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Habitat mapping for bird conservation in North America

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Summary

In view of the continuing appropriation and conversion of natural land areas in North America for human uses, there is growing concern about the impacts of changing land use on terrestrial bird species. In order to promote conservation of critical remaining habitats for birds, Partners in Flight (PIF) initiated a project in 1997 in which bird conservation plans were prepared by members in each of 60 ecologically defined physiographical areas throughout the United States. Accurate, nationwide information on the location and extent of vegetative cover types, as well as lands under state and federal management, are critically important elements in the creation of effective bird conservation plans. The National Fish and Wildlife Foundation (NFWF) awarded a challenge grant to The Nature Conservancy's (TNC) Wings of the Americas Program to assist Partners in Flight in acquiring land cover data to serve as the foundation of the planning effort. Canon U.S.A., Inc. and the American Bird Conservancy also contributed support toward this goal. The Center for Advanced Spatial Technology at the University of Arkansas was contracted to produce the needed land cover maps and associated tabular products. Digital land cover databases created by the U.S. Forest Service, the U.S. Geological Survey, the Canada Centre for Remote Sensing, the University of California-Santa Barbara Department of Geography, and the U.S. Department of Transportation, Bureau of Transportation Statistics were used in this project. The final spatial products were produced during 1998–1999 and are described in this paper. This effort represents the first nationwide habitat mapping project in the United States aimed at supporting and enhancing conservation of terrestrial bird species.

Introduction

Populations of terrestrial birds in North America face a range of problems related to both land management practices focused on non-wildlife priorities and to adverse impacts of introduced species. Declines in some breeding bird populations may be due to reduced nesting productivity and higher predation rates. In turn these may be due to conversion of native forests to short-rotation pine plantations, conversion of lowland forests and native grasslands to row-crop agriculture (Robbins *et al.* 1992), loss of habitat to urbanization (Harris and Scheck 1991, Robinson 1997), overgrazing of grasslands (Herkert 1991, Martin 1993), increased rates of brood parasitism by Brown-headed Cowbird *Molothrus ater* in increasingly fragmented forests (DellaSala *et al.* 1995, Pashley 1995), and higher nest predation rates in fragmented, disturbed forests (Martin 1993, Robinson 1993, Martin *et al.* 1996). Evidence suggests that declines in forest bird populations occurring in North America are a result of the decline or disappear-

ance of birds from fragmented, smaller forest patches; breeding populations in large, unbroken native forest tracts have remained fairly stable over the past 50 years (Terborgh 1989, Askins *et al.* 1990). Conversion of native prairies to grazing and agricultural uses in the northeast and midwest has caused dramatic declines in grassland bird species, primarily through destruction of breeding habitats (Askins 1993).

Conservation and restoration of large, contiguous native forests, as well as protection and enlargement of remaining grassland prairies, may be vital to stopping and reversing population declines (Robbins *et al.* 1989, Robinson *et al.* 1995, Fahrig 1997, Robinson 1997). In areas where no large, unbroken native habitats remain, identification, protection and establishment of linkages between isolated reserves is of the highest priority (Harris and Scheck 1991). Protection or restoration of habitable corridors connecting adjacent, insular reserves may promote persistence of species dependent upon those habitats (Harris and Scheck 1991, Noss 1993, Walker and Craighead 2001). The first step in any habitat conservation effort must be an inventory of land cover types in a region of interest.

The National Fish and Wildlife Foundation (NFWF), along with associated organizations and agencies, initiated Partners in Flight (PIF) in 1990 for the purpose of combining the efforts of concerned citizens and natural resource professionals toward conservation of birds in the Western Hemisphere. PIF is an international effort comprised of avian conservationists from widely diverse backgrounds, including individual volunteers from state and federal natural resource agencies, conservation organizations, and natural resource industries. PIF sets conservation priorities through state and regional working groups, whose members work toward implementation of agreed-upon conservation objectives within their respective professional organizations. In 1995 PIF was able to hire four full-time regional coordinators to oversee the completion of bird habitat conservation plans for each of 60 physiographical areas in the United States. The aim in creating PIF physiographical areas was to define ecoregions for bird conservation based on broad vegetation and landscape types at a scale that will lend itself to efficient management by local and regional cooperators. These ecologically defined physiographical areas are considered to be more suitable for bird habitat conservation efforts than are regions based on political boundaries (Pashley 1995). The conservation plans will form a groundwork upon which bird conservation efforts in the physiographical areas may be based.

To address the need for a consistent, nationwide set of spatial data products describing major habitat types that will form the foundation for bird conservation plans in each physiographical area, NFWF awarded a challenge grant to The Nature Conservancy-Wings of the Americas Program (TNC). The Wings of the Americas Program was directed to acquire the needed land cover data. With additional support from Canon U.S.A., Inc. and the American Bird Conservancy, TNC entered into a working partnership with the Center for Advanced Spatial Technology (CAST) at the University of Arkansas in 1997. CAST was contracted to produce a set of land cover and land use maps, with summary tabular data, for each of the 60 PIF physiographical areas in the United States. These spatial data products were produced from the most recent and best available digital land cover databases covering the conterminous United States and parts of Canada. The primary purposes served by these map products were (1) to aid in

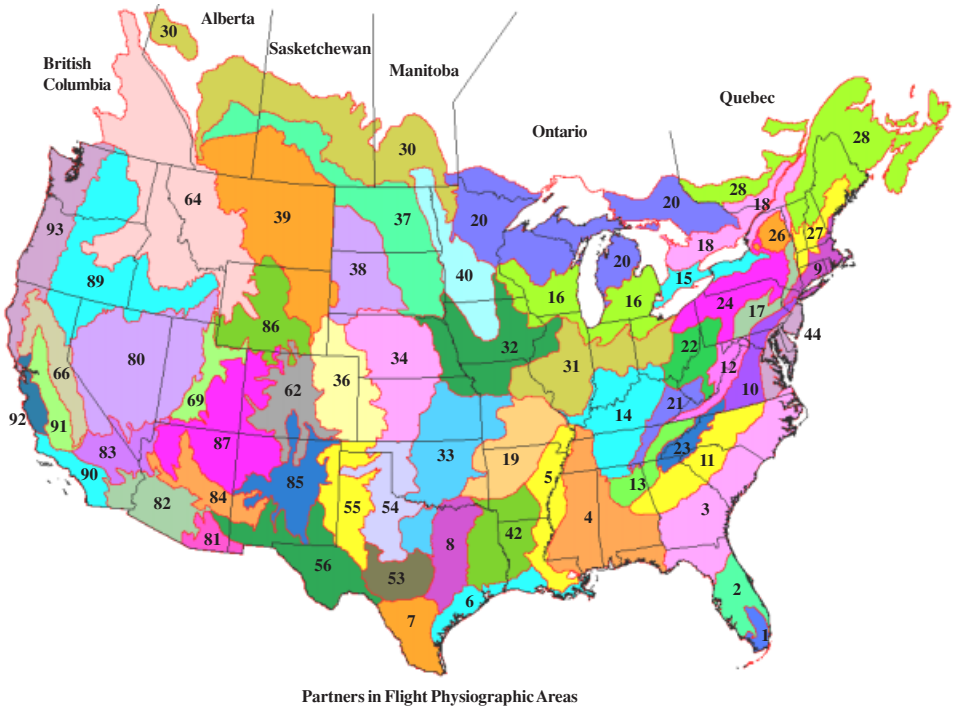

Figure 1. Partners in Flight physiographical areas in the United States, including those overlapping into Canada, for which sets of land cover and land use products were created in this project.

the identification of large tracts of major land cover habitat types, which could then receive focused conservation attention; (2) to provide illustration, clarification and explicit spatial data on each habitat type discussed in the 60 Physiographic Area Bird Habitat Conservation Plans; and (3) to identify and map as completely as possible the diversity of lands under state and federal ownership.

This paper describes that habitat mapping project, provides examples of sample mapset products and access information for the full suite of data supplied to TNC and PIF at project completion in July 1999, and finally, includes excerpts from a sample habitat analysis from the West Gulf Coastal Plain Bird Habitat Conservation Plan, illustrating the way in which these mapsets will be used in the PIF conservation effort. This effort represents the first such project in which a nationwide set of land cover maps, and other spatial data resources, has been produced to enhance conservation efforts directed toward land birds in the United States.

Production of the national mapset collection.

