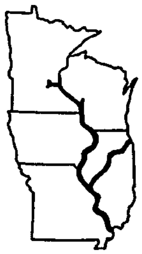

Long Term Resource Monitoring Program

Technical Report

97-T001

Geographic Information System Modeling Procedures for the Upper Mississippi River System Migratory Bird Pilot Project

February 1997

LTRMP Technical Reports provide Long Term Resource Monitoring Program partners with scientific and technical support.

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Geographic Information System Modeling Procedures for the Upper Mississippi River System Migratory Bird Pilot Project

by
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February 1997

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Prepared in partial fulfillment of *Monitor and Evaluate Wildlife* (Strategy 2.2.9)
and *Prepare Management Alternatives* (Strategy 3.2.1) of the
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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report was prepared by the Geographic Information Systems and Remote Sensing Applications Branch, Information Systems Support Division of the EMTC. The strategies for conducting spatial analysis to map migratory bird habitat in the Upper Mississippi River Basin are included in the LTRMP Operating Plan (USFWS 1993) as Strategy 2.2.9, *Monitor and Evaluate Wildlife*, and Strategy 3.2.1, *Prepare Management Alternatives*. This report was developed with partial funding provided by the Long Term Resource Monitoring Program.

Geographic Information System Modeling Procedures for the Upper Mississippi River System Migratory Bird Pilot Project

By Carol D. Lowenberg

Abstract

The Management Strategy for Migratory Birds on the Mississippi River corridor from Wabasha, Minnesota, to St. Louis, Missouri (Strategy), is a cooperative effort of the U.S. Fish and Wildlife Service, the Biological Resources Division of the U.S. Geological Survey, the Illinois Department of Natural Resources, the Illinois Natural History Survey, the Iowa Department of Natural Resources, the Minnesota Department of Natural Resources, the Missouri Department of Conservation, and the Wisconsin Department of Natural Resources and is designed to create an "integrated, ecological, and proactive approach to management of habitats used by migratory bird populations" within the Upper Mississippi River System. The Migratory Bird Pilot Project was conducted to determine what types of products could be generated from data collected through a literature search. The initial literature search was conducted by the U.S. Fish and Wildlife Service, followed by a literature search conducted by the National Biological Service's Upper Mississippi River Science Center. These data were delivered to the Environmental Management Technical Center where they were compiled and entered into a geographic information system (GIS). The information were then processed for three study sites along the Mississippi River to determine what types of products could be produced. This report addresses technical issues associated with the creation of the potential habitat coverages. The results have garnered the support of the U.S. Fish and Wildlife Service and the five participating states as a potential and viable management tool. Follow-up will include the verification of GIS habitat coverages through ground surveys, expansion to a larger study area for an increased number of bird species, and the development of tools required for technology transfer to managers in the field. The data and analysis procedures will be valuable in assisting the U.S. Army Corps of Engineers and participating federal and state agencies in planning and constructing future Habitat Rehabilitation and Enhancement Projects as part of the Upper Mississippi River Environment Management Program.

Introduction

The Upper Mississippi River (UMR) corridor provides critical habitat for millions of migratory birds each year. The long-term viability of the UMR as a resource for migratory birds is threatened by the adverse effects of sedimentation and many human-induced influences. Wise stewardship of this politically and ecologically complex river system depends on a thorough understanding of its biological relations.

The Management Strategy for Migratory Birds on the Mississippi River corridor from Wabasha, Minnesota, to St. Louis, Missouri (Strategy), proposes an "integrated, ecological, and proactive approach to management of habitats used by migratory bird populations." The critical management concern is to "ensure that habitat quality and availability on the UMR corridor are sufficient to support and enhance populations of migratory birds." The U.S. Fish and Wildlife Service proposed a cooperative effort on a Pilot Project for the Strategy to address these concerns. The Environmental Management Technical Center (EMTC) provided the technical assistance in the development of geographic information system (GIS) coverages and spatial analyses to meet the goals of the Pilot Project. The names of bird species studied during the Pilot Project follow.

Common and scientific names of birds:

Spotted sandpiper	*Actitis macularia*
Brown-headed cowbird	*Molothrus ater*
Pileated woodpecker	*Dryocopus pileatus*

Swamp sparrow	*Melospiza georgiana*
Cerulean warbler	*Dendroica cerulea*
Golden-winged warbler	*Vermivora chrysoptera*
Wood thrush	*Hylocichla mustelina*
Carolina wren	*Thryothorus ludovicianus*
Great crested flycatcher	*Myiarchus crinitus*
Mallard	*Anas platyrhynchos*
Canvasback	*Aythya valisineria*
Red-shouldered hawk	*Buteo lineatus*
Great blue heron	*Ardea herodias*
American bittern	*Botaurus lentiginosus*
Yellow-billed cuckoo	*Coccyzus americanus*
Barred owl	*Strix varia*
Prothonotary warbler	*Protonotaria citrea*

Discussion

The portion of the Pilot Project conducted at the EMTC addresses the technical aspect of the Strategy. This includes the development of potential habitat coverages, in a GIS format, for a selected set of species on the basis of their associations with vegetation classes, as determined by a literature review. The land cover/use classes contained in GIS coverages for selected study areas would be linked to the habitat requirements of the bird species, resulting in the development of a matrix. This document shows the use and application of GIS technology to develop individual species potential habitat coverages and how the coverages were combined to display species-rich areas. The success of the Pilot Project has garnered the support of the U.S. Fish and Wildlife Service and the five participating states as a potential and viable management tool. Followup will include the verification of GIS habitat coverages through ground surveys, expansion to a larger study area for an increased number of bird species, and the development of tools required for technology transfer to managers in the field. The data and analysis procedures will be valuable in planning and constructing future habitat projects by the U.S. Army Corps of Engineers as part of the Upper Mississippi River Environment Management Program.

Study Sites

Two regions of the UMR and three study sites were chosen for the Pilot Project. Two of the study sites coincided with areas where existing high-resolution land cover/use data were available—UMR Pools 8 and 19. The third study site was a 64-km corridor coverage that included upland areas adjacent to Pool 8.

Pool 8 is a 39-km impounded stretch of the Mississippi River extending from Lock and Dam 8 (River Mile 679) near Genoa, Wisconsin, to Lock and Dam 7 (River Mile 703) just north of La Crosse, Wisconsin. The study site extended from Lock and Dam 8 in the south to Lock and Dam 7 in the north, with the Wisconsin bluff line defining the eastern boundary, and the Minnesota bluff line defining the western boundary.

Pool 19 is a 76-km stretch of the Mississippi River extending from Lock and Dam 19 (River Mile 364) near Keokuk, Iowa, to Lock and Dam 18 (River Mile 411) north of Burlington, Iowa, with the Illinois bluff line defining the eastern boundary, and the Iowa bluff line defining the western boundary. Pool 19 is unique in that Dam 19 was the first navigation dam built on the Mississippi, and it is also the only hydroelectric dam within the region of the river that is open to commercial navigation.

Methods

GIS Coverages

Floodplain Data

The selection of the study sites was influenced by the availability of existing computerized land cover/use data. Both 1975 and 1989 high-resolution land cover/use data were available for Pools 8 and 19. Background information about the creation and automation of the 1975 coverages, a listing of the 1975 land classification scheme, and color prints of the generalized land cover/use data are in Appendix A. Appendix A also contains similar data for the 1989 coverages and a master listing of the Long Term Resource Monitoring Program's (LTRMP) land cover/use classification codes.

Corridor Data

The 64-km corridor coverage was created by using 1989 Landsat Thematic Mapper Data, Digital Elevation Model data (DEM), U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) data, Wisconsin Wetland Inventory Data, and U.S. Geological Survey Digital Line Graph (DLG) data.

According to the U.S. Natural Resource Conservation Service (unpublished data), agricultural fields within this area tend to be located outside the main floodplain of a river or stream and in areas that have <20% slope. Therefore, if an area originally classified as grasses/forbs existed in an area with <5% slope and >91-m elevation, the area was reclassified as upland agriculture. Areas classified as agriculture at elevations <91 m and slopes <5% were classified as grasses/forbs, since these parameters describe very flat areas of grasses that occur at the elevation of the river. Areas classified as agriculture occurring on slopes >20% were reclassified as grasses/forbs.

Groundtruthing revealed the Landsat imaging scanners had difficulties detecting areas of open water and aquatic vegetation occurring outside of the Mississippi River's floodplain. These losses were compensated for by incorporating wetland and DLG data. Both coverages were rasterized by using a 5-m cell resolution before they were incorporated onto the 30-m Landsat coverage. The final coverage utilized during the Pilot Project was 30 m, so much of the DLG data and some of the smallest NWI features were not included in the final coverage.

The resulting coverage contained the following land cover/use types ([1]from NWI data):

[1]Open water
[1]Submergents
[1]Submergents-rooted floating aquatics
[1]Rooted floating aquatics
[1]Rooted floating aquatics-emergents
[1]Emergents
[1]Emergents-grasses/forbs
Grasses/forbs
Woody terrestrial

Upland forests
[1]Bottomland forests
[1]Bottomland shrub
Agriculture
Urban/developed

Literature Search and Matrix Development

Information from the literature search was not always consistent with habitat on the UMR; however, for the purposes of the Pilot Project, matrices were developed to demonstrate the use of GIS to locate potential migratory bird habitat. Field verification will be used to update the matrices and models.

Two types of literature searches were conducted: (1) the gathering of knowledge learned through the personal experience of individuals working on the river, and (2) a search of written documentation.

Appendix B contains the results of the first search. The planning team for the Pilot Project reviewed each species and discussed habitat requirements; the findings were then recorded and entered into matrix tables containing LTRMP's generalized land cover/use classification codes.

The second search (Appendix C) was completed in two phases. The first phase began with a computerized literature search conducted by library personnel of the Upper Mississippi Science Center (UMSC) at La Crosse, Wisconsin. Articles located by this search were then mailed to the U.S. Fish and Wildlife Service, Rock Island, Illinois, where the documents were reviewed and synthesized (Jacobson 1993).

The second phase was conducted at the UMSC using documents housed at the center. Data generated from these searches were then entered into matrices developed by the UMSC.

The matrices related the LTRMP's genus-level classification codes to seven life-cycle categories and management classifications used by the Upper Mississippi River National Wildlife and Fish Refuge and the UMSC:

Spring migration
Pre-breeding
Nesting
Brood rearing
Post-breeding
Fall migration
Wintering
Management area: WAM-1
Management area: WAM-2
Spatial modifier: close
Spatial modifier: medium
Spatial modifier: far
Minimum area requirements: hectares

The persons who conducted the literature search converted habitat data contained within the literature to the matrices by using one of two methods. Direct references categorizing particular land cover/use types as habitat were entered into the matrix as numeric entries. References mentioning specific land cover relations or minimum habitat requirements were recorded as literature citations accompanying the matrices.

Automating the Matrix Data

As each matrix was completed, it was compiled at the EMTC and entered into the GIS program ARC/INFO.

The numeric matrix data were automated as INFO lookup tables. Seven lookup tables were created, one for each of the seven life-cycle categories (spring migration, pre-breeding, nesting, brood rearing, post-breeding, fall migration, and wintering). The remaining six categories were not automated since few entries were made within them. Each INFO lookup table contained entries for all LTRMP land cover/use classification codes and each classification code was related to 24 data categories or items. A single record from the nesting cycle lookup table follows. The land cover/use category listed in the example was used to define which species of birds have the potential for using cattails (*Typha*) as nesting habitat:

```
VEG_CODE            = 719
LCU                 = Typha
LCU-13              = Emergents
CLASS               = 7
VALUE               = 2
TOTAL               = 4
AMERICAN_BITTERN    = 1
GREAT_B_HERON       = 0
CANVASBACK          = 0
MALLARD             = 1
RED_S_HAWK          = 0
SORA                = 1
SPOT_SANDPIPER      = 0
YELLOW_B_CUCKOO     = 0
BARRED_OWL          = 0
PIL_WOODPECKER      = 0
CAROLINA_WREN       = 0
GR_CR_FLYCATCHER    = 0
WOOD_THRUSH         = 0
BR_HEAD_COWBIRD     = 0
CERULEAN_WARBLER    = 0
GOLDEN_W_WARBLER    = 0
PROTH_WARBLER       = 0
SWAMP_SPARROW       = 1
```

The first five items in the lookup table were used to relate matrix data to the LTRMP land cover/use coverages. The items VEG_CODE and LCU link the habitat data to LTRMP genus-level data. The next two items, LCU-13 and CLASS, link habitat data to LTRMP's 13-class generalized land cover/use data. The last land cover item is VALUE. VALUE links the habitat data to the 1989 Landsat Thematic Mapper coverage created for the entire UMRS floodplain.

The remaining items name which species and how many species use *Typha* as potential nesting habitat. All species that have the potential of using *Typha* as nesting habitat were assigned a numeric value of 1. Likewise, species unlikely to use *Typha* are assigned a numeric value of zero. The numeric entries were chosen to make species richness calculations easier. Once modeling is completed for a region, a numeric calculation could be performed to total the number of species using an area. A total value of 1 would mean that only one species would potentially use the area, whereas a total value of 5 would mean that five species may potentially use the area.

The final lookup tables were rather complicated, so initial data entry was completed in several stages for easier data verification. Initially, seven lookup tables were created for each species, one for each life-cycle category. Each table contained two items, VEG_CODE and species. Land cover/use types listed within the matrices as potential habitat were then entered into the lookup tables one record at a time.

The creation of individual lookup tables proved to be an effective way to enter the data. Although many (126) lookup tables were created, the individual lookup tables made data addition and verification fairly easy. This was important, since groups of matrices were arriving every few days for several weeks. An example of a lookup table created for the sora's nesting cycle is as follows:

$RECNO	VEG_CODE	SORA
1	507	1
2	702	1
3	706	1
4	708	1
5	709	1
6	710	1
7	712	1
8	713	1
9	714	1
10	715	1
11	716	1
12	717	1
13	718	1
14	719	1
15	720	1
16	721	1
17	722	1
18	723	1
19	724	1
20	725	1
21	902	1
22	903	1
23	905	1
24	914	1
25	918	1
26	1301	1

Appendix D contains the ARC/INFO commands used to create the lookup tables.

Once all the matrix data were entered, the individual tables were combined with a master lookup table containing all LTRMP classification codes.

Computer Modeling

The matrix data and supplementary data (literature citations) were used to create habitat coverages that classified a study area as either habitat or nonhabitat. The matrix entries defined which land cover types should be considered potential habitat, and the supplementary data were used to further define the regions. While the modeling procedure used to identify areas containing potential habitat were customized for each species studied, all computer-generated habitat models were created using one of three methods:

1. Matrix data were the only source of input data used to create the potential habitat coverages.

2. Vegetation densities, tree heights, and minimum habitat size were used in conjunction with the matrix data to locate potential habitats.

3. Habitat relations (e.g., distance from water, locating adjacent land cover types) were also used to locate potential habitat types.

Each process produced coverages that located potential habitat within the study areas.

Method One

Supplementary data were provided for most of the species studied during the Pilot Project. However, for three of the species studied either these data were not available or they could not be effectively modeled. Species whose habitat coverages were created by using only data contained within their matrices were the sora (*Porzana carolina*), the spotted sandpiper (*Actitis macularia*), and the brown-headed cowbird (*Molothrus ater*). The following sections contain information on modeling procedures used to create potential habitat coverages for these birds.

Sora. Most of the literature citations provided with the sora's matrices referenced the sora's use of specific plant types. The only spatial modeling references provided state the sora can be found in shallower waters (i.e., <15 cm; Griese et al. 1980K[1]). Also, migratory sora along the northern Mississippi River use water depths of 5–15 cm (Sayre and Rundle 1984K).

Unfortunately, modeling such narrow water depth requirements would not be accurate as the bathymetric data are accurate to 0.3 m. Also, mention was made as to river level or pool condition. All bathymetric data are calculated to "flat pool." The Mississippi is a dynamic river system, and such a narrow water depth restriction, if mappable, would not be static. Specific, narrow-ranged, shallow water depth requirements can be expected to shift in their location whenever river flows change.

The sora's habitat coverages were created by relating the individual matrices to the land cover/use coverages, then by performing dissolves.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 spring6 lcu89//sora
 Dissolving lcu89 by lcu89//sora to create spring6
 Creating spring6.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =       6172         298
Number of Arcs     (Input,Output) =      16091         347
 Creating spring6.PAT...
```

[1]The letters J and K following the year in text citations refer to the persons who recorded the citation from the literature. K represents C. E. Korschgen and J represents T. Jacobson.

Spotted Sandpiper. Literature citations provided with the matrices for the spotted sandpiper mentioned the birds tend to inhabit water edges, while the matrices listed several vegetation types as potential habitat. According to one literature citation, the spotted sandpiper can sometimes be found far from water in dry fields, pastures, and weedy shoulders of roads (DeGraaf et al. 1991J). Another citation stated the spotted sandpiper could be found along rivers, wooded ponds, dikes, and roadways near water (Dinsmore et al. 1984J).

No "near to water" or "far from water" distances were provided, so these variables were not mapped. Therefore, the spotted sandpiper coverages were created by relating the matrices to the land cover/use coverages.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 spring7 lcu89//spot_sandpiper
 Dissolving lcu89 by lcu89//spot_sandpiper to create spring7
 Creating spring7.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6172        249
Number of Arcs     (Input,Output) =     16091        419
 Creating spring7.PAT...
```

Brown-headed Cowbird. The only literature citations provided for use with the brown-headed cowbird's matrices stated the species is known to occur in Louisiana borrow pits (Landin 1985J), and it has been observed living in woodlands defoliated by gypsy moths (*Lymantria dispar*; DeGraaf 1987J). Several seasonal plant food references were also supplied. Since no spatial references were provided, habitat coverages were created only by relating information contained within the matrices to the land cover/use data and performing dissolves.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 spring14 lcu89//br_head_cowbird
 Dissolving lcu89 by lcu89//br_head_cowbird to create spring14
 Creating spring14.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6172        1666
Number of Arcs     (Input,Output) =     16091        2191
 Creating spring14.PAT...
```

Method Two

Most matrices came with literature citations that referenced specific vegetation densities, tree heights, or minimum habitat size requirements. An example of a habitat coverage created using these data are those created for the golden-winged warbler (*Vermivora chrysoptera*). Supplemental data for the golden-winged warbler indicate that it prefers nesting sites where vegetation is clumped over dense stands. The golden-winged warbler typically nests in old fields that contain many small trees (<6 m tall) and in shrubs. Modeling for this species began with the elimination of polygons labeled as trees >6 m tall and tree stands that have >33% vegetation cover from the database. The resulting data were then modeled by using the nesting season matrix. (Only areas containing trees were altered before processing the data with the nesting matrix. All data for aquatic vegetation, grasslands, urban developments, and unvegetated regions were unaltered.)

The seven bird species with habitat coverages created by this method were the following: pileated woodpecker (*Dryocopus pileatus*), swamp sparrow (*Melospiza georgiana*), cerulean warbler (*Dendroica cerulea*), golden-winged warbler (*Vermivora chrysoptera*), wood thrush (*Hylocichla mustelina*), Carolina wren (*Thryothorus ludovicianus*), and great crested flycatcher (*Myiarchus crinitus*). The following contains information on modeling procedures used to create potential habitat coverages for these birds.

Pileated Woodpecker. Most of the literature citations provided with the pileated woodpecker matrices mention that the birds use dense, older forests. Mellen et al. (1992K) found that in Oregon the pileated woodpecker roosted in the >70-yr habitat classes. Bull (1975K) defined the critical habitat of the pileated woodpecker as consisting of large snags and trees, diseased trees, dense forest stands, and high snag densities. Sayre and Rundle (1984J) stated that the pileated woodpecker uses the edges of balsam and cedar swamps when surrounded with forests of hardwood and hemlocks. Their nesting places are ordinarily in lowlands and near water. Bohlen and Zimmerman (1989J) also mentioned that the birds nest in bottomland forests.

A. Temporary coverages were created from the 1989 land cover/use data files. For the temporary coverages, all woody terrestrial vegetation <15 m tall and woody terrestrial vegetation >15 m that covered <90% of the polygon were removed. This was accomplished by utilizing ARC's reselect command. According to the first reselect statement, only areas classified as woody vegetation will be acted on. The second statement enables selection, from among the woody vegetation, of any polygon in which vegetation covers <90% of the polygon or contains woody vegetation <15 m tall. The third statement reverses the selection, creating a coverage containing polygons of tall, dense, woody vegetation, open water, aquatic vegetation, grasses, agriculture, urban areas, and bare ground.

```
Arc: reselect lcu89 pileat_t poly
 Reselecting POLYGON features from LCU89 to create PILEAT_T
Enter a logical expression. (Enter a blank line when finished)
>: res class = 10
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res closure_code < 4 or height_code < 3
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 6540 features out of 8489 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       8489       8109
Number of Arcs     (Input,Output) =      21321      20903
 Creating PILEAT_T.pat...
14517 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/PILEAT_T
```

B. The temporary file created for use with the 1975 coverages had the following classes removed from the land cover/use coverages.

Cottonwood and/or willow (ave. ht. <6 m)
Mixed lowland hardwoods (ave. ht. <6 m)
Open stand of mixed hardwoods with grass understory

```
Arc: reselect lcu75 pileat_t poly
 Reselecting POLYGON features from LCU75 to create PILEAT_T
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1055 or veg_code = 1057 or veg_code = 1058
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1739 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1808       1806
Number of Arcs     (Input,Output) =      4654       4652
 Creating PILEAT_T.pat...
3131 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/PILEAT_T
```

C. The pileated woodpecker habitat coverages were then created by relating the matrices to the pileated woodpecker's temporary files and then by performing dissolves.

```
Arc: relate add
Relation Name: pileat_t
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve pileat_t spring10 pileat_t//pil_woodpecker
 Dissolving pileat_t by pileat_t//pil_woodpecker to create spring10
 Creating spring10.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6084       1631
Number of Arcs     (Input,Output) =     15999       2713
 Creating sping10.PAT...
```

One major change was made to the pileated woodpecker's matrix; the matrix stated that open water was potential nesting habitat. If that category had been left in, all tributaries, backwaters, impounded areas, and the navigation channel would be considered nesting habitat. Water was removed from the matrix as possible nesting habitat since it was considered unlikely that a pileated woodpecker would build its nests in or on open water. If water is an important factor in nest site selection, it should be referenced as a spatial relation, not a habitat requirement. One way this could be addressed is to include a distance relation between suitable nesting habitat and open water (e.g., suitable habitat occurring within 0.6 km of open water).

Swamp Sparrow. Literature citations provided with the swamp sparrow's matrices state the swamp sparrow nests only in swamps and marshes. The swamp sparrow will reject a swamp overgrown with numerous trees and shrubs and will avoid open areas that dry up as the nesting season progresses. During fall migration, the swamp sparrow will disperse into more varied habitats, but it still shows a preference for tall grass (Robbins 1991K). Nests built within cattail stands are often built 0.3 m above water that is 15–60 cm deep (Bent ?J). DeGraaf et al. (1991J) noted the swamp sparrow prefers to nest within mixed vegetation stands over pure cattail stands. Bent (?J) noted the swamp sparrow regularly leaves the marshlands and can be found in all but deep woodland habitats. In winter, the swamp sparrow frequents springs, seeps, and open brooks that have brushy cover nearby (Bent ?J).

Since most of the literature citations referenced the breeding season, and exceptions were listed specifically for the migration and wintering season, modeling processes were only completed on the pre-breeding, nesting, brood rearing, and post-breeding coverages.

A. Temporary coverages were created for the breeding season habitat coverages by first reselecting for woody terrestrial polygons. The second statement looks at the woody terrestrial vegetation to select polygons containing vegetation densities >68%. The third statement reverses selected features so the temporary coverage will contain all woody terrestrial polygons with vegetation densities <67%, open water, aquatic vegetation, grasses/forbs, agriculture, urban development, and bare soils.

```
Arc: reselect lcu89 swamp_t poly
 Reselecting POLYGON features from LCU89 to create SWAMP_T
Enter a logical expression. (Enter a blank line when finished)
>: res class = 10
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res closure_code = 3 or closure_code = 4
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 6220 features out of 8063 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      8063      7554
Number of Arcs     (Input,Output) =     20187     19587
 Creating SWAMP_T.pat...
13734 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/SWAMP_T
```

B. Temporary coverages for the 1975 land cover/use data were created by removing the following vegetation types:

Cottonwood and/or tree willow (ave. ht. > 20 ft)
Cottonwood and/or willow (ave. ht. <6 m)
Mixed lowland hardwood (ave. ht. > 20 ft)
Mixed lowland hardwoods (ave. ht. <6 m)

```
Arc: reselect lcu75 swamp_t poly
 Reselecting POLYGON features from LCU75 to create SWAMP_T
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1055 or veg_code = 1056 or veg_code = 1057 or
veg_code = 1059
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1449 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1808      1774
Number of Arcs     (Input,Output) =      4654      4611
 Creating SWAMP_T.pat...
3128 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/SWAMP_T
```

C. The pre-breeding, nesting, brood rearing, and post-breeding habitat coverages were then created by relating the temporary coverage to the matrices and by performing dissolves.

```
Arc: relate add
Relation Name: swamp_t
Table Identifier: pre_breeding.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve swamp_t pre_brd18 swamp_t//swamp_sparrow
 Dissolving swamp_t by swamp_t//swamp_sparrow to create pre_brd18
 Creating pre_brd18.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      7554        2045
Number of Arcs     (Input,Output) =     19587        2355
 Creating pre_brd18.PAT...
```

D. The spring migration, fall migration, and wintering habitat coverages were created by relating the land cover/use coverages to the matrices and then by performing dissolves.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 sprint18 lcu89//swamp_sparrow
 Dissolving lcu89 by lcu89//swamp_sparrow to create spring18
 Creating spring18.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      8063          3
Number of Arcs     (Input,Output) =     20187          6
 Creating spring18.PAT...
```

Cerulean Warbler. Literature citations state the nests of the cerulean warbler are often found in deciduous forests (Kirkwood 1901K; Southern 1962K). Nests can be found in upland and lowland sites during the breeding season (Kirkwood 1901K; Bond 1957K; Southern 1962K; Lynch 1981K), but the cerulean warbler prefers floodplain sites (Chapman 1968K; Lynch 1981K; Graber et al. 1983K). In North Carolina, sites with the highest densities of cerulean warblers were characterized by a 24–30-m canopy (Lynch 1981K). In Wisconsin, cerulean warblers are likely to be found in medium (16–32 ha) and large (>32 ha) forest tracts (Bond 1957K). Cerulean warbler habitat in Missouri is characterized by a "large number of live stems >30 cm dbh (range = 50–150/ha) and a high (always >18 cm), closed canopy (>85%, never <65%; Hammel 1992K). Nests are generally built in large deciduous trees (Hands et al. 1989aJ), and cerulean warblers prefer rather open forests with tall trees and little undergrowth (DeGraaf et al. 1991J). The size of a forest tract seemingly is an important component of cerulean warbler habitat. Cerulean warblers were detected in a greater proportion of medium (16–36 ha) and large (>36 acres) tracts than in small (<40 acres; Hands et al. 1989aJ).

A. Temporary coverages were created from the 1989 land cover/use coverages using reselect. The first command reselects for all vegetation (trees) >15 m tall. The second statement then reselects the tall vegetation to remove polygons listed as having a vegetation cover of >90%.

```
Arc: reselect lcu89 cerulean_t polys
 Reselecting POLYGON features from LCU89 to create CERULEAN_T
Enter a logical expression. (Enter a blank line when finished)
>: res height_code = 3
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res closure_code = 4
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 575 features out of 8063 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      8489       751
Number of Arcs     (Input,Output) =     21321      3653
 Creating CERULEAN_T.pat...
3618 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/CERULEAN_T
```

B. Temporary coverages created from the 1975 land cover/use data had the following cases removed:

Cottonwood and/or willow (ave. ht. <6 m)
Mixed lowland hardwoods (ave. ht. <6 m)
Open stand of mixed hardwoods with grass understory

```
Arc: reselect lcu75 cerul_t poly
 Reselecting POLYGON features from LCU75 to create CERUL_T
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1055 or veg_code = 1057 or veg_code = 1058
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1739 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1808      1806
Number of Arcs     (Input,Output) =      4654      4652
 Creating CERUL_T.pat...
3131 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/CERUL_T
```

C. Spring migration, pre-breeding, brood rearing, post-breeding, fall migration, and wintering coverages were created by relating the matrices to the land cover/use data and then by performing dissolves. This procedure was also used to create a second temporary file for the nesting season.

```
Arc: relate add
Relation Name: cerul_t
Table Identifier: post_breeding.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve cerul_t post_brd15 cerul_t//cerulean_warbler
 Dissolving cerul_t by cerul_t//cerulean_warbler to create post_brd15
 Creating post_brd15.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      1806       449
Number of Arcs     (Input,Output) =      4652       638
 Creating post_brd15.PAT...
```

D. A reselect was then performed on the second temporary nesting coverage to identify blocks of habitat (polygons) >16.188 ha (161,880 m^2).

```
Arc: reselect cerul_n nest15 poly
 Reselecting POLYGON features from CERUL_N to create NEST15
Enter a logical expression. (Enter a blank line when finished)
>: res area > 161880
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 31 features out of 451 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =        451        359
Number of Arcs     (Input,Output) =        648        548
 Creating NEST15.pat...
514 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/NEST15
```

Golden-winged Warbler. Literature citations supplied with the matrices stated the golden-winged warbler prefers sites where vegetation is clumped rather than in dense stands (Confer and Knapp 1981K). In Michigan, golden-winged warblers were located primarily at old-field sites 10–35 yr into succession (Confer and Knapp 1981K; Will 1986K). Golden-winged warblers typically nest in old fields containing many small trees (<6 m tall) and in shrubs adjacent to forests (Ficken and Ficken 1968K). Nests are usually located along edges, between second-growth forests, and in old fields (Will 1986). Titus (1984J) listed golden-winged warbler habitat as open fields with shrub that grades from open marshlands with few or no trees to acres of dense aspen coppice and parkland vegetation.

