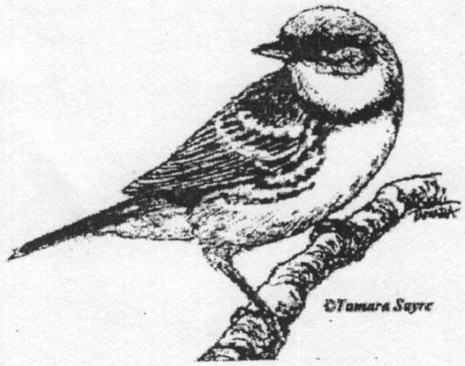
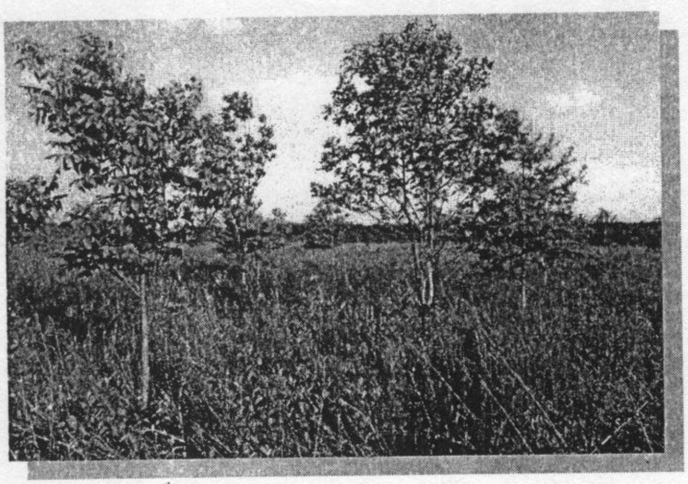
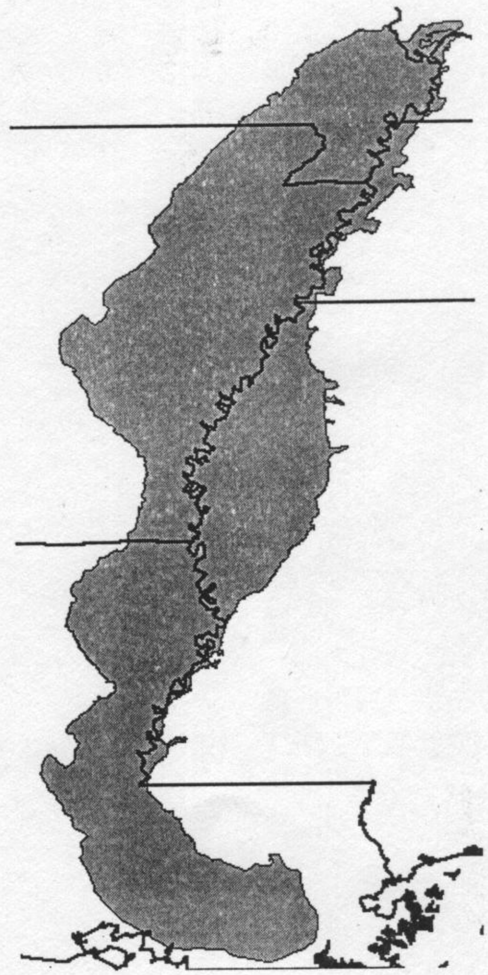
LANDSCAPE LEVEL REFORESTATION PRIORITIES FOR FOREST BREEDING LANDBIRDS IN THE MISSISSIPPI ALLUVIAL VALLEY







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Landscape Level Reforestation Priorities for Forest Breeding Landbirds in the Mississippi Alluvial Valley

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Abstract -- Thousands of ha of cleared wetlands are being reforested annually in the Mississippi Alluvial Valley (MAV). Despite the expansive and long-term impacts of reforestation on the biological communities of the MAV, there is generally a lack of landscape level planning in its implementation. To address this deficiency we used raster-based digital data to assess the value of forest restoration to migratory landbirds for each ha within the MAV. Raster themes were developed that reflected distance from 3 existing forest cover parameters: (1) extant forest, (2) contiguous forest patches between 1012 and 40,000 ha, and (3) forest cores with contiguous area <5,200 ha. Forest core habitat was any forest habitat >1 km from an agricultural, urban, or pastoral edge. Two additional raster themes were developed that combined information on the proportion of forest cover and average size of forest patches, respectively, within landscapes of 50,000, 100,000, 150,000, and 200,000 ha. Data from these 5 themes were amalgamated into a

single raster using a weighting system that gave increased emphasis to existing forest cores, larger forest patches, and moderately forested landscapes while de-emphasizing reforestation near small or isolated forest fragments and within largely agricultural landscapes. This amalgamated raster was then modified by the geographic location of historical forest cover and the current extent of public land ownership. Because reforestation is not required on areas with extant forest cover and because restoration is unlikely on areas of open water and urban communities, these lands were excluded from consideration of reforestation priorities. Spatially explicit reforestation priorities were then used to simulate reforestation of 368,000 ha (5%) of the highest priority lands in the MAV. Targeting restoration to these high priority areas resulted in a 54% increase in forest core -- an area of forest core that exceeded the area of simulated reforestation. Bird Conservation Regions, developed within the framework of the Partners in Flight: Mississippi Alluvial Valley Bird Conservation Plan, encompassed a large proportion (circa 70%) of the area with highest priority for reforestation. Similarly, lands enrolled in the Wetland Reserve Program contain a high proportion of lands with high reforestation priority.

BACKGROUND

The area and distribution of bottomland hardwoods in the Mississippi Alluvial Valley (MAV) have been greatly reduced (MacDonald et al. 1979, Turner et al. 1981, Twedt and Loesch 1999) due to conversion to agriculture incited by extensive flood control projects along the Mississippi River and its tributaries (Galloway 1980). Even so, many areas of the MAV remain vulnerable to frequent flood events, thereby rendering these agricultural lands as marginal in terms of production. Marginal crop production and fluctuating market demand for agricultural commodities have reinvigorated hardwood forestry as a viable land use practice within the MAV. Spearheaded by conservation agencies (Haynes et al. 1995), restoration of formerly forested wetlands has dramatically increased with the advent of the U.S. Department of Agriculture's Wetland Reserve Program. Stanturf et al. (1998) suggest that up to 200,000 ha will be reforested within the MAV by 2005. Through 1997, over 120,000 ha had been enrolled for wetland restoration through the Wetland Reserve Program within the 7 states comprising the MAV (D. Stamps, USDA-NRCS, pers. comm.). Despite the expansive and long-term impact that restoration through the Wetland Reserve Program will have on the MAV, there is generally a lack of landscape level planning in its implementation. Case in point, selections for enrollment in the Wetland Reserve Program in the MAV are determined within each state based on criteria that can vary among states and among years. Although all forest restoration in the MAV undoubtedly benefits local biological communities, proactively targeting reforestation to meet the needs of wildlife populations will likely have the greatest positive impact on landscape and ecosystem restoration. For example, targeting reforestation to increase the area of interior forest (core) habitat will directly benefit migratory landbirds that depend on bottomland forests as breeding habitat (Robinson et al. 1995). The relationship between interior forested area and breeding success of forest landbirds has prompted establishment of forest habitat goals in the MAV (Mueller 1996). Because these habitat goals assume that forest breeding landbirds require >4,000 ha (>2,100 ha of forest core) , >8,000 ha (>5,200 ha of core), or >40,000 ha (>34,000 ha of core) of contiguous forest, reforestation priorities should give preference to sites that reduce forest fragmentation. Increased area of forest core can best be accomplished by increasing the area of forest blocks that do not currently meet the minimum contiguous habitat requirements and by reforestation of spacial intrusions within existing forest fragments.

To promote this conservation goal, 87 Forest Bird Conservation Regions (FBCR) were delineated within the MAV (Fig. 1). Each FBCR is intended to provide contiguous forest core habitat in one, or more, of the 3 aforementioned forest patch sizes. The location and boundaries of FBCR were delineated based on extant forest area and configuration, location of public land holdings, historic forest distribution, political and physiographic boundaries, and "expert" opinion regarding the likelihood of reforestation (Mueller et al. 1996). Although FBCR locations are based on current and historic landscape characteristics, their boundaries were, in many instances, based on a subjective assessment of perceived reforestation opportunities. Because many FBCR encompass an area larger than their habitat objective, achievement of habitat objectives within each FBCR does not require reforestation of the entire region. However, reforestation priorities within each FBCR are at present only vaguely defined as being better when adjacent to existing forests. Thus, isolated forest restoration within a FBCR will increase the total area of forest but may not contribute to an increase in the area of forest core.

Furthermore, restoration priorities among FBCR are based primarily on their attainment of one of the 3 designated patch sizes, in conjunction with subjective estimates of "habitat values" with the FBCR, perceived opportunities for reforestation, and probable cost of restoration (C. Brown, unpublished data). Maximizing benefits of future reforestation for the conservation of migratory birds, however, requires more clearly defined prioritization of potential reforestation sites based on the benefit that restoration can provide to forest breeding landbirds.

Although development of FBCR was a milestone in the conservation of migratory forest birds that breed in the MAV, more objectively based reforestation priorities are needed. To address this need, we used spatially explicit data in a geographic information system (GIS) to assign objectively based "bird conservation values" that reforestation imparts to forest breeding landbirds. Our objectives were to (1) assign a reforestation priority to each ha in the MAV based on its relative value to the conservation of forest breeding landbirds, (2) assess existing FBCR boundary definitions with respect to the proportion of priority reforestation habitat within and among these regions, and (3) assess the performance of recent enrollments in the Wetland Reserve Program with regard to their location relative to priority reforestation habitat.

STUDY AREA

The MAV is an ~10 million ha alluvial floodplain that extends >800 km from Cape Girardeau, Missouri to New Orleans, Louisiana (Fig. 1). Physiographically, the MAV is characterized as a ridge and swale topographic landscape intersected by the Mississippi River and its tributaries. The MAV floodplain was once dominated by bottomland hardwood forests subjected to frequent and widespread flooding. However, the forested landscape has been largely cleared (75%) and its hydrology altered for agricultural purposes.

