} $*$ stopover length in days^{-1}) $*$ 100, where mass change is estimated from body mass difference between last capture and initial capture, and stopover length is estimated from the difference between last and initial capture date; and
2. regression slope of hourly rate of mass change of all birds at initial capture:
% body mass change = (hourly rate of mass change $*$ 8 hr $*$ lean body mass^{-1}) x 100,

where the lean body mass was estimated from average body mass of all birds in the fat class 0 of each species, hourly rate of mass change is estimated from regression slope; we assumed birds had 8 hour to gain body mass per day.

We examined differences in the rate of mass gain between groups by testing the equality of slopes between regression models with analysis of covariance (ANCOVA). We assumed that water gain or loss was negligible (Nisbet and others 1963, Rogers and Odum 1994, 1966, Winker 1995).

We followed Robbins and others (1989b) and Hussell and others (1992) in classifying species as tropical or temperate migrants in accordance with winter distributions (AOU 1998, Root 1988). Migratory species wintering mainly north of 25°N were classified as temperate and all others were tropical migrants.

Data Analysis

The netting efforts were recorded as net hr (net-hour), that is, one net operated for 1 hr = 1 net hr. To compare the relative abundance of migrants among habitats, we adjusted net hr variation by calculating a capture-rate index for each species in relation to each habitat. We divided the total number of captures by the total number of net hr in a given habitat, and then multiplied the result by 1,000. This calculation produced an abundance index of birds/1,000 net hr. We used total number of species captured, Shannon diversity, and evenness indices (Krebs 1998) to estimate avian species richness and diversity in each habitat. Shannon diversity and evenness indices were based on birds/1,000 net hr so that netting effort variations among habitat types were adjusted. To compare the species composition between habitats, we used Jaccard's similarity coefficient: $S_j = a * (a + b + c)^{-1}$, where a is the number of species occurring in both habitats, and b and c are the number of species occurring only in the first or the second habitat, respectively (Krebs 1998). To summarize bird community characteristics, we applied a detrended correspondence analysis (DCA). DCA is an ordination method for adapting a multidimensional dataset (species and habitat) in such a way that when it is projected onto a reduced dimensional space, the intrinsic pattern that the dataset may possess becomes apparent (Pielou 1984). We used DCA instead of principle component analysis because we expected that migrants might not respond linearly to environment gradients. To control variation in sampling effort among habitats and to avoid the disproportional effect of accidental or rare species on the analyses, DCA was based on relative abundance data (birds/1,000 net hr) and on species with captures ≥ 1 bird/1,000 net hr.

Our research represents the first comprehensive study of stopover ecology of migratory landbirds in both spring and fall along the middle Rio Grande. Hink and Ohmart (1984) studied riparian habitats and associated terrestrial vertebrate communities of the middle Rio Grande from 1981 to 1983. Their study provided a comprehensive dataset on landbird species composition and relative abundance in the area. As a follow-up to Hink and Ohmart, and to assess bird population changes, Hoffman (1990) conducted avian surveys in the middle Rio Grande Valley State Park from 1987 to 1990. We compared our data with results from these two studies by applying a relative abundance scale modified from Hink and Ohmart (1984) and Hoffman (1990). We classified 146 captured species into four categories based on relative capture rate: Abundant (≥ 5 birds/1,000 net hr), Common (≥ 1 birds/1,000 net, but < 5 birds/1,000 net hr), Uncommon (≥ 0.1 birds/1,000 net hr, but < 1 birds/1,000 net hr), R = rare (< 0.1 birds/1,000 net hr) (table 1). We then examined the relationship among these datasets with Spearman's rank correlation.

Table 1—Comparison of species composition and relative abundance of middle Rio Grande migrants captured during this study and recorded by Hoffman (1990) and Hink and Ohmart (1984). Species are arranged in the order of total captures. See appendix I for species codes and taxonomic groups.

Species	Total[1]	%[2]	Birds/1,000nh[3]	Class[4]	Hoffman[5]	Hink & Ohmart[6]
WIWA	3354	14.09	35.02	A	C	A
CHSP	2706	11.37	28.25	A	R	C
PISI	1687	7.09	17.61	A	C	C
WCSP	1457	6.12	15.21	A	A	A
MGWA	1304	5.48	13.61	A	C	C
YRWA	870	3.66	9.08	A	C	A
DEJU	857	3.60	8.95	A	A	A
OCWA	831	3.49	8.68	A	R	C
RCKI	636	2.67	6.64	A	U	C
LAZB	623	2.62	6.50	A	R	C
LASP	567	2.38	5.92	A		C
BRSP	506	2.13	5.28	A		C
YWAR	489	2.05	5.11	A	R	C
SOSP	446	1.87	4.66	C	A	C
BLGR	430	1.81	4.49	C	C	A
LISP	416	1.75	4.34	C	R	U
DUFL	398	1.67	4.16	C		C
LEGO	397	1.67	4.15	C	C	C
BHGR	349	1.47	3.64	C	A	A
HOFI	324	1.36	3.38	C	C	C
AMGO	295	1.24	3.08	C	U	C
HETH	254	1.07	2.65	C	U	C
SPTO	251	1.05	2.62	C	U	C
VIWA	248	1.04	2.59	C		C
VESP	248	1.04	2.59	C		U
RWBL	238	1.00	2.48	C	C	A
WAVI	229	0.96	2.39	C	C	C
GTTO	225	0.95	2.35	C	R	C
AMRO	221	0.93	2.31	C	A	C
SAVS	217	0.91	2.27	C		C
WEWP	215	0.90	2.24	C	U	C
WIFL	213	0.89	2.22	C	R	C
COYE	213	0.89	2.22	C	U	C

(con.)

Table 1 (Con.).

Species	Total[1]	%[2]	Birds/1,000nh[3]	Class[4]	Hoffman[5]	Hink & Ohmart[6]
CCSP	202	0.85	2.11	C		R
BEWR	160	0.67	1.67	C	U	C
HOWR	153	0.64	1.60	C	U	C
WETA	139	0.58	1.45	C	C	C
SUTA	107	0.45	1.12	C	R	C
BUOR	82	0.34	0.86	U	U	U
WEFL	72	0.30	0.75	U		R
GRFL	70	0.29	0.73	U		U
SOVI	64	0.27	0.67	U	R	U
BLPH	56	0.24	0.58	U	R	C
YBCH	55	0.23	0.57	U	U	C
RSFL	46	0.19	0.48	U	C	C
HAFL	41	0.17	0.43	U		R
MOCH	41	0.17	0.43	U	U	R
ATFL	36	0.15	0.38	U	U	C
WEKI	35	0.15	0.37	U	R	C
BHCO	34	0.14	0.35	U	A	C
BCCH	33	0.14	0.34	U	C	U
NOWA	33	0.14	0.34	U		U
COBU	32	0.13	0.33	U		U
MODO	30	0.13	0.31	U	A	A
WBNU	30	0.13	0.31	U	U	U
BRCR	28	0.12	0.29	U	U	C
BARS	24	0.10	0.25	U	C	C
DOWO	21	0.09	0.22	U	U	C
NRWS	21	0.09	0.22	U	U	C
INBU	21	0.09	0.22	U	R	C
SCJA	18	0.08	0.19	U	U	C
GRCA	18	0.08	0.19	U	R	C
NOMO	18	0.08	0.19	U	R	C
TOWA	15	0.06	0.16	U		R
WTSP	15	0.06	0.16	U	R	U
OVEN	14	0.06	0.15	U		R
YHBL	14	0.06	0.15	U	R	C
GTGR	14	0.06	0.15	U	C	U
SSHA	13	0.05	0.14	U	U	U
YBCU	13	0.05	0.14	U	R	U
RBNU	13	0.05	0.14	U	R	R
LARB	13	0.05	0.14	U		R
SAPH	12	0.05	0.13	U	R	C
BGGN	12	0.05	0.13	U	U	U
SWTH	11	0.05	0.11	U	R	R
OSFL	10	0.04	0.10	R	R	C
MAWR	10	0.04	0.10	R	R	C
RNSA	9	0.04	0.09	R		U
NAWA	9	0.04	0.09	R		R
COHA	8	0.03	0.08	R	U	C
HAWO	7	0.03	0.07	R	R	R
BEKI	6	0.03	0.06	R	U	C
LUWA	6	0.03	0.06	R		R
PABU	6	0.03	0.06	R		
WEME	6	0.03	0.06	R	U	C
CAFI	6	0.03	0.06	R	R	R
AMKE	5	0.02	0.05	R	U	C
BCFL	5	0.02	0.05	R		
GCKI	5	0.02	0.05	R		R
LBWO	4	0.02	0.04	R		R
LEFL	4	0.02	0.04	R		R
VERD	4	0.02	0.04	R		U
BTYW	4	0.02	0.04	R	R	U

(con.)

Table 1 (Con.).

Species	Total[1]	%[2]	Birds/1,000nh[3]	Class[4]	Hoffman[5]	Hink & Ohmart[6]
BAWW	4	0.02	0.04	R		R
HETA	4	0.02	0.04	R		
RBGR	4	0.02	0.04	R		R
CANT	4	0.02	0.04	R		U
TOSO	3	0.01	0.03	R	R	R
PROW	3	0.01	0.03	R		R
MAWA	3	0.01	0.03	R		R
AMRE	3	0.01	0.03	R		R
KEWA	3	0.01	0.03	R		R
HOWA	3	0.01	0.03	R		R
BTSP	3	0.01	0.03	R		C
GRSP	3	0.01	0.03	R		
SWSP	3	0.01	0.03	R	R	R
OROR	3	0.01	0.03	R		
GRRO	2	0.01	0.02	R	C	C
WISA	2	0.01	0.02	R		R
ROWR	2	0.01	0.02	R		R
GRVI	2	0.01	0.02	R		
REVI	2	0.01	0.02	R	R	R
CSWA	2	0.01	0.02	R		
PYRR	2	0.01	0.02	R	R	
DICK	2	0.01	0.02	R		R
WWDO	1	0.00	0.01	R		
CONI	1	0.00	0.01	R	R	C
VGSW	1	0.00	0.01	R	C	C
BANS	1	0.00	0.01	R	R	U
PLTI	1	0.00	0.01	R		U
CACW	1	0.00	0.01	R		
WIWR	1	0.00	0.01	R		R
CARW	1	0.00	0.01	R		
SATH	1	0.00	0.01	R		R
BRTH	1	0.00	0.01	R		R
CRTH	1	0.00	0.01	R		U
BEVI	1	0.00	0.01	R		
YTVI	1	0.00	0.01	R		R
BWWA	1	0.00	0.01	R		
LAWA	1	0.00	0.01	R		
BTBW	1	0.00	0.01	R		
BLBW	1	0.00	0.01	R		
PRAW	1	0.00	0.01	R		
WPWA	1	0.00	0.01	R		R
TEWA	1	0.00	0.01	R	R	R
MOWA	1	0.00	0.01	R		
CAWA	1	0.00	0.01	R		
SCTA	1	0.00	0.01	R		
CASP	1	0.00	0.01	R		
ATSP	1	0.00	0.01	R		U
SAGS	1	0.00	0.01	R		U
FOSP	1	0.00	0.01	R		R
GCSP	1	0.00	0.01	R		R
COGR	1	0.00	0.01	R		U
WWCR	1	0.00	0.01	R		
EVGR	1	0.00	0.01	R	U	R

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[1] Total birds captured (not include recaptures).

[2] Percent of all captures (23,800 birds).

[3] Birds captured/1,000 net-hr.

[4] Relative abundance class based on capture rate: A = abundant (capture rate ≥ 5 birds/1,000 net hr), C = common (1 birds/1,000 net hr ≤ capture rate < 5 birds/1,000 net hr), U = uncommon (0.1 birds/1,000 net hr ≤ capture rate < 1 birds/1,000 net hr), R = Rare (capture rate < 0.1 birds/1,000 net hr).

[5] "Accidental" species group in the original study (Hoffman 1990) was combined with "rare" species group for the comparison.

[6] "Fairly common" species group in the original study (Hink and Ohmart 1984) was combined with "common" species group for the comparison.

Normality and homogeneity testing variables were examined. We applied a fixed effect general linear model to examine among-group variations when assumptions for parametric statistics were met, and used nonparametrical procedures otherwise. After careful examination of among-year variation, we combined the 3 years of data for all the analyses. We also grouped the data from the two sites for some analyses. Data grouping was justified based on the following reasons: (1) we were interested in the general stopover patterns of migratory landbirds along the middle Rio Grande, (2) our research was exploratory, (3) data combination made our analysis more robust to among-year or between-site variations, (4) the two sites were close to each other (approximately 100 km), (5) net locations at the two study sites represented different habitats in most cases, and (6) combining data allowed us to test some hypotheses that otherwise would not be possible because of sample size limitations. Data grouping should have limited effect about our conclusions because we operated mist-nets concurrently at most net locations during the study, and variation among years was small.

Means and standard deviations are reported through the manuscript. A statistical significance level of a = 0.05 was used unless otherwise indicated. Most analyses were performed with SPSS/PC (SPSS 1996). Shannon diversity and evenness indices, Jaccard's similarity coefficient were calculated with MVSP software (Kovach 1995), and detrended correspondence analysis was performed with CANOCO (ter Braak and Smilauer 1998).

Results

Species Composition and Relative Abundance

We operated 35,190 net hr in spring and 60,587 net hr in fall over 3 years. Between-season variation in netting effort was due to a longer migration season in fall. On average, we operated 43 ± 3 days/year in spring and 63 ± 4 days/year in fall at BNWR, and 47 ± 3 days/year in spring and 94 ± 5 days/year in fall at RGNC. In total, 23,800 landbirds, representing 146 species, were banded during the study. Neotropical migrants accounted for 77 species and 62.6 percent of all captures, temperate migrants accounted for 47 species and 35.7 percent of all captures, and resident species accounted for 18 species and 1.6 percent of the total captures. The White-winged Dove, Brown-crested Flycatcher, Cactus Wren, and Lucy's Warbler bred primarily south of the U.S. and Mexican border and entered the United States along the Rio Grande Valley; these four species accounted for 0.1 percent of the total captures. The five most abundant species made up 44 percent of total captures. Wilson's Warbler was the most abundant species (12.1 percent), followed by the Chipping Sparrow (11.2 percent), Pine Siskin (7.1 percent), White-crowned Sparrow (6.1 percent), and MacGillivray's Warbler (5.5 percent) (table 2). The next five most abundant species were Yellow-rumped Warbler (3.7 percent), Dark-eyed Junco (3.6 percent), Orange-crowned Warbler (3.5 percent), Ruby-crowned Kinglet (2.7 percent), and Lazuli Bunting (2.6 percent) (table 2).

Species richness and relative abundance were lower in spring than in fall. Of 23,800 birds, 4,673 (19.6 percent) birds of 108 species were captured in spring and 19,127 (80.4 percent) birds of 125 species were captured in fall. Capture rate on average was 133 birds/1,000 net hr in spring and 315 birds/1,000 net hr in fall. In spring, 10 species made up 65 percent of the captures; the MacGillivray's Warbler was the most abundant species (16.9 percent), followed by the Wilson's Warbler (14.1 percent), White-crowned Sparrow (6.1 percent), Dusky Flycatcher (5.6 percent), Yellow-rumped Warbler (5.5 percent), Red-winged Blackbird (4.2 percent), Black-headed Grosbeak (3.9 percent), Common Yellowthroat (2.8 percent), Yellow Warbler (2.7 percent), and American Robin (2.7 percent) (table 2). In fall, 10 species made up 63 percent of the captures; the Wilson's Warbler was the most abundant species (14.1 percent), followed by the Chipping Sparrow (13.9 percent), Pine Siskin (8.8 percent), White-crowned Sparrow (6.1 percent), Dark-eyed Junco (4.1 percent), Orange-crowned Warbler (4.0 percent), Yellow-rumped Warbler (3.2 percent), Lazuli Bunting (3.2 percent), Ruby-crowned Kinglet (2.9 percent), and Lark Sparrow (2.9 percent) (table 2).

Twenty-one species were captured only during spring migration (spring-only species). Most were *Parulinae* warblers including species such as the Blackburnian Warbler, Blue-winged Warbler, Canada Warbler, Chestnut-sided Warbler, Hooded Warbler, Kentucky Warbler, Lawrence's Warbler, Magnolia Warbler, Mourning Warbler, and Prairie Warbler. These species breed mostly in the Eastern North America and are considered as rare and accidental species along the middle Rio Grande during spring migration (Hubbard 1978). Of the 21 spring-only species, 76.2 percent were Neotropical migrants, 14.3 percent were temperate migrants, and 9.5 percent had a breeding range along the U.S./Mexico board. Thirty-eight species were captured only during fall migration (fall-only species). Compared to spring-only species, fall-only species were composed of more diverse taxonomic groups, more temperate migratory species (45 percent) and fewer Neotropical migratory species (36.8 percent), and fewer Eastern breeding species (the Least Flycatcher, Orchard Oriole, Painted Bunting, Prothonotary Warbler, Tennessee Warbler, and Scarlet Tanager).

Table 2—Landbirds captured during spring and fall migration of 1994, 1995, and 1996 at Bosque del Apache National Wildlife Refuge (BNWR) and Rio Grande Nature Center (RGNC) of the middle Rio Grande Valley of New Mexico.

	BNWR		**RGNC**		**Total by season and site**				
Species	**Spring**	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**	**BNWR**	**RGNC**	**Total**
SSHA	1	0	0	12	1	12	1	12	13
COHA	0	1	2	5	2	6	1	7	8
AMKE	1	0	1	3	2	3	1	4	5
MODO	0	0	13	17	13	17	0	30	30
WWDO	0	0	1	0	1	0	0	1	1
YBCU	7	6	0	0	7	6	13	0	13
GRRO	0	1	0	1	0	2	1	1	2
CONI	0	0	0	1	0	1	0	1	1
BEKI	0	0	0	6	0	6	0	6	6
DOWO	1	6	5	9	6	15	7	14	21
HAWO	2	5	0	0	2	5	7	0	7
RNSA	0	5	0	4	0	9	5	4	9
WISA	0	1	0	1	0	2	1	1	2
LBWO	2	2	0	0	2	2	4	0	4
RSFL	2	11	1	32	3	43	13	33	46
OSFL	6	0	1	3	7	3	6	4	10
WEWP	56	37	43	79	99	116	93	122	215
HAFL	9	9	1	22	10	31	18	23	41
LEFL	0	0	0	4	0	4	0	4	4
WIFL	47	34	46	86	93	120	81	132	213
DUFL	177	33	85	103	262	136	210	188	398
GRFL	19	21	13	17	32	38	40	30	70
WEFL	6	21	3	42	9	63	27	45	72
BLPH	22	2	10	22	32	24	24	32	56
SAPH	1	1	0	10	1	11	2	10	12
ATFL	23	0	10	3	33	3	23	13	36
BCFL	3	2	0	0	3	2	5	0	5
WEKI	2	0	3	30	5	30	2	33	35
BARS	7	6	4	7	11	13	13	11	24
VGSW	1	0	0	0	1	0	1	0	1
BANS	0	0	1	0	1	0	0	1	1
NRWS	19	0	1	1	20	1	19	2	21
SCJA	0	5	5	8	5	13	5	13	18
MOCH	1	6	0	34	1	40	7	34	41
BCCH	0	0	6	27	6	27	0	33	33
PLTI	0	0	0	1	0	1	0	1	1
COBU	0	1	1	30	1	31	1	31	32
VERD	0	4	0	0	0	4	4	0	4
RBNU	0	6	0	7	0	13	6	7	13
WBNU	5	7	7	11	12	18	12	18	30
BRCR	0	13	0	15	0	28	13	15	28
ROWR	0	1	0	1	0	2	1	1	2
CACW	0	1	0	0	0	1	1	0	1
BEWR	31	57	4	68	35	125	88	72	160
HOWR	39	21	20	73	59	94	60	93	153
MAWR	1	5	1	3	2	8	6	4	10
WIWR	0	1	0	0	0	1	1	0	1
CARW	1	0	0	0	1	0	1	0	1
RCKI	56	369	17	194	73	563	425	211	636
GCKI	2	1	0	2	2	3	3	2	5
BGGN	4	0	5	3	9	3	4	8	12
TOSO	1	2	0	0	1	2	3	0	3
SWTH	6	4	0	1	6	5	10	1	11
HETH	24	33	41	156	65	189	57	197	254
AMRO	32	2	93	94	125	96	34	187	221

(con.)

Table 2 (Con.)

	BNWR		RGNC		Total by season and site				
Species	**Spring**	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**	**BNWR**	**RGNC**	**Total**
GRCA	5	7	4	2	9	9	12	6	18
NOMO	7	0	10	1	17	1	7	11	18
SATH	0	0	1	0	1	0	0	1	1
BRTH	0	1	0	0	0	1	1	0	1
CRTH	0	1	0	0	0	1	1	0	1
BEVI	0	0	1	0	1	0	0	1	1
GRVI	1	0	1	0	2	0	1	1	2
SOVI	18	16	1	29	19	45	34	30	64
WAVI	57	64	22	86	79	150	121	108	229
REVI	1	1	0	0	1	1	2	0	2
YTVI	1	0	0	0	1	0	1	0	1
PROW	0	2	0	1	0	3	2	1	3
BWWA	1	0	0	0	1	0	1	0	1
LAWA	0	0	1	0	1	0	0	1	1
OCWA	45	94	18	674	63	768	139	692	831
NAWA	4	0	1	4	5	4	4	5	9
MAWA	2	0	1	0	3	0	2	1	3
VIWA	29	59	14	146	43	205	88	160	248
LUWA	6	0	0	0	6	0	6	0	6
YWAR	83	131	43	232	126	363	214	275	489
CSWA	2	0	0	0	2	0	2	0	2
YRWA	79	105	177	509	256	614	184	686	870
BTYW	2	0	0	2	2	2	2	2	4
BTBW	0	1	0	0	0	1	1	0	1
BLBW	0	0	1	0	1	0	0	1	1
TOWA	3	5	0	7	3	12	8	7	15
PRAW	1	0	0	0	1	0	1	0	1
BAWW	1	2	0	1	1	3	3	1	4
AMRE	1	2	0	0	1	2	3	0	3
WPWA	0	0	1	0	1	0	0	1	1
NOWA	0	10	7	16	7	26	10	23	33
OVEN	9	0	4	1	13	1	9	5	14
TEWA	0	0	0	1	0	1	0	1	1
MOWA	1	0	0	0	1	0	1	0	1
MGWA	319	145	473	367	792	512	464	840	1304
COYE	114	65	15	19	129	84	179	34	213
KEWA	2	0	1	0	3	0	2	1	3
CAWA	1	0	0	0	1	0	1	0	1
WIWA	547	1026	110	1671	657	2697	1573	1781	3354
HOWA	2	0	1	0	3	0	2	1	3
YBCH	38	10	3	4	41	14	48	7	55
HETA	0	2	0	2	0	4	2	2	4
SUTA	34	65	4	4	38	69	99	8	107
WETA	8	44	7	80	15	124	52	87	139
SCTA	0	0	0	1	0	1	0	1	1
PYRR	0	2	0	0	0	2	2	0	2
RBGR	2	0	1	1	3	1	2	2	4
BHGR	97	80	84	88	181	168	177	172	349
BLGR	77	121	20	212	97	333	198	232	430
LAZB	6	43	4	570	10	613	49	574	623
INBU	7	6	2	6	9	12	13	8	21
PABU	0	3	0	3	0	6	3	3	6
DICK	0	0	0	2	0	2	0	2	2
GTTO	21	22	51	131	72	153	43	182	225
CASP	0	0	1	0	1	0	0	1	1
SPTO	61	79	7	104	68	183	140	111	251

(con.)

Table 2 (Con.)