Reselects were performed on the land cover/use data to identify and remove polygons containing tall trees and dense woody vegetation. Unfortunately, no modeling information was provided that could be used to identify grasslands adjacent to woodlots. If a distance had been provided, a buffer could have been created around the woodlots. Since no such distance was provided, all grasslands mentioned in the matrix were considered habitat.

A. The first statement selects trees >6 m tall. The second statement then reselects the >6-m-tall trees to identify polygons containing tree densities >33%. The third statement reverses the selections, so the temporary coverage will contain trees <6 m tall that cover <34% of their polygons along with open water, aquatic vegetation, grasses/forbs, agriculture, urban areas, and bare soil.

```
Arc: reselect lcu89 golden_t poly
 Reselecting POLYGON features from LCU89 to create GOLDEN_T
Enter a logical expression. (Enter a blank line when finished)
>: res height_code > 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res closure_code > 2
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 4750 features out of 6172 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      6172       5862
Number of Arcs     (Input,Output) =     16091      15724
 Creating GOLDEN_T.pat..
10890 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL19_1989/GOLDEN_T
```

B. Temporary files created from the 1975 land cover/use coverages had the following vegetation classes removed:

Cottonwood and/or tree willow (ave. ht. >6 m)
Mixed lowland hardwood (ave. ht. >6 m)
Open stand of mixed hardwoods with grass understory

```
Arc: reselect lcu75 golden_t poly
 Reselecting POLYGON features from LCU75 to create GOLDEN_T
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1056 or veg_code = 1058 or veg_code = 1059
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1420 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       1808       1758
Number of Arcs     (Input,Output) =       4654       4596
 Creating GOLDEN_T.pat...
3127 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/GOLDEN_T
```

C. The golden-winged warbler habitat coverages were then created by relating the matrices to the temporary files, then performing dissolves.

```
Arc: relate add
Relation Name: golden_t
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve golden_t spring16 golden_t//golden_w_warbler
 Dissolving golden_t by golden_t//golden_w_warbler to create spring16
 Creating spring16.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =       5862       1857
Number of Arcs     (Input,Output) =      15724       2480
 Creating spring16.PAT...
```

Wood Thrush. Literature citations provided with the wood thrush's matrices state the wood thrush is found in low, cool, damp forests, often near swamps and streams (Sayre and Rundle 1984J; DeGraaf et al. 1991J). Undergrowth and the presence of saplings seem to help determine the suitability of an area during the breeding season (Bent ?J). Nests are generally located on horizontal limbs, 1.5–3 m aboveground level (Robbins 1991J). Bertin's (1977) study suggested that moisture regime was either the dominant factor in the wood thrush's habitat selection or was more correlated to site selection than other dependent variables. Wood thrushes also seem to require one or more trees ≥12 m tall, possibly for song perches (Bertin 1977J).

A. Reselect was used to create a temporary wood thrush coverage from the 1989 land cover/use data. The first statement reselects all woody vegetation. The second statement searches the woody terrestrial vegetation to select all vegetation <6 m tall. The third statement then reverses the selection so all woody terrestrial vegetation >6 m tall, open water, aquatic vegetation, grasses/forbs, agriculture, urban areas, and bare soil areas will be written to the temporary file, since several are utilized in the wood thrush's matrix.

```
Arc: reselect lcu89 wood_t poly
 Reselecting POLYGON features from LCU89 to create WOOD_T
Enter a logical expression. (Enter a blank line when finished)
>: res class = 10
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res height_code = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 5948 features out of 6172 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      6172      6170
Number of Arcs     (Input,Output) =     16091     16089
 Creating WOOD_T.pat...
10916 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL19_1989/WOOD_T
```

B. Temporary files created from the 1975 land cover/use data were created by reselecting for and removing the following classes:

Cottonwood and/or willow (ave. ht. <6 m)
Mixed lowland hardwoods (ave. ht. <6 m)

```
Arc: reselect lcu75 wood_t poly
 Reselecting POLYGON features from LCU75 to create WOOD_T
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1055 or veg_code = 1057
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: nsel
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1788 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1808      1808
Number of Arcs     (Input,Output) =      4654      4654
 Creating WOOD_T.pat...
3131 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/WOOD_T
```

C. Individual habitat coverages were then created by relating the temporary wood thrush coverages to the matrices, and then by performing dissolves.

```
Arc: relate add
Relation Name: wood_t
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve wood_t spring13 wood_t//wood_thrush
 Dissolving wood_t by wood_t//wood_thrush to create spring13
 Creating spring13.PAT format...
```

```
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6170        409
Number of Arcs     (Input,Output) =     16089        525
 Creating spring13.PAT...
```

Carolina Wren. Literature citations provided with the Carolina wren's matrices stated that the Carolina wren is found in a variety of habitats, from lowland stream bank tangles to upland brushy slopes and woodland edges (DeGraaf et al. 1991J). The Carolina wren stays low in the brush and undergrowth and is most numerous in bottomland woods (Bohlen and Zimmerman 1989J). The Carolina wren also has a minimum habitat size of 10 ha for nesting (Robbins 1979K).

Coverages were first created containing features listed in the Carolina wren's matrices, then reselected for habitat sizes ≥10 ha. Information regarding understory habitats was not included in the land cover/use data, so no modeling could be performed on those parameters.

A. Habitat coverages for spring migration, pre-breeding, brood rearing, post-breeding, fall migration, and wintering were created by relating the matrices to the land cover/use data, and then by performing dissolves. This procedure was also used to create the nesting season temporary file.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 sping11 lcu89//carolina_wren
 Dissolving lcu89 by lcu89//carolina_wren to create sping11
 Creating sping11.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6172       1106
Number of Arcs     (Input,Output) =     16091       1543
 Creating sping11.PAT...
```

B. The nesting coverage was then created by performing a reselect on the temporary file to select suitable habitat polygons ≥10 ha.

```
Arc: reselect carol_n nest11 poly
 Reselecting POLYGON features from CAROL_N to create NEST11
Enter a logical expression. (Enter a blank line when finished)
>: res area ge 100000
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 87 features out of 1699 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1699       1503
Number of Arcs     (Input,Output) =      2236       2011
 Creating NEST11.pat...
1959 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL19_1989/NEST11
```

Great Crested Flycatcher. Literature citations provided with the great crested flycatcher's matrices state that the great crested flycatcher is usually not found in dense timber, but prefers areas with at least a few openings and enough dead wood to offer suitable feeding perches and nesting cavities (Robbins 1991K; Bent ?J). The great crested flycatcher needs at least 10 ha of habitat for nesting (Robbins 1979), and the bird nests in both upland and bottomland woods (Bohlen and Zimmerman 1989J). Bohlen and Zimmerman (1989J) also state that the great crested flycatcher tends to stay mostly within forest interiors and has a preference for oaks. Bent (?J) states that the great crested flycatcher prefers the more open portions of forests and is seldom found in the depths of extensive forested areas.

We decided that only the nesting coverage would be modeled, to select habitat polygons ≥10 ha. No modeling was performed on forest densities, sizes, interior or edge regions, or cover densities, since some of the literature citations seemed to conflict.

A. Habitat coverages for spring migration, pre-breeding, brood rearing, post-breeding, fall migration, and wintering were created by relating the matrices to the land cover/use data, then performing dissolves. This procedure was also used to create the nesting season temporary file.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 spring12 lcu89//gr_cr_flycatcher
 Dissolving lcu89 by lcu89//gr_cr_flycatcher to create spring12
 Creating spring12.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6172       1106
Number of Arcs     (Input,Output) =     16091       1543
 Creating spring12.PAT...
```

B. The nesting coverage was then created by performing a reselect on the temporary file to select suitable habitat polygons ≥10 ha.

```
Arc: reselect flycat_t nest12 poly
 Reselecting POLYGON features from FLYCAT_T to create NEST12
Enter a logical expression. (Enter a blank line when finished)
>: res area ge 100000
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 128 features out of 1472 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1472       1298
Number of Arcs     (Input,Output) =      2005       1792
 Creating NEST12.pat...
1727 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL19_1989/NEST12
```

Method Three

Some of the literature citations referenced specific habitat relation (e.g., distance from water or locating adjacent land cover types). Whenever possible, these data were also included in the development of computer-generated habitat coverages.

An example of modeling for a habitat relation is the creation of potential nesting habitat of the prothonotary warbler. One selection parameter mentioned in the literature citations is that nest placement is usually within 1–2 m from water. After all other habitat modeling had been performed, a 2-m buffer was created around the study areas's land/water interface. The buffer was then used to identify areas containing potential habitat located within 2 m of water.

The eight bird species whose potential habitat coverages were created in this way were the mallard (*Anas platyrhynchos*), canvasback (*Aythya valisineria*), red-shouldered hawk (*Buteo lineatus*), great blue heron (*Ardea herodias*), American bittern (*Botaurus lentiginosus*), yellow-billed cuckoo (*Coccyzus americanus*), barred owl (*Strix varia*), and prothonotary warbler (*Protonotaria citrea*). The following sections contain information on modeling procedures used to create potential habitat coverages for these birds.

Mallard. Literature citations provided with the mallard's matrices list the mallard as nesting on top of muskrat houses among cattails (Bent ?J). Bent (?J) also lists the mallard in Wisconsin as nesting in trees, or far back in the dense fir timber on the ground, often 0.4 km (0.25 mi) from water. Typically, the mallard nests on the ground in dry or slightly marshy areas within 91 m of water, sometimes as far as 2.4 km (1.5 mi) away in grasslands (DeGraaf et al. 1991J). In Iowa, the mallard nests along roadsides and in drainage ditches (Dinsmore et al. 1984J). The favorite nesting cover for mallard broods is flooded whitetop, sedge, and hardstem bulrush beds (Bent ?J).

A. The spring migration, pre-breeding, brood rearing, post-breeding, fall migration, and wintering coverages were created by relating the matrices to the land cover/use data, then performing dissolves.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 mall_spr lcu89//mallard
 Dissolving lcu89 by lcu89//mallard to create mall_spr
 Creating mall_spr.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      8489       900
Number of Arcs     (Input,Output) =     21321      1014
 Creating mall_spr.PAT...
```

B. A temporary nesting file was created by relating the land cover/use data to the matrices, then performing dissolves.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: nesting.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 mall_n lcu89//mallard
 Dissolving lcu89 by lcu89//mallard to create mall_n
 Creating mall_n.PAT format...
 Creating dissolve table...
```

```
 Dissolving...
Number of Polygons (Input,Output) =       8489        1535
Number of Arcs     (Input,Output) =      21321        1727
 Creating mall_n.PAT...
```

C. Several distances to water were provided within the mallard's literature citations, and several buffering distances attempted. Problems arose within Pool 8 when a 1.5-m buffer was attempted. As with the American bittern's buffers, the data files were too complex for ARC/INFO to process, and buffering attempts failed. A 91-m buffer was created around the water coverage created for the American bittern, since the 91-m distance was listed as typically used by the mallard (DeGraaf et al. 1991J).

```
Arc: buffer water w_buff_91m # # 91
 Buffering ...
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Finding inside polygons...
 Dissolving...
 Creating w_buff_91m.PAT...
```

D. The temporary nesting coverage was then unioned to the 91-m buffer coverage.

```
Arc: union mall_n w_buff_91m mall_n2
 Unioning mall_n with w_buff_91m to create mall_n2
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating mall_n2.PAT...
** Item "AREA" duplicated, Join File version dropped **

** Item "PERIMETER" duplicated, Join File version dropped **

** Item "AREA" duplicated, Join File version dropped **

** Item "PERIMETER" duplicated, Join File version dropped **
```

E. A reselect was then performed on the unioned file to extract only the polygons listed as suitable mallard habitat that occur within 91 m of the land/water interface.

```
Arc: reselect mall_n2 mall_n3 poly
 Reselecting POLYGON features from MALL_N2 to create MALL_N3
Enter a logical expression. (Enter a blank line when finished)
>: res mallard = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res inside_water = 100
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 488 features out of 2554 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       2554        1496
Number of Arcs     (Input,Output) =       4076        2665
 Creating MALL_N3.pat...
2616 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/MALL_N3
```

F. Nesting habitat coverages were then created by performing dissolves on the reselected coverage.

```
Arc: dissolve mall_n3 mall_nest mallard
 Dissolving mall_n3 by mallard to create mall_nest
```

```
 Creating mall_nest.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =        1496        1496
Number of Arcs      (Input,Output) =        2665        1636
 Creating mall_nest.PAT...
```

Canvasback. Only two literature citations were provided for use with the canvasback matrices. The first citation stated that the canvasback remained on the Mississippi River until freeze-up (Bellrose 1976). Unfortunately, no mention was made as to where on the Mississippi this information was collected. The second literature citation stated that the length of migration stopover was inversely related to a canvasback's fat reserves (Serie and Sharp 1989).

Neither literature citation provided information that could be applied to modeling land cover/use data. As a result, the original habitat coverages (and those entered into the species richness coverages) were created by relating the matrices to the land cover/use data, then performing dissolves.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 spring4 lcu89//canvasback
 Dissolving lcu89 by lcu89//canvasback to create spring4
 Creating spring4.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =        6172        735
Number of Arcs      (Input,Output) =       16091        917
```

One problem associated with this coverage was the literal interpretation of the matrix data. For example, since no land cover-related modeling parameters were provided, all land cover types were considered potential regardless of their size or shape (Figure 1). Open water was one of the land cover types listed in the matrix, and open water is used to classify any nonvegetated water body. When open water was selected as habitat, all tributaries, backwaters, side channels, impoundments, and the main navigation channel became suitable habitat. If a minimum mapping size had been provided, similar results would have been created because most of these habitats are interconnected and considered one continuous habitat block by the computer.

If the computer is to be used to "model" for large blocks of uniform habitat, a search statement such as the following should be made: "The canvasback searches out and utilizes large, open, uniform areas along the river. Canvasbacks are usually seen within the impounded regions of the Upper Mississippi River System." If such a search parameter had been provided, then contiguous blocks of undisturbed habitat could have been searched for.

Modified coverages were created from data not supplied by the literature search:

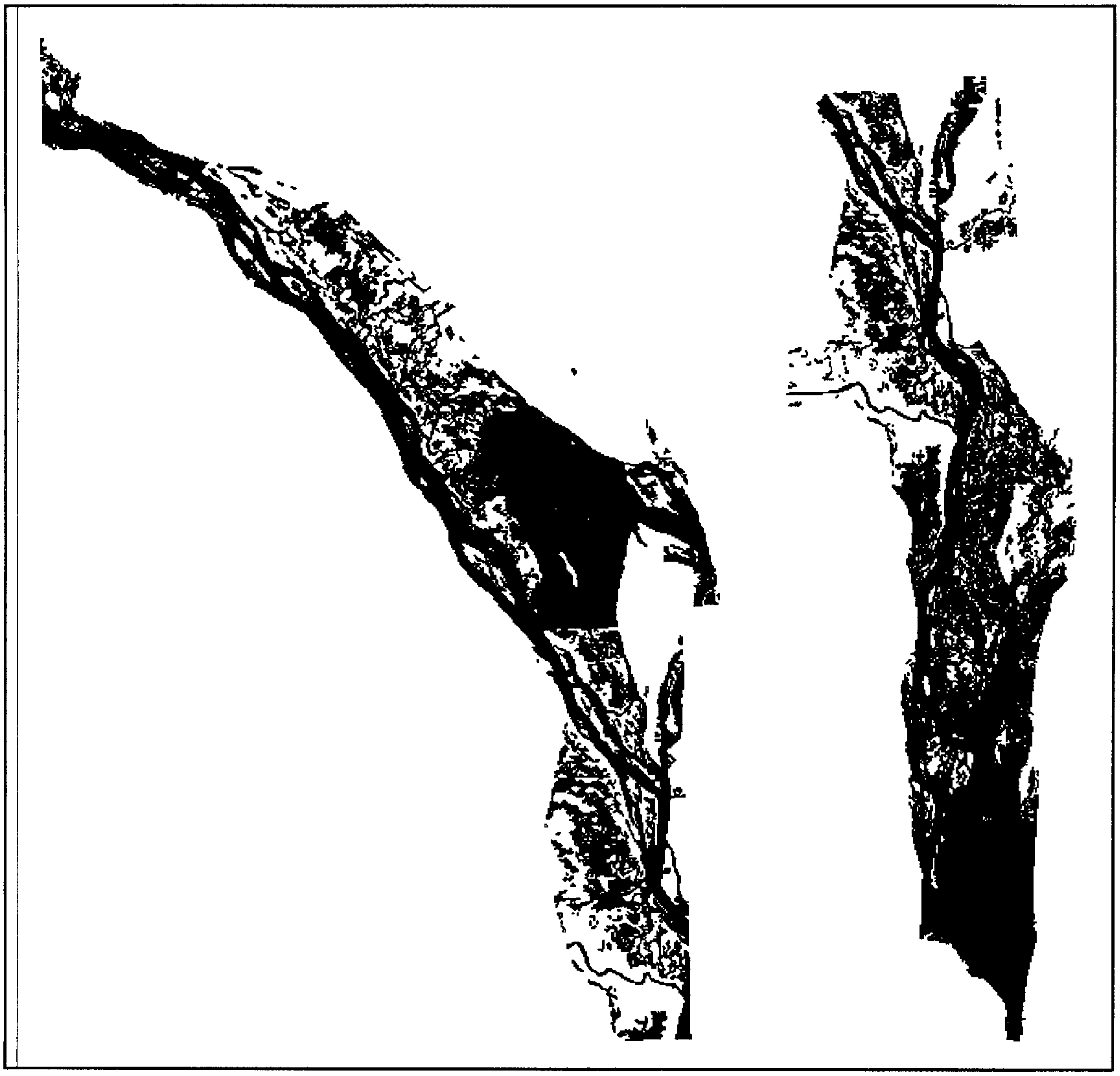


Figure 1. Canvasback (*Aythya valisineria*) fall migration habitat (*black*) generated from data provided from the literature search, Upper Mississippi River System Pools 7 and 8.

1. A fishnet coverage was created that contained 1,000- × 1,000-m cells. File size and coordinates used to create the fishnet are consistent with the classified Landsat coverage.

```
Arc: generate fishnet_1000
Copyright © 1989,1990,1991,1992 Environmental Systems Research Institute, Inc.
              All Rights Reserved Worldwide.
GENERATE Version 6.1.1  (December 23, 1992)
Generate: fishnet
Fishnet Origin Coordinate (X,Y): 602000, 4825000
Y-Axis Coordinate (X,Y): 602000, 4859000
Cell Size (Width,Height): 1000,1000
Number of Rows, Columns: 34,74
Generate: quit
Externalling BND and TIC...
```

2. A dissolve was then performed on fall season's total use coverage to extract the canvasback habitat coverage.

```
Arc: dissolve lcu89_fall canvasback_1 canvasback
 Dissolving lcu89_fall by canvasback to create canvasback_1
 Creating canvasback_1.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =     15025      1748
Number of Arcs     (Input,Output) =     34547      1874
 Creating canvasback_1.PAT...
```

3. The canvasback's habitat coverage and the 1,000-m grid coverage were then combined using ARC/INFO's intersect command. The resulting coverage contained the same habitat data as before, but areas mapped as suitable migration habitat were broken down into multiple polygons (Figure 2).

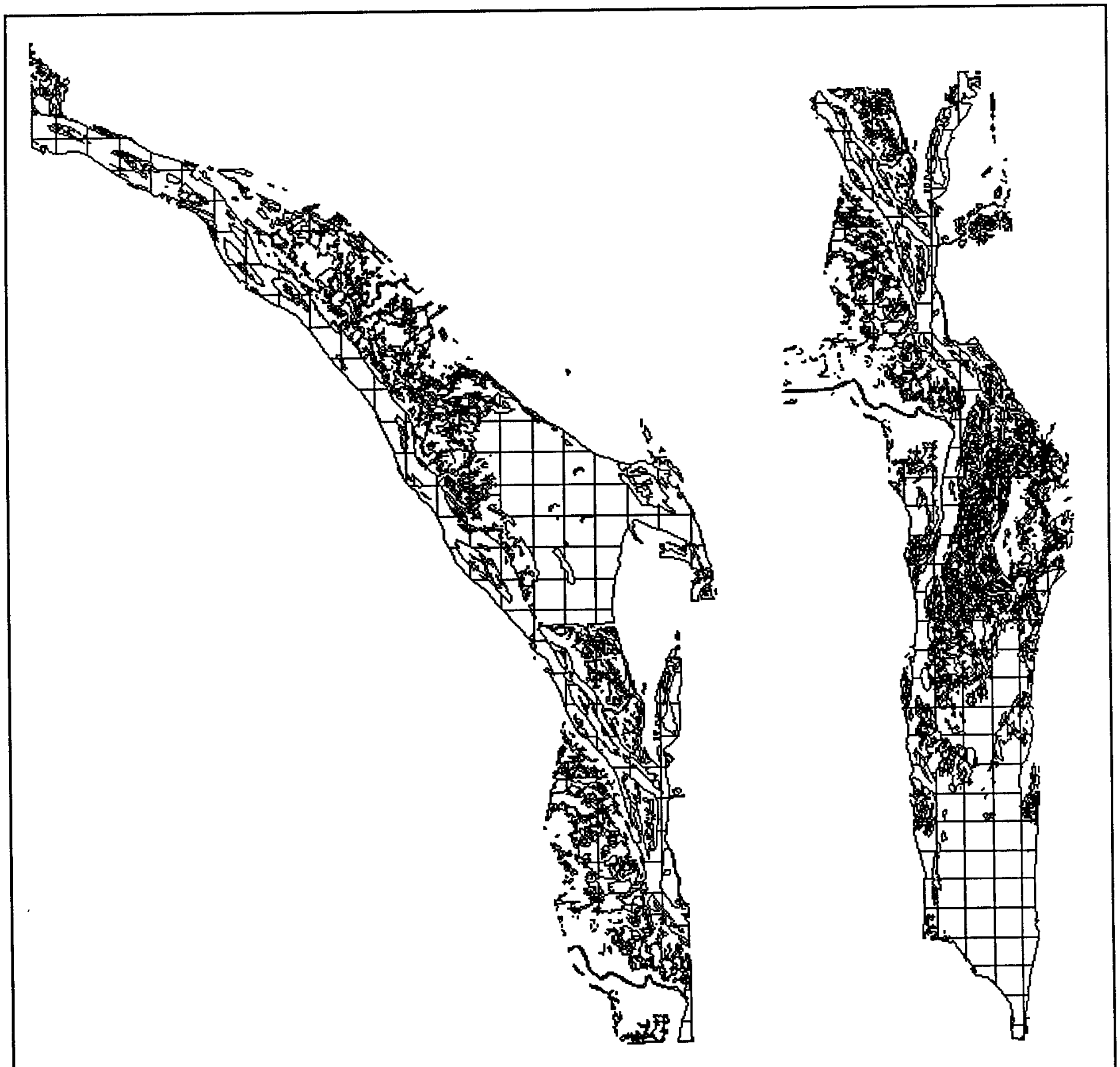


Figure 2. Canvasback (*Aythya valisineria*) habitat intersected with the 1,000- × 1,000-m grid.

```
Arc: intersect fishnet_1000 canvasback_1 canvasback_2
 Intersecting fishnet_1000 with canvasback_1 to create canvasback_2
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating canvasback_2.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

4. The first reselect identified polygons containing at least 50% (500,000 m^2) migration habitat.

```
Arc: reselect canvasback_3 canvas_500000
 Reselecting POLYGON features from CANVASBACK_3 to create CANVAS_500000
Enter a logical expression. (Enter a blank line when finished)
>: res canvasback = 1
Do you wish to re-enter expression (Y/N)? n

Do you wish to enter another expression (Y/N)? y
>: res area ge 500000
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 57 features out of 2494 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      2494       351
Number of Arcs     (Input,Output) =      4837       1108
 Creating CANVASBACK_4.pat...
1003 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/CANVAS_500000
```

5. When the coverage was plotted, several polygons within the main channel near La Crosse and within Target Lake were labeled suitable habitat. A second reselect was then performed to identify polygons mapped as 80% (800,000 m^2) suitable habitat.

```
Arc: reselect canvasback_3 canvas_800000
 Reselecting POLYGON features from CANVASBACK_3 to create CANVAS_800000
Enter a logical expression. (Enter a blank line when finished)
>: res canvasback = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res area ge 800000
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 26 features out of 2494 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      2494        60
Number of Arcs     (Input,Output) =      4837       224
 Creating CANVAS_800000.pat...
191 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/CANVAS_800000
```

The second reselect created a coverage that placed most of the suitable habitat polygons within the impounded region (Figure 3).

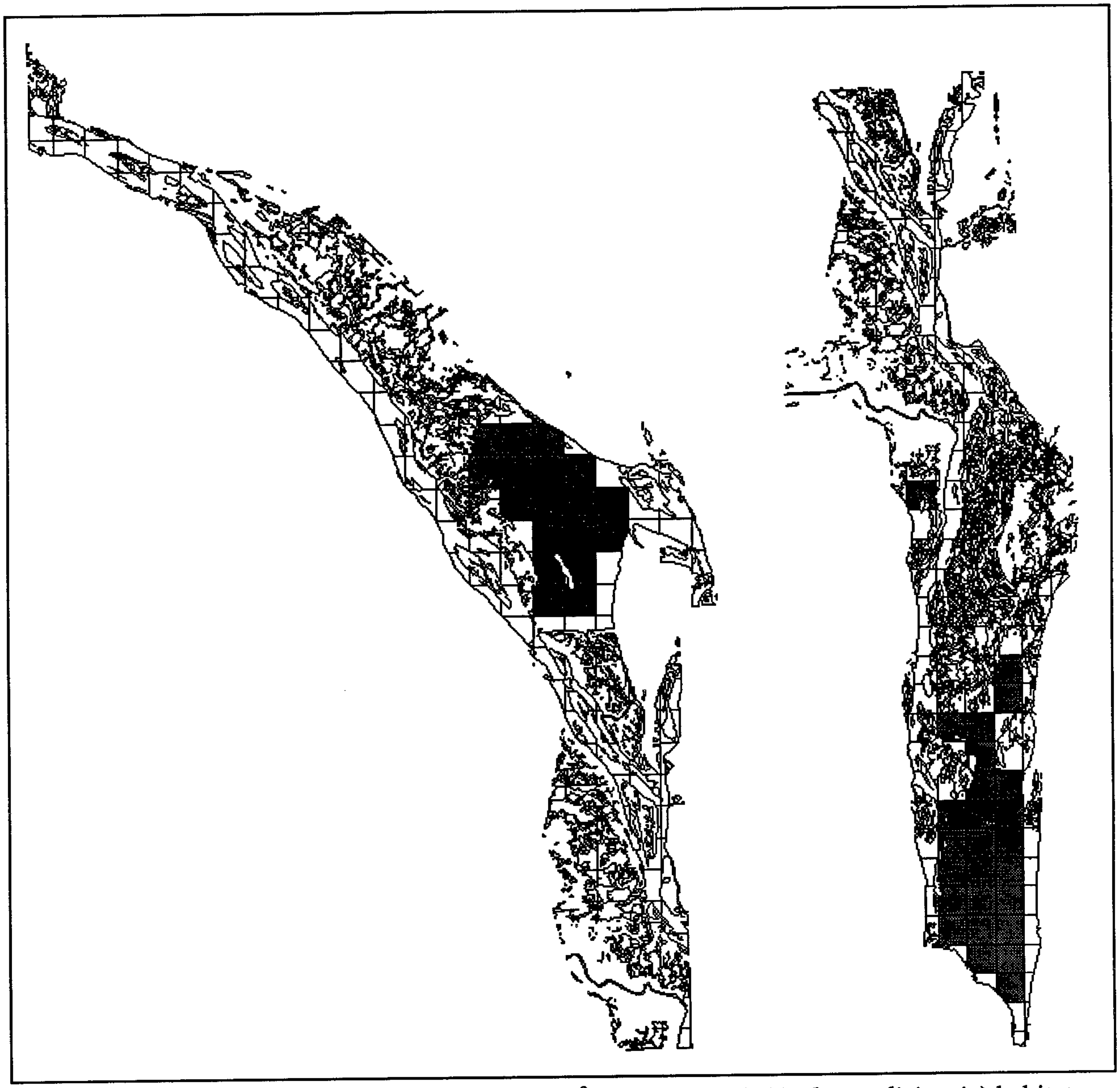


Figure 3. Polygons containing at least 800,000 m^2 of canvasback (*Aythya valisineria*) habitat.

We performed satellite extension processing as follows:

1. First, the canvasback suitability coverage was converted from a vector file into a raster coverage. Coordinates used during the conversion process were collected from the satellite coverage (to make sure the two files matched).

```
Arc: polygrid canvasback_1 can_grd1 canvasback
 Converting polygons from canvasback_1 to grid can_grd1
Cell Size (square cell): 30
Convert the Entire Coverage? (Y/N): n
Grid Origin (x, y): 601967.315,4825749.942
Grid Size (nrows, ncolumns): 1109,2462
Number of Rows     = 1109
```

```
Number of Columns = 2462
Percentage of Gridded Cells...100%
```

2. Then a reclass was performed on the raster coverage to change any zero values to NODATA. This was done so future processing would only be performed on cells labeled as suitable habitat. (The reclass file contained only one entry, 1:1.)

```
Grid: can_grd1b = reclass(can_grd1,can.rcl,nodata)
```

3. A reclass was then performed on the classified Landsat coverage to identify canvasback habitat. Vegetation types regrouped into canvasback habitat were open water and submergents.

```
Grid: can_grd2b = reclass(extension_cov,can.rcl,nodata)
```

4. The two coverages were then joined together.

```
Grid: can_cov1 = merge(can_grd1b,can_grd2b)
```

5. A copy of the coverage was then created that had each 30-m cell subset into nine, 10-m cells.

```
Grid: setcell 10
Grid: can_cov2 = can_cov1
```

6. A focal search was performed on the 10-m coverage. The focalsum analyzed each cell in the file, one at a time. A search of 100 × 100 cells was made around the cell being analyzed, then the focal search assigned the cell being processed with the number of positive responses it located within the search window.

```
Grid: can_cov3 = focalsum(can_cov2,rectangle,100,100)
```

Since the focalsum worked on each cell independently, processing of the 10-m coverage proved to be time-intensive. The focalsum was started at 3:05 p.m. one afternoon, and by 6:50 a.m. the next morning only 10% of the file had been processed.

