Studies in Avian Biology No. 20:88–98, 2000.

LANDBIRD MIGRATION IN RIPARIAN HABITATS OF THE MIDDLE RIO GRANDE: A CASE STUDY

DEBORAH M. FINCH AND WANG YONG

Abstract. Growing human populations and rapid ecological changes threaten the sustainability of the middle Rio Grande, a river corridor important to numerous species of wintering, breeding, and migrating waterfowl, shorebirds, and songbirds. We review the vegetational and human history of the middle Rio Grande, substantiate the importance of this system to landbirds in migration, relate patterns and trends of migratory bird populations to variation of stopover habitats, and present new data on stopover habitat use and biology of landbird migrants. We supplemented our review of the literature by evaluating banding and survey data from a new study we implemented on the river in 1994, and we re-analyzed population trend data from unpublished banding records. Analyses of data from Hink and Ohmart (1984) and our own study showed that assemblages of migratory landbirds varied in species richness and abundance among seasons and among cottonwood-willow, mesquite, salt cedar, Russian olive, drainage, and agricultural habitats. Our fat deposition data demonstrated that migrating landbirds use the bosque to replenish energy stores during travel. Stopover along the middle Rio Grande may be especially important for those species that migrate across the Chihuahuan Desert. We suggest that spatial and temporal changes in habitat cover, structure, and composition of the middle Rio Grande bosque have potential to influence habitat use, food availability, health and survival during migration, and ultimately, success of future populations of stopover migrants.

Key Words: habitat use, Middle Rio Grande, migratory landbirds, mist-netting, riparian habitats, stopover.

Hot and cold deserts, grasslands, and shrubsteppe dominate much of the interior midwestern and western United States, forming the Great Plains, the Great Basin, and the Chihuahuan, Mohave, and Sonoran Deserts (Allen 1967, Bender 1982, Brown 1985). Climate, water, and people are primary forces driving ecological systems in aridland environments of the West, influencing the amounts, varieties, patterns, and persistence of plant communities (Finch and Tainter 1995a). These lowland environments are inhospitable to many animal species that require habitats having greater amounts of moisture, forage, and structure, affecting the abundance and richness of resident animal communities.

Birds that travel for long distances over these arid deserts and plains frequently follow the rivers and streams that dissect these landscapes, stopping over in riparian habitats that provide water, food, and cover from sun and predators (Wauer 1977). The Bosque del Apache Wildlife Refuge in the middle Rio Grande Valley is an example of a famous stopover site for migrating and wintering cranes and waterfowl. Less well-understood are the habitat use patterns and values of western riparian corridors for migrating songbirds (Stevens et al. 1977). In contrast, several studies have documented the high species richness and abundance of breeding songbirds in desert and plains riparian woodlands (Knopf et al. 1988, Hodorff et al. 1988, Finch 1989, Finch and Ruggiero 1993, Rosenberg et al. 1991). Only recently has this kind of information been effective in guiding policy development for the conservation and restoration of riparian habitats (e.g., Bosque Biological Management Plan for the Middle Rio Grande; Crawford et al. 1993). In the Southwest in particular, where water is scarce, drought is common, livestock grazing is pervasive, and human populations are growing rapidly, desert river systems are swiftly changing beyond recognition (Dick-Peddie 1993, Scurlock 1995). The recent advent of restoration and recovery plans for southwestern riparian ecosystems appears driven by the federal listing of threatened and endangered species. It is unfortunately a sign of our times that a species such as the Bell's Vireo (*Vireo bellii*) or the Willow Flycatcher (*Empidonax traillii*) must first become endangered in part or all of its range before the deterioration of an entire ecosystem is addressed.

DeSante and George (1994) concluded that the most important factor contributing to the population declines of western landbird species over the last 100 years was loss or destruction of riparian and marsh habitats, affecting as many as 20 western species, or 26% of those western species whose numbers have declined. By abstracting those landbird species that use riparian habitats to migrate and breed from DeSante's and George's overall list of declines of species state-by-state, we distinguished a consistent pattern among species in where they experienced population decreases. Specifically, declines of western bird species were clustered in California, Arizona, and other southwestern states (Table 1). Likewise, a recent report by Flather and

TABLE 1. STATES WITH POPULATION DECREASES OVER THE LAST 100 YEARS OF LANDBIRD SPECIES THAT MIGRATE AND BREED IN RIPARIAN ZONES OF THE WESTERN UNITED STATES (MODIFIED FROM DESANTE AND GEORGE 1994)

Species	Scientific Name	State
Yellow-Billed Cuckoo (N)[a]	*Coccyzus americanus*	*BC WA OR* **CA NV ID** UT AZ[b]
Willow Flycatcher (N)	*Empidonax traillii*	**CA AZ NM**
Vermillion Flycatcher (T)	*Pyrocephalus rubinus*	**CA NV**
Bank Swallow (N)	*Riparia riparia*	CA
Bell's Vireo (N)	*Vireo bellii*	**CA AZ**
Lucy's Warbler (N)	*Vermivora luciae*	CA AZ
Yellow Warbler (N)	*Dendroica petechia*	OR **CA AZ**
Common Yellowthroat (N)	*Geothlypis trichas*	CA AZ
Yellow-breasted Chat (N)	*Icteria virens*	CA **NV**
Summer Tanager (N)	*Piranga rubra*	CA AZ
Song Sparrow (T)	*Melospiza melodia*	AZ

[a] N = Nearctic-neotropical migrant, T = Temperate migrant. (Partners in Flight 1992).
[b] *Italic* = Extirpated, **Bold** ≥ 50% population decline.

Joyce (1994) on endangerment patterns of plant and vertebrate species graphically showed that the Southwest and California had higher concentrations of federally-listed threatened and endangered bird species than most other regions of the United States. We suggest that rapid environmental changes, coupled with high levels of endemism, may explain high endangerment rates in the Southwest.