	BNWR		RGNC		Total by season and site				
Species	**Spring**	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**	**BNWR**	**RGNC**	**Total**
CANT	1	0	0	3	1	3	1	3	4
CHSP	34	392	7	2273	41	2665	426	2280	2706
ATSP	0	0	0	1	0	1	0	1	1
CCSP	0	40	0	162	0	202	40	162	202
BRSP	58	111	8	329	66	440	169	337	506
VESP	4	6	2	236	6	242	10	238	248
LASP	5	63	1	498	6	561	68	499	567
BTSP	1	2	0	0	1	2	3	0	3
SAGS	0	1	0	0	0	1	1	0	1
LARB	0	0	0	13	0	13	0	13	13
SAVS	0	56	23	138	23	194	56	161	217
GRSP	0	0	0	3	0	3	0	3	3
SOSP	7	244	7	188	14	432	251	195	446
FOSP	0	1	0	0	0	1	1	0	1
LISP	15	160	11	230	26	390	175	241	416
SWSP	0	1	0	2	0	3	1	2	3
WTSP	2	5	2	6	4	11	7	8	15
GCSP	0	0	0	1	0	1	0	1	1
WCSP	178	373	106	800	284	1173	551	906	1457
DEJU	56	327	14	460	70	787	383	474	857
YHBL	0	1	0	13	0	14	1	13	14
RWBL	1	1	197	39	198	40	2	236	238
WEME	0	0	1	5	1	5	0	6	6
COGR	0	0	0	1	0	1	0	1	1
GTGR	0	0	12	2	12	2	0	14	14
BHCO	21	2	6	5	27	7	23	11	34
OROR	0	0	0	3	0	3	0	3	3
BUOR	11	10	3	58	14	68	21	61	82
CAFI	0	0	0	6	0	6	0	6	6
HOFI	18	2	1	303	19	305	20	304	324
PISI	0	0	0	1687	0	1687	0	1687	1687
LEGO	9	16	1	371	10	387	25	372	397
WWCR	0	0	0	1	0	1	0	1	1
AMGO	2	4	0	289	2	293	6	289	295
EVGR	0	0	0	1	0	1	0	1	1
Total	2735	4775	1938	14352	4673	19127	7510	16291	23800

More species and more individuals were captured at BNWR (2,735 individuals of 91 species) than at RGNC (1,938 individuals of 81 species) in spring. The pattern was reversed in fall: 4,775 individuals of 91 species at BNWR and 14,352 individuals of 108 species at RGNC. The species composition and relative abundance of each species were generally similar between the two sites. The relative abundance of species was correlated between the two sites in spring ($r_s = 0.60$, $P < 0.001$) and in fall ($r_s = 0.65$, $P < 0.001$) (table 2). There is a high similarity of species composition between the two sites: 90 species were captured at both sites while 26 species were captured at BNWR only (BNWR-only species), and 29 species were captured at RGNC only (RGNC-only species). Of these 55 single-site species, 31 species (56 percent) were captured only once during the study; most of these species were rare or accidental in the area. There was a tendency for edge or suburban-related species (for example, the American Robin, House Finch, American Goldfinch, Pine Siskin, and Lesser Goldfinch) to be more abundant at RGNC. Whereas desert species or species breeding along the border of Mexico and the United States (such as the Ladder-backed Woodpecker, Pyrrhuloxia, Verdin, Brown-crested Flycatcher, Lucy's Warbler, and Cactus Wren) were more likely to be captured at BNWR.

In contrast to the 146 species we captured, Hink and Ohmart detected 124 species while Hoffman recorded 79 species. Twenty-one species captured during our study were not recorded in either study; most of these species were rare or accidental. Among them, 12 species (Blackburnian Warbler, Black-throated Blue Warbler, Blue-winged Warbler, Carolina Wren, Canada Warbler, Chestnut-sided Warbler, Lawrence's Warbler, Mourning Warbler, Orchard Oriole, Painted Bunting, Prairie Warbler, and Scarlet Tanager) were Eastern breeding species while six (Brown-crested Flycatcher, Belted Vireo, Cactus Wren, Cassin's Sparrow, Gray Vireo, and White-winged Dove) had breeding ranges restricted mostly to Mexico and Southwestern United States. Our classification of 146 captured species was correlated with Hink and Ohmart's (1984) classification (Spearman's $r = 0.64$, $P < 0.001$, $n = 124$) and Hoffman's (1990) (Spearman's $r = 0.35$, $P < 0.005$, $n = 79$) (table 1). Hink and Ohmart's (1984) and Hoffman's (1990) species classifications were also correlated (Spearman's $r = 0.50$, $P < 0.001$, $n = 78$).

Migration Timing

During our daily mist-netting operation, capture rate was the highest during the morning hours and gradually declined after 0900 am (MST) both in spring and fall (fig. 1). We found that proportionally more Neotropical migratory birds were captured in the early hours than temperate migratory species in spring ($X^2 = 25.54$, df = 7, $P < 0.005$) and in fall ($X^2 = 407.71$, df = 7, $P < 0.005$, fig.1). Daily mean capture time of Neotropical migrants was about 40 minutes earlier in spring and was about 30 minutes earlier in fall than that of resident species.

Seasonally, spring migration peaked in late-April and the first half of May, while fall migration peaked after the last week of August and continued through mid-October (fig. 2). In general, temperate migrants migrated through our sites earlier than Neotropical migrants in spring, and the pattern was reversed in fall (fig. 2). The mean capture date for temperate migrants was Julian day 121 and 284 in spring and fall, respectively, while it was Julian day 137 and 252 for Neotropical migrants in spring and fall, respectively. The mean capture date differed by 16 days in spring and by 32 days in fall between the two groups.

We tested seasonal passage time between the two sites in spring and fall for 27 species that had ≥ 5 captures/site/season (table 3). In spring, the majority of these species (67 percent) had a similar passage time between the two sites. In spring, the median passage date at BNWR was earlier than RGNC for six species: the Western Wood-Pewee, Willow Flycatcher, Warbling Vireo, Black-headed Grosbeak, Green-tailed Towhee, and Brewer's Sparrow; and was earlier at RGNC than BNWR for three species: the Yellow-rumped Warbler, Hermit Thrush, and White-crowned Sparrow. In fall, the median passage time did not differ between the two sites for 13 of the 27 species; but it was earlier at BNWR than RGNC for eight species: the Gray Flycatcher, Yellow Warbler, Common Yellowthroat, Black-headed Grosbeak, Green-tailed Towhee, Spotted Towhee, Chipping Sparrow, and Song Sparrow. It was earlier at RGNC for six species: the White-breasted Nuthatch, Ruby-crowned Kinglet, Orange-crowned Warbler, Yellow-rumped Warbler, Lincoln's Sparrow, and White-crowned Sparrow (table 3). Of these 27 species, the median capture dates in spring were negatively correlated with that in fall [$r = -0.73$, $n = 27$, $P < 0.001$ for BNWR (fig. 3a); $r = -0.70$, $n = 27$, $P < 0.01$ for RGNC (fig. 3b)]. This pattern suggests that temporal migration patterns were reversed for a given species between spring and fall migration, that is, species that migrated through the

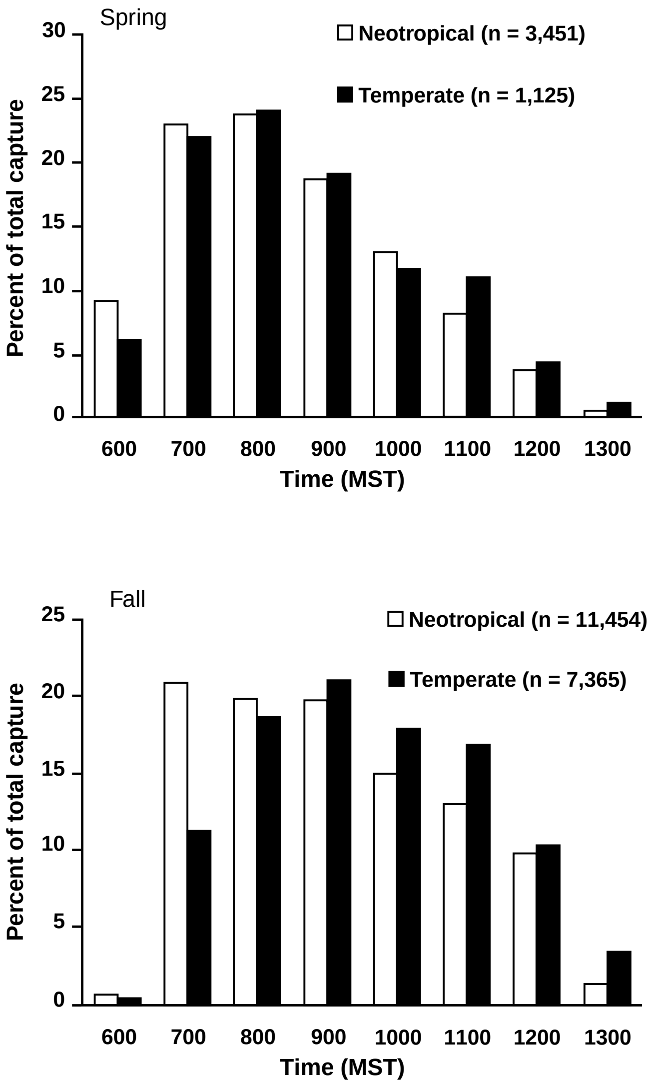

Figure 1—Temporal distribution of daily captures of migrants during spring and fall migration stopover along the middle Rio Grande.

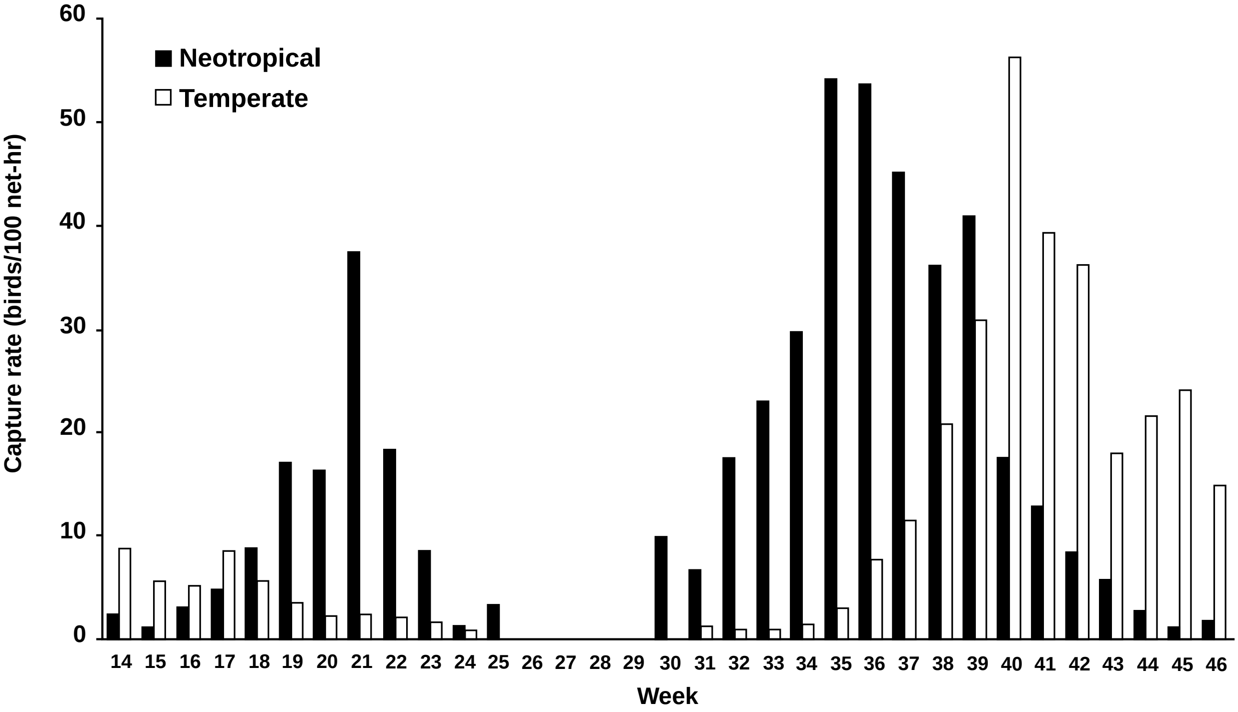

Figure 2—Distribution of weekly captures of landbirds during spring and fall migration along the middle Rio Grande. Week 14 is the first week in April.

Table 3—Median (range) capture date (Julian day) of landbirds during spring and fall migration at Bosque del Apache National Wildlife Refuge (BNWR) and Rio Grande Nature Center (RGNC). See table 2 for sample sizes and appendix I for species codes.

	Spring			Fall		
Species	**BNWR**	**RGNC**	**Combined**	**BNWR**	**RGNC**	**Combined**
SSHA	118 (0)		118 (0)		291 (51)	291 (51)
COHA		120 (19)	120 (19)	222 (0)	248 (48)	241 (48)
AMKE	111 (0)	150 (0)	131 (39)		244 (70)	244 (70)
MODO		138 (41)	137 (41)		264 (97)	264 (97)
WWDO		115 (0)	115 (0)			
YBCU	157 (10)		156 (10)	223 (20)		223 (20)
GRRO				243 (0)	240 (0)	242 (3)
CONI					262 (0)	262 (0)
BEKI					241 (40)	241 (40)
DOWO	160 (0)	158 (45)	152 (45)	244 (70)	266 (81)	253 (89)
HAWO	103 (9)		103 (9)	271 (74)		271 (74)
RNSA				299 (46)	280 (23)	285 (46)
WISA				274 (0)	290 (0)	282 (16)
LBWO	151 (14)		151 (14)	233 (21)		233 (21)
RSFL	139 (41)	107 (0)	128 (52)	285 (57)	278 (49)	285 (69)
OSFL	129 (9)	140 (0)	130 (17)		251 (19)	251 (19)
WEWP	138 (34)	149 (20)***	143 (39)	253 (42)	247 (49)ns	250 (49)
HAFL	141 (17)	144 (0)	141 (17)	256 (48)	266 (38)	266 (52)
LEFL					250 (20)	250 (20)
WIFL	150 (25)	152 (27)*	149 (27)	245 (53)	240 (39)ns	240 (54)
DUFL	131 (40)	130 (37)ns	133 (40)	249 (63)	250 (57)ns	249 (64)
GRFL	130 (47)	123 (39)ns	128 (48)	234 (87)	244 (46)*	242 (87)

(con.)

Table 3 (Con.)

	Spring			Fall		
Species	**BNWR**	**RGNC**	**Combined**	**BNWR**	**RGNC**	**Combined**
WEFL	143 (11)	150 (8)	145 (13)	248 (41)	244 (59)	245 (59)
BLPH	139 (63)	114 (62)	131 (63)	249 (4)	255 (100)	253 (100)
SAPH	114 (0)		114 (0)	254 (0)	262 (93)	260 (93)
ATFL	130 (44)	132 (41)	132 (47)		226 (16)	226 (16)
BCFL	123 (8)		123 (8)	250 (9)		250 (9)
WEKI	142 (30)	138 (4)	139 (30)		230 (47)	230 (47)
BARS	131 (34)	138 (46)	137 (46)	254 (24)	226 (26)	241 (31)
VGSW	146 (0)		146 (0)			
BANS		128 (0)	128 (0)			
NRWS	126 (41)	153 (0)	128 (44)	(82)	240 (0)	240 (0)
SCJA		124 (49)	125 (49)	273 (33)	264 (40)	265 (40)
MOCH	129 (0)		129 (0)	299 (13)	283 (83)	283 (83)
PLTI					270 (0)	270 (0)
BCCH		157 (43)	157 (43)		245 (99)	245 (99)
COBU		101 (0)	101 (0)	311 (0)	243 (99)	260 (100)
VERD				290 (35)		290 (35)
RBNU				253 (60)	272 (41)	263 (60)
WBNU	130 (54)	152 (52)ns	139 (57)	271 (42)	247 (66)**	260 (73)
BRCR				299 (28)	286 (33)	294 (35)
ROWR				256 (0)	291 (0)	274 (35)
CACW				278 (0)		278 (0)
BEWR	121 (56)	117 (15)	123 (56)	262 (101)	263 (99)	259 (102)
HOWR	134 (32)	136 (42)ns	135 (42)	256 (43)	257 (51)ns	259 (51)
MAWR	151 (0)	124 (0)	138 (27)	298 (41)	267 (21)	284 (45)
WIWR				306 (0)		306 (0)
CARW	130 (0)		130 (0)			
RCKI	120 (43)	117 (23)ns	119 (43)	292 (60)	279 (62)***	288 (62)
GCKI	125 (57)		125 (57)	290 (0)	288 (25)	288 (25)
BGGN	115 (7)	121 (6)	118 (14)		262 (13)	261 (13)
TOSO	124 (0)		124 (0)	280 (2)		280 (2)
SWTH	139 (13)		141 (13)	261 (16)	270 (0)	263 (17)
HETH	133 (51)	123 (56)	126 (56)	291 (44)	290 (62)ns	289 (62)
AMRO	109 (57)	114 (71)	121 (71)	279 (23)	283 (99)	275 (99)
GRCA	146 (28)	142 (14)	145 (28)	256 (65)	286 (16)	264 (65)
NOMO	143 (40)	128 (21)	132 (40)		235 (0)	235 (0)
SATH		105 (0)	105 (0)			
BRTH				289 (0)		289 (0)
CRTH				233 (0)		233 (0)
BEVI		109 (0)	109 (0)			
GRVI	128 (0)	128 (0)	128 (0)			
SOVI	128 (34)	118 (0)	130 (34)	256 (50)	264 (41)	261 (50)
WAVI	146 (29)	154 (17)**	148 (29)	229 (50)	236 (61)ns	236 (61)
REVI	149 (0)		149 (0)	263 (0)		263 (0)
YTVI	128 (0)		128 (0)			
PROW				259 (19)	273 (0)	263 (24)
BWWA	143 (0)		143 (0)			
LAWA		136 (0)	136 (0)			
OCWA	131 (46)	127 (38)ns	131 (46)	271 (77)	265 (68)***	265 (77)
NAWA	124 (12)	118 (0)	125 (17)		262 (24)	262 (24)
VIWA	131 (36)	131 (27)ns	130 (36)	236 (68)	241 (60)ns	243 (72)
LUWA	117 (27)		116 (27)			
MAWA	148 (5)	140 (0)	145 (10)			
YWAR	132 (34)	136 (46)ns	135 (46)	234 (51)	239 (53)**	239 (53)
CSWA	154 (4)		154 (4)			
YRWA	123 (38)	119 (52)**	121 (52)	278 (60)	271 (63)***	274 (63)
BTYW	136 (10)		136 (10)		228 (14)	228 (14)

(con.)

Table 3 (Con.)

	Spring			Fall		
Species	**BNWR**	**RGNC**	**Combined**	**BNWR**	**RGNC**	**Combined**
BTBW				275 (0)		275 (0)
BLBW		156 (0)	156 (0)			
TOWA	145 (2)		144 (2)	262 (27)	263 (35)	262 (38)
PRAW	149 (0)		149 (0)			
BAWW	137 (0)		137 (0)	250 (7)	249 (0)	250 (7)
AMRE	142 (0)		142 (0)	273 (17)		273 (17)
WPWA		140 (0)	140 (0)			
NOWA		131 (15)	130 (15)	242	243 (35)	243 (86)
OVEN	137 (21)	147 (23)	141 (23)		252 (0)	252 (0)
TEWA					253 (0)	253 (0)
MOWA	132 (0)		132 (0)			
MGWA	143 (42)	143 (38)ns	142 (44)	250 (67)	250 (66)ns	250 (68)
COYE	137 (46)	135 (33)ns	138 (46)	249 (100)	261 (61)*	250 (100)
KEWA	153 (11)	141 (0)	149 (17)			
CAWA	143 (0)		143 (0)			
WIWA	138 (51)	142 (51)ns	136 (55)	254 (69)	253 (75)ns	254 (75)
HOWA	151 (14)	141 (0)	148 (17)			
YBCH	142 (31)	152 (35)	142 (35)	237 (66)	252 (41)ns	245 (66)
HETA				250 (20)	235 (0)	243 (25)
SUTA	136 (34)	145 (8)	140 (34)	243 (56)	222 (15)	239 (56)
WETA	142 (26)	133 (23)ns	137 (26)	250 (58)	249 (70)ns	247 (70)
SCTA					221 (0)	221 (0)
PYRR				305 (12)		305 (12)
RBGR	130 (1)	128 (0)	129 (2)		274 (0)	274 (0)
BHGR	143 (39)	149 (48)*	144 (48)	225 (60)	233 (52)***	231 (60)
BLGR	145 (32)	145 (26)ns	145 (34)	245 (62)	249 (65)ns	247 (69)
LAZB	139 (19)	123 (34)	134 (38)	249 (44)	239 (54)	240 (54)
INBU	155 (17)	154 (2)	152 (17)	238 (39)	239 (30)	237 (39)
PABU				255 (24)	257 (42)	254 (60)
DICK					250 (12)	250 (12)
GTTO	128 (20)	132 (42)**	132 (43)	250 (34)	259 (56)**	258 (56)
SPTO	131 (66)	134 (63)ns	132 (71)	269 (99)	283 (90)***	274 (104)
CANT	127 (0)		127 (0)		274 (3)	274 (3)
CASP		125 (0)	125 (0)			
CHSP	122 (44)	123 (33)ns	123 (44)	264 (104)	254 (103)***	257 (110)
ATSP					314 (0)	314 (0)
CCSP				251 (49)	247 (45)	248 (59)
BRSP	122 (35)	131 (15)***	123 (42)	249 (53)	247 (76)ns	248 (76)
VESP	110 (12)	110 (15)	109 (16)	251 (7)	259 (59)	260 (59)
LASP	122 (47)	123 (0)	126 (47)	243 (65)	240 (59)	241 (80)
BTSP	129 (0)		129 (0)	247 (23)		247 (23)
SAGS				286 (0)		286 (0)
LARB					241 (31)	241 (31)
SAVS		108 (47)	110 (47)	301 (36)	278 (71)	285 (71)
GRSP					248 (22)	248 (22)
SOSP	102 (33)	110 (24)ns	108 (34)	289 (58)	294 (64)***	291 (64)
FOSP				309 (0)		309 (0)
LISP	124 (42)	136 (58)ns	127 (58)	278 (63)	276 (86)*	278 (86)
SWSP				284 (0)	301 (29)	295 (31)
WTSP	121 (19)	100 (11)	110 (36)	303 (25)	298 (23)	298 (25)
GCSP					288 (0)	288 (0)
WCSP	121 (62)	106 (69)	116 (69)	290 (56)	285 (66)***	287 (66)
DEJU	114 (36)	124 (41)ns	115 (41)	299 (60)	299 (57)ns	297 (64)
YHBL				256 (0)	240 (7)	241 (19)
RWBL	144 (0)	116 (68)	121 (68)	300 (0)	304 (80)	295 (80)
WEME		108 (0)	108 (0)		305 (19)	305 (19)

(con.)

Table 3 (Con.)

	Spring			Fall		
Species	**BNWR**	**RGNC**	**Combined**	**BNWR**	**RGNC**	**Combined**
COGR					211 (0)	211 (0)
GTGR		151 (19)	149 (19)		211 (0)	211 (0)
BHCO	146 (29)	151 (37)	147 (37)	239 (7)	240 (16)	237 (17)
OROR					240 (16)	240 (16)
BUOR	150 (28)	155 (31)	149 (36)	239 (41)	229 (36)	230 (43)
CAFI					304 (10)	304 (10)
HOFI	124 (56)	150 (0)	130 (56)	248 (44)	282 (92)	280 (92)
PISI					285 (86)	285 (86)
LEGO	152 (22)	152 (0)	150 (22)	255 (85)	263 (80)	262 (85)
WWCR					279 (0)	279 (0)
AMGO	149 (0)		149 (0)	291 (9)	293 (83)	293 (83)
EVGR					292 (0)	292 (0)

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[1] Mann-Whitney U test was performed to examine the difference between the sites for each season for species with ≥ 5 capture/site/season. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; and ns, not significant.

