SHARED MIGRATORY BIRDS BETWEEN NORTH
AND LATIN AMERICA

by

C. John Ralph, Greg Butcher, Kelly K. Busse,
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INTRODUCTION

In order to evaluate priorities for potential cooperative relationships in the Sister Forest program of National Forest units in the United States and various units in Latin America, we have compiled an analysis of the shared migratory avifauna of the two regions. It is intended that these Sister Forest relationships would be based in part on the Neotropical Migratory Bird Conservation Program which involves a mutual concern about the status of various species breeding in North America and wintering in Latin America. The Program includes aspects of inventory, monitoring, in-depth research, and education about the birds.

For purposes of this demonstration of the potential of the method, we show some of the parameters placed in the data base and a few of the many potential applications to determine relationships between the breeding and wintering grounds of migrants. As an example of an application, we compare four candidate National Forest units with prospective areas in Latin America. To enable readers to use the database, tables and appendices are provided on diskette as ASCII files accompanying this report. Examples of those tables are included in the report.

METHODS

Ranges of species.—We plotted the breeding and wintering ranges of 156 species (Appendix A - on diskette) of migratory birds in a GIS environment. We used Arc/Info version 6.1 running on a Sun SPARC station #2 workstation. We plotted those species that have the majority of their breeding range north of the U.S. and Mexico border, and the majority of their winter range in Latin America, from Mexico south. We first consulted Inkley (1985) for bird ranges in both North America and Mexico, then AOU (1983) to confirm these ranges and to add South American ranges. Finally, we consulted standard field guides such as NGS (1987) and Peterson and Chalif (1990). Ranges of birds are subject to much interpretation and it is likely that no two observers would agree on the range of any single species. This is primarily a problem of scale and determination of abundance within that scale. The standard field guides allocate range according to a very large scale of several hundred kilometers. Areas with small or marginal populations can be included or excluded in what might seem to be a capricious manner. An example would be a species that does not normally breed in numbers in the Central Valley of California, a former grassland, now almost entirely agriculture. However, the valley might well be included in its range if substantial numbers breed at its forested margins, and occasionally penetrate into the valley itself. Despite these problems, the ranges as we entered them are, to the best of our ability, a composite of scales, but equivalent approximately to that in standard field guides.

¹U.S.D.A. Forest Service, Pacific Southwest Forest Experiment Station, Redwood Sciences Laboratory, Arcata, California 95521

²American Birding Association, P.O. Box 6599, Colorado Springs, Colorado 80934

³Colorado Bird Observatory, 13401 Piccadilly Road, Brighton, Colorado 80601
The range of a bird was considered to be within a given ecoregion if its range occupied at least 25% of that ecoregion. Presence or absence of each bird species by ecoregion was determined for both the breeding and wintering ranges (Appendix B and Appendix C - on diskette). Of the 255 North American species which are migratory to some extent, we excluded 99 species. We included short-distance migrants that barely make it south of the U.S. border, species that barely breed north of the Mexico-U.S. border, and species that breed only in Florida.

Ecoregions.--The habitat types of North and Central America were then compiled, based on the Bailey (1976) ecoregions, resulting in 43 separate ecoregions (Figure 1 and Table 1). Habitat types in South America were based on UNESCO (1980), resulting in 68 separate ecoregions in the same continent (Figure 2 and Table 2). We simplified the UNESCO system that is based on a multi-level classification of climate and vegetation. Some ecoregions had disjunct distributions, and each disjunct ecoregion was treated separately. For simplicity, we have referred to only the vegetation component in these classifications, and have simplified and consolidated some of the vegetation types.

Species at risk.--In order to determine a priority weighting scheme, we derived a rating system from the Colorado Bird Observatory's Partners in Flight Prioritization Ranks (1993) (Appendix E - on diskette) that estimates the risk of extinction to the species on the basis of various attributes. Each species was ranked on a scale of 1 to 5 in six different categories. A ranking of 5 would mean a species at highest possible risk, and a 1 would indicate no perceived risk. The six categories were as follows, with a high ranking of 5 describing: (1) a marked downward trend population trend based on Breeding Bird Surveys of the U.S. Fish and Wildlife Service over the last ten years; (2) only small, local populations remaining; (3) a small breeding range; (4) a small wintering range; (5) high perceived threats to the breeding habitat; and (6) high perceived threats to the wintering grounds. The highest ranking species totaled 28 out of 30 points were the Bachman's, Golden-cheeked, and Kirtland's warblers. The lowest ranked, with 5 points, was the globally-distributed, and very common, House Wren.