We elected to focus our paper on southwestern riparian woodlands because nowhere has the decline of environmental quality been more evident. We highlight the middle Rio Grande, a river system considered by many to be in jeopardy (American Rivers 1993). In this paper, we describe the vegetational and human history of the middle Rio Grande system, review patterns and trends of migratory bird populations in relation to avian habitat use and vegetation change, present new data on stopover biology of migrants, and identify management problems. Our primary intent was to summarize the literature, but so little information was available on migrating birds along the Rio Grande or in other southwestern systems that we decided to supplement the review by evaluating banding and survey data from a new study we implemented on the river in 1994. We also re-analyzed population trend data from an unpublished study. Thus, our presentation covers a mixture of existing literature and new data, the latter of which we plan to publish in more detail elsewhere (e.g., Yong and Finch 1997b).

HISTORY OF CHANGE

The Rio Grande, one of two major river systems that drain the Southwest, originates in the mountains of Colorado and runs south about 3,220 km into the Mexico states of Chihuahua and Coahuila. The river and its associated riparian vegetation meander through an arid landscape of desert grasslands, canyons, arroyos, and mesas. It links natural environments from the highlands of the Rocky Mountains to the lowlands of the Chihuahuan Desert, and serves as an important dispersal route or corridor for many plants and animals.

The middle Rio Grande valley extends approximately 260 km from Cochiti Dam to Elephant Butte Reservoir, New Mexico (Finch and Tainter 1995b; Fig. 1); its width ranges from 1.5 km to about 10 km (Crawford et al. 1993). From north to south, it traverses three major biotic communities: Great Basin Grassland, Semidesert Grassland, and Chihuahuan Desertscrub. Historically, the middle Rio Grande contained one of the most extensive riparian gallery forests of cottonwoods (*Populus deltoides, P. fremontii*) in the southwestern United States (Howe and Knopf 1991). Associated with cottonwoods were a variety of native floodplain-adapted trees and shrubs including Goodding willow (*Salix gooddingii*), coyote willow (*Salix exigua*), New Mexico olive (*Forestiera neomexicana*), seepwillow (*Baccharis glutinosa*), wolfberry (*Lycium torreyi*), indigo bush (*Amorpha fruticosa*), and screwbean mesquite (*Prosopis pubescens*). The understory included grasses such as *Bouteloua* spp., *Sporobolus* spp., rabbitbrush (*Chrysothamnus nauseosus*), tumbleweed (*Salsola kali*), snakeweed (*Gutierrezia microcephala*), arrowweed (*Tessaria sericea*), sagebrush (*Artemisia* spp.), *Kochia* spp., and other forbs.

Human populations have increased dramatically along the middle Rio Grande since European settlement (Scurlock 1995, 1998). The floodplain riparian vegetation along the river has been impacted more by human activities than any other vegetation type in New Mexico (Dick-Peddie 1993). Current middle Rio Grande flood-

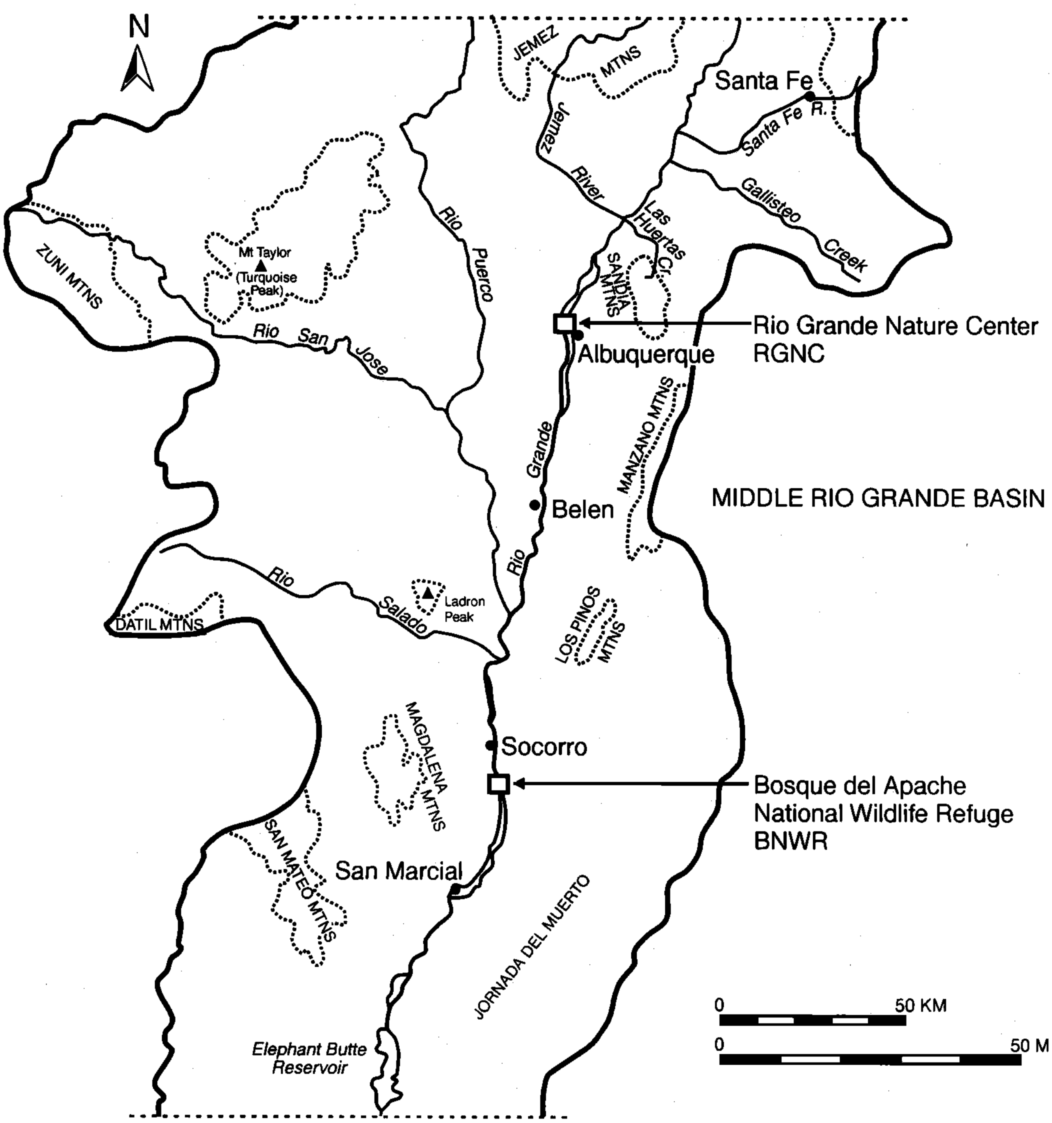

FIGURE 1. Map of the middle Rio Grande valley with square symbols marking locations of two banding stations, Rio Grande Nature Center and Bosque del Apache National Wildlife Refuge. Adapted from Scurlock (1998).