METHODS

We used raster-based digital data to address the 3 objectives of this investigation. Assignment of restoration values (reforestation priorities) to each ha within the MAV, including a 1 km buffer, was based on 13 raster layers--each having a spatial resolution of 1 ha (pixel = 100 m x 100 m). All geographic data were manipulated using TNT-MIPS (Microimages, Inc., Lincoln, Nebraska) and statistical analyses were completed using SAS (SAS Inst., Cary, North Carolina).

Reforestation Priorities

Reforestation priorities were identified by first developing 5 theme rasters based on 11 data rasters (i.e., information layers) that reflected information about existing forest conditions relative to the hypothesized needs of forest breeding birds. Data from these 5 theme rasters were then amalgamated into a single raster. This resultant raster was subsequently modified by information from 2 additional data rasters. This final raster depicted reforestation priorities that are targeted to enhance breeding conditions for forest breeding landbirds in the MAV.

Theme Development.-- Using land cover classification from 1992 thematic mapper imagery (Twedt and Loesch, 1996), we generated a raster that depicted linear distance, in 100 m intervals, from existing forest habitat (Theme 1, Fig. 2a). Raster values, and likewise priority for forest restoration, decline with distance from existing forest.

Because we assumed contiguous forest patches of a minimum area are required to support breeding bird populations, reforestation adjacent to small, isolated forest fragments is of lesser value to the conservation of forest breeding birds than is reforestation abutting larger tracts of contiguous forest that approached or exceeded stated habitat objectives. However, reforestation that enlarges forest patches beyond the maximum forest habitat objective (i.e., >40,000 ha) may be superfluous. Therefore, we generated a raster that depicted the distance, in 100 m intervals, from forest fragments that are >1,012 ha but <40,000 ha (Theme 2, Fig. 2b). The lower limit of 1,012 ha was used to conform with previous studies on forest patch dynamics in the MAV

(Rudis 1995), and because we felt the benefit to cost ratio of reforesting smaller patches would be counter productive.

Although bird conservation goals are couched in terms of contiguous forest area, these are in reality convenient surrogates for forest core habitat (Mueller et al. in press), which is more difficult to determine. To estimate forest core habitat in the MAV, we considered water (lakes, rivers, etc.), sand bars, and shrub-scrub habitats to be "buffers" that mitigate the adverse impacts associated with agricultural edge on forest breeding birds (Marini et al. 1995). Thus, forest core habitat, as applied in this study, was generally any forested habitat >1km from agricultural, urban, or pastoral habitats. After delineating forest core habitat, we quantified the area of each contiguous forest core.

Forest core habitat is of lesser concern in the largest (>40,000 ha) conservation category because bird species thought to require forest patches of this magnitude are, for the most part, not forest interior specialists (e.g., Swallow-tailed Kite). Thus, a more appropriate objective for core habitats is to ensure that forest patches have >5,200 ha of forest core. Therefore, we excluded from analysis all patches of forest core habitat that exceeded the 5,200 ha objective. Distance from core forest, at 100 m intervals was generated from all forest cores <5,200 ha, with highest priorities given to areas adjacent to existing core areas (Theme 3, Fig. 3).

The proportion of the landscape occupied by forest may be as important to the nesting success of breeding birds as the size of forest fragments (Freemark and Collins 1992). Robinson et al. (1995) found that nest mortality was negatively correlated with the percent of forest in a landscape, with nest mortality of most species dramatically increased when forest cover occupied <60% of the landscape (our interpretation of Robinson et al. 1995). Because the forests in the

MAV are highly fragment (Rudis and Birdsey 1986), we established a slightly more conservative forest cover objective of 65%. Based on this forest cover objective, reforestation has increasingly greater conservation value as forest cover within the landscape increases from 0% to <65%. Following a similar logic, we assumed that reforesting landscapes that contained >65% forest cover was of lesser value to avian conservation than increasing forest cover in landscapes harboring <65% forest cover.

To determine landscape level forest coverage, we established non-overlapping grids of hexagon cells that covered the extent of the MAV at 4 spatial scales (50,000, 100,000, 150,000, and 200,000 ha) and calculated the proportion of forest cover within each hexagon. The conservation value of reforestation within hexagons was established as percent forest cover when forest cover was ≤65%. However, when forest cover exceeded our threshold criteria of >65%, the conservation value of reforestation within the hexagon was reduced to the difference between existing percent forest cover and 100%. For example, if a hexagon contained 80% forest cover, its conservation value for reforestation was reduced to 100% - 80% = 20%; equivalent to that of a hexagon with 20% forest cover. The resultant conservation values were smoothed using an interpolation algorithm to mitigate abrupt transitions between adjacent hexagons. Subsequent values of each ha within the four resulting rasters of hexagons were averaged to produce a raster depicting conservation values relative to percent forest cover at these different landscape scales (Theme 4, Fig. 4a).

Robinson et al. (1995) also recognized mean forest patch size was a landscape parameter important to forest breeding landbirds because of its relationship with nest mortality. Therefore, we determined the mean size of contiguous forest patches within each of the four hexagon grids described above. As was done with the percent forest cover, we smoothed boundaries between hexagons and combined the four landscape scale rasters into a single raster that depicted the average of the mean size of forest patches at these different landscape scales. (Theme 5, Fig. 4b).

Theme Amalgamation. – Before amalgamating themes we standardized values among rasters by expanded the range of cell values such that each raster spanned the breath of an 8-bit raster (i.e., value from 0 to 255). Spreading the range of cell values equalized the conservation values among rasters and allowed for an increased separation among reforestation priorities. In all cases, higher values represented greater conservation value for forest breeding landbirds which implied increased reforestation priority. All 5 themes were then combined as:

$$RV = [(Forest) + (2 \bullet Patch) + (3 \bullet Core) + (2 \bullet Percent) + (Area)]/9$$

where

RV = reforestation value,

Forest = distance from all existing forest (Theme 1),

Patch = distance from forest patches between 1,012 and 40,000 ha (Theme 2),

Core = distance from forest cores <5,200 ha (Theme 3),

Percent = "adjusted" percent forest cover in landscape (Theme 4), and

Area = mean forest patch size in landscape (Theme 5).

The above weighting system provided increased emphasis on adding to existing forest cores, larger forest patches, and moderately forested landscapes. Conversely, reforestation near small or isolated forest fragments, and on largely agricultural landscapes was de-emphasized.

Finally, because the most recently converted forests may be logistically the easiest to restore, we increased the priority of reforestation within areas in forest cover in the 1950s, and further increased the priority of areas in forest as recently as the 1970s (Fig. 5). Similarly, lands under public ownership may be, in theory, more readily restored to forests than are privately owned lands. Thus, the conservation priority for reforestation was also increased on public land holdings (Fig. 6).

This model characterized the reforestation priority of every ha within the MAV. However, areas currently underwater (lakes, river, and aquaculture ponds) are unlikely to be reforested. Similarly reversion of areas of human habitation (cities and towns) to forest cover is not likely. Finally, we assumed the areas forested during 1992 remained forested and therefore, reforestation on these lands is unnecessary. Thus, all areas of open water, urban development, and extant forest cover were removed from the raster of reforestation priorities. These areas were considered unavailable for restoration when determining the distribution of reforestation priorities.

Assessment of Bird Conservation Regions and Wetland Reserve Program Enrollments

To assess the congruence of spatially defined FBCR and reforestation priorities for avian conservation, as identified by the above methodology, we calculated the area of each reforestation priority value among and within FBCR. To accomplish this, raster data for reforestation priorities within the boundaries of each FBCR were extracted and summed within reforestation priority classes.

To evaluate effectiveness of the Wetland Reserve Program relative to meeting the needs of forest breeding birds requires complete coverage of the spatial location of all lands enrolled in the program. Unfortunately, complete spatially defined coverage of Wetland Reserve Program enrollments is not currently available. However, we were able to acquire or create digital data depicting the spacial location of 45,609 ha (~40%) of lands enrolled in the MAV. Thus we assesses the performance of the Wetland Reserve Program on only a subset of all lands enrolled in this program. As was done with Bird Conservation Regions, we determining the distribution of reforestation priorities on lands enrolled in the Wetland Reserve Program within the limits our data.

RESULTS

Reforestation Priorities

Amalgamation of the 5 themes resulted in a distribution of reforestation priorities centered around the mid-point of possible values in an 8-bit raster ($\bar{x} \pm SD = 128 \pm 43$). Given this distribution of restoration priorities, we elected to increase the priority of recently forested lands, as well as the priority of public land holdings, by one-half of a standard deviation (SD = 43). Thus, the reforestation value of lands forested in the 1950s was increased by 21 whereas the value of those lands that remained forested into the 1970's was increased by 42. The reforestation value of all publicly owned lands was further increased by one-half of a standard deviation. The increased reforestation values were shifted downward to yield a maximum reforestation value of 255. Final distribution of reforestation priorities within the entire MAV retained more land with moderate reforestation priorities and less land with low or high priority than would be expected in a normally distributed population ($D = 0.046$, $P < 0.01$). However, because we shifted the data to conform to a maximum value of 255, values ≤ 0 were rounded to 1. Rounding resulted in an anomalous, albeit slight, increase in the lowest reforestation priority value. Rather than identifying 255 reforestation priorities, we used the standard deviation of the distribution to group priorities into 10 categories (Fig. 7).

Although most states mirrored overall reforestation priorities within the MAV, the distribution of reforestation priorities varied among states (Table 1; Fig. 8). Notably, Louisiana contained a greater proportion of lands with high reforestation priorities whereas land in Missouri had predominantly low restoration priorities.

Assessment of Bird Conservation Regions

We found just over 1 million ha available for reforestation within Bird Conservation Regions (Fig. 9). The mean reforestation priority within FBCR was 172 ± 30 but the distribution of reforestation priorities was not normally distributed ($D = 0.05$, $P < 0.01$). A disproportionate amount of the area had higher reforestation priorities (skewness = -0.63). Of the potential area for reforestation within FBCR: 94% had a reforestation priority value greater than the mean reforestation priority for the entire MAV, 55% had a reforestation value in the highest 3 categories (i.e., >1 SD above the mean for the entire MAV), and 6% was of the highest priority (category10). This latter value markedly contrasted with the distribution of highest priority in the entire MAV which was only 1%.