In this project, eight map products were created for each of the 60 PIF physiographical areas in the conterminous United States, including those areas which partially overlap into Canada (Figure 1, Table 1). The primary geographical information system (GIS) software employed was GRASS (Geographic Resources

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Table 1. Identification of the 60 Partners in Flight physiographical areas depicted in Figure 1

Area no.	Physiographical area name	Area no.	Physiographical area name
1	Subtropical Florida	33	Osage Plains
2	Peninsular Florida	34	Central Mixed Grass Prairie
3	South Atlantic Coastal Plain	36	Central Shortgrass Prairie
4	East Gulf Coastal Plain	37	Norther Mixed Grass Prairie
5	Mississippi Alluvial Plain	38	Glaciated Missouri Plateau
6	Coastal Prairies	39	Northern Shortgrass Prairie
7	South Texas Brushlands	40	Northern Tallgrass Prairie
8	Oaks and Prairies	42	West Gulf Coastal Plain
9	Southern New England	44	Mid Atlantic Coastal Plain
10	Mid Atlantic Piedmont	53	Edwards Plateau
11	Southern Piedmont	54	Rolling Red Plains
12	Mid Atlantic Ridge and Valley	55	Pecos and Staked Plains
13	Southern Ridge and Valley	56	Chihuahuan Desert
14	Interior Low Plateaus	62	Southern Rocky Mountains
15	Lower Great Lakes Plain	64	Central Rocky Mountains
16	Upper Great Lakes Plain	66	Sierra Nevada
17	Northern Piedmont	69	Utah Mountains
18	St Lawrence Plain	80	Basin and Range
19	Ozark–Ouachita Plateau	81	Mexican Highlands
20	Boreal Hardwood Transition	82	Sonoran Desert
21	Northern Cumberland Plateau	83	Mohave Desert
22	Ohio Hills	84	Mogollon Rim
23	Southern Blue Ridge	85	New Mexico Mesa and Plains
24	Allegheny Plateau	86	Wyoming Basin
26	Adirondack Mountains	87	Colorado Plateau
27	Northern New England	89	Columbia Plateau
28	Eastern Spruce-Hardwood	90	Southern California Ranges
30	Aspen Parklands	91	Central Valley
31	Prairie Peninsula	92	California Foothills
32	Dissected Till Plains	93	Southern Pacific Rainforests

Analysis Support System, U.S. Army Corps of Engineers 1993). All land cover databases used in this project were created during the period 1990–1997. Current vegetative cover may be different from that depicted here due to landscape alterations since the imagery used here was acquired. Examples of spatial data products provided in the major categories below are taken from the West Gulf Coastal Plain physiographical area. The example showing Canadian land cover is taken from the Central Rocky Mountains physiographical area.

Forest cover types

Two primary digital land cover databases were used in this project: (1) the 1993 USFS Forest Inventory and Analysis (USFS FIA) Forest Types database, produced under the Forest and Rangeland Renewable Resources Planning Act (RPA) Assessment Update Program (1993, see Resources), and (2) the United States Geological Survey (USGS) Land Cover Characteristics Data Set (Loveland *et al.* 1991). In their standard format, neither of these databases is ideally suited for use by PIF conservation plan authors, however. The USFS FIA database describes

only forest types; all other cover types are combined under the category ''non-forest''. The USGS Land Cover database described all cover types but contains 159 land cover categories. Some categories contain a collection of several vegetation types and other groups of categories have identical descriptors. In order to provide conservation plan authors with land cover data that they could more efficiently analyse, some modification and manipulation of the original classifications was required.

Both the USFS FIA and USGS land cover databases used in this project report forest coverage. The two databases do not agree on the extent of forest coverage, however. The USGS database generally describes a higher proportion of land cover as forest, compared with the USFS FIA system. After consultation with a group of experienced field biologists and foresters familiar with local forest cover conditions in several regions of the eastern United States, we decided to use the USFS FIA forest database as the authority for forest types and coverage in this mapping project. The USFS FIA database was derived from Advanced Very High Resolution Radiometer (AVHRR) satellite imagery at a resolution of 1 km^2 with use of multi-temporal, multi-source remote sensing data analysis (Zhu and Evans 1994).

Data on urban area coverage throughout the United States were obtained from the 1990 Conterminous U.S. Land Cover Characteristics Data Set (Loveland *et al.* 1991), a USGS product at a resolution of 1 km^2. A mask of each physiographical area was created with urban habitats removed. Into this resulting mask were projected forest type data from the USFS FIA database.

In addition to the USFS FIA Forest Types database, a second product of the 1993 RPA program is the USFS FIA Percent Forest Cover map. In this database pixels having $> 25\%$ forest canopy cover were classified as forest; those with $\leqslant 25\%$ forest canopy cover, non-forest (Zhu and Evans 1994). This forest assignment criterion is also used by the USDA Soil Conservation Service (Zhu and Evans 1994). Review of initial classification results by the USFS FIA, regional Forest Service offices, and other cooperators, resulted in modification of criteria for forest classification in areas of high forest fragmentation (Zhu and Evans 1994). Zhu and Evans (1994) found that a predicted forest canopy cover of $\geqslant 40\%$ appeared to more closely match ground reference data in highly developed or urbanized regions; therefore, the $\geqslant 40\%$ cover criterion was used as the criterion for forest category assignment in many such areas, primarily east of the Mississippi River.

The USFS FIA Forest Types database identifies 24 different land cover categories, including a ''non-forest'' category (Appendix 1), with the aid of such references as: USFS FIA publications, regional forest type maps, regional and local vegetation studies, and Landsat images (Zhu and Evans 1994). Those land cover category designations were used in maps produced in this project (Figure 2).

Non-forest cover types

A GIS mask layer was created for areas labelled ''non-forest'' in the USFS FIA database. Into those areas we projected land cover data modified from the Land Cover Characteristics Data Set (Loveland *et al.* 1991). This nationwide data set is comprised of 159 categories of vegetation cover types based on AVHRR imagery

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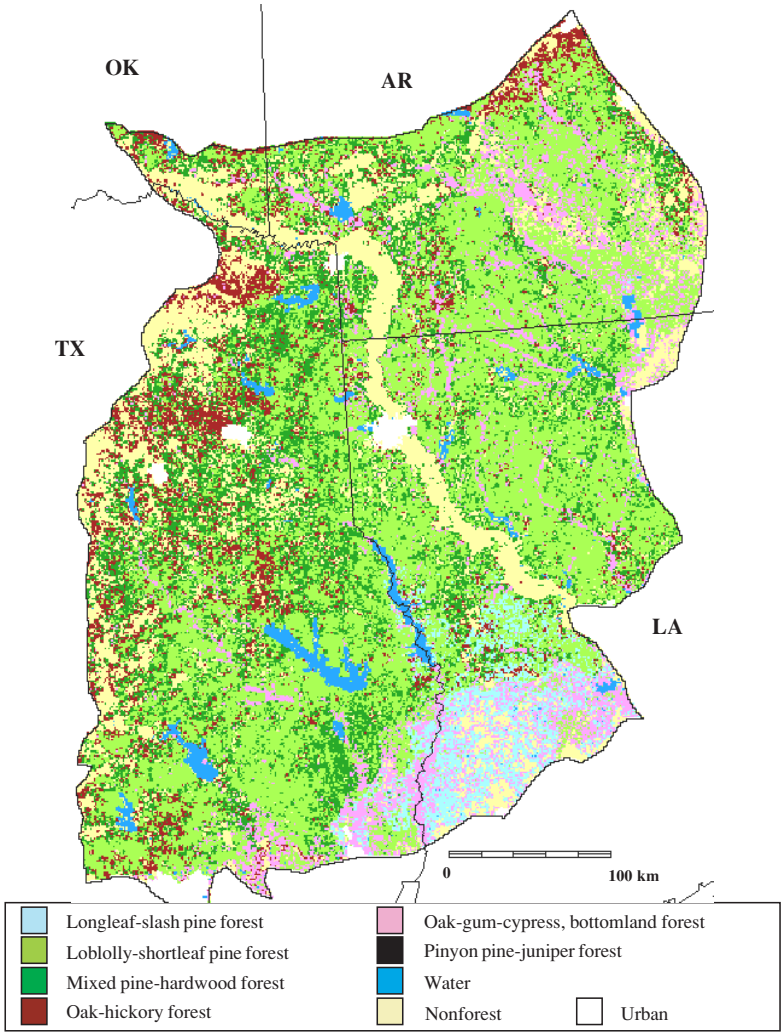

Figure 2. Forest types in the West Gulf Coastal Plain, Physiographical Area 42.

at 1 km^2 resolution. Cover categories describe forest types as well as grassland and shrubland cover types. By combining similar habitat types we created a new database containing 29 different vegetation types, including forest, shrub and grassland coverage (Appendix 2).

Since the USFS FIA and USGS coverage do not coincide precisely in land cover type estimates, the USGS vegetation cover map often contained some pixels classified as a forest type within the area labelled ''non-forest'' in the USFS FIA database. In the USGS database category system a particular cover type may contain several vegetation types in order of their relative frequency of occurrence in a pixel. For example, one land cover type is labelled ''oak-hickory forest, bluestem grassland, irrigated crops''. In the new database condensing the 159 original categories to 29, we used the first category label as the descriptor for that