plain vegetation greatly differs in both composition and extent from pre-European plant communities owing to human-induced hydrological and ecological changes during the last two centuries (Bullard and Wells 1992; Scurlock 1995, 1998). While livestock grazing and timber and firewood harvesting reduced some of the existing woods and understory vegetation, the construction of riverside drains, levees, and irrigation structures in the early 1900s lowered the water table, draining much of the riverside wetland habitat and allowing further agricultural development of the floodplain (Wozniak 1995, 1998). Channelization and dam construction controlled annual floods and suppressed the regeneration of flood-dependent native species, particularly cottonwoods. Although cottonwood and willow were, and remain, dominant vegetation, they have been reduced to a narrow band of mid- to old-age forest stands between levees in the middle Rio Grande floodplain. Introduction and escape of saltcedar (*Tamarix chinensis*) and Russian olive (*Elaeagnus angustifolia*) since the turn of the century have further changed the

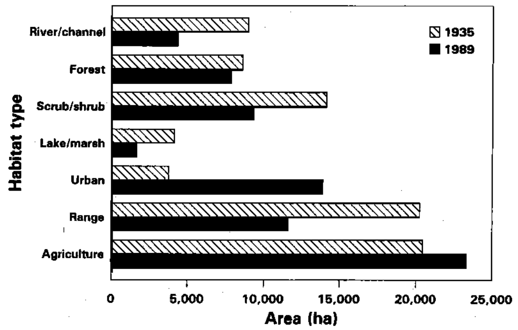

FIGURE 2. Changes in habitat availability along the middle Rio Grande between 1935–1989. Data were summarized from survey maps of the National Wetlands Inventory, Fish and Wildlife Service, U. S. Department of the Interior (Crawford et al. 1993).

composition and dominance of woody species, and the structure and successional stages of plant communities along the middle Rio Grande (Hunter et al. 1988, Dick-Peddie 1993).

More recently, growing human populations and associated housing and development have intruded into previously unoccupied and undisturbed areas, causing further modification to the riparian woodland, referred to locally as "the bosque" (Spanish for forest). Although the middle Rio Grande bosque appears continuous from the air, it is interspersed with residential areas, recreational parks, powerlines, bridges, road and trail networks, dams and diversion structures, exotic woody plants, croplands, pastures, and protected wildlife refuges (Finch et al. 1995). Maps comparing vegetation cover along the middle Rio Grande in 1935 to that in 1989 (National Wetlands Inventory maps prepared for Crawford et. al 1993), documented substantial changes in all cover types of the five river reaches (Cochiti, Albuquerque, Belen, Socorro, and Bosque del Apache) surveyed. When we totaled and compared cover values in 1935 and 1989 for each habitat across all five reaches, habitat turnovers over the 54-yr period were evident: river channel (−106% of 1935 channel), forest (−8%), scrubland (−50%), "range" grassland (−75%), lake/marsh (−150%), urban cover (+270%) and agriculture (+14%) (Fig. 2). The low amount of change in forest cover reported by the National Wetlands Inventory (Crawford et al. 1993) is somewhat misleading because the inventory did not distinguish native woodland from areas having introduced saltcedar or Russian olive, species that can exist as dominant plant communities or as understory layers in cottonwood communities. If the increased covers of introduced plant species were accounted for, the

TABLE 2. Predicted Human Population Changes in the Middle Rio Grande Valley (Modified from Crawford et al. 1993)

County	1991	2020	Change	% change
Sandoval	63,841	128,996	65,155	+102
Bernalillo	481,689	614,265	132,576	+27
Valencia	45,545	91,831	46,286	+102
Socorro	14,804	21,216	6,412	+43
Total	605,879	856,308	250,429	+41

actual percent change in native forests would be much higher (e.g., Mount et al. 1996).

In a national report on endangered ecosystems of the United States, Noss et al. (1995) concluded that riparian forests in New Mexico were endangered. The environmental organization American Rivers (1993) identified the Rio Grande as one of the "most endangered rivers in North America". Alteration of river and riparian resources in the Southwest is associated with human population growth and accompanying land usages and impacts (Scurlock 1995 1998; Wozniak 1995, 1998). Human populations are predicted to almost double in size in the middle Rio Grande Basin by the Year 2020 (Table 2). The actual numbers of people may seem insignificant compared to large metropolitan areas such as Los Angeles or New York City, but given additional factors such as climate change in this arid region, declining water supply of the Albuquerque aquifer, deteriorating quality of the water and land, and geomorphological and land ownership constraints to urban growth, many scientists and land managers question whether ecosystems, human populations, and biological diversity in the Basin can be sustained (Finch and Tainter 1995a). Because migrating birds contribute in a vital way to the rich biological diversity of southwestern riparian systems (Rosenberg et al. 1991, Yong et al. 1995), no assessment of the sustainability of the middle Rio Grande valley would be complete without an account of this dynamic biological resource (Finch et al. 1995).

HABITAT VALUE TO MIGRATING BIRDS

River corridors may be more important as travel pathways for transient migrants in arid regions than waterways in areas with greater moisture and vegetation (Wauer 1977) because aridland river habitats offer fueling resources and shelter to birds from weather and predators. Although the dynamics of landbird migration along the Rio Grande have never been quantified, it is clear from the frequent displays and guided tours at local visitor centers that most refuge managers, park officials, and birders are fully aware that the middle Rio Grande provides recreational opportunities for observing numerous species of waterfowl, shorebird, and songbird in migration. Terrestrial riparian habitats along the Rio Grande provide diverse stopover sites for migratory landbirds that use the Great Plains-Rocky Mountain flight route (Finch et al. 1995). Yong et al. (1995) postulate that the hot and dry conditions of the Chihuahuan desert in Mexico and New Mexico may cause birds to funnel through the Rio Grande channel in search of available food, water, cover, and suitable north-south routing (see also Wauer 1977).