Performance of Wetland Reserve Program enrollments

The distribution of reforestation priorities within Weltand Reserve Program enrollments was similar to that within FBCR (Fig. 9); the distribution was not normally distributed ($D = 0.16$, $P < 0.01$) and skewed (skewness = -1.65). Within the limited spatial coverage of our data, it appears that lands enrolled in the Wetland Reserve Program are among the higher reforestation priorities. However, overall reforestation priorities within Wetland Reserve enrollments were lower and more variable (169 ± 38) than reforestation priorities within FBCR. Even so, 88% of the area enrolled in the Wetland Reserve Program exceeded the average priority for the MAV and 57% was in the highest 3 reforestation priority categories.

DISCUSSION

The effectiveness of this reforestation prioritization model at increasing forest core area was examined by simulating reforestation on the highest priority areas. We arbitrarily chose to simulate reforestation on 5% of the landbase available for reforestation. Thus, we assumed all pixels with avian conservation value >191 (reforestation priority categories 10, 9, and part of 8) were reforested. This represented reforestation on 368,000 ha-- 4.9% of the landbase available for reforestation. We did not consider this an unrealistic long-term expectation, given that >120,000 ha of private land in the MAV have already been enrolled in the Wetland Reserve Program, and increased forest cover continues to be an objective public land managers. Simulated reforested lands were combined with existing forest cover and, using the previously described methodology, we determined the resultant areas of forest core.

Reforestation of 4.9% of the available landbase with the highest reforestation priority resulted in a 54% increase in the area of forest core within the MAV. Existing area of forest core (780,598 ha) was increased to 1,201,140 ha after simulated reforestation. Note that the increase in forest core (419,514 ha) exceeded the area of simulated reforestation (368,000). Thus, the benefits derived from reforestation of the areas with highest reforestation priority are substantially greater than the direct impact of increasing the total area of forest in the MAV.

Although FBCR were delineated without the benefit of the spatial data and technological capabilities we employed in development of these reforestation priorities, most FBCR aligned well with the reforestation priorities identified using this model. Their high correlation is not simply coincidental, as much of the same information was used to define both spatial data sets. Departure between the methods is primarily a function of the arbitration required to finalize the spatial boundaries of the original FBCR.

Although we did not have comprehensive spatial coverage of Wetland Reserve Program enrollments in the MAV, our coverage indicates that enrollment often included those lands identified herein as having a high priority for reforestation. However, this has not been due to deliberate "targeting" of enrollment locations, but rather is considered an artifact attributed to landowners' desire for more compatible land use practices on their property within the constraints of existing environmental conditions. That is, agricultural lands that are marginal for crop production due to their susceptibility to natural flooding during the growing season are often proximate to existing forested habitat that remains extant due to high frequency of flooding. Thus, these marginal croplands are also those lands where restoration affords the greatest positive impact to forest breeding landbirds.

The reforestation model presented here was developed to depict reforestation priorities at a landscape scale, therefore these results may not be applicable for specific locations at a local scale. Thus, local events which have occurred since 1992 may alter reforestation priorities. For example, forests cleared after 1992 (the date of our land cover classification) and in situ forest restorations were not considered in development of our model but both could alter reforestation priorities within a local area surrounding these altered habitats.

MANAGEMENT IMPLICATION

Development of FBCR enabled managers to set landscape level habitat objectives designed to meet the needs of forest breeding landbirds. Reforestation priorities developed herein can be conveniently adopted to assign reforestation priorities within established FBCR. Thus, reforestation priorities provide land managers with the opportunity to improve forest habitat objectives through assignment of reforestation priority to lands within FBCR and to establish a relative rank among FBCR based on the objective criteria of increasing forest core habitat. After review of these objective priorities, conservation planners may consider redefining FBCR boundaries, adding additional FBCR within areas of high potential for augmenting forest core habitat, or eliminating FBCR that have low reforestation priority.

Although reforestation priorities defined by this model may not universally provide the greatest increase in forest core, we believe emphasizing reforestation of the highest priority areas will provide the greatest overall benefit to breeding birds. The relatively simplistic simulation routine presented here demonstrated that reforestation of <5% of the available landbase in the MAV resulted in an increase in the number of FBCR which met habitat goals from 18 to 39 (Table 2). Further, unlike Although 71% of simulated reforestation was within FBCR, restricting simulated reforestation to within the boundaries of FBCR would undoubtedly further increase achievement of habitat objectives. Moreover, in several FBCR the forest core goal was greatly exceeded. Further reforestation within a FBCR after its habitat objective has been achieved benefits breeding birds by increasing forest core but maximizing attainment of habitat objectives within all FBCR mandates reduced reforestation priority within a FBCR after its habitat objective is achieved.

Land managers may benefit from more complicated simulation routines. For example, examination of repeated, incremental, simulated reforestation within each FBCR would provide estimates of the minimum area of reforestation required to achieve the habitat objective with each region that could be summed to obtain the minimum reforestation required to fulfill forested habitat objectives within the MAV. However, because multiple examinations of FBCR would require extensive, tedious, and repetitive computations, we tentatively assumed all high priority reforestation within a FBCR contributed to forest core. This probably is a valid assumption when considering reforestation of high priority areas. Under this assumption, we computed the ratios of the area of highest priority (category 10), very-high priority (category 9), etc. reforestation and the area of forest core remaining to achieve habitat objectives within each zone. We used these ratios to assign relative reforestation ranks among FBCR. For example, those FBCR that would achieve their habitat objective by reforesting only highest priority (category 10) lands were assigned a reforestation rank of 10. Relative ranks of Bird Conservation Regions were progressively decreased as attainment of habitat goals required reforestation of an increased proportion of lower reforestation priority lands. Notably, habitat objectives within some FBCR could not be met when reforestation was constrained by FBCR boundaries even when all areas with reforestation potential were restored! In these instances, relative ranks were assigned based on the proportion of the habitat objective that was obtainable (Table 2). Unfortunately, the boundaries of a few FBCR (most notably Upper Ouachita in northern Louisiana) extended beyond the limits of our digital data; their relative ranks were assigned within the limits of existing data. Finally, FBCR where habitat objectives have been met were assigned negative ranks based on the ratio of the area of high priority reforestation relative to the amount of area by which the region exceeded its habitat objective (Table 2).

We believe that failure to consider landscape level effects of extensive reforestation programs such as the Wetland Reserve Program diminishes their potential contribution to this ecosystem. We suggest conservation programs establish well-defined objectives intended to address broad economic or environmental needs. We further recommend utilizing results from landscape analyses, such as identified herein, to define biologically-based restoration objectives through an objective scoring process. However, we acknowledge that these reforestation priorities only consider reforestation needs of forest breeding landbirds, when in fact there are other economic and environmental benefits to reforestation.

Identifying benefactors from reforestation is crucial if restoration is to be effectively implemented in a holistic ecosystem approach. Forested landscapes provide myriad benefits (Mitsch and Gosselink 1993), but are generalized as (1) improved air and water quality, (2) flood damage abatement, (3) enhanced wildlife habitat, (4) economic development, and (5) ameliorated quality of life or aesthetics. Although all reforestation has the potential to provide these benefits, the juxtaposition of reforestation within existing landscapes can markedly impact which of these potential benefits are best realized. To further this objective, we recommend development of models that identify reforestation priorities for other benefactors. Multiple models depicting reforestation priorities would assist land managers and conservation planners in their decision making process regarding restoration of forested wetlands within the MAV.

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Table 1. Spatial distribution (ha) among ten reforestation priority categories within the Mississippi Alluvial Valley (MAV). Increased reforestation priority connotes increased conservation benefits afforded to forest-breeding landbirds.

	Reforestation Priority (low)							(high)		
State	1	2	3	4	5	6	7	8	9	10
Arkansas	293	35,968	228,500	480,062	639,122	735,390	514,164	185,106	31,556	5,189
Illinois	16	844	5,929	6,658	17,513	12,409	4,592	613	15	5
Kentucky	5	0	0	680	2,348	9,823	19,052	9,239	1,618	56
Louisiana	20,246	18,556	64,082	119,624	190,204	370,895	515,870	428,328	162,750	47,639
Mississippi	87,797	101,061	166,600	183,251	236,729	231,570	207,154	121,907	59,745	19,838
Missouri	185,196	153,406	189,810	163,285	138,381	79,151	31,443	5,864	2,215	800
Tennessee	6	0	3,195	13,494	33,195	46,149	45,856	29,140	6,075	921
MAV	293,559	310,835	658,116	967,054	1,257,492	1,485,387	1,338,131	780,197	264,974	74,443

Table 2. Area (ha), existing forest cover, proposed objective(s) and spatial distribution among reforestation priority categories within the 87 Forest Bird Conservation Regions (FBCR) designated within the Partners in Flight: Mississippi Alluvial Valley Bird Conservation Plan.

State		Existing forest		Core	Potential	Restoration priority			Restoration
FBCR	Area	Area	Core	objective[a]	restoration	Highest[b]	High[c]	Moderate[d]	rank[e]
ARKANSAS									
Ashbrook	16,708	13,191	8,406	5,200	1,372	7	873	546	G1
Bayou DeView	7,303	3,464	246	2,100	3,476	4	554	2,683	1
Bayou Meto	34,481	2,137	6,323	5,200	10,645	51	7,191	3,246	G2
Big Ditch	6,497	4,345	897	2,100	1,376	0	1,190	162	3
Big Lake	14,316	9,455	5,044	5,200	3,160	22	1,084	1,960	7
Black River	27,703	16,106	3,345	5,200	10,277	51	4,965	5,174	5
				2,100					
Boeuf Farms	3,740	465	0	2,100	3,147	0	0	69	0
Brandywine Isl.	10,956	5,528	1,210	5,200	4,480	0	2,329	2,157	1
Cut-off Creek	13,620	6,922	2,451	5,200	6,468	42	3,953	2,552	5
Dermot	5,713	1,582	1	2,100	4,019	0	450	3,533	0
Island 65	7,099	4,131	1,598	2,100	1,882	407	1,477	38	9
Overflow	9,370	4,758	2,003	5,200	4,516	759	2,436	1,292	7
Peters Island	10,015	5,370	803	2,100	3,408	78	3,235	240	6
Rainy Brake	15,795	6,883	1,447	5,200	8,157	87	3,299	4,749	3

Table 2. cont.