Sister Forests.--Each of the four U.S. candidate forests selected for this example were in different ecoregions (Figure 3). For each we tallied the number of breeding bird species occurring in the ecoregion and determined the number of those birds that winter in each Latin American ecoregion. Potential Sister Forest matches were derived by finding ecoregions with a high number of matches in Latin America for each of the U.S. forest candidates.

RESULTS

Example of Breeding and Wintering Ranges

The breeding and wintering range of each of the 150 species was plotted and was the basis of this comparison. An example is that of the Western Tanager (Figure 4), a neotropical migrant of western North America. It breeds typically in the mountain west and winters from the southern tip of Baja California and from southern Mexico down along the western coast of Central America. The Golden-winged Warbler (Figure 5) is a eastern North American migrant, generally found in the forested regions of the northeastern U.S. and southeast Canada, migrating to Central America and northern South America.

Density of Species per Ecoregion

Based on breeding range, the highest number of neotropical migrants occurs in the Eastern Deciduous Forest and Tall-grass Prairie ecoregions, with more than 70 species in each (Figure 6). Substantial numbers of more than 60 species each are found in the Rocky Mountain Forest and Colorado Plateau ecoregions, as well as the eastern U.S. ecoregions of Laurentian Mixed Forest and the Prairie Parkland. Further north, fewer species occur in the harsher boreal and arctic regions, and further south more species are resident.

During the winter season, there is an increased concentration of species from the Mexican Central Plateau through the Central American Mountains and into the Greater Antilles (Figure 7), with more than 80 species in the four ecoregions in those areas. Substantial numbers are also found in the three mountain ecoregions of central Mexico, and the Central American Atlantic Lowlands. Northern South Amer-
ica has relatively few species, as most are intercepted by the rich areas to the north.

Degree of risk to species in each ecoregion. We found a similar distribution when we weighted each species by the degree of perceived risk to the species from population declines, small ranges, or other factors. The areas which had the largest total number of species did not change their relative ranks, either in their breeding (Figure 8) or wintering (Figure 9) grounds when we examined the total weighted number of species.

Breeding Ranges of Migrants Wintering in Latin America

We have compiled the breeding ranges of all species that winter in each of the ecoregions of Latin America. Overall, as other authors have suggested (e.g. Hutto 1986, Carter and Barker 1992), species wintering in Mexico, especially western Mexico, derive from populations in the western United States. Species wintering in northern South America derive from species breeding in the eastern United States and southern Canada. We present a complete listing of the source of all migrants in North America for each of ecoregions in Latin America (Appendix D - on diskette). As a graphic example we present two of the Latin American ecoregions and the areas of origin of the species wintering there.

Central Pacific Coast of Mexico. -- This area of western Mexico, in the states of Sinaloa and Nayarit, derives its breeding birds from much of mountain and intermountain areas of the western United States (Figure 10). Of the 76 species wintering there, the majority of species come from the Rocky Mountains and Sierra Nevada Mountains. Far fewer come from the eastern United States and Canada.

Extremely Moist Forest of Northwestern South America. -- By contrast to the above, of the 37 species of neotropical migrants wintering in this forest area, the great majority come from the eastern United States and southern Canada (Figure 11).

Wintering ranges of North American Migrants

As a reciprocal analysis to the above, we have also compiled the Latin American wintering ranges of all species of neotropical migrants for each North American ecoregion. As before, we present a complete listing of the wintering range of all migrants from Latin America for each of the ecoregions of North America (Appendix D - on diskette). We will also show a representative sample of the ecoregions in North America and the winter distribution of their breeding species.

Intermountain Sagebrush. -- Of the 52 species breeding in this ecoregion, the majority winter in Mexico (Figure 12), with 40 in the Highlands of Central Mexico Ecoregion. Relatively few winter in Central America and fewer still in South America.

Great Plains-Shortgrass Prairie. -- The wintering grounds of the 58 species breeding in this ecoregion (Figure 13) are also largely found wintering in Mexico, although less concentrated there, with more farther south and east. The species are numerous into the Greater Antilles, down into Central America, and in northern South America.