A review of earlier studies identified at least 241 landbird species that use the middle Rio Grande valley (Finch et al. 1995). Only 54 (23%) of these species are residents, and the rest are nearctic-neotropical and short distance migrants. Migrants include breeding residents (54 species, 22%) that are present in late spring and summer; winter residents (52 species, 22%) that are present for varying lengths of time between September and April; and transient species (71 species, 30%) that migrate through the valley in large numbers during spring and fall. Using categories of migratory status defined by Partners in Flight (1992), 96 of the 241 species (40%) are nearctic-neotropical or long-distance migratory species; 74 species (31%) are temperate migrants that have some populations wintering into the Neotropics; 4 species (2%) breed primarily along or south of the U.S./Mexican border; and the remaining 67 species (27%) are residents or migrants not defined by the Partners in Flight list.

In addition to being rich in migratory species, the riparian habitats of the middle Rio Grande support high densities of migratory birds. Densities of over 1,000 birds/100 acres (2,200 birds/km^2) have been recorded in cottonwood-willow habitats of the Rio Grande (Freehling 1982, Hink and Ohmart 1984, Hoffman 1990). High bird abundance and species richness in the middle Rio Grande valley are consistent with data reported for other riparian ecosystems in the Southwest (Hubbard 1971, Carothers et al. 1974, Ohmart and Anderson 1982; Rosenberg et al. 1982, 1991). Similarities in patterns of migration use along different southwestern drainages indicate the high value of these unique and limited habitats to landbirds migrating through semi-arid environments.

SEASON AND HABITAT EFFECTS

In 1981 and 1982, Hink and Ohmart (1984) conducted a biological survey along the middle Rio Grande. To evaluate whether bird abundance and species richness during spring and fall migration differed from abundance and richness in winter and summer, we reorganized and reanalyzed unpublished annual bird count data collected from 78 transects representing 21 different vegetation and structure types (see Hink and Ohmart 1984:104). We tested the effects of habitat type (cottonwood-willow, cottonwood-Russian olive, Russian olive, drainage habitat, and cattail marsh), vegetation structure (6 classes ranging from high to low foliage volumes in combinations of lower, middle, and upper strata; Hink and Ohmart 1984), and season (spring, summer, fall, and winter) on species richness and average density of birds. The results of our three-way analyses of variance showed that habitat type, vegetation structure, and season influenced species richness ($F_{12,63}$ = 5.43, P ≤ 0.001) and avian density ($F_{12,63}$ = 2.62, P = 0.008) in different ways. Species richness varied among seasons ($F_{12,3}$ = 10.12, P ≤ 0.001) with more species observed during spring and fall when migratory species move through the middle Rio Grande than in summer and winter (Fig. 3). Species richness also varied among habitat types ($F_{12,4}$ = 6.97, P ≤ 0.001) with more species detected in cottonwood-Russian olive and drainage habitats than in pure Russian olive or cottonwood-willow (Fig. 3). However, richness did not vary with vegetation structure ($F_{12,5}$ = 1.56, P = 0.187).

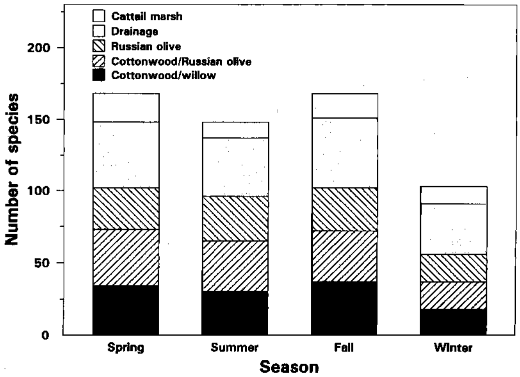

FIGURE 3. Species richness in relation to habitat type and season.

In contrast to species richness, bird densities reported by Hink and Ohmart (1984) were not influenced by season ($F_{12,3}$ = 1.50, P = 0.226), but were affected by habitat type ($F_{12,4}$ = 0.02) and vegetation structure ($F_{12,5}$ = 32.97, P = 0.02). Birds were more abundant at sites with intermediate-aged cottonwood trees and thick understories of willow or Russian olive; these formations occurred primarily along levees and river edges.

POPULATION TRENDS OF MIGRATING BIRDS

Although native riparian habitats have clearly changed since European settlement along the Rio Grande, long-term population data for different avian species are needed to determine whether habitat changes have affected migrating landbirds. Previous studies, including the long-term Breeding Birds Survey (BBS) coordinated by U.S. Geological Survey, Biological Resources Division, focused on breeding birds and offer little information on migration populations, habitat use, and effects of habitat alteration on landbirds that migrate through riparian systems in the western United States. Thompson et al. (1994) suggested that most bird species that were historically documented in the Rio Grande valley are still present, with the exception of Purple Martin (*Progne subis*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), and Hooded Oriole (*Icterus cucullatus*). However, their historical information was qualitative, and population data were not available to be compared. A species could experience substantial population declines or increases over time while continuing to be recorded as present. We must be cautious in using records of continued species presence over time as indicative of the stability or well-being of a population. Over the short-term, evaluations of demographic data focused on nesting success, fledgling survival, and recruitment rates among local populations, habitats, and years may offer insight into the population status of a species.

We hypothesize that the habitat changes recorded along the Rio Grande (Fig. 2) have affected bird populations both positively and negatively, whether the populations are transitory, resident, wintering, or breeding. Some populations may have increased in response to changes in local conditions that have promoted increased availability of preferred habitats or structural types. Others have probably declined owing to invasion of alien plant species and associated increases in midstory shrub structure, expansion of urban areas, aging of cottonwoods, loss of marshes, and range expansion of cowbirds (Howe and Knopf 1991, Mount et al. 1996, Schweitzer et al. 1996). Because the middle Rio Grande is used by migrating birds that breed over a broader geographic area of western North America than that covered by the river itself (Yong and Finch 1996), alteration or loss of riverine stopover habitat could potentially have a large-scale effect on landbird populations.

Our hypothesis was supported by analyses of banding data collected by Rio Grande Bird Research, Inc. (RGBR; Yong and Finch 1997b).