State FBCR	Area	Existing forest Area	Existing forest Core	Core objective[a]	Potential restoration	Restoration priority Highest[b]	Restoration priority High[c]	Restoration priority Moderate[d]	Restoration rank[e]
St. Francis NF	15,409	6,693	1,631	5,200	6,823	122	4,618	2,017	3
				2,100					
Sunken Lands	31,736	13,521	2,875	5,200	16,563	8	2,970	10,927	4
White River (N)	194,516	70,634	12,006	34,000	105,612	779	27,667	65,513	3
				5,200					
				2,100					
White River (S)	173,944	129,421	80,292	34,000	32,945	1,180	13,839	18,259	G2
				34,000					
ILLINOIS									
Cache River[f]	18,410	4,749	0	5,200	12,467	0	356	6,721	0
KENTUCKY									
Ballard	13,670	5,555	18	5,200	6,789	19	3,172	3,568	2
Obion	7,171	3,077	2	2,100	3,708	0	1,628	2,278	2
West Island	5,450	2,174	0	2,100	2,811				
Westvaco	3,569	1,375	0	2,100	1,867	12	1,199	667	2
LOUISIANA									
Three Rivers	114,611	69,776	32,481	34,000	33,083	7,247	23,940	1,629	10
Atchafalaya Basin (E)	220,925	154,090	75,925	34,000	43,845	2,825	33,598	13,884	G1
Atchafalaya Basin (W)	44,318	21,906	7,706	2,100	11,305	264	6,774	4,148	8
				2,100					
				2,100					
				2,100					
Lower Atchafalaya	30,547	18,916	6,078	5,200	6,579	1,452	6,150	200	G3
Maurepas	137,868	95,963	45,699	34,000	24,290	3,285	10,039	8,719	G2

Table 2. cont.

State FBCR	Area	Existing forest Area	Existing forest Core	Core objective[a]	Potential restoration	Restoration priority Highest[b]	Restoration priority High[c]	Restoration priority Moderate[d]	Restoration rank[e]
Bayou Boeuf	53,030	22,950	7,738	34,000	26,256	1,618	18,225	5,932	3
Bayou Cocodrie	24,404	10,301	868	5,200	13,059	411	8,897	3,683	6
Bayou Macon	12,079	2,514	213	2,100	9,541	208	1,561	5,657	3
Boggy Bayou	10,226	5,561	288	2,100	4,402	96	2,820	1,438	6
Buckhorn	23,490	8,979	288	2,100	14,100	519	8,664	4,806	8
Cat Island	15,268	10,413	4,444	5,200	3,245	1,315	2,282	0	10
Concordia	8,001	5,651	3,426	2,100	922	183	816	45	G2
Cypress Island	16,737	9,668	1,082	5,200	5,415	0	2,501	2,787	1
D'Arbonne[f]	9,139	3,724	741	2,100	2,872	1,193	2,446	477	9
Davis Island	32,787	20,224	4,413	2,100	10,858	970	9,122	654	10
				2,100					
Deltic Lands	11,407	3,300	5	2,100	7,893	0	1,582	5,088	3
Des Allemandes	186,936	93,048	28,677	34,000	63,048	2,577	18,563	37,568	8
Fletcher's Lake	4,980	2,250	67	2,100	2,453	0	1,495	902	2
Atchafalaya Basin Floodway	249,691	201,792	166,805	34,000	10,017	2,149	9,206	1,465	G1
Glade Woods	13,184	6,099	1,377	2,100	6,163	0	4,499	1,581	4
Glasscock Island	11,184	7,549	3,491	5,200	2,018	112	1,859	133	6
Morganza Floodway	22,399	15,024	6,651	5,200	6,799	366	6,062	375	9
				2,100					
Palmetto	26,008	12,105	1,228	5,200	13,601	999	8,555	3,821	8
Raccouci Island	15,287	10,600	7,976	5,200	1,137	656	880	160	G1
Russell Sage	31,489	16,004	4,784	5,200	14,020	708	11,051	2,128	8
				2,100					

Table 2. cont.

State FBCR	Area	Existing forest Area	Existing forest Core	Core objective[a]	Potential restoration	Restoration priority Highest[b]	Restoration priority High[c]	Restoration priority Moderate[d]	Restoration rank[e]
Saline	51,559	36,823	23,133	5,200	9,993	1,284	8,333	1,023	G1
Short Bayou	10,179	4,113	57	2,100	5,633	0	3,597	1,944	4
Tensas River	77,499	39,753	16,228	34,000	36,498	4,162	26,778	5,234	8
Thistlewaite	25,444	12,225	1,751	5,200	12,449	606	6,999	4,629	7
Upper Ouachita[f]	3,488	1,642	161	5,200	1,630	424	1,242	1,011	1
West False River	14,292	10,057	3,434	5,200	4,039	907	3,150	1	9
West Atchafalaya Floodway	62,772	26,589	5,854	5,200	32,728	5,312	20,120	6,900	10
				5,200					
				2,100					
Yucatan	9,881	6,313	1,248	2,100	2,007	420	1,624	0	9
MISSOURI									
Big Oak Tree	5,965	2,557	4	2,100	2,909	0	483	2,407	0
Black River	11,174	5,132	224	2,100	5,688	13	1,467	3,924	3
Mingo	14,432	7,927	1,441	5,200	4,983	770	2,983	1,388	4
New Madrid	8,263	3,400	360	2,100	4,137	6	911	3,235	2
River	8,936	3,735	292	2,100	4,547	0	2,046	2,479	4
Ten Mile	7,109	960	0	2,100	6,102	0	0	584	0
Wileminna State Forest	6,764	1,666	0	2,100	4,845	0	0	97	0
MISSISSIPPI									
Belzoni	23,761	8,630	0	2,100	12,390	0	379	8,260	0
Big Black	12,085	9,122	5,512	5,200	2,265	169	2,291	0	G3
Buffalo River	7,295	4,940	1,809	2,100	922	430	641	0	10
Coahoma	29,841	19,510	8,106	5,200	7,537	526	4,962	2,161	G2
Coldwater Creek	21,191	2,081	0	2,100	18,544	0	12	998	0

Table 2. cont.

State FBCR	Area	Existing forest Area	Existing forest Core	Core objective[a]	Potential restoration	Restoration priority Highest[b]	Restoration priority High[c]	Restoration priority Moderate[d]	Restoration rank[e]
Dahomey	7,989	3,394	115	2,100	4,513	96	1,190	3,199	3
Delta NF	125,248	57,932	22,793	34,000	62,721	3,014	30,339	22,466	8
Gunnison	8,508	6,474	3,301	2,100	1,172	368	760	78	G2
Hillside	9,765	6,836	1,589	2,100	2,460	582	1,568	272	10
Homochitto	24,302	14,696	6,154	5,200	7,372	3,386	4,322	0	G3
Mahannah	113,295	61,540	22,054	34,000	41,342	7,358	28,976	5,238	9
Malmaison	34,387	13,375	781	5,200	18,353	381	9,819	7,876	6
Mathews Brake	10,881	2,591	20	2,100	7,248	0	1,212	5,755	2
Morgan Brake	8,192	3,985	271	2,100	3,695	186	3,094	294	7
O'Keefe	33,029	6,164	112	2,100	25,205	64	777	16,480	1
Pittman Island	8,477	5,570	2,250	2,100	1,666	0	1,239	411	G2
St. Catherine's Creek	9,703	4,386	1,672	2,100	4,368	1,009	3,727	609	10
Tribble	10,189	2,915	0	2,100	6,085	0	220	3,736	0
Tunica	25,978	16,411	6,098	5,200	5,571	701	3,358	1,561	G3
Whittington	38,267	26,077	17,059	5,200	7,773	339	6,394	2,051	G1
				2,100					
Yazoo	10,706	4,488	73	2,100	5,757	208	3,374	2,048	7
TENNESSEE									
Chickasaw	59,408	24,954	5,650	34,000	29,347	578	18,591	10,026	2
Meeman Shelby	8,518	5,061	2,322	2,100	2,049	179	1,178	802	G3
Reelfoot	23,313	8,504	2,966	5,200	10,825	188	4,480	5,674	6
FBCA Totals	2,955,271	1,649,397	708,050	738,400	1,017,446	66,447	502,708	380,482	

[a] Some FBCA have >1 habitat objective.