7. The focalsum was then performed on the 30-m coverage, and processing was completed within 2.5 h. This 20-m file had not been used in the first processing attempt because a 1,000- × 1,000-m search window would have matched modeling previously performed on the vector coverage.

```
Grid: can_cov4 = focalsum(can_cov1,rectangle,33,33)
```

8. A reclass was then performed to locate areas where the entire 33- × 33-cell block contained suitable habitat (1089:20).

```
Grid: can_cov5 = reclass(can_cov4,can_cov.rcl,nodata)
```

The results of the GRID analysis were similar to those created by the vector analysis.

Red-shouldered Hawk. Several modeling parameters were provided for use with the red-shouldered hawk. These include:

The birds nest in trees averaging 25–29 m tall.

Nest densities are highest in areas with >75% forest cover.
Nest distances to water were from 232 to 572 m.
No nests in Iowa have been found within 600 m of main channel.
75% of nests are within 400 m of bluff or ridge.
Nests tend to be >0.4 km (0.25 mi) from nearest road.
Nests tend to be >0.8 km (0.5 mi) from human dwellings.

We spent more than 2 weeks trying to process the red-shouldered hawk data before deciding to remove this bird from the study. Many problems occurred while analyzing the data: ARC/INFO limitations were encountered during the creation of the 232- and 572-m buffers; the 600-m main channel buffer removed one, and possibly two, known nest sites; and road and urban buffers automatically canceled the 400-m bluff buffer.

Attempts were made to evade these problems to see if a relatively accurate coverage could be created, but each solution only created new problems. Ultimately, the red-shouldered hawk was dropped from the Pilot Project. There was not enough time to address these problems and still complete the pilot within a reasonable amount of time.

Great Blue Heron. Literature citations provided with the great blue heron's matrices state that the great blue heron prefers to nest in trees 5–15 m aboveground (Burleigh 1958K; Cotrille and Cotrille 1958K; Vermeer 1969K; McAloney 1973K), and often above 15 m (DeGraaf et al. 1991J), and many of the nests tend to be in dead trees (Brown and Dinsmore 1986K; Bent ?J). Great blue heron colonies are often located on islands (Vermeer 1969K; English 1978K; Markam and Brechtel 1979K), and most nests are located within 91 m of water (Palmer 1962K; Short and Cooper 1985K). One Minnesota study noted that heron rookeries were located at least 3.3 km from human dwellings and 1.3 km from the nearest surfaced road (Mathisen and Richards 1978K). Minimum habitat areas for heronries in Minnesota were 0.4–8.4 ha and averaged 1.2 ha (Mathisen and Richards 1978K). In Illinois, tracts of forest habitat used for nesting were 103–1,969 ha, with an average of 608 ha (matrix entry 16, author unknown). In Iowa, the great blue heron can winter virtually any place that has open water (Dinsmore et al. 1984J).

Because most of the literature citations referred to the great blue heron's nesting requirements, modeling parameters were applied only to the nesting and brood rearing coverages.

A. The spring migration, pre-breeding, post-breeding, fall migration, and wintering coverages were created by relating the matrices to the land cover/use coverages, then performing dissolves.

```
Arc: relate add
Relation Name: lcu75
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu75 heron_spr lcu75//great_b_heron
 Dissolving lcu75 by lcu75//great_b_heron to create gbh_s
 Creating gbh_s.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =        1808        410
Number of Arcs     (Input,Output) =        4654        533
 Creating gbh_s.PAT...
```

B. Since the great blue heron prefers to place its nests in trees more than 15 m tall, the 1989 land cover/use data were reselected to create a temporary file that contained only woody vegetation more than 15 m tall.

```
Arc: reselect lcu89 tree_50ft poly
 Reselecting POLYGON features from LCU89 to create TREE_50FT
Enter a logical expression. (Enter a blank line when finished)
>: res class = 10
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res height_code = 3
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1319 features out of 8489 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       8489       1516
Number of Arcs     (Input,Output) =      21321       5882
 Creating TREE_50FT.pat...
5778 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/TREE_50FT
```

C. The temporary file created from the 1975 land cover/use data had the following classes removed.

```
Arc: reselect lcu75 tree_50ft poly
 Reselecting POLYGON features from LCU75 to create TREE_50FT
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1056 or veg_code = 1058 or veg_code = 1059
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 388 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       1808        424
Number of Arcs     (Input,Output) =       4654       1683
 Creating TREE_50FT.pat...
1622 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/
HABITAT_COVS/TREE_50FT
```

D. The minimum habitat area requirement for a heron rookery in Minnesota was 0.4–8.4 ha. A reselect was performed on the coverage containing trees more than 15 m tall to select for polygons 0.4 ha or larger.

```
Arc: reselect tree_50ft tree_plots poly
 Reselecting POLYGON features from TREE_50FT to create TREE_PLOTS
Enter a logical expression. (Enter a blank line when finished)
>: res area ge 4000
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 506 features out of 1516 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       1516        671
Number of Arcs     (Input,Output) =       5882       4077
 Creating TREE_PLOTS.pat...
3997 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/TREE_PLOTS
```

E. Temporary nesting and brood rearing coverages were created by relating the matrices to the reselect file and performing dissolves.

```
Arc: relate add
Relation Name: tree_plots
Table Identifier: nesting.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve tree_plots heron_n tree_plots//great_b_heron
 Dissolving tree_plots by tree_plots//great_b_heron to create heron_n
 Creating heron_n.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =       841        772
Number of Arcs     (Input,Output) =      4730        979
 Creating heron_n.PAT...
```

Several buffering parameters were provided with the literature citations, but not all were used in this model. One of the buffers mentioned (Mathisen and Richards 1978K) listed the great blue heron as building its nests 3.3 km away from human dwellings. When the 3.3-km buffer was applied to the Mississippi River, the entire study area was classified as unsuitable for nesting (housing developments line both sides of the river). Several known great blue heron rookeries are located within the study area, therefore it was decided to remove the urban buffer from the model.

F. The great blue heron was observed not to build nests within 160 m of roads, so a 160-m buffer was created around road coverages for the study areas.

```
Arc: buffer r_buff_160m # # 160
 Buffering ...
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Finding inside polygons...
 Dissolving...
 Creating r_biff_160m.PAT...
```

G. The great blue heron usually builds its nests within 91 m of water, so the water coverage created for use with the American bittern was used for the creation of the 91-m buffer.

```
Arc: buffer water w_buff_91m # # 91
 Buffering ...
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Finding inside polygons...
 Dissolving...
 Creating w_buff_91m.PAT...
```

H. The great blue heron model required the unioning of the water and roads buffers. Before this could be accomplished, the polygon attribute item INSIDE needed to be assigned unique names. This was accomplished within INFO.

```
ENTER COMMAND >SEL W_BUFF_91M.PAT
    211 RECORD(S) SELECTED

ENTER COMMAND >ITEMS
DATAFILE NAME: W_BUFF_91M.PAT                                  09/03/1993
   5 ITEMS: STARTING IN POSITION     1
```

```
COL  ITEM NAME          WDTH OPUT  TYP N.DEC  ALTERNATE NAME
   1  AREA                 8   18   F     5
   9  PERIMETER            8   18   F     5
  17  W_BUFF_91M#          4    5   B     -
  21  W_BUFF_91M-ID        4    5   B     -
  25  INSIDE               4    5   B     -

ENTER COMMAND >ALTER
ITEM NAME>INSIDE
  25  INSIDE               4    5   B     -     4    -     -     -    -    -   -   -
ITEM NAME>INSIDE_WATER
ITEM OUTPUT WIDTH>
ITEM TYPE>
ITEM PROT. LEVEL>
ALTERNATE ITEM NAME >
ENTER KEY LEVEL>
ENTER INDEX NUMBER>

  25  INSIDE_WATER         4    5   B     -     4    -     -     -    -    -   -   -

ENTER COMMAND >SEL R_BUFF_160M.PAT
    683 RECORD(S) SELECTED

ENTER COMMAND >ITEMS
DATAFILE NAME: R_BUFF_160M.PAT                                      09/03/1993
   5 ITEMS: STARTING IN POSITION     1
COL  ITEM NAME          WDTH OPUT  TYP N.DEC  ALTERNATE NAME
   1  AREA                 4   12   F     3
   5  PERIMETER            4   12   F     3
   9  R_BUFF_160M#         4    5   B     -
  13  R_BUFF_160M-ID       4    5   B     -
  17  INSIDE               4    5   B     -

ENTER COMMAND >ALTER
ITEM NAME>INSIDE
  17  INSIDE               4    5   B     -     4    -     -     -    -    -   -   -
ITEM NAME>INSIDE_ROADS
ITEM OUTPUT WIDTH>
ITEM TYPE>
ITEM PROT. LEVEL>
ALTERNATE ITEM NAME >
ENTER KEY LEVEL>
ENTER INDEX NUMBER>

  17  INSIDE_ROADS         4    5   B     -     4    -     -     -    -    -   -   -
```

I. The two buffer coverages were then unioned together.

```
Arc: union r_buff_160m w_buff_91m gbh_buffers
 Unioning r_buff_160m with w_buff_91m to create gbh_buffers
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating gbh_buffers.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

J. The buffered coverages were then unioned to the temporary nesting and brood rearing coverages.

```
Arc: union gbh_buffers gbh_n gbh_n_union1
 Unioning gbh_buffers with gbh_n to create gbh_n_union1
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
```

```
Creating gbh_n_union1.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

K. Reselect was then used to identify areas located more than 1.3 km from the nearest surfaced roads, within 100 m of the land/water interface, and containing suitable great blue heron rookery habitat.

```
Arc: reselect gbh_n_union1 gbh_n_union2
 Reselecting POLYGON features from GBH_N_UNION1 to create GBH_N_UNION2
Enter a logical expression. (Enter a blank line when finished)
>: res inside_roads = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res inside_water = 100
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res great_b_heron = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1544 features out of 4593 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      4593        1823
Number of Arcs      (Input,Output) =      7500        3070
 Creating GBH_N_UNION2.pat...
3047 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/GBH_N_UNION2
```

L. Dissolves were then performed on the reselected coverage to create a coverage whose only feature was suitable great blue heron habitat.

```
Arc: dissolve gbh_n_union2 gbh_n_union3 great_b_heron
 Dissolving gbh_n_union2 by great_b_heron to create gbh_n_union3
 Creating gbh_n_union3.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      1823        1823
Number of Arcs      (Input,Output) =      3070        1860
 Creating gbh_n_union3.PAT...
```

M. The last reselect was used to identify all polygons listed as suitable for the great blue heron, ≥0.4 ha.

```
Arc: reselect gbh_n_union3 heron_nest poly
 Reselecting POLYGON features from GBH_N_UNION3 to create HERON_NEST
Enter a logical expression. (Enter a blank line when finished)
>: res area ge 4000
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 440 features out of 1823 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1823        668
Number of Arcs      (Input,Output) =      1860        705
 Creating HERON_NEST.pat...
692 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/HERON_NEST
```

American Bittern. Literature citations provided with the American bittern's matrices stated that American bitterns are found only on wetlands >10 ha (Brown and Dinsmore 1986K). Bohlen and Zimmerman (1989J) stated that the American bittern could also be found in wet woodlands and wet, weedy fields. In Illinois, the

American bittern is noted to breed in wet prairies, prairie sloughs, and marshes. Nests were found in thick marsh grass, sometimes adjacent to stands of willow and tamarack, within 6 m of water (Bohlen and Zimmerman 1989J). Svedarsky (1992J) never observed American bitterns close to trees or in water deeper than 15 cm.

A. Before any analysis of the matrices could take place, the land cover/use data needed to be analyzed to create a land/water coverage. The first step involved adding an item to the polygon attribute coverage of the land cover/use data.

   Arc: **additem lcu89.pat lcu89.pat land_water 1 1 I**
   Adding land_water to lcu89.pat to produce lcu89.pat.

B. Within the land cover/use polygon attribute table is an item termed CLASS. Each interpreted polygon is assigned a value that corresponds to LTRMP's generalized classification scheme and is written in this column. INFO was used to resample the land cover/use polygon attribute table according to the CLASS assignments, then the land/water assignments were made. A listing of the generalized classification scheme and INFO commands follows:

   Open water
   Submergents
   Submergents-rooted floating aquatics
   Submergents-rooted floating aquatics-emergents
   Rooted floating aquatics
   Rooted floating aquatics-emergents
   Emergents
   Emergents-grasses/forbs
   Grasses/forbs
   Woody terrestrial
   Agriculture
   Urban/developed
   Sand/mud

```
ENTER COMMAND >SEL LCU89.PAT
    8489 RECORD(S) SELECTED
 ENTER COMMAND >RESELECT FOR CLASS > 0
    8485 RECORD(S) SELECTED
 ENTER COMMAND >RESELECT FOR CLASS < 9
    3969 RECORD(S) SELECTED
 ENTER COMMAND >CALC LAND_WATER = 1
 ENTER COMMAND >SEL LCU89.PAT
    8489 RECORD(S) SELECTED
 ENTER COMMAND >RESELECT FOR CLASS > 8
    4516 RECORD(S) SELECTED
 ENTER COMMAND >CALC LAND_WATER = 2
```

C. Land/water coverages were then created by performing dissolves on the item land_water.

```
Arc: dissolve lcu89 land_water land_water
 Dissolving lcu89 by land_water to create land_water
 Creating land_water.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      8489       1358
Number of Arcs     (Input,Output) =     21321       1505
 Creating land_water.PAT...
```

D. Reselect was then used to create a coverage containing only water polygons.

```
Arc: reselect land_water water
 Reselecting POLYGON features from LAND_WATER to create WATER
Enter a logical expression. (Enter a blank line when finished)
>: res land_water = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 512 features out of 1358 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =        1358        1341
Number of Arcs     (Input,Output) =        1505        1479
 Creating WATER.pat...
1455 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/WATER
```

E. Normally, the next step would be to the buffer water coverage to identify all areas within 6 m of the land/water interface. Although this occurred for the 1975 and 1989 Pool 19 coverages, the 1989 Pool 8 water coverage required further processing.

Pool 8 contains one of the most intricate island complexes in the Upper Mississippi River. Attempts to create a 6-m buffer around the Pool 8 water coverage kept failing because of file size errors. The problem was solved by splitting the Pool 8 water coverage into several coverages.

The first split was made by creating a coverage that had a division line drawn through the main channel and the Goose Island complex. The coverage was split, and the buffering process reattempted. File size restrictions were still a problem, so a third water coverage was created by reediting the previous split coverage to add another division line within lower Pool 8 (Figure 4).

The buffer command was then used to create the 6-m land/water interface buffer.

```
Arc: buffer water_3 w_buff_6m3 # # 6

 Buffering ...
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Finding inside polygons...
 Dissolving...
 Creating w_buff_6m3.PAT...
```

F. Each of the buffer coverages contained an item called INSIDE. Before the water buffers could be joined together, INSIDE needed to be assigned unique names.

```
ENTER COMMAND >SEL W_BUFF_6M2.PAT
   1908 RECORD(S) SELECTED
ENTER COMMAND >ITEMS
DATAFILE NAME: W_BUFF_6M2.PAT                                        09/17/1993
   5 ITEMS: STARTING IN POSITION     1
COL  ITEM NAME            WDTH OPUT TYP N.DEC  ALTERNATE NAME
   1  AREA                    8   18  F     5
   9  PERIMETER               8   18  F     5
  17  W_BUFF_6M2#             4    5  B     -
  21  W_BUFF_6M2-ID           4    5  B     -
  25  INSIDE                  4    5  B     -
```

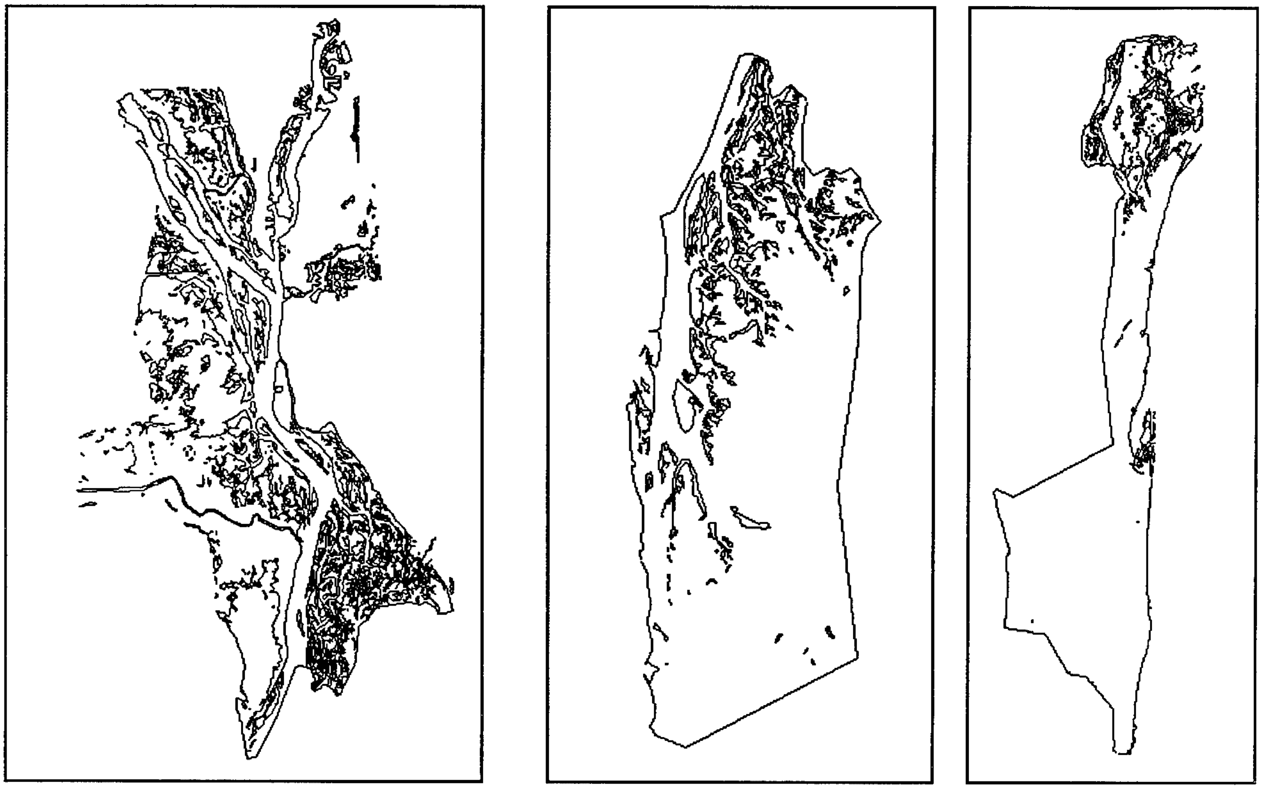


Figure 4. Water coverages used to create the 6-m buffer coverage.

```
ENTER COMMAND >ALTER
ITEM NAME>INSIDE
  25  INSIDE              4    5  B    -    4    -     -     -     -    -   -
ITEM NAME>INSIDE_2
ITEM OUTPUT WIDTH>
ITEM TYPE>
ITEM PROT. LEVEL>
ALTERNATE ITEM NAME >
ENTER KEY LEVEL>
ENTER INDEX NUMBER>

  25  INSIDE_2            4    5  B    -    4    -     -     -     -    -   -
```

G. The three water buffers were then joined together by using the union command.

```
Arc: union w_buff_6m2 w_buff_6m3 w_buff_6ma
 Unioning w_buff_6m2 with w_buff_6m3 to create w_buff_6ma
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating w_buff_6ma.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **

Arc: union w_buff_6ma w_buff_6m4 w_buff_6m
 Unioning w_buff_6ma with w_buff_6m4 to create w_buff_6m
 Sorting...
 Intersecting...
```

```
 Assembling polygons...
 Creating new labels...
 Creating w_buff_6m.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

H. The 6-m buffer files were then unioned to the LCU89 coverage to create a temporary American bittern coverage.

```
Arc: union lcu89 w_buff_6m bittern_t
 Unioning lcu89 with w_buff_6m to create bittern_t
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating bittern_t.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

I. Reselects were then used to create a second American bittern coverage. The first reselect statement states that all aquatic oriented polygons are to be included. The second statement adds any area located within the 6-m buffers.

```
Arc: reselect bittern_t bittern
 Reselecting POLYGON features from BITTERN_T to create BITTERN
Enter a logical expression. (Enter a blank line when finished)
>: res class < 9
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: asel inside_2 = 100 or inside_3 = 100 or inside_4 = 100
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 14850 features out of 19856 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      19856       15936
Number of Arcs     (Input,Output) =      44649       38637
 Creating BITTERN.pat...
25767 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/BITTERN
```

J. Individual American bittern coverages were then created by relating the reselected coverage to the matrices and performing dissolves.

```
Arc: relate add
Relation Name: bittern
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve bittern bittern_spr bittern//american_bittern
 Dissolving bittern by bittern//american_bittern to create bittern_spr
 Creating bittern_spr.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      15936       3943
Number of Arcs     (Input,Output) =      38637       7438
```

```
Creating bittern_spr.PAT...
```

Yellow-billed Cuckoo. Information provided with the yellow-billed cuckoo's matrices states that the yellow-billed cuckoo nests and forages when willow–cottonwood tree densities are at least 150 trees/ha (Anderson and Laymon 1989K). Laymon and Halterman (1989K) list optimum yellow-billed cuckoo habitat in California as consisting of >80 ha of willow–cottonwood. Gaines (1974J) noticed that California cuckoos occurred where riparian vegetation exceeds 300 × 100 m, water is present within 100 m, and dense understory vegetation and thickets of willow are present. They are lacking where understory vegetation is sparse or absent; vegetation is not sufficiently extensive, as along the 20–1,000-m-wide strip of otherwise suitable habitat; or understory vegetation has been removed, such as in parks.

A. Temporary yellow-billed cuckoo coverages were created by reselecting for vegetation covering >68% of the polygon (no understory information was available).

```
Arc: reselect lcu89 cuckoo_t poly
 Reselecting POLYGON features from LCU89 to create CUCKOO_T
Enter a logical expression. (Enter a blank line when finished)
>: res closure_code = 3 or closure_code = 4
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 7085 features out of 8489 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =       8489       7585
Number of Arcs     (Input,Output) =      21321      19952
 Creating CUCKOO_T.pat...
14197 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/CUCKOO_T
```

B. The individual, temporary habitat coverages were then created by relating the information tables to the temporary cuckoo coverages and performing dissolves.

```
Arc: relate add
Relation Name: cuckoo_t
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve cuckoo_t cuckoo_s cuckoo_t//yellow_b_cuckoo
 Dissolving cuckoo_t by cuckoo_t//yellow_b_cuckoo to create cuckoo_s
 Creating cuckoo_s.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =       7585       1143
Number of Arcs     (Input,Output) =      19952       1220
 Creating cuckoo_s.PAT...
```

C. The temporary habitat coverages were then unioned with the 100-yd buffer coverage.

```
Arc: union cuckoo_s w_buff_91m cuckoo_s2
 Unioning cuckoo_s with w_buff_91m to create cuckoo_s2
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating cuckoo_s2.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

```
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

D. Reselects were performed to identify areas within 100 m of water that had been identified as suitable yellow-billed cuckoo habitat.

```
Arc: reselect cuckoo_pr2 cuckoo_pr3 poly
 Reselecting POLYGON features from CUCKOO_PR2 to create CUCKOO_PR3
Enter a logical expression. (Enter a blank line when finished)
>: reselect inside_water = 100
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: reselect yellow_b_cuckoo = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 1274 features out of 4149 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =        4149        1461
Number of Arcs     (Input,Output) =        7938        3344
 Creating CUCKOO_PR3.pat...
3322 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/CUCKOO_PR3
```

E. Individual yellow-billed cuckoo habitat coverages were then created by performing dissolves.

```
Arc: dissolve cuckoo_pr3 cuckoo_pre yellow_b_cuckoo
 Dissolving cuckoo_pr3 by yellow_b_cuckoo to create cuckoo_pre
 Creating cuckoo_pre.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =        1461        1461
Number of Arcs     (Input,Output) =        3344        1478
 Creating cuckoo_pre.PAT...
```

The minimum length–width measurement was not modeled for. It was unclear if the 100 m width of habitat had to be totally within 100 m of water, or if it could be 100 m of habitat where at least part of it was within 100 m of the water. Because the data came from another state (California), one with great habitat variability, these data were not to be utilized until a local expert could be contacted. It was unclear if such habitat requirements would be applicable to the Upper Mississippi River.

Barred Owl. Literature citations provided with the barred owl's matrices describe the barred owl as a forest-loving bird, living mainly in the deep, dark woods; heavily wooded swamps; gloomy hemlock forests or tall, dense pines (Bent ?J); or in mature forests close to moist river bottoms (Bohlen and Zimmerman 1989J; DeGraaf et al. 1991J; Robbins 1991). Much of its hunting is done in the open fields, clearings, and wetlands near woods (DeGraaf et al. 1991J; Bent ?J). In fall and winter, a stray bird may venture into a residential neighborhood (Bent ?J; Robbins, 1991J), but the barred owl usually frequents dense, mature forests far from human disturbance (Robbins 1991J).

A. The first step was to reselect all woody vegetation stands that contained trees more than 15 m tall. For the 1989 LCU coverages, the tree height category was used for the reselect.

```
Arc: reselect lcu89 tallwood poly
 Reselecting POLYGON features from LCU89 to create TALLWOOD
Enter a logical expression. (Enter a blank line when finished)
>: res class = 10
>:
```

```
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res height_code = 3
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 973 features out of 6172 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      6172       1215
Number of Arcs     (Input,Output) =     16091       5566
 Creating TALLWOOD.pat...
5391 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL19_1989/TALLWOOD
```

B. For the 1975 LCU coverages, the tall tree category was created by reselecting on the following vegetation classes.

Cottonwood and/or tree willow (ave. ht. >6 m)
Mixed lowland hardwood (ave. ht. >6 m)
Open stand of mixed hardwoods with grass understory

```
Arc: reselect lcu75 talltree poly
 Reselecting POLYGON features from LCU75 to create TALLTREE
Enter a logical expression. (Enter a blank line when finished)
>: res veg_code = 1056 or veg_code = 1058 or veg_code = 1059
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 388 features out of 1808 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      1808        424
Number of Arcs     (Input,Output) =      4654       1683
 Creating TALLTREE.pat...
1622 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1975/TALLTREE
```

C. A dissolve was performed on the tall tree coverage to make it easier for ARC/INFO to buffer.

```
Arc: dissolve tallwood tallwood_d class
 Dissolving tallwood by class to create tallwood_d
 Creating tallwood_d.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      1516       1430
Number of Arcs     (Input,Output) =      5882       1461
 Creating tallwood_d.PAT...
```

D. Although the barred owl hunts in open fields and wetlands near woods, no references were made regarding the distance of these fields to the woodlots. To avoid overestimating foraging distances, a 300-m buffer was chosen.

```
Arc: buffer tallwood_d wood_buff300 # # 300 # poly
 Buffering ...
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Finding inside polygons...
 Dissolving...
 Creating wood_buff300.PAT...
```

E. Individual coverages were created from the matrices that showed habitat types the birds may use. These coverages were created by relating the matrices to the LCU coverages, then performing dissolves according to information stored within the matrices.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 barred_s lcu89//barred_owl
 Dissolving lcu89 by lcu89//barred_owl to create barred_s
 Creating barred_s.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      6172       1585
Number of Arcs     (Input,Output) =     16091       2086
 Creating barred_s.PAT...
```

F. Information stored within the tall tree buffer and the habitat coverage was combined into a single coverage.

```
Arc: union barred_s wood_buff300 sprowl_join1
 Unioning barred_s with wood_buff300 to create sprowl_join1
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating sprowl_join1.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

G. A reselect was performed on the unioned coverage so that only habitats used by the birds within 300 m of a woodlot containing tall trees would remain.

```
Arc: reselect sprowl_join1 sprowl_join2 poly
 Reselecting POLYGON features from SPROWL_JOIN1 to create
SPROWL_JOIN2
Enter a logical expression. (Enter a blank line when finished)
>: res barred_owl = 1 and inside = 100
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 367 features out of 2143 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      2143       1269
Number of Arcs      (Input,Output) =      3507       2329
 Creating SPROWL_JOIN2.pat...
2293 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL19_1989/SPROWL_JOIN2
```

H. The individual habitat coverages were then created by performing dissolves on the item barred_owl.

```
Arc: dissolve sprowl_join2 br_owl_spr barred_owl
 Dissolving sprowl_join2 by barred_owl to create br_owl_spr
 Creating br_owl_spr.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      1269       1269
```

```
Number of Arcs     (Input,Output) =      2329       1451
 Creating br_owl_spr.PAT..
```

According to some literature citations, the barred owl prefers to live in dense, mature forests far from human disturbance; however, no references provided a minimum forest size or a definition of human disturbance (i.e., residential dwellings, roads). Therefore, these factors were not modeled. The resultant coverage included wooded fence rows, including areas <0.4 ha (<1 acre) located within large agricultural areas.