Subarctic Low Forest. -- Thirty-six species breed in this ecoregion, spread across most of Canada. The highest density of wintering species is found in Central America and northern South America (Figure 14), further east and south of the two previous ecoregions.

Eastern Deciduous Forest. -- Of the 71 species breeding here, the highest densities are found in Central America and northwestern South America (Figure 15). In general, the birds of this ecoregion are more widely distributed than those to the north and west.

Sample Candidate Forests

Below we will take up four North American units and evaluate their association with Latin American areas as an example of the way in which the data can be used.

Prescott National Forest, Arizona. -- This forest is located in the Rocky Mountain Forest Ecoregion II (#25) (Figure 3 and Figure 1). A proposed match for this forest is Sierra de Manantlan Biosphere Reserve in Jalisco, Mexico, located primarily in the Highlands of Southern Mexico Ecoregion (#40) and near the Pacific Coast of Southern Mexico Ecoregion (#41). The highland ecoregion contains the highest match for the Prescott in Latin America (Table 3), with 55 species shared. Other ecoregions in central Mexico and northern Central
America have fewer shared species. Weighting this comparison for species at risk, results in the same ordering of Latin American regions.

Appalachian Mountains forests, Virginia and West Virginia.--These forests are in the Eastern Deciduous Forest Ecoregion (#30), and on the boundary of the Southeastern Mixed Forest Ecoregion I (#31). A proposed Sister Forest is in the vicinity of Amistad, Costa Rica, along the Caribbean slope of the country located in the Central American Mountains Ecoregion (#42), and the Central American Atlantic Lowlands ecoregion (#43). Among the highest matches of shared avifauna of the U.S. forests in the Deciduous Forest Ecoregion are these two Latin American ecoregions with 47 and 46 species shared, respectively. Weighting for declining species results in identical matches. These Latin American ecoregions also have high matches with the nearby Southeastern Mixed Forest ecoregion (Table 3).

Mark Twain National Forest, Missouri.--This forest is located in the center of the Eastern Deciduous Forest Ecoregion (#30). The proposed Sister Forest is in the El Cid City of La sphere Reserve in Tamaulipas, Mexico, located in the Sierra Madre Occidental Ecoregion (#34), and near the Central American Atlantic Lowlands Ecoregion (#43). While the latter, nearby ecoregion shares 46 species, a high number, the primary ecoregion shares only 19 species, fairly low in comparison with other ecoregions in Latin America. This is also only a moderate match when the weighted values are used.

Hiawatha and other National Forests, Michigan.--The Hiawatha is located in the Laurentian Mixed Forest Ecoregion (#13). A suggested match is the Sierra de las Minas in Guatemala, located in the Central American Mountains ecoregion, close to the lowland ecoregion matched in other comparisons above. Both these two ecoregions have a high number shared species with 38 species shared. Using the weighted value, the two regions are also quite similar.

DISCUSSION

The data base described here has great value for evaluating opportunities associated with the conservation of migratory neotropical birds. We have attempted to show a few facets of the data base. However, the complexity of the potential uses of the data base precludes a detailed approach for this report. The main value of the data base will be its use in answering a variety of specific questions revolving around questions of biogeography and the declines of certain species.

Of the comparisons made between ecoregions for matches of shared avifauna, the highest values for shared species were the Eastern Deciduous Forests with the Central American Mountains and Lowlands ecoregions. There are, however, other ways of considering these data which may give a different perspective on some of these comparisons. For instance, they could involve limiting the comparisons to species not previously covered by other Sister Forest relationships. We will be glad to assist anyone seeking information or wishing to use the data base.

ACKNOWLEDGMENTS

We are especially grateful to Jim Burchfield for his inspiration and support in putting this complex undertaking together. We also thank J.P. Freetley and Roger G. Satre for their work on early generations of the GIS that this report is based on, as well as the staff and students of the Cornell University Department of Statistics and the Laboratory of Ornithology who supported Butcher in carrying out some of the work in this report.