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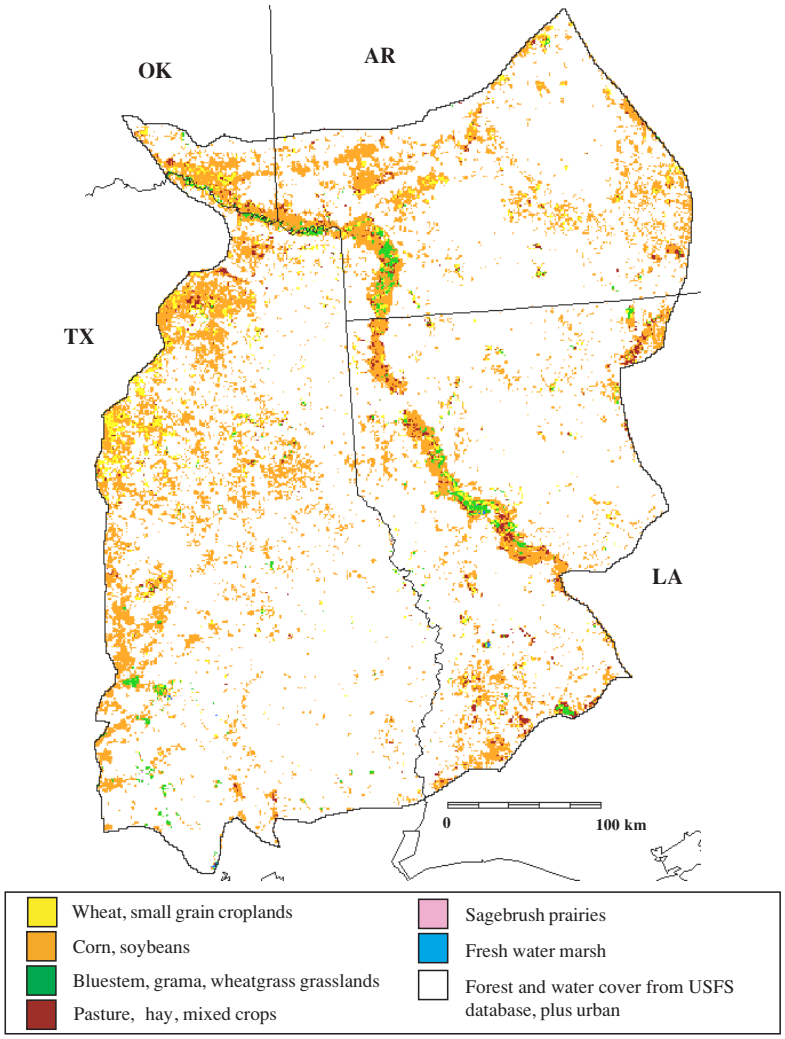

Figure 3. Non-forest cover types in the West Gulf Coastal Plain, Physiographical Area 42; data are shown only in the areas labelled ''non-forest'' in the USFS FIA Forest Types database (Figure 2). Cover types are modified from the USGS Land Cover Characteristics Data Set (Loveland *et al.* 1991) (Appendix 2).

type (''oak-hickory forest'' in the above example). For consistency of classification when mapping areas in the Midwest, South-east, and North-east regions of PIF, we reclassified any USGS forest types appearing in the non-forest area to the next non-forest cover type listed in the category label. In the example above, ''oak-hickory forest'' was reclassified to ''bluestem grassland'' (Figure 3).

In the Western PIF region (generally including west Texas, western Oklahoma, Colorado, Wyoming, Montana, and states farther west) concern for underestimating forest coverage in the more open forests was addressed by adding any additional forest encountered in the USGS database in the ''non-forest'' portion

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of the USFS FIA map to the forest coverage already documented in the USFS FIA forest map. For example, additional ponderosa pine forest coverage in the USGS database occurring in the non-forest portion was added to any ponderosa pine forest coverage shown in the USFS FIA Forest Types database, in the summary data table, and in the individual map of ponderosa pine forest cover in that physiographical area.

Cover types for portions of physiographical areas overlapping into Canada were taken from the database Land Cover of Canada 1995 version 1.1 (Canada Centre for Remote Sensing 1998). This database is derived from AVHRR imagery at a 1 km^2 resolution. We re-projected the data to the Lambert Equal Area Projection in order to conform to other U.S. databases (Figure 4).

A summary report was produced for each physiographical area showing total areal coverage of all land cover types in the physiographical area, as well as total coverage and percentage of area taken by each listed forest and non-forest vegetation type, by water, urban and any unclassified areas (Table 2).

Each forest and non-forest vegetation type was mapped individually in order to provide the clearest illustration of estimated location and extent of that habitat type in the physiographical area (Figure 5). The Managed Areas Database, created by the University of California-Santa Barbara, Department of Geography, is a 1 km^2 resolution, national coverage map showing lands managed by state and federal agencies, as well as some private reserves. These data were used to create a map of managed lands in each of the 60 areas (Figure 6).

A table was produced for each physiographical area showing areal coverage, and percentage of total, covered by each ownership category in the Managed Areas Database (see Resources below). For each physiographical area, a map of major roads was created to aid in orientation and location of habitat areas of interest. Road data were taken from the U.S. Department of Transportation, Bureau of Transportation Statistics sources (USDOT BTS 1999). The extent of each physiographical area was mapped on a state outline background at a regional scale to provide orientation for the physiographical area among nearby states (Figure 7).

Mapsets containing the above products were created for each of the 60 PIF physiographical areas and were supplied to the PIF regional coordinators during 1998 and 1999 as aids in writing bird conservation plans for each area. To provide universal access to these products for all interested parties, these maps and tables were also saved in several standard electronic formats (GeoTIFF, PDF, and GIF) and a web site created at which all documents could be retrieved (see Resources below). GeoTIFF versions are suitable for importing into a GIS for manipulation of habitat coverage data. PDF files are best for online viewing or printing. GIF files are readily read in most computer operating systems and are suitable for electronic transfer of images.

Example of the use of these mapset products for habitat analysis and conservation planning in the West Gulf Coastal Plain physiographical area.

The bird habitat conservation process initiated by PIF involves two principal stages of investigation, which culminate in a conservation plan tailored specific-

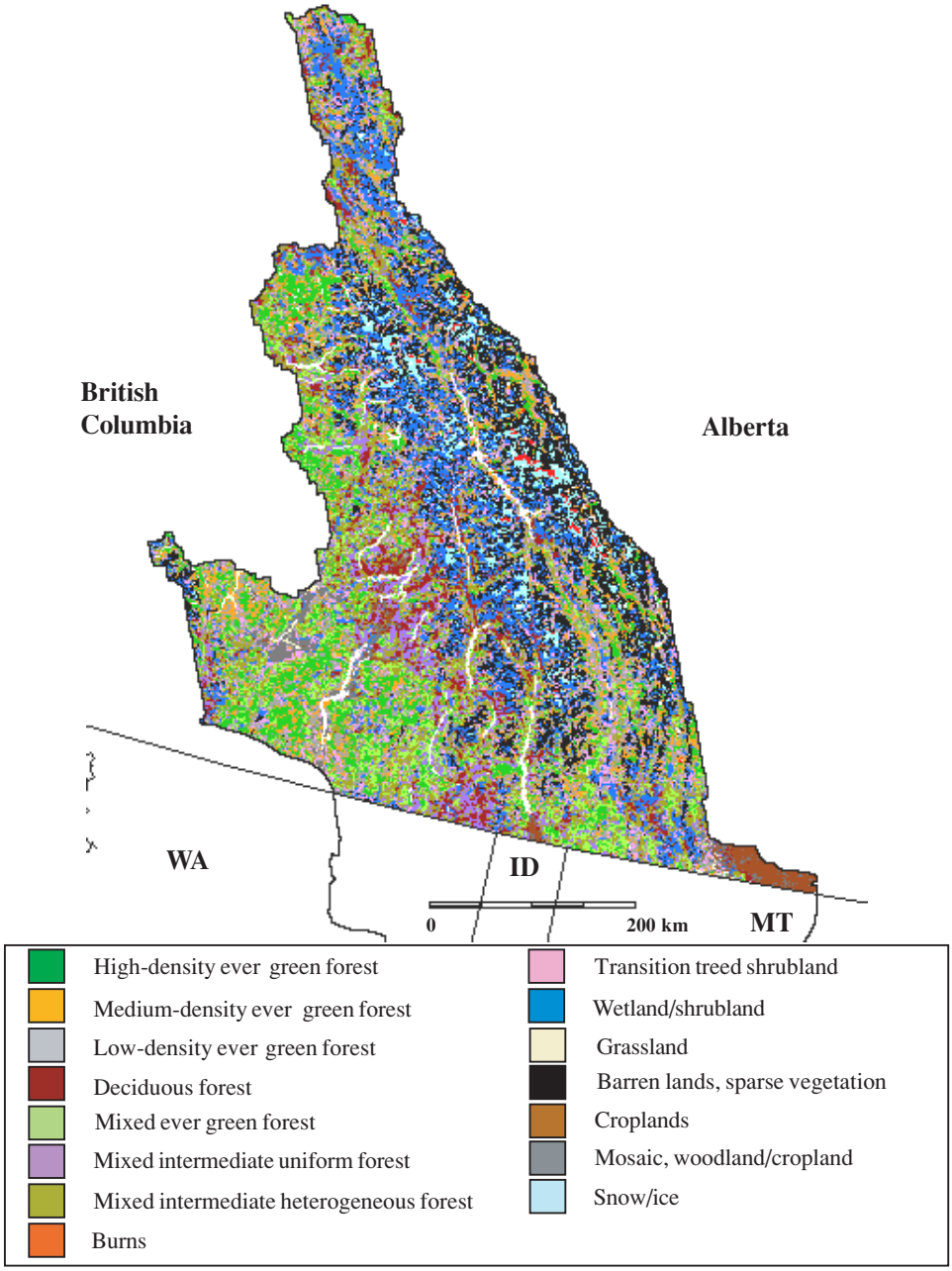

Figure 4. Land cover types in the Canadian portion of The Central Rocky Mountains, Physiographical Area 64. Data are taken from Land Cover of Canada 1995 Version 1.1 (Canada Centre for Remote Sensing 1998).