Prothonotary Warbler. The nests of the prothonotary warbler tend to be placed within 2 m of the water's edge in relatively large trees (Blem and Blem ?K) and in fallen branches of willows, maples, and buttonbush (*Cephalanthus occidentalis*; Bohlen 1989J).

A. Habitat coverages for spring migration, pre-breeding, post-breeding, fall migration, and wintering were created by relating the matrices to the land cover/use data, then performing dissolves. This same procedure was also used to create temporary files for the nesting and brood rearing coverages.

```
Arc: relate add
Relation Name: lcu89
Table Identifier: spring_migration.lut
Database Name: info
INFO Item: veg_code
Relate Column: veg_code
Relate Type: ordered
Relate Access: rw
Relation Name:
Arc: dissolve lcu89 proth_s lcu89//proth_warbler
 Dissolving lcu89 by lcu89//proth_warbler to create proth_s
 Creating proth_s.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      8489       1949
Number of Arcs     (Input,Output) =     21321       2133
 Creating proth_s.PAT...
```

B. A 2-m buffer coverage was created around the water coverages. It was possible to create the 1975 and 1989 Pool 19 buffers without dividing the water coverage, but the 1989 Pool 8 area required the creation of two water coverages. Documentation on the creation and division of the water coverages is listed under American bittern.

C. The nesting and brood rearing coverages were then unioned with the 2-m buffer.

```
Arc: union w_buff_2m proth_n proth_n2
 Unioning w_buff_2m with proth_n to create proth_n2
 Sorting...
 Intersecting...
 Assembling polygons...
 Creating new labels...
 Creating proth_n2.PAT...
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
** Item "AREA" duplicated, Join File version dropped **
** Item "PERIMETER" duplicated, Join File version dropped **
```

D. Reselects were performed on the unioned coverages to locate areas of suitable nesting and brood rearing habitat occurring within 2 m of the land/water interface.

```
Arc: reselect proth_n2 proth_n3 poly
 Reselecting POLYGON features from PROTH_N2 to create PROTH_N3
```

```
Enter a logical expression. (Enter a blank line when finished)
>: res inside_w1 = 100 or inside_w2 = 100
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? y
>: res proth_warbler = 1
>:
Do you wish to re-enter expression (Y/N)? n
Do you wish to enter another expression (Y/N)? n
 2229 features out of 7432 selected.
 Reselecting polygons...
Number of Polygons (Input,Output) =      7432        2449
Number of Arcs      (Input,Output) =     13271        5782
 Creating PROTH_N3.pat...
5689 unique nodes built for
/USR5/ARC_WORK/CDL0/MIGRATORY_PROJECT/POOL8_1989/PROTH_N3
```

E. The reselected coverages were then dissolved to create the nesting and breeding coverages.

```
Arc: dissolve proth_n3 proth_nest proth_warbler
 Dissolving proth_n3 by proth_warbler to create proth_nest
 Creating proth_nest.PAT format...
 Creating dissolve table...
 Dissolving...
Number of Polygons (Input,Output) =      2449        2447
Number of Arcs      (Input,Output) =      5782        2455
 Creating proth_nest.PAT...
```

It should be noted that the spatial accuracy of the base coverage is ~20 m. Although a 2-m buffer was created for use as a visual reference to habitat locations, the data should not be used to calculate habitat acreage.

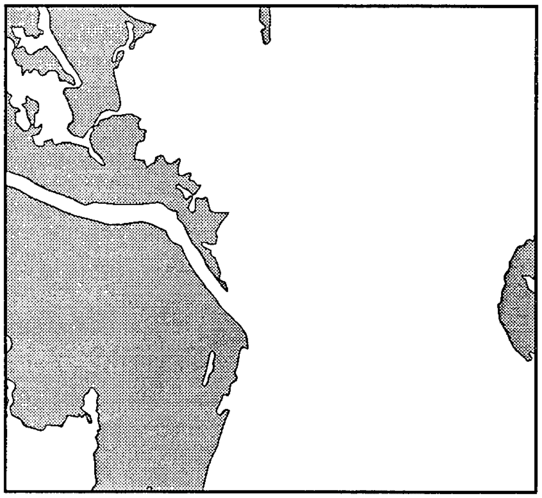
Species Richness

The computer-generated habitat coverages have a variety of potential uses. One way they were used during the Pilot Project was to create species richness coverages. The species richness coverage was created by overlaying the individual habitat coverages, then totaling the number of species that have the potential for using each area. This was accomplished by using the ARC/INFO command Union.

The Union command overlays one vector coverage with another, then physically joins the two. The new coverage contains both the vectors from both input coverages and the original coverages attributes. An example of how the vector portion of a coverage is modified by the unioning process is shown in Figure 5. An example of how data stored within a coverage's polygon attribute table (.pat) is modified follows.

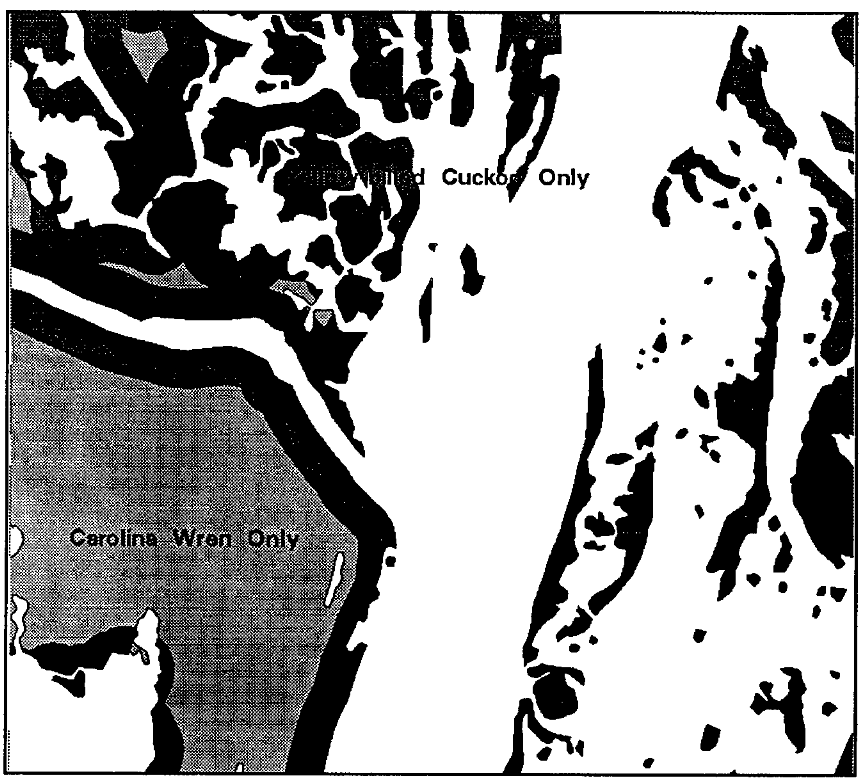
A coverage's .pat contains polygon specific information, both computer defined and user defined. The potential habitat codes are user-defined items. The first five records from the potential nesting habitat coverage created for the Carolina wren are listed here:

```
Arc: list nest-11.pat
Record            AREA      PERIMETER NEST-11# NEST-11-ID CAROLINA_WREN
     1    -51667067.95833  530740.52102    1        0            0
     2     19695023.90558  110002.57186    2        1            1
     3      6706871.47852   50110.90539    3        2            1
     4        95281.14134    1646.97666    4        3            0
     5        61383.27315    1385.91179    5        4            0
```



Potential nesting habitat
Carolina wren

Potential nesting habitat
yellow-billed cuckoo



Unioned coverage

Figure 5. Unioning process used to create the species richness coverages.

The first three items are computer-defined items. ARC/INFO automatically calculates the size of each polygon in a coverage and assigns a numeric value to it. The ID value can be either computer or user defined. Within the potential habitat coverages, these values were computer defined. The only human-defined item in the .pat table is the item CAROLINA_WREN. This is used to identify which polygons were considered potential habitat (1 = potential habitat, 0 = nonhabitat). Whenever a Union is performed on two potential habitat coverages, the resulting .pat resembles the following:

```
Arc: list union_cover.pat
                    1
AREA                               =     -58553648.73097
PERIMETER                          =        904099.04384
UNION_COVER#                       =      1
UNION_COVER-ID                     =      0
NEST-8#                            =      1
NEST-8-ID                          =      0
YELLOW_B_CUCKOO                    = 0
NEST-11#                           =      1

NEST-11-ID                         =      0
CAROLINA_WREN                      = 0
                    2
AREA                               =           7200.85612
PERIMETER                          =            589.89814
UNION_COVER#                       =      2
UNION_COVER-ID                     =      1
NEST-8#                            =      2
NEST-8-ID                          =      1
YELLOW_B_CUCKOO                    = 1
NEST-11#                           =      2
NEST-11-ID                         =      1
CAROLINA_WREN                      = 1

                  3
AREA                               =          36425.61284
PERIMETER                          =           1860.15019
UNION_COVER#                       =      3
UNION_COVER-ID                     =      2
NEST-8#                            =      3
NEST-8-ID                          =      2
YELLOW_B_CUCKOO                    = 1
NEST-11#                           =      3
NEST-11-ID                         =      2
CAROLINA_WREN                      = 1
```

The new .pat contains habitat information for both the Carolina wren and the yellow-billed cuckoo. This coverage can then be unioned with the potential habitat coverage of another species; that coverage can be used as a base for a union with a fourth coverage, and so on. Once all 17 potential habitat coverages were joined together, the historical polygon numbers and ID values were removed and the coverage was unioned to a land cover coverage for the area. A single polygon entry for one of the resulting species richness coverages is shown:

```
                    2
AREA                               =           5669.51470
PERIMETER                          =            575.73118
LCU89_NEST#                        =      2
LCU89_NEST-ID                      =      1
LCU                                = Acer
LCU-13                             = Woody Terrestrial
CLASS                              =   10
VALUE                              =              4
VEG_CODE                           = 1001
PERCENT_CLOSURE                    = >90
CLOSURE_CODE                       =    4
TREE_HEIGHT                        = >50
HEIGHT_CODE                        =    3
```

```
LAND_WATER           = 2
SYMBOL               =  73
AMERICAN_BITTERN     = 0
GREAT_B_HERON        = 0
CANVASBACK           = 0
MALLARD              = 1
SORA                 = 0
SPOT_SANDPIPER       = 0
YELLOW_B_CUCKOO      = 1
BARRED_OWL           = 0
PIL_WOODPECKER       = 1
CAROLINA_WREN        = 1
GR_CR_FLYCATCHER     = 1
WOOD_THRUSH          = 1
BR_HEAD_COWBIRD      = 1
CERULEAN_WARBLER     = 0
GOLDEN_W_WARBLER     = 0
PROTH_WARBLER        = 0
SWAMP_SPARROW        = 0
TOTAL                =     7
```

Contained within this table are data for the 17 species studied during the Pilot Project. The item that defines species richness is the item TOTAL, which was added to the coverage by using ARC's ADDITEM command. The value of TOTAL was calculated by using INFO commands (CALC TOTAL = AMERICAN_BITTERN + GREAT_B_HERON + CANVASBACK + ...). Appendix E contains plots of the species richness coverages.

Initial response to the species richness coverages was favorable. Refuge managers are using these coverages to locate and identify areas that have the potential for supporting large numbers of birds, but may have been overlooked in the past. One such site is Turtle Island, located within Pool 8.

Turtle Island consistently mapped out as having the potential to support a large number of species within a region typically used by only a few species. Refuge managers have utilized these data to establish voluntary avoidance areas within selected areas of Turtle Island. Another group working with UMRS habitat rehabilitation and enhancement projects (HREP) has discussed the possibility of using Turtle Island as a possible reference model for islands built by the Corps of Engineers.

Accuracy Assessment

Despite high water during summer 1994, efforts were made to groundtruth the habitat coverages. Staff of the UMSC supervised a crew that made informal bird counts within the Pool 8 study area. Each day the crew traveled a random search route within the study area, periodically noting which species were present. Initially, the survey concentrated on locating soras and rails by playing recordings of their songs. Positive and negative responses to the recordings were noted and the location of the search was collected by global positioning system receivers. As the survey season progressed, the searches included other bird species and recording the search route.

At the time this document was prepared, much of these data were not analyzed. A second season of groundtruthing has been planned and the results, along with the results from the first season, are to be published in a separate document.

Results and Recommendations

Preliminary responses to the Pilot Project have been extremely positive. Some persons have shown an interest in the individual habitat coverages, while others have found the species richness coverages valuable. The individual species coverages help provide an overall view of where a species might be located. If the groundtruthing proves that these coverages accurately reflect potential habitat for a species, the coverages could be used in the development of Refuge management plans. The coverages will also be valuable in assisting the U.S. Army Corps of Engineers and other participating federal and state agencies in planning and constructing future habitat projects as part of the Upper Mississippi River Environment Management Program.

Interest was expressed in single species habitat coverages such as those for the American bittern and the sora. These birds can be difficult to locate because of their secretive nature. Review of the habitat coverages revealed that while individuals searching for the birds may have been searching within a potential habitat area, some of the most abundant habitat areas were not surveyed because of accessibility problems. Upon reviewing the coverages, it was noted that the extra effort required to enter some of the marshes might prove worthwhile.

The species richness coverages for Pool 8 also received favorable feedback. Several areas within Pool 8 had consistently high species richness counts throughout the year, especially Turtle Island. Turtle Island is located within lower Pool 8 on the edge of the impounded region. Floodplain forest habitat within this region is fairly scarce. During the nesting season, Turtle Island has the potential for hosting 7 of the 17 species that had habitat coverages created for them, and in fall the island has the potential for hosting 11. The actual species count is probably much lower because the island is a popular recreation site.

In spring and summer, the beaches of Turtle Island are popular picnicking and camping sites. In fall, Turtle Island receives a lot of hunting pressure because it is located adjacent to an area closed to waterfowl hunters. As result, there is a near-constant human presence on the island throughout the nesting season and into the fall migration season. The U.S. Fish and Wildlife Service has responded to this by posting the island as a voluntary closed area. Picnicking and camping are still allowed on the island's beaches, but the public is asked to leave the rest of the island undisturbed.

The two main recommendations for future implementation of the Strategy are (1) a more intensive peer-reviewed literature search should be conducted before a project is initiated, and (2) the computer analysis should be completed by using a raster-based GIS instead of operating a vector environment.

Persons conducting the literature review were given a large amount material to read and synthesize within a short time. If the persons conducting the literature review had been allotted sufficient time to thoroughly review the literature and have their results peer-reviewed, perhaps many of the inconsistencies could have been avoided.

One of the first oddities noted was several habitat coverages that highlighted areas a species may use on occasion, yet completely ignored its primary habitat requirements. This phenomenon was observed for only a couple of species, all of which had been studied for years by individuals who had tried to determine the exact habitat requirements of those species. On occasion, persons documenting the habitat requirements of a well-documented species ignored or only referenced in passing that species' basic habitat requirements. This was believed to occur because such information is considered common knowledge within the scientific community. A peer-review of such data would help detect such omissions, as well as evaluate the data to determine if it is applicable to the UMRS.

The second recommendation involves the use of a raster-based GIS for future modeling projects. The recommended changeover from vector-based modeling to raster-based modeling is a logistical one. When fully implemented, the Strategy will evaluate the habitat requirements of more than 200 bird species throughout the

UMRS study area (Wabasha, Minnesota, to St. Louis, Missouri). It is doubtful if the present status of vector-based GIS systems would be able to process the data load within a reasonable time.

The Pilot Project modeled habitat data for 18 bird species within two study reaches. Even though the vector-based modeling utilized a sophisticated software program (ARC/INFO rev. 6.1.2) and workstation technology (SUN Sparc 690), processing was often slow. Although most of the time work-arounds were discovered so that modeling could continue, that was not always the case. Modeling for the red-shouldered hawk was eventually suspended after nearly 2 weeks of modeling failed to produce the last two buffer coverages required to locate potential nesting sites.

A few work-arounds were also developed for the creation of the species richness coverages. Large amounts of computer resources (processing time and disk space) were required to create these coverages. The resulting coverages were so complex that the computer had problems identifying the smallest polygons. When this happened, it was impossible to shade the entire coverage on the computer's screen. Printing these data or performing searches among the data to locate specific relations also required extensive computer resources.

Most of these problems would be resolved if future analysis projects used a raster-based GIS, ArcGrid. Since a raster-based GIS would classify the earth by using a grid cell approach instead of vectors, vertices and segment errors would not be limiting factors. The need to physically join two coverages before a relational analysis, can be performed is also removed. Coverages that measure items, such as the distance to water or the distance from an urban area, can be created and stored as individual identities. Each coverage would contain all possible distances to the feature in question. This way, modifying a particular model by changing a distance requirement would only require changing a distance value in the multiple-file query command. If a similar change was to be performed by using a vector-based GIS, a new buffer coverage would have to be created, the old buffer coverage would need to be replaced with the new coverage, and a new search would need to be performed on the resulting vector coverage. Raster coverages also require less computer disk space for file storage and file size limits would allow for the use of coverages containing the entire UMRS study area (Wabasha, Minnesota, to St. Louis, Missouri).

Acknowledgments

The Upper Mississippi River System Migratory Bird Pilot Project was a cooperative effort that received funding or personnel assistance from:

U.S. Fish and Wildlife Service, Region 3
- Mark Twain National Wildlife Refuge
- Rock Island Enhancement Field Office
- Upper Mississippi River National Wildlife and Fish Refuge (NWFR)

Biological Resources Division, U.S. Geological Survey
- Environmental Management Technical Center (EMTC)—Long Term Resource Monitoring Program
- Upper Mississippi Science Center (UMSC)

J. Nissen (Upper Mississippi River NWFR) was project supervisor. The literature searches were conducted by C. Korschgen and T. Jacobson. Data generated from the searches were entered into a database and compiled at the EMTC. Computer assistance was provided by S. Moe (St. Cloud University, St. Cloud, Minnesota). The 64-km corridor coverage was created by M. Laustrup (EMTC).

Appendix A

Land Cover/Use Data, 1975 and 1989

Appendix A contains background information on the land cover/land use datasets used in this study (Figures A-1-A-4).

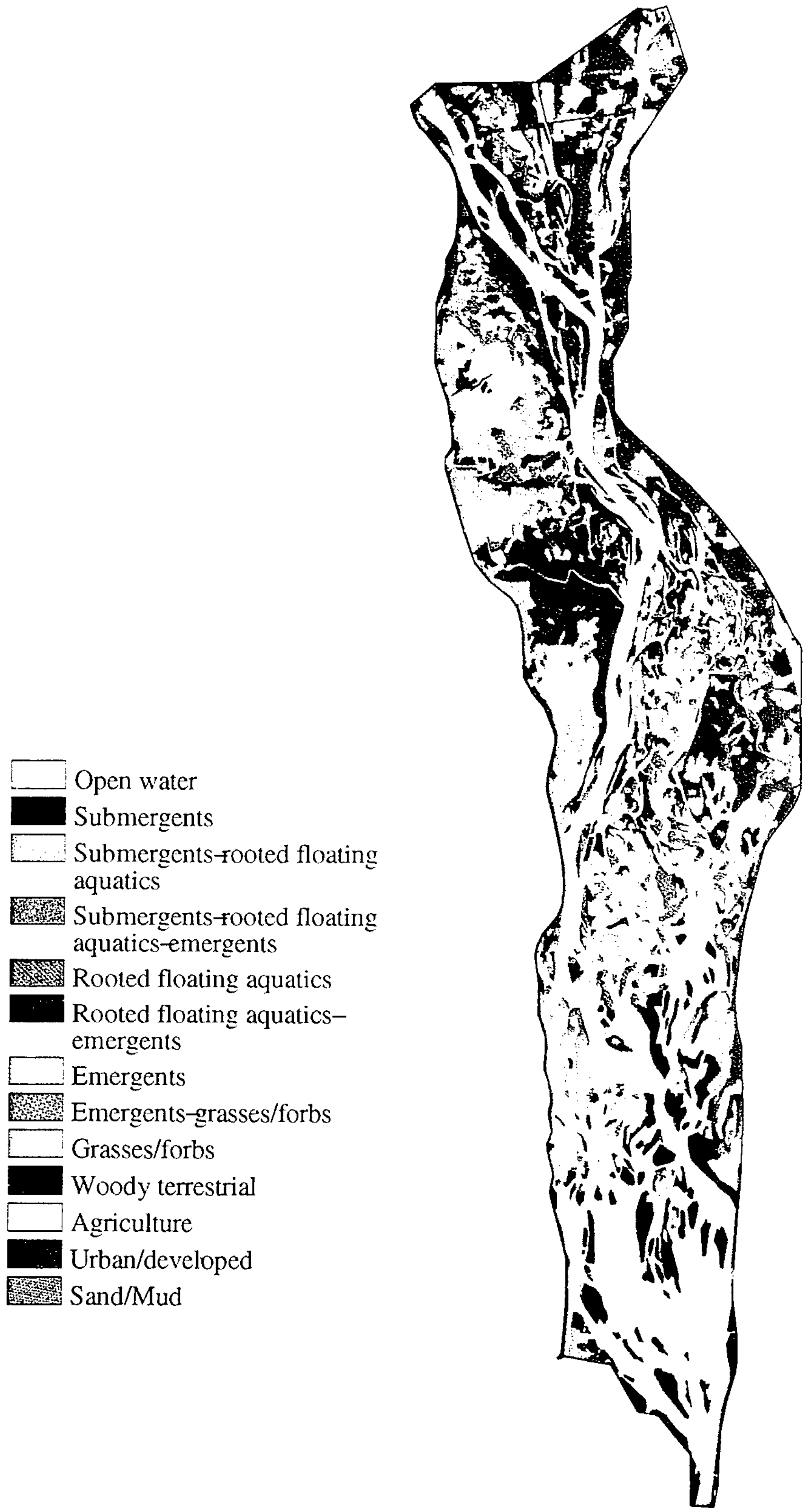


Figure A-1. Generalized 1975 land cover/use data—Upper Mississippi River Pool 8.

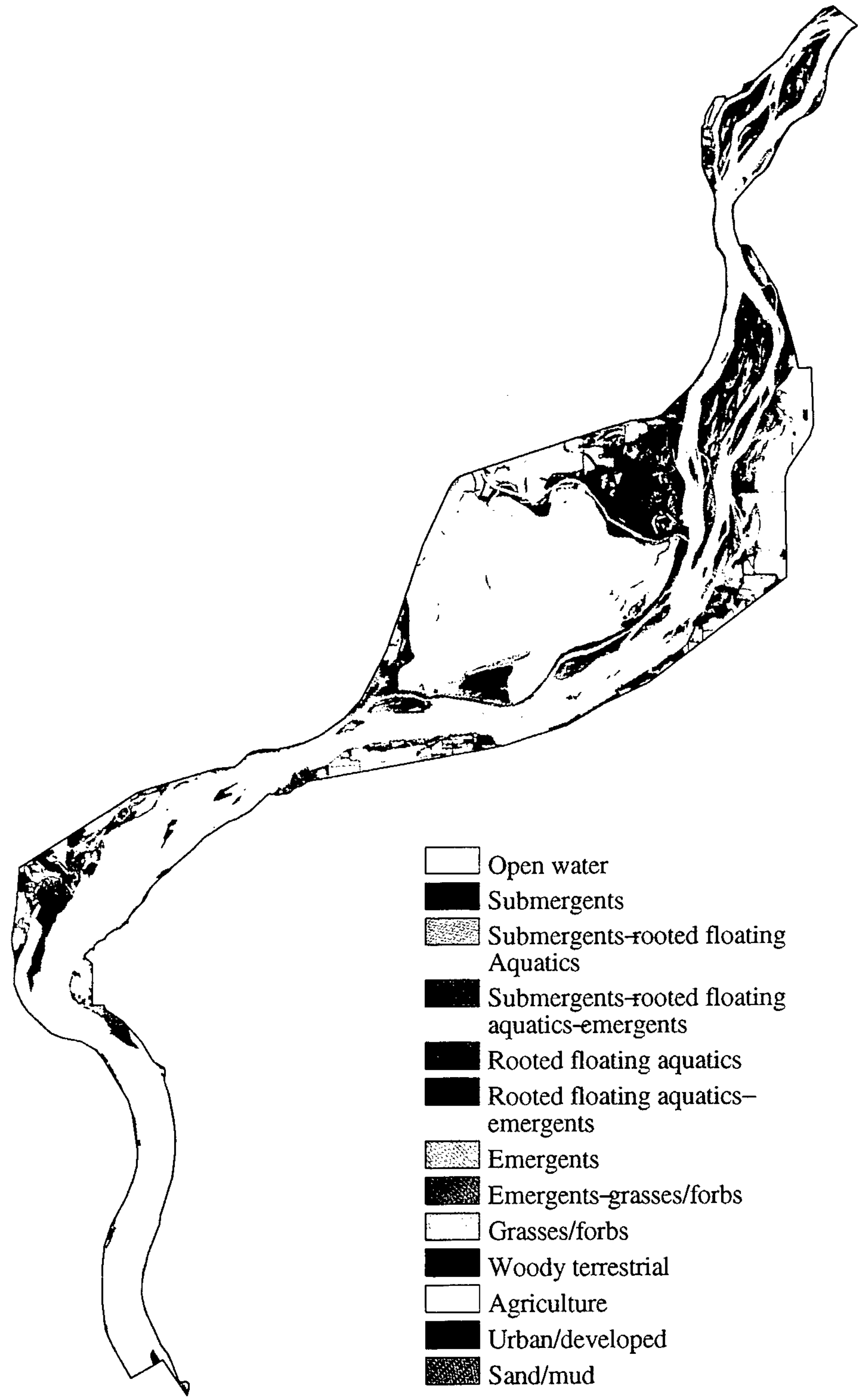


Figure A-2. Generalized 1975 land cover/use data—Upper Mississippi River Pool 19.

Data Descriptions, 1975

Great River Environmental Action Teams I, II, and III (1970s) Land Cover/Use Classification List

Version 2.05
21 January 1994

The Great River Environmental Action Teams (GREAT) of the late 1970s were composed of persons from:

Bureau of Outdoor Recreation, Ann Arbor, Michigan
Department of Transportation, St. Louis, Missouri
Environmental Protection Agency, Chicago, Illinois
Minnesota-Wisconsin Boundary Area Commission, Hudson, Wisconsin
Soil Conservation Service, Des Moines, Iowa
State of Illinois, Department of Conservation, Springfield, Illinois
State of Iowa, Iowa Conservation Commission, Des Moines, Iowa
State of Minnesota, Minnesota Department of Natural Resources, St. Paul, Minnesota
State of Missouri, Department of Natural Resources, Jefferson City, Missouri
State of Wisconsin, Department of Natural Resources, Madison, Wisconsin
Upper Mississippi River Conservation Committee, Rock Island, Illinois
U.S. Army Corps of Engineers, Rock Island, Illinois
U.S. Army Corps of Engineers, St. Louis, Missouri
U.S. Army Corps of Engineers, St. Paul, Minnesota
U.S. Environmental Protection Agency, Kansas City, Missouri
U.S. Fish and Wildlife Service, St. Paul, Minnesota
U.S. Fish and Wildlife Service, Rock Island, Illinois

GREAT I studied the Upper Mississippi River System (UMRS) from St. Paul–Minneapolis, Minnesota, to Guttenberg, Iowa. GREAT II studied the UMRS from Guttenberg, Iowa, to Saverton, Missouri. And GREAT III studied the UMRS from Saverton, Missouri, to the confluence with the Ohio River.

One of the main objectives of the GREAT research teams was to evaluate current resource management practices, then develop a series of management strategies. One of the problems facing GREAT was the lack of available information on many of the river's components. One project implemented by GREAT was the creation of a land cover/use database derived from aerial photography.

In 1975, 1:9,600-scale color infrared photography was collected for UMRS Pools 3 through 10, and 1:24,000-scale color infrared photography was collected from Lock and Dam 10 to the confluence with the Ohio River. In 1978, 1:24,000-scale color infrared photography was collected for Pools 1 and 2. All photographs were groundtruthed and interpreted, then data for Pools 1 through 14 were automated. During the automation process, interpreted data were transferred to 1:24,000-scale U.S. Geological Survey quad maps, then entered into a computer by using the geographic information system (GIS) PIOS. As the data were transferred, they were generalized to create coverages with a minimum mapping unit of 2.5 acres. Some polygons smaller than 2.5 acres and linear features were incorporated into nearby polygons. Others were manually enlarged so that the data contained within them would be preserved. All generalizations were made in accordance with guidelines established for GREAT projects. Individuals working for the GREAT projects worked extensively with the automated data. One project converted the genus-level automated data into genus/species data. The PIOS data were then converted into ARC/INFO format by the Long Term Resource Monitoring Program (LTRMP).

The LTRMP has copies of the mylar overlays created by GREAT's photointerpreters. In 1992, the LTRMP commissioned the National Ecology Research Center (NERC) to computerize the data for Pools 19, 26, and

LTRMP's open river study reach. NERC transferred the data to 1:24,000-scale quadrangles, then automated it using the GIS program ARC/INFO.

Differences exist between the two datasets. Coverages automated by NERC were attributed according to the classification scheme used by the photointerpreters, not the enhanced genus/species scheme developed by the GREAT project. A comparison listing of the two classification schemes appears at the end of this document.

Each land cover/use type has been assigned a numeric classification code. The codes relate the GREAT data to the LTRMP classification scheme. The LTRMP utilizes a genus-level classification scheme on its aerial photography, and it has also developed a 13-class generalized classification scheme for regrouping similar land cover types. An explanation of the coding system follows.

- Each LTRMP generalized vegetation group has been assigned a number that is a multiple of 100. Example: open water is 100, submergents is 200.

- Each vegetation type was then assigned a numeric value that related it to the 13 vegetation groups. Example: The submergent *Myriophyllum* (water milfoil) is 202.