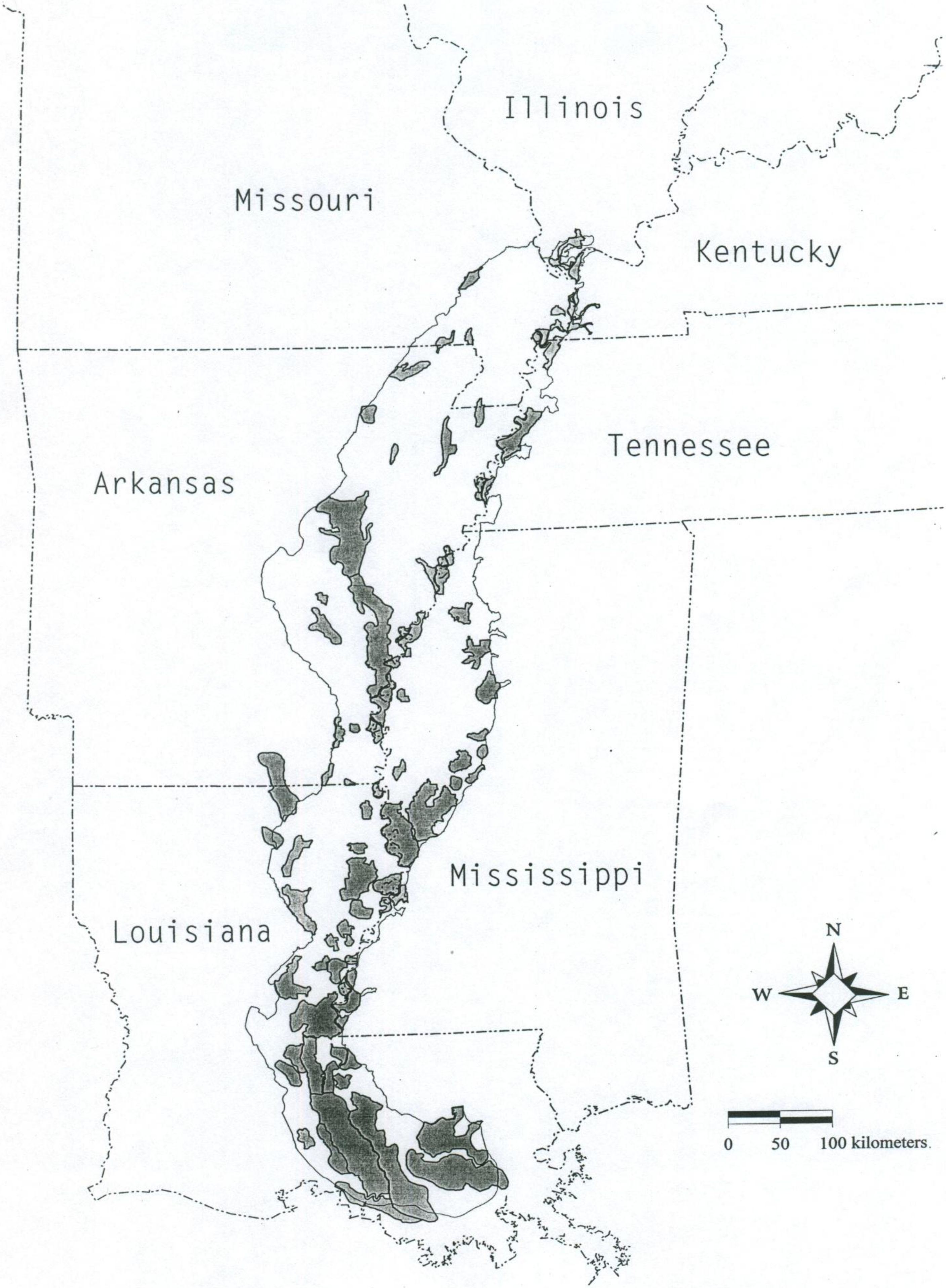
[b] Highest restoration priority lands were ≥2 standard deviations (SD) above mean reforestation priority.

Table 2. cont.

State FBCR	Area	Existing forest Area	Core	Core objective[a]	Potential restoration	Restoration priority Highest[b]	High[c]	Moderate[d]	Restoration rank[e]

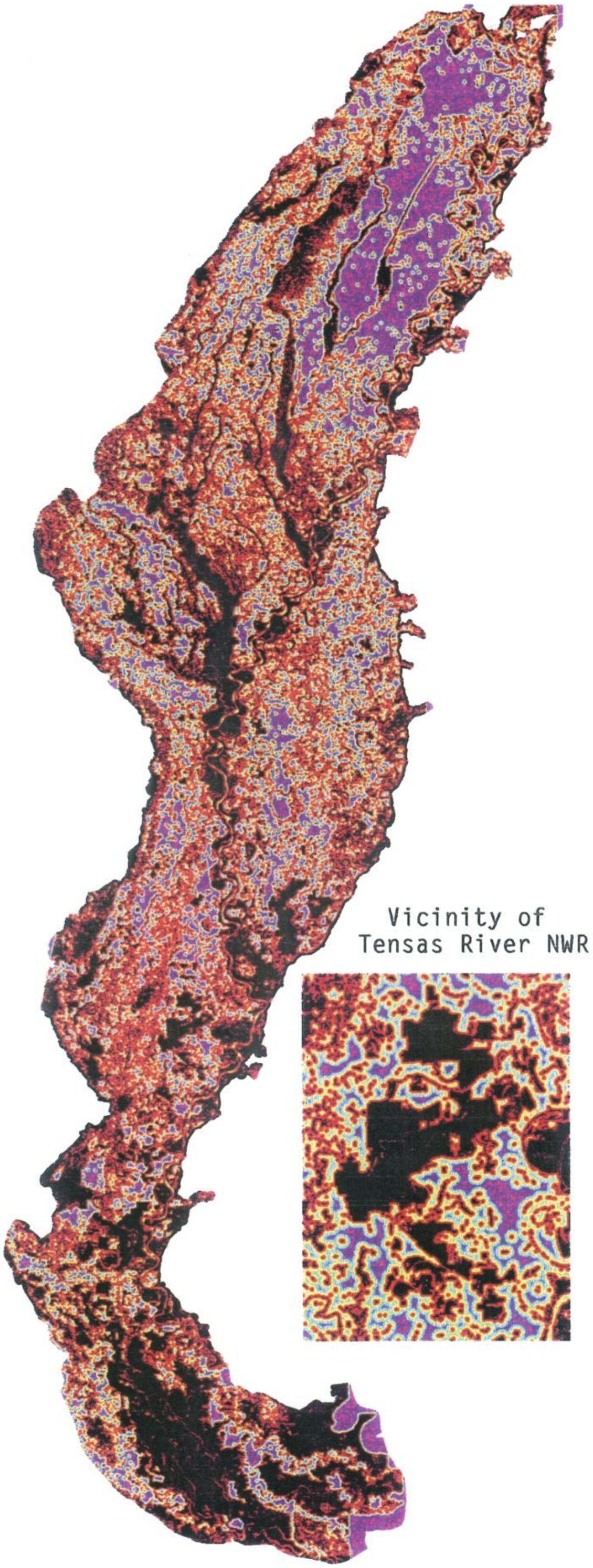
[c] High reforestation priority lands were ≥1 to <2 SD above mean reforestation priority.
[d] Moderate reforestation priority lands were <1 SD above mean reforestation priority.
[e] Relative rank for restoration among FBCR based on proportion of habitat objectives met by reforesting high priority areas (see below).
[f] Portions of FBCR lies outside our spatial coverage, hence data only reflect available information.

Restoration rank	Proportion of habitat objective met by reforestation of lands with highest reforestation priority.	Proportion of habitat objective met by reforestation of lands with highest reforestation priority.	Proportion of habitat objective met by reforestation within BCR regardless of reforestation priority.
10	>100%	-	-
9	>50%	>100%	-
8	>25%	-	>100%
7	>10%	-	>100%
6	>5%	-	>100%
5	<5%	-	>100%
4	-	>100%	-
3	-	-	>80%
2	-	-	>50%
1	-	-	>25%
0	-	-	<25%
G3	High proportion of high reforestation priority land; habitat objective marginally exceeded.		
G2	Moderate proportion of high reforestation priority land relative to area by which habitat objective exceeded.		
G1	Low proportion of high reforestation priority land; habitat objective greatly exceeded.		

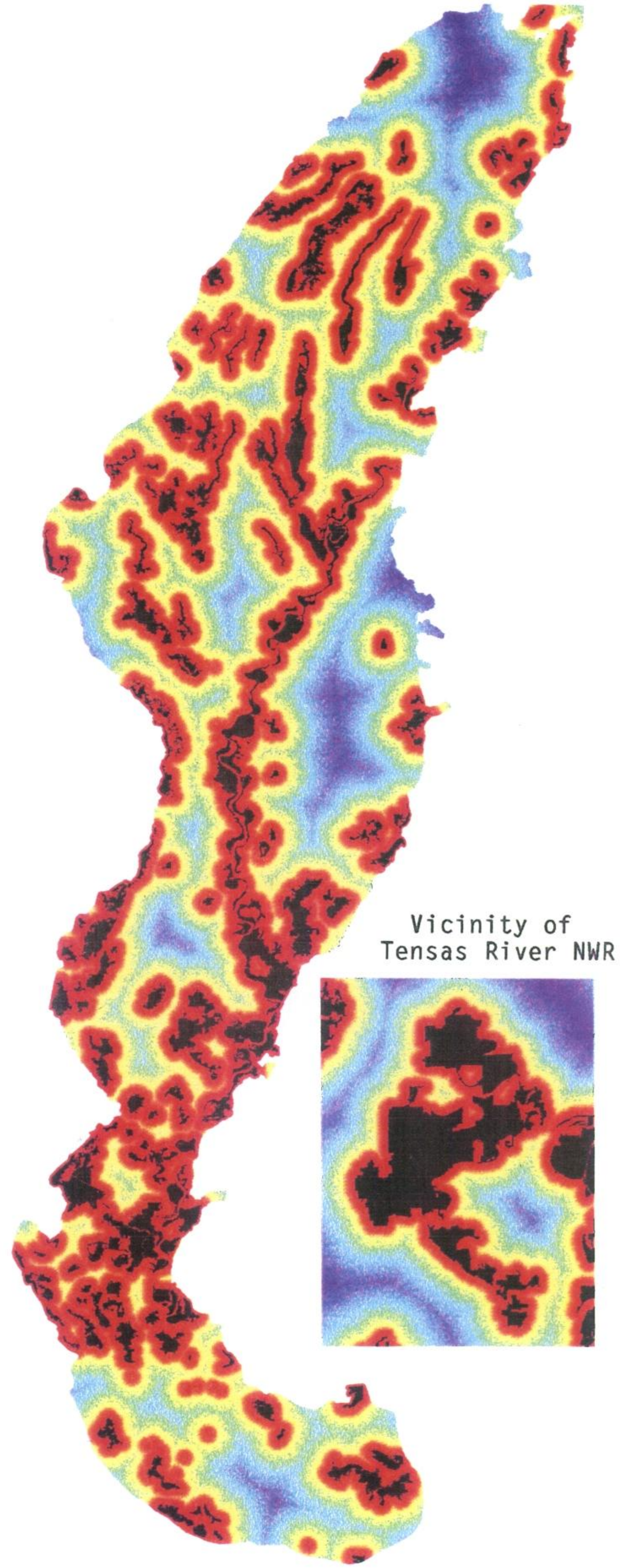


Illinois
Missouri
Kentucky
Tennessee
Arkansas
Mississippi
Louisiana
N
W
E
S
0
50
100 kilometers