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Table 2. Areas of vegetative cover types in West Gulf Coastal Plain, physiographical area 42. Forest coverages are taken from USFS FIA data, non-forest cover types are modified from USGS data. Water coverage is combined from both databases by adding USGS water in the 'non-forest' section of the USFS database

Cover types	Area (ha)	Area (acres)	Percentage of Total
Longleaf–slash pine forest	529,079	1,307,355	3.52
Loblolly–shortleaf pine forest	5,970,510	14,753,130	39.73
Oak–pine forest	2,781,101	6,872,099	18.51
Oak–hickory forest	1,237,770	3,058,531	8.24
Oak–gum–cypress forest	1,383,033	3,417,475	9.20
Pinyon pine–juniper forest	896	2,214	0.01
Wheat, small grain crops	282,859	698,945	1.88
Corn, soybeans, irrigated agriculture	2,079,180	5,137,653	13.84
Bluestem, grama, wheatgrass grassland	110,515	273,083	0.73
Pasture, hay, mixed crops	149,843	370,261	1.00
Sagebrush prairie	797	1,968	0.01
Freshwater marsh	2,290	5,658	0.02
Water	343,095	847,788	2.28
Urban	154,622	382,071	1.03
No data	298	736	0.00
Totals	15,025,888	37,128,969	100

ally to the species at risk and major land cover types in a given physiographical area.

Identification of species at risk in each physiographical area.

The PIF prioritization process was developed to prioritize inventory, monitoring, management and research actions among diverse birds and habitats (Hunter *et al.* 1993, Carter *et al.* 2000). The system ranks each species based on seven measures of conservation vulnerability: (1) relative abundance, (2) and (3) size of breeding and non-breeding ranges, respectively, (4) and (5) threats during breeding and non-breeding seasons, respectively, (6) population trend, and (7) relative density. In addition, Rosenburg and Wells (1995) have provided the percentage of a species' global breeding population that occurs in each physiographical region. To further refine species prioritization within a physiographical area, population trend and area importance are examined independently of total scores.

Identification of the location and coverage of major habitat types

The creation of maps identifying the major habitat types in each physiograhical area in the United States, with accompanying tabular summary data, was the goal of the project described in this paper. Using these mapsets, an individual or group within PIF is authorized by one of four regional coordinators to draft the Bird Habitat Conservation Plan for each physiographical area. The Conservation Plan presents a prescribed set of analyses and discussions for each major habitat type found in the physiographical area, including: (1) information on the status and importance of a given habitat to birds of concern in the

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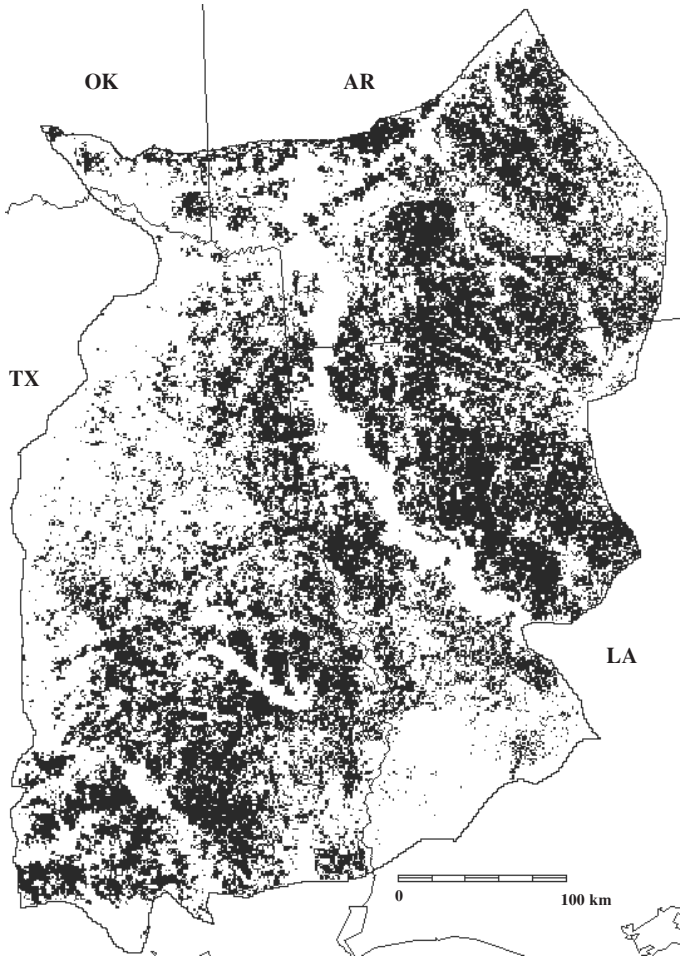

Figure 5. Loblolly-shortleaf pine forest in the West Gulf Coastal Plain, Physiographical Area 42, covering 5,970,510 ha or 39.73% of the area.

physiographical area; (2) a discussion of priority bird species and their known habitat requirements for nesting and foraging; (3) objectives for conservation of each major habitat type in areas large enough to permit the probable persistence of populations of birds of concern; (4) recommendations for specific conservation actions or programmes to bring about identified habitat conservation objectives; and (5) an evaluation of assumptions on which the preceding recommendations and actions are based.

In 1998 one of us (JFT) was contracted to lead the effort to prepare the draft Bird Habitat Conservation Plan for the West Gulf Coastal Plain (WGCP) physiographical area (Taulman *et al.* 1998). A portion of that plan follows, a sample analysis of the oak/hickory forest type. This example will serve to illustrate the ways in which the map products presented in this paper are being used by PIF to analyse habitat requirements of birds of concern, to determine the availability of habitats deemed valuable for conservation, and to make recommendations for

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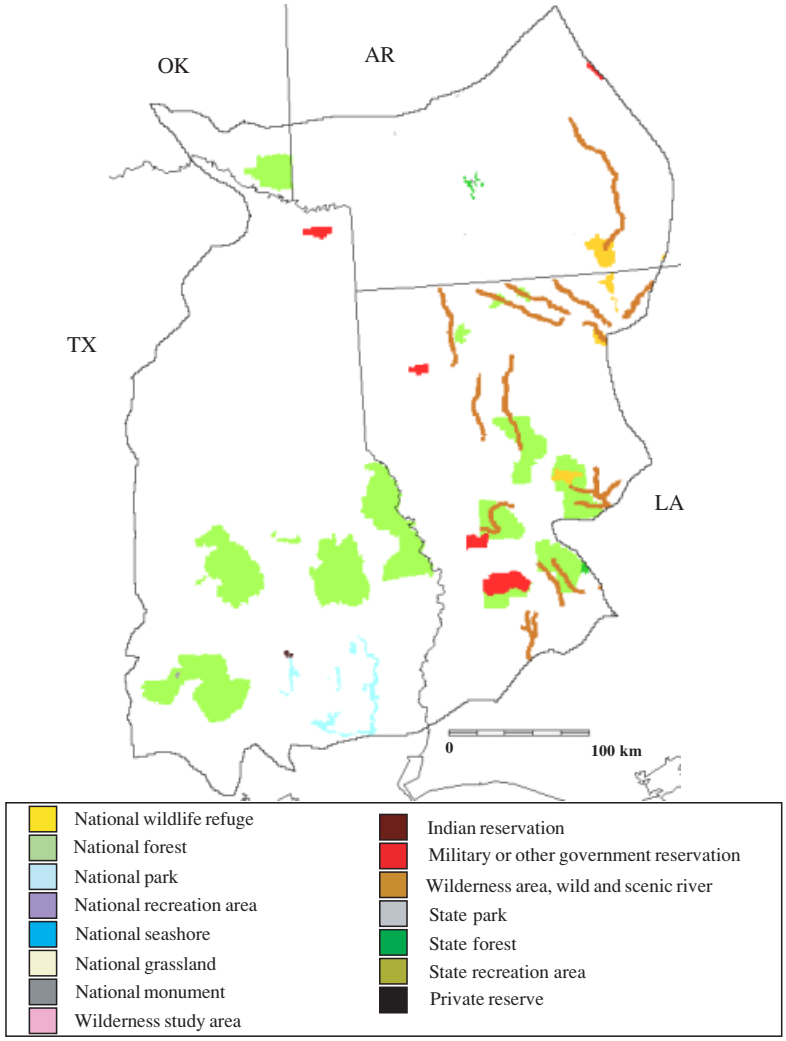

Figure 6. Managed lands in the West Gulf Coastal Plain, Physiographical Area 42. Data from the Managed Areas Database, created by the University of California-Santa Barbara, Department of Geography.

habitat conservation measures to benefit birds of concern in each physiographical area. We will briefly discuss (a) the prioritization process for birds of concern, (b) the primary reference used for bird habitat associations and densities within those habitats, (c) goals for conservation area size, (d) manipulations performed on habitat maps in this paper, (e) considerations for interpretation of these habitat maps, and (f) habitat management issues.