LITERATURE CITED


Table 1. Ecoregions of North America based on R.G. Bailey, 1976

| 2. Yukon Parkland                 | 25. Rocky Mountain Forest II        |
| 4. Yukon Forest                   | 27. Chihuahuan Desert              |
| 6. Arctic Tundra                  | 29. Prairie Parkland                |
| 7. Subarctic Mountain, Far North  | 30. Eastern Deciduous Forest        |
| Rockies, Mackenzie-Selwyn-Pelly   | 31. Southern Mixed Forest I         |
| 8. Subarctic Low                  | 32. Southern Mixed Forest II        |
| 9. Pacific Forest                 | 33. Central Pacific Coast Mexico,   |
|                                | Sinaloa-Nayarit                     |
| 10. Warm Continental Plateau,     | 34. Sierra Madre Occidental         |
| Fraser Plateau                   | 35. Mexican Highland Shrub Steppe   |
| 11. Columbia Forest I             | 36. Sierra Madre Oriental           |
| 12. Tall-grass Prairie            | 37. Outer Coastal Plain Forest      |
| 13. Laurentian Mixed Forest       | 38. Everglades                      |
| 15. Palouse Grassland             | 40. Highlands of Southern Mexico    |
| 16. Intermountain Sagebrush       | 41. Atlantic Coast of Mexico,       |
| 17. Rocky Mountain Forest I       | Yucatan, Isthmus of Tehuantepec,    |
| 18. Wyoming Basin                 | Pacific Coast of Southern          |
| 19. Columbia Forest II            | Mexico and Central America         |
| 20. Great Plains Short-grass Prairie | 42. Central American Mountains     |
| 21. Sierran Forest                | 43. Central American Lowlands       |
| 22. California Grassland          | 44. California Chaparral            |
| 23. California Chaparral          |                                           |

Table 2. Ecoregions of South America based on UNESCO, 1980

| 44. Extremely Moist Forest | 79. Puna                                      |
| 45. Very Moist Forest     | 80. Grassland with Palms                     |
| 46. Forest/Woodland/Thicket | 81. Swamp Forest             |
| 47. Forest/Woodland/Thicket | 82. Deciduous Forest and "Cerrado"         |
| 48. Forest/Woodland/Thicket | 83. Deciduous Forest and "Cerrado"         |
| 49. Swamp Forest          | 84. Grassland with Woody Species          |
| 50. Grassland with Woody Species | 85. Degraded Formations and Crops   |
| 51. Swamp Forest          | 86. Scrub                                   |
| 52. Extremely Moist Forest | 87. Drought-deciduous Woodland and "Chaco" |
| 53. Flooded Grassland     | 88. Flooded Grassland and "Pantanal"       |
| 54. Seasonal Forest       | 89. Grassland with Woody Species          |
| 55. Paramo                | 90. Grassland with Woody Species          |
| 56. Evergreen Submontane Forest | 91. Crops                  |
| 57. Crops                 | 92. Degraded Formations and Crops          |
| 58. Grassland with Woody Species | 93. Degraded Formations and Crops   |
| 59. Seasonal Forest       | 94. Seasonal Forest                        |
| 60. Ombrophilous Submontane Forest | 95. Deciduous Forest and "Cerrado" |
| 61. Extremely Moist Forest | 96. Grassland with Palms                  |
| 62. Evergreen Submontane Forest | 97. Xeromorphic Forest        |
| 63. Ombrophilous Submontane Forest | 98. Grassland         |
| 64. Grassland with Woody Species | 99. Crops            |
| 65. Deciduous Forest and "Cerrado" | 100. Riparian Thorn Forest |
| 66. Grassland with Woody Species | 101. Evergreen Shrubland       |
| 67. Flooded Grassland      | 102. Subpolar Deciduous Shrubland        |
| 68. Flooded Grassland      | 103. Deciduous Forest                  |
| 69. Extremely Moist Forest | 104. Crops                             |
| 70. Very Moist Forest      | 105. Xeromorphic Woodland              |
| 71. Seasonal Forest        | 106. Semi-deciduous Shrubland           |
| 72. Deciduous Forest and "Cerrado" | 107. Deciduous Scrub     |
| 73. Xeromorphic Forest    | 108. Subpolar Deciduous Shrubland       |
| 74. Deciduous Forest and "Cerrado" | 109. Deciduous Open Shrubland |
| 75. Thorn-forest with Succulents | 110. Tundra                     |
| 76. Seasonal Forest        | 111. Moist/Very Moist Forest            |
| 77. Desert                | 112. Tundra                             |
| 78. Mixed Mountain Forest  |                                           |
Table 3. Number of species in common and weighted species values for potential sister forest units in ecoregions of North and Latin America. Ecoregions are identified by name and number.