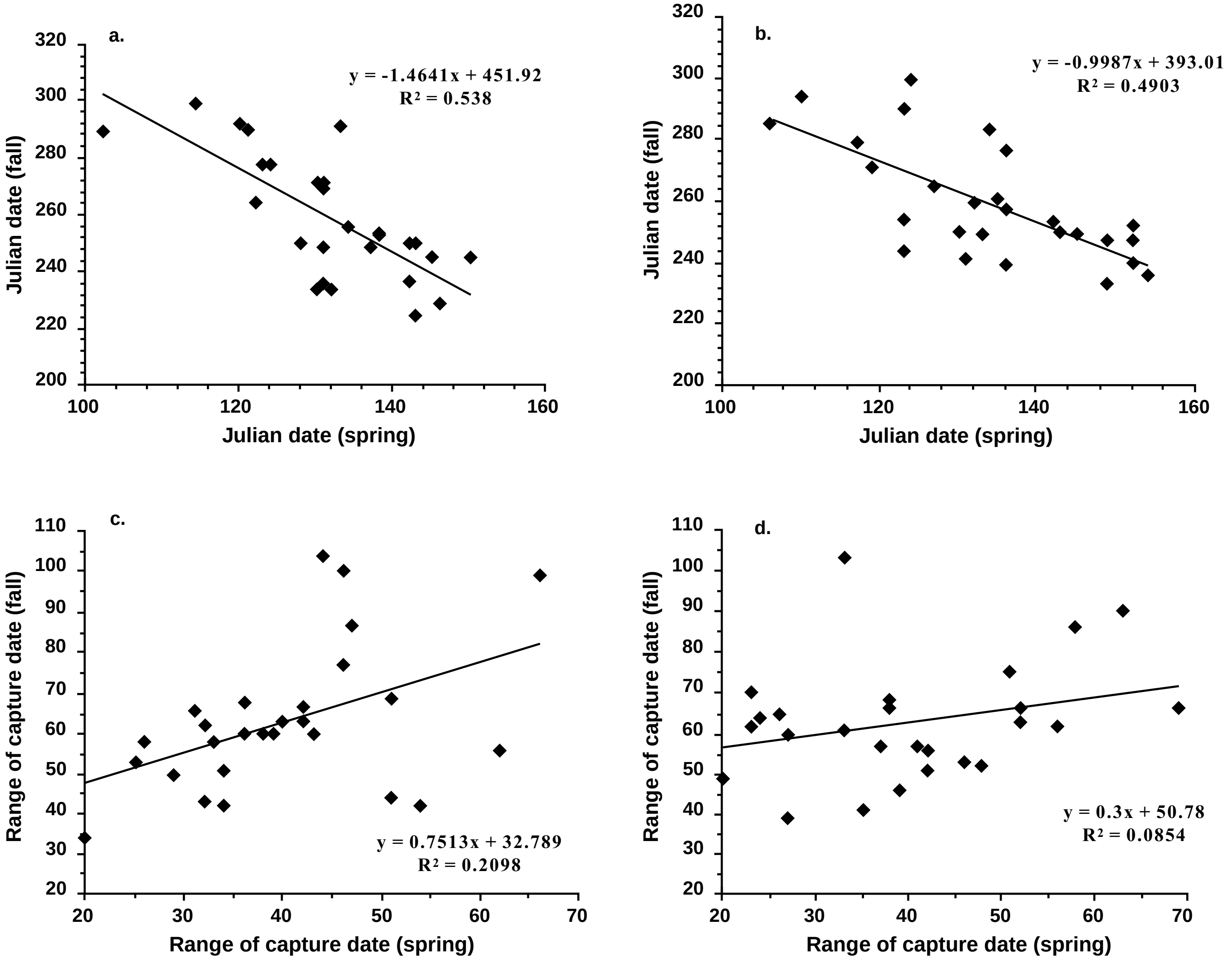

Figure 3—Relationships between spring median capture date and fall median capture date at Bosque National Wildlife Refuge of New Mexico (a) and at Rio Grande Nature Center of New Mexico (b); and relationships between the range of spring capture date and the range of fall capture date at Bosque National Wildlife Refuge of New Mexico (c) and at Rio Grande Nature Center of New Mexico (d).

sites earlier in spring migrated through the sites later in fall (many temperate migrants), and the species that migrated through the site later in spring migrated through the sites earlier in fall (many Neotropical migrants). For example, the median capture date of the Song Sparrow (a typical temperate migrant species) was Julian date 102 in spring and 289 in fall at BNWR and was 110 in spring and 294 in fall at RGNC. The median capture date of the Warbling Vireo (a typical Neotropical species) was 44 days later than that of the Song Sparrow at both sites in spring, and was 60 days earlier at BNRW and 58 days earlier at RGNC in fall. Duration of a migration period for a given species, as indicated by the range of capture dates (the difference between last capture date and first capture date), tended to be positively correlated in spring and fall [$r = 0.46$, n = 27, $P < 0.05$ at BNWR (fig. 3c) and $r = 0.29$, n = 27, $P = 0.14$ at RGNC (fig. 3d)]. In other words, species with short migration seasons in spring (many Neotropical species) also tended to have short migration seasons in fall.

We used the range of capture data of each species as an indicator of the precision of migration timing. Of 33 species with ≥ 20 captures, Neotropical migrants had more precise migration times (range of capture dates = 43.26 ± 9.15 days, n = 23) in spring than temperate species (range of capture dates = 55.00 ± 12.95 days, t = 2.98, df = 31, P < 0.01). Among the 47 species with ≥ 20 captures in fall, Neotropical species again tended to have less variation of the migration timing (range of capture dates = 66.80 ± 16.35 days, n = 30) than temperate species (range of capture dates = 74.35 ± 18.24 days, $t = 1.46$, df = 45, $P = 0.15$).

Fat Stores and Body Mass

The birds captured during this study were dominated by low fat individuals; about 50 percent of the individuals captured had no visible subcutaneous fat (fat class 0); and fewer than 10 percent of the birds were in the fat class 3 or above in both spring and fall (fig. 4). Fat class distributions did not differ between the two sites or between spring and fall. However, more individuals of Neotropical migrants were in the lower fat classes than temperate migrants in spring (G = 13.36, df = 3, $P < 0.01$), while the pattern was reversed in fall (G = 15.41, df = 3, $P < 0.01$).

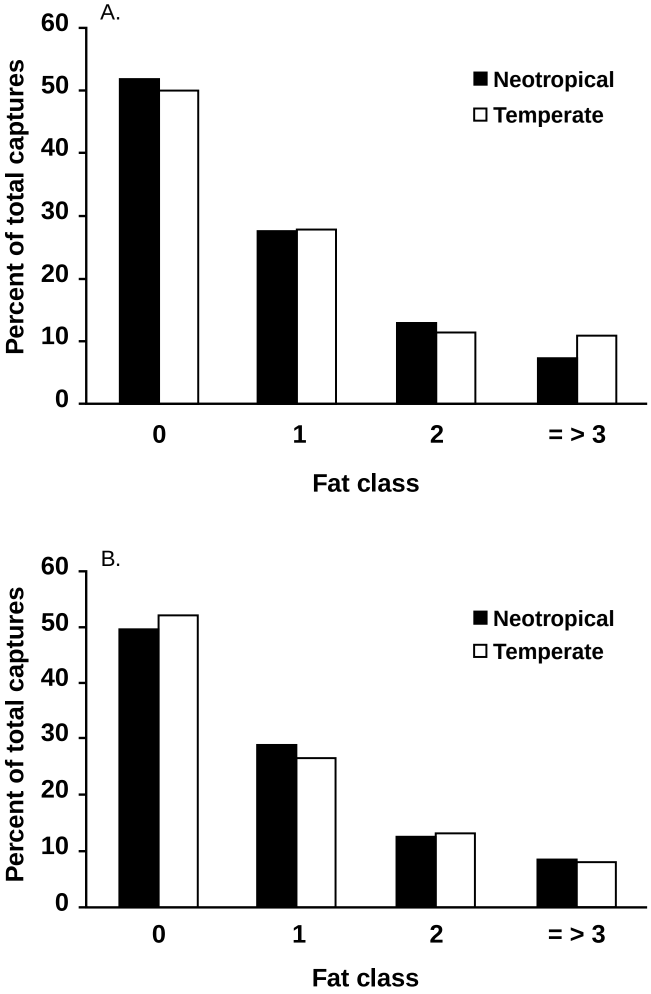

Figure 4—Distribution of fat classes of landbird migrants in spring (a) and fall (b). The total number of birds captured was 4,673 in spring and 16,291 in fall.

Using species mean body mass as the sampling unit, we found that spring birds tended to have lower body mass than fall birds at BNWR for species captured in both seasons (Wilcoxon test, $Z = 1.68$, $P = 0.09$), and the pattern was reversed for the species at RGNC: spring birds had higher body mass than fall birds (Wilcoxon test, $Z = 2.80$, $P < 0.01$, table 4). To further test site and seasonal effects on body mass, we performed two-way ANOVA for 27 species for each individual species that had ≥ 5 captures each season at each site. Nine of the 27 species (the Black-headed Grosbeak, Chipping Sparrow, Orange-crowned Warbler, Ruby-crowned Kinglet, Virginia Warbler, Western Tanager, Wilson's Warbler, Yellow-rumped Warbler, and Yellow Warbler) showed site and seasonal interactions in body mass. This was because spring body mass was higher than fall body mass at RGNC in these species, while the pattern was either reversed or did not change in the same species at BNWR. Nine species showed seasonal difference of body mass. However, the trends were not consistent among species. While six species (the Dusky Flycatcher, Lincoln's Sparrow, MacGillivray's Warbler, White-crowned Sparrow, West Wood-Pewee, and Willow Flycatcher) had higher body masses in spring than in fall, the body mass of the House Wren, Spotted Towhee, and Warbling Vireo was higher in fall than in spring (table 4).

Table 4—Body mass (mean ± SD) of landbirds captured during spring and fall migration at Bosque del Apache National Wildlife Refuge (BNWR) and Rio Grande Nature Center (RGNC). See table 2 for sample sizes and appendix I for species codes.

	Spring		Fall			
Species	**BNWR**	**RGNC**	**BNWR**	**RGNC**	**All**	***P*[1]**
SSHA	161.6			127.5 ±40.5	130.1 ±39.9	
COHA		302.5 ±26.9		237 ±89.1	269.8 ±65.7	
AMKE	103.2	87.0		103.8 + 6.3	100.3 ±8.7	
MODO		112.1 ±15.9		90.4 ±23.5	99.9 ±23.2	
WWDO						
YBCU	60.6 ±7.5		57.3 ±7.8		59.1 ±7.5	
GRRO			284.0			
CONI						
BEKI				130.9 ±15.5	130.9 ±15.5	
DOWO	25.5	25.6 ±2.3	25.9 ±0.4	25.2 ±1.6	25.5 ±1.5	
HAWO	63.1 ±2.5		56.3 ±5.4		58.2 ±5.6	
RNSA			52.4 ±2.2	41.7 ±11.2	47.0 ±9.4	
WISA			43.1	47.7	45.4 ±3.3	
LBWO	33.8 ±0.7		28.6 ±2.4		31.2 ±3.3	
RSFL	117.5 ±23.8	186	137.0 ±13.4	132.0 ±9.5	133.8 ±13.9	
OSFL	31.3 ±1.7	34		28.1 ±1.5	30.6 ±2.4	
WEWP	13.2 ±1.3^{A}	13.2 ±1.3^{A}	12.5 ±0.9^{B}	12.3 ±0.8^{B}	12.8 ±1.2	***
HAFL	9.4 ±0.5	10.3	9.8 ±0.5	9.9 ±0.7	9.8 ±0.6	
LEFL				9.3 ±1.1	9.3 ±1.1	
WIFL	12.6 ±1.1^{AB}	13.1 ±1.1^{A}	12.2 ±1.1^{BC}	12.1 ±1.1^{C}	12.4 ±1.1	***
DUFL	11.3 ±1.1^{B}	11.8 ±0.9^{A}	10.7 ±0.9^{C}	10.8 ±0.7^{BC}	11.2 ±1.1	***
GRFL	11.2 ±1.1	11.9 ±0.8	11.7 ±1.1	11.3 ±0.8	11.5 ±1.0	ns
WEFL	11.4 ±0.8	12.3 ±0.7	11.3 ±1.2	11.2 ±1.0	11.3 ±1.0	
BLPH	16.8 ±1.2	16.3 ±1.1	17.0 ±1.7	17.5 ±1.5	17.0 ±1.4	
SAPH	21.4		22.7	21.3 ±1.6	21.5 ±1.5	
ATFL	27.3 ±2.4	26.3 ±2.4		24.5 ±1.5	26.8 ±2.4	
BCFL	28.9 ±2.4		33.3 ±2.1		30.7 ±3.1	
WEKI	39.5 ±1.7	35.5 ±2.8		36.1 ±2.6	36.2 ±2.6	
BARS	16.0 ±0.7	17.0 ±1.5	15.1 ±1.7	15.7 ±1.1	15.8 ±1.3	
VGSW	13.6				13.6	
BANS		10.3			10.3	
NRWS	14.2 ±1.2	13.3		15.8	14.3 ±1.2	
SCJA		70.3 ±5.7	70.8 ±6.1	78.6 ±6.8	51.8 ±11.6	
MOCH	11.8		10.6 ±0.6	10.9 ±0.7	10.9 ±0.7	
BCCH		10.9 ±0.7		10.7 ±1.0	10.8 ±0.9	
PLTI				15.5	15.5	
COBU			5.6	5.5 ±0.3	5.5 ±0.3	
VERD			7.4 ±0.4		7.4 ±0.4	
RBNU			9.8 ±0.6	9.4 ±0.7	9.5 ±0.7	
WBNU	15.8 ±3.0	17.4 ±1.2	17.4 ±1.3	17.0 ±0.8	17.0 ±1.6	ns
BRCR			7.3 ±0.9	7.4 ±0.7	7.4 ±0.8	
ROWR			17.1	13.5	15.3 ±2.5	
CACW			34.8		34.8	
BEWR	9.6 ±0.9	10.4 ±1.04	9.6 ±0.6	9.5 ±0.7	9.6 ±0.7	
HOWR	9.7 ±0.7^{A}	9.9 ±0.7^{AB}	10.1 ±1.1^{AB}	10.4 ±0.7^{B}	10.1 ±0.8	***
MAWR		10.2	10.8 ±0.6	10.6 ±1.1	10.7 ±0.7	
WIWR			8.9		8.9	
CARW	16.9				16.9	
RCKI	5.8 ±0.4^{A}	6.3 ±0.4^{B}	6.1 ±0.5^{AB}	6.1 ±0.9^{AB}	6.1 ±0.7	*
GCKI	6.0 ±0.6		6.0	6.1 ±0.5	6.0 ±0.4	
BGGN	6.0 ±0.5	5.9 ±0.3		5.2 ±0.1	5.8 ±0.5	
TOSO	33.9		33.0 ±2.2		33.3 ±1.6	
SWTH	26.4 ±1.9		29.7 ±2.4	30.7	28.0 ±2.7	

(con.)

Table 4 (Con.)

Species	Spring		Fall		All	*P*[1]
	BNWR	RGNC	BNWR	RGNC		
HETH	24.1 ±3.3	24.4 ±2.6	23.7 ±2.2	23.8 ±2.4	23.9 ±2.5	ns
AMRO	77.4 ±6.6	77.0 ±6.4	77.2 ±0.5	79.9 ±9.8	78.3 ±8.1	
GRCA	33.3 ±2.6	34.6 ±2.3	35.1 ± 1.5	33.2 ± 2.7	34.3 ± 2.1	
NOMO	45.2 ± 3.0	44.7 ± 3.0		44.4	44.9 ± 3.0	
SATH		45.3			45.3	
BRTH			75.7		75.7	
CRTH			59.3		59.3	
BEVI		8.8			8.8	
GRVI	13.3	12.4			12.9 ± 0.6	
SOVI	14.9 ± 2.2	14.6	15.0 ± 1.4	14.8 ± 2.1	14.9 ± 1.9	
WAVI	11.2 ± 0.9^{A}	11.6 ± 0.9^{AB}	11.8 ± 1.0^{B}	11.9 ± 0.9^{B}	11.6 ± 1.0	***
REVI	15.8		18.7		17.3 ± 2.1	
YTVI	18				18	
PROW			13.3 ± 1.3	14.1	13.6 ± 1.0	
BWWA	8.0				8	
LAWA		8.6			8.6	
OCWA	8.8 ± 1.1^{A}	9.9 ± 1.0^{B}	8.8 ± 0.8^{A}	8.7 ± 0.7^{A}	8.8 ± 0.8	***
NAWA	7.2 ± 1.0	8.1		7.3 ± 0.4	7.4 ± 0.7	
VIWA	8.4 ± 1.0^{AB}	8.9 ± 0.8^{A}	8.4 ± 0.8^{B}	8.0 ± 0.6^{B}	8.2 ± 0.8	***
LUWA	6.3 ± 0.3				6.3 ± 0.3	
MAWA	8.4 ± 0.8	7.4			8.4 ± 0.8	
YWAR	8.9 ± 0.8^{A}	10.0 ± 0.9^{B}	9.1 ± 1.0^{A}	8.9 ± 0.7^{A}	9.0 ± 0.9	***
CSWA	8.5 ± 0.6				8.5 ± 0.6	
YRWA	11.6 ± 1.2^{A}	13.1 ± 1.3^{C}	12.0 ± 1.1^{B}	11.7 ± 1.1^{AB}	12.1 ± 1.3	***
BTYW	7.2 ± 0.2			7.6 ± 0.5	7.4 ± 0.4	
BTBW			10.7		10.7	
BLBW		9.7				ns
TOWA	8.5 ± 0.7		9.5 ± 0.8	8.4 ± 0.4	8.8 ± 0.8	
PRAW	7.5				7.5	
BAWW	8.3		9.8 ± 0.1	9.6	9.4 ± 0.7	
AMRE	7.5		7.6		7.6 ± 0.4	
WPWA		9.2			9.2	
NOWA		18.5 ± 2.6	17.3 ± 1.7	17.5 ± 1.6	17.6 ± 1.8	
OVEN	16.7 ± 1.2	17.7 ± 1.7			17.0 ± 1.4	
TEWA				8.6	8.6	
MOWA	11.1				11.1	
MGWA	10.5 ± 1.0^{A}	11.0 ± 1.0^{B}	10.4 ± 1.0^{A}	10.7 ± 0.8^{C}	10.7 ± 1.0	***
COYE	9.6 ± 1.0^{A}	9.6 ± 1.2^{A}	10.0 ± 0.8^{B}	10.0 ± 1.0^{B}	10.1 ± 1.3	*
KEWA	13.2 ± 1.0	13.7			13.4 ± 0.8	
CAWA	8.4				8.4	
WIWA	7.3 ± 0.7^{A}	7.7 ± 0.8^{B}	7.3 ± 0.6^{A}	7.3 ± 0.5^{A}	7.3 ± 0.6	***
HOWA	10.5 ± 0.9	10.1			10.3 ± 0.7	
YBCH	23.8 ± 2.2	26.2 ± 2.4	26.0 ± 2.0	28.7 ± 2.6	24.7 ± 2.6	
HETA			38.1 ± 2.0	39.3 ± 0.3	38.7 ± 1.3	ns
SUTA	33.9 ± 2.3	32.8 ± 1.6	35.6 ± 3.4	34.0 ± 1.5	34.9 ± 3.1	
WETA	28.9 ± 3.4	31.8 ± 1.9	29.9 ± 2.0	29.8 ± 3.1	29.8 ± 2.8	ns
SCTA				28.9	28.9	
PYRR			35.1 ± 1.8		35.1 ± 1.8	
RBGR	38.4 ± 5.7	40.9		39.3	39.3 ± 3.5	
BHGR	43.4 ± 3.6^{A}	45.7 ± 3.7^{B}	45.6 ± 4.0^{B}	43.7 ± 5.5^{A}	44.5 ± 4.4	***
BLGR	27.9 ± 2.1	28.3 ± 2.7	28.3 ± 2.8	28.8 ± 2.5	27.9 ± 2.5	ns
LAZB	13.6 ± 1.0	13.4 ± 1.3	14.6 ± 1.9	14.7 ± 1.4	14.7 ± 1.4	
INBU	12.7 ± 0.9	14.5 ± 2.8	14.0 ± 1.4	13.8 ± 0.7	13.5 ± 1.3	
PABU			15.4 ± 2.2	15.2 ± 1.1	15.3 ± 1.6	
DICK				29.5 ± 5.6	29.5 ± 5.6	
GTTO	27.2 ± 2.7	28.2 ± 3.0	27.6 ± 3.5	28.1 ± 2.5	28.0 ± 2.7	ns

(con.)

Table 4 (Con.)

	Spring		Fall			
Species	**BNWR**	**RGNC**	**BNWR**	**RGNC**	**All**	***P*[1]**
SPTO	36.5 ± 2.7^{A}	33.6 ± 2.0^{B}	37.3 ± 3.0^{A}	36.2 ± 2.8^{A}	36.6 ± 2.9	**
CANT	44.0			41.4 ± 1.6	42.1 ± 1.8	
CASP		15.6			15.6	
CHSP	11.4 ± 1.2^{A}	12.3 ± 0.4^{B}	12.2 ± 0.9^{B}	12.0 ± 0.9^{AB}	12.0 ± 0.9	***
ATSP				14.8	14.8	
CCSP			10.3 ± 0.8	10.8 ± 0.9	10.7 ± 0.9	
BRSP	10.8 ± 1.5^{A}	10.2 ± 0.5^{B}	10.3 ± 0.9^{B}	10.6 ± 1.1^{C}	10.5 ± 1.1	*
VESP	20.6 ± 1.7	23.7 ± 1.3	23.0 ± 1.2	23.4 ± 1.9	23.3 ± 1.9	
LASP	28.3 ± 1.0	25.7	26.6 ± 2.6	27.2 ± 2.1	27.2 ± 2.2	
BTSP	12.2		12.0 ± 0.3		12.1 ± 0.2	
SAGS			18.1		18.1	
LARB				33.4 ± 1.9	33.4 ± 1.9	
SAVS		17.4 ± 1.7	16.4 ± 1.0	16.6 ± 1.3	16.6 ± 1.3	
GRSP				16.3 ± 0.5	16.3 ± 0.5	
SOSP	19.7 ± 1.4	20.0 ± 0.9	19.5 ± 1.4	19.8 ± 1.4	19.6 ± 1.4	ns
FOSP						
LISP	16.2 ± 2.0	17.3 ± 1.1	16.0 ± 1.7	16.2 ± 1.7	16.1 ± 1.7	ns
SWSP			13.9	16.0 ± 0.3	15.3 ± 1.2	
WTSP	26.3 ± 4.4	24.3 ± 3.0	23.1 ± 1.4	25.1 ± 1.0	24.5 ± 2.0	
GCSP				29.9	29.9	
WCSP	25.0 ± 2.6^{A}	25.7 ± 2.8^{B}	23.9 ± 2.1^{C}	24.6 ± 2.4^{A}	24.6 ± 2.4	***
DEJU	18.0 ± 2.4^{A}	17.9 ± 1.5	17.7 ± 1.4^{C}	17.4 ± 1.3^{B}	17.6 ± 1.4	***
YHBL			75.4	47.7 ± 3.3	49.6 ± 8.1	
RWBL	62.3	51.8 ± 11.6	47.6	43.1 ± 6.1	50.6 ± 11.3	
WEME		132.7		92.2 ± 14.4	98.9 ± 21.0	
COGR				81.5	81.5	
GTGR		156.0 ± 50.6		93.0 ± 10.7	147.0 ± 51.9	
BHCO	34.8 ± 4.4	33.9 ± 4.9	35.3 ± 2.4	31.5 ± 3.8	34.2 ± 4.3	
OROR				19.6 ± 1.1	19.6 ± 1.1	
BUOR	36.0 ± 2.5	35.0 ± 7.6	33.2 ± 2.8	34.0 ± 3.1	34.2 ± 3.2	
CAFI				26.9 ± 2.2	26.9 ± 2.2	
HOFI	18.8 ± 1.8	19.6	21.1 ± 1.2	19.7 ± 1.1	19.7 ± 1.2	
PISI				12.3 ± 0.9	12.3 ± 0.9	
LEGO	9.8 ± 0.6	9.4	9.4 ± 0.5	9.3 ± 0.6	9.4 ± 0.6	
WWCR				25.7	25.7	
AMGO	12.2 ± 0.9		12.8 ± 0.5	12.9 + 0.8	12.8 ± 0.8	
EVGR				56.9	56.9	

[1] One-way ANOVA test for species with ≥ 5 captures at each site in each season. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; and ns, not significant.