(a) Prioritization of birds of concern Birds were prioritized for conservation action for the WGCP Bird Habitat Conservation Plan according to the criteria of Carter *et al.* (2000) (Table 3). Category I lists the highest priority birds and includes 24

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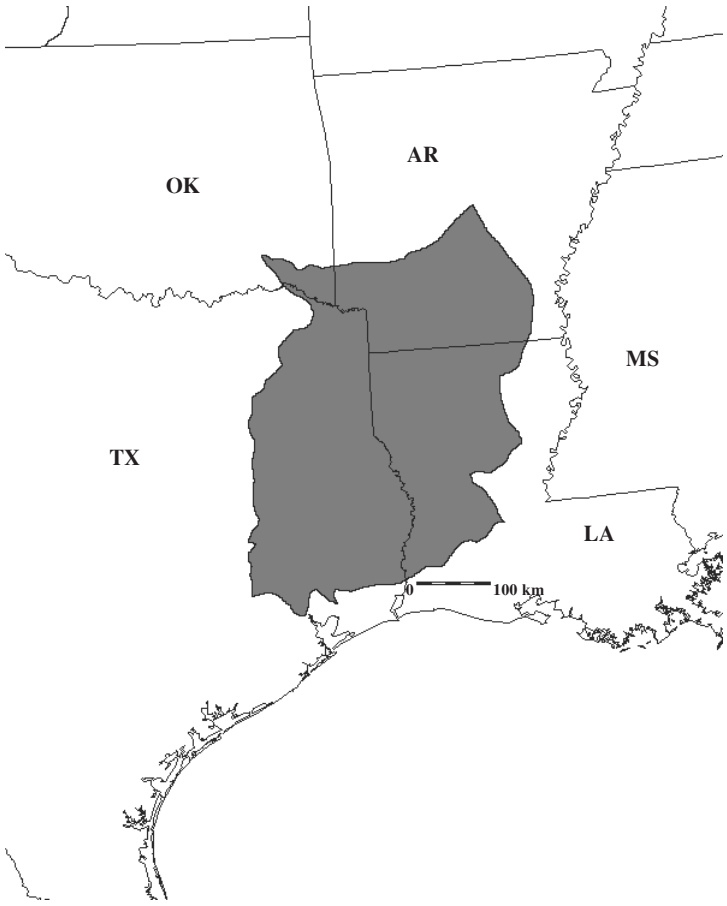

Figure 7. Location map of the West Gulf Coastal Plain, Physiographical Area 42, among surrounding states, covering 15,025,888 ha.

species that received a total PIF score of 22 or greater. Habitat requirements for these species range widely from grassland and early succession to mature bottomland hardwood forest. Focal, or umbrella, species listed in Category Ia are those with total PIF scores ⩾ 28 and include species that are the most habitat sensitive and/or in need of immediate attention to restore or sustain populations in the WGCP. These include Red-cockaded Woodpecker *Picoides borealis*, Swallow-tailed Kite *Elanoides forficatus*, Swainson's Warbler *Limnothlypis swainsonii*, Bewick's Wren *Thryomanes bewickii* and Henslow's Sparrow *Ammodramus henslowii*. It is assumed that Ivory-billed Woodpecker *Campephilus principalis* is now extinct.

Category II provides a listing of seven species receiving slightly lower priority scores (19–21), but a high combined score for area importance and population trend. Three species are listed in Category III that received high global concern scores, or Watch List Species (e.g. Carter *et al.* 2000), regardless of their status in the WGCP.

Category IV birds have a high combination of scores for area importance and

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Table 3. Priority bird species for the West Gulf Coastal Plain physiographical area listed by total Partners in Flight (PIF) concern score, and segregated by entry criteria. Other measures include area of importance (AI) and population trends (PT) concern scores, percentage of breeding bird survey (BBS) population, and local migratory status

Priority entry criteria and species	Total PIF score	Concern scores		Percentage BBS	Local migratory status[a]
		AI	PT		
Ia. Highest overall priority					
Ivory-billed Woodpecker	35	5	5	–	R
Red-cockaded Woodpecker	32	5	4	8.1	R
Swallow-tailed Kite	29	3	5	–	E
Swainson's Warbler	29	5	3	32.1	B
Bewick's Wren	28	2	5	–	B
Henslow's Sparrow	28	4	4	–	C
Ib. High overall priority					
American Kestrel	27	4	4	–	R
Bachman's Sparrow	27	4	3	10.1	D
Kentucky Warbler	26	5	5	18.4	B
Cerulean Warbler	25	2	3	1.3	B
Prothonotary Warbler	24	3	5	6.2	B
Chuck-will's-widow	24	5	5	9.4	B
Brown-headed Nuthatch	24	5	2	13.8	R
Worm-eating Warbler	24	3	3	4.4	B
Hooded Warbler	24	5	4	20.2	B
Scissor-tailed Flycatcher	23	3	4	4.1	B
Bell's Vireo	23	2	3	–	B
White-eyed Vireo	23	5	5	19.5	B
Prairie Warbler	23	3	5	4.4	B
Orchard Oriole	22	5	5	7.6	B
Yellow-billed Cuckoo	22	5	5	9.4	B
Red-headed Woodpecker	22	4	5	3.2	D
Eastern wood Pewee	22	5	5	6.2	B
Louisiana Waterthrush	22	3	3	4.0	B
II. Physiographical area priority species					
Northern Bobwhite	21	4	5	–	R
Ruby-throated Hummingbird	20	5	4	8.1	B
Carolina Chickadee	20	5	4	13.5	R
Loggerhead Shrike	20	3	5	–	D
Black-and-white Warbler	20	4	4	–	B
Field Sparrow	20	3	5	–	R
Eastern Kingbird	19	4	5	–	B
III. Additional species: global priority					
Wood Thrush	21	3	3	3.3	B
Painted Bunting	21	3	3	5.8	B
Dickcissel	21	3	3	–	B
IV. Additional species: abundant and declining in the physiographical area					
Blue-grey Gnatcatcher	18	5	4	8.5	B
Eastern Meadowlark	18	4	5	–	D
V. Additional species: responsibility for monitoring (>10% BBS)					
Pine Warbler	19	5	2	20.4	D
Summer Tanager	19	5	2	16.5	B
Yellow-breasted Chat	17	5	1	14.6	B
Carolina Wren	17	5	2	14.5	R

Table 3. *Continued*

Priority entry criteria and species	Total PIF score	Concern scores		Percentage BBS	Local migratory status[a]
		AI	PT		
Purple Martin	17	4	1	10.9	B
Red-shouldered Hawk	16	4	1	12.9	D
Tufted Titmouse	15	5	2	10.1	R
Acadian Flycatcher	21	3	3	7.3	B
Yellow-throated Warbler	20	3	3	4.7	B
Yellow-throated Vireo	20	4	2	7.3	B
VI. Federal listed species					
Bald Eagle	17	2	3	–	D
VII. Local, state or regional interest species					
American Woodcock	19				
Northern Parula Warbler	18				
American Redstart					
Sharp-shinned Hawk					
Chipping Sparrow					
Yellow Warbler					
Willow Flycatcher					
Baltimore Oriole					
Warbling Vireo					
Great-crested Flycatcher	17				
Yellow-crowned Night Heron					
Wild Turkey	21				
Mississippi Kite	20				

[a] R, resident; E, at distributional limit in the region, but at population levels above peripheral; B, breeding and transients; A, transient migrants, breeds and winters out of region; C, winter resident and transient; D, breeds and winters in region, also some transients.

population trend, regardless of total score. In the WGCP only Blue-grey Gnatcatcher *Polioptila caerulea* and Eastern Meadowlark *Sturnella magna* are in this category. Category V consists of species which have > 10% of their national breeding population within the West Gulf Coastal Plain region. Ten species are in this category. Categories VI lists federally threatened and endangered species in the region; only the Bald Eagle *Haliaeetus leucocephalus* is included in this category. Species of local concern within the WGCP are listed in Cagegory VII; this category contains 13 species ranging from grassland to interior forest inhabitants.

(b) Primary reference for bird habitats and densities Throughout the WGCP plan, the comprehensive summary of bird–habitat relationships produced by Hamel (1992) was used as a resource to provide: (1) estimates of suitability of various habitat types and successional stages for individual bird species during the breeding and winter seasons; (2) foraging and nesting guild membership of bird species; (3) estimated breeding densities of species; and (4) general and key habitat requirements (Table 4). Petit *et al.* (1994) studied bird populations in mature pine/hardwood forests in the Ouachita Mountains of Arkansas and predicted future changes in population densities after proposed harvest treatments based on the expected changes in key environmental components identified for each species. Their predictions for bird densities in future forest types agreed well

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with Hamel's (1992) estimated densities of bird species in similar habitats. Petit *et al.*'s (1994) research is presented here as a validation of the use of Hamel's (1992) work as a reference resource.

(c) Conservation area size considerations Bingham and Noon (1997) advised that a key challenge for conservationists is to estimate in a scientifically defensible manner the size and composition of habitats which will meet critical life history requirements for species of interest. They suggest focusing habitat conservation efforts on species with the largest area requirements. In so doing a reasonable size estimate could be determined for a conservation preserve which would also provide sufficient habitat for other species with smaller area requirements.