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Appendix A. Common and Latin names of neotropical migratory birds species used in this analysis

American Swallow-tailed Kite
Mississippi Kite
Common Black-Hawk
Broad-winged Hawk
Swainson’s Hawk
Zone-tailed Hawk
Merlin
Peregrine Falcon
Mountain Plover
Upland Sandpiper
Long-billed Curlew
Band-tailed Pigeon
White-winged Dove
Black-billed Cuckoo
Yellow-billed Cuckoo
Flammulated Owl
Elk Owl
Burrowing Owl
Lesser Nighthawk
Common Nighthawk
Chuck-will’s-widow
Whip-poor-will
Black Swift
Chimney Swift
Vaux’s Swift
White-throated Swift
Ruby-throated Hummingbird
Black-chinned Hummingbird
Costa’s Hummingbird
Caliope Hummingbird
Broad-tailed Hummingbird
Rufous Hummingbird
Allen’s Hummingbird
Olive-sided Flycatcher
Greater Pewee
Western Wood-Pewee
Eastern Wood-Pewee
Yellow-bellied Flycatcher
Acadian Flycatcher
Alder Flycatcher
Willow Flycatcher
Least Flycatcher
Hammond’s Flycatcher
Dusky Flycatcher
Gray Flycatcher
Pacific-slope Flycatcher
Cordilleran Flycatcher
Buff-breasted Flycatcher
Vermilion Flycatcher
Ash-throated Flycatcher
Great Crested Flycatcher
Cassin’s Kingbird
Western Kingbird
Eastern Kingbird
Scissor-tailed Flycatcher
Purple Martin
Violet-green Swallow
Northern Rough-winged Swallow
Bank Swallow
Cliff Swallow
Cave Swallow
Barn Swallow
House Wren
Blancoides forficatus
Ictinia mississippiensis
Buteo regalis
Buteo platypterus
Buteo swainsoni
Buteo albonotatus
Falco columbarius
Falco peregrinus
Charadrius montanus
Bartramia longicauda
Numenius americanus
Columba fasciata
Zenaida asiatica
Coccyzus erythropthalmus
Coccyzus americanus
Oreus flammolus
Micrathene whitneyi
Athene cunicularia
Chordeiles acutipennis
Chordeiles minor
Caprimulgus carolinensis
Caprimulgus vociferus
Cypseloides niger
Chaetura pelagica
Chaetura vauxi
Aerodramus saxatalis
Archilochus colubris
Archilochus alexandri
Calypte costae
Stellula calliope
Selasphorus platycercus
Selasphorus rufus
Selasphorus sasin
Contopus borealis
Contopus pertinax
Contopus sordidulus
Contopus virens
Empidonax flaviventris
Empidonax virescens
Empidonax alnorum
Empidonax traillii
Empidonax minimus
Empidonax hammondii
Empidonax oberholseri
Empidonax wrightii
Empidonax difficilis
Empidonax occidentalis
Empidonax fulvifrons
Pyrocephalus rubinus
Myiarchus cinerascens
Myiarchus crinitus
Tyrannus vociferans
Tyrannus verticalis
Tyrannus tyrannus
Tyrannus forficatus
Progne subis
Tachycineta thalassina
Steigidopteryx serripennis
Riparia riparia
Hirundo pyrrhomena
Hirundo fulva
Hirundo rustica
Troglodytes aedon
Blue-gray Gnatcatcher
Veery
Gray-cheeked Thrush
Swainson's Thrush
Wood Thrush
Gray Catbird
Phainopepla
White-eyed Vireo
Bell's Vireo
Black-capped Vireo
Gray Vireo
Solitary Vireo
Yellow-throated Vireo
Warbling Vireo
Philadelphia Vireo
Red-eyed Vireo
Bachman's Warbler
Blue-winged Warbler
Golden-winged Warbler
Tennessee Warbler
Orange-crowned Warbler
Nashville Warbler
Virginia's Warbler
Lucy's Warbler
Northern Parula
Yellow Warbler
Chestnut-sided Warbler
Magnolia Warbler
Cape May Warbler
Black-throated Blue Warbler
Black-throated Gray Warbler
Townsend's Warbler
Hermit Warbler
Black-throated Green Warbler
Golden-cheeked Warbler
Blackburnian Warbler
Yellow-throated Warbler
Grace's Warbler
Kirtland's Warbler
Prairie Warbler
Palm Warbler
Bay-breasted Warbler
Blackpoll Warbler
Cerulean Warbler
Black-and-white Warbler
American Redstart
Prothonotary Warbler
Worm-eating Warbler
Swainson's Warbler
Ovenbird
Northern Waterthrush
Louisiana Waterthrush
Kentucky Warbler
Connecticut Warbler
Mourning Warbler
MacGillivray's Warbler
Common Yellowthroat
Hooded Warbler
Wilson's Warbler
Canada Warbler
Red-faced Warbler
Painted Redstart
Yellow-breasted Chat
Olive Warbler
Hepatic Tanager
Summer Tanager
Polioptila caerulea
Catharus fuscescens
Catharus minimus
Catharus ustulatus
Hylocichla mustelina
Dumetella carolinensis
Phainopepla nitens
Vireo griseus
Vireo bellii
Vireo atricapillus
Vireo vicinior
Vireo solitarius
Vireo flavifrons
Vireo gilvus
Vireo philadelphicus
Vireo olivaceus
Vermivora bachmani
Vermivora pinus
Vermivora chrysoptera
Vermivora peregrina
Vermivora celata
Vermivora ruficapilla
Vermivora virginiae
Vermivora luciae
Parula americana
Dendroica petechia
Dendroica pensylvanica
Dendroica magnolia
Dendroica tigrina
Dendroica caerulescens
Dendroica nigrescens
Dendroica townsendi
Dendroica occidentalis
Dendroica virens
Dendroica chrysoparia
Dendroica fusca
Dendroica dominica
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Dendroica kirtlandii
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Mniotilta varia
Setophaga ruticilla
Protonotaria citrea
Helmitheros vermivorus
Limnothlypis swainsonii
Seiurus aurocapillus
Seiurus noveboracensis
Seiurus motacilla
Oporornis formosus
Oporornis agilis
Oporornis philadelphia
Oporornis olivaceus
Geothlypis trichas
Wilsonia citrina
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<td>Grasshopper Sparrow</td>
<td>Ammodramus savannarum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lincoln's Sparrow</td>
<td>Melospiza lincolnii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bobolink</td>
<td>Dolichonyx oryxivorus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow-headed Blackbird</td>
<td>Xanthocephalus xanthocephalus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronzed Cowbird</td>
<td>Molothrus aeneus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orchard Oriole</td>
<td>Icterus spurius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hooded Oriole</td>
<td>Icterus cucullatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Oriole</td>
<td>Icterus galbula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scott's Oriole</td>
<td>Icterus parisorum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix B. Short-term (10-year) and long-term (26-year) priority ranking for each species from the Colorado Bird Observatory (Sample of complete data set from diskette)