[2] Values with same superscripts indicate no significant difference in Tukey's multiple comparison tests among site/season categories.

Recapture Rate, Body Condition Change, and Length of Stay

A total of 2,870 individuals (12 percent of the total captures) were recaptured after the day of initial capture. Log-linear model tests suggested that recapture rates differed between the two sites (Partial $X^2 = 30.25$, df = 1, $P < 0.001$), but not between spring and fall. The spring recapture rate was 11 percent at BNWR and was 12.8 percent at RGNC; the fall recapture rate was 9.7 percent at BNWR and was 13 percent at RGNC.

Body condition is expected to affect stopover decisions. When we compared the body mass of birds that were never recaptured (nonrecaptures) and initial body mass of birds that were recaptured (recaptures), we found that body mass variation was usually large within each species, and the mass difference between the two groups was generally small: mean mass difference between nonrecaptures versus recaptures is 1.71 percent (minimum = 0.19 percent and maximum = 5.88 percent birds, table 5). The body mass of the two groups differed in five species: body masses of nonrecaptures of four species, Hermit Thrush (2.34 percent), Willow Flycatcher (3.83 percent), Wilson's Warbler (1.38 percent), and Yellow-rumped Warbler (3.60 percent), were higher than initial body masses of recaptures. In the Bewick's Wren, the pattern was reversed: body mass of nonrecaptures was 2.16 percent lower than that of recaptures. When we examined average body mass differences between the two groups using species as sampling units for 30 species having ≥ 20 individuals captured at each site in fall (table 5), the initial body mass of recaptures was significantly lower than the body mass of nonrecaptures (Wilcoxon Singed Rank Test, $Z = 3.52$, $P < 0.001$).

Data for recaptured birds suggest that they gained 0.37 ± 1.74 g between the first capture and last capture. The percentage of their daily body mass gain birds was 0.24 ± 2.76 percent/day. Among 2,870 recapture birds, about 29 percent showed fat class increases, 21 percent had fat class decreases, while 50 percent maintained a constant fat class between the initial capture and last capture. The average time between the first and last capture was 9.63 ± 12.04 days.

Forty-nine species had ≥ 5 recaptures, including 25 Neotropical, 18 temperate, and six resident species (table 6). Based on the summary data for these 49 species, the median duration between first and last captures differed among Neotropical (5.2 ± 3.69 days), temperate (8.31 ± 7.33 days), and resident species (34.76 ± 28.42 days) ($F = 18.75$; df = 2, 46; $P < 0.001$; table 6). The percent body mass change also differed among Neotropical (2.36 ± 2.09 percent), temperate (0.46 ± 3.26 percent), and resident species (2.56 ± 1.77

Table 5—Body mass (mean ± SD) of nonrecaptured birds and initial body mass of recaptured birds during spring and fall migration along the middle Rio Grande. See appendix I for species codes.

	Nonrecaptures		Recaptures		
Species	**N**	**Body mass**	**N**	**Body mass**	**t^1**
BEWR	101	9.51 ± 0.70	52	9.72 ± 0.81	1.62 *
BHGR	284	44.57 ± 4.57	55	44.27 ± 3.25	0.47 ns
BLGR	324	28.56 ± 2.69	97	28.2 ± 2.09	1.22 ns
BRSP	445	10.54 ± 1.14	37	10.56 ± 0.87	0.12 ns
CCSP	184	10.69 ± 0.90	7	10.59 ± 0.64	0.28 ns
CHSP	2304	12.04 ± 0.89	338	12.07 ± 0.81	0.63 ns
DEJU	664	17.56 ± 1.47	176	17.62 ± 1.26	0.47 ns
DUFL	365	11.22 ± 1.04	20	10.95 ± 1.17	1.16 ns
GTTO	130	28.02 ± 2.90	83	27.94 ± 2.48	0.22 ns
HETH	174	24.10 ± 2.66	76	23.55 ± 1.94	1.60 *
HOWR	125	10.13 ± 0.83	14	9.94 ± 0.58	0.84 ns
LASP	527	27.12 ± 2.19	17	26.91 ± 2.04	0.40 ns
LAZB	539	14.74 ± 1.46	68	14.36 ± 1.10	2.07 *
LISP	294	16.17 ± 1.77	106	15.98 ± 1.49	0.99 ns
MGWA	1006	10.71 ± 0.99	267	10.64 ± 0.90	1.03 ns
OCWA	729	8.77 ± 0.82	81	8.66 ± 0.60	1.24 ns
RCKI	550	6.04 ± 0.68	79	6.09 ± 0.61	0.61 ns
SAVS	203	16.67 ± 1.31	10	15.94 ± 1.11	1.75 *
SOSP	329	19.58 ± 1.37	96	19.72 ± 1.45	0.87 ns
SPTO	153	36.59 ± 2.84	84	36.51 ± 2.96	0.21 ns
VIWA	217	8.22 ± 0.79	25	7.98 ± 0.57	1.52 ns
WAVI	213	11.63 ± 0.98	9	11.71 ± 0.70	0.25 ns
WCSP	904	24.61 ± 2.51	504	24.46 ± 2.22	1.11 ns
WEFL	60	11.33 ± 1.02	8	10.81 ± 1.16	1.32 ns
WETA	132	29.87 ± 2.79	5	30.00 ± 2.12	0.10 ns
WEWP	206	12.78 ± 1.19	6	12.07 ± 0.85	1.46 ns
WIFL	186	12.48 ± 1.15	18	12.02 ± 0.95	1.65 *
WIWA	2997	7.34 ± 0.59	294	7.24 ± 0.56	2.85 **
YRWA	790	12.08 ± 1.31	64	11.66 ± 0.88	2.50 **
YWAR	447	9.05 ± 0.89	31	8.93 ± 0.85	0.74 ns

[1]. One-tail t test. *, $P < 0.05$; **, $P < 0.01$.

Table 6—Body mass change (g), percent body mass change, fat class change, and length of stay of recaptured landbirds during spring and fall migration along the middle Rio Grande.

		Mass change (g)		% mass change		Fat class change		Length of stay
Species	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Median**
RSFL	7	–6.95	20.30	–5.08	15.02	0.00	0.00	7.0
WEWP	7	0.43	0.90	3.71	7.95	0.00	0.58	5.0
WIFL	13	0.11	0.36	0.87	2.88	0.15	0.99	1.0
DUFL	16	0.66	1.22	6.76	12.94	0.06	0.93	2.0
BLPH	12	0.71	1.18	4.33	7.49	0.33	0.49	15.5
ATFL	6	0.75	1.77	3.03	7.02	–0.17	0.75	8.5
MOCH	13	0.26	0.54	2.44	4.99	0.08	0.76	18.0
BCCH	19	0.25	1.14	3.43	13.99	0.37	0.90	57.0
COBU	6	0.14	0.33	2.64	6.07	–0.17	0.41	81.0
WBNU	18	–0.05	1.12	–0.30	6.06	0.17	0.71	19.0
BRCR	5	–0.16	0.62	–1.79	7.53	–0.20	0.45	19.0
BEWR	49	0.14	0.81	2.06	9.75	–0.08	1.00	27.6
HOWR	13	0.13	0.54	1.40	5.59	–0.08	1.19	2.0
RCKI	63	0.01	0.54	0.52	8.90	–0.11	1.54	3.0
HETH	74	1.60	1.98	6.90	8.55	0.58	1.41	4.0
AMRO	22	–1.60	4.38	–1.74	5.34	–0.18	0.85	6.0
WAVI	8	0.18	0.87	1.70	7.64	0.63	0.74	2.5
OCWA	65	0.23	0.58	2.81	6.86	0.25	1.31	2.0
VIWA	22	0.14	0.43	1.86	5.39	0.32	0.84	2.5
YWAR	17	0.23	0.62	2.30	6.03	0.24	1.39	2.0
YRWA	60	0.40	0.87	3.56	7.36	0.42	1.09	3.0
MGWA	218	0.33	0.79	3.27	7.53	0.32	1.14	2.0
COYE	15	0.36	0.75	3.90	7.80	0.73	1.49	6.0
WIWA	216	0.09	0.52	1.42	7.50	0.15	0.94	2.0
YBCH	11	0.35	0.83	1.50	3.44	0.55	0.93	10.0
SUTA	18	0.31	1.53	0.94	4.42	0.06	0.54	13.0
WETA	6	–0.62	2.68	–1.97	9.16	–0.33	1.37	7.0
BHGR	50	1.19	3.29	2.85	7.58	0.28	1.21	8.0
BLGR	72	0.29	2.47	1.28	8.72	0.28	0.91	7.0
LAZB	68	0.63	1.37	4.56	9.42	0.38	1.52	4.0
GTTO	78	1.34	2.26	5.10	8.56	0.31	1.44	6.0
SPTO	85	0.02	2.90	0.34	7.90	–0.06	0.89	12.0
CHSP	336	0.24	0.86	2.21	7.08	0.05	1.14	11.0
CCSP	5	0.48	1.02	4.43	9.36	0.00	1.22	2.0
BRSP	38	0.37	0.89	3.71	8.14	0.21	1.02	6.5
VESP	41	0.01	1.14	0.16	4.92	–0.07	0.96	4.0
LASP	20	–0.05	1.70	0.08	6.50	0.15	0.81	1.0
SAVS	7	0.39	0.72	2.51	4.70	0.71	1.98	10.0
SOSP	77	0.60	1.15	3.06	6.29	0.10	0.74	7.0
LISP	102	0.66	1.55	4.35	9.53	0.18	1.21	8.0
WCSP	473	0.70	1.92	3.09	7.84	0.24	1.21	8.0
DEJU	149	0.23	1.03	1.43	5.77	0.01	0.82	7.0
RWBL	5	–1.28	3.07	–2.79	6.63	0.00	0.00	12.0
BHCO	8	0.73	1.79	2.46	5.61	0.13	0.35	3.0
BUOR	10	1.63	2.93	4.81	9.12	0.10	0.99	3.0
HOFI	18	–0.26	1.38	–1.12	6.88	0.22	1.00	31.0
PISI	34	–0.27	0.76	–2.02	6.12	–0.15	1.10	1.0
LEGO	19	–0.42	0.62	–4.20	6.77	–0.05	1.27	5.0
AMGO	21	–0.54	2.18	–4.07	16.88	–0.29	0.90	4.0

percent) ($F = 3.27$; df = 2, 46; $P < 0.05$, table 6). The fat class and body mass change between the first and last capture was not different among the three groups. Birds gained body mass between initial and last capture: Neotropical (0.18 ± 0.24 g), temperate (0.09 ± 0.28g), and resident species (0.11 ± 0.21g) (table 6). The daily rate of body mass change was highest in Neotropical migratory species (0.79 ± 0.81 percent) ($F = 5.22$; df = 2, 46; $P < 0.01$) and did not differ between temperate (0.03 ± 0.84 percent) and resident species (0.19 ± 1.77 percent). The 10 species that had highest rates of daily mass change were the Dusky Flycatcher (3.38 percent/day), Clay-colored Sparrow (2.22 percent/day), Hermit Thrush (1.72 percent/day), MacGillivray's Warbler (1.64 percent/day), Bullock's Oriole (1.60 percent/day), Orange-crowned Warbler (1.41 percent/day), Yellow-rumped Warbler (1.19 percent/day), Yellow Warbler (1.15 percent/day), Lazuli Bunting (1.14/day), and Willow Flycatcher (0.87 percent/day) (table 6).

Most regression equations between body mass and capture time for species with ≥ 20 captures/season (two sites combined) had positive slopes, indicating birds gained body mass during the daylight hours when we operated the mist-nets. For example, of the 34 species examined for spring migration, the slopes of the regression model between body mass and capture time were positive in 29 species and were significant in 12 species (table 7); of the 50 species examined for fall migration, regression slopes were positive in 45 species (90 percent) and were significant in 21 species (42 percent), all of which had positive slopes. The average hourly rate of body mass changeH (regression coefficient) was 0.17 ± 0.33 g/hour in spring and 0.13 ± 0.24 g/hour in fall. This translates to a body mass increase of 6.86 ± 9.63 percent/day in spring and 4.68 ± 0.72 percent/day in fall, assuming 8 hours available for gaining body mass. These estimates are about 29 times (in spring) and 19 times (in fall) higher than what were estimated based on recapture data (mean mass change = 0.24 percent/day).

In spring, daily percent body mass change estimated based on regression coefficients tended to be higher in Neotropical migrant species (8.34 ± 8.53 percent, n = 23 species) than in temperate migrant species (3.57 ± 12 percent, n = 10 species). There were no differences between Neotropical migrants (5.05 ± 4.89 percent, n = 29 species) and temperate migrants (5.40 ± 3.01 percent, n = 17 species) in fall. However, the resident species (-1.15 ± 5.80 percent, n = 4 species) differed from Neotropical and temperate migrants.

Habitat Use

Capture rate was not constant among habitats in spring ($X^2 = 292.01$, df = 5, P < 0.001) and in fall ($X^2 = 807.93$, df = 5, P < 0.001). In spring, capture rate was highest in willow habitat (288 birds/1,000 net hr), followed by agricultural field/edges (155 birds/1,000 net hr), cottonwood/Russian olive (120 birds/1,000 net hr), saltcedar (94 birds/1,000 net hr), and cottonwood/native understory (64 birds/1,000 net hr), and cottonwood/saltcedar (51 birds/1,000 net hr) (table 8). In fall, capture rate was highest in agricultural field/edges (718 birds/1,000 net hr); it was similar among cottonwood/Russian olive (286 birds/1,000 net hr), willow (238 birds/1,000 net hr), saltcedar (214 birds/1,000 net hr), and cottonwood/native understory (203 birds/1,000 net hr). Similar to spring migration, cottonwood/saltcedar habitat had the lowest capture rate in fall (97 birds/1,000 net hr). A two-contingency table test (season by habitat type) suggests that capture rate by habitat types varied by season ($X^2 = 219.26$, df = 5, P < 0.001).

The number of species captured varied by habitats in spring ($X^2 = 42.43$, df = 5, P < 0.001) and in fall ($X^2 = 31.38$, df = 5, P < 0.001) (table 8). In spring, cottonwood/Russian olive and willow habitats had the highest species richness (80 and 79 species, respectively), followed by agricultural field/edges (56 species), cottonwood/saltcedar (52 species), and cottonwood/native understory (38 species); and saltcedar had the lowest species richness (26 species). In fall, cottonwood/Russian olive again had the highest species richness (94 species), followed by agricultural field/edges (82 species); species richness was similar among willow (69 species), cottonwood/saltcedar (68), and cottonwood/native understory (62). Similar to spring migration, species richness was lowest in saltcedar (33). In both seasons, species diversity was lowest in saltcedar habitat but its species evenness was not (table 8).

Capture rate was habitat-dependent in many species. For example, most warbler species had highest capture rates in willow habitat. Among the seven most abundant warbler species captured in spring, the capture rates of the Orange-crowned Warbler, Virginia Warbler, Yellow Warbler, and Common Yellow were about four to five times higher in willow than in cottonwood/Russian olive (table 8); the Wilson's Warbler had the highest capture rate in willow (77.37 birds/1,000 net hr), which was 11 times greater than capture rate in cottonwood/Russian olive. Most of these species prefer shrub and secondary growth for breeding. On the other hand, the Yellow-rumped Warbler, a species that forages and breeds in canopies, had the highest capture rate in cottonwood/Russian olive. The MacGillivray's Warbler was similar between willow (33 birds/1,000 net hr) and cottonwood/Russian olive (29 birds/1,000 net hr). In fall, of these seven most common species, four species, the Orange-crowned Warbler, Virginia Warbler, MacGillivray's Warbler,

Table 7—Daily body mass change (% change/day) of landbirds during spring and fall migration along the middle Rio Grande of New Mexico. One day is 8 available hours for birds to forage and gain body mass. Column “a” is from y = ax + b where y is body mass at capture, x is the capture time (hr), b is the y-intercept, and a is the slope. SE is the standard error of the slope. The r measures the strength of the relationship between body mass and time, and t statistics indicate how well the linear model fits the data. % change/d is calculated as: slope x 8 hr/mean body mass of the species. The analysis was performed for species with sample size (N) ≥ 20 in each season. See appendix I for species codes.

	Spring							Fall						
Species	N	a	SE	r	t	P	%change/d	N	a	SE	r	t	P	%change/d
RSFL								43	1.58	1.14	0.21	0.14	ns	9.48
WEWP	99	0.30	0.09	0.32	3.33	**	18.15	116	0.07	0.05	0.13	1.38	ns	4.53
WIFL	93	0.19	0.08	0.26	2.52	*	11.80	120	0.08	0.06	0.12	1.30	ns	5.29
DUFL	262	0.05	0.04	0.07	1.50	ns	3.50	136	0.10	0.04	0.20	2.34	*	7.43
GRFL	32	0.23	0.12	0.33	1.89	0.07	16.01	38	–0.20	0.11	0.29	0.18	0.08	–13.90
WEFL								63	0.05	0.09	0.08	0.61	ns	3.57
BLPH	32	0.00	0.11	0.00	0.01	ns	0.00	24	0.15	0.17	0.18	0.86	ns	6.89
ATFL	33	0.15	0.22	0.12	0.67	ns	4.45							
WEKI								30	0.09	0.32	0.06	0.30	ns	1.99
NRWS	20	0.29	0.27	0.24	1.05	ns	16.36							
MOCH								40	–0.03	0.07	0.08	0.48	ns	–2.21
BCCH								27	–0.13	0.15	0.17	0.84	ns	–9.68
COBU								31	0.01	0.05	0.03	0.15	ns	1.44
BRCR								28	0.12	0.09	0.25	1.33	ns	13.06
BEWR	35	0.08	0.09	0.15	0.86	ns	6.59	125	0.07	0.03	0.19	2.14	*	5.87
HOWR	59	0.09	0.05	0.23	1.78	0.08	7.37	94	0.11	0.04	0.28	2.74	**	8.51
RCKI	73	0.08	0.04	0.26	2.22	*	10.76	563	0.01	0.02	0.02	0.41	ns	1.32
HETH	65	0.15	0.24	0.08	0.63	ns	4.94	189	0.09	0.11	0.06	0.85	ns	3.02
AMRO	125	0.30	0.38	0.07	0.79	ns	3.11	96	0.39	0.58	0.07	0.68	ns	3.91
SOVI								45	0.07	0.18	0.06	0.37	ns	3.76
WAVI	79	0.16	0.07	0.24	2.14	*	11.36	150	0.10	0.05	0.16	1.97	0.05	6.76
OCWA	63	0.08	0.11	0.09	0.72	ns	7.03	768	0.09	0.02	0.20	5.75	***	8.25
VIWA	43	0.16	0.09	0.27	1.76	0.09	14.92	205	0.03	0 3	0.08	1.08	ns	2.96
YWAR	126	0.12	0.06	0.19	2.16	*	10.39	363	0.05	0.03	0.09	1.78	0.08	4.46
YRWA	256	0.10	0.05	0.11	1.84	0.07	6.32	614	0.07	0.03	0.11	2.70	**	4.75
NOWA								26	0.34	0.36	0.19	0.94	ns	15.62
MGWA	792	0.09	0.02	0.13	3.76	***	6.69	512	0.07	0.02	0.15	3.31	**	5.28
COYE	129	–0.04	0.06	0.06	0.67	ns	–3.32	84	0.14	0.06	0.27	2.55	*	11.16
WIWA	657	0.09	0.02	0.17	4.43	***	9.80	2697	0.06	0.01	0.18	9.47	***	6.56
YBCH	41	–0.18	0.25	0.11	0.72	ns	–6.02							
SUTA	38	0.31	0.26	0.19	1.17	ns	9.40	69	0.05	0.24	0.02	0.20	ns	1.34
WETA								124	0.31	0.15	0.19	2.12	*	8.32
BHGR	181	0.52	0.19	0.20	2.78	**	9.35	168	–0.08	0.22	0.03	0.38	ns	–1.44
BLGR	97	0.09	0.14	0.07	0.64	ns	2.57	333	0.20	0.09	0.13	2.31	*	5.59
LAZB								613	0.06	0.03	0.07	1.75	0.08	3.26

(con.)

Table 7 (Con.)

Species	Spring							Fall						
	N	**a**	**SE**	**r**	**t**	**P**	**%change/d**	**N**	**a**	**SE**	**r**	**t**	**P**	**%change/d**
GTTO	72	0.00	0.20	0.00	0.01	ns	0.00	153	0.21	0.13	0.13	1.62	0.1	6.00
SPTO	68	0.15	0.21	0.08	0.68	ns	3.32	183	0.05	0.09	0.08	0.61	ns	1.09
CHSP	41	0.25	0.02	0.33	2.18	*	17.32	2665	0.12	0.01	0.23	12.33	***	7.97
CCSP								202	0.08	0.04	0.17	2.37	*	5.99
BRSP	66	0.26	0.11	0.29	2.39	*	19.44	440	0.06	0.03	0.10	2.04	*	4.56
VESP								242	0.21	0.08	0.16	2.57	*	7.19
LASP								561	0.29	0.05	0.23	5.45	***	8.56
SAVS	23	–0.28	0.24	0.25	1.16	ns	–12.87	194	0.07	0.07	0.08	1.09	ns	3.38
SOSP								432	0.19	0.04	0.22	4.56	***	7.75
LISP	26	–0.29	0.28	0.21	1.03	ns	–13.93	390	0.05	0.06	0.04	0.82	ns	2.49
WCSP	284	0.15	0.09	0.10	1.60	ns	4.75	1173	0.16	0.04	0.12	4.22	***	5.25
DEJU	71	–0.31	0.18	0.21	1.75	0.09	–13.78	787	0.10	0.03	0.13	3.66	***	4.56
RWBL	198	1.25	0.43	0.21	2.94	**	19.27	40	0.20	0.55	0.06	0.37	ns	3.70
BHCO	27	1.26	0.55	0.41	2.27	*	29.11							
BUOR								68	0.34	0.22	0.19	1.55	ns	8.03
HOFI								305	0.15	0.05	0.16	2.85	**	6.09
PISI								1687	0.10	0.01	0.18	7.30	***	6.50
LEGO								387	0.06	0.02	0.16	3.08	**	5.13
AMGO								293	0.04	0.03	0.09	1.49	ns	2.49

[1] * P, <0.05; **, P < 0.01; ***, P, < 0.001; and ns, not significant.

Table 8—Capture rate (birds/1,000 net hr) by habitat type (AGFI = agriculture field/edge, CWNA = cottonwood/native understory, CWRO = cottonwood/Russian olive, CWSC = cottonwood/saltcedar, SASC = saltcedar, and WILL = willow) during spring and fall migration. See appendix I for species codes.