In order to systematically and consistently estimate required habitat areas for the conservation of source bird populations, Hunter *et al.* (1997) used Hamel's (1992) estimates of mean densities of breeding birds taken from Breeding Bird Survey data in their Mississippi Alluvial Valley Conservation Plan. From these density estimates they extrapolated to estimate the area required for 500 breeding pairs, then doubled that to approximate an area of suitable, interior habitat surrounded by a 1 km buffer zone of similar vegetation. For consistency of application across physiographical areas and among bird conservation plans, the same procedure was followed in the WGCP plan. For each species of concern in Table 3 (for which densities are listed in Hamel (1992)), we estimated a patch size of suitable habitat that could support 500 breeding pairs. We then doubled that to create a total area encompassing the core area and an approximately 1 km buffer zone (Table 5).

(d) Habitat maps in this paper Hunter *et al.* (1997) recommended categorizing classes of landscape for conservation into four sizes: (1) those contiguous areas < 4,000 ha, (2) 4,000–8,000 ha, (3) 8,000–40,000 ha, and (4) > 40,000 ha. The same procedure was followed in the WGCP plan to produce habitat–area objectives for conservation of all at-risk species (Table 5).

Figures in this plan depicting the location of contiguous tracts of each habitat type were created from USFS FIA forest inventory data compiled within the past eight years (Louisiana 1991, Texas 1992, Oklahoma 1993, Arkansas 1995) and shown at a 1 km^2 resolution. Forests of each type treated in this paper were subjected separately to a clumping procedure in a GIS that assigned all cells connected to other similar types to a clump with a distinct category identity. After sorting all of those different-sized clumps into the four large area categories (< 4,000 ha, 4,000–8,000 ha, 8,000–40,000 ha and > 40,000 ha), we recategorized the resulting data layer and produced the contiguous forest area maps (Figure 8), also creating the accompanying Table 6 with numbers of distinct forest patches (clumps) and total area in each area category.

(e) Map interpretation considerations The 1 km^2 resolution of the land cover databases used in this project is coarse, but they have the advantages of being consistent throughout the United States and Canada, possessing a similar scale to the managed areas database also presented here, and the land cover databases are contained in files small enough to allow easy manipulation by end users. Use of higher resolution data would result in some physiographical areas lacking land

Table 4. Bird species assemblages designated for the oak/hickory forest type within the West Gulf Coastal Plain physiographical area, sorted within habitats by total Partners in Flight score.

Habitat	Species	Total PIF score	AI	PT	TB	Habitat score	Habitat suitability by successional stage, B/W				Overall score
							1	2	3	4	
Oak/hickory forest	Kentucky Warbler	29	5	5	3	13		S/	S/	S/	IV
	Bewick's Wren	28	2	5	5	12	M/	M/M			
	American Kestrel	27	4	4	4	12	S/O	/M			
	Chuck-will's-widow	24	5	5	3	13		S/	M/	S/	III
	Hooded Warbler	24	5	4	3	12		O/	M/	O/	IV
	Worm-eating warbler	24	3	3	3	9			M/	S/	IV
	White-eyed Vireo	23	5	5	3	13		S/	S/	S/	IV
	Yellow-billed Cuckoo	22	5	5	3	13			S/	O/	III
	Eastern Wood-pewee	22	5	5	3	13			M/	O/	VI
	Louisiana Waterthrush	22	3	3	3	9			S/	S/	III
	Orchard Oriole	22	5	5	3	13	M/	S/	M/	S/	IV
	Wild Turkey	21				11		M/M	M/M	O/O	III
	Acadian Flycatcher	21	3	3	3	9			M/	S/	III
	Wood Thrush	21	3	3	3	9			S/	O/	IV
	Yellow-throated Vireo	20	4	2	3	9				S/	VI
	Ruby-throated Hummer	20	5	4	2	11		M/	S/	S/	VI
	Black-and-white Warbler	20	4	4	3	11			M/	O/	VI
	Baltimore Oriole	20					M/		M/M	M/M	
	Carolina Chickadee	20	5	4	2	11		/M	M/M	S/S	
	American Redstart	20							M/	S/	
	Summer Tanager	19	5	2	3	10			M/	O/	VI
	Grasshopper Sparrow	19				8	O/O				VI
	American Woodcock	19				8	S/S		M/M	S/S	III
	Eastern Kingbird	19	4	5	3	12	M/	S/			VI
	Great-crested Flycatcher	17				8			M/	O/	VI
	Sharp-shinned Hawk	17							M/M	O/M	

Table 4. *Continued*

Habitat	Species	Total PIF score	AI	PT	TB	Habitat score	Habitat Suitability by Successional Stage, B/W 1	2	3	4	Overall Score
	Broad-winged Hawk	15				8			/M	O/M	VI
	Warbling Vireo	15							M/		
	Chipping Sparrow	12					S/S		M/	M/	
	Yellow Warbler	12					M/	M/			

The sum of Area Importance (AI), Population Trend (PT), and Threats to Breeding (TB) estimates comprises the Habitat Score, and provides an indication of the importance of the habitat in the physiographical area (see Carter *et al.* 1999, for explanation of these variables). Habitat suitability estimates are indicated by O (optimal), S (suitable), and M (marginal) for four successional stages in each habitat type : 1, grass/forb; 2, shrub/seedling; 3, sapling/poletimber; 4, sawtimber (mature forest). Additionally, habitat suitability estimates are further broken down into breeding (B) and winter (W) seasons. Habitat suitability estimates are from Hamel (1992). The overall score indicates action levels for recommended management: I, crisis recovery necessary; II, immediate management and/or policy action necessary range-wide; III, active management needed to reverse, stabilize, or increase populations; IV, long-term planning and habitat responsibility needed, immediate action may not be necessary; V, investigations and research are necessary to clarify further population status or level of threat to the species or population; VI, monitor population trends and develop habitat management only as needed.

Table 5. Hypothesized forest area (ha) required to support about 500 breeding pairs, based on Hamel's (1992) estimated mean densities for breeding pairs from Breeding Bird Survey data. Number of hectares per breeding pair has been multiplied by 1000 in order to double area estimate for 500 pairs and thus provide an approximate 1 km buffer zone around the area required for 500 breeding pairs

Species	Concern score	Patch size recommendation	Habitat area objective
Red-cockaded Woodpecker	32	40,000	40,000
Swallow-tailed Kite	29	40,000	40,000
Swainson's Warbler	29	4,700	4,000
Bachman's Sparrow	27	7,700	8,000
Kentucky Warbler	26	8,000	8,000
Cerulean Warbler	25	4,000	4,000
Prothonotary Warbler	24	2,700	4,000
Chuck-will's-widow	24	50,000	40,000
Brown-headed Nuthatch	24	8,900	8,000
Worm-eating Warbler	24	2,900	4,000
Hooded Warbler	24	2,500	4,000
White-eyed Vireo	23	3,700	4,000
Orchard Oriole	22	6,500	8,000
Yellow-billed Cuckoo	22	6,600	8,000
Red-headed Woodpecker	22	17,400	40,000
Eastern Wood-pewee	22	5,400	8,000
Louisiana Waterthrush	22	7,100	8,000
Wood Thrush	21	2,800	4,000
Acadian Flycatcher	21	2,800	4,000
Wild Turkey	21	57,100	40,000
Painted Bunting	21	12,000	40,000
Ruby-throated Hummingbird	20	10,500	40,000
Carolina Chickadee	20	4,300	4,000
Black-and-white Warbler	20	11,100	40,000
Yellow-throated Warbler	20	7,800	8,000
Yellow-throated Vireo	20	7,800	8,000
Mississippi Kite	20	40,000	40,000
Pine Warbler	19	4,500	4,000
Summer Tanager	19	6,600	8,000
American Woodcock	19	4,500	4,000
Blue-gray Gnatcatcher	18	4,000	4,000
Northern Parula Warbler	18	2,900	4,000
Carolina Wren	17	2,400	4,000
Great-crested Flycatcher	17	7,100	8,000
Purple Martin	17	40,000	40,000
Bald Eagle	17	40,000	40,000
Red-shouldered Hawk	16	57,100	40,000
Tufted Titmouse	15	3,300	4,000

cover maps since 30-m land cover data are not available for the entire United States, nor for Canada, in a consistent classified format as of mid-2002. The map products presented here are intended as a useful first hierarchical level for identification of the largest remaining areas of key land cover types in a region. After a potential large tract is located a thorough survey of the area is appropriate, either through an aerial reconnaissance or through consultation with local owners. When completed, the National Land Cover Data Set for the Contermin-