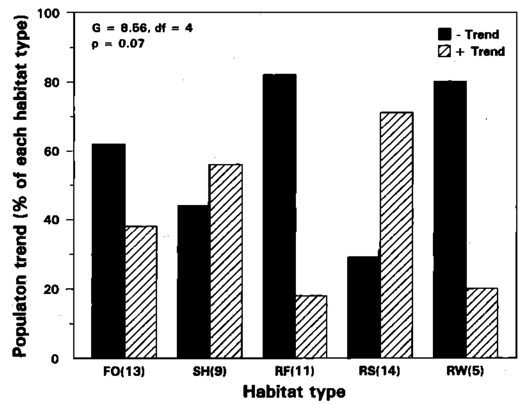

FIGURE 4. Relationship between population trends and breeding habitat types: FO = nonriparian forest, SH = nonriparian shrub/scrub/grassland, RF = riparian forest, RS = riparian shrub, and RW = riparian wetland, backwater, or marsh. Sample size of species is in parentheses along x-axis.

RGBR is a nonprofit group of volunteers who have banded fall migrants on weekends at Rio Grande Nature Center (RGNC; Fig. 1), within the city boundary of Albuquerque, New Mexico (35°07′N, 106°41′W), since 1979. The banding site is a riparian habitat that included bosque, two man-made ponds, and agricultural fields. We analyzed population trends of migrating landbirds based on data collected between 1985 and 1995. We excluded data collected prior to 1985 because the sampling methodology varied from year to year. We assigned migrating species to habitat use categories based on which habitats they most typically breed in and calculated what proportion of species showed negative or positive trends within each habitat category: upland forest, upland nonforest, riparian woods, riparian shrub, and wetlands. Trend direction was assigned based on slope calculated from regressions of birds captured/100 net-hrs with year as the predictor variable.

The most obvious pattern of population change was in riparian bird species, with 81% of shrub-using riparian species tending to increase and 29% decreasing; 82% of forest-dwelling species tending to decrease in population versus 18% increasing; and 80% of wetland species showing decreasing populations versus 20% having increases (Fig. 4). Examples of riparian forest birds that had negative population trends included Western Wood Pewee (*Contopus sordidulus*), Black-Headed Grosbeak (*Pheucticus melanocephalus*), and Warbling Vireo (*Vireo gilvus*). Riparian shrub dwellers with positive population trends included Blue Grosbeak (*Guiraca caerulea*), Lazuli Bunting (*Passerina *amoena*), and Lincoln's Sparrow (*Melospiza lincolnii*). Common Yellowthroat, Black Phoebe (*Sayornis nigricans*), and Red-winged Blackbird (*Agelaius phoeniceus*) were some of the wetland species with negative trends.

STOPOVER ECOLOGY

Banding and Counting Study

Passerine birds may preferentially select riparian habitats as stopover sites during migration in the Southwest (according to Stevens et al. 1977, Hehnke and Stone 1979). During spring and fall migration, riparian systems can attract more than 10 times the number of migratory birds than surrounding upland sites (Steven et al. 1977, Hehnke and Stone 1979). Little information is available, however, on migrant stopover behavior and biology within riparian habitats during migration. To investigate timing and pattern of migration, migrant use of native, introduced, and agricultural habitats, and energetic condition and foraging behavior of migrants, we began a study of stopover birds in the middle Rio Grande. In spring 1994, we established a new banding station at Bosque del Apache National Wildlife Refuge (BNWR, N33°48′ and W106°52′; Fig. 1), located about 90 miles south of Albuquerque, New Mexico, and we expanded the existing banding program at RGNC (see above; Yong et al. 1995). Twenty nylon mist-nets (12 m × 2.6 m with 30- or 36-mm mesh) were used at each site to capture migrants during spring and fall migration. We also established 16 transects in the five dominant vegetation types: cottonwood, saltcedar, screwbean mesquite, willow transects, and agriculture lands. Each transect was 1 km long with point count stations located at 200-m intervals (6 stations/transect). Nets and transects were sampled every weekday.

Seasonal and Habitat Use During Migration

A total of 6,471 individuals of 108 species was captured at the two sites (data combined) during the 1994 field seasons. We captured 18 more species in the fall (93 species total) than in the spring (75 species). In addition, far more individuals (5,615 total birds) were captured during fall migration than in spring (856 birds; Fig. 5). Although mist-netting effort was constant between fall and spring with respect to numbers of net sites and netting hours per day, the number of fall migration days exceeded the number of migration days in spring, which may partially explain why more birds were captured in fall. In addition, hatching-year birds contribute to higher total numbers of fall migrants than spring migrants. More birds were detected from

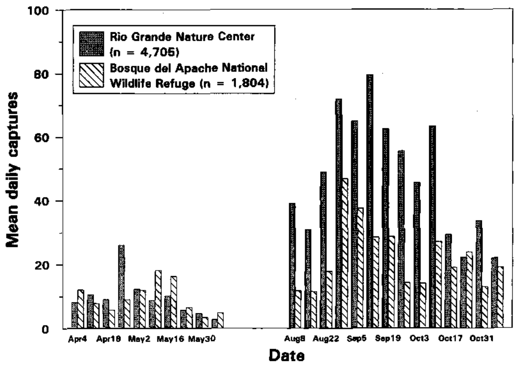

FIGURE 5. Seasonal capture pattern of landbird migrants at Rio Grande Nature Center and Bosque del Apache National Wildlife Refuge, New Mexico during spring and fall 1994. Daily averages are calculated based on weekly total captures.

mid-April to mid-May during spring migration and between early September to mid-October in fall migration than at other times. Our capture data for two seasons conflict with results of analyses from Hink and Ohmart's (1984) transect data, which suggested no seasonal variation in bird densities along the middle Rio Grande. Our data may not be directly comparable to Hink and Ohmart's data, however, because their intensive study area emphasized habitats north of ours and their methods of detecting birds differed from ours.