- Vegetation types unique to historical coverages have been assigned values of 50 or above. Example: *Sagittaria latifolia* (broad arrowhead) is 751. The 700 portion of the number signifies that *Sagittaria latifolia* is an emergent, while the 51 signifies that this vegetation class is not in use by LTRMP photointerpreters.

- A single bold asterisk (*****) after a type description signifies a vegetation type utilized only within the enhanced GREAT coverages (Pools 1–14).

- A double bold asterisk (******) after a type description signifies a vegetation type utilized only within the GREAT coverages automated by NERC (Pools 19, 26, and the open river study reach).

****

100 Open Water - Any unvegetated body of water. All 100-numbered water types within the 13-class land cover/use coverages are grouped into open water. Note: Industrial ponds are classified under urban/developed (1200s).

101 Lemnaceae - Duckweed (floating) - Duckweed has been assigned an open water classification because of its mobile tendencies; duckweed goes wherever the wind takes it.

150 Lake** - Note: Some artificial ponds have been grouped with the urban classes (1200s).

****

200 Submergents** - Used to classify any area with submergent vegetation whose species composition is unknown. All 200-numbered submergents within the 13-class land cover/use coverages are grouped into submergents. Note: The order in which plant combinations are listed does not reflect plant dominance.

201 Lemnaceae/submergents** - Duckweed/submergent vegetation mixture

250 Vallisneria/Potamoget/Heteran* - Wildcelery/pondweed/water stargrass mixture

251 Ceratophyllum* - Coontail

252 Lemnaceae/Ceratophyllum* - Duckweed/coontail mixture

253 Lemna/Ceratophyll/Potamogeton* - Duckweed/coontail/pondweed mixture

254 Potamogeton* - Pondweed

255 Vallisneria - Wildcelery - This vegetation class, while contained in the classification list for the enhanced coverages, has not been located in any of the automated coverages.

****

300 Submerg-Rooted Floating Aqua

- This class is used only to regroup 300-numbered submergent-rooted floating aquatics for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

350 Nelumbo/Lemna/Ceratophyllum* - American lotus/duckweed/coontail mixture

351 Nymphaea/Ceratophy/Potamogeton* - White waterlily/coontail/pondweed mixture

352 Nymph/Ceratophy/Potamog/Lemna* - White waterlily/coontail/pondweed/duckweed mixture

****

400 Submerg-Rooted Floating-Emerg

- This class is used only to regroup all 400-numbered submergent-rooted floating aquatic-emergents for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

450 Sag latif/Lemna/Ceratophyllum* - Broad arrowhead/duckweed/coontail mixture

****

500 Rooted Floating Aquatics

- This class is used only to regroup all 500-numbered rooted/floating aquatics for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

502 Jussiaea** - Water primrose

503 Nelumbo - American lotus

504 Nelumbo/Lemnaceae** - American lotus/duckweed mixture

507 Nymphaea* - White waterlily

****

700 Emergents

- This class is used only to regroup all 700-numbered emergents for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

703 Cyperus* - Flat sedge

709 Sagittaria** - Arrowhead

714 Scirpus - Bulrush

717 Sedge meadow* - A very wet meadow dominated by sedges. Other emergents may be mixed within.

718 Sparganium* - Burreed

719 Typha - Cattail

722 Typha/Scirpus/Sparganium* - Cattail/bulrush/burreed mixture

724 Zizania* - Wild rice

751 Sagittaria latifolia* - Broad arrowhead or duck potato

752 Sagittaria rigida* - Stiff arrowhead

753 Sag latifolia/Sag rigida* - Broad arrowhead/stiff arrowhead

754 Scirpus/Sagittaria latifolia* - Bulrush/broad arrowhead

****

800 Emergents-Grasses/Forbs - This class is used only to regroup all 800-numbered emergents-grasses/forbs for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

811 Scirpus/Phragmites* - Bulrush/common reed mixture

812 Scirpus/Polygonum* - Bulrush/smartweed mixture

850 Sagittaria latifolia/Phalaris* - Broad arrowhead/reed canarygrass mixture

851 Leers/Carex/Sag latifolia/Poly* - Cutgrass/sedges/broad arrowhead/smartweed mixture

852 Scirp/Echinocyst/Xanthium/Poly* - Bulrush/cucumber family/cocklebur/smartweed mixture

****

900 Grasses/Forbs - Nonwoody plants. This class is used only to regroup all 900-numbered grasses/forbs for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

901 Ambrosia - Ragweed - This vegetation class, while contained in the classification list for the enhanced coverages, has not been located in any of the automated coverages.

902 Grass* - Used to delineate areas of mixed grasses. Abandoned/set-aside fields are also placed within this class.

904 Pasture (heavily grazed areas)* - "Hay fields" regularly pastured with cattle or similar livestock.

905 Leersia - Cutgrass

907 Meadow* - Upland areas regularly cut and baled for hay.

908 Mixed forbs and/or grasses** - Class used to describe a mixture of many different grasses and forbs.

910 Phalaris* - Reed canarygrass

912 Phragmites* - Common reed

914 Polygonum - Smartweed

916 Rdside-levee/grass/forbs/shrub - Any roadside ditch or levee. Example of a roadside: Delineation of a north/south roadway would begin on the far west side of the western ditch and go to the far eastern side of the eastern ditch. Both ditches and the road are included within the same polygon.

918 Spartina* - Cordgrass

919 Vines as dense overgrowth - Any live stem vine growing as a dense covering. Within LMIC's coverages, *Echinocystis* (wild cucumber) and brush covered with *Echinocystis* were grouped into 919. The class is utilized "as is" in the coverages automated by NERC.

****

1000 Woody Terrestrial - All trees and shrubs. This class is used only for regrouping all the woody terrestrial vegetation for the 13-class land cover/use coverages. This class does not appear in any GREAT coverages. Note: The order in which plant combinations are listed does not reflect plant dominance.

1005 Brush - Any small shrubby species

1007 Cephalanthus** - Buttonbush

1011 Plantation - Any group of planted, cultivated trees. Examples include apple orchards, Christmas tree farms, and stands of planted pines.

1014 Salix* - Willows

1055 >50% Cottonwd &/or Willow <20' - This class is used to classify stands of *Populus* and/or *Salix* trees less than 20 ft tall that cover at least 50% of the polygon.

1056 >50% Cottonwd &/or Willow >20' - This class is used to classify stands of *Populus* and/or *Salix* trees more than 20 ft tall that cover at least 50% of the polygon.

1057 >50% Lowland Hardwoods <20' - This class is used to classify stands of mesic hardwood less than 20 ft tall that cover at least 50% of the polygon.

1058 >50% Lowlnd Hardwds >20'-grass - This class is used to classify stands of mesic hardwood more than 20 ft tall that cover at least 50% of the polygon and have an understory of grasses.

1059 >50% Lowland Hardwoods >20' - This class is used to classify stands of mesic hardwood more than 20 ft tall that cover at least 50% of the polygon.

1060 Sagittaria latifolia/Salix* - Broad arrowhead/willow mixture

****

1100 Agriculture - Any cultivated field that is either turned with a plow or worked with a disk. Crops include corn, soybeans, and oats. LMIC's class cropland-farmstand has been assigned to agriculture.

****

1200 Urban/Developed - Any area "developed" by humans. This class is used only to regroup all 1200-numbered urban classes for use in the 13-class generalized land cover/use coverages. This class does not appear in any GREAT coverages.

1201 Developed** - Shopping malls, industrial parks, military depots, farmsteads, storage facilities, and isolated industrial sites (built in the middle of a rural area) are considered developed.

1202 Developed parks** - City and state parks are included in this category but only those areas actively used by humans. Examples are picnic areas, campgrounds, administrative buildings, and interpretive complexes.

1203 Industrial pond - Examples of industrial ponds are water coolant ponds and fish ponds actively managed for industrial or research use (i.e., fish farms and hatcheries).

1204 Urban* - Residential areas, including schools

1250 Farm Pond

1251 Residential**

****

1300 Sand/Mud - This class is used only to regroup all 1300-numbered sand/mud classes for use in the 13-class generalized land cover/use coverages. This class does not appear in any of the GREAT coverages.

1301 Mud - Mud

1303 Sand - Sand

****

1450 Unknown - Polygons whose attributes were either lost or undecipherable

Land Cover/Use—Pools 1 Through 14

- Created from interpreted photos, then modified by the GREAT program -

Descriptions appear as listed within the coverages

Brush
Ceratophyllum (coontail)
Cottonwood and/or tree willow (ave. ht. > 20 ft)
Cottonwood and/or willow (ave. ht. <6 m)
Cropland-farmsteads
Cyperus (nutgrass)
Echinocystis (wild cucumber)
Farm pond
Grassland
Improved-pasture
Industrial pond
Leersia (rice cutgrass)
Leersia-Carex-Sagittaria latifolia-polygonum
Lemnaceae (duckweed)
Lemnaceae-*Ceratophyllum*
Lemnaceae-*Ceratophyllum-Potamogeton*
Mixed lowland hardwoods (ave. ht. > 20 ft)
Mixed lowland hardwoods (ave. ht. <6 m)
Mud
Nelumbo (American lotus)
Nelumbo-Lemnaceae-Ceratophyllum
Nymphaea (waterlily)
Nymphaea-Ceratophyllum-Potamogeton
Nymphaea-Ceratophyllum-Potamogeton-Lemnaceae
Open water
Open stand of mixed hardwoods with grass understory
Phalaris (reed canarygrass)
Phragmites (reedgrass)
Polygonum (smartweed)
Potamogeton (pondweed)
Roadside levee grass and brush
Sagittaria latifolia (broadleaf arrowhead)
Sagittaria latifolia - Phalaris
Sagittaria latifolia - S. rigida
Sagittaria latifolia - Salix
Sagittaria latifolia-Lemnaceae-Ceratophyllum
Sagittaria rigida (bur arrowhead)
Salix (willow)
Sand (>90% bare sand)
Scirpus (bulrush)
Scipus-Echinocystis-Xanthium-Polygonum
Scirpus-Phragmites
Scirpus-Polygonum
Scirpus-Sagittaria latifolia
Sedge meadow
Sparganium (burreed)
Spartina (cordgrass)
Tree farm
Type 35 covered by *Echinocystis*
Typha (cattail)
Typha-Scirpus-Sparganium
Unknown
Upland meadow
Urban
Vallisnaria-Potamogeton-Heteranthra
Zizania (wild rice)

****

Land Cover/Use—Pools 19, 26, and Open River Study Reach

- Created from interpreted photos -

Descriptions appear as listed within the coverages

>50% cottonwd &/or willow <20'
>50% cottonwd &/or willow >20'
>50% lowland hardwoods <20'
>50% lowland hardwoods >20'
Agriculture
Brush
Cephalanthus
Developed
Developed park
Farm pond
Grasses/forbs
Industrial pond
Jussiaea
Lake
Leersia
Lemnaceae
Lemnaceae/submergents
Lemnaceae/submergents
Mixed forbs and/or grasses
Mud
Nelumbo
Nelumbo/Lemnaceae
Plantation
Polygonum
Potamogeton
Rdside-levee/grass/forbs/shrub
Residential
Sagittaria
Sand
Scirpus
Submergents
Typha
Unknown
Vines as dense overgrowth
Water

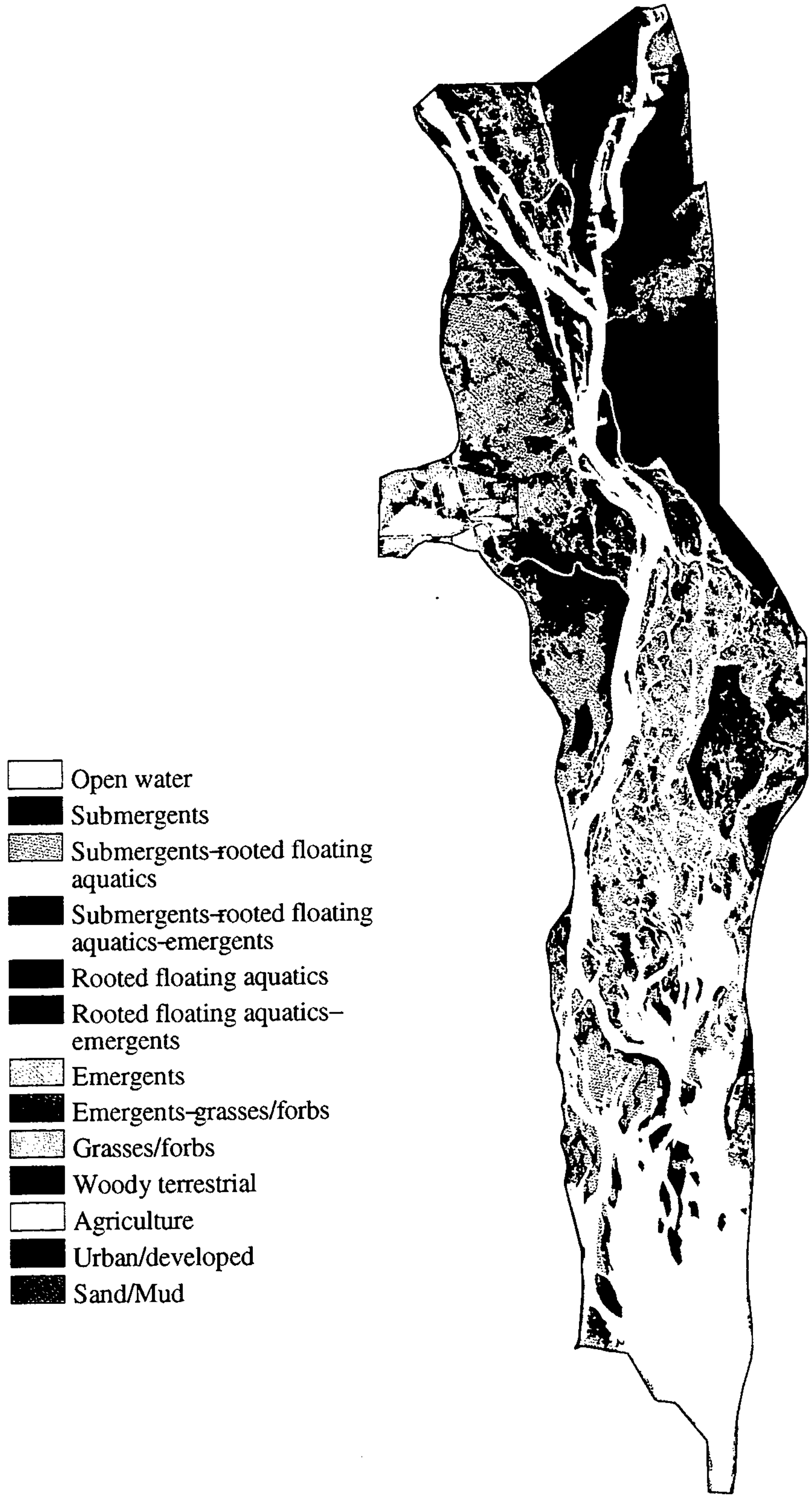


Figure A-3. Generalized 1989 land cover/use data—Upper Mississippi River Pool 8.

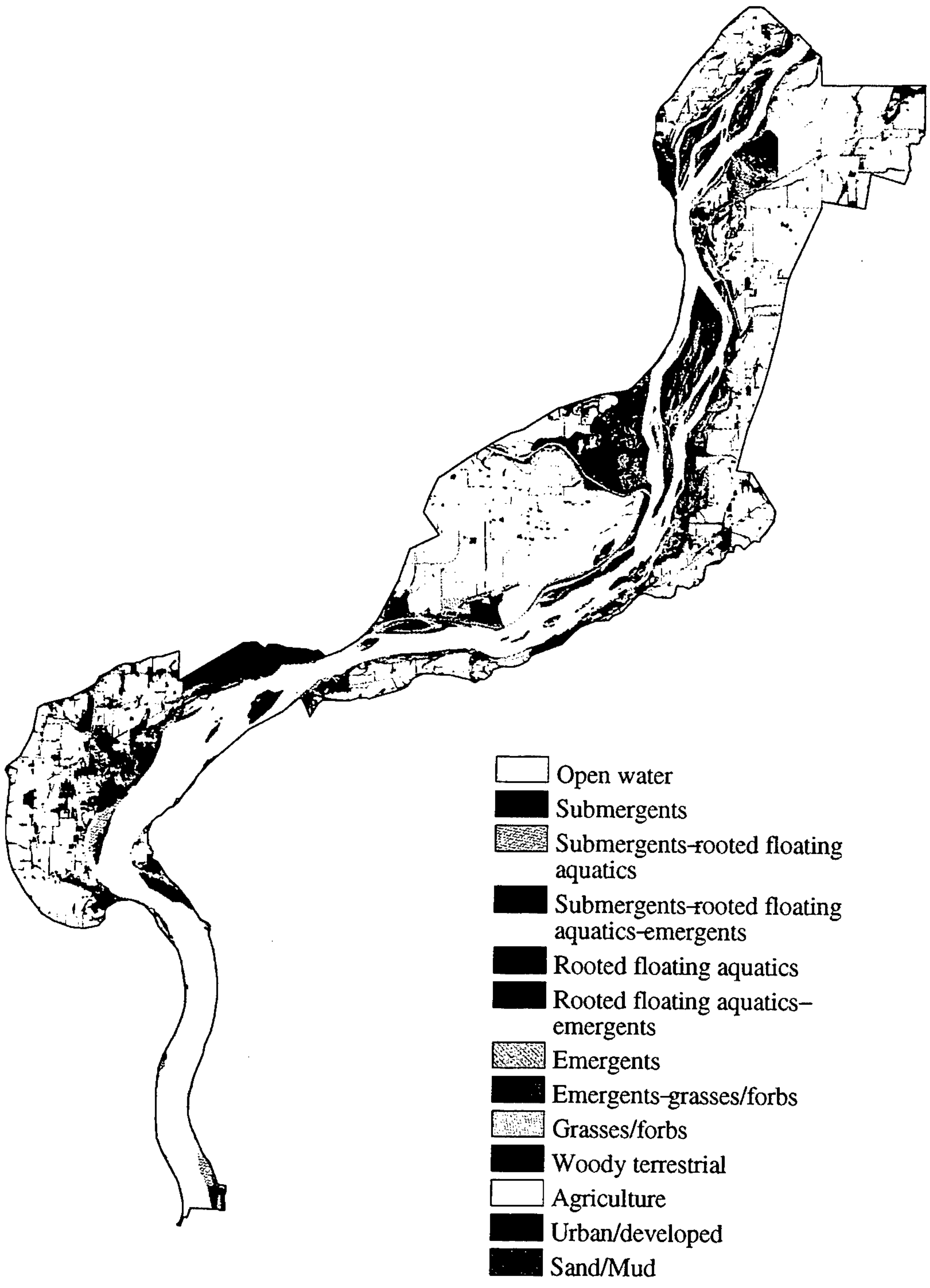


Figure A-4. Generalized 1989 land cover/use data—Upper Mississippi River Pool 19.

Data Descriptions, 1989

Long Term Resource Monitoring Program
Land Cover/Use Classification List
Version 2.05
28 January 1994

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center (EMTC), an office of the National Biological Survey, in cooperation with the five Upper Mississippi River System States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, with guidance and Program responsibility provided by the U.S. Army Corps of Engineers.

The mission of the LTRMP is to provide decision makers with information for maintaining the Upper Mississippi River System (UMRS) as a viable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

In 1989, the LTRMP began collecting aerial photography, photographing the entire UMRS floodplain in both true color and color infrared (scale, 1:15,000). In the years since, color infrared photography has been collected for selected regions of the river. At the time the present document was prepared, the EMTC was planning to photograph the entire UMRS floodplain in 1994.

The LTRMP has field stations collecting data within six study reaches of the UMRS. The National Ecology Research Center (NERC) was contracted to interpret and computerize 1989 photography of LTRMP study reaches and four other project areas. In 1991, LTRMP personnel began interpreting aerial photography. NERC interpreters used a minimum mapping unit of <0.4 ha (1 acre) and a minimum of 10% vegetation cover; LTRMP interpreters use a minimum mapping unit of 0.4 ha (1 acre) and a minimum of 10% vegetation cover.

Photography is interpreted to delineate three feature types: land cover/use, percent vegetation cover, and tree height. Examples of how photographs are interpreted follow:

1. Working within an area of forested islands, no aquatic vegetation.

   The interpreter first locates, then marks the land/water interface. Each island is studied to see if more than one land cover/use type is present. If multiple types are present, the interpreter analyzes the area to see if the trees are growing in a mixture or if unique stands of trees are present. Each polygon is then labeled with the appropriate vegetation code followed by a character describing the percent of the island covered by the trees (i.e., canopy closure). The average tree height is then calculated and recorded.

2. A sand bar/dredge spoil island sparsely vegetated with grass.

   As with the previous example, the interpreter first marks the outer boundary of the sand bar. If all of the vegetation is localized within one region of the sand bar and the area is large enough to be mapped, a boundary line is drawn around the vegetation. If the vegetation is so sparse that it does not cover at least 10% of the sand surface, the grasses are ignored and the area is mapped as sand. If the grasses cover more than 10% of the sand surface, the area is mapped as grass and the percent vegetation cover is noted. Vegetation height is recorded only when trees are present.

3. A transition zone containing a mixture of various rooted and floating vegetation, emergents, and submergents.

The area containing the mixture is first separated from its surrounding features. The mixture is then analyzed to see if the region contains a uniform mixture of plants or several distinct regions of different plant mixtures. Each polygon is labeled with the appropriate vegetation code, then the percent vegetation cover is noted. LTRMP interpreters do not analyze plant mixtures to determine plant dominance. Therefore, the sequence in which mixed vegetation types are listed is arbitrary and does not represent plant dominance.

Average size and size ranges of the mixed plant beds vary within the UMRS, and are site-specific. It should be noted that while LTRMP interpreters use a small minimum mapping unit, sometimes the mixed vegetation beds are very large. Example: Within UMRS Pools 7 and 8, the mean size of a mixed vegetation polygon is 0.8–2.0 ha (2–5 acres), but they range in size from 0.04 ha (0.1 acre) to 72 ha (178 acres). Single polygons >20 ha (50 acres) have been created for

Nelumbo/Nymphaea/Sagittaria
*Nelumbo/Nymphaea/*submerg/*Lemn*
*Nymphaea/*submergents/*Lemnaceae*

and polygons >61 ha (150 acres) have been created for

*Nymphaea/Nelumbo/*submergents
*Nymphaea/*Submergents

LTRMP photointerpreters use a genus-level classification scheme. A 13-class generalized classification scheme was also developed for regrouping the data. A numeric classification scheme is then used to relate the two classification schemes. An explanation of LTRMP vegetation codes follows.

- Each LTRMP generalized vegetation group has been assigned a number that is a multiple of 100. Example: Open water is 100, submergents is 200.
- Each vegetation type was then assigned a numeric value that related it to the 13 vegetation groups. Example: The submergent *Myriophyllum* (water milfoil) is 202.
- Vegetation types unique to historical coverages have been assigned values of 50 or above. Example: *Sagittaria latifolia* (broad arrowhead) is 751. The 700 portion of the number signifies that *Sagittaria latifolia* is an emergent, while the 51 signifies that this vegetation class is not in use by LTRMP photointerpreters.

****

100 Open Water - Any unvegetated body of water. Includes rivers, streams, lakes, and ponds. All 100-numbered water types within the 13-class land cover/use coverages are grouped into open water. Note: Industrial ponds are classified under urban/developed (1200s).

101 Lemnaceae - Duckweed (floating) - Duckweed has been assigned an open water classification because of its mobile tendencies; duckweed goes wherever the wind takes it.

****

200 Submergents - Used to classify any area with submergent vegetation whose species composition is unknown. All 200-numbered submergents within the 13-class land cover/use coverages are grouped into submergents. Note: Species classification of submergents within LTRMP coverages began in 1992, only for plant beds that had been groundtruthed. The order in which plant combinations are listed does not reflect plant dominance.

201 Lemnaceae/submergents - Duckweed/submergent vegetation mixture

202 Myriophyllum - Water milfoil

203 Zosterella - Water stargrass

204 Vallisneria/Zosterella - Wildcelery/water stargrass mixture

205 Myriophyllum/Zosterella - Water milfoil/water stargrass mixture

206 Vallisneria/Potamogeton - Wildcelery/pondweed mixture

207 Myrioph/Potamoget/Vallis - Water milfoil/pondweed/wildcelery mixture

208 Potamoget/Vallis/Zost/Cerat - Pondweed/wildcelery/water stargrass/coontail mixture

209 Elodea - Waterweed

250* Vallisneria/Potamoget/Heteran - Wildcelery/pondweed/water stargrass mixture. Note: The name of this class was established by the classification of the GREAT data. Since then, the genus *Heterantha* has been changed to *Zosterella.*

251* Ceratophyllum - Coontail

252* Lemnaceae/Ceratophyllum - Duckweed/coontail mixture

253* Lemna/Ceratophyll/Potamogeton - Duckweed/coontail/pondweed mixture

254* Potamogeton - Pondweed

255* Vallisneria - Wildcelery

* This class was assigned a historical classification number (50's) because at the time it was assigned its number, this class was only utilized within the GREAT river study coverages (1970's).

****

300 Submerg-Rooted Floating Aqua

- This class is used only to regroup 300-numbered submergent-rooted floating aquatics for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: Species classification of submergents within LTRMP coverages first began in 1992, only for plant beds that had been groundtruthed. The order in which plant combinations are listed does not reflect plant dominance.

301 Brasenia/submergents - Watershield/submergent vegetation mixture

302 Nelumbo/Nymphaea/submerg/Lemn - American lotus/white waterlily/submergent vegetation/duckweed mixture

303 Nelumbo/submergents - American lotus/submergent vegetation

304 Nelumbo/submergents/Lemnaceae - American lotus/submergent vegetation/duckweed mixture

305 Nymphaea/Nelumbo/submergents - White waterlily/American lotus/submergent vegetation mixture

306 Nymphaea/submergents - White waterlily/submergent vegetation mixture

307 Nymphaea/submergents/Lemnaceae - White waterlily/submergent vegetation/duckweed mixture

308 Nymphaea/Myriophyllum - White waterlily/water milfoil mixture

309 Nelumbo/Myriophyllum - American lotus/water milfoil mixture

310 Nelumbo/Nymphaea/Myriophyllum - American lotus/white waterlily/water milfoil mixture

****

400 Submerg-Rooted Floating-Emerg

- This class is used only to regroup all 400-numbered submergent-rooted floating aquatic-emergents for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: Species classification of submergents within LTRMP coverages began in 1992, only for plant beds that had been groundtruthed. The order in which plant combinations are listed does not reflect plant dominance.

401 Nelum/Nymph/Sag/Sparg/sub/Lemn - American lotus/white waterlily/arrowhead/burreed/submergents/duckweed mixture

402 Nelum/Nymph/Ponted/sub/Lemn - American lotus/white waterlily/pickerelweed/submergents/duckweed mixture

403 Scirpus/Nelumbo/submergents - Bulrush/American lotus/submergents mixture

404 Scirpus/Nymphaea/submergents - Bulrush/white waterlily/submergents mixture

405 Zizania/Nymphaea/Nelumbo/sub - Wild rice/white waterlily/American lotus/submergents mixture

406 Pontederia/Nymph/Nelumbo/sub - Pickerelweed/white waterlily/American lotus/submergents mixture

407 Sagit/Ceratophyllum/Lemnaceae - Arrowhead/coontail/duckweed mixture

****

500 Rooted Floating Aquatics

- This class is used only to regroup all 500-numbered rooted/floating aquatics for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: The order in which plant combinations are listed does not reflect plant dominance.

501 Brasenia - Watershields

502 Jussiaea - Water primrose

503 Nelumbo - American lotus

504 Nelumbo/Lemnaceae - American lotus/duckweed mixture

505 Nelumbo/Nymphaea - American lotus/white waterlily mixture

506 Nuphar - Yellow waterlily - Note: *Nuphar* and *Nymphaea* cannot be differentiated on aerial photography. *Nuphar* is used in areas where it is known to occur; otherwise, *Nymphaea* is the default waterlily genus.

507 Nymphaea - White waterlily

508 Nelumbo/Nymphaea/Lemnaceae - American lotus/white waterlily/duckweed mixture

509 Nymphaea/Lemnaceae - White waterlily/duckweed mixture

****

600 Rooted Floating Aqua-Emergents - This class is used only to regroup all 600-numbered rooted floating aquatic-emergents for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: The order in which plant combinations are listed does not reflect plant dominance.

601 Nelumbo/Nymphaea/Sagittaria - American lotus/white waterlily/arrowhead mixture

602 Nymphaea/Sagittaria - White waterlily/arrowhead mixture

603 Nymphaea/Scirpus - White waterlily/bulrush mixture

604 Sagittaria/Nelumbo - Arrowhead/American lotus mixture

****

700 Emergents - This class is used only to regroup all 700-numbered emergents for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: The order in which plant combinations are listed does not reflect plant dominance.

701 Acorus - Sweetflag grass

702 Carex - Sedges

703 Cyperus - Flatsedge

704 Decodon - Water willow

705 Echinodorus - Burheads

706 Eleocharis - Spikerush

707 Lythrum salicaria - Purple loosestrife

708 Pontederia - Pickerelweed

709 Sagittaria - Arrowhead

710 Sagittaria/Lemnaceae - Arrowhead/duckweed mixture

712 Sagittaria/Scirpus/Sparganium - Arrowhead/bulrush/burreed mixture

713 Sagittaria/Sparganium - Arrowhead/burreed mixture

714 Scirpus - Bulrush

715 Scirpus/Sagittaria - Bulrush/arrowhead mixture

716 Scirpus/Sparganium - Bulrush/burreed mixture

717 Sedge meadow - A very wet meadow dominated by sedges. Other emergents may be mixed within.

718 Sparganium - Burreed

719 Typha - Cattail

720 Typha/Sagittaria - Cattail/arrowhead mixture

721 Typha/Scirpus - Cattail/bulrush mixture

722 Typha/Scirpus/Sparganium - Cattail/bulrush/burreed mixture

723 Typha/Sparganium - Cattail/burreed mixture

724 Zizania - Wild rice

725 Equisetum - Horsetail - To date, only a handful of polygons have been recognizable on aerial photos. All were located within UMRS Pools 5a and 6.