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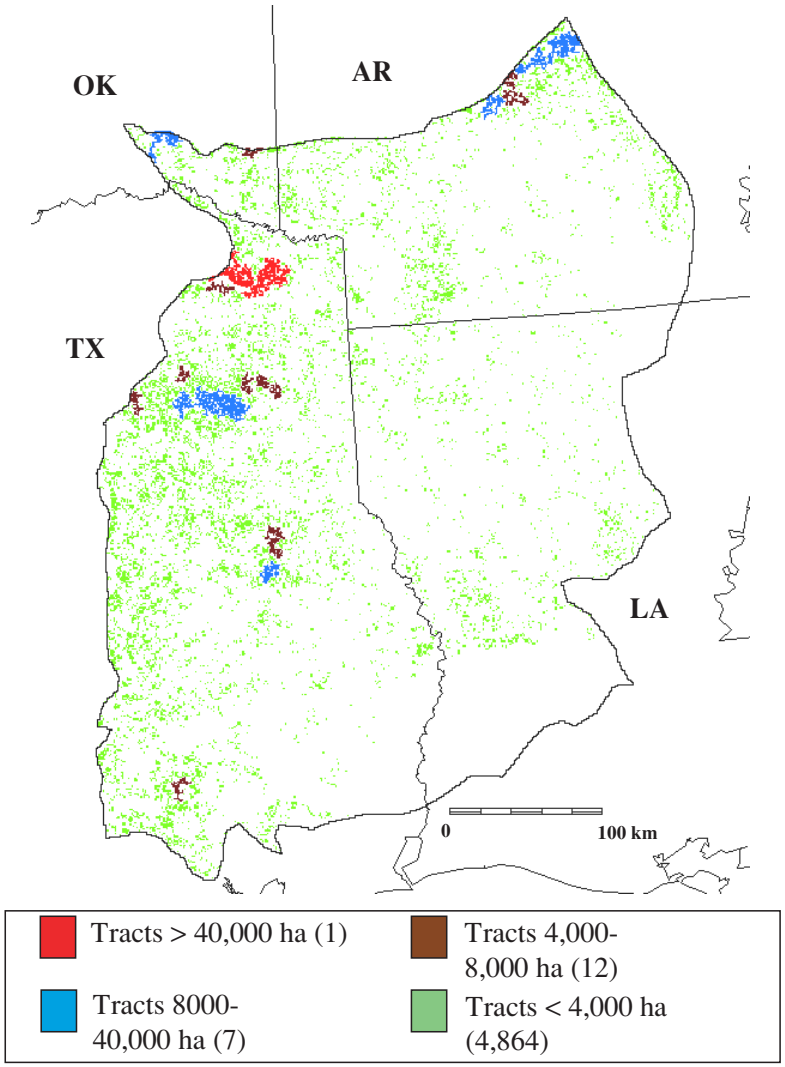

Figure 8. The West Gulf Coastal Plain Physiographical Area of Partners in Flight, encompassing portions of east Texas, western Louisiana, southern Arkansas, and south-eastern Oklahoma. Oak-hickory forest in the West Gulf Coastal Plain, from the USFS FIA Forest Types database. Contiguous forest areas are shown in four size classes: <4,000 ha, 4,000–8,000 ha, 8,000–4,0000 ha and >40,000 ha.

ous United States (Vogelmann *et al.* 2001), at 30-m resolution, will make an excellent second tier habitat analysis tool. After a determination is made that a large tract of an important land cover type exists, ownership of specific parcels can be determined. Subsequent building of new relationships with land owners, or strengthening of existing partnerships, may further bird conservation goals shared by all interested parties.

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(f) Management within conservation areas Hunter *et al.* (1997) make the important point that within large areas of any habitat type managed for conservation, efforts must ensure that all seral stages and natural vegetative diversity occur in order to supply the entire range of needs of bird species using the area. For example, among the high priority species in longleaf/slash pine forest in the WGCP all four successional stages provide optimal breeding and/or wintering habitat for one or more species. In addition, Hunter *et al.* (1997) advise that extant forest remnants are often less than ideal for conservation; that is, a large contiguous forest tract may be quite elongate and narrow or well dissected and, effectively, fragmented, with a large linear edge and little buffered interior habitat. Those conditions will be seen to occur frequently in the forests described in this paper for the WGCP. Therefore, while recommended conservation areas for certain species may seem large for the maintenance of 500 breeding pairs, referring to the particular forest map will show that the high dissection of even large forest parcels effectively makes the recommended areas for habitat and species conservation conservative.

Field verification of contiguous forests shown in individual habitat maps may prove that tracts of some habitat types in the largest size classes no longer occur in the WGCP. Where large tracts of optimal habitat are no longer available, Robbins *et al.* (1989) have determined that smaller habitat patches in close proximity to other similar areas could serve to attract and retain area-sensitive species. However, they caution that core areas of protected habitats should be selected to maximize the critical microhabitat requirements of concern species.

Oak/hickory forest, sample habitat analysis from the WGCP conservation plan

Status and importance

With the aid of maps described in this paper, conservation plan authors will provide information on location, extent, and status of major land cover types in the physiographical area. Major vegetation occurring in the community will be described. Included in the habitat analysis will be a listing of bird species commonly occurring in the land cover type as well as available information on specific threats or opportunities related to ownership or management of existing parcels in the area.

For example, in the WGCP analysis of the oak/hickory forest association, this cover type occurs in 8.2% of the area, or 1,240,000 ha (Figure 8) . Of the approximately 3,400 ha of high-quality mixed mesic upland oak/hickory forest in the Louisiana portion of the WGCP, only about 570 ha are on public land. The current condition of many of these sites is unknown, as they have not been surveyed since 1988 or 1990.

Birds typically found in oak/hickory forests are Red-bellied Woodpecker *Melanerpes carolinus*, Hairy Woodpecker *Picoides villosus*, Downy Woodpecker *P. pubescens*, Blue Jay *Cyanocitta cristata*, Tufted Titmouse *Parus bicolor*, White-breasted Nuthatch *Sitta carolinensis*, Carolina Wren *Thryothorus ludovicianus*, Wood Thrush *Hylocichla mustelina*, Red-eyed Vireo *Vireo olivaceous*, Ovenbird *Seiurus aurocapillus*.

Priority species, species suites, and habitat requirements

In this section species receiving PIF concern scores ⩾ 22 (Carter *et al.* 2000) will be noted. Their natural history in the habitat type under consideration will be discussed. High-priority species in the WGCP are Kentucky Warbler *Oporornis formosus*, Bewick's Wren, American Kestrel *Falco sparverius*, Chuck-will's-widow *Caprimulgus carolinensis*, Hooded Warbler *Wilsonia citrina*, Worm-eating Warbler *Helmitheros vermivorus*, White-eyed Vireo *Vireo griseus*, Yellow-billed Cuckoo *Coccyzus americanus*, Eastern Wood-pewee *Contopus virens*, Louisiana Waterthrush *Seiurus motacilla* and Orchard Oriole *Icterus spurius*.

As an example of the type of habitat analysis presented for each species of concern, Kentucky Warbler nests on the ground or in ground-covering vegetation in moist deciduous forests with an abundant understorey component (Anderson and Shugart 1974). The requirement for a dense understorey vegetation precludes occurrence of the species in closed-canopy mature forests, as well as old-growth forests under selection logging more than a year or two after harvest (Palmer-Ball 1996). Kentucky Warbler is an insectivore foraging in the leaf litter or gleaning from herbaceous vegetation. Forest interior is the preferred habitat with minimum tract requirements of about 45 ha (110 acres) (Whitcomb *et al.* 1981). Dawson *et al.* (1993) found that a mixed pine/hardwood forest of 1,320 ha was the minimum area at which the probability of occurrence of Kentucky Warbler was 0.90. However, Gibbs and Faaborg (1990) found no difference in nesting success or density between fragmented and unfragmented forests.

Habitat and population objectives

Of the high-priority species using each land cover type featured in the paper, a discussion will be provided of the area requirements to sustain about 500 breeding pairs of each species. Further, the author will review the imagery and discuss the availability of suitably large habitat patches in the physiographical area.

For example, in the WGCP oak/hickory forest type, Worm-eating Warblers, Hooded Warblers, and White-eyed Vireos require at least 4,000 ha of forest to sustain 500 breeding pairs. Hooded Warblers find the mature oak/hickory forest optimal breeding habitat; that stage is suitable for Worm-eating Warbler. The shrub/seedling stage is marginal for White-eyed Vireos.

Only one oak/hickory forest > 40,000 ha (50,000 ha, Table 6) occurs in the WGCP. It is spread across western Bowie and eastern Red River counties in far north-eastern Texas west of Texarkana and just north of the Sulphur River. Like other large contiguous forests in the region, it is well dissected. Only seven tracts ranging from 8,000 to 40,000 ha occur in the WGCP. One is in Nacogdoches County, Texas, just east of the city of Nacogdoches. The largest tract in this category covers sections of Gregg, Upshur, and Wood counties in north-east Texas to the north-west of the city of Longview. Smaller areas of forest in this size class occur in Pushmataha county, Oklahoma and in Pulaski, Saline and Hot Springs counties in Arkansas. The 12 areas of oak/hickory forest in the 4,000–8,000 ha range are found toward the northern and western periphery of the WGCP and generally occur near the larger tracts in the 8,000–40,000 ha range. The 4,864 forest stands < 4,000 ha are scattered throughout the east Texas, south-

Table 6. Total area of contiguous forest clumps in four size categories in the West Gulf Coastal Plain, with number of different forest patches of each type below area

Vegetation cover type	Contiguous forest area				Total area/% region
	< 4,000 ha	4,000–8,000 ha	8,000–40,000 ha	> 40,000 ha	
Loblolly–shortleaf pine	1,099,079 3,475	223,320 39	327,464 25	4,320,647 13	5,970,510 ha/39.62%
Mixed pine–hardwood	2,063,946 7,149	232,779 43	413,685 26	70,690 1	2,781,101 ha/18.46%
Bottomland hardwoods	992,347 3,778	108,026 24	226,706 16	55,955 1	1,383,033 ha/9.18%
Longleaf–slash pine	1,018,731 946	66,309 9	102,650 7	50,080 1	1,237,770 ha/3.51%
Oak–hickory	1,018,731 4,784	66,309 12	102,650 7	50,080 1	1,237,770 ha/8.21%
Urban					195,257 ha/1.30%
Wheat, small grain crops					282,859 ha/1.88%
Corn, soybeans					2,079,180 ha/13.80%
Bluestem, grama, wheatgrass grasslands					110,515 ha/0.73%
Pasture					149,843 ha/0.99%
Sagebrush					797 ha/0.00%
Fresh-salt marsh					2290 ha/0.00%
Water					343,095 ha/2.28%
Other					4069 ha/> 0.02%
Total					15,069,397 ha/100%

east Oklahoma, and southern Arkansas areas. A few widely scattered smaller patches of oak/hickory forest are found in west-central to north-western Louisiana.