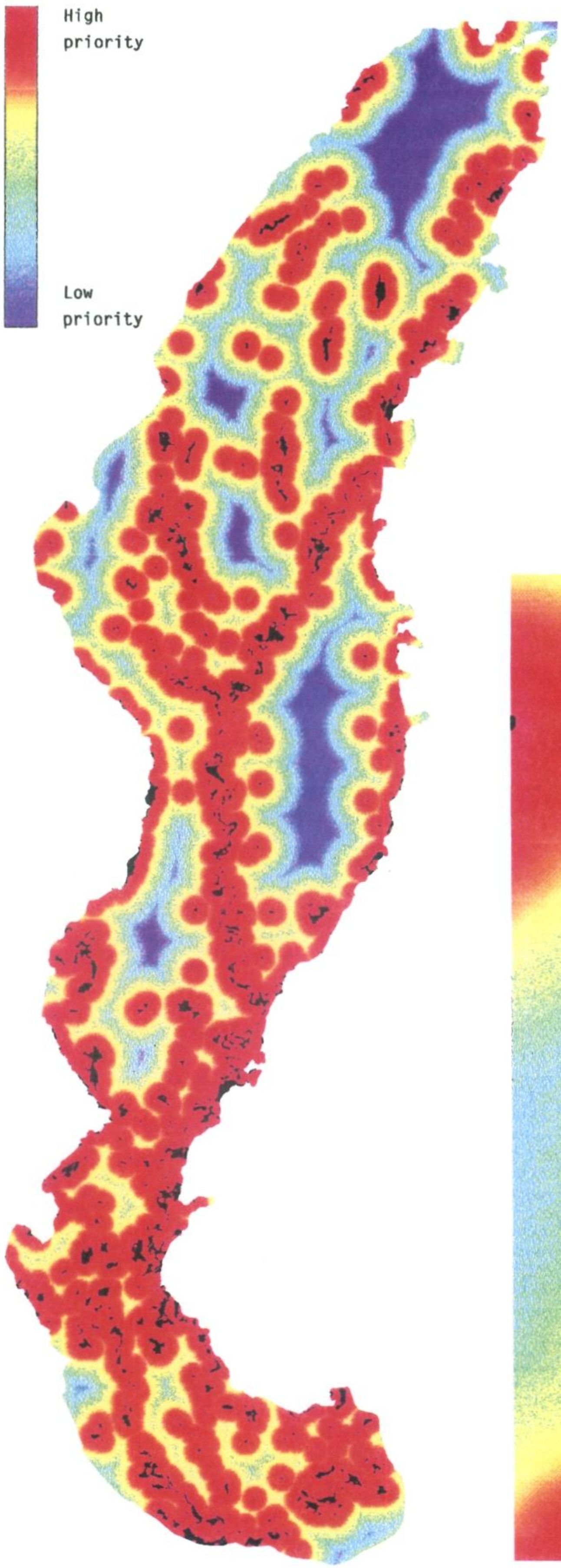
Distance from all existing forest patches