726 Dead Emergents - Added in 1993 to map emergent vegetation beds containing standing crop killed by the 1993 flood.

****

800 Emergents-Grasses/Forbs - This class is used only to regroup all 800-numbered emergents-grasses/forbs for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: The order in which plant combinations are listed does not reflect plant dominance.

801 Leersia/Carex/Polygonum - Cutgrass/sedges/smartweed mixture

802 Leersia/Carex/Sagit/Polygonum - Cutgrass/sedges/arrowhead/smartweed mixture

803 Leer/Phalar/Scirp/Lythr/Phrag - Cutgrass/reed canarygrass/bulrush/purple loosestrife/common reed mixture

804 Leersia/Sagittaria - Cutgrass/arrowhead mixture

805 Sagittaria/Phalaris - Arrowhead/reed canarygrass mixture

806 Sagittaria/Polygonum - Arrowhead/smartweed mixture

807 Sag/Sparg/Typ/Scirp/Leer/Phrag - Arrowhead/burreed/cattail/bulrush/cutgrass/common reed mixture

808 Scirpus/Leersia - Bulrush/cutgrass mixture

809 Scirpus/Carex/Leersia/Polygon - Bulrush/sedges/cutgrass/smartweed mixture

810 Scirpus/Phalaris - Bulrush/reed canarygrass mixture

811 Scirpus/Phragmites - Bulrush/common reed mixture

812 Scirpus/Polygonum - Bulrush/smartweed mixture

813 Scirpus/Typha/Phalaris - Bulrush/cattail/reed canarygrass mixture

814 Sparganium/Leersia - Burreed/cutgrass mixture

****

900 Grasses/Forbs - Nonwoody plants. This class is used only to regroup all 900-numbered grasses/forbs for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs. Note: The order in which plant combinations are listed does not reflect plant dominance.

901 Ambrosia - Ragweed

902 Grass - Used to delineate areas of mixed grasses. Abandoned/set-aside fields are also placed within this class.

903 Hay meadow - Lowland (temporarily wet) areas, regularly cut and baled for hay.

904 Pasture (heavily grazed areas) - "Hay fields" regularly pastured with cattle or similar livestock.

905 Leersia - Cutgrass

906 Leersia/Polygonum - Cutgrass/smartweed mixture

907 Meadow - Upland areas regularly cut and baled for hay.

908 Mixed forbs and/or grasses - Class used to describe a mixture of many different grasses and forbs. Note: Photointerpreters should not intermix the use of this class and class 900. Class 900 is to be used only for regrouping purposes.

909 Nettles - Nettles

910 Phalaris - Reed canarygrass

911 Phalaris/Polygonum - Reed canarygrass/smartweed mixture

912 Phragmites - Common reed

913 Phragmites/Phalaris - Common reed/reed canarygrass mixture

914 Polygonum - Smartweed

915 Polygonum/Nelumbo - Smartweed/American lotus mixture

916 Rdside-levee/grass/forbs/shrub - Any roadside ditch or levee. Example of a roadside: Delineation of a north/south roadway would begin on the far west side of the western ditch and go to the far eastern side of the eastern ditch. Both ditches and the road are included within the same polygon.

917 Sand-prairie - A very sandy area covered with very dry-soil grasses.

918 Spartina - Cordgrass

919 Vines as dense overgrowth - Any live stem vine growing as a dense covering.

920 Polygonum/Eupatorium - Smartweed/*Eupatorium* mixture

921 Dead Grass - Added in 1993 to map vegetation beds of standing crop killed by the 1993 flood.

****

1000 Woody Terrestrial - All trees and shrubs. This class was intended to be used only for regrouping all 1000-numbered classes, but photointerpreters for Pools 4, 8, and 13 used this class on 1991 and 1992 aerial photos as a time-saving measure. When woody terrestrial is used on a photograph, it signifies that any or all of the 1000-group plants can be found in those areas. The use of woody terrestrial ended in 1993 with the introduction of forest mesic. Pool 26, open river, and La Grange have concentrated their efforts on classifying the floodplain forest to the genus level since their study areas do not contain as much aquatic vegetation as the upper pools. Woody terrestrial was not used in the 1989 coverages prepared by NERC and should no longer appear on any interpreted photographs. Note: The order in which plant combinations are listed does not reflect plant dominance.

1001 Acer - Maples

1002 Acer/Populus and/or Salix - Maples/cottonwood or willow mixture

1003 Amorpha - False indigo

1004 Betula - Birches

1005 Brush - Any small shrubby species

1006 Carya/Nyssa - Hickory/sourgums

1007 Cephalanthus - Buttonbush

1008 Forest-mesic (moist soil sp.) - Plant communities occurring at low elevations. Forest-mesic can contain any combination of the following: *Acer, Acer/Populus* and/or *Salix, Carya/Nyssa, Fraxinus, Betula*, brush, *Cephalanthus*, conifers, *Populus, Salix, Salix* and/or *Populus, Salix* and/or *Populus* - grass, *Quercus, Taxodium, Taxodium/Nyssa,* and *Ulmus.*

1009 Forest-upland (dry soil sp.) - Plant communities occurring above the floodplain. Forest-upland can contain any combination of the following: *Acer, Betula*, brush, conifers, *Fraxinus, Juniperus*, plantation, *Populus*, and *Quercus.*

1010 Fraxinus - Ash

1011 Plantation - Any group of planted, cultivated trees. Examples include apple orchards, Christmas tree farms, and stands of planted pines.

1012 Populus - Cottonwood

1013 Quercus - Oaks

1014 Salix - Willows

1015 Salix and/or Populus - Willows and/or cottonwood

1016 Salix and/or Populus - grass - Willows and/or cottonwood mixed with grasses

1017 Shrub/grass/forbs - Shrub/grass/forbs mixture

1018 Shrub/Scirpus - Shrub/bulrush mixture

1019 Taxodium - Baldcypress

1020 Taxodium/Nyssa - Baldcypress/sourgum

1021 Ulmus - Elm

1022 Conifers - Naturally occurring cone-bearing trees (unplanted)

1023 Juniperus - Eastern redcedar

****

1100 Agriculture - Any cultivated field that is either turned with a plow or worked with a disk. Crops include corn, soybeans, and oats.

****

1200 Urban/Developed - Any area "developed" by humans. This class is used only to regroup all 1200-numbered urban classes for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs.

1201 Developed - Shopping malls, industrial parks, military depots, farmsteads, storage facilities, and isolated industrial sites (built in the middle of a rural area) are considered developed.

1202 Developed parks - City and state parks are included in this category but only those areas actively used by humans. Examples are picnic areas, campgrounds, administrative buildings, and interpretive complexes.

1203 Industrial pond - Examples of industrial ponds are water coolant ponds and fish ponds actively managed for industrial or research use (i.e., fish farms and hatcheries).

1204 Urban - Residential areas, including schools

1205 Revetted Bank - Riprap used to control bank erosion.

****

1300 Sand/Mud - This class is used only to regroup all 1300-numbered sand/mud classes for use in the 13-class generalized land cover/use coverages. This class should not appear on any interpreted photographs.

1301 Mud - Mud

1303 Sand - Sand

****

1400 No Coverage - Used to label areas within the floodplain study area (a) not covered by aerial photography or (b) with no aerial photography available.

Modifiers:

The first group of modifiers is used to describe the average height of polygons containing woody terrestrial vegetation.

1. **0–20 ft tall**
2. **21–50 ft tall**
3. **>50 ft tall**

The second group of modifiers is used to describe vegetation density within an interpreted polygon. No attempts have been made to utilize these modifiers to describe plant dominance within mixed species polygons.

A. 10%–33% vegetation cover
B. 34%–67% vegetation cover
C. 68%–90% vegetation cover
D. >90% vegetation cover

Appendix B

The First Matrix

The first matrix was developed during a planning meeting for the Migratory Bird Pilot Project. Persons attending the meeting used their own knowledge and experiences to complete the matrix. These data were then used to create potential habitat maps. The maps were used by Project personnel to identify potential benefits and limitations of using generalized land cover/use data. This particular matrix was not entered into ARC/INFO as an INFO lookup table. (Further information regarding the generalized land cover/use classification codes is contained in Appendix A.)

	EMTC generalized land cover/use classification codes												
Species	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Common loon	X												
Pied-billed grebe	X	X					X						
Horned grebe	X	X											
Red-necked grebe	X	X											
American white pelican	X	X											X
Double-crested cormorant	X	X	X							X			
American bittern							X	X	X				
Least bittern							X	X					
Great blue heron							X	X	X	X	X		X
Great egret							X	X	X	X	X		X
~~Snowy egret~~													
~~Little blue heron~~													
Green-backed heron							X	X		X			
Black-crowned night-heron							X	X		X			
Yellow-crowned night-heron							X	X	X	X			
Tundra swan	X	X	X	X	X	X	X				X		X
Trumpeter swan	X	X	X	X	X	X	X				X		X
~~Greater white-fronted goose~~													
Snow goose	X	X	X	X	X	X	X		X		X		X
Canada goose	X	X	X	X	X	X	X		X		X		X
Wood duck	X	X	X	X	X	X	X	X	X	X			
Green-winged teal	X	X	X	X	X	X	X	X	X	X	X		
American black duck	X	X	X	X	X	X	X	X	X	X	X		
Mallard	X	X	X	X	X	X	X	X	X	X	X		
Northern pintail	X	X	X	X	X	X	X	X	X	X	X		
Blue-winged teal	X	X	X	X	X	X	X	X	X	X	X		
Northern shoveler	X	X	X	X	X	X	X	X	X	X	X		
Gadwall	X	X	X	X	X	X	X	X	X	X	X		
American wigeon	X	X	X	X	X	X	X	X	X	X	X		
Canvasback	X	X	X	X	X	X	X	X					
Redhead	X	X	X	X	X	X	X	X					
Ring-necked duck	X	X	X	X	X	X	X	X	X	X	X		
Greater scaup	X	X	X	X	X	X	X	X					
Lesser scaup	X	X	X	X	X	X	X	X					
~~Oldsquaw~~													

Species	EMTC generalized land cover/use classification codes												
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
~~Black scoter~~													
~~White-winged scoter~~													
Common goldeneye	X	X	X	X									
Bufflehead	X	X	X	X									
Hooded merganser	X	X	X	X	X	X	X	X	X	X	X		
Common merganser	X	X	X	X									
Red-breasted merganser	X	X	X	X									
Ruddy duck	X	X	X	X	X	X	X	X					
Turkey vulture									X	X	X	X	X
Osprey	X	X	X	X						X			
Bald eagle	X	X	X	X						X	X		X
Northern harrier							X	X	X		X		
Sharp-shinned hawk										X		X	
Cooper's hawk										X		X	
Northern goshawk										X			
Red-shouldered hawk							X	X	X	X			
Broad-winged hawk										X			
~~Swainson's hawk~~													
Red-tailed hawk									X	X	X	X	
Rough-legged hawk								X	X		X		
Golden eagle									X	X	X		
American kestrel									X		X	X	
Merlin										X	X		
Peregrine falcon							X	X	X			X	X
Gray partridge									X		X		
Ring-necked pheasant							X	X	X	X	X		
Ruffed grouse										X	X		
Wild turkey									X	X	X		
Northern bobwhite									X	X	X		
King rail			X	X	X	X	X	X	X				
Virginia rail			X	X	X	X	X	X					
Sora			X	X	X	X	X	X	X				
Common moorhen	X	X	X	X	X	X	X	X	X				
American coot	X	X	X	X	X	X	X	X	X				
Sandhill crane							X	X	X	X	X		
Black-bellied plover *									X		X		X
Lesser golden-plover *									X		X		X
Semipalmated plover *									X		X		X
Killdeer									X		X	X	X
American avocet *									X		X		X
Greater yellowlegs *									X		X		X
Lesser yellowlegs *									X		X		X
Solitary sandpiper *									X		X		X
Willet *									X		X		X
Spotted sandpiper									X	X	X		X

Species	EMTC generalized land cover/use classification codes												
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Upland sandpiper									X		X		
Hudsonian godwit *									X		X		X
Marbled godwit *									X		X		X
Ruddy turnstone *											X		X
Sanderling *									X		X		X
Semipalmated sandpiper*									X		X		X
Least sandpiper *									X		X		X
White-rumped sandpiper*									X		X		X
Baird's sandpiper *									X		X		X
Pectoral sandpiper *									X		X		X
Dunlin *									X		X		X
Stilt sandpiper *									X		X		X
Short-billed dowitcher *									X		X		X
Long-billed dowitcher *									X		X		X
Common snipe							X	X	X		X		
American woodcock									X	X	X		
Wilson's phalarope	X	X	X	X					X		X		
Red-necked phalarope	X	X	X	X					X		X		
***** *Long-distance migrant shorebirds*													
Franklin's gull	X	X									X	X	X
Bonaparte's gull	X	X									X	X	X
Ring-billed gull	X	X									X	X	X
Herring gull	X	X									X	X	X
Gulls	X	X									X	X	X
Caspian tern	X	X											X
Common tern	X	X											X
Forster's tern	X	X	X	X	X	X	X	X	X				
Least tern	X	X	X										X
Black tern	X	X	X	X	X	X	X	X	X				
Rock dove											X	X	X
Mourning dove									X	X	X	X	
Black-billed cuckoo										X			
Yellow-billed cuckoo										X			
Eastern screech-owl										X	X		
Great horned owl							X	X	X	X	X	X	
~~Snowy owl~~													
Barred owl									X	X	X		
Long-eared owl									X	X	X		
Short-eared owl									X		X		
Northern saw-whet owl										X			
Common nighthawk											X	X	
Whip-poor-will									X	X	X		
Chimney swift									X	X	X	X	
Ruby-throated hummingbird									X	X	X	X	

	EMTC generalized land cover/use classification codes												
Species	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Belted kingfisher	X	X	X	X	X	X						X	X
Red-headed woodpecker									X	X	X		
Red-bellied woodpecker										X		X	
Yellow-bellied sapsucker										X		X	
Downy woodpecker										X		X	
Hairy woodpecker										X		X	
Northern flicker									X	X	X	X	
Pileated woodpecker										X			
~~Olive-sided flycatcher~~													
Eastern wood-peewee										X			
~~Yellow-bellied flycatcher~~													
Alder flycatcher										X			
Willow flycatcher										X			
Least flycatcher										X			
Eastern phoebe									X	X	X	X	
Great crested flycatcher									X	X			
Eastern kingbird									X	X	X	X	
Horned lark									X		X	X	
Purple martin									X		X	X	
Tree swallow									X		X		
Northern rough-winged swallow											X	X	
Bank swallow											X	X	
Cliff swallow											X	X	
Barn swallow											X	X	
Blue jay									X	X	X	X	
American crow							X	X	X	X	X	X	X
Black-capped chickadee										X		X	
Tufted titmouse										X			
Red-breasted nuthatch										X		X	
White-breasted nuthatch										X		X	
Brown creeper										X			
Carolina wren										X			
Bewick's wren										X			
House wren									X	X	X	X	
Winter wren										X			
Sedge wren							X	X	X				
Marsh wren							X	X					
Golden-crowned kinglet										X		X	
Ruby-crowned kinglet										X		X	
Blue-gray gnatcatcher										X			
Eastern bluebird									X	X	X	X	
Veery										X			
Gray-cheeked thrush										X			
Swainson's thrush										X			

	EMTC generalized land cover/use classification codes												
Species	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Hermit thrush										X			
Wood thrush										X			
American robin									X	X	X	X	
Grey catbird									X	X	X	X	
Northern mockingbird									X	X	X	X	
Brown thrasher									X	X	X	X	
~~American pipit~~													
~~Bohemian waxwing~~													
Cedar waxwing							X	X	X	X	X	X	
Northern shrike									X		X	X	
Loggerhead shrike									X	X	X	X	
European starling									X	X	X	X	
White-eyed vireo										X			
Bell's vireo									X	X			
Solitary vireo										X			
Yellow-throated vireo										X			
Warbling vireo									X	X			
Philadelphia vireo										X			
Red-eyed vireo										X			
Blue-winged warbler *									X	X			
Golden-winged warbler *									X	X			
Tennessee warbler *									X	X			
Orange-crowned warbler*									X	X			
Nashville warbler *									X	X			
Northern parula *									X	X			
Yellow warbler							X		X	X			
Chestnut-sided warbler *									X	X			
Magnolia warbler *									X	X			
Cape May warbler *									X	X			
Black-throated blue warbler *									X	X			
Yellow-rumped warbler*									X	X			
Black-throated green warbler *									X	X			
Blackburnian warbler *									X	X			
Pine warbler *									X	X			
Palm warbler *									X	X			
Bay-breasted warbler *									X	X			
Blackpoll warbler *									X	X			
Cerulean warbler *									X	X			
Black-and-white warbler*									X	X			
American redstart *									X	X			
Prothonotary warbler *									X	X			
Worm-eating warbler *										X			
Ovenbird *									X	X			
Northern waterthrush *									X	X			

Species	EMTC generalized land cover/use classification codes												
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Louisiana waterthrush *									X	X			
Kentucky warbler *									X	X			
Connecticut warbler *									X	X			
Mourning warbler *									X	X			
Common yellowthroat							X	X	X	X			
Hooded warbler *									X	X			
Wilson's warbler *									X	X			
Canada warbler *									X	X			
Yellow-breasted chat *									X	X			
Warblers*									X	X			
Scarlet tanager										X			
Northern cardinal									X	X	X	X	
Rose-breasted grosbeak									X	X		X	
Indigo bunting									X	X			
Dickcissel									X		X		
Rufous-sided towhee									X	X		X	
American tree sparrow									X	X	X	X	
Chipping sparrow									X	X	X	X	
Clay-colored sparrow									X	X			
Field sparrow									X		X		
Vesper sparrow									X		X		
Lark sparrow									X		X		
Savannah sparrow									X		X		
Grasshopper sparrow									X		X		
Henslow's sparrow									X		X		
Le Conte's sparrow							X	X	X				
Fox sparrow									X	X		X	
Song sparrow							X	X	X	X	X	X	
Lincoln's sparrow									X	X			
Swamp sparrow							X	X	X	X			
White-throated sparrow									X	X	X	X	
White-crowned sparrow									X	X	X	X	
Harris sparrow									X	X	X	X	
Dark-eyed junco									X	X	X	X	
~~Lapland longspur~~													
~~Snow bunting~~													
Bobolink									X		X		
Red-winged blackbird			X	X	X	X	X	X	X	X	X	X	
Eastern meadowlark									X		X	X	
Western meadowlark									X		X	X	
Yellow-headed blackbird			X	X	X	X	X	X	X				
Rusty blackbird							X	X	X	X	X		
Brewer's blackbird							X	X	X	X	X		
Common grackle							X	X	X	X	X	X	
Brown-headed cowbird							X	X	X	X	X	X	

Species	EMTC generalized land cover/use classification codes												
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Orchard oriole									X	X			
Northern oriole									X	X		X	
~~Pine grosbeak~~													
Purple finch									X	X		X	
House finch										X		X	
Red crossbill										X			
White-winged crossbill										X			
Common redpoll									X		X	X	
~~Hoary redpoll~~													
Pine siskin										X		X	
American goldfinch									X	X	X	X	
Evening grosbeak										X		X	
House sparrow											X	X	

Appendix C

Individual Species Matrices

Species matrices are shown for each species studied. Blank matrix forms containing Environmental Management Technical Center (EMTC) land cover/use classification codes were given to persons performing the literature search. When a land cover type was listed in the literature as habitat, a matrix entry was made in the appropriate life cycle category. Numeric entries printed in a regular roman font were supplied by the Upper Mississippi Science Center. Entries underlined and printed in boldface italics were supplied by the U.S. Fish and Wildlife Service, Rock Island, Illinois. Entries designated by a pound sign (#) were added by the EMTC to denote equivalencies between data of different years and between generalized entries and their genus-level equivalents. Literature citations appearing before the matrix table contain supplementary data, whereas literature sources listed at the end of the table are used to link matrix and supplementary data to their source documentation. Individual numbers link each entry to the source documentation. Appendix C contains a complete listing of the LTRMP VEG_CODEs and common name equivalents.

Sora

1. "This bird does not require large expanses of marsh for nesting. Any slough with a few acres of shallow water overgrown with sedges, cattails, or various kinds of grasses may attract a breeding pair."

1. "Monotypic invasions by alien purple loosestrife and the native water willow—triggered by water level alteration and eutrophication—may exclude [sora]."

1. Sora usually are *not* found in native stands of *Phalaris arundinacea* or *Phragmites communis*.

2., 3., 4. Sora are usually found in water depths of 20–50 cm (2), but they can also be found in shallower waters—i.e. <15 cm (3). Migratory sora, along the northern Mississippi, prefer water depths of 5–15 cm (4).

26. In Iowa, Tanner and Hendrickson (1956) reported a breeding density of 35 nests in 43 ha and a hatch of 1.7 birds per acre (4.2 per ha) and a hatch of 1.7 birds per acre (4.2 per ha) on an 81-acre (33-ha) study area.

20. Locates nest 15 cm to more than 30 cm above water, or occasionally on the ground. Generally nests over water 15–20 cm deep, preferably among sedges.

37. They are found not only in marshes but also around ponds, the shallow end of lakes, flooded fields, and occasionally drier places, such as hayfields.

28. The density of breeding soras (territories per hectare of emergent vegetation) was positively correlated with a ratio of shoreline length. Sites dominated by glaucous cattail received the greatest percentage of sora use. Sora use of giant burreed stands significantly exceeded availability. Sites dominated by sedges were used in proportion to availability. Use of tule bulrush also increased. Common arrowhead occurred significantly more often on sora territories than at random sites. Mean water depth was 40.3 cm (0–90 cm). Rails may avoid emergent stands with high stem densities or stands heavily lodged with residual vegetation which could impede movement.

15. Sora spring migration flush sites were dominated by rice cutgrass (*Leersia oryzoides*) and *Carex* sedges. Sora fall migration flush sites were dominated by barnyard grass–nutsedge mix (*Echinochloa* spp. and *Cyperus* spp.) and marsh smartweed.

27. Spring migrants used dead emergent stems of beggerticks (*Bidens* spp.), broomsedge (*Andropogon virginicus*), or emerging sedges (*Carex* spp. and *Cyperus* spp.). Fall migrants used pure and mixed stands of composites (*Bidens* spp. and *Eupatorium* spp.) and annual grasses (*Panicum* spp., *Echinochloa* spp., *Digitaria* spp.), *Xanthium* spp., *Polygonum pensylvanicum, Diodia virginiana, Polygonum hydropiperoides*, and *Ambrosia artemisiifolia*. Both fall and spring migrants used *Ludwigia* spp., *Eleocharis obtusa*.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
100 Open Water							
101 Lemnaceae			1				
150 Lake	37	37	37	37	2,37	2,37	
500 Rooted/Float Aquatics							
507 Nymphaea			1,TJ3				
700 Emergents							
702 Carex	TJ15,*19, 27,28*	*19,28*	1,TJ3,*19, 28*	*19,28*	*19*	*19*	*19*
703 Cyperus	*27*					*15*	
705 Echinodorus	*19,27*	*19*	*19*	*19*	*19*	*19,27*	
708 Pontederia			1				
709 Sagittaria		*28*	1,TJ3,*28*	*28*			
710 Sagittaria/Lemnaceae			1				
712 Sagit/Scirpus/Sparg			1,TJ3				
713 Sagittaria/Sparganium			1,TJ3				
714 Scirpus	*19*	*19,28*	1,TJ3,*2, 19,20,28*	*19,28*	*19*	*19*	
715 Scirpus/Sagittaria			1,TJ3				
716 Scirpus/Sparganium			1,TJ3				
717 Sedge meadow			1				
718 Sparganium		*28*	1,TJ3,*28*	*28*			
719 Typha		*28*	1,TJ3,*2, 28*	*28*			
720 Typha/Sagittaria		*28*	1,TJ3,*28*	*28*			
721 Typha/Scirpus			1,TJ3				
722 Typha/Scirpus/Sparg		*28*	1,TJ3,*28*	*28*			
723 Typha/Sparganium			1,TJ3				
724 Zizania			TJ3,*19*	*2,19,35*	*2,19,35*	*2,19,35*	
900 Grasses/Forbs							
901 Ambrosia						*27*	
902 Grass	*19*		*37*			*19,27*	
903 Hay meadow			*37*				
905 Leersia	TJ15,*19*	*19*	*19*	*19*	*19*	*19*	
908 Mixed forbs and/or grasses						*27*	
909 Nettles							*1*
914 Polygonum			*19*	*19*	*19*	TJ15,*19, 27*	
918 Spartina			1				

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
920 Polygonum/Eupatorium						27	
1300 Sand/Mud							
1301 Mud			37	37			

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Spotted Sandpiper

1. "Open gravelly hilltops, dunes, sandy river islands and terraces, and wide sand or gravel beaches are natural nest sites for the spotted sandpiper. Spotted sandpipers are often found along sandy beaches, rocky lakeshores, and riverbanks."

16. Levee (around borrow pit and river with bottomland hardwoods) during winter, spring, fall census.

35. Found along rivers, wooded ponds, dikes, and roadways near water.

37. Gravel pits and sewage lagoons.

20. Inhabits the edges of ponds, lakes, rivers, and streams and open terrain with temporary pools, as high as 4,267 m in elevation. It is sometimes found far from water in dry fields, pastures, and weedy shoulders of roads. Roosts on stumps, stranded logs, or rocks affording a clear view. In winter, frequents water courses shaded by trees, and prefers shallow, muddy lagoons, creeks, canals, and higher mudflats.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
100 Open Water							
150 Lake			1				
900 Grasses/Forbs							
907 Meadow			*2*	*2*	*2*		
916 Roadside-levee/grass/forbs/shrub	*16*		*35*			*16*	*16*
919 Vines as dense overgrowth							
920 Polygonum/Eupatorium							
1100 Agriculture		*2*	*2*	*2*	*2*	*2*	
1200 Urban/Devel							
1250 Farm pond			*2*				
1300 Sand/Mud							
1301 Mud	*2*	*2*	*2*	*2*	*2*	*35,2*	*20*
1303 Sand	*2*	*2*	*1,2*	*2*	*2*	*2*	

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37. Bohlen, H. D. 1989. The birds of Illinois. Indiana University Press, Indianapolis. 221 pp.

Brown-headed Cowbird

16. Borrow pits, levees, Mississippi River censuses during winter, spring, summer, and fall.

21. Three brown-headed cowbird observations were in foliated plots (mixed oaks), while 11 observations were in defoliated (gypsy moth) plots [Pennsylvania].

19. Plant food in the diet: summer, fall, winter, and spring: bristlegrass, knotweed; fall, winter, and spring: ragweed; summer, fall, and winter: corn, crabgrass; summer, fall, and spring: wheat.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
700 Emergents							
719 Typha							*2*,9
900 Grasses/Forbs							
902 Grass		*37,35*	1,2,3,4,*2, 37,35*	*35,37*	*35,37*	*2*	
904 Pasture (heavily grazed areas		*35,37*	1,*35,37*	*35,37*	*35,37*	*2*	
907 Meadow			1,2,3,4,6,7			*2*	
908 Mixed forbs and/or grasses		*37*	TJ10,*37*	*37*	*37*	*2*	
910 Phalaris			TJ10				
916 Roadside-levee/grass/forbs/shrub	*16*	*16,37*	*16,37*	*16,37*	*16,37*	*16*	
919 Vines as dense overgrowth	*16*	*16*	*16*	*16*	*16*	*16*	
1000 Woody Terrest							
1001 Acer	1,8	14	12,TJ10 14	14	#	#	1,8
1002 Acer/Populus and/or Salix	#	#	#	#	#	#	#
1003 Amorpha	#	#	#	#	#	#	#
1004 Betula			12,TJ10				
1005 Brush			1				
1006 Carya/Nyssa	#	14	11,12,14	14	#	#	#
1008 Forest-mesic (moist soil spp.)	*16*	*16*	*16*	*16*	*16*	*16*	*16*
1010 Fraxinus		14	11,12, TJ10,14	14			
1011 Plantation							
1012 Populus	#	#	12,13	#	#	#	#
1013 Quercus		14	11,12,TJ101 4,*21*	14			
1014 Salix	#	#	13	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1017 Shrub/grass/forbs		*37*	1,2,3,4,6,7,*37*	*37*	*37*		10
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	14	11,12, TJ1,14,*10*	14	#	#	#
1054 Wooded Swamp							*2*
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	#	#	#	#	#
1060 Sag latifolia/Salix	#	#	#	#	#	#	#
1100 Agriculture	*20*	*20*	1,*5*,*20*	*20*	*20*	*2*,*20*	10,*2*,*7*,*20*
1200 Urban/Devel							
1204 Urban	#	#	1,5,10	#	#	#	#
1251 Residential	*20*	*20*	1,5,10,*20*	*20*	*20*	*20*	10,*2*,*20*,*7*

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13. Van Velzen, W. T., editor. 1981c. Forty-fourth breeding bird census. American Birds 35:75.

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Pileated Woodpecker

Mellen et al. (1992) found that pileated woodpeckers (*Dryocopus pileatus*) in western Oregon nested and roosted in >70-yr habitat classes. Nest trees averaged 71 cm dbh and ranged from 40 to 138 cm; roost trees averaged 112 cm and ranged from 40 to 208 cm. Home ranges averaged 478 ha and ranged from 267 to 1,056 ha.