Implementation recommendations and opportunities

In this sample analysis of oak/hickory forests in the WGCP, private landowners, and especially industrial forest owners, will largely determine the fate of mixed mesic-upland hardwood forests. Many sites exist today with mature trees because they are inaccessible to timber harvest. Private landowners should be encouraged to protect these sites through Nature Conservancy registries, conservation easements, and Forest Stewardship incentives. Because of their relative rarity in the region, high-quality oak/hickory stands are of high priority for protection by The Nature Conservancy, state and federal agencies, and Natural Heritage Programmes. There is potential to protect these hardwood-dominated sites for non-game birds through management plans focusing on Wild Turkey *Meleagris gallopavo*, or through quality deer management programs. When harvests are undertaken, Hardin and Evans (1977) have recommended that in order to sustain cavity-nesting birds in managed oak/hickory forests, clearcuts should be kept small and dispersed within a landscape of diverse stand-age classes, and standing dead trees should be retained to provide potential nesting habitat.

The largest oak/hickory forest sites identified in this mapset need to be surveyed on the ground to ascertain current extent and condition. The many rela-

tively small oak/hickory forest patches in the WGCP should be field checked for current status due to their importance as stopover sites for spring migrants after the Gulf of Mexico crossing (W. C. Barrow, pers. comm.).

Evaluation of assumptions

Assumptions regarding habitat areas needed for sustainability of bird species of concern will be reviewed in this section based on the number of contiguous patches found in various size categories. For example, management recommendations for habitat needed to sustain breeding populations of Kentucky Warbler, Yellow-billed Cuckoo, Eastern Wood-pewee, Louisiana Waterthrush, and Orchard Oriole *Icterus spurius* are based on the assumption that contiguous oak/hickory forests > 8,000 ha still occur in the WGCP. Furthermore, recommendations for habitat conservation aimed at providing for sustaining populations of Bewick's Wren, American Kestrel, and Chuck-will's-widow assume that at least one forest > 40,000 ha still occurs in the WGCP.

Only one oak/hickory forest > 40,000 ha is indicated on the USFS FIA forest inventory database in the WGCP (Figure 8). This area should be surveyed and if largely intact, efforts should begin immediately to gain the cooperation of owners in bird habitat conservation goals. Seven contiguous patches ranging in size from 8,000 to 40,000 ha are shown in this mapset in Texas, Oklahoma, and Arkansas. These eight forest parcels need to be visited and surveyed to determine their current status. Where they still occur, ownership of these large oak/hickory tracts should be determined and preservation efforts actively pursued.

Conclusion

The preceding sample habitat analysis demonstrates the intended application for the mapset products presented here in Partners in Flight Bird Habitat Conservation Plans to be written for each physiographical area in the United States. These plans began to be formulated in about 1998. Some are now complete and others are still in preparation in 2002. Specific conservation measures on valued habitats identified through these maps and plan analyses will be implemented by Partners in Flight working together with land owners and cooperating agencies in the future.

''Conservation is essentially a debate over land-use policy, because land-use patterns determine the blend of habitats available to support wildlife'' (Terborgh 1989). Loss of habitats to development in avian breeding areas (Robbins *et al.* 1989), including the cumulative effects of successive small forest removal events (Parry 1990), massive tropical forest removal in wintering areas (Terborgh 1989, Askins *et al.* 1990, Bradshaw 1993), as well as conversion of extensive native grassland prairies to agricultural and grazing uses (Swengel and Swengel 2001), have forced the awareness that habitat conservation priorities must be given a significant role in future public and private land management decisions if terrestrial bird species in North America are to be assured the highest probability of long-term persistence (Robinson 1997).

This project represents the first attempt to produce a comprehensive nationwide land coverage map system focused on avian conservation efforts. By making the mapsets universally available online it is hoped that other researchers engaged in habitat conservation at a regional scale will also be able to use them beneficially. For example, after determining the approximate location and extent of a regional land cover type from the data set described in this paper, the relevant portions of higher resolution databases, such as the National Gap Analysis Program (GAP, Scott *et al.* 1993) or the National Land Cover Data Set for the Conterminous United States (Vogelmann *et al.* 2001) may be examined. As of spring 2002 neither the National Gap Analysis Program nor the National Land Cover Data Set are complete. Since both data sets use 30-m resolution imagery they contain over 900 times more information for a given area than the AVHRR-derived data used in the maps presented in this paper, with a resulting proportional increase in file size. Using the present mapset for a first-tier search for the largest remaining areas of a given land cover type in a physiographical area can save time and expense otherwise necessary to obtain and process the denser state and national data sets.

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Appendix 1. Categories contained in USFS FIA Forest Types database.

1. White–red-jack pine forest	13. Ponderosa pine forest
2. Spruce–fir forest	14. Western white pine forest
3. Longleaf–slash pine forest	15. Lodgepole pine forest
4. Loblolly–shortleaf pine forest	16. Larch forest
5. Oak–pine forest	17. Fir–spruce forest
6. Oak–hickory forest	18. Redwood forest
7. Oak–gum-cypress forest	19. Chaparral forest
8. Elm–ash–cottonwood forest	20. Pinyon–juniper forest
9. Maple–beech–birch forest	21. Western hardwoods
10. Aspen–birch forest	22. Aspen–birch forest
11. Douglas fir forest	23. Non-forest
12. Hemlock–sitka spruce forest	24. Water

Appendix 2. Land cover categories reclassified from USGS database for use in this project.

	New Categories	USGS category numbers
1.	Wheat, small grain crops	1–5, 7, 9, 12–14, 33, 37
2.	Corn, soybeans	6, 8, 10–11, 15–17, 19–21, 41–42, 45, 54
3.	Irrigated agriculture	22–32, 34
4.	Bluestem grassland	35, 39, 57, 65, 86
5.	Grama grassland	36, 58, 80, 82–83
6.	Wheatgrass grassland	38, 55–56, 59–61, 63–64
7.	Riparian woods	40
8.	Mixed oak–pine forest	43, 50, 53
9.	Pasture, hay, mixed crops	18, 44, 48, 51–52
10.	Maple, birch forest	46, 90, 92–93, 133–134, 137
11.	Oak, hickory forest	47, 94–95
12.	Open oak, bluestem woodland	87–89
13.	Loblolly, slash pine forest	49, 98, 139
14.	Loblolly, shortleaf pine forest	140–141
15.	Annual grasses, manzanita, oak	62, 84–85
16.	Sagebrush	66, 73–74, 76, 78–79, 81, 127
17.	Greasewood	67, 71–72, 75
18.	Creosote	68–70, 77
19.	Oak, maple forest	91, 136
20.	Longleaf, slash pine forest	138
21.	Aspen	96–97
22.	Fir, spruce forest	99–100, 110, 112, 119, 122–123, 135
23.	Ponderosa pine	101, 104, 106, 108–109, 111, 114–116, 118, 120–121, 124–126, 128–129, 131, 147–148
24.	Lodgepole pine forest	102–103, 105, 107, 113, 117, 142–146, 156
25.	Pinyon pine, juniper	130, 132
26.	Water	149
27.	Fresh–salt water marsh	150–154
28.	Barren, sparse vegetation	155
29.	Alpine tundra	157–159

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Internet resource sites

http://www.cast.uark.edu/pif/main/maincont.htm
Partners in Flight Bird Conservation Plan Habitat Map Site

http://www.blm.gov/wildlife/pifplans.htm
Partners in Flight Bird Habitat Conservation Plans

http://www.epa.gov/airmarkets/cmap/summary/sum—forest—sum.html
USFS FIA Forest Types Database, 1 km^2 AVHRR, 1993

http://www.epa.gov/airmarkets/cmap/summary/sum—frstden—sum.html
USFS FIA Forest Density Database, 1 km^2 AVHRR, 1993

http://www.srsfia.usfs.msstate.edu
U.S.D.A. Forest Service Forest Inventory and Analysis Data

http://edcwww.cr.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/landchar
USGS Land Cover Characteristics Data Set, 1 km^2 AVHRR, 1991

http://www.cast.uark.edu/pif/tables/cantext.rtf
Land Cover of Canada, 1 km^2 AVHRR

http://www.ncgia.ucsb.edu/sb/mad/mad.html
University of California, Santa Barbara Managed Areas Database, 1 km^2
http://www.bts.gov/ntda/nortad/desc.html
USDOT BTS road data
http://landcover.usgs.gov/natllandcover.html
USGS National Land Cover Characterization Data Set, 30 m Landsat TM, 2001 (in progress)

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