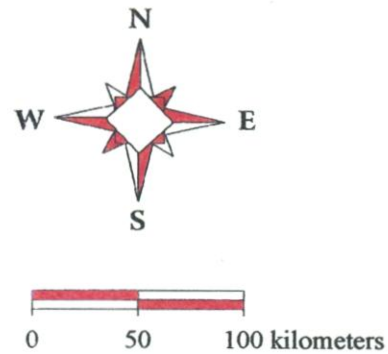


Distance from forest patches between 1,012 and 40,000 ha

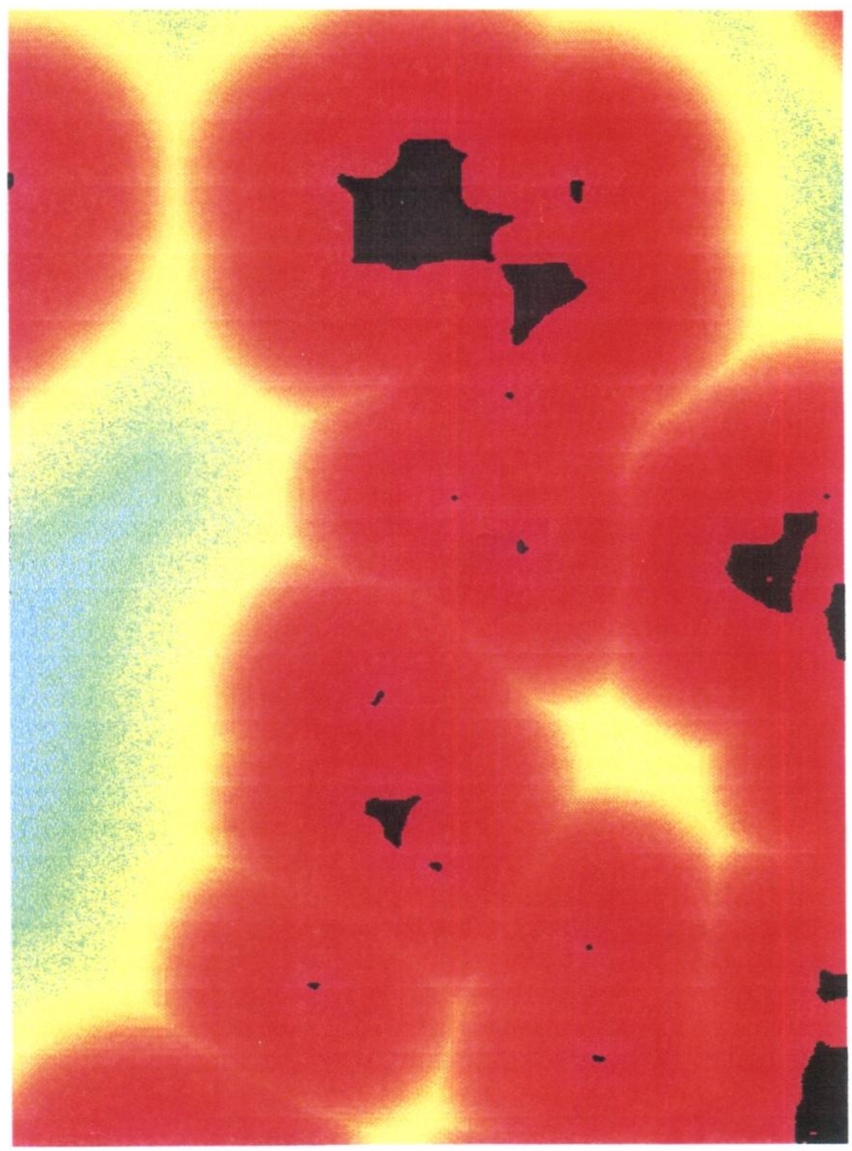


Distance from forest cores of <5,200 ha



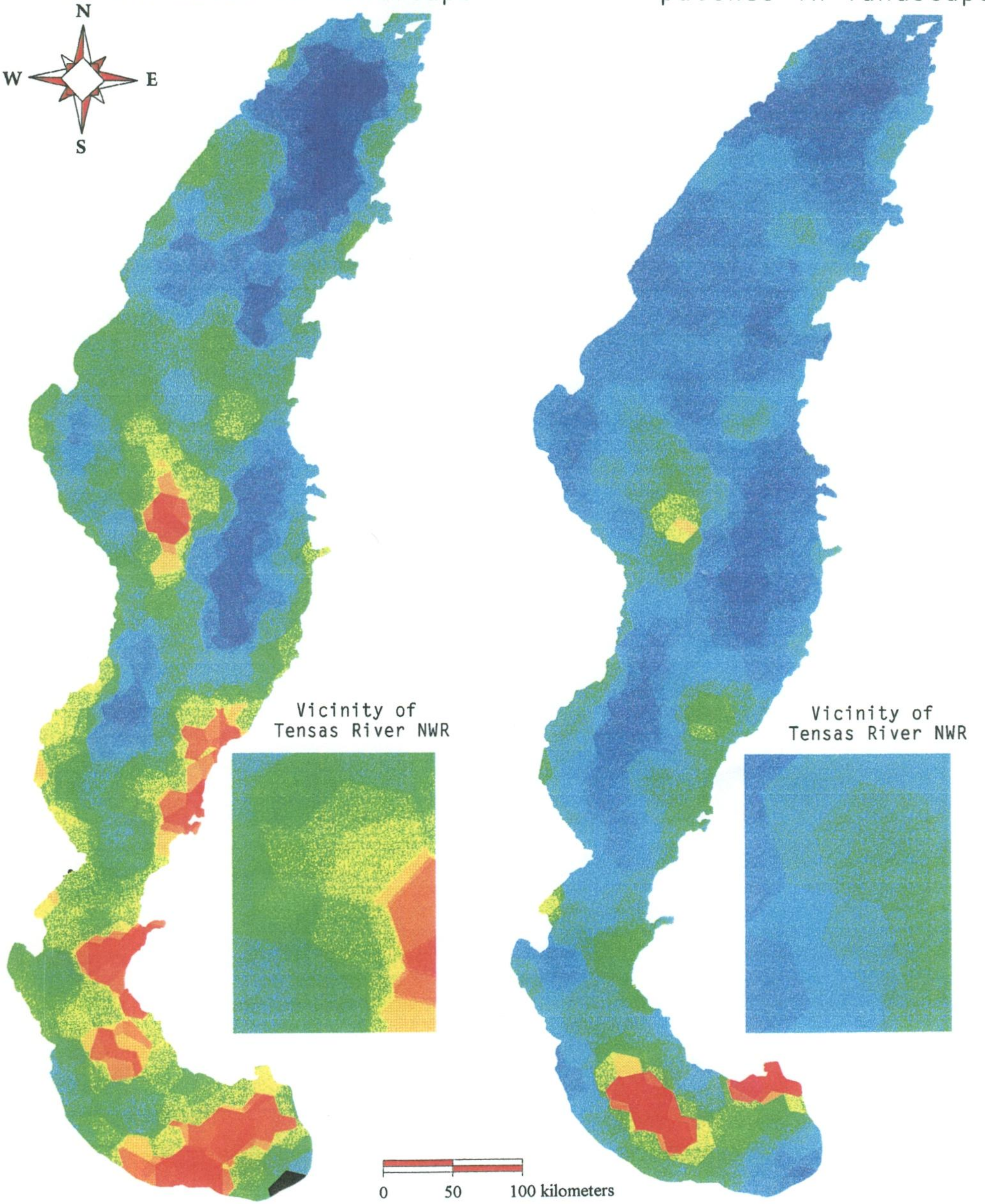


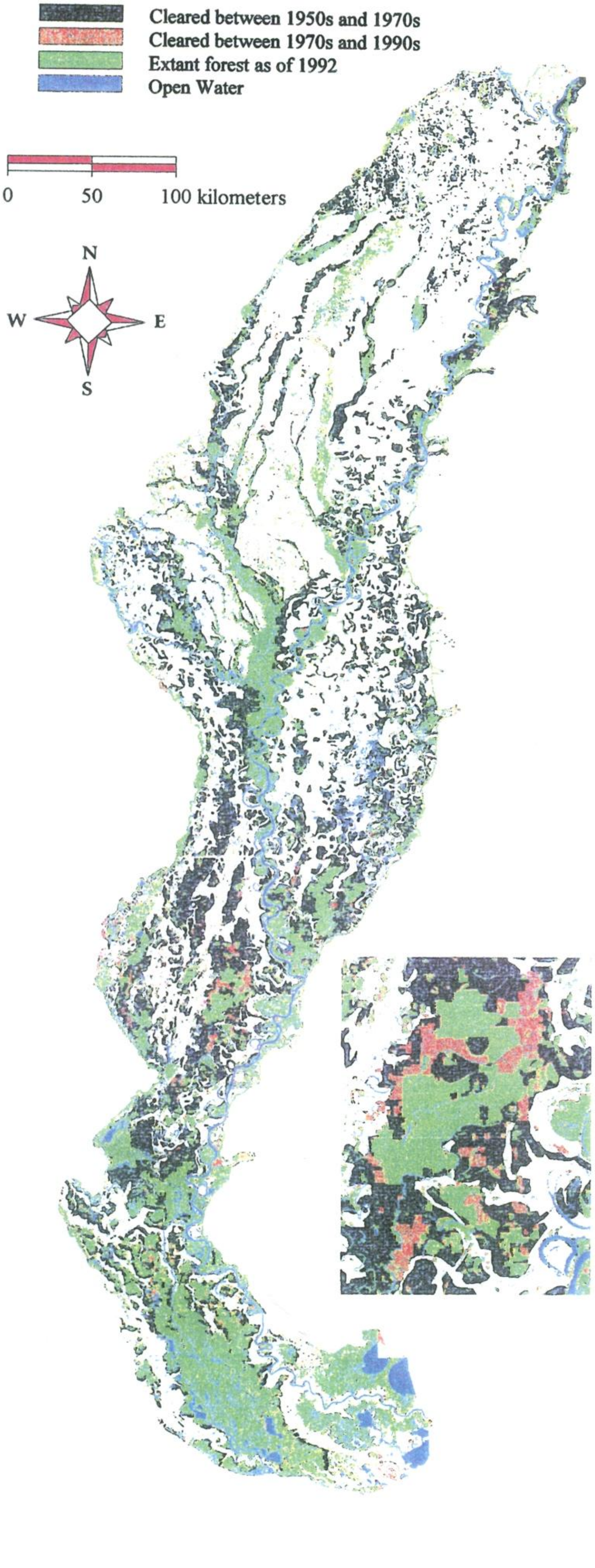
Vicinity of Tensas River NWR
Tallulah, LA



"Adjusted" percent forest cover in landscape

Mean size of forest patches in landscape




Cleared between 1950s and 1970s
Cleared between 1970s and 1990s
Extant forest as of 1992
Open Water
0
50
100 kilometers
N
W
E
S