Bull (1975) defined the critical habitat of the pileated woodpecker to consist of large snags and trees, diseased trees, dense forest stands, and high snag densities.

27. They prefer "the edges of balsam and cedar swamps, when surrounded with forests of hardwood and hemlocks." Their nesting places are ordinarily in lowlands, and near water. ...after the nesting season has passed, and throughout fall and winter, the birds wander and appear in areas where at other seasons they are unknown....

20. Nest trees included: beech, cottonwood, yellow poplar birch, oak, hickory, maple, hemlock, pine, ash, elm, basswood, and aspen.

37. Pileated woodpeckers nest...particularly [in] sycamores, in bottomland forests.

16. Borrow pits, levees, Mississippi River censused during winter, spring, summer, and fall.

25. Missouri: pileated woodpecker territory size ranged from 53 to 160 ha. Percent forest overstory canopy cover, percent raw timber cover, and log and stump volume within territories were negatively related to territory size.

19. Plant food in the diet: summer, fall, and winter: grape; fall and winter: black gum; winter: Virginia-creeper and holly; summer: sassafras, dogwood, greenbrier, viburnum, poison-ivy, and palmetto.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
100 Open Water			9				
900 Grasses/Forbs							
916 Roadside-levee/ grass/ forbs/shrub	***16***	***16***	***16***	***16***	***16***	***16***	***16***
919 Vines as dense overgrowth					***2***	9,***2,19***	***2***
1000 Woody Terrest							
1001 Acer	#	7,8	5,7,8,***10,20***	7,8	#	#	2,3,TJ10
1002 Acer/Populus and/or Salix	#	7	7	7	#	#	#
1003 Amorpha	#	#	#	#	#	#	#
1004 Betula		7	7,9	7			2
1005 Brush		9					
1006 Carya/Nyssa	#	#	6,9,10	#	#	#	2
1008 Forest-mesic (moist soil spp.)	***16***	***16***	5,***16,37***	***16***	***16***	***16***	2,***16***
1009 Forest-upland (dry soil spp.)		7	7	7			2
1010 Fraxinus		8	8,9,10,***20***	8			3,TJ10
1012 Populus	#	#	9,***20***	#	#	#	#

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1013 Quercus			6,9,10,20		2	2	2,2
1014 Salix	#	#	#	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1017 Shrub/grass/forbs					2	2	2
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	8	2,8,9,10	8	#	#	2
1051 Deadening Forest			5,2				
1054 Wooded Swamp			5,9,2				
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	2	#	#	#	2
1060 Sag latifolia/Salix	#	#	#	#	#	#	#
1200 Urban/Devel							
1204 Urban			#				#
1251 Residential			2				9

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16. Landin, M. C. 1985. Bird and mammal use of selected lower Mississippi River borrow pits. Ph.D. Thesis, Mississippi State University. 425 pp.

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Swamp Sparrow

1. "Swamp sparrows nest only in swamps and marshes...[they] will reject a swamp overgrown with numerous trees and shrubs, and will avoid an open area that dries up as the season progresses. But wherever extensive areas of open sedges and cattails thrive together with a good supply of standing or running water, the swamp sparrow is common....the nests are usually inches away from water.... During fall migration this species disperses into more varied habitats. It still shows a preference for tall grass, but scatters to dry upland areas as well as the wetter marshes...and moves to farm hedgerows and even to residential shrubbery."

2. Cattail nests were often built directly above the water, where depth varied from 15 to 60 cm, and were usually built about 0.3 m or more above the surface. In the less alkaline swamps, many nests were built in green sedge tussocks of *Carex*.

2. "...regularly leaves the marshlands and occurs in all types of habitat with the exception of deep woodlands."

2. Numerous returns to the same banding stations during successive spring and fall migrations suggest the bird retraces the same migration routes each year in both directions.

20. ...nests preferably in areas with mixed vegetation rather than in pure cattails.

37. ...found in wet meadows. In migration, they also occur in woodlands, weedy fields, and thickets.

20. In winter, frequents springs, seeps, and open brooks that have brushy cover nearby.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
700 Emergents							
702 Carex			1,2,5				
703 Cyperus			5				
704 Decodon			5				
709 Sagittaria			TJ3				
714 Scirpus			1,5,TJ3				
717 Sedge meadow			1				
718 Sparganium			TJ3				
719 Typha			1,TJ3,*2*				
720 Typha/Sagittaria			*3*				
721 Typha/Scirpus			5,*3*				
724 Zizania			5,TJ3				
725 Equisetum			*3*				
800 Emerg-Grasses/ Forbs							
801 Leersia/Carex/Polyg			*2*				
802 Leer/Carex/Sag/ Polyg			*2*				
809 Scirpus/Carex/Leer/ Polygonum			*2*				
851 Leers/Carex/Sag lat Poly			*2*				
900 Grasses/Forbs							
902 Grass			1,*2*				
907 Meadow							*16*
908 Mixed forbs and/or grasses							*16*
910 Phalaris			5				
911 Phalaris/Polygonum			5				
912 Phragmites			5,TJ3				
914 Polygonum			5				
916 Roadside-levee/grass/ forbs/shrub			1				*16*
919 Vines as dense overgrowth			1				*16*

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1000 Woody Terrest							
1001 Acer		#	1,TJ3	#			#
1002 Acer/Populus and/or Salix		#	#	#			*16*
1003 Amorpha		#	#	#			#
1005 Brush			4				
1006 Carya/Nyssa		#	#	#			#
1007 Cephalanthus							*16*
1010 Fraxinus			1				
1012 Populus		#	2	#			#
1014 Salix		#	1,2	#			*16*
1015 Salix and/or Populus		#	#	#			#
1016 Salix and/or Populus - grass		#	#	#			*16*
1017 Shrub/grass/forbs	*2,19*	*19*	1,*19*	*19*	*19*	*2,19*	*16,19*
1019 Taxodium		#	#	#			#
1020 Taxodium/Nyssa		#	#	#			#
1021 Ulmus		#	#	#			#
1054 Wooded Swamp		3	1,3,*2*	3			*16*
1055 >50% Cottonwood and/or Willow <20'		#	#	#			#
1056 >50% Cottonwood and/or Willow >20'		#	#	#			#
1057 >50% Lowland Hardwoods <20'		#	#	#			#
1058 >50% Lowland Hardwoods >20'-grass		#	#	#			#
1059 >50% Lowl Hardwds >20'		#	#	#			#
1060 Sag latifolia/Salix		#	#	#			#
1200 Urban/Devel							
1204 Urban						#	
1251 Residential						1	

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2. Van Velzen, W. T., editor. 1981c. Forty-fourth breeding bird census. American Birds 35:75.

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20. DeGraaf, R. M., V. E. Scott, R. H. Hamre, L. Ernst, and S. H. Anderson. 1991. Forest and rangeland birds of the United States—natural history and use. Forest Service Agriculture Handbook 688. 625 pp.

37. Bohlen, H. D. 1989. The birds of Illinois. Indiana University Press, Indianapolis. 221 pp.

Cerulean Warbler

2., 3., 4., 5., 6., 7. Nests of the cerulean warbler are often found in deciduous forests (2, 3). Although nests can be found in upland and lowland sites during the breeding season (2, 3, 4, 5), the birds prefer floodplain sites (5, 6, 7).

5. In North Carolina, sites with the highest densities of cerulean warblers were characterized by a 24–30-m canopy dominated by sycamore (*Platanus occidentalis*), green ash *(Fraxinus pennsylvanica)*, and sugarberry (*Celtis laevigata*) with box elder (*Acer negundo*) as the principal understory tree species; a distinct shrub layer dominated by spice bush *(Lindera benzoin)*, pawpaw (*Asimina triloba*), and buckeye (*Aesculus sylvatica*); and a ground cover of 100% (usually of grasses and sedges (*Carax* spp.).

4. In Wisconsin, cerulean warblers were more likely to be found in medium (16–32 ha) and large (>32 ha) forest tracts.

20. In some parts of the range, the bird favors elm for nesting, but will nest in oaks, maples, basswood, and yellow poplar.

34. Nests are generally built in large deciduous trees such as basswoods, elms, maples, sycamores, cottonwoods, and oaks.

20. Favors moist deciduous swamp and bottomland forests and shady, mature upland woods. Prefers rather open forests with tall trees and little undergrowth.

37. ...inhabits the treetops in bottomland forests. ...tends to inhabit the river areas of the state [Illinois]. Because this warbler breeds in bottomland forests, it is distributed along Illinois watercourses in summer. There is a lesser amount of breeding in upland forests.

16. Borrow pits, levees, Mississippi River censused during summer and spring.

34. The size of a forest tract seemingly is an important component of cerulean warbler habitat. In Wisconsin, birds were detected in a greater proportion of medium (16–36 ha) and large (>36 ha) tracts than in small (<16 ha). The minimum area requirement estimated for nesting cerulean warblers in the Middle Atlantic states was 700 ha. However, these warblers were detected at least twice in isolated (>0.048 km from the nearest tract of >40 ha) tracts of 138 and 637 ha.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
700 Emergents							
702 Carex			5				
900 Grasses/Forbs							
916 Roadside-levee/ grass/ forbs/shrub	***16***	***16***	***16***	***16***			
1000 Woody Terrest							
1001 Acer	6	6,12	6,11,3, 5,10,11,12,***20,34***	6,12	#	#	#
1002 Acer/Populus and/or Salix	6	6,***34,37***	3,6,10, 11,***34,37***	6,***34,37***	6,***34,37***	***37***	#
1003 Amorpha	#	#	#	#	#	#	#
1004 Betula	#	12	12	12	#	#	#
1006 Carya/Nyssa	#	#	#	#	#	#	#
1008 Forest-mesic (moist soil spp.)	6,***16,20, 37***	6,***16,20, 37***	4,6,***16, 20,37***	6,***16,20,37***	6,***20,37***	6,***20,37***	6
1009 Forest-upland (dry soil spp.)	6	6	4,6	6	6	6	6
1010 Fraxinus	#	#	1,5	#	#	#	#
1011 Plantation	#	#	#	#	#	#	#
1012 Populus	#	#	3,10,11,***34,37***	#	#	#	#
1013 Quercus	#	12	12,***34,37***	12	#	#	#
1014 Salix	#	#	#	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	#	1,3,10, 11,***34***	#	#	#	#
1054 Wooded Swamp		13	13	13			
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	#	#	#	#	#
1060 Sag latifolia/Salix	#	#	#	#	#	#	#

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16. Landin, M. C. 1985. Bird and mammal use of selected lower Mississippi River borrow pits. Ph.D. Thesis, Mississippi State University. 425 pp.

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Golden-winged Warbler

5., 6. In Wisconsin, Michigan, and Ontario, territories often include the edge of tamarack (*Larix*) bogs (6). In Minnesota, nests often are found in wetlands dominated by alders (*Alnus rugosa*) and in young conifer plantations (*Pinus* spp. and *Picea* spp.; 5).

In southeastern Michigan, golden-winged warblers were found almost exclusively in tamarack swamps in the south in Washtenaw and Jackson Counties, and north to Clinton and Shiawassee Counties.

2. Golden-winged warblers prefer sites where vegetation was clumped rather than in dense stands.

2., 3. In Michigan, golden-winged warblers were located primarily at old-field sites 10–35 yr into succession.

3., 4. Golden-winged warblers typically nest in old fields with many small trees (<6 m tall) and shrubs adjacent to forests (4). Nests are usually located along the edge between a second-growth forest and an old field (3).

5. In northeastern Minnesota, golden-winged warblers were detected most frequently in wetlands dominated by alders (*Alnus rugosa*) and in young conifer (*Pinus* spp.) with dense growths of aspens and herbaceous vegetation.

TJ4. Golden-winged warbler habitat was classified as open fields with shrub, which grades from open marshland with few or no trees to areas of dense aspen coppice and parkland vegetation.

35. Although old records suggest that this species bred in Iowa, there are no recent nesting records. Two nests were reported from Grundy County in 1898. It is possible that this species has been replaced by the blue-winged warbler....

36. The most favored habitat is the dense, deciduous brushy area that borders small creeks and swamps. Birds are sometimes found along the edges of tamarack spruce bogs, but otherwise usually avoid conifers. ...in Oconto County [Wisconsin]. All [nests] were located on the ground, well concealed by grass, nettles, or jewelweed.

37. ...feed at midheight in both upland and bottomland forests. Golden-winged warblers generally nest in deciduous woodlands with thick undergrowth. The nest is placed on or near the ground.... Ridgway (1889) stated that golden-winged warblers were breeding in Richland County [Illinois], and Poling. Butler (1897) found them nesting in the Mississippi bottoms.

52. ...the warbler inhabits shrubby fields with small trees, often with borders of taller trees.

20. Inhabits openings in deciduous or forest edges where there is a dense understory of saplings, forbs, grasses, or ferns. Also commonly inhabits damp fields heavily vegetated with thick grass, overgrown pastures, dense scrubby thickets, second-growth woods, and brush-bordered lowland areas.

4. ...classifying this warbler into the open fields with shrub category [Minnesota].

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
700 Emergents							
702 Carex			8				
900 Grasses/Forbs							
902 Grass			***36***				
907 Meadow			1,7,***36***	***36***			
908 Mixed forbs and/or grasses			***36***	***36***			
909 Nettles			***36***	***36***			
1000 Woody Terrest							
1001 Acer	#	#	#	#	#	#	#
1002 Acer/Populus and/or Salix	#	#	#	#	#	#	#
1003 Amorpha	#	#	#	#	#	#	#
1004 Betula	***20***	***20***	3,***20***	***20***	***20***	***20***	
1006 Carya/Nyssa	#	#	#	#	#	#	#
1008 Forest-mesic (moist soil spp.)	***37***	***37***	9,***37***	***37***	***37***	***37***	***37***
1009 Forest-upland (dry soil spp.)	***37***	***37***	9,***37***	***37***	***37***	***37***	***37***
1010 Fraxinus	#	#	3	#	#	#	#
1011 Plantation	#	#	#	#	#	#	#
1012 Populus	#	#	1,3,8	#	#	#	#
1013 Quercus	#	#	#	#	#	#	#
1014 Salix	#	#	8	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1017 Shrub/grass/forbs	***20***	***20***	1,2,6,7,***20***	***20***	***20***	***20***	
1018 Shrub/Scirpus							
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	#	#	#	#	#	#
1050 Clearing Forest			3				
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	#	#	#	#	#
1060 Sag latifolia/Salix	#	#	#	#	#	#	#

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Wood Thrush

6. Wood thrush territories range from about 0.8 to 2.8 ha, with the average about 1.2 ha.

2. The territory of a wood thrush may be as small as 0.08 ha or as large as 0.8 ha. Nest trees are basswood, juneberry, birch, locust, grapevine, maple, witch-hazel, hawthorn, elm, hemlock cedar, and balsam fir.

8. Average peak abundance was around September 21 for wood thrush resident.

2. Bent ...found in low, cool, damp forests, often near streams. Undergrowth and the presence of samplings seem to help determine the suitability of an area during the breeding season. A nest was reported inside a garden conservatory, St. Louis, Missouri. ...[wood thrushes] choose places near human habitations, or in parks or gardens.

36. For song, nesting, and all other purposes...restricts itself to dense woodlands. Nest trees are bur oak, dogwood, black cherry, black ash, balsam fir, hemlock, spruce, cedar, and maple. Nests are generally located on horizontal limbs 1.5–3 m above ground, occasionally as low as 0.9 or as high as 4.5 m.

20. Nests are generally 1.8–4.5 m (average, 0.3 m) above ground,... in a fork of a sapling or tree,... or in dense shrubbery...

37. Illinois: along the Mississippi River bluffs the wood thrush sings from wooded ravines.

20. Inhabits cool, mature, lowland deciduous or mixed forests, particularly damp situations and near swamps or water. In New England, also found on wooded slopes; is adapted to gardens and city parks.

16. Borrow pits, levees, Mississippi River. Found during summer and fall census in bottomland hardwoods, dense vines, and understory (baldcypress, American sycamore, cottonwood, black willow, bur oak, American elm, hickory, locust, green ash, buttonbush, red maple, silver maple).

21. Pennsylvania: mixed oak stands <mean dbh 15–20 cm) 27 wood thrush observations were in foliated 16-ha plots while three observations were in defoliated (gypsy moth) plots. Wood thrush were less abundant in defoliated stands.

8. Illinois: mesic woods composed of *Acer, Celtis, Quercus, Fraxinus, Tilia*, shrubs, shrub-like herbs and vines, *Sambucus canadensis, Phytoelacca americana, Toxicodendron radicans, Vitis vulpina, Parthenocissus quinquefolia, Smilax hispida, Menispermum canadense,* and *Zindera benzoin.*

10. Wisconsin: wooded island sizes ranged from 1.58 ha to 69.96 ha for a breeding census of Wisconsin.

11. Wood thrush was considered an intolerant species to habitat alteration.

44. Study suggested that moisture regime was either dominant factor in wood thrush habitat selection or was more highly correlated...with other dependent variables. Running water may be desirable but is probably less important than moisture regime. Wood thrush also seem to require one or more trees at least 12 m tall, possible for song perches. Wood thrush nests are regularly placed below 12 m (22 or 24 nests were below 6 m) At one study area, wood thrush territories were clustered along streams and in wetter areas.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
916 Roadside-levee /grass/forbs/shrub			16,19	19	19	16,19	
919 Vines as dense overgrowth			8,16,19	19	19	16,19	
1000 Woody Terrest							

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1001 Acer		5	1,3,TJ8, TJ10, TJ11,5	5,*8*	*8*	*8*	
1002 Acer/Populus and/or Salix			#	#	#	#	
1003 Amorpha			#	#	#	#	
1004 Betula			3,4,TJ10				
1006 Carya/Nyssa			2,3	#	#	#	
1007 Cephalanthus							
1008 Forest-mesic (moist soil spp.)			1,*8,11*	*8*	*8*	*8*	
1009 Forest-upland (dry soil spp.)			*11*				
1010 Fraxinus		5	1,2,3,TJ8, TJ10, TJ11,5	5			
1012 Populus			3,4,*44*	#	#	#	
1013 Quercus			1,2,3,TJ8, TJ10, TJ11				
1014 Salix			4	#	#	#	
1015 Salix and/or Populus			#	#	#	#	
1016 Salix and/or Populus - grass			#	#	#	#	
1017 Shrub/grass/forbs			*8,19*	*8,19*	*8,19*	*8,19*	
1019 Taxodium			#	#	#	#	
1020 Taxodium/Nyssa			#	#	#	#	
1021 Ulmus		5	1,2,3,TJ10,TJ11,5	5	#	#	
1055 >50% Cottonwood and/or Willow <20'			#	#	#	#	
1056 >50% Cottonwood and/or Willow >20'			#	#	#	#	
1057 >50% Lowland Hardwoods <20'			#	#	#	#	
1058 >50% Lowland Hardwoods >20'-grass			#	#	#	#	
1059 >50% Lowl Hardwds >20'			#	#	#	#	
1060 Sag latifolia/Salix			#	#	#	#	
1200 Urban/Devel							
1204 Urban	#	#	#	#	#	#	
1251 Residential	*2*	*2*	*2*	*2*	*2*	*2*	

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Carolina Wren

2. Minimum habitat size for nesting Carolina wren is 10 ha.

37. ...Stays low in the brush and undergrowth in woodlands and in vines and thickets in residential areas. ...most numerous in bottomland woods [Illinois].

20. Found in a variety of habitats from lowland streambank tangles to upland brushy slopes and woodland edges, especially in moist areas with thickets and undergrowth such as honeysuckle, greenbrier, and brush piles. Also frequents cutover forests, cultivated areas with brush heaps or old buildings, and suburban parks and gardens. In winter, moves to narrow valleys and deep ravines. Low, brushy vegetation needed for nesting.

16. Borrow pit, levee, Mississippi River censused here during winter, spring, summer, and fall census.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
902 Grass			*20*				
916 Roadside-levee/grass/ forbs/shrub	*16*	*16*	*16*	*16*	*2,16*	*2,16*	*2,16*
919 Vines as dense overgrowth	*16*	*16*	1,*16*	*16*	*16*	*16*	*16*
1000 Woody Terrest							
1001 Acer	#	3	1,3	3	#	#	#
1002 Acer/Populus and/or Salix	#	#	#	#	#	#	#
1003 Amorpha	#	#	#	#	#	#	#
1004 Betula		3	3	3			
1006 Carya/Nyssa	#	#	#	#	#	#	#
1008 Forest-mesic (moist soil spp.)	*16,35*	*16,35*	*16,35*	*16,35*	*16,35*	*16,35*	*16,35*
1010 Fraxinus		3	1,3	3			
1012 Populus	#	#	#	#	#	#	#
1013 Quercus					*2*	*2*	*2*
1014 Salix	#	#	#	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1017 Shrub/grass/forbs	*37*	*37*	1,*2,20, 37*	*37*	*2,37*	*2,37*	1,*2,37*
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	#	1	#	#	#	#
1054 Wooded Swamp			*2*				
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	#	#	#	#	#
1060 Sag latifolia/Salix	#	#	#	#	#	#	#
1100 Agriculture			*2*				
1200 Urban/Devel							
1204 Urban	#	#	#	#	#	#	#
1251 Residential	*37*	*37*	*37*	*37*	*37*	*37*	1,*37*

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Great Crested Flycatcher

1. The great crested flycatcher is usually not found in dense timber but prefers areas with at least a few openings and with enough dead wood to offer suitable feeding perches and nesting cavities.

2. Great crested flycatchers need at least 10 ha of habitat for nesting.

2. Seems to prefer the more open portions [of forests], the edges of clearings and woodland glades, and the borders of the woods. It is seldom found in the depths of extensive forested areas....in old orchards, in isolated trees in open lots and even about human habitats. Nest trees are oak, ash, tuliptree, pear, tupelo, sycamore, cottonwood, locust, maple, birch, pine, cedar, apple [orchards], chinaberry, ashleaf maple, and cypress. Uses natural cavities, abandoned woodpecker holes, purple martin nest boxes, human-made structures, hollow logs, hollow posts....

37. Great crested flycatchers nest in both upland and bottomland woods. They stay mostly in forest interiors, with a preference for oaks.

16. Borrow pits, levee, Mississippi River found during census of summer, fall, and spring.

21. Pennsylvania: nine great crested flycatcher observations were in foliated plots (oaks), while 12 observations were in defoliated (gypsy moth) plots.

19. Plant food (fruits) in the diet during summer and fall: sassafras, Virginia creeper, spicebush, viburnum, dogwood, grape, wild cherry, blueberry, pokeweed, mulberry, and blackberry.

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
916 Roadside-levee/grass/ forbs/shrub	*16*	*16*	*16*	*16*	*16*	*16*	*16*
919 Vines as dense overgrowth	*16*	*16*	*2,16,19*	*2,16,19*	*2,16,19*		
1000 Woody Terrest							
1001 Acer	#	3	1,4,TJ10,3,*2*	3,*2*	#	#	
1002 Acer/Populus and/or Salix	#	#	1	#	#	#	
1003 Amorpha	#	#	#	#	#	#	
1004 Betula		3	1,4,TJ10,3,*2*	3,*2*			
1006 Carya/Nyssa	#	#	1,4	#	#	#	
1008 Forest-mesic (moist soil spp.)	*16*	*16*	1,*2,11, 16*	*2,16*	*16*	*16*	
1009 Forest-upland (dry soil spp.)			1,*2,11*				
1010 Fraxinus			1,4,TJ10				
1012 Populus	#	#	1,4,5	#	#	#	
1013 Quercus			1,4,TJ10,*2,11*				
1014 Salix	#	#	1,5	#	#	#	
1015 Salix and/or Populus	#	#	1	#	#	#	
1016 Salix and/or Populus - grass	#	#	#	#	*2*	#	
1017 Shrub/grass/forbs	*2*	*2*	*2,11,19*	*2,19*	*2,19*	*2,19*	
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	#	1,4,TJ10	#	#	#	#
1050 Clearing Forest			1				
1051 Deadening Forest			*2*				
1053 Orchards			*2*	*2*			
1054 Wooded Swamp			*2*				
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	1	#	#	#	#
1060 Sag latifolia/Salix	#	#	#	#	#	#	#
1200 Urban/Devel							
1204 Urban	#	#	#	#	#	#	
1251 Residential	*2*	*2*	*2*	*2*	*2*	*2*	

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Mallard

2. Bent: record of mallard nest on top of muskrat house among cattails. Washington: early nests in trees, or far back in the dense fir timber on the ground, often 0.4 km (0.25 mi) from H_2O.

20. Mallards typically nest on the ground in dry or slightly marshy areas within 91 m of water, sometimes as far as 2,400 m away in grasslands.

35. Iowa: Mallards nest along roadsides and drainage ditches....

16. Borrow pits, levees, Mississippi River [bottomland hardwood] all year around.

2. Flooded whitetop, sedge, and hardstem bulrush beds provide favorite cover for mallard broods.

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
100 Open Water	4,*2*	9	9		15	16	9,*2*
101 Lemnaceae	#	#	#	8	8	16	11
150 Lake	#	#	#		#	16	#
200 Submergents						#	#
201 Lemnaceae/submergents						16	#
251 Ceratophyllum						16	
253 Lemna/Cerat/Pot						16	
254 Potamogeton						16	11
400 Submerg-Rooted/Float-Emerg							
407 Sagit/Lemn/ Ceratophyllum						16	
450 Sag latif/Lemna/Cerat						16	
500 Rooted/Float Aquatics							
502 Jussiaea						16	
700 Emergents							
702 Carex		7	7,*13*			16	
703 Cyperus	4					16	11
709 Sagittaria				8	8	16	
714 Scirpus		7	6,7,*13*			16	11
715 Scirpus/Sagittaria						16	13
717 Sedge meadow			2				
719 Typha			2,6,*3,13*		15		
721 Typha/Scirpus		9	6,7,9,14,*3,13*				11
722 Typha/Scirpus/Sparg		7	7	7			
751 Sagittaria latifolia						16	
753 Sag latifolia/Sag rigida						16	
754 Scirpus/Sag latifolia						16	
800 Emerg-Grasses/Forbs							
801 Leersia/Carex/Polyg	4					16	
802 Leer/Carex/Sag/Polyg						16	
804 Leersia/Sagittaria						16	
806 Sagittaria/Polygonum						16	
808 Scirpus/Leersia						16	
809 Scirpus/Carex/Leer/ Polygonum	4					16	
812 Scirpus/Polygonum						16	
851 Leers/Carex/Sag lat Poly						16	
900 Grasses/Forbs							
901 Ambrosia							11
902 Grass	4	3,9	3,5,9,10,*20*		3		
903 Hay meadow		9	1,6,10,*1*				
905 Leersia	4					16	11,13

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle					
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
906 Leersia/Polygonum						16	
907 Meadow			6				
908 Mixed forbs and/or grasses			2,*20*				
910 Phalaris			2				
912 Phragmites			*2*				
914 Polygonum	4					16	11,13
916 Roadside-levee/grass/ forbs/shrub		7	7,*1,16,35*				
1000 Woody Terrest			6				
1001 Acer			#	#		#	
1002 Acer/Populus and/or Salix			#	#		#	
1003 Amorpha			#				
1004 Betula			#				
1005 Brush			#				
1006 Carya/Nyssa			#				
1007 Cephalanthus			#			16	
1008 Forest-mesic (moist soil spp.)			#			16	
1009 Forest-upland (dry soil spp.)			#				
1010 Fraxinus			#				
1011 Plantation			#				
1012 Populus			#	#		#	
1013 Quercus			#				13
1014 Salix	4		2	#		#	
1015 Salix and/or Populus			#	#		#	
1016 Salix and/or Populus - grass			#	#		#	
1017 Shrub/grass/forbs			5,10				
1018 Shrub/Scirpus			6				
1019 Taxodium			#	#		#	
1020 Taxodium/Nyssa			#	#		#	
1021 Ulmus			#	#		#	
1050 Clearing Forest			10			16	
1054 Wooded Swamp			10	12		#	
1055 >50% Cottonwood and/or Willow <20'			#	#		#	
1056 >50% Cottonwood and/or Willow >20'			#	#		#	
1057 >50% Lowland Hardwoods <20'			#	#		#	
1058 >50% Lowland Hardwoods >20'-grass			#	#		#	
1059 >50% Lowl Hardwds >20'			#	#		#	

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1060 Sag latifolia/Salix			#	#		#	
1100 Agriculture		20			3	3	3,9,13
1200 Urban/Devel							
1204 Urban				#			
1251 Residential				12			
1300 Sand/Mud							
1301 Mud						16	
1303 Sand				12	15		

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Canvasback

1. ... remain there until forced out by the freeze-up in mid-December (Mississippi River).

30. The length of [migration] stopover seems to be related to fat reserves. The stopover period seems to be inversely related to fat reserves on arrival and is likely an important factor influencing population turnover.