	Spring							Fall						
Species[1]	AGFI	CWNA	CWRO	CWSC	SASC	WILL	Total	AGFI	CWNA	CWRO	CWSC	SASC	WILL	Total
SSHA	0.00	0.00	0.00	0.14	0.00	0.00	0.03	0.00	0.21	0.50	0.00	0.00	0.00	0.20
COHA	0.00	0.00	0.13	0.00	0.00	0.00	0.06	0.18	0.00	0.14	0.10	0.00	0.00	0.10
AMKE	0.40	0.00	0.06	0.00	0.00	0.00	0.06	0.09	0.00	0.09	0.00	0.00	0.00	0.05
MODO	0.00	1.37	0.57	0.00	0.00	0.00	0.37	1.08	0.00	0.23	0.00	0.00	0.00	0.28
WWDO	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YBCU	0.00	0.34	0.00	0.14	0.00	0.81	0.20	0.00	0.00	0.00	0.48	0.00	0.10	0.10
GRRO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.10	0.03
CONI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.02
BEKI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.09	0.00	0.00	0.00	0.10
DOWO	0.00	0.00	0.32	0.14	0.00	0.00	0.17	0.00	0.62	0.36	0.38	0.00	0.00	0.25
HAWO	0.00	0.00	0.00	0.14	0.00	0.16	0.06	0.00	0.00	0.00	0.48	0.00	0.00	0.08
RNSA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.14	0.29	0.00	0.10	0.15
WISA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.60	0.00	0.03
LBWO	0.40	0.00	0.00	0.14	0.00	0.00	0.06	0.00	0.21	0.00	0.00	0.00	0.10	0.03
RSFL	0.00	0.00	0.06	0.14	0.00	0.16	0.09	0.00	1.03	1.31	0.86	0.00	0.00	0.71
OSFL	0.40	0.00	0.06	0.43	0.00	0.33	0.20	0.00	0.00	0.14	0.00	0.00	0.00	0.05
WEWP	3.62	2.05	2.81	1.42	0.00	4.88	2.81	2.61	2.89	2.16	1.44	0.60	0.87	1.91
HAFL	1.21	0.00	0.06	0.14	1.09	0.65	0.28	0.18	0.83	0.81	0.48	0.60	0.10	0.51
LEFL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.14	0.00	0.00	0.00	0.07
WIFL	2.01	0.00	2.94	0.28	1.09	6.34	2.64	3.33	0.83	2.16	0.29	4.17	2.04	1.98
DUFL	1.61	3.07	5.30	6.25	15.26	17.55	7.45	2.34	1.03	3.33	1.06	4.17	1.26	2.24
GRFL	0.00	0.68	0.77	0.57	3.27	1.79	0.91	0.45	0.41	0.54	0.48	1.19	1.16	0.63
WEFL	0.00	0.68	0.19	0.28	0.00	0.33	0.26	0.81	1.03	1.53	1.15	0.60	0.19	1.04
BLPH	2.81	0.68	0.64	0.57	0.00	1.46	0.91	0.09	2.27	0.50	0.00	0.00	0.10	0.40
SAPH	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.81	0.00	0.05	0.00	0.60	0.00	0.18
ATFL	1.21	1.37	0.64	0.57	2.18	1.63	0.94	0.00	0.00	0.14	0.00	0.00	0.00	0.05
BCFL	0.40	0.00	0.00	0.14	0.00	0.16	0.09	0.00	0.00	0.00	0.00	0.00	0.19	0.03
WEKI	0.80	0.00	0.19	0.00	0.00	0.00	0.14	2.52	0.00	0.09	0.00	0.00	0.00	0.50
BARS	0.00	0.00	0.26	0.00	0.00	1.14	0.31	0.45	0.00	0.14	0.00	0.00	0.48	0.21
VGSW	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BANS	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRWS	5.62	0.00	0.06	0.00	0.00	0.81	0.57	0.09	0.00	0.00	0.00	0.00	0.00	0.02
SCJA	0.00	0.00	0.32	0.00	0.00	0.00	0.14	0.00	0.21	0.36	0.38	0.00	0.00	0.21
MOCH	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.18	1.45	1.17	0.38	0.00	0.10	0.66
BCCH	0.00	0.00	0.38	0.00	0.00	0.00	0.17	0.00	1.03	0.99	0.00	0.00	0.00	0.45
PLTI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.02
COBU	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.36	0.00	1.22	0.00	0.00	0.00	0.51
VERD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.29	0.07
RBNU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.38	0.00	0.19	0.21
WBNU	0.00	0.34	0.45	0.28	0.00	0.33	0.34	0.00	0.41	0.45	0.58	0.00	0.00	0.30

(con.)

Table 8 (Con.)

Species[1]	Spring AGFI	Spring CWNA	Spring CWRO	Spring CWSC	Spring SASC	Spring WILL	Spring Total	Fall AGFI	Fall CWNA	Fall CWRO	Fall CWSC	Fall SASC	Fall WILL	Fall Total
BRCR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.59	0.96	0.00	0.19	0.46
ROWR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.10	0.03
CACW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02
BEWR	0.40	2.73	0.26	1.71	3.27	1.14	0.99	1.17	1.86	2.75	1.06	3.57	2.42	2.06
HOWR	3.62	1.37	1.21	1.42	1.09	2.60	1.68	1.80	0.83	2.52	0.29	0.60	0.97	1.55
MAWR	0.00	0.00	0.06	0.00	0.00	0.16	0.06	0.18	0.00	0.14	0.00	0.00	0.29	0.13
WIWR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.02
CARW	0.00	0.00	0.00	0.14	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCKI	0.80	3.07	0.96	1.14	0.00	6.34	2.07	3.69	6.81	7.52	9.21	7.14	20.76	9.29
GCKI	0.00	0.34	0.00	0.00	0.00	0.16	0.06	0.00	0.00	0.09	0.00	0.00	0.10	0.05
BGGN	0.00	0.68	0.19	0.28	0.00	0.33	0.26	0.09	0.00	0.09	0.00	0.00	0.00	0.05
TOSO	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.10	0.60	0.00	0.03
SWTH	0.00	0.68	0.00	0.28	0.00	0.33	0.17	0.00	0.00	0.09	0.19	0.00	0.10	0.08
HETH	0.40	2.73	2.62	1.14	3.27	0.65	1.85	0.36	5.58	6.30	1.25	1.19	0.29	3.12
AMRO	5.62	2.39	5.68	1.14	0.00	1.14	3.55	0.09	7.23	2.61	0.19	0.00	0.00	1.58
GRCA	0.00	0.34	0.26	0.43	0.00	0.16	0.26	0.09	0.00	0.09	0.10	0.60	0.39	0.15
NOMO	1.21	0.00	0.57	0.00	1.09	0.65	0.48	0.00	0.21	0.00	0.00	0.00	0.00	0.02
SATH	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRTH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.02
CRTH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.02
BEVI	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRVI	0.00	0.00	0.06	0.00	1.09	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOVI	2.01	0.00	0.06	0.28	1.09	1.63	0.54	0.18	0.41	1.22	0.77	0.00	0.58	0.74
WAVI	3.21	0.68	1.28	0.71	1.09	6.99	2.24	1.35	1.86	2.93	1.06	7.14	3.69	2.48
REVI	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.10	0.00	0.00	0.02
YTVI	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PROW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.19	0.00	0.00	0.05
BWWA	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAWA	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OCWA	2.01	0.34	1.09	0.28	2.18	5.85	1.79	28.69	3.51	16.34	0.67	2.98	5.53	12.68
NAWA	0.40	0.00	0.06	0.00	0.00	0.49	0.14	0.09	0.00	0.14	0.00	0.00	0.00	0.07
VIWA	1.21	0.00	0.89	0.14	2.18	3.74	1.22	5.04	2.07	4.01	0.86	1.79	3.69	3.38
LUWA	0.80	0.34	0.00	0.28	0.00	0.16	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAWA	0.40	0.00	0.06	0.00	0.00	0.16	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YWAR	2.01	0.68	2.62	0.00	1.09	12.52	3.58	10.70	1.03	5.31	0.38	0.00	11.35	5.99
CSWA	0.40	0.00	0.00	0.14	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YRWA	6.43	0.68	11.24	1.42	0.00	8.45	7.27	4.32	11.77	18.86	4.99	0.60	3.59	10.13
BTYW	0.00	0.00	0.00	0.00	1.09	0.16	0.06	0.09	0.00	0.05	0.00	0.00	0.00	0.03
BTBW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.02
BLBW	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(con.)

Table 8 (Con.)

	Spring							Fall						
Species[1]	AGFI	CWNA	CWRO	CWSC	SASC	WILL	Total	AGFI	CWNA	CWRO	CWSC	SASC	WILL	Total
TOWA	0.00	0.00	0.00	0.00	1.09	0.33	0.09	0.09	0.00	0.27	0.38	0.00	0.10	0.20
PRAW	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAWW	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	0.00	0.05	0.10	0.00	0.00	0.05
AMRE	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	0.00	0.00	0.00	0.00	0.10	0.03
WPWA	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOWA	0.00	0.00	0.45	0.00	0.00	0.00	0.20	0.09	0.62	0.63	0.10	0.00	0.68	0.43
OVEN	0.40	0.00	0.26	0.85	0.00	0.33	0.37	0.00	0.00	0.05	0.00	0.00	0.00	0.02
TEWA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.02
MOWA	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MGWA	14.06	13.32	28.98	6.25	15.26	33.48	22.51	11.33	4.75	10.89	2.02	3.57	9.12	8.45
COYE	5.22	0.68	1.02	0.71	0.00	15.12	3.67	1.80	0.21	0.41	0.10	0.60	5.04	1.39
KEWA	0.00	0.00	0.06	0.14	0.00	0.16	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAWA	0.00	0.00	0.00	0.14	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIWA	14.06	1.37	6.83	3.84	8.72	77.37	18.67	56.39	29.74	48.79	27.93	18.45	50.44	44.51
HOWA	0.40	0.00	0.06	0.00	0.00	0.16	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YBCH	0.00	1.02	0.19	0.99	1.09	4.39	1.17	0.00	0.41	0.14	0.10	0.00	0.78	0.23
HETA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.05	0.19	0.00	0.00	0.07
SUTA	3.62	2.05	0.32	1.28	0.00	1.46	1.08	0.27	1.86	0.14	3.84	0.00	1.36	1.14
WETA	1.21	0.00	0.45	0.14	0.00	0.65	0.43	0.09	1.65	3.33	2.30	0.60	1.55	2.05
SCTA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.02
PYRR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.10	0.03
RBGR	0.40	0.00	0.06	0.14	0.00	0.00	0.09	0.00	0.00	0.05	0.00	0.00	0.00	0.02
BHGR	5.62	2.73	5.36	4.55	1.09	6.83	5.14	1.98	3.30	2.84	5.76	2.38	0.29	2.77
BLGR	5.22	2.39	1.21	1.71	0.00	7.48	2.76	13.94	1.86	3.87	2.40	1.19	5.43	5.50
LAZB	0.00	0.00	0.26	0.00	0.00	0.98	0.28	43.62	0.21	4.73	0.29	0.00	1.84	10.12
INBU	0.00	0.34	0.06	0.00	0.00	1.14	0.26	0.54	0.00	0.05	0.10	0.00	0.39	0.20
PABU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.14	0.10	0.00	0.10	0.10
DICK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.03
GTTO	2.01	1.02	3.06	0.43	1.09	1.95	2.05	2.70	1.65	4.28	0.29	5.95	0.68	2.53
SPTO	2.81	4.10	0.51	2.70	2.18	3.25	1.93	1.17	5.58	3.60	2.21	7.74	2.62	3.02
CANT	0.40	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.21	0.09	0.00	0.00	0.00	0.05
CASP	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHSP	2.01	0.00	0.45	0.00	3.27	4.23	1.17	139.13	14.04	34.25	2.30	72.02	13.97	43.99
ATSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.02
CCSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.41	0.21	1.35	0.00	0.00	3.20	3.33
BRSP	2.81	0.00	0.51	0.71	16.35	5.04	1.88	19.52	0.21	5.72	0.10	6.55	8.05	7.26
VESP	1.21	0.00	0.13	0.00	0.00	0.16	0.17	15.74	0.41	2.70	0.00	0.00	0.48	3.99
LASP	0.80	0.00	0.06	0.00	0.00	0.49	0.17	39.03	0.83	3.33	0.10	0.00	4.66	9.26
BTSP	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	0.00	0.00	0.10	0.00	0.00	0.03
SAGS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02

(con.)

Table 8 (Con.)

	Spring							Fall						
Species[1]	**AGFI**	**CWNA**	**CWRO**	**CWSC**	**SASC**	**WILL**	**Total**	**AGFI**	**CWNA**	**CWRO**	**CWSC**	**SASC**	**WILL**	**Total**
LARB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	0.21	0.00	0.00	0.00	0.00	0.21
SAVS	0.00	0.00	1.47	0.00	0.00	0.00	0.65	9.53	0.21	1.58	0.10	0.00	4.95	3.20
GRSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.05
SOSP	1.21	0.00	0.45	0.00	0.00	0.65	0.40	8.72	4.34	5.67	0.29	1.79	17.65	7.13
FOSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.02
LISP	0.40	0.34	0.64	0.00	0.00	2.28	0.74	16.10	3.10	4.41	0.48	2.38	8.63	6.44
SWSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.05	0.00	0.00	0.00	0.05
WTSP	0.40	0.00	0.13	0.00	0.00	0.16	0.11	0.27	0.62	0.14	0.10	0.00	0.10	0.18
GCSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.02
WCSP	26.11	1.37	6.83	0.71	0.00	16.74	8.07	25.36	34.69	19.31	0.77	23.21	23.96	19.36
DEJU	6.83	2.39	0.89	1.85	2.18	2.60	1.96	4.41	16.52	18.18	11.33	27.98	8.54	12.99
YHBL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.10	0.23
RWBL	0.40	1.37	12.32	0.00	0.00	0.00	5.63	3.24	0.00	0.14	0.00	0.00	0.10	0.66
WEME	0.40	0.00	0.00	0.00	0.00	0.00	0.03	0.45	0.00	0.00	0.00	0.00	0.00	0.08
COGR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.02
GTGR	0.00	1.71	0.45	0.00	0.00	0.00	0.34	0.00	0.00	0.09	0.00	0.00	0.00	0.03
BHCO	0.40	0.00	0.38	0.71	0.00	2.44	0.77	0.36	0.00	0.05	0.10	0.00	0.10	0.12
OROR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.05
BUOR	0.40	0.00	0.19	0.71	0.00	0.81	0.40	0.90	3.30	1.58	0.48	0.00	0.19	1.12
CAFI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.10
HOFI	2.81	0.00	0.06	0.00	0.00	1.79	0.54	14.21	11.77	3.96	0.10	0.00	0.10	5.03
PISI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	144.07	0.21	3.78	0.00	0.00	0.00	27.84
LEGO	1.61	0.00	0.06	0.00	0.00	0.81	0.28	31.39	0.41	1.13	0.58	0.60	0.39	6.39
WWCR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.02
AMGO	0.00	0.00	0.00	0.00	0.00	0.33	0.06	20.86	0.00	2.57	0.00	0.00	0.39	4.84
EVGR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.02
Evenness	0.83	0.87	0.69	0.84	0.83	0.69	0.71	0.65	0.76	0.72	0.69	0.70	0.71	0.69
All species	154.68	63.86	120.14	51.29	93.73	287.86	132.77	717.85	203.20	285.32	97.04	213.69	237.74	315.70
Spp richness	56	38	80	52	26	79	108	82	62	94	68	33	69	125
H’	4.81	4.58	4.38	4.78	3.89	4.37	4.81	4.12	4.50	4.75	4.22	3.54	4.35	4.78

[1] Spp richness = total species detected; H’ = Shannon diversity index. Evenness is calculated based on Shannon diversity index (Krebs 1998)

and Wilson's Warbler, had highest capture rate in agricultural habitat (table 8); capture rates were highest in willow habitat for the Yellow Warbler. Consistent with spring migration, the Yellow-rumped Warbler preferred cottonwood/Russian olive habitat for stopover during fall migration.

Jaccard's similarity coefficient suggested that in spring, species composition was most similar between agricultural habitat and cottonwood/Russian olive, followed by cottonwood/Russian olive and willow habitats; the species similarity was low between saltcedar and the other four habitats (table 9). In fall, bird species composition was most similar between habitats with a cottonwood overstory component (cottonwood/native understory, cottonwood/saltcedar, and cottonwood/Russian olive); saltcedar and all other habitats examined were the least similar (table 9), which was related to low species richness in saltcedar both in spring and fall.

We selected species with capture rates ≥ 1 bird/1,000 net hr in each habitat (table 8) to perform the detrended correspondence analyses. There were 26 species and 39 species that met this condition for spring and fall, respectively. The distribution of a given species among habitats was more uniform among the five habitats studied in spring than in fall, which was suggested by the low variation accounted for by DCA components. The first two DCA axes of spring data accounted for 36 percent and 8 percent of the total variance, respectively. The first component tended to separate species captured frequently in saltcedar from those species captured more often in other habitats; the second component tended to separate species that frequented habitats with cottonwood overstory from species captured more often in agricultural or willow habitats (fig. 5). The biplot suggests that the relative abundances of the Black-headed Grosbeak, Blue Grosbeak, Chipping Sparrow, Common Yellow-throat, Dusky Flycatcher, MacGillivray's Warbler, Orange-crowned Warbler, Ruby-crowned Kinglet, Virginia Warbler, Warbling Vireo, Western Wood-pewee, Willow Flycatcher, Wilson's Warbler, Yellow-breasted Chat, Yellow-rumped Warbler, and Yellow Warbler were the highest in willow habitat; and the Dark-eyed Junco, House Wren, White-crowned Sparrow were most abundant in agricultural field/edges. Habitats with cottonwood overstory were similar in species composition and relative abundance (fig. 5).

In fall, the first two components of detrended correspondence analysis accounted for 55 percent and 17 percent of the total variance, respectively. The first component tended to separate species that were captured most often in agricultural habitat from those species that were captured more frequently in cottonwood/saltcedar and cottonwood/native understory habitats (fig. 6). The second component tended to separate species captured in willow habitat from species captured more often in saltcedar. In general, species distribution among habitats differed between the two seasons. While 17 of the 39 species selected for analysis were relatively more abundant in agriculture than in other habitats in fall, the Ruby-crowned Kinglet, Common Yellowthroat, and Yellow Warbler were captured more frequently in willow. The Chipping Sparrow, Dark-eyed Junco, Dusky Flycatcher, Green-tailed Towhee, and Warbling Vireo were most abundant in saltcedar (fig. 6). Canopy species such as the American Robin, Black-headed Grosbeak, Bullock's Oriole, Dark-eyed Junco, Hermit Thrush, Ruby-crowned Kinglet, Spotted Towhee, Summer Tanager, Western Flycatcher, Western Tanager, and Yellow-rumpled Warbler, clustered along the cottonwood overstory side of the first component (fig. 6). The Brewer's Sparrow, Hermit Thrush, Dusky Flycatchers, and Chipping Sparrow were grouped on the saltcedar direction for analyses in spring (fig. 5) and fall (fig. 6). Species that feed on seeds usually had high or highest capture rates in agricultural habitat in fall. These species included finches, for example, the Pine Siskin, Lesser Goldfinch, and American Goldfinch; sparrows, such as the Lark Sparrow, Vesper Sparrow, Clay-colored Sparrow, and Savanna Sparrow; and the Lazuli Bunting (fig. 6).

Age-Related Migration

Of the 19,127 birds captured in fall, 59 percent were hatching-year birds (immatures); 32 percent were after-hatching year birds (adults); and the rest were not classified because of the overlap in morphological or developmental characteristics between immature and adult birds. After excluding the birds of unknown age, we detected an overall interaction between age and site ($G = 862.31$, $df = 1$, $P < 0.001$). The immature/adult ratio was about 1:1 at BNWR and was 2:1 at RGNC. We selected 30 species, having >20 capture/site to test effects of site on age ratio (table 10). All species except the Savanna Sparrow showed site-dependent variations in age composition. Seven species—the Bewick's Wren, Hermit Thrush, Yellow Warbler, Chipping Sparrow, Savannah Sparrow, Lincoln's Sparrow, and White Crowned Sparrow—had more immatures at both sites. The age structure pattern was reversed between sites in the remaining 25 species: young birds were more abundant at RGNC and adults were more abundant at BNWR (except the Dark-eyed Junco) (table 10).

Two-way ANOVA (site x age) suggested that the timing of fall migration differed between adults and immatures in 13 of the 30 species (table 11); 12 of these 13 species were Neotropical migrants. Young birds of nine significant species—the Willow Flycatcher, Dusky

Table 9—Landbird species similarity (Jaccard's similarity coefficient) among habitat types during spring and fall migration along the middle Rio Grande Valley of New Mexico. Jaccard's similarity coefficient (Krebs 1998) was calculated based on birds/1,000 net hr (see table 6).

	Agriculture field/edge	Cottonwood/ native understory	Cottonwood/ Russian olive	Cottonwood/ saltcedar	Saltcedar
		Spring			
Cottonwood/native understory	0.382				
Cottonwood/Russian olive	0.581	0.405			
Cottonwood/saltcedar	0.521	0.525	0.467		
Saltcedar	0.344	0.333	0.293	0.345	
Willow	0.552	0.427	0.574	0.523	0.313
		Fall			
Cottonwood/native understory	0.469				
Cottonwood/Russian olive	0.586	0.592			
Cottonwood/saltcedar	0.485	0.625	0.558		
Saltcedar	0.369	0.439	0.337	0.443	
Willow	0.573	0.578	0.583	0.593	0.417

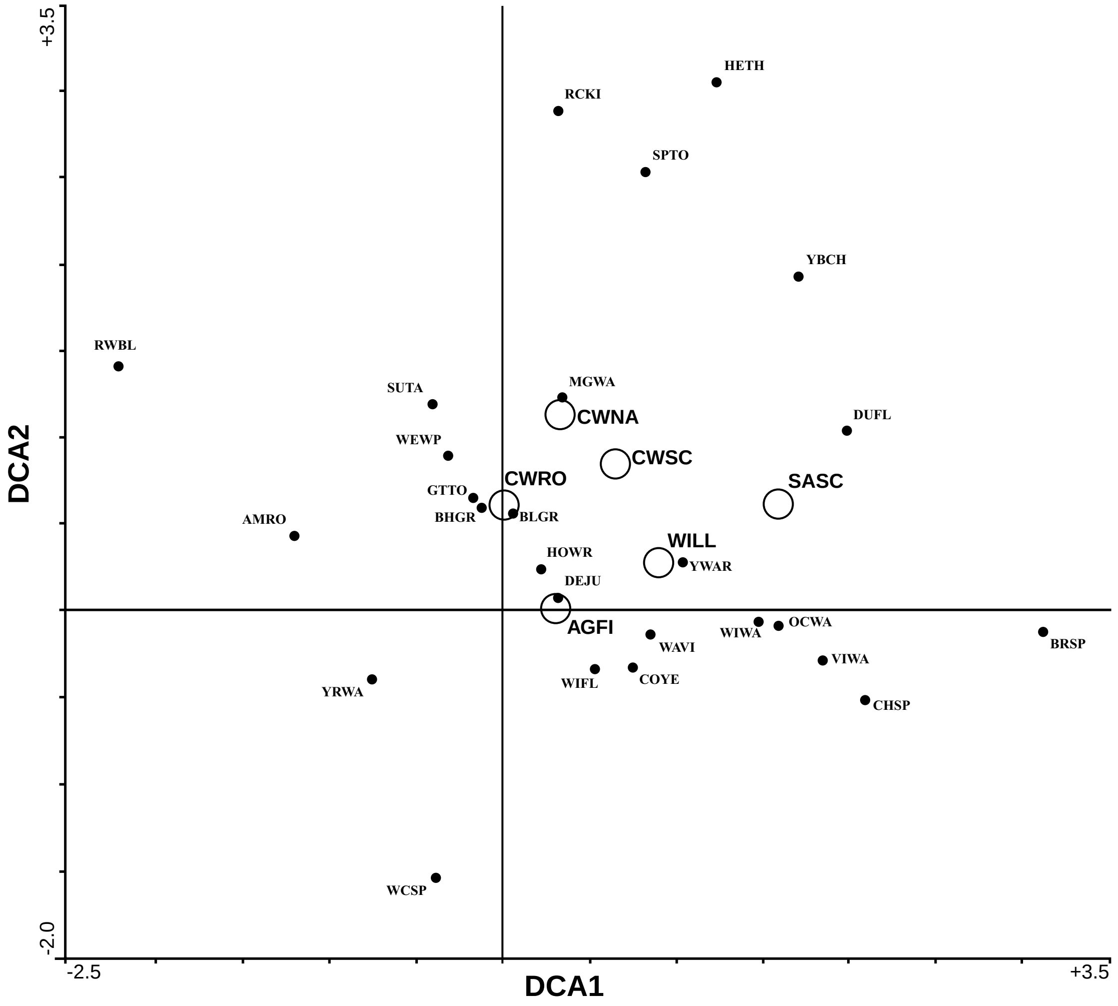

Figure 5—Joint plot based on detrended correspondence analysis (DCA) of bird species captured in spring along the middle Rio Grande, New Mexico. The plot shows the DCA-scores of 26 most abundant species. Habitat type scores ± are based on bird scores (AGFI = agriculture field/edge, CWNA = cottonwood/native understory, CWRO = cottonwood/Russian olive, CWSC = cottonwood/saltcedar, SASC = saltcedar, and WILL = willow). See appendix I for species codes.