Numbers of landbird migrants captured and counted at BNWR and RGNC during spring migration varied among habitat types, suggesting that migrants differentially selected habitats during stopover. Given that we sampled a greater variety of habitats using transects than mist nets, we evaluated our transect data to detect any additional differences in stopover use among habitats. Based on results from our transect data for all migrants combined, 21% of migrants were observed in cottonwood-willow habitats, 25% in mesquite, 18% in saltcedar, and 35% in agricultural fields. Some species were observed in specific stopover habitats more frequently than others. For example, at the BNWR site surveyed in spring 1994, the relative distribution of Black-headed Grosbeak was 50.6% in cottonwood habitat, 16.1% in mesquite, 24.1% in saltcedar, and 8.0% in cropland, while the closely-related Blue Grosbeak was 15.79%, 19.55%, 19.55%, and 45.11%, respectively (Finch et al. 1995). Comparing stopover use of habitats by grosbeaks to habitat availability as approximated by 1989 National Wetlands Inventory data (Fig. 2), Black-headed Grosbeaks apparently selected forest types more frequently than they were available while avoiding agricultural fields despite their

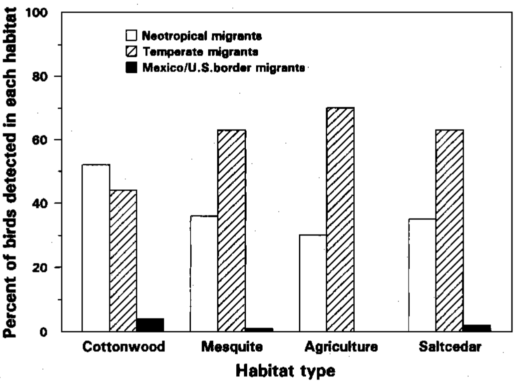

FIGURE 6. Proportions of total migrants observed in cottonwood-willow, mesquite, agriculture, and saltcedar in relation to Partners in Flight (PIF; Partners in Flight 1992) migratory status. Proportions are based on survey data from Bosque del Apache National Wildlife Refuge, spring 1994.

dominant presence. In contrast, cropland stopover use by Blue Grosbeaks more closely reflected cropland availability.

Nearctic-neotropical migrants used native cottonwood-willow habitat more often than other habitats in spring and more than temperate migrants (Chi-square = 18.36, df = 6, P = 0.005; Fig. 6). In contrast to findings based on Hink and Ohmart's data (Fig. 4), our current study suggests that more birds use native cottonwood-willow during stopover than habitats dominated by an exotic plant species, in this case, salt cedar (Fig. 6). For some bird species, this may reflect availability of habitats at local sites, but for certain tree-affiliated species (e.g., Black-headed Grosbeak, Western Wood Pewee) cottonwood forests are selected more often during stopover than would be expected based on availability (D. Finch and W. Yong, unpubl. data).

Differences in local availability, selection, age and structure of salt cedar (surveyed at BNWR) versus Russian olive (a dominant exotic in Hink and Ohmart's study) may influence stopover frequency in cottonwood-willow habitats. Birds may frequent cottonwood-willow habitats more than salt cedar when the former is more available at a site or if it provides more abundant or suitable resources, but may switch to Russian olive habitats in areas where olive is a prominent plant species. In the absence of cottonwoods, willows, and olives, monotypic stands of salt cedar may be the only wooded habitat available for riparian-dwelling bird species along some southwestern drainages (Livingston and Schemnitz 1996). Similarly to Hink and Ohmart's data for drainage habitats (Fig. 4), our unpublished mist-netting results suggest that even the recently established native coyote willow stands along drainage channels provided habitat for many nearctic-neotropical migrating landbirds such as Willow Flycatchers, Yellow-breasted Chats, MacGillivray's Warblers (*Oporornis tolmiei*), and Yellow Warblers.

STOPOVER TIME LENGTH AND FAT GAIN

We evaluated whether fat deposition and stopover length varied with time of day, species, or migration distance using methods defined by Moore and Kerlinger (1987). Such variation may reflect the relative importance or use of Rio Grande riparian habitats as refueling sites during migration. We selected Chipping Sparrow (*Spizella passerina*) to evaluate weight change over time because it was the most abundant species in fall 1994, thus providing a large sample size for detecting small changes in mass. Chipping Sparrows caught late in the banding morning weighed significantly more than sparrows caught early, with adults showing a higher rate of weight gain (0.12 g/hr) than hatching year birds (0.08 g/hr; Fig. 7). Weight gain over the morning suggests that birds were using stopover habitats to actively forage and replenish energy stores during migration.

We found mixed daily weight-gain results among species as well as intraspecific differences in weight gain by sex, age, season, habitat, and locality that we plan to publish in depth elsewhere. For example, female Wilson's Warblers (*Wilsonia pusilla*) showed significant (P > 0.05) mass gains of 0.16 g/6 hr to 0.36 g/6 hr in agricultural and cottonwood habitats at the RGNC during fall migration but not at the BNWR. In contrast, male Wilson's Warblers in fall showed significant weight gains of 0.20 g/6 hr to 0.32 g/6 hr in various cottonwood habitats at both RGNC and BNWR but not in agricultural or willow habitats. In some species, hatching year birds had lower and more variable weight gain than adults, possibly because they were less experienced and less skillful in finding and consuming food during fall migration through unfamiliar habitats (Woodrey *this volume*).

Our fall 1994 banding data from RGNC and BNWR suggest that stopover time is dependent on whether specific species need to replenish energy stores. Species that stopped in habitats during our morning netting periods most frequently exhibited zero or very slight fat stores (Fig. 8), suggesting that the stopover was needed for refueling. Numbers of nearctic-neotropical migrants did not differ from temperate migrants among five fat classes (Chi-Square = 2.88, df = 4, P = 0.58) (Fig. 8), although in comparing the first two fat classes only, long-distance migrants