<table>
<thead>
<tr>
<th>Bird</th>
<th>Species</th>
<th>10-year</th>
<th>26-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Swallow-tailed Kite</td>
<td></td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Mississippi Kite</td>
<td></td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Common Black-Hawk</td>
<td></td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Broad-winged Hawk</td>
<td></td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Swainson's Hawk</td>
<td></td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Zone-tailed Hawk</td>
<td></td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Merlin</td>
<td></td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scott's Oriole</td>
<td></td>
<td>19</td>
<td>17</td>
</tr>
</tbody>
</table>
Appendix C. Breeding species present (with at least 25% overlap) in each ecoregion (Sample of complete data set from diskette)

0 indicates absence  
1 indicates presence

<table>
<thead>
<tr>
<th>Bird</th>
<th>Breeding Ecoregion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 ... 43</td>
</tr>
<tr>
<td>American Swallow-tailed Kite</td>
<td>0 0 0 0 0 0 0 1</td>
</tr>
<tr>
<td>Mississippi Kite</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Common Black-Hawk</td>
<td>0 0 0 0 0 1 0 0</td>
</tr>
<tr>
<td>Broad-winged Hawk</td>
<td>0 0 0 1 1 0 0 0</td>
</tr>
<tr>
<td>Swainson's Hawk</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Zone-tailed Hawk</td>
<td>1 1 1 1 1 1 1 0</td>
</tr>
<tr>
<td>Merlin</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