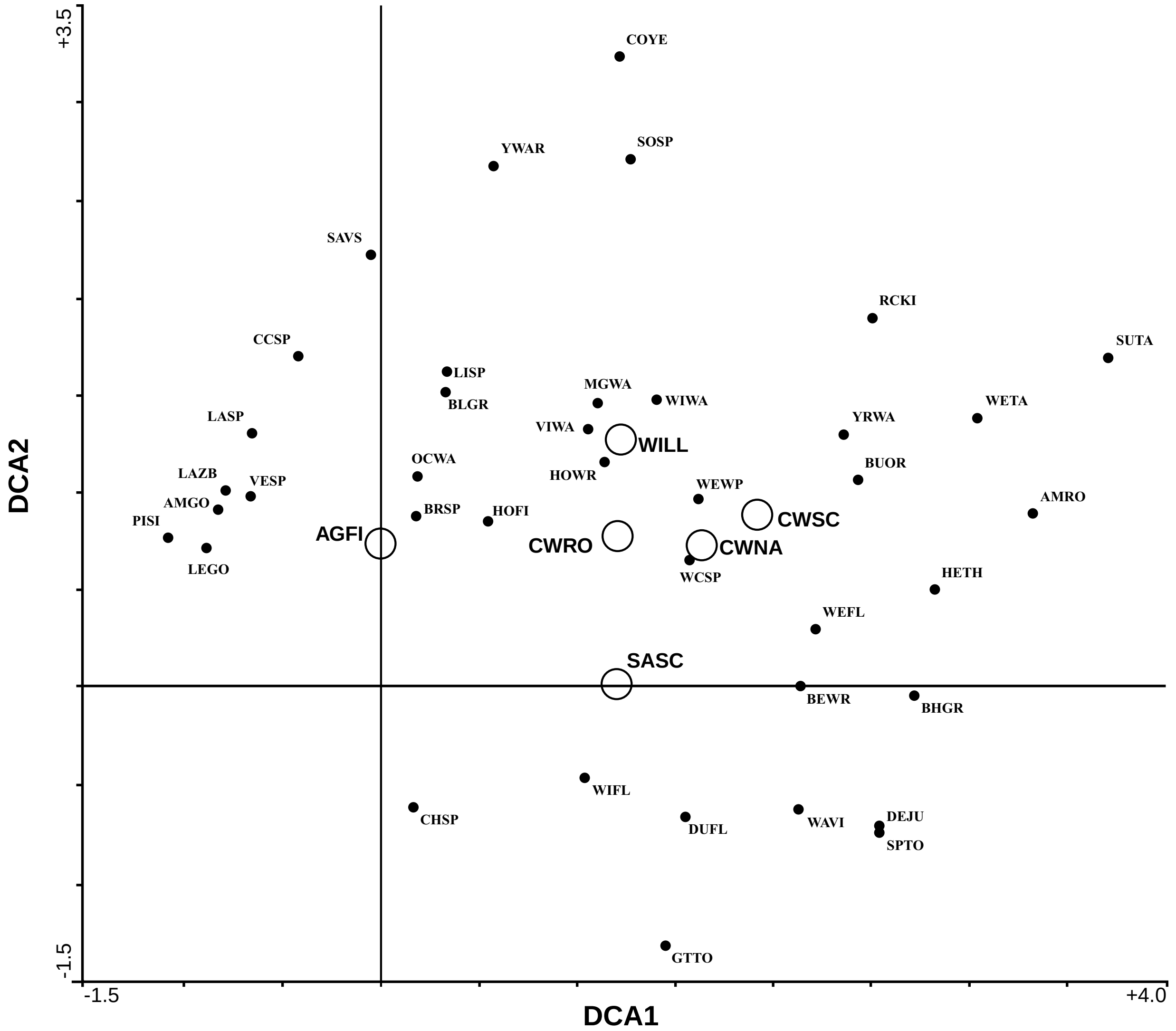

Figure 6—Joint plot based on detrended correspondence analysis (DCA) of bird species captured in fall along the middle Rio Grande, New Mexico. The plot shows the DCA-scores of 39 most abundant species. Habitat scores ± are based on bird scores (AGFI = agriculture field/edge, CWNA = cottonwood/native understory, CWRO = cottonwood/Russian olive, CWSC = cottonwood/saltcedar, SASC = saltcedar, and WILL = willow). See appendix I for species codes.

Flycatcher, Western Flycatcher, Warbling Vireo, Orange-crowned Warbler, Black-headed Grosbeak, Blue Grosbeak, Lazuli Bunting, and Dark-eyed Junco—migrated through the study sites later than adults. Young of the other four species—the House Wren, Yellow Warbler, MacGillivray's Warbler, and Brewer's Sparrow—migrated through the sites earlier than adults (table 11).

Because body mass variation within species was large, most species did not differ in body mass between the two age classes. Of the 30 species examined, only five species—the Hermit Thrush, Lazuli Bunting, Chipping Sparrow, Lark Sparrow, and Clay-colored Sparrow—differed in body mass by age (table 12). But when we treated 30 species as repeated samples at each site, we found that body mass of adult birds was higher than that of young birds at BNWR (Wilcoxon test, Z = 2.633, $P < 0.01$) and at RGNC (Wilcoxon test, Z = 3.836, $P < 0.001$). The amount of observable fat was age-dependent. Proportionally more young birds than adults were likely to be fat-depleted (table 13). Among 4,797 adults of the 30 species, 45 percent had no observable fat (fat class = 0), while among 8,991 young birds, 53 percent had no observable fat reserves upon initial capture ($X^2 = 96.09$, df=1, $P < 0.001$). The amount of fat stores was age-dependent in 13 of the 30 species. In the majority of these 13 species, adults tended to carry more fat stores than young birds. For example, in the Wilson's Warblers, 66 percent of the adult birds had fat stores while 56 percent of the young

Table 10—Age composition of landbirds captured during fall migration at Bosque National Wildlife Refuge (BNWR) and Rio Grande Nature Center (RGNC). Only species with >20 captures at each site were included. AHY = after hatching year; HY = hatching year; and U = unknown. See appendix I for species codes.

	BNWR				RGNC					
SPP	Total	AHY%	HY%	U%	Total	AHY%	HY%	U%	G[1]	P
WEWP	37	78	22		79	18	81	1	51.47	***
WIFL	34	50	44	6	86	41	55	5	7.63	**
DUFL	33	64	30	6	103	20	77	3	87.76	***
WEFL	21	52	38	10	42	26	69	5	8.13	**
BEWR	57	25	47	28	68	15	56	29	15.76	***
HOWR	21	67	14	19	73	19	67	14	48.05	***
RCKI	369	23	15	62	194	22	29	49	14.42	***
HETH	33	39	52	9	156	23	72	5	13.39	***
WAVI	64	75	25		86	49	50	1	22.01	***
OCWA	94	45	36	19	674	26	59	15	64.51	***
VIWA	59	73	24	3	146	36	64	1	43.48	***
YWAR	131	48	52		232	28	71	1	40.18	***
YRWA	105	48	39	18	509	20	65	15	52.42	***
MGWA	145	64	35	1	367	31	66	4	60.84	***
WIWA	1026	55	43	2	1671	26	66	9	494.76	***
WETA	44	66	32	2	80	20	79	1	27.98	***
BHGR	80	75	23	3	88	24	76		38.4	***
BLGR	121	65	33	2	212	26	70	4	92.3	***
LAZB	43	51	49		570	40	59	1	5.01	*
GTTO	22	64	32	5	131	17	76	7	24.6	***
SPTO	79	54	44	1	104	39	58	4	24.54	***
CHSP	392	29	59	12	2273	27	70	4	15.87	***
CCSP	40	80	20		162	6	90	4	91.85	***
BRSP	111	75	24		329	13	82	6	224.67	***
LASP	63	59	37	5	498	33	67		23.63	***
SAVS	56	41	50	9	138	34	63	3		ns
SOSP	244	50	32	18	188	26	52	22	24.06	***
LISP	160	42	49	9	230	18	77	5	33.93	***
WCSP	373	31	66	3	800	22	77		73.08	***
DEJU	327	36	36	28	460	14	63	23	103.25	***

[1] Log likelihood ratio test was performed between site and age class (unknowns were excluded). ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$; and ns, not significant.

birds were fat-depleted upon initial capture; in the MacGillivray's Warbler, 56 percent of adults carried stored fat while only 47 percent of young birds had fat (table 13). However, the pattern was reversed in the Western Tanager and Lark Sparrow; proportionally, more adults were fat-depleted than young.

The relationship between capture time and body mass was positive in most species regardless of age, suggesting that both age groups were able to gain body mass during the day. Among the 30 species examined, adults of 18 species and immatures of 19 species had daily rates of body mass gain ≥ 4.5 percent of lean body mass (table 14). The daily rate of body mass gain was > 10 percent of lean body mass in adults of Chipping Sparrow, Hermit Thrush, House Wren, Orange-crowned Warbler, Western Flycatcher, Western Tanager, and Willow Flycatcher; and in immatures of the Blue Grosbeak, Clay-colored Sparrow, Lark Sparrow, Song Sparrow, and Warbling Vireo. Of the 30 species tested, the average daily rate of mass gain did not differ between adults (6.15 percent ± 5.58) and immatures (6.10 percent ± 4.16) (table 14).

Discussion

Species Composition and Relative Abundance

Data presented in this report were based on mist-netting captures. Mist-netting may undersample certain species and lead to biased estimates of species richness and relative abundance (Remsen and Good 1996, Yong and Finch 2002.). Typically, mist-netting is an effective tool for detecting birds using habitat within 2 to 3 m off the ground. Compared to our count data from the same period, mist-netting tended to

Table 11—Median (range) of capture dates (Julian day) of adult (AHY) and hatching-year (HY) birds captured during fall migration along the middle Rio Grande. See table 9 for species selection and appendix I for species codes.

	BNWR		RGNC		P[1]		
SPP	**AHY**	**HY**	**AHY**	**HY**	**SITE**	**AGE**	**SITE X AGE**
WEWP	255 (40)	254 (29)	246 (36)	248 (43)	*	ns	ns
WIFL	243 (37)	248 (53)	232 (37)	242 (27)	*	**	ns
DUFL	243 (56)	263 (51)	228 (57)	253 (54)	**	***	ns
WEFL	248 (61)	249 (33)	236 (33)	250 (58)	ns	*	ns
BEWR	237 (68)	260 (89)	264 (91)	256 (80)	ns	ns	ns
HOWR	261 (21)	254 (8)	262 (41)	254 (51)	ns	*	ns
RCKI	276 (60)	292 (40)	268 (46)	276 (54)			*
HETH	291 (43)	292 (35)	284 (50)	291 (53)	*	ns	ns
WAVI	228 (50)	245 (36)	226 (42)	245 (61)	ns	***	ns
OCWA	269 (57)	273 (75)	261 (61)	265 (68)	***	**	ns
VIWA	236 (68)	246 (41)	250 (50)	237 (60)			*
YWAR	240 (51)	231 (47)	239 (47)	239 (53)	**	**	ns
YRWA	276 (60)	280 (46)	270 (42)	271 (63)	***	ns	ns
MGWA	253 (45)	248 (46)	253 (63)	247 (57)	ns	***	ns
WIWA	255 (61)	254 (62)	255 (60)	250 (75)			*
WETA	249 (58)	253 (17)	229 (37)	250 (55)			**
BHGR	223 (49)	230 (55)	228 (25)	234 (52)	*	*	ns
BLGR	242 (62)	254 (57)	240 (56)	250 (65)	ns	**	ns
LAZB	243 (44)	253 (21)	235 (39)	242 (52)	***	***	ns
GTTO	251 (28)	248 (28)	262 (35)	259 (56)	**	ns	ns
SPTO	268 (59)	269 (99)	287 (45)	282 (90)	***	ns	ns
CHSP	270 (94)	256 (99)	231 (91)	259 (98)			***
CCSP	249 (29)	254 (49)	249 (20)	246 (45)	ns	ns	ns
BRSP	249 (41)	243 (53)	253 (54)	246 (70)	ns	**	ns
LASP	243 (27)	243 (23)	229 (50)	245 (54)			***
SAVS	300 (33)	301 (32)	278 (54)	276 (69)	***	ns	ns
SOSP	288 (58)	289 (45)	291 (44)	293 (61)	*	ns	ns
LISP	276 (57)	283 (63)	273 (49)	276 (86)	*	ns	ns
WCSP	286 (56)	292 (56)	287 (56)	284 (66)			**
DEJU	292 (47)	298 (53)	292 (53)	299 (57)	ns	**	ns

[1] Two-way ANOVA was performed on rank transformed data. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; and ns, not significant.

underestimate large species such as raptors, pheasants, crows, and doves; aerial species such as swallows and night hawks; and nocturnal species such as owls (Yong and Finch 2002, appendix II, appendix III). In addition to providing insight into an individual's fitness (body condition) and population structure of species (for example, age and sex ratio), mist-netting is more effective than other methods in detecting secretive or quiet species especially nonterritorial migrants (Karr 1981, Remsen and Good 1996). Other researchers (for example Dunn and others 1997) have found that intensive daily banding at stopover sites is useful in detecting population changes over time. The technique may be especially valuable for tracking populations of species poorly monitored by breeding and wintering counts. We believe that our mist-netting operation was effective in achieving our objectives given that our research focused on landbird migrants, the majority of which were songbirds (passerines). Mist-netting has proven to be effective in documenting and quantifying species of this group (Sutherland 1996).

During this study, we captured 146 species in 3 years: 108 species and 133 birds/1000 net hr in spring, and 125 species and 315 birds/1000 net hr in fall. These figures suggest substantial use of our sites by stopover migratory landbirds during spring and fall migration. During their study on Appledore Island, Maine, between 1990 and 1991, Morris and others (1994) captured 69 species in spring and 82 species in fall. Vega and Rappole (1994) operated 22,323 net hr at Mcmullen and Duval Counties, Texas, capturing 59 species. The Migratory Bird Group of the University of Southern Mississippi (Moore pers. comm.) captured 72 species on the Mississippi Gulf barrier islands during spring migration between 1988 and 1992, and

Table 12—Body mass (mean ± SD) of adult (AHY) and hatching-year birds (HY) captured during fall migration along the middle Rio Grande. See table 9for species selection and appendix I for species codes.

	BNWR		RGNC		P[1]		
SPP	**AHY**	**HY**	**AHY**	**HY**	**SITE**	**AGE**	**SITE X AGE**
WEWP	12.52±0.81	12.20±1.36	12.41±0.70	12.32±0.87	ns	ns	ns
WIFL	12.40±1.11	11.86±1.03	12.20±1.09	11.97±1.06	ns	ns	ns
DUFL	10.62±0.93	10.74±1.01	11.04±0.69	10.74±0.75	ns	ns	ns
WEFL	11.91±1.07	10.51±0.92	11.60±0.81	10.99±1.02	ns	ns	ns
BEWR	9.40±0.75	9.57±0.59	9.36±1.19	9.48±0.65	ns	ns	ns
HOWR	10.31±1.18	9.33±0.29	10.42±0.83	10.37±0.69	ns	ns	ns
RCKI	5.93±0.48	6.02±0.45	6.02±0.45	5.85±0.43	ns	ns	*
HETH	22.95±1.41	24.04±2.64	24.71±3.17	23.53±1.98	ns	**	ns
WAVI	11.75±0.90	11.86±1.27	11.99±0.71	11.72±1.10	ns	ns	ns
OCWA	8.78±0.90	8.71±0.76	8.97±0.77	8.61±0.70	ns	ns	ns
VIWA	8.46±0.87	8.05±0.63	8.01±0.52	8.03±0.68	ns	ns	ns
YWAR	9.17±0.72	9.03±1.21	9.04±0.69	8.84±0.72	ns	ns	ns
YRWA	12.14±1.14	11.91±1.04	12.15±1.29	11.59±1.04	ns	ns	ns
MGWA	10.32±0.99	10.52±0.98	10.79±0.77	10.64±0.84	ns	ns	ns
WIWA	7.40±0.64	7.23±0.56	7.5±0.49	7.26±0.48	ns	ns	ns
WETA	29.84±2.03	29.99±2.12	29.89±3.10	29.75±3.10	ns	ns	ns
BHGR	45.97±3.99	44.32±4.16	43.27±5.66	43.82±5.50	ns	ns	ns
BLGR	28.82±2.70	27.44±2.88	30.06±2.80	28.28±2.30	ns	ns	ns
LAZB	14.99±2.36	14.26±1.18	15.23±1.39	14.39±1.28	ns	*	ns
GTTO	27.09±1.48	27.00±3.50	29.10±2.98	27.85±2.33	ns	ns	ns
SPTO	38.23±3.11	36.15±2.39	36.68±2.46	35.95±2.99	ns	ns	ns
CHSP	12.27±0.97	12.22±0.95	12.04±0.80	11.99±0.88	**	*	ns
CCSP	10.22±0.78	10.39±0.86	10.95±0.94	10.77±0.89	ns	**	ns
BRSP	10.27±0.91	10.29±0.86	10.99±1.62	10.55±1.00	ns	ns	ns
LASP	27.07±2.23	26.32±2.14	27.68±2.06	26.93±2.12	**	**	ns
SAVS	16.37±1.09	16.39±0.98	16.39±0.94	16.64±1.39	ns	ns	ns
SOSP	19.55±1.31	19.30±1.36	19.64±1.59	19.76±1.35	ns	ns	ns
LISP	16.15±1.53	15.85±1.62	16.65±1.56	16.02±1.64	ns	ns	ns
WCSP	24.30±2.27	23.80±1.94	25.00±2.48	24.28±2.34	ns	ns	ns
DEJU	17.79±1.40	17.74±1.51	17.74±1.51	17.36±1.23			**

[1] Two-way ANOVA was performed on rank transformed data. *, P < 0.05; **, P < 0.01; ***, P < 0.001; and ns, not significant.

92 species along the Alabama Gulf coast during fall migration between 1990 and 1992. Winker and others (1992b) operated 71,398 net hr in spring and 65,799 net hr in fall at a stopover site at Washington County, Minnesota, and captured 100 species total. At a banding site on Block Island, Rhode Island, 62 to 78 species/year were captured during a 10-year fall migration between 1984 and 1993 (Patton pers. comm.).

In the Western United States, the year-round banding operation at Coyote Creek Riparian Station, California, caught 90 to 102 species/year (minimum = 90 species, maximum = 102 species) between 1987 and 1993 (Shields and Katano 1994). At the Palomarin Field Station, California, 77 species were captured during 1996 and 1997 migrations: 64 species between April and July and 66 species between August and November (Point Reyes Bird Observatory 1998). During 6 years (1992 through 1997) of fall migration banding at Creamer's Field Migration Station, Alaska (Alaska Bird Observatory 1998), 24,545 birds and 55 species were captured. Direct comparisons of capture rates and species encountered at stopover sites over a large geographic scale may be misleading owing to variations in mist-netting operations such as daily and seasonal netting time, length of operation, frequency of net checking, and habitats sampled. However, we believe that differences in species richness and relative capture rates between our sites and sites in other studies may reflect true variation of stopover patterns across the landscape. In contrast to other sites, our middle Rio Grande Valley sites were dominated by Western species, but were also used by species that breed mostly in Eastern North America. In our study, we detected many species considered Eastern in range such as the Gray Catbird, Red-eyed Vireo, Prothonotary Warbler, Blue-winged Warbler,

Table 13—Fat condition by age class (AHY = adults, HY = hatching-year immatures) of fall migrants along middle Rio Grande. X^2 test was performed on the frequency distribution of age by fat class (Lean = no observable fat, and Fat = with observable fat) for each species. See table 9 for species selection and appendix I for species codes.

	AHY			HY				
Species	**N**	**Lean**	**Fat**	**N**	**Lean**	**Fat**	**x^2**	**p <**
WEWP	43	51%	49%	72	68%	32%	3.25	0.07
WIFL	52	56%	44%	62	63%	37%	0.60	ns
DUFL	42	52%	48%	89	63%	37%	1.32	ns
WEFL	22	55%	45%	37	65%	35%	0.62	ns
BEWR	24	58%	42%	65	69%	31%	0.93	ns
HOWR	28	39%	61%	52	40%	60%	0.01	ns
RCKI	127	32%	68%	111	30%	70%	0.09	ns
HETH	49	41%	59%	130	51%	49%	1.41	ns
WAVI	90	36%	64%	59	32%	68%	0.18	ns
OCWA	217	46%	54%	433	52%	48%	2.50	ns
VIWA	95	59%	41%	107	59%	41%	0.00	ns
YWAR	128	56%	44%	233	64%	36%	2.06	ns
YRWA	149	42%	58%	371	53%	47%	5.35	*
MGWA	205	44%	56%	292	58%	42%	8.78	**
WIWA	997	34%	66%	1532	56%	44%	112.40	***
WETA	45	53%	47%	77	35%	65%	3.90	*
BHGR	81	36%	64%	85	48%	52%	2.63	ns
BLGR	135	61%	39%	188	78%	22%	10.83	**
LAZB	248	32%	68%	358	37%	63%	1.37	ns
GTTO	36	33%	67%	107	40%	60%	0.54	ns
SPTO	83	76%	24%	95	73%	27%	0.25	ns
CHSP	723	49%	51%	1800	50%	50%	0.33	ns
CCSP	41	24%	76%	154	40%	60%	3.24	0.07
BRSP	126	37%	63%	295	48%	52%	4.29	*
LASP	200	44%	56%	355	27%	73%	16.01	***
SAVS	54	50%	50%	130	72%	28%	7.80	**
SOSP	171	66%	34%	174	71%	29%	5.01	*
LISP	108	58%	42%	255	64%	36%	1.19	ns
WCSP	295	46%	54%	866	57%	43%	11.75	**
DEJU	183	53%	47%	407	62%	38%	4.63	*
All birds	4797	47%	53%	8991	54%	46%		

[1] *, P < 0.05; **, P < 0.01; ***, P < 0.001; and ns, not significant.

Lawrence's Warbler, Tennessee Warbler, Kentucky Warbler, Magnolia Warbler, Chestnut-sided Warbler, Blackburnian Warbler, Prairie Warbler, Black-and-White Warbler, American Redstart, Northern Waterthrush, Ovenbird, Mourning Warbler, Canada Warbler, Nashville Warbler, Hooded Warbler, Scarlet Tanager, Painted Bunting, Dicksissel Orchard Oriole, Rose-breasted Grosbeak, and White-throated Sparrow. Previous to our study, Kentucky Warbler, Mourning Warbler, Swainson's Thrush, and Red-eyed Vireo were not detected at BNWR. Magnolia Warbler, Palm Warbler, Lawrence's Warbler, and Cassin's Sparrow were not previously observed at RGNC.

About 85 percent of the 144 species and over 98 percent of the individuals captured in this study were migratory. The majority are Neotropical-Nearctic migratory species. Riparian habitat along the middle Rio Grande may create a population bottleneck for these species during migration if limited resources dictate time to refuel. Because migratory birds may be vulnerable to navigational mistakes, starvation, and predation risk, the probability is high that migration for some species will be altered or disrupted in response to disturbances and habitat changes (Yong and Finch 1997b).