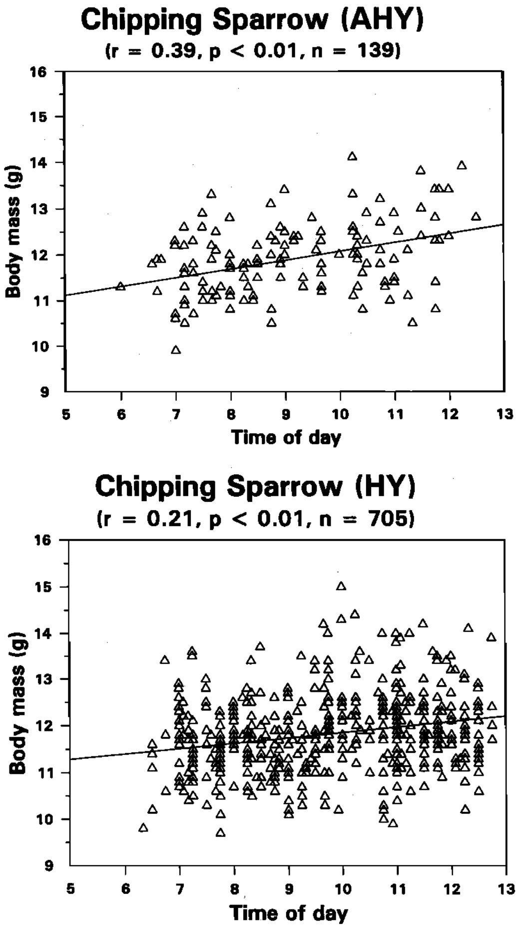

FIGURE 7. Weight change (g) over time in adult (AHY) and hatching year (HY) Chipping Sparrows captured during morning mist-netting sessions in fall, 1994.

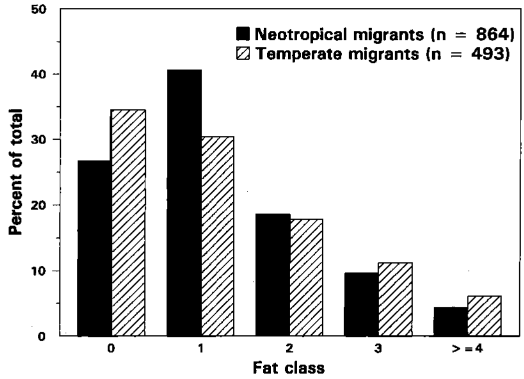

FIGURE 8. Fat class distributions of nearctic-neotropical (PIF A) and temperate (PIF B) migrants captured at the Bosque del Apache National Wildlife Refuge and Rio Grande Nature Center in spring 1994. Fat classes range from 0 to 5, with 0 = no fat to 5 = very fat (sensu Moore and Kerlinger 1987).

appeared proportionately more abundant in Fat Class One than temperate migrants (Chi-square = 2.42, df = 1, P = 0.12; Fig. 8). Perhaps long-distance migrants prepare for longer flights by storing more fat than temperate or short-distance migrants. For those species crossing the Chihuahuan Desert during spring migration, the bosque of the middle Rio Grande may serve as an especially important stopover site for refueling.

Analyses of recapture data for three transient species, Dusky Flycatchers (*Empidonax oberholseri*; nearctic-neotropical) MacGillivray's Warblers (nearctic-neotropical), and Hermit Thrushes (*Catharus guttatus*; temperate), showed that they had relatively short stopover lengths (1.5 days, 1.75 days, and 2.71 days, respectively) and relatively large amounts of individual mass (fat) gain (4.07%, 13.44%, and 3.01%, respectively) on average (Fig. 9). In contrast, Blue Grosbeak, a nearctic-neotropical migrant that breeds locally in the middle Rio Grande bosque, had a longer average stopover length (11 days) and smaller average mass change (−0.15%; Fig. 9). These preliminary data, while limited in sample size, support the idea that transients fortify themselves during stopover more than do migrants that are close to or within the vicinity of their breeding grounds.

DISCUSSION AND RECOMMENDATIONS

Based on analyses of 1984 bird count data and more recent bird capture data, we conclude that species richness and abundance of birds are greatly influenced by season and habitat type along the Rio Grande. Our mist-netting results showed that season influenced overall bird abundance more than the results of our analyses of Hink's and Ohmart's 1984 transect data suggested. Our comparisons of spring and fall bird-banding data demonstrated strong differences in abundances between these two seasons alone. The transect method used by Hink and Ohmart may not adequately sample some bird species in migration because migrating birds are less vocal than breeding birds, more transient than both breeding and wintering birds, and more difficult to identify in spring, fall, or hatching-year plumages. In addition, many transient species are rare or accidental. Therefore, migrating birds are often difficult to detect using traditional counting methods. We recommend that birds in migration be sampled using mist-nets in association with other counting methods to estimate abundance and species presence. Nevertheless, traditional counting methods such as point counts and tran-

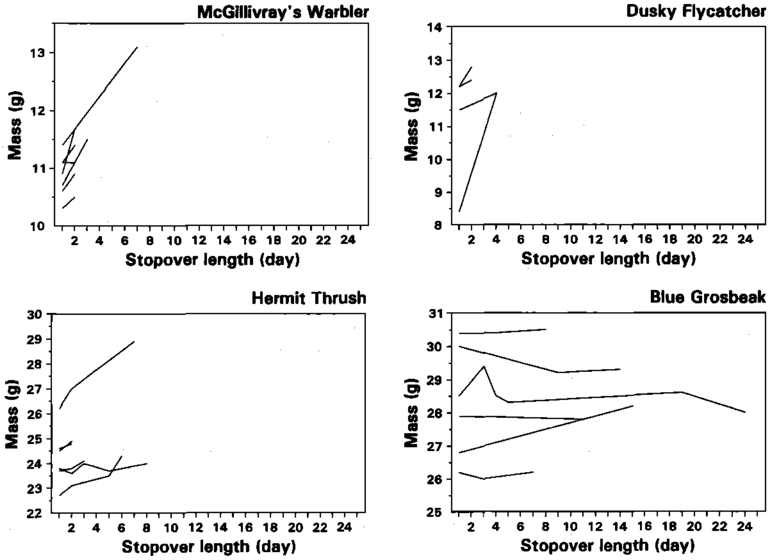

FIGURE 9. Body mass (g) gain in relation to length of stopover time based on recapture data for MacGillivray's Warbler, Dusky Flycatcher, Hermit Thrush, and Blue Grosbeak in fall, 1994. Each line represents an individual bird.

sects are recommended as the most efficient, economical means for sampling relative abundance of populations among habitats and species over a broad number of sites. A species-by-species or guild-level analysis of Hink and Ohmart's data may further clarify patterns of abundance and species richness among habitats and seasons.