Appendix D. Wintering species present (with at least 25% overlap) in each ecoregion (Sample of complete data set from diskette)

0 indicates absence  
1 indicates presence

<table>
<thead>
<tr>
<th>Bird</th>
<th>Wintering Ecoregion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21 22 23 24 25 26 27 ... 112</td>
</tr>
<tr>
<td>American Swallow-tailed Kite</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Mississippi Kite</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Common Black-Hawk</td>
<td>0 0 0 1 0 0 0 0</td>
</tr>
<tr>
<td>Broad-winged Hawk</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Swainson's Hawk</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Zone-tailed Hawk</td>
<td>1 1 1 1 1 1 1 0</td>
</tr>
<tr>
<td>Merlin</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

Appendix E. Number of species in common between breeding and wintering ranges by ecoregion (Sample of complete data set from diskette)

<table>
<thead>
<tr>
<th>Breeding Ecoregion</th>
<th>Wintering Ecoregion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21 22 23 24 25 26 27 ... 112</td>
</tr>
<tr>
<td>1</td>
<td>4 5 4 4 4 5 2</td>
</tr>
<tr>
<td>2</td>
<td>4 5 6 4 4 6 2</td>
</tr>
<tr>
<td>3</td>
<td>5 6 8 6 5 9 3</td>
</tr>
<tr>
<td>4</td>
<td>5 5 8 6 5 8 3</td>
</tr>
<tr>
<td>5</td>
<td>4 4 4 4 4 4 2</td>
</tr>
<tr>
<td>6</td>
<td>2 2 2 2 2 2 1</td>
</tr>
<tr>
<td>7</td>
<td>5 5 8 9 5 4 2</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>43</td>
<td>3 2 7 12 7 4 13 0</td>
</tr>
</tbody>
</table>
Ecoregions of North and Central America

Figure 1
Ecoregions of South America

Figure 2
Locations of Potential Sister Forest Pairings
Between the US and Mexico

Figure 3
Breeding and Wintering Ranges of the Western Tanager
Breeding and Wintering Ranges of the Golden-winged Warbler

breeding range
wintering range

Figure 5
Density of Species per Ecoregion in the Breeding Ranges of Neotropical Migrants

Number of Species

- 0 - 15
- 16 - 30
- 31 - 45
- 46 - 60
- 61 - 75

Figure 6
Density of Species per Ecoregion in the Wintering Ranges of Neotropical Migrants

Number of Species

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

Figure 7
Weighted Density of Species per Ecoregion in the Breeding Ranges of Neotropical Migrants

Weighted Number of Species

- 1 - 300
- 301 - 600
- 601 - 900
- 901 - 1200
- > 1201

Figure 8
Weighted Density of Species per Ecoregion in the Wintering Ranges of Neotropical Migrants

Weighted Number of Species

- 1 - 300
- 301 - 600
- 601 - 900
- 901 - 1200
- > 1201

Figure 9
Breeding Ranges of Neotropical Migrants That Winter in Latin America

Wintering Ecoregion:
Central Pacific Coast of Mexico
Total Species = 76

Number of Species
- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 +

Figure 10
Breeding Ranges of Neotropical Migrants That Winter in Latin America

Wintering Ecoregion:
Extremely Moist Forest of Northwestern South America
Total Species = 37

Number of Species

- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

Figure 11
Wintering Ranges of Neotropical Migrants That Breed in North America

Breeding Ecoregion:
Intermountain Sagebrush
Total Species = 52

Number of Species

- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 +

Figure 12
Wintering Ranges of Neotropical Migrants That Breed in North America

Breeding Ecoregion:
Great Plains Short-Grass Prairie
Total Species = 58

Number of Species

- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 +

Figure 13
Wintering Ranges of Neotropical Migrants That Breed in North America

Breeding Ecoregion:
Subarctic Low
Total Species = 36

Number of Species
- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

Figure 14
Wintering Ranges of Neotropical Migrants That Breed in North America

Breeding Ecoregion:
Eastern Deciduous Forest
Total Species = 71

Number of Species

- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 +

Figure 15