There were inconsistencies of the relative abundances estimates between our study and data from Hink and Ohmart (1984) and Hoffman (1990). Disparities among the three studies could be the result of variation in: (1) sampling techniques, (2) time period sampled, (3) habitat types sampled, (4) sampling locations, and (5) population changes among

Table 14—Comparison of daily body mass change (% change/day) of adult and hatching-year landbirds during fall migration along the middle Rio Grande. One day is 8 available hours for birds to foraging and gaining body mass. Column “a” is from y = ax + b where y is body mass at capture, x is the capture time (hr), b is the y-intercept, and a is the slope. Lean mass is the average body mass of “0” fat individuals captured during the study. % change/d is calculated as: slope x 8 hr/lean mass. See table 9 for species selection and appendix I for species codes.

	Adults						Immatures					
Species	**N**	**b**	**a**	**Gain/d**	**Lean mass**	**%gain/d**	**N**	**b**	**a**	**Gain/d**	**Lean mass**	**%gain/d**
BEWR	21	8.33	0.11 ns	0.88	9.50	9.26	61	9.03	0.05 ns	0.4	9.51	4.21
BHGR	76	44.27	0.11 ns	0.88	44.15	1.99	81	45.11	–0.13 ns	–1.04	42.19	–2.47
BLGR	131	28.60	0.09 ns	0.72	28.30	2.54	184	24.50	0.40 ****	3.2	28.06	11.40
BRSP	124	10.30	0.02	0.16	10.53	1.52	281	9.85	0.07 **	0.56	10.12	5.53
CCSP	39	11.06	–0.07	–0.56	10.18	–5.50	148	9.45	0.14***	1.12	10.31	10.86
CHSP	699	10.72	0.15 ****	1.20	11.82	10.15	1770	10.96	0.11 ****	0.88	11.84	7.43
DEJU	180	17.05	0.06	0.48	17.45	2.75	402	16.12	0.14 ****	1.12	17.25	6.49
DUFL	40	9.72	0.13	1.04	11.06	9.40	86	9.72	0.11 **	0.88	10.63	8.28
GTTO	33	25.98	0.26	2.08	26.34	7.90	106	26.42	0.14	1.12	26.67	4.20
HETH	47	21.16	0.36	2.88	23.09	12.47	126	23.41	0.02	0.16	23.01	0.70
HOWR	25	8.97	0.16 *	1.28	9.61	13.32	47	9.29	0.11 **	0.88	9.88	8.91
LASP	193	25.91	0.18 *	1.44	27.19	5.30	343	23.49	0.36 ***	2.88	26	11.08
LAZB	241	13.89	0.15 **	1.20	14.51	8.27	347	14.02	0.04	0.32	13.69	2.34
LISP	102	16.22	0.01	0.08	16.14	0.50	249	15.19	0.09	0.72	15.58	4.62
MGWA	197	9.47	0.12 ***	0.96	10.35	9.28	287	10.17	0.05 *	0.4	10.45	3.83
OCWA	212	7.83	0.12 ****	0.96	8.73	11.00	420	7.63	0.10 ****	0.8	8.33	9.60
RCKI	124	5.40	0.06 *	0.48	5.79	8.29	110	5.69	0.02	0.16	5.66	2.83
SAVS	53	17.22	–0.09 *	–0.72	16.64	–4.33	127	15.18	0.15 *	1.2	16.42	7.31
SOSP	163	18.99	0.07	0.56	19.40	2.89	169	16.87	0.30 ****	2.4	19.52	12.30
SPTO	80	37.67	–0.02	–0.16	36.61	–0.44	88	33.47	0.27 *	2.16	35.95	6.01
VIWA	92	7.99	0.03	0.24	8.16	2.94	104	7.66	0.04	0.32	7.89	4.06
WAVI	87	11.48	0.04	0.32	11.15	2.87	54	10.06	0.18 *	1.44	11.09	12.98
WCSP	283	23.07	0.18 **	1.44	24.26	5.94	836	22.80	0.16 *	1.28	23.8	5.38
WEFL	19	9.61	0.24	1.92	11.44	16.78	36	10.51	0.04	0.32	10.85	2.95
WETA	44	25.27	0.49 **	3.92	29.05	13.49	75	27.49	0.24	1.92	28.87	6.65
WEWP	42	12.05	0.05	0.40	12.58	3.18	69	11.47	0.09	0.72	12.2	5.90
WIFL	48	10.85	0.17	1.36	12.22	11.13	59	11.39	0.06	0.48	11.83	4.06
WIWA	982	6.83	0.07 ****	0.56	7.19	7.79	1503	6.69	0.06 ****	0.48	7.11	6.75
YRWA	146	10.95	0.12 **	0.96	11.60	8.28	363	10.99	0.06 *	0.48	11.15	4.30
YWAR	126	8.61	0.06	0.48	8.81	5.45	226	8.47	0.05	0.4	8.75	4.57

[1] P, ≤ 0.1; ** P, <0.05; ***, P < 0.01; ****, P, < 0.001; and ns, not significant.

study time periods. We used mist-netting to sample stopover migrants while the other two studies used transect surveys. Mist-netting, as noted earlier, tends to be more effective at detecting rare or secretive species than point counts or transects. The other two studies also surveyed birds less frequently than ours did. While our banding stations were located at two sites along the Rio Grande, Hink and Ohmart's (1984) study encompassed 163 river miles between Espanola, at the south end of the Rio Grande Gorge, and the San Acacia Constriction, in north-central New Mexico, and used 78 (each 600 m x 30 m) transects. Hoffman's (1990) study was restricted to State parks in the middle Rio Grande Valley.

Migration Route

If migrants use the same routes for both spring and fall migrations, capture rates at a single stopover site would be higher in fall than in spring because of the contribution of hatching-year birds (Winker and others 1992b). In our study, fall captures (75 percent of 30 species) exceeded spring captures, although in 25 percent of the species spring captures were greater than fall captures. Several alternative hypotheses may explain this deviation: (1) species used different migration routes in spring and fall, (2) breeding success was low for some species, or (3) age groups differed use of migration routes in fall. Species with lower fall captures (fall captures/spring captures <1) were the Red-Winged Blackbird (0.20), Dusky Flycatcher (0.52), MacGillivray's Warbler (0.65), Common Yellowthroat (0.65), Black Phoebe (0.75), American Robin (0.77), and Black-headed Grosbeak (0.93). The ratio of fall capture to spring capture was high in the Chipping Sparrow (65.00), Lincoln's Sparrow (15.00), Orange-crowned Warbler (12.19), and Dark-eyed Junco (11.08). Given that these species usually have one to two broods per breeding season and about four eggs per brood (Ehrlich and others 1988), and given our intensive sampling, we suggest that these species may use different routes for spring and fall migrations. The capture rates of three *Fringillidae* species, the Pine Siskin, Lesser Goldfinch, and American Goldfinch, were biased toward fall migration. While we never captured the Pine Siskin in spring at either site in any year during the study, 1,687 individuals were captured during fall migration; only two American Goldfinches were captured in spring and 293 birds were captured in fall. Intraspecific changes in migration route between spring and fall is the most probable explanation. Seasonal variation in available resources is another factor that may influence fall capture rate. For example, agriculture fields were loaded with corn, sunflowers, and insects in the fall (Yong and Finch pers. obs.) and not in the spring; and the capture rates in these fields were much higher in fall than in spring. During the first spring operation, we decided not to mist-net at RGNC fields in the spring because we hardly captured any birds there.

To better understand seasonal migration routes and landscape scale associations, future researchers should investigate migrant use of nonriparian habitats. Such research will provide more complete data for describing migration routes of different species, will clarify how and when migratory populations are limited, and hence help in designing effective management and conservation plans.

Migration Timing

Spring migration peaked in late April and the first 2 weeks of May while fall migration peaked after the last week of August and through mid-October. Given high relative abundances and species richness, demands for stopover resources along the middle Rio Grande were greatest during peak migration periods. By examining seasonal passage of time, we gained a general idea of the time species allocated to breeding grounds, wintering grounds, and stopover sites. Temperate migrants and Neotropical species spent different amounts of time on the breeding grounds. The difference between spring and fall median capture date for temperate migrants was 163 days, suggesting that these species spent about 45 percent of their annual life on the breeding grounds. The difference for Neotropical species was 115 days, suggesting these birds spent only 32 percent of their annual life on breeding grounds.

Our analyses suggest that Neotropical migrants spent about 45 percent of their annual life cycle away from their wintering grounds (33 percent for breeding and 12 percent for migration) while temperate migrants spent about 63 percent of their annual life away from their wintering grounds (45 percent for breeding and 18 percent for migration). Eight Neotropical species—the Western Wood-Pewee, Willow Flycatcher, Warbling Vireo, Yellow Warbler, MacGillivray's Warbler, Summer Tanager, Black-headed Grosbeak, and Blue Grosbeak—spent less than 30 percent of their annual life cycle on the breeding grounds. Winker and others (1992b,c) found a similar pattern in Minnesota among Neotropical migratory species, although the sampled species were mostly Eastern breeders. Because Neotropical migrants are more constrained by time for breeding than temperate migrants, adverse effects of disturbances at stopover sites or on breeding grounds may have greater influence on breeding chronology, breeding success, and population dynamics of Neotropical migrants than of temperate migrants.

Comparing temperate to Neotropical migrants is difficult for two primary reasons. First, some temperate migrants have not finished fall migration by the beginning of November and have started spring migration by early April. Therefore, the capture data from our sites do not encompass the migration period entirely for temperate species. Second, some temperate species winter in the study area, and thus it would be difficult to separate stopover and winter individuals in these species. However, because our calculation of percentage of an average temperate migrant's annual cycle on the breeding grounds was based on a later starting date in spring and on an earlier finishing date in fall than what would be desired, we would underestimate the actual time that temperate migrants spent on the breeding grounds. Alternatively temperate migrants moved more slowly and spent 13 percent more time in migration after they left our sites.

Fat Stores, Body-Mass Change, and Stopover Length

More than 50 percent of the birds we captured had no fat stores, and only 10 percent had moderate or large fat stores (fat class ≥ 3), which suggests that landbirds migrating through our sites do not carry large fat loads, and hence, they may need to restore fat periodically en route. Body mass was variable between sites and seasons depending on species. Neotropical migrants had generally fewer fat stores than temperate migrants during spring migration.

Recapture rates varied widely depending on species. The overall recapture rate of 12 percent was, however, comparable to other studies. For example, Morris and others (1996) reported a recapture rate of 13.4 percent on Appledore Island in Maine. Yong and Moore (1997) indicated a recapture rate of 14 percent for stopover thrushes in spring along the northern coast of the Gulf of Mexico. Migrants were more likely to be recaptured in fall (13 percent) than in spring (10 percent), suggesting that fall migrants may be slightly less time-constrained. This pattern is consistent with results reported by Morris and others (1994) and Winker and others (1992a).

Stopover length may depend on energetic condition—that is, availability of fat stores—upon arrival at the stopover site (Bairlein 1985, Moore and Kerlinger 1987, Yong and Moore 1997). Our results support this idea. Intraspecific body mass at initial capture of nonrecaptured birds was higher than initial mass of recaptured birds, suggesting that lean birds are more likely to stay overnight at our sites. Body-mass differences between recaptured and nonrecaptured birds were usually small but apparently sufficient enough for birds to base stopover decisions on. This pattern was also detected among spring landbird migrants along the northern coast of the Gulf of Mexico (Moore and Kerlinger 1987, Yong and Moore 1997). A migrant may use incremental changes in its energetic condition to help weigh the cost of finding and settling at a new stopover site against the benefit of staying and refueling at the current site (Alerstam and Lindström 1990). Overall migration speed may be maximized through a migrant's ability to gauge such costs and benefits. In addition, carrying less fat may be less costly for some migrants than stopping periodically to redeposit fat along the way. Given the continuity and north-south direction of riparian habitat in the middle Rio Grande where we were mist-netting, the advantage for a migrant of flying nonstop through this area carrying large fat stores may be less than the advantage of flying light and stopping periodically to refuel.

Energetic status may not be the only contributing factor influencing stopover decisions. Migratory distance may affect stopover patterns. Safriel and Lavee (1988) suggested that stopover length of migratory birds is sensitive to time constraints during passage. Alerstam and Lindström (1990) proposed a time-optimal model for stopover migrants. We suggest that migration time is a greater constraint in spring than fall because of the need to synchronize arrival time with the period when weather and food supplies are suitable for successful nesting. In our study, Neotropical migratory species not only differed in temporal migration patterns, they also tended to have lower recapture rates, shorter stopover periods, and higher rates of body-mass gain than temperate migrants, especially in spring. Neotropical migratory species have typically traveled longer distances than temporal migrants by the time they are captured at our sites. To ensure sufficient time for breeding activities, short stopover lengths and fast migrations are more likely to be favored in long-distant migrants than in temperate migrants.

Although migrants face many obstacles during migration, insufficient energy stores may be the most critical barrier limiting migration. Lindström (1991) found that maximum daily gains of recaptured birds in his study were between 4 to 5 percent body mass for small passerines. Winker and others (1992a) and Winker (1995) suggested that a daily gain of 4.5 percent body mass was needed to offset overnight losses. If birds are depositing fat, diurnal gains should exceed overnight losses, resulting in a net positive daily (24 hour) gain (Winker and others 1992a). When energetic reservoirs cannot be replenished during stopover to the level needed to compensate for the cost of delayed migration produced by stopping, then stopover sites could potentially serve as "sink" habitats that reduce migrant fitness for individuals that stop. In our study, the average rate of diurnal body mass gain was 7.46 percent in spring and 4.68 percent in fall, exceeding rates reported for other areas. By offering stopover sites that allow rapid mass regain, the middle Rio Grande bosque may be especially valuable for migrants that need to stop en route to feed, gain mass, and resume migration quickly.

Our data demonstrated that spring birds captured at our study sites were able to accumulate body mass (fat stores) faster during the day than fall birds. Several hypotheses may explain why fall birds gained mass at a somewhat slower rate than spring birds: (1) migration timing may be more flexible in fall than in spring leading to reduced selective pressure for short stopovers and quick body mass gain in fall, (2) a large proportion (about 60 percent) of fall migrants are hatching-year birds, unable to forage and replenish fat stores as efficiently as adults (Burger 1988, Wunderle 1991), or (3) the presence of large numbers of migrants—adults plus young—at fall stopover sites may magnify the competition potential among individuals, forcing some birds to use less favorable habitat, resulting in lowered rates of mass gain. These hypotheses may be interdependent. Our research on the Wilson's Warbler (Yong and others 1998) suggests that variation in fall stopover patterns was age-related. Young Wilson's warblers had lower fat stores, higher recapture rates, and longer stopovers than adults. Future in-depth analyses of other migratory species captured during our study will help to clarify factors that influence stopover ecology of Rio Grande migrants in spring and fall.

The rate of body-mass change estimated from recaptured birds was lower than the rate derived from linear regression analysis of body mass and initial capture time, a pattern characteristic of landbird stopover studies (Winker and others 1992a, Morris and others 1996, Yong and others 1998). Rates of mass gain based on recaptures may underestimate actual rates. Recaptured birds usually represent only 10 to 15 percent of the total birds captured at stopover sites. Recaptured birds typically have lower fat stores than birds that were never recaptured and may represent a subset of migrants that take longer to restore mass. Small sample sizes and atypical fat conditions of recaptured birds may bias estimates of stopover length and rate of mass gain. However, the rates of mass gain estimated based on the slopes of the regressions between body mass and capture time may overestimate the mass change because many migrants were probably rehydrating after nocturnal flight and therefore appeared to be gaining mass more rapidly than they actually were.

Habitat Use

Migrant species composition varied by habitat in spring and in fall. Because standard mist-netting can sample a vertical stratum of about only 2 to 3 m high, interpretations of habitat use based on capture rates should account for the potential to undersample canopy birds (Yong and Finch 2002). To compensate for this potential bias (1) we established 6-m "high nets" in habitats with cottonwoods, (2) we standardized mist-netting procedures (Ralph and others 1993) to control variation in netting samples among days, seasons, and years, (3) we sampled available habitats at study sites concurrently, and (4) we operated mist-nets through entire migration periods rather than truncating seasons as capture rates decreased. We also compared spring and fall capture rates by habitat to evaluate whether differences in capture rates may reflect changes in stopover habitat selection by season. However, capture rate could also be affected by other confounding factors such as net effort variations among habitats. For example, we added 20 additional mist-nets (14 at willow stretch along a irrigation channel and six at an adjacent saltcedar site) at BNWR. The addition of these nets could bias our comparison of species richness and relative abundance among habitats. More detailed analysis such as comparisons using rarefaction method (Krebs 1998) is needed. Our analyses and discussions about habitat related variations are intended to provide a general description.

Cottonwood/Russian olive understory habitat was used by more migrant species than other habitats in spring (80 species) and fall (94 species). Saltcedar was used by fewest species (spring - 26 species, fall - 33 species). Cottonwood/Russian olive habitat at our sites comprised mature or mixed age classes with foliage present in all vertical layers similar to the dense foliage and foliage height diversities of this habitat observed by Hink and Ohmart (1984). Cottonwood reached 15 to 18 m in height, and Russian olive was present as a shrub or small tree. High foliage volume and structural variation of cottonwood/Russian olive sites may attract migrants in need of rest and food because such habitats may signal abundant or diverse food resources and cover. Willow and saltcedar habitats had lower canopies and forage diversity than cottonwood/olive habitat and were usually dense, especially monotypic stands of saltcedar. Willow habitats were used as stopover sites by many insectivore passerines such as warblers. Russian olive and saltcedar are invasive, nonnative species that have altered successional stages, physical structure, and species composition of plant communities in the middle Rio Grande (Campbell and Dick-Peddie 1964). Although our study indicates that migrants use stopover habitats containing Russian olive as an understory, the role of Russian olive in providing stopover resources is unclear.

Although saltcedar habitat in the Southwest has been reported to have lower species richness than native riparian vegetation (Anderson and others 1977, 1978, Engel-Wilson and Ohmart 1978), Ellis's (1995) study in the middle Rio Grande found that bird species richness did not differ between cottonwood and saltcedar in migration and breeding seasons. Thompson and others (1994) and Leal and others (1996) suggest that saltcedar and Russian olive mixed with native plant species provide valuable current structure that was historically supplied by cottonwood-willow communities. Discrepancies among studies in the extent to which migrants use exotic habitats may be related to local differences among study sites or to differences in sampling techniques. Overall species richness in Ellis's (1995) study was lower than ours, and many migrant species were not detected. Ellis (1995) observed 18 species in saltcedar in spring and 27 in fall; in cottonwood, she detected 27 in spring and 31 in fall. Several species that call at low frequencies were detected during our study but were not recorded by Ellis. We suggest that differences in sampling methods explain differences in species richness and composition between the two studies.

Ellis (1995) suggested that certain components of mature, native forest must be important to specific bird species during spring migration given their restricted use of cottonwood habitats. In our study, several migrant species such as the Dusky Flycatcher, Gray Flycatcher, Bewick's Wren, Chipping Sparrow, and Brewer's Sparrow were captured more frequently in saltcedar than in other habitats regardless of spring or fall season, whereas other species were captured in saltcedar more often than in other vegetation in only one but not both seasons. For example, Ash-throated Flycatcher and Hermit Thrush were captured more in saltcedar than in other habitats in spring, whereas the Warbling Vireo and Green-Tailed Towhee were captured more in saltcedar than elsewhere in fall.

The Willow Flycatcher, an endangered species in the Southwest, was captured more frequently in saltcedar than in other habitats during fall migration. In the Southwestern United States, the Willow Flycatcher is a riparian-obligate species. The Southwestern Willow Flycatcher is endangered owing to loss of native vegetation along water ways (USFWS 1995). Use of saltcedar by willow flycatchers during migration may represent an adjustment to this introduced plant species or may simply reflect the limited availability of suitable native vegetation such as coyote willow. Willow Flycatchers are known to use saltcedar as nesting substrate (Muiznieks and others 1993), and insect food resources may be sufficiently abundant in saltcedar to support nesting flycatchers (Mark Sogge unpubl.) The presence of scattered native plants in areas dominated by saltcedar may greatly enhance the value of saltcedar habitat to birds (Anderson and others 1977, Raitt and others 1980, Ellis 1995).

Using indices of species richness and relative abundance alone to assess suitability of stopover habitat could be misleading. For example, our studies of stopover Willow Flycatchers (Yong and Finch 1997a) and Wilson's Warblers (Yong and others 1998) suggest that differences in capture rates among habitats do not necessarily reflect variation in migrant energetic conditions (fat stores) among habitats. To better understand the relative value of different habitats to migrating landbirds, experimental manipulations of habitat that can be linked to changes in fitness are required.

Age-Related Differences in Capture Rates

More than 60 percent total migrants in fall are young birds. Whether fall migrations by young birds are successful or not in any given year can directly affect the annual population status of the species. Young birds typically forage less efficiently than adults (Wunderle 1991) and may be less efficient at extracting energy and nutrients (Karasov 1990). These factors may constrain their ability to build up fat stores during migration. Young birds are also often socially subordinate to adults during the nonbreeding season (Gauthreaux 1978, Terrill 1987), which could be disadvantageous to hatching-year migrants if status limits foraging opportunity or foraging efficiency and consequent deposition of energy stores. Subordinate status and lack of experience could limit migration success of young birds especially given the heightened energy demand for long-distance migration. Studies of age-related stopover ecology may be useful in detecting habitat deterioration if young birds respond with greater sensitivity to habitat disturbance.

To minimize predation risk and orientation errors, and maximize habitat use and survivorship during migration, immatures might be expected to migrate with their parents. Natural selection may favor immatures that follow their migrating parents in fall because parents have greater experience than young in selecting stopover habitats, avoiding predators, setting direction, and negotiating terrain. Timing of adult and immature migrations varied, however, by species and by site. In some species, adults migrated through our banding sites earlier in fall than young birds, but in other species, the pattern was reversed. For the majority of species in our study, however, age-dependent differences in migration timing were not detected. Stewart and others (1974) observed that adults migrated earlier than immatures in fall, while Nilsson (1970) found that immatures migrated earlier than females. Murray (1966) and Lebeman and Clench (1970) reported that adults and immatures of many Eastern passerines traveled at approximately the same time in fall. Inconsistencies in age-related timing among species and studies could be related to stopover location along migration routes. Variations in migration distance, wintering locations, breeding and molting chronology, and social dominant status between age classes will influence migration times within each age class and obscure differences between age classes. Inconsistency may also be an artifact of a statistical parameter (median date) used for measuring migration timing. For a better understanding of migration timing of adult and young birds, monitoring offspring and their parents along the migration route is needed.

Age structure (immature versus adult ratio) is also useful in interpreting migration patterns. Many studies report differences in composition of immatures and adults among sites at different geographical locations (Drury and Keith 1962, Murray 1966, Ralph 1981, Stewart and others 1974, Winker 1995, Morris and others 1996). In our study, about 48 percent of the birds captured during fall migration were hatching-year birds, and 45 percent were adults. The resulting 1:1 ratio of immature and adults in our study is lower than ratios reported at other locations. For example, immatures typically represented over 80 percent of Atlantic Coast (Drury and Keith 1962, Murray 1966, Ralph 1981, Morris and others 1996) and Pacific Coast migrants (Ralph 1971, Stewart and others 1974). At Block Island of Rhode Island, over 90 percent of the fall-migrating birds of most species were immatures (Reinert pers. comm.). However, Winker (1995) reported that immatures only accounted for 28 percent of American Redstarts and 37 percent of Magnolia Warblers captured in southern Veracrus, Mexico. Low ratios of immatures to adults at a given stopover site could be linked to (1) low breeding success, (2) high mortality of migrating immatures prior to arrival at the stopover site, (3) variation in stopover patterns between age classes (for example, if young birds stopped less often than adults), and (4) larger variation in use of a migration route among young birds than adults. Given that our study sites were inland and were not associated with major water barriers such as the Gulf of Mexico, Pacific, and Atlantic Ocean, we suspect that factor 4 best explains low immature and adult ratio at our sites. Ralph (1981) found that age ratio was much higher at his coastal study site than at an inland site and suggested that coastal sites were peripheral to the main migratory route of the species. Our hypothesis that the middle Rio Grande Valley is a central migration corridor for many species is supported by the low age ratios we detected at our banding sites if they are interpreted in light of Ralph's idea. To gain a better understanding of age-dependent migration differences, individuals in both age classes would need to be radio-tagged on their breeding grounds and tracked over migration routes. Conducting such a study for small songbirds using current available technology would be difficult.