Our analysis of Hink and Ohmart's data documented that Russian olive, an alien plant species, was used to a considerable extent by birds year round. Its olive crop provides a food source to many bird species, and its structural form offers cover and nest substrate to understory birds (Van Dersal 1939, Freehling 1982). Questions have been raised as to whether this introduced woody species has added value to the system (Freehling 1982), or whether it should be viewed as a disturbance feature that should be eliminated or controlled. This question is difficult to answer because of lack of information on bird populations and habitat use of these systems under pre-Russian olive conditions. Teasing out whether specific bird species are closely tied to or avoid Russian olive habitats in relation to arthropod supplies or nutritional value of olives, and in the presence and absence of cottonwood-dominated overstories, may help to quantify precisely whether and how Russian olive adds value, and whether this value offsets the disturbance factor.

The same reservation holds true for salt cedar habitats, which are reported to differ in bird species composition from native habitats (Hunter et al. 1988, Farley et al. 1994, Ellis 1995). However, when mixed with other woody plants, salt cedar habitat is reported to be more valuable to landbird species along the Rio Grande than monotypic or manipulated vegetation (Leal et al. 1996). Along certain New Mexico drainages such as the Pecos River, salt cedar offers new wooded habitat where few woods were historically available (Livingston and Schemnitz 1996). Even so, habitats dominated by such alien woody plants may represent an ecological trap or sink if populations of some of the bird species that use them are unable to sustain productivity. In addition, if other habitats such as grasslands or marshes are gradually being displaced by invasive alien plants, some of the bird species associated with the displaced habitats are likely being lost from sites also (Livingston and Schemnitz 1996). We recommend studies that compare breeding success of species' populations among habitats dominated by alien and native plant species. Habitat use of introduced plants by nearctic-neotropical migratory bird species that have been identified as high priorities for conservation (e.g., Hunter et al. 1993) should be assessed and closely monitored. If priority bird species are positively or negatively associated with exotic plant species, then conservation action may be important (Leal et al. 1996).

While our analyses of local population data collected between 1985 and 1995 from the Rio

Grande Nature Center in Albuquerque were limited in sample size and did not explain whether populations changes were associated with events on the breeding grounds, wintering grounds, migratory routes, or a combination of these, they did suggest that selected species that use the Rio Grande during fall migration have experienced changes in numbers over a period of ten years. In addition, numerical increases and declines of riparian-breeding species tended to separate out into broad habitat categories. Changes specific to riparian shrub, riparian forest, and wetland species may be related to western expansion of exotic woody species resulting in increased cover of shrub understories and mixed overstories along rivers and streams (e.g., Mount et al. 1996, Leal et al. 1996), aging and dying of cottonwoods in many western riparian systems (Howe and Knopf 1991, Finch et al. 1995), and widespread loss of western marshes and wetlands (Mitsch and Gosselink 1986, DeSante and George 1994, Noss et al. 1995). Population changes that we observed may or may not be directly linked to local habitat changes along the Rio Grande, but certainly the Rio Grande is symptomatic of, and contributes to, problems in western riparian and wetland systems.

Although our stopover data were preliminary, they suggest that riparian woodlands along the middle Rio Grande are valuable to numerous species of migrating landbirds. As our fat deposition results demonstrated, migrating birds use the bosque to replenish energy stores during travel. We postulate that stopover along the middle Rio Grande may be especially important for those species whose migration flights cross the Chihuahuan Desert of Chihuahua, Mexico, southern New Mexico, and western Texas. With regard to the need for depositing fat reserves, migration over vast deserts may be analogous to flights over large water bodies such as the Gulf of Mexico (e.g., Moore and Kerlinger 1987, Moore et al. 1995). Because most riparian woodlands along the Rio Grande in New Mexico are north of Elephant Butte Reservoir, some spring migrants may travel for a considerable distance across inhospitable desert, possibly following the river channel, before reaching the bosque of the middle Rio Grande. Survival of some individuals could conceivably depend on reaching this woodland resource before energy stores are completely depleted. In fall, survival of inexperienced hatching year birds that stop in the bosque on their first flight south could hinge on how much fat they have deposited before departure over desert country. When the Rio Grande is viewed in such a light, the need to conserve its bosque becomes as obvious as the bosque's importance to birds.

Variation in the abundance distributions of migrating species suggest that Rio Grande habitat types differ in value among species (for breeding birds, see also Leal et al. 1996). Thus, changes in habitat cover, structure, and composition may influence habitat use, food availability, health, and survival during migration, thus potentially influencing population trends (e.g., Moore and Simons 1992a). Factors that reduce the suitability of riparian habitats as stopover sites in the middle Rio Grande valley may affect not only local birds, but also populations at larger geographic scales, and may conceivably jeopardize the future of some populations. Riparian woodlands along other major drainages of the Southwest appear similarly important to transients and locally-breeding migrants (e.g., the lower Colorado River; Rosenberg et al. 1991). Conservation of the Rio Grande bosque has already been elevated to a high priority based on its high biological diversity (Crawford et al. 1993). We concur and further recommend that migration habitats be recognized and included as an important factor in the planning and design of conservation and restoration projects not only for reaches along the middle Rio Grande, but for riparian vegetation along southwestern rivers and streams in general.

ACKNOWLEDGMENTS

We thank Rio Grande Bird Research, Inc., for providing banding data from the Rio Grande Nature Center for our analyses. We are grateful to the staff at the Rio Grande Nature Center and Bosque del Apache National Wildlife Refuge for access, housing, and assistance with our migratory bird studies at these two sites. We thank V. C. Hink, R. D. Ohmart, and Army Corps of Engineers for permission to use their unpublished report. Many technicians and volunteers collected data in the field, and we appreciate their help. In particular, we acknowledge G. Bodner, D. Hawksworth, J. Sevigny, and M. Sevigny for their stalwart field assistance. We are especially indebted to Frank Moore for supporting a cooperative agreement between the Rocky Mountain Experiment Station and University of Southern Mississippi to finance W. Yong's visiting postdoctoral position in Albuquerque. We thank two anonymous reviewers for their thoughtful comments on the manuscript.