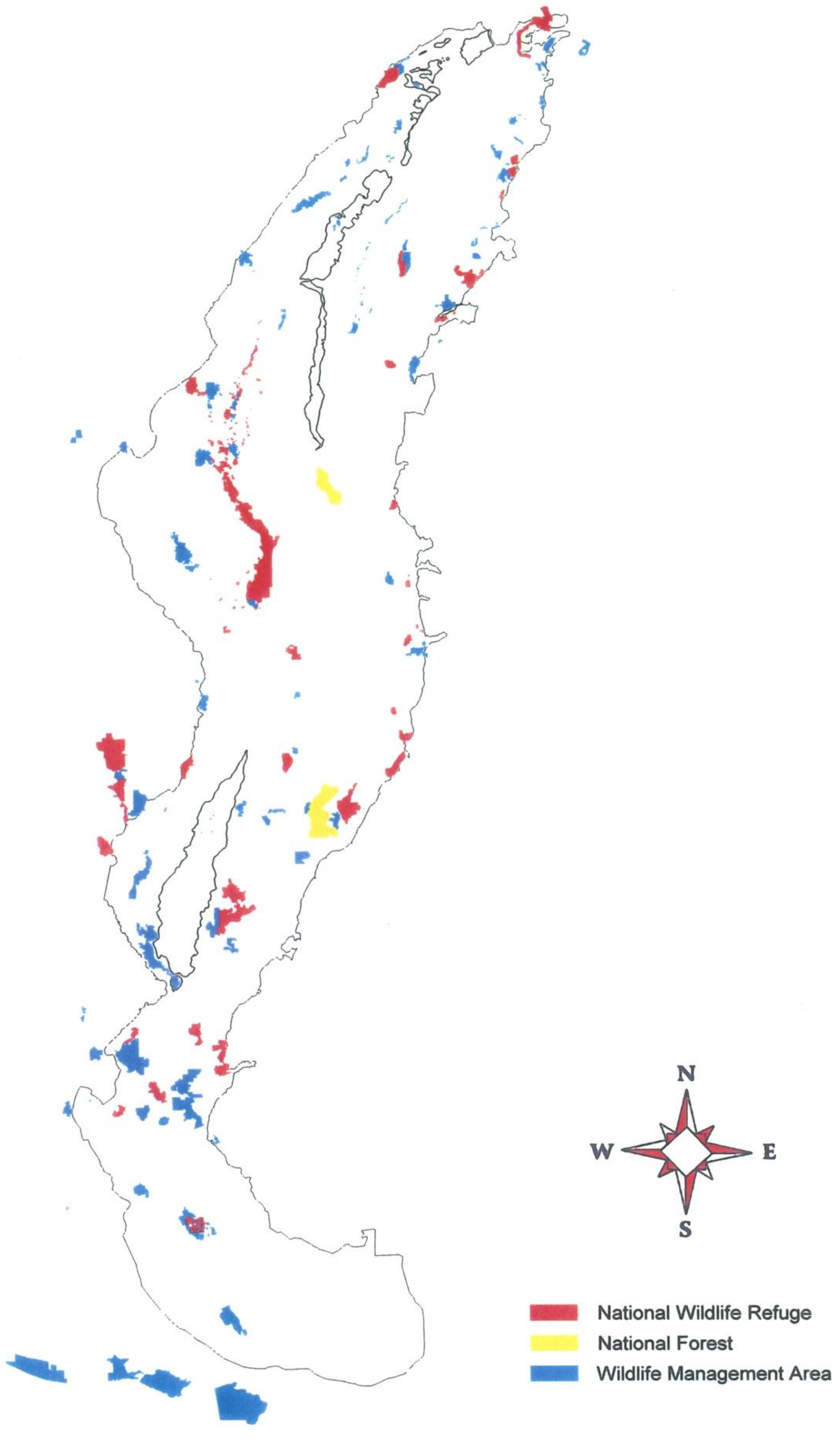
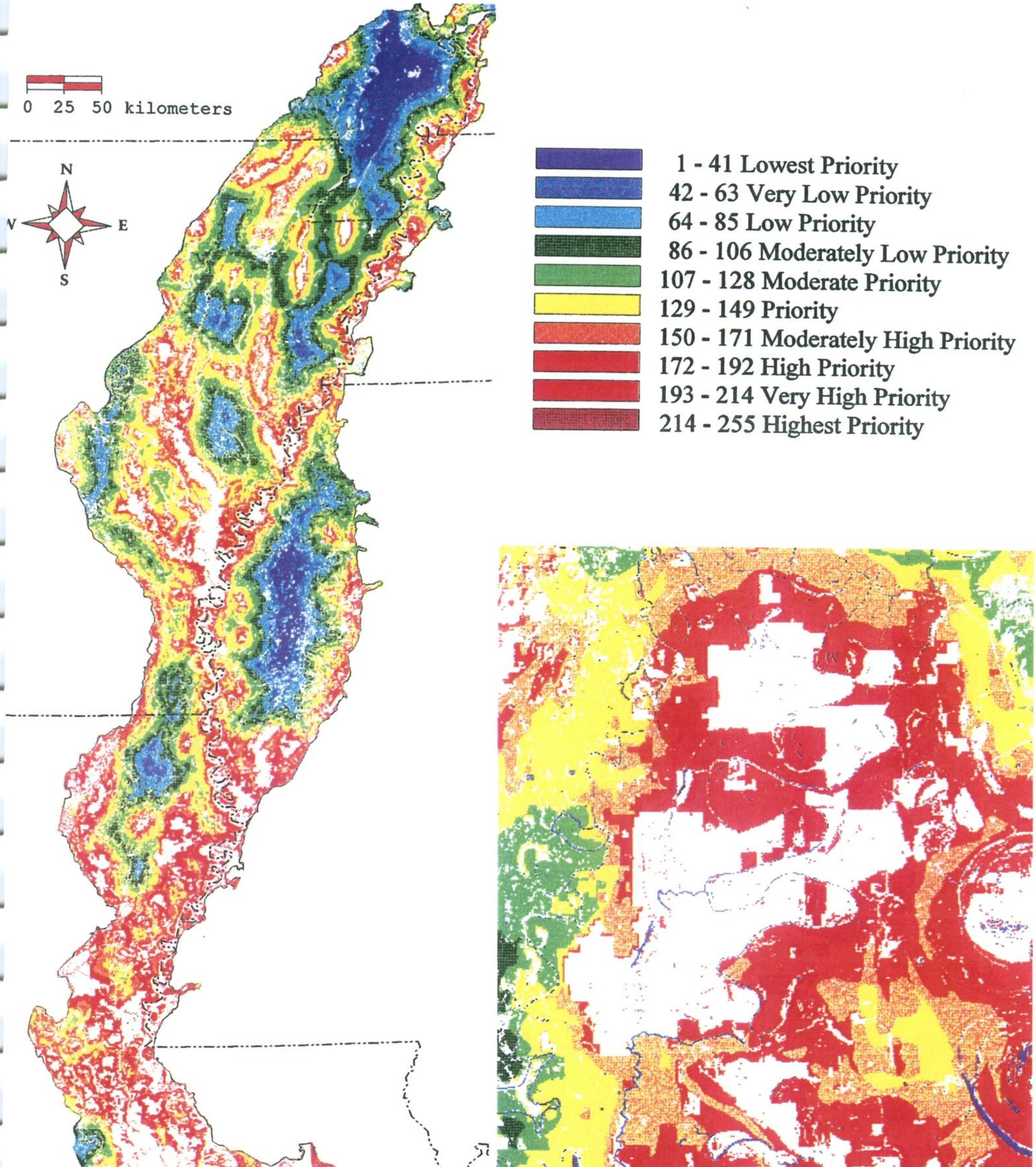
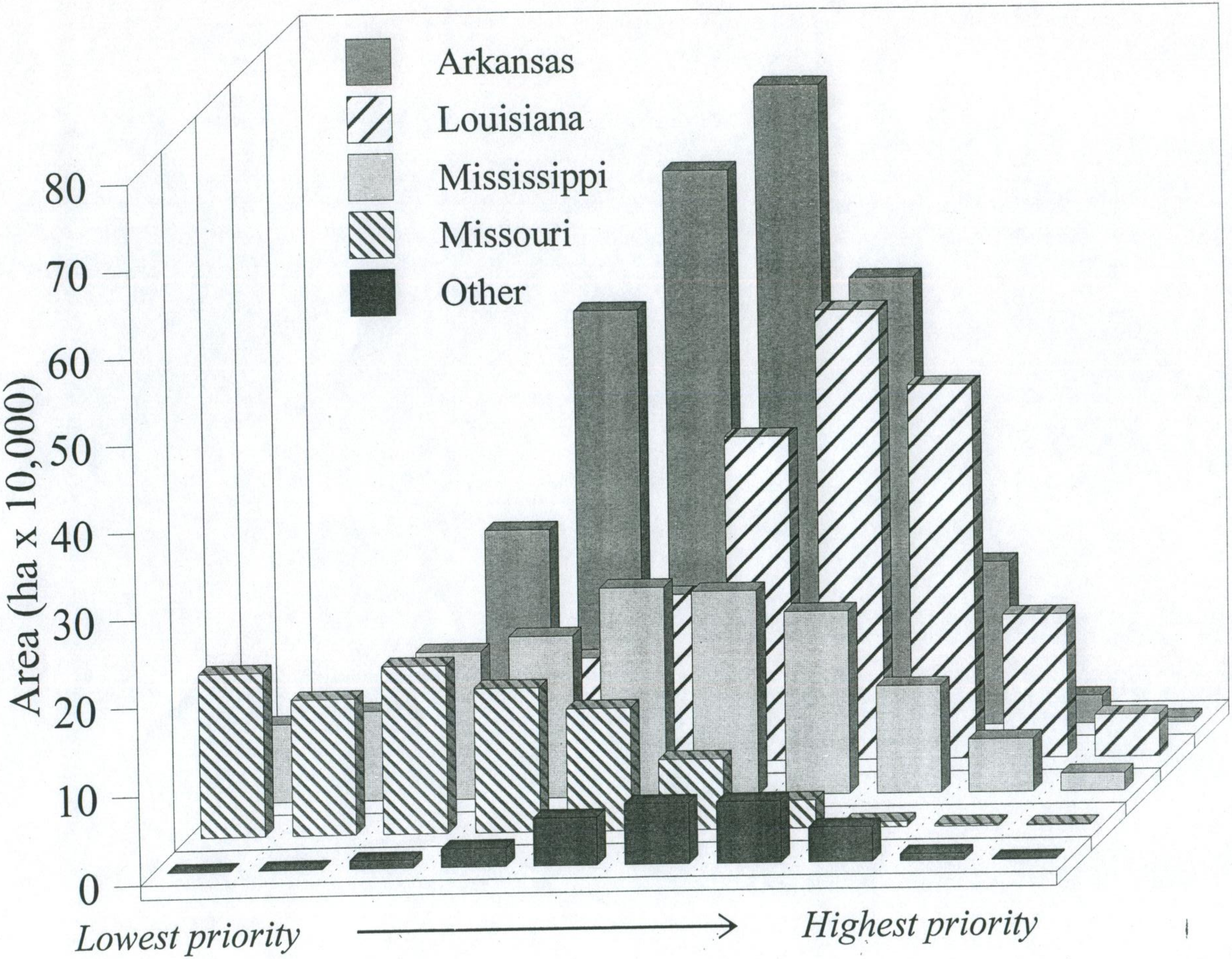
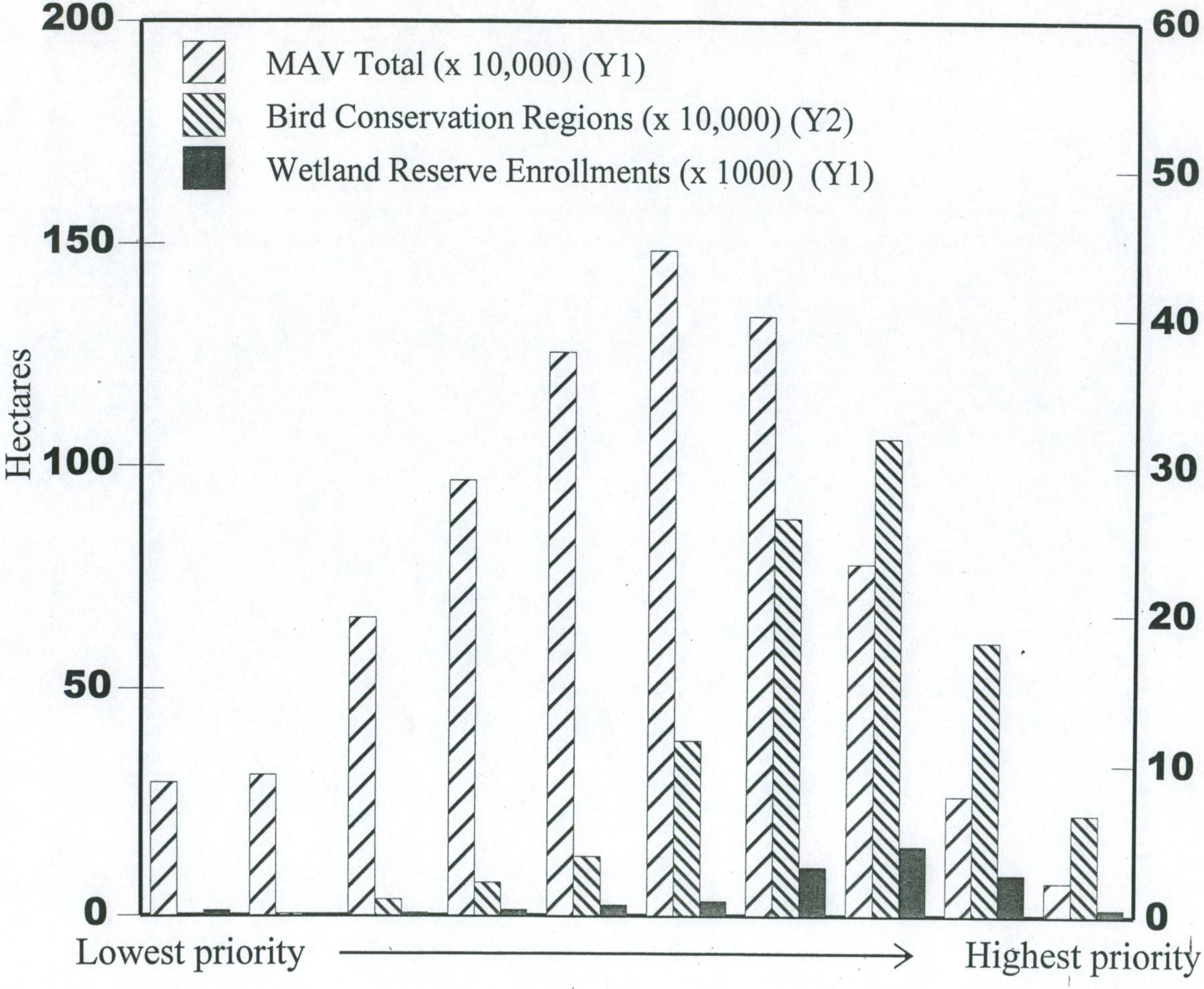

N
W
E
S
National Wildlife Refuge
National Forest
Wildlife Management Area

FIGURE 6.


0 25 50 kilometers
N
W
E
S
1 - 41 Lowest Priority
42 - 63 Very Low Priority
64 - 85 Low Priority
86 - 106 Moderately Low Priority
107 - 128 Moderate Priority
129 - 149 Priority
150 - 171 Moderately High Priority
172 - 192 High Priority
193 - 214 Very High Priority
214 - 255 Highest Priority


Arkansas
Louisiana
Mississippi
Missouri
Other
Area (ha x 10,000)
0
10
20
30
40
50
60
70
80
Lowest priority
Highest priority


MAV Total (x 10,000) (Y1)
Bird Conservation Regions (x 10,000) (Y2)
Wetland Reserve Enrollments (x 1000) (Y1)
Hectares
200
150
100
50
0
60
50
40
30
20
10
0
Lowest priority
Highest priority