Immature and adult birds gained body mass during daylight hours in our study. In many species, both age classes gained more body mass than was necessary for regular daily metabolism (but not for nocturnal migration). Based on regression analysis of capture time and body mass, average rate of daily mass gain did not differ between the two age classes, but we did find that mass-gain rate in examined adults and immatures varied by taxonomic group. For example, among 10 species of captured warblers and flycatchers, adults of eight species (80 percent) tended to have higher rates of daily mass gain than immatures, but among 14 species of *Caradinalinae* and *Emberznae,* adults of only five species (36 percent) had higher rates of daily mass gain than immatures. Migratory distance cannot explain this inconsistency between age classes because the difference in mass gain seems independent of migratory status. Variation in molting schedules between age classes could potentially affect rates of body mass change within species (Winker and others 1992a), leading to species-specific patterns of age-related mass change. But most fall migrants captured at our sites had completed molting (Finch and Yong unpubl.), so molting schedules are unlikely to cause age-dependent differences in rates of mass gain. Stopover habitats were used by young and adult Wilson's Warbler differently during fall migration, with young birds frequently using less inferior habitat than adults and resuming migration more slowly (Yong and others 1998). We suggest that such age-related differences in habitat use may explain some of the differences in rates of mass gain between age groups.

Site Differences in Capture Rates

Mist-netting landbirds requires personnel who are proficient in operating nets and handling birds. In addition, because nets need to be checked frequently, the technique is labor-intensive. To our knowledge, most mist-net studies of landbird stopover ecology operate at a single banding site or at maximum, two to three sites in a targeted area (such as at Manomet Bird Observatory, Long Point Bird Observatory, Point Reyes Bird Observatory, and Migratory Bird Group of the University of Southern Mississippi). Site selection is typically nonrandom, a function of specific geographical locations (for example, along major migration routes), accessibility, and targeted habitat features. Nonrandom site selection is used even in large-scale mist-netting programs such as MAPS (DeSante and

Rosenberg 1998). Our study was no exception. We selected our two sites based on three criteria: (1) habitats were representative of those available along the middle Rio Grande Valley of New Mexico, (2) a historical or vested interest in research was present at the two sites, and (3) long-term research was technically and logistically feasible at the sites.

Because our sites were not randomly selected or replicated, our interpretations are specific to observations made at the two sites during the sampling period. Our RGNC site lay within the city limits of Albuquerque, NM, was dominated by cottonwood-Russian olive stands with some willows and saltcedar clumps, was surrounded by agricultural fields and residential areas, and was available as a narrow riverine band adjacent to urban growth. Our BNWR site was rural, with vegetation available across a wide floodplain, and it contained a diversity of habitats such as cottonwood/willow, monotypic saltcedar, willow stands along the water channels, and agricultural fields. Given these site differences, we assumed that habitats would be more suitable for migratory landbirds at BNWR than at RGNC. We captured more individuals and more species at RGNC than BNWR during fall migration, and more at BNWR than RGNC in fall. We suggest that fall capture rates and immature/adult ratios were higher at the urban RGNC site than the rural site because available habitat was more restricted at RGNC, causing adult and hatching-year migrants to concentrate in a smaller area. When available habitats are more spread out, fewer immatures may be captured at net sites where suitable habitat is present if inexperience has led them to fan out into less suitable vegetation.

Other site-specific factors may also have influenced our results. For example, more edge or suburban species such as the American Robin, House Finch, American Goldfinch, Pine Siskin, House Sparrow (*Passer domesticus*), and European Starling (*Sturnus vulgaris*) were detected at RGNC, where human disturbance was more common. In contrast, the Yellow-billed Cuckoo, a species repeatedly petitioned by conservation organizations to be listed as threatened or endangered in the Western United States, was captured only at BNWR. Cuckoos generally prefer lowland deciduous woodlands, willow and alder thickets, second-growth woodlands, and deserted farmlands and orchards (Johnsgard 1986), conditions more available at BNWR than at RGNC.

Latitudinal limits of species' distributions may also influence relative abundance and species richness at our middle Rio Grande sites. For example, BNWR probably represents the northern distributional limits of the Pyrrhuloxia, Verdin, Brown-crested Flycatcher, and Lucy's Warbler in the middle Rio Grande Valley. Analyzing our wood warbler data set, Kelly and others (1999) found that migrant abundance at our netting sites could be predicted by summer range size and by distance between summer ranges and study sites.

Conservation Implications

The large volume and complex species-and-age composition of landbirds migrating through our sites illustrate the value of middle Rio Grande riparian habitats as stopover sites. Middle Rio Grande migrants appeared to accumulate small fat loads and repeatedly replenish fat stores at stopover sites en route, rather than accumulate large fat loads and stop infrequently. This "short-stopover/low-fat-loads" strategy was also reported for migratory thrushes along the northern coast of the Gulf of Mexico after spring trans-Gulf migration (Yong and Moore 1997). Our simulation suggests that if birds stopped 10 times en route, taking on fat stores equal to 5 percent of body mass at each stop, they would be able to fly about 20 percent farther than if they deposited the entire fat stores (50 percent body mass) at a single stopover site (see also Yong and Moore 1997). Migrants may apply this strategy when north-south habitat is continuously available between the wintering and breeding grounds, or they may switch to this strategy when they encounter extensive stretches of suitable habitat. When availability of stopover sites is limited or unpredictable, the strategy of loading large fat stores prior to undertaking long flights may be superior (Alerstam and Lindström 1990). Migration over ecological barriers such as the Gulf of Mexico and Sahara Deserts seems to elicit the latter strategy in many landbird species. Deforestation and habitat deterioration caused by catastrophic fires, exotic plant invasions, river dewatering, and urbanization along the Rio Grande migration corridor may reduce the number and quality of stopover sites. If high-quality stopover sites become increasingly hard to find along the Rio Grande, migrant success at replenishing fat loads periodically or quickly will decrease, and it will in turn reduce the probability of successful migration. To ensure that sufficient stopover sites remain available for landbird migration in the Southwest, we urge that conservation and restoration of habitats and water along the middle Rio Grande be emphasized through collaborative agreements among the river's diverse land managers.

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Appendix I—Common and Scientific Names and Alpha Codes

Common name, scientific name, and alpha code of landbird species captured during spring and fall migration along the middle Rio Grande Valley of New Mexico.

Common name	Scientific name[2]	Alpha code[3]	Status[4]
Accipitridae			
Sharp shinned Hawk	*Accipiter striatus*	SSHA	B
Cooper's Hawk	*Accipiter cooperii*	COHA	B
Falconidae			
American Kestrel	*Falco sparverius*	MAKE	B
Columbidae			
Mourning Dove	*Zenaida macroura*	MODO	B
White-winged Dove	*Zenaida asiatica*	WWDO	C
Cuculidae			
Yellow billed Cuckoo	*Coccyzus americanus*	YBCU	A
Greater Roadrunner	*Geococcyx californianus*	GRRO	R
Caprimulgidae			
Common Nighthawk	*Chordeiles minor*	CONI	A
Alcedinidae			
Belted Kingfisher	*Ceryle alcyon*	BEKI	B
Picidae			
Red napped Sapsucker	*Sphyrapicus nuchalis*	RNSA	B
Williamson's Sapsucker	*Sphyrapicus thyroideus*	WISA	B
Downy Woodpecker	*Picoides pubescens*	DOWO	R
Hairy Woodpecker	*Picoides villosus*	HAWO	R
Ladder-backed Woodpecker	*Picoides scalaris*	LBWO	R
Northern Flicker	*Colaptes auratus*	RSFL	B
Tyrannidae			
Olive sided Flycatcher	*Contopus borealis*	OSFL	A
Western Wood Pewee	*Contopus sordidulus*	WEWP	A
Willow Flycatcher	*Empidonax traillii*	WIFL	A
Least Flycatcher	*Empidonax minimus*	LEFL	A
Hammond's Flycatcher	*Empidonax hammondii*	HAFL	A
Dusky Flycatcher	*Empidonax oberholseri*	DUFL	A
Gray Flycatcher	*Empidonax wrightii*	GRFL	A
Western Flycatcher[3]	*Empidonax difficilis*	COFL	A
Black Phoebe	*Sayornis nigricans*	BLPH	B
Say's Phoebe	*Sayornis saya*	SAPH	B
Ash throated Flycatcher	*Myiarchus cinerascens*	ATFL	A
Brown-crested Flycatcher	*Myiarchus tyrannulus*	BCFL	C
Western Kingbird	*Tyrannus verticalis*	WEKI	A
Hirundinidae			
Barn Swallow	*Hirundo rustica*	BARS	A
Violet green Swallow	*Tachycineta thalassina*	VGSW	A
Bank Swallow	*Riparia riparia*	BANS	A
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS	A
Corvidae			
Scrub Jay	*Aphelocoma coerulescens*	SCJA	R

Common name	Scientific name[2]	Alpha code[3]	Status[4]
Parid			
Mountain Chickadee	*Poecile gambelli*	MOCH	R
Black capped Chickadee	*Poecile atricapillus*	BCCH	R
Oak Titmouse	*Baeolophus inornatus*	PITI	R
Remizidae			
Verdin	*Auriparus flaviceps*	VERD	B
Aegithalidae			
Common Bushtit	*Psaltriparus minimus*	COBU	R
Sittidae			
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	R
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	R
Certhiidae			
Brown Creeper	*Certhia americana*	BRCR	B
Troglodytidae			
Rock Wren	*Salpinctes obsoletus*	ROWR	B
Cactus Wren	*Camphlorhynchus brunneicapillus*	CACW	C
Bewick's Wren	*Thryomanes bewickii*	BEWR	R
House Wren	*Troglodytes aedon*	HOWR	A
Marsh Wren	*Cistothorus palustris*	MAWR	B
Winter Wren	*Troglodytes troglodytes*	WIWR	R
Carolina Wren	*Thryothorus ludovicianus*	CARW	B
Muscicapidae			
Sylviinae			
Ruby-crowned Kinglet	*Regulus calendula*	RCKI	B
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	R
Blue-gray Gnatcatcher	*Polioptila caerulea*	BGGN	A
Turdinae			
Townsend's Solitaire	*Myadestes townsendi*	TOSO	B
Swainson's Thrush	*Catharus ustulatus*	SWTH	A
Hermit Thrush	*Catharus guttatus*	HETH	B
American Robin	*Turdus migratorius*	AMRO	B
Mimidae			
Gray Catbird	*Dumetella carolinensis*	GRCA	A
Northern Mockingbird	*Mimus polyglottos*	NOMO	B
Sage Thrasher	*Oreoscoptes montanus*	SATH	B
Brown Thrasher	*Toxostoma rufum*	BRTH	B
Crissal Thrasher	*Toxostoma dorsale*	CRTH	B
Vireonidae			
Bell's Vireo	*Vireo bellii*	BEVI	A
Gray Vireo	*Vireo vicinior*	GRVI	A
Plumbeous Vireo	*Vireo plumbeous*	SOVI	A
Warbling Vireo	*Vireo gilvus*	WAVI	A
Red-eyed Vireo	*Vireo olivaceous*	REVI	A
Yellow-throated Vireo	*Vireo flavifrons*	YTVI	A
Emberizidae			
Parulinae			
Prothonotary Warbler	*Protonotaria citrea*	PROW	A
Blue-winged Warbler	*Vermivora pinus*	BWWA	A
Lawrence's Warbler	*Vermivora pinus* x *V. chrysoptera*	LAWA	A

Common name	Scientific name[2]	Alpha code[3]	Status[4]
Tennessee Warbler	*Vermivora peregrina*	TEWA	A
Orange-crowned Warbler	*Vermivora celata*	OCWA	A
Nashville Warbler	*Vermivora ruficapilla*	NAWA	A
Virginia Warbler	*Vermivora virginiae*	VIWA	A
Lucy's Warbler	*Vermivora luciae*	LUWA	C
Yellow Warbler	*Dendroica petechia*	YWAR	A
Magnolia Warbler	*Dendroica magnolia*	MAWA	A
Chestnut-sided Warbler	*Dendroica pensylvanica*	CSWA	A
Yellow-rumped Warbler	*Dendroica coronata*	YRWA	B
Black-throated Gray Warbler	*Dendroica nigrescens*	BTYW	A
Black-throated Blue Warbler	*Dendroica caerulescens*	BTBW	A
Blackburnian Warbler	*Dendroica fusca*	BLBW	A
Townsend's Warbler	*Dendroica townsendi*	TOWA	A
Prairie Warbler	*Dendroica discolor*	PRAW	A
Western Palm Warbler	*Dendroica palmarum*	WPWA	A
Black-and-white Warbler	*Mniotilta varia*	BAWW	A
American Redstart	*Setophaga ruticilla*	AMRE	A
Northern Waterthrush	*Seiurus noveboracensis*	NOWA	A
Ovenbird	*Seiurus aurocapillus*	OVEN	A
Kentucky Warbler	*Oporornis formosus*	KEWA	A
Mourning Warbler	*Oporornis philadelphia*	MOWA	A
MacGillivray's Warbler	*Oporornis tolmiei*	MGWA	A
Common Yellowthroat	*Geothlypis trichas*	COYE	A
Canada Warbler	*Wilsonia canadensis*	CAWA	A
Wilson's Warbler	*Wilsonia pusilla*	WIWA	A
Hooded Warbler	*Wilsonia citrina*	HOWA	A
Yellow-breasted Chat	*Icteria virens*	YBCH	A
Thraupinae			
Scarlet Tanager	*Piranga ludoviciana*	SCTA	A
Summer Tanager	*Piranga rubra*	SUTA	A
Western Tanager	*Piranga ludoviciana*	WETA	A
Hepatic Tanager	*Piranga flava*	HETA	A
Cardinalinae			
Pyrrhuloxia	*Cardinalis sinuatus*	PYRR	R
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	A
Black-headed Grosbeak	*Pheucticus melanocephalus*	BHGR	A
Blue Grosbeak	*Guiraca caerulea*	BGGR	A
Lazuli Bunting	*Passerina amoena*	LAZB	A
Indigo Bunting	*Passerina cyanea*	INBU	A
Painted Bunting	*Passerina ciris*	PABU	A
Dicksissel	*Spiza americana*	DICK	A
Emberizinae			
Green-tailed Towhee	*Pipilo chlorurus*	GTTO	A
Spotted Towhee	*Pipilo erythrophthalmus*	SPTO	B
Canyon Towhee	*Pipilo fuscus*	CANT	R
Cassin's Sparrow	*Aimophila cassinii*	CASP	B
American Tree Sparrow	*Spizella arborea*	ATSP	B
Chipping Sparrow	*Spizella passerina*	CHSP	A
Clay-colored Sparrow	*Spizella pallida*	CCSP	A
Brewer's Sparrow	*Spizella breweri*	BRSP	A

Common name	Scientific name[2]	Alpha code[3]	Status[4]
Vesper Sparrow	*Pooecetes gramineus*	VESP	B
Lark Sparrow	*Chondestes grammacus*	LASP	A
Black-throated Sparrow	*Amphispiza bilineata*	BTSP	B
Sage Sparrow	*Amphispiza belli*	SASP	B
Lark Bunting	*Calamospiza melanocorys*	LARB	A
Savannah Sparrow	*Passerculus sandwichensis*	SAVS	B
Grasshopper Sparrow	*Ammodramus savannarum*	GRSP	A
Song Sparrow	*Melospiza melodia*	SOSP	B
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	A
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	B
Golden-crowned Sparrow	*Zonotrichia atricapilla*	GCSP	B
White-crowned Sparrow	*Zonotrichia leucophrys*	WCSP	B
Dark-eyed Junco	*Junco hyemalis*	DEJU	B
Icterinae			
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	YHBL	A
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	B
Western Meadowlark	*Sturnella neglecta*	WEME	B
Common Grackle	*Quiscalus quiscula*	COGR	R
Great-tailed Grackle	*Quiscalus mexicanus*	GTGT	R
Brown-headed Cowbird	*Molothrus ater*	BHCO	B
Orchard Oriole	*Icterus spurius*	OROR	A
Bullock's Oriole	*Icterus galbula*	BUOR	A
Fringillidae			
Cassin's Finch	*Carpodacus cassinii*	CAFI	B
House Finch	*Carpodacus mexicanus*	HOFI	B
Pine Siskin	*Carduelis pinus*	PISI	B
Lesser Goldfinch	*Carduelis psaltria*	LEGO	B
American Goldfinch	*Carduelis tristis*	AMGO	B
White-winged Crossbill	*Loxia leucoptera*	WWCR	B
Evening Grosbeak	*Coccothraustes vespertinus*	EVGO	B

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[1] Common and scientific names are from the Check-list of North American Birds (AOU 1983) and its supplements.

[2] Alpha code is from the Manual of North American Bird Banding (BBL 1984) and its supplements.

[3] Status is as designated by the Partners in Flight preliminary list: A = Neotropical migrants, those that breed in North America and spend their nonbreeding period primarily south of the United States; B = temperate migrants, those that breed and winter extensively in North America; C = migrants whose breeding range is primarily south of the United States/Mexican border, and enter the United Sates along the Rio Grande Valley or where the Mexican highlands extend across the United States border. These populations largely vacate the United States during the winter months. R = permanent resident species that primarily have overlapping breeding and nonbreeding areas.

[4] No attempt was made to separate the Pacific-slope Flycatcher (*Empidonax difficilis*) and Cordilleran Flycatcher (*E. occidentalis*). Authors suspected both species were captured during migration along the middle Rio Grande.

Appendix II—Species Captured by Mist Netting

List of avian species captured by mist netting but not detected by point counts during spring and fall migration of 1994, 1995, and 1996 along the middle Rio Grande. See appendix I for scientific names.

Species	Total captures
Bell's Vireo	1
Black-throated Blue Warbler	1
Blue-winged Warbler	1
Cactus Wren	1
Carolina Wren	1
Cassin's Sparrow	1
Canada Warbler	1
Clay-colored Sparrow	202
Fox Sparrow	1
Golden-crowned Sparrow	1
Gray Vireo	2
Hepatic Tanager	4
Hooded Warbler	3
Lawrence's Warbler	1
Least Flycatcher	4
Magnolia Warbler	3
Orchard Oriole	3
Painted Bunting	6
Plain Titmouse	1
Prairie Warbler	1
Prothonotary Warbler	3
Red-Eyed Vireo	2
Sage Sparrow	1
Sage Thrasher	1
Scarlet Tanager	1
Tennessee Warbler	1
Western Palm Warbler	1
White-winged Crossbill	1

Appendix III—Species Detected Over 3-Year Study

List of avian species detected during point counts but not captured by mist netting during spring and fall migration of 1994, 1995, and 1996 along the middle Rio Grande Valley of New Mexico.

Common name	**Scientific name**[1]
Pied-billed Grebe	*Polilymbus podiceps*
Ring-billed Gull	*Larus delawarenis*
Franklin's Gull	*Larus pipixcan*
Double-crested Cormorant	*Phalacrocorax auritus*
Olivaceous Cormorant	*Phalacrocorax olivaceus*
American White Pelican	*Pelecanus erythrorhynchos*
Common Merganser	*Mergus merganser*
Mallard	*Anas platyrhynchos*
American Black Duck	*Anas rubripes*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
American Green-winged Teal	*Anas crecca*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Wood Duck	*Aix sponsa*
Snow Goose	*Chen caerulescens*
Greater White-fronted Goose	*Anser albifrons*
Canada Goose	*Branta canadensis*
White-faced Ibis	*Plegadis chihi*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Snowy Egret	*Egretta thula*
Cattle Egret	*Bulbulcus ibis*
Green-backed Heron	*Butorides striatus*
Black-crowned Night-heron	*Nycticorax nycticorax*
Whooping Crane	*Grus americana*
Sandhill Crane	*Grus canadensis*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
American Coot	*Fulica americana*
Red-necked Phalarope	*Phasianus colchicus*
American Avocet	*Recurvirostra americana*
Common Snipe	*Gallinago gallinago*
Western Sandpiper	*Calidris mauri*
Greater Yellowlegs	*Tringa flavipes*
Lesser Yellowlegs	*Tringa flavipes*
Willet	*Catoptrophorus semipalmatus*
Spotted Sandpiper	*Actitis macularia*
Long-billed Curlew	*Numenius americanus*
Killdeer	*Charadrius vociferus*
Semipalmated Plover	*Charadrius semipalmatus*
Scaled Quail	*Callipepla squamata*
Gambel's Quail	*Callipepla gambelii*
Wild Turkey	*Meleagris gallopavo*
Turkey Vulture	*Cathartes aura*
Mississippi Kite	*Ictinia mississippiensis*
Northern Harrier	*Circus cyaneus*
Northern Goshawk	*Accipiter gentilis*
Red-tailed Hawk	*Buteo jamaicensis*
Swainson's Hawk	*Buteo swainsoni*
Gray Hawk	*Buteo nitidus*
Golden Eagle	*Aquila chrysaetos*

Common name	Scientific name[1]
Bald Eagle	*Haliaeetus leucocephalus*
Prairie Falcon	*Falco mexicanus*
Peregrine Falcon	*Falco peregrinus*
Merlin	*Falco columbarius*
Osprey	*Pandion haliaetus*
Western Screech-owl	*Otus kennecotti*
Great Horned Owl	*Bubo virginianus*
Burrowing Owl	*Athene cunicularia*
Acorn Woodpecker	*Melanerpes formicivorus*
Lewis’ Woodpecker	*Melanerpes lewis*
Whip-poor-will	*Caprimulgus vociferus*
Common Poor-will	*Phalaenoptilus nuttallii*
Lesser Nighthawk	*Chordeiles acutipennis*
Black-chinned Hummingbird	*Archilochus alexandri*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Rufous Hummingbird	*Selasphorus rufus*
Calliope Hummingbird	*Stellula calliope*
Eastern Kingbird	*Tyrannus tyrannus*
Cassin’s Kingbird	*Tyrannus vociferans*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Horned Lark	*Eremophila alpestris*
Black-billed Magpie	*Pica pica*
Blue Jay	*Cyanocitta cristata*
Steller’s Jay	*Cyanocitta stelleri*
Common Raven	*Corvus corax*
Chihuahuan Raven	*Corvus cryptoleucus*
American Crow	*Corvus brachyrhynchos*
Pinyon Jay	*Gymnorhinus cyanocephalus*
European Starling	*Sturnus vulgaris*
Bobolink	*Dolichonyx oryzivorus*
Hooded Oriole	*Icterus cucullatus*
Brewer’s Blackbird	*Euphagus cyanocephalus*
Harris’ Sparrow	*Zonotrichia guerula*
Mountain White-crowned Sparrow	*Zonotrichia leucophrys*
Gambel’s White-crowned Sparrow	*Zonotrichia leucophrys*
Chipping Sparrow	*Spizella passerina*
Slate-colored Junco	*Junco hyemalis*
Oregon Junco	*Junco hyemalis*
Rufous-crowned Sparrow	*Aimophila ruficeps*
Purple Martin	*Progne subis*
Cliff Swallow	*Hirundo pyrrhonota*
Tree Swallow	*Tachycineta bicolor*
Cedar Waxwing	*Bombycilla cedrorum*
Phainopepla	*Phainopepla nitens*
Loggerhead Shrike	*Lanius ludovicianus*
Myrtle Warbler	*Dendroica coronata*
Audubon’s Warbler	*Dendroica coronata*
Blackpoll Warbler	*Dendroica striata*
Grace’s Warbler	*Dendroica graciae*
Pine Warbler	*Dendroica pinus*
Painted Redstart	*Myioborus pictus*
House Sparrow	*Passer domesticus*
American Pipit	*Anthus spinoletta*
Long-billed Thrasher	*Toxostoma longirostre*
Pygmy Nuthatch	*Sitta pygmaea*
Eastern Bluebird	*Sialia sialis*
Western Bluebird	*Sialia mexicana*
Mountain Bluebird	*Sialia currucoides*

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[1] Common and scientific names are from the Check-list of North American Birds (AOU 1998) and its supplements.

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