EMTC land cover/use classification codes	Portion of life cycle						
(Historical classifications are shown in italics)	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
100 Open Water	4,*2*	4				*1*,4	*1,37*
101 Lemnaceae	10	#				3,10	10
150 Lake	*20*	#				*20*	*20*
200 Submergents	#				#	#	#

EMTC land cover/use classification codes (*Historical classifications are shown in italics*)	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
201 Lemnaceae/ submergents	10				#	10	10
202 Myriophyllum	6,10					6,10	2,10
203 Zosterella							1
206 Vallisneria/Potamogeton	10,*2*					1,8,10,*2*	10,*2,20*
207 Myrioph/Potamoget/Vallis	10					10	10
208 Potamoget/Vallis/ Zost/Cerat						*1*	
251 Ceratophyllum	6,10					9,10,*1*	1,2,10
253 Lemna/Cerat/Pot	10					10	10
254 Potamogeton	6,10,*19*				8	1,3,4,9, 10,*19,38*	1,2,10,*19*
255 Vallisneria	10,*19*				8	1,7,10	2,10
300 Submerg-Rooted/Float Aqua							
306 Nymphaea/ submergents	*2*					*2*	*2*
308 Nymphaea/ Myriophyllum	*2*					*2*	*2*
400 Submerg-Rooted/Float-Emerg							
407 Sagit/Lemn/ Ceratophyllum	10					10	10
450 Sag latif/Lemna/Cerat							
500 Rooted/Float Aquatics							
506 Nuphar	2					2	2
507 Nymphaea	2					2	2
700 Emergents							
702 Carex	6						
709 Sagittaria	10					8,9,10,*1*	10
710 Sagittaria/Lemnaceae	10					10	10
712 Sagit/Scirpus/Sparg	10					10	10
713 Sagittaria/Sparganium	10					8,10	10
714 Scirpus	6,10					3,6,10	2,5,10
715 Scirpus/Sagittaria	10					10	2,10
716 Scirpus/Sparganium	10					10	10
718 Sparganium	10					8,10	10
724 Zizania	10					8,10	10
751 Sagittaria latifolia							1
752 Sagittaria rigida						7	2
800 Emerg-Grasses/Forbs							
806 Sagittaria/Polygonum	10					10	10
812 Scirpus/Polygonum	10					3,10	10
900 Grasses/Forbs							
914 Polygonum	10					3,10	10

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38. HSI Model

(Peterson and Crocoll 1992) Indiana nest densities were highest in areas with >75% forest cover.

7. Red-shouldered hawks build nests in large trees averaging 25–29 m tall and 46-63 cm (dbh).

4., 5. In Missouri, the average tree density (per hectare) of nest habitat ranged from 622 (4) to 888 (5). The mean canopy height was 22 m. The average distances (per meter) of nests to water ranged from 232 (4) to 572 (5).

3., 4., 9. Red-shouldered hawks typically nest in large woodlots with an average woodlot size of 98 ha for 12 nests in Iowa (approximately 8 ha/nest; 3). In Missouri, home ranges of radio-tracked red-shouldered hawks were 108–126 ha (4). In California, home range sizes were 1.21/km^2 for seven males and 1.01/km^2 for six females (9).

9. "A mosaic of habitats in an area encompassing ≥1.21 km^2 of predominantly (39%) woodland habitats appeared adequate for one pair of red-shouldered hawks in southern California" (9).

(Stravers 1992) In Iowa, no red-shouldered hawk nests were within 600 m of the main channel of the Mississippi River, and 75% of the nests were within 400 m of a bluff or ridge. No nests were found on Mississippi River islands. Typically the nests were >0.4 km from the nearest road and were >0.8 km from human dwellings.

2. Massachusetts: of 177 nests in the hardwood, 49 were in chestnuts, 46 in red oaks, 26 in white pines (usually scattered among the hardwoods), 19 in white oaks, 15 in swamp oaks, 13 in scarlet oaks, 8 in maples, and 1 in ash. Of 41 nests in the white pine region, 31 were in pines, 4 in beeches, 4 in red oaks, 1 in maple, and 1 in chestnut. Few of the nests were actually in swampy woods, although many were in dry parts of woods near swamps or streams; but some were in high, dry woods, far from water.

20. Has built nests in oak, pine, bald cypress, mangrove, cottonwood, birch, beech, sycamore, yellow poplar, ash, sweetgum, and maple...often uses the same nest site year after year. Nests 6–18 m above ground in tall trees. Usually builds nest 11–14 m above ground on a main fork and close to the tree trunk.

16. Found winter, summer, and fall in bottomland hardwoods by borrow pits, levees, Mississippi River. (black willow, buttonbush, cottonwood, box elder, American elm, American sycamore, green ash, red maple, persimmon, hickories, locust, rose mallow, basswood...)

10. 69.96 ha upland forest and lowland/successional growth sugar maple dominated canopy with white ash, American beech, and ironwood. 18.34 ha woods of canopy red and white oaks and subcanopy sugar maple.

34. New Jersey: Red-shouldered hawks nested in 10- and 24-ha woodlots in the Middle Atlantic states. The minimum area requirement estimate was 225 ha; however, red-shouldered hawks were detected in isolated tracts of 52, 20, and 39.6 ha. Missouri: only 1 of 14 nests were in upland forest. Forest stands with nests were characterized by a tall and relatively closed canopy, a mean tree density of 179–365 trees/ha (442–900 trees/acre), and variable shrub and ground covers. The dbh ranged from 18 to 22 cm and the mean basal area was 44–69 m^2/ha. Michigan: winter home range estimate was 127, 389, and 503 ha. Maryland: Red-shouldered hawks foraged along the edge between fields and forests more than in forests during winter.

14. Maryland: 73% of nests were either in *Quercus alba* or *Quercus rubra*. Other nest trees were *Quercus coccinea, Fraxinus americana, Fraxinus grandifolia, Liriodendron tulipifera*, and dead. Ninety percent of the nest trees were greater than 40% dbh. Red-shouldered hawks selected areas with high canopy heights, great understory cover, a low density of small overstory trees, many large trees, high basal areas, and mature understory stratum. Often nests were near water with little or no slope.

14. Wisconsin: Red-shouldered hawks selected areas with little ground cover, little shrub complexity, a low density of small trees and many large trees. Nest trees were *Fraxinus grandifolia, Betula papyrifera, Betula lutea, Quercus rubra, Carya glabra, Acer saccharum, Acer rubrum, Populus tremuloides,* and *Populus deltoides.*

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
916 Roadside-levee/grass/forbs/shrub			*16*			*16*	*16*
919 Vines as dense overgrowth			*16*			*16*	*16*
1000 Woody Terrest							
1001 Acer		TJ10	8,TJ10, *14,16,20*			*16*	8,TJ10,*14,16*
1002 Acer/Populus and/or Salix			#			#	#
1003 Amorpha			#			#	#
1004 Betula			4,5,6,7,*14,20*				*14*
1006 Carya/Nyssa			10,*14*				8,*14*
1008 Forest-mesic (moist soil spp.)			8,*2,16, 35*			*16*	8,*16*
1009 Forest-upland (dry soil spp.)							8
1010 Fraxinus		TJ10	8,10, TJ10,*14,20*				TJ10,*14*
1012 Populus			12,*14,20*			#	*14*
1013 Quercus		TJ10	4,5,6,7,9,10, *10,14,20*				8,*14*
1014 Salix			#			#	#
1015 Salix and/or Populus			#			#	#
1016 Salix and/or Populus - grass			#			#	#
1019 Taxodium			#			#	#
1020 Taxodium/Nyssa			7			#	#
1021 Ulmus			7,8,10			#	8
1054 Wooded Swamp			7,*2*			#	#
1055 >50% Cottonwood and/or Willow <20'			#			#	#
1056 >50% Cottonwood and/or Willow >20'			#			#	#
1057 >50% Lowland Hardwoods <20'			#			#	#
1058 >50% Lowland Hardwoods >20'-grass			#			#	#
1059 >50% Lowl Hardwds >20'			1,2,3,*20*			#	8
1060 Sag latifolia/Salix			#			#	#

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Great Blue Heron

5., 6., 7., 8., 11., _2_. The great blue heron prefers to nest in trees 5 to 15 m above the ground (5, 6, 7, 8). Many of the nests are in dead trees (11, TJ2).

1. Proximity of nests to dams is within 16 km (10 mi) downstream. Nests were near oxbow lakes and sloughs and also within several miles of extensive marshland. The nests were mostly within 91 m to water. Their proximity to river junctions and dams was within 4 km. All colonies were over 160 m from traveled roads.

3. Great blue herons usually nest on islands or in wooded swamps, isolated locations that discourage predation by snakes and mammals.

5., 7., 10., 12., 13., 14., 15. Great blue heron nests are usually "near" water (12). Nests colonies are often on islands (7, 10, 13), but only if isolated from human habitation and disturbance (5, 14). In Minnesota, heronries were located at least 3.3 km from human dwellings and 1.3 km from the nearest surfaced road (15).

15. Minimum habitat area for heronries in Minnesota ranged from 0.4 to 8.4 ha and averaged 1.2 ha (15).

16. In Illinois, the tracts of forest habitat used for nesting ranged from 103 to 1,969 ha, with an average of 608 ha (16).

_20_. Builds nests in tops of the tallest trees, live or dead, often above 15 m, but also in bushes, on rock ledges, sea cliffs, in the rushes, and on the ground. May travel as far as 16 km from nest sites to foraging areas.

_35_. Great blue herons could winter virtually any place in Iowa that has open water.

_2_. Bent: Nest found in pines, pin oaks, white oaks, chestnuts, tuliptrees, swamp maples, black ash, cedar swamps, spruces, firs, elm, sycamore, cottonwoods, poplars, and box elders.

_16_. Borrow pits, levees, Mississippi River censused year-round at some sites in bottomland hardwoods.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
100 Open Water							
150 Lake							4
700 Emergents							
714 Scirpus			1				
1000 Woody Terrest							
1001 Acer	#		1,2			#	#

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1002 Acer/Populus and/or Salix	#		1,2			#	#
1004 Betula			1				
1008 Forest-mesic (moist soil spp.)	***16***		***16***			***16***	***16***
1012 Populus	#		1,2,10			#	#
1013 Quercus			1				
1014 Salix	#		1			#	#
1015 Salix and/or Populus	#		1,2			#	#
1016 Salix and/or Populus - grass	#		#			#	#
1019 Taxodium	#		16			#	#
1020 Taxodium/Nyssa	#		9			#	#
1021 Ulmus	#		1,2			#	#
1054 Wooded Swamp			***36***				
1055 >50% Cottonwood and/or Willow <20'	#		#			#	#
1056 >50% Cottonwood and/or Willow >20'	#		#			#	#
1057 >50% Lowland Hardwoods <20'	#		#			#	#
1058 >50% Lowland Hardwoods >20'-grass	#		#			#	#
1059 >50% Lowl Hardwds >20'	#		#			#	#
1060 Sag latifolia/Salix	#		#			#	#

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American Bittern

1., *9*. In Missouri, American bittern were flushed (in both spring and fall) from sites of a mean water depth of 26 cm (10.2 inches) (1). Theresa Jacobson <9> reported that, in a Minnesota study, American bitterns were never observed in water deeper than 15 cm. In spring, American bittern were flushed from vegetation with a mean height of 62 cm (24.3 inches); in fall, the mean vegetation height was 117 cm (46.0 inches) (1).

8. American bittern very rarely perch in trees.

10., 11. In Iowa, American bittern are found only on wetlands >10 ha (11). American bittern can be found on wetlands ranging from 0.1 to 1,000 ha, but they are more abundant on larger than smaller wetlands (10).

37. ... also found in wet woodlands and wet weedy fields [Illinois] breed in wet prairies, prairie sloughs, and marshes.

16. Borrow pits, levees, Mississippi River censused during summer and fall.

37. Most nests were found in thick marsh grass, sometimes adjacent to stands of willow and tamarack, within 6 m (20 ft) of water.

17. Were never observed close to trees...or in water deeper than 15 cm....quackgrass–redtop habitat where five nests were located. Most (80%) of the incidental observations were along wetland edges with gradual slopes and a predominance of emergent vegetation, mostly cattails and softstem bulrush.

34. Spring: flush sites had a mean water depth of 10.2 inches (5-14 inches).

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
700 Emergents							
702 Carex			4,13	13			
712 Sagit/Scirpus/Sparg				*3*			
714 Scirpus	1,*15*	1	4,12,*17*	12		1	
716 Scirpus/Sparganium	1,*15*		*3*			1	
717 Sedge meadow			13	13			
718 Sparganium	1,*15*	1	*3*,4		TJ15	1,TJ15	
719 Typha	1,15	1	2,*2,3*,3,12	12	1,TJ15	1,TJ15	
721 Typha/Scirpus	1		*2,3,17*,12	12		1	
722 Typha/Scirpus/Sparg	*15*,1	1				1	
723 Typha/Sparganium	1,*15*					1	
800 Emerg-Grasses/Forbs							
812 Scirpus/Polygonum	1					1	
813 Scirpus/Typha/Phalaris			*17*				
900 Grasses/Forbs							
902 Grass			5				
907 Meadow				*20*	*20*	*20*	
908 Mixed forbs and/or grasses			*17*				
912 Phragmites			4,7				
914 Polygonum					1,TJ15	1,TJ15	
916 Roadside-levee/grass/forbs/shrub			*16,17*	*16*	*16*	*16*	
918 Spartina			6				
1000 Woody Terrest							
1001 Acer	#	#	#	#	#	#	#
1002 Acer/Populus and/or Salix	#	#	#	#	#	#	#
1008 Forest-mesic (moist soil spp.)	*37*	*37*	*37*	*37*	*37*	*37*	*37*
1012 Populus	#	#	#	#	#	#	#
1014 Salix	#	#	#	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	#	#	#	#	#	#
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	#	#	#	#	#	#
1060 Sag latifolia/Salix	#	#	#	#	#	#	#

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Yellow-billed Cuckoo

Optimum habitat in California (Laymon and Halterman 1989) consists of >80 ha willow/cottonwood.

Anderson and Laymon (1989) reported that yellow-billed cuckoos nest and forage when willow/cottonwood densities are at least 150 trees/ha.

45. California: birds occur where (1) riparian vegetation exceeds 300 m in length and 100 m in width, (2) water is present within 100 m, (3) there are dense understory vegetation and thickets of willow. They are lacking where (1) understory vegetation is sparse or absent or (2) the vegetation is not sufficiently extensive, as along the 20–100-m-wide strip of otherwise suitable habitat....usually in cottonwoods and willows....not found in oaks (*Quercus lobata*), sycamores, or in areas such as parks where understory vegetation has been removed.

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
916 Roadside-levee/grass/ forbs/shrub			*16*			*16*	
919 Vines as dense overgrowth			1,*16,20*			*16*	
1000 Woody Terrest							
1001 Acer		3	1,2,3,*10*	3		#	
1002 Acer/Populus and/or Salix			*10,11,16*			*16*	
1003 Amorpha			#			#	
1004 Betula			2	#			
1006 Carya/Nyssa			1,2			#	
1007 Cephalanthus			*16*			*16*	
1008 Forest-mesic (moist soil spp.)			1,*16*			*16*	
1009 Forest-upland (dry soil spp.)		3	1,3	3			
1010 Fraxinus		3	1,2,3,*10*	3			
1011 Plantation			#	#			
1012 Populus			2,4				
1013 Quercus		3	1,2,3,TJ10,*16*	3		*16*	
1014 Salix			4,*16*			*16*	
1015 Salix and/or Populus			*16*			*16*	
1016 Salix and/or Populus - grass			#			#	
1017 Shrub/grass/forbs			1,*20*			#	
1019 Taxodium			#			#	
1020 Taxodium/Nyssa			#			#	
1021 Ulmus		3	1,2,3,TJ10	3		#	
1053 Orchards			*20,37*				
1055 >50% Cottonwood and/or Willow <20'			#			#	
1056 >50% Cottonwood and/or Willow >20'			#			#	
1057 >50% Lowland Hardwoods <20'			#			#	
1058 >50% Lowland Hardwoods >20'-grass			#			#	
1059 >50% Lowl Hardwds >20'			1			#	
1060 Sag latifolia/Salix			#			#	

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37. Bohlen, H. D. 1989. The birds of Illinois. Indiana University Press, Indianapolis. 221 pp.

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Barred Owl

1. In the south and central regions of Wisconsin, barred owl nest cavities are more likely to be found in mature forests close to moist river bottoms. Farther north the barred owl can be found in isolated stands of maple–beech hardwoods.

1. Most nest cavities are in large maple, beech, and aspen trees, 5.5–15.2 m (18 to 50 ft) above the ground (1).

6. In Minnesota, cover types preferred most by barred owls were oak woodlands and mixed deciduous/coniferous woodlands, especially if they were free of dense understory vegetation.

3., 9., 10. The most critical component of barred owl nesting habitat seems to be the availability of trees of sufficient size and age (3). Trees suitable for nest cavities are usually ≥51 cm dbh.

3., 4. Stands of mature and old-growth forest that provide the cover and nest cavities seem to be more important to barred owls in determining nesting habitat than how far they are from water.

7., 8. Barred owls require large tracts of woodland and prefer to nest in interior sections.

6., 12. The average home range for barred owls in Minnesota is 228.6 ha (range 86.1–369.0 ha) (6). The average home range of breeding females in Minnesota is 507.8 ha (12).

11. Barred owls require at least 0.02 snags/ha, with the optimum, 0.1 snags/ha.

2. It is a forest-loving bird, living mainly in the deep, dark woods, heavily wooded swamps, gloomy hemlock forests, or thick growths of tall, dense pines....Much of its hunting is done in the open country and about the farms, and in fall and winter it occasionally ventures into the villages and even into cities in search of food. Massachusetts: 21 nests in white pine...18 were in old red-shouldered hawk or Cooper's hawk nests, 15 were in hollow trees, 5 were in old squirrel's nests....nest fidelity. Complementary habitat and nest sites/nest trees with red-shouldered hawks.

20. Cool, damp lowlands with large-cavity trees 51 cm (20 inches) dbh or greater for nesting. May use the same nest for many years.

36. ...it frequents the mature forests close to the moist river bottoms...frequents dense stands of maple-beech hardwoods far from human disturbance. Occasionally a stray bird comes into a residential neighborhood....Nest trees: maple, beech, aspen, and cottonwood.

37. Its main habitat is bottomland forest, but it also occurs in upland woods and sometimes roosts in conifers in winter.

20. Prefers dense woodlands bordering lakes, streams, swamps, marshes, or low meadows. Favors oak woodlands or mixed forests free of dense understory but also inhabits deciduous, coniferous, and mixed forests. May also inhabit isolated woodlots with numerous mature trees.

16. Borrow pits, levees, Mississippi River (censused here during winter, spring, summer and fall) in bottomland hardwoods.

10. Wooded island (2.19 ha) surrounded with agricultural land except for a wet depression that supports a swamp forest. Basswood dominates canopy, red oak being about half as important. Dead elms.

20. Hunts for prey over open fields, clearings, and wetlands near woodlands.

38. Barred owls are not restricted to specific floristic associations in their foraging activities. Average home size in Michigan (Upper Peninsula) was 282 ha. The area used decreased to an average of 118 ha during summer. Differences between the home range size of barred owls seemed to be associated with the breeding status, season, or owl age.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
902 Grass	20	20	20	20	20	20	20
903 Hay meadow	20	20	20	20	20	20	20
907 Meadow	20	20	20	20	20	20	20
908 Mixed forbs and/or grasses	20	20	20	20	20	20	20

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
916 Roadside-levee/grass/ forbs/shrub	16,20, 38	16,20,38	16,20,38	16,20,38	16,20,38	16,20,38	16,20, 38
1000 Woody Terrest							
1001 Acer	#	6	1,3,6	6	6	#	1,6
1002 Acer/Populus and/or Salix	#	#	#	#	#	#	#
1003 Amorpha	#	#	#	#	#	#	#
1004 Betula		6	1,5,6	6	6		1,6
1006 Carya/Nyssa	#	#	2	#	#	#	#
1008 Forest-mesic (moist soil spp.)	2,16	2,16	1,3,5,2,16	2,16	2,16	2,16	2,16
1009 Forest-upland (dry soil spp.)			3,6				
1010 Fraxinus			2				
1012 Populus	#	#	#	#	#	#	#
1013 Quercus		6	1,2,5,6, TJ10	6	6		1,6, TJ10
1014 Salix	#	#	#	#	#	#	#
1015 Salix and/or Populus	#	#	#	#	#	#	#
1016 Salix and/or Populus - grass	#	#	#	#	#	#	#
1019 Taxodium	#	#	#	#	#	#	#
1020 Taxodium/Nyssa	#	#	#	#	#	#	#
1021 Ulmus	#	#	1,2,5, TJ10	#	#	#	1,TJ10
1050 Clearing Forest		20	2,20	20			
1051 Deadening Forest			2				
1054 Wooded Swamp			1,2,20				
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#	#	#	#
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#	#	#	#
1057 >50% Lowland Hardwoods <20'	#	#	#	#	#	#	#
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#	#	#	#
1059 >50% Lowl Hardwds >20'	#	6	1,5,6	6	6	#	6
1060 Sag latifolia/Salix	#	#	#	#	#	#	#
1100 Agriculture	20	20	20	20	20	20	20
1200 Urban/Devel							
1204 Urban	#	#	#	#	#	#	#
1251 Residential	2,20,38	2,20,38	2,20,38	2,20,38	2,20,38	2,20,38	2,20,38

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38. HSI Model

Prothonotary Warbler

3. Prothonotary warbler nests usually are 1–2 m from water and are surrounded by "relatively large" trees.

2. Approximately 50% of prothonotary warbler nests are found in fallen branches, willows, maples, and buttonbushes.

37. Illinois: inhabits swampy places and bottomland forests. On rare occasions, it is found in other wooded areas, even city parks, during migration. Forages low, usually in trees such as willows that overhang water or logs floating in the water. Southern Illinois: favored habitat is the cypress swamps. May move up rivers during spring migration.

20. Nests in natural cavities, old cavities of woodpeckers (especially Downy) and chickadees, in stumps or snags that are standing in or near water. Occasionally use nest box, usually nest low, about 1.5 m (5 ft) above the ground

16. Found in borrow pits, levees, and the Mississippi River in spring. Censused in bottomland hardwoods, vines, and understory in summer and fall.

EMTC land cover/use classification codes	Portion of life cycle						
Historical classifications are shown in italics.	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
900 Grasses/Forbs							
916 Roadside-levee/grass/forbs/shrub	*16*		*16*			*16*	
919 Vines as dense overgrowth	*16*	2	2,*16*			*16*	
1000 Woody Terrest							
1001 Acer	*16*	2	1,2,4,5,7,*16*	#		*16*	
1002 Acer/Populus and/or Salix	*16*	#	*16*	#		*16*	
1003 Amorpha	#	#	#	#		#	
1004 Betula		2	2,4,7				
1005 Brush							
1006 Carya/Nyssa	#	#	7	#		#	
1007 Cephalanthus	*16*	2	2,4,*16*			*16*	
1008 Forest-mesic (moist soil spp.)	*16*	6	1,5,6,*16*,*20*	6		*16*	
1010 Fraxinus			5,7				
1011 Plantation							
1012 Populus	#	6	6,7	6		#	
1013 Quercus	*16*		7,*16*			*16*	
1014 Salix	#	2,6	2,4,6,*37*	6		#	

EMTC land cover/use classification codes *Historical classifications are shown in italics.*	Portion of life cycle						
	Spring migration	Pre-breeding	Nesting	Brood rearing	Post-breeding	Fall migration	Wintering
1015 Salix and/or Populus	*16*	#	*16*	#		*16*	
1016 Salix and/or Populus - grass	#	#	#	#		#	
1017 Shrub/grass/forbs	*16*	2	2,*16*			*16*	
1019 Taxodium	#	#	#	#		#	
1020 Taxodium/Nyssa	#	#	#	#		#	
1021 Ulmus	#	2	1,2,4,7	#		#	
1051 Deadening Forest		2	2				
1054 Wooded Swamp			*20,37*				
1055 >50% Cottonwood and/or Willow <20'	#	#	#	#		#	
1056 >50% Cottonwood and/or Willow >20'	#	#	#	#		#	
1057 >50% Lowland Hardwoods <20'	#	#	#	#		#	
1058 >50% Lowland Hardwoods >20'-grass	#	#	#	#		#	
1059 >50% Lowl Hardwds >20'	#	#	#	#		#	
1060 Sag latifolia/Salix	#	#	#	#		#	
1200 Urban/Devel			5				

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Appendix D

Computerization of the Matrices

Not all of the matrices arrived at the Environmental Management Technical Center (EMTC) at the same time. Data came in over a period of several weeks; therefore, a method for data entry that could be easily updated was needed. The decision was made to create multiple lookup tables, each a subset of final product.

Seven lookup tables were created for each bird, one for each life cycle category. Each lookup table contained two items, VEG_CODE and a species name. Whenever possible, the individual species names were spelled out completely to make future references to the matrices easier. The tables were created within ARC/INFO's INFO program. For example, the parameters used to define a lookup table for the American bittern are

VEG_CODE 4 4 I
AMERICAN_BITTERN 1 1 I

VEG_CODE's input column width, output column width, and field type (I = integer) were previously established by the Long Term Resource Monitoring Program's (LTRMP) coding scheme. Format consistency during data input is very important. If any alterations had been made, ARC/INFO would have considered the lookup table's VEG_CODE a new and unique item. Then relations between the lookup table and LTRMP's VEG_CODE classification scheme would have been possible.

Items defined by a species name were each assigned the INFO parameters of one column of input data, one column of output data; the data were all integers. The files were set up this way because all the entries were numeric, 1 indicating potential habitat and 0 indicating nonhabitat. The numbers 1 and 0 were chosen to simplify later analysis (one bird, one value).

Matrix data were entered into the lookup tables by using the INFO command ADD. Only VEG_CODEs listed within the matrices as potential habitat were entered into the initial lookup tables. Each VEG_CODE was entered exactly as it appeared in the matrices, and then the number 1 was entered in the species column. Entering nonhabitat VEG_CODEs was not necessary. When the lookup tables are joined together, VEG_CODEs that have no entries are automatically assigned the number 0.

When all the individual lookup tables were completed and checked for accuracy they needed to be joined to master lookup tables. The master lookup tables were created by using the ARC command COPYINFO and copying existing LTRMP lookup tables. Seven master lookup tables were created: spring_migration.lut, pre_breeding.lut, nesting.lut, brood_rearing.lut, post_breeding.lut, fall_migration.lut, and wintering.lut. Lookup tables created for the individual birds were then joined to the master tables by using the ARC command JOINITEM. The commands used to join the American bittern's spring migration lookup table to the master spring migration lookup table follows:

Joinitem spring_migration.Lut ambi_spr.Lut spring_migration.Lut veg_code total

The preceding command statement reads as follows:

A JOINITEM will be performed on the lookup table SPRING_MIGRATION.LUT. Data unique to the lookup table AMBI_SPR.LUT will be added to those of SPRING_MIGRATION.LUT, and the file created from the process will be written to the file SPRING_MIGRATION.LUT (overwriting the old file SPRING_MIGRATION.LUT). VEG_CODE is the item that will be used to relate these two files together. New items will be written into the old file SPRING_MIGRATION.LUT after the item TOTAL (TOTAL already existed within SPRING_MIGRATION.LUT).

Once all JOINITEMs were completed, the number of birds that have the potential of using each vegetation type was calculated. The original plan was to use INFO's CALC command to calculate the total number of species that have the potential of using each vegetation class by using the command:

CALC TOTAL = AMERICAN_BITTERN + GREAT_B_HERON + ...

Unfortunately, the species names as written were too long for such a command to be written. The problem was then solved by changing the bird names to shorter names using the command ALTER. For example, GREAT_B_HERON was change to B2, CANVASBACK became B3. The shortening of the names allowed for the totaling of positive habitat use responses.

The original names were then restored to their original format by using the INFO command ALTER. Calculating TOTAL may not have been necessary, though; at the time this document was prepared, persons using the data were more interested in the species richness coverages than in the vegetation class totals.

Commands performed on LTRMP's master lookup table to create a listing of unique vegetation codes were the following:

1. Copy EMTC's master lookup table to the migratory_bird work area using COPYINFO.

   Arc: copyinfo /usr3/lkp_tables/master.lkp master.lut

2. Define a second lookup table in INFO that would eventually contain only LCU information, not the LCU/NWI information stored in the master lookup table. The new lookup table (NEW.LUT) needs to contain two items, LCU and CLASS. In INFO, define new.lut using the parameters

   LCU 30 30 C
   CLASS 3 3 I

3. Select the master lookup table using

   SEL MASTER.LKP

4. Sort the master lookup by VEG_CODEs.

   SORT ON VEG_CODE

5. Relate the two lookup tables by the item LCU.

   RELATE NEW.LUT BY LCU INIT

6. The desired result was a listing of all VEG_CODE descriptions in numeric order with no repeats or duplications. To do this, a numeric calculation needs to be performed. The calculation analyzed each VEG_CODE one by one, then totaled the number of different NWI combinations that were available for that class within the lookup table. Each unique VEG_CODE is then written to the newly created lookup table, and the total number of entries multiplied by the class number is listed. Note: Class was used only because it was an already existing numeric number within the lookup table. Any numeric item would have worked since we are not interested in the numeric output.

   CALC $1CLASS = $1CLASS + CLASS

7. INFO was then exited and the ARC command DROPITEM used to remove CLASS from the listing of unique VEG_CODEs.

   Arc: dropitem new.lut new.lut class

8. The remaining contents from LTRMP's master lookup table were then joined to NEW.LUT using the command JOINITEM.

   Arc: joinitem new.lut master.lut new.lut veg_code veg_code

9. DROPITEM was then used to remove the category TYPE_DESCRIPTION from NEW.LUT. This was done because TYPE_DESCRIPTION is a combination of land cover descriptions and national wetlands inventory code information, and most VEG_CODE categories have multiple TYPE_DESCRIPTION listings. The resulting table contained the following categories:

VEG_CODE	(numeric LCU codes)
LCU	(written LCU descriptions)
LCU-13	(written LCU-13 descriptions)
EPPL_CODE	(numeric codes used with the EPPL7 GIS program)
CLASS	(numeric LCU-13 codes)
VALUE	(numeric LCU classification used with systemic Landsat data).

Appendix E

Modeling Results

Appendix E contains images of the GIS coverages created for the Pilot Project. Upon reviewing this section, the reader should keep in mind that the purpose of the Pilot Project was to evaluate the types of computer data that could be generated from information collected in a literature search, evaluate those data for usefulness and accuracy, and then use the data to determine the best way that similar processes can be used in a landscape/species guild approach to managing the Upper Mississippi River System. The biological accuracy and usefulness of the literature search data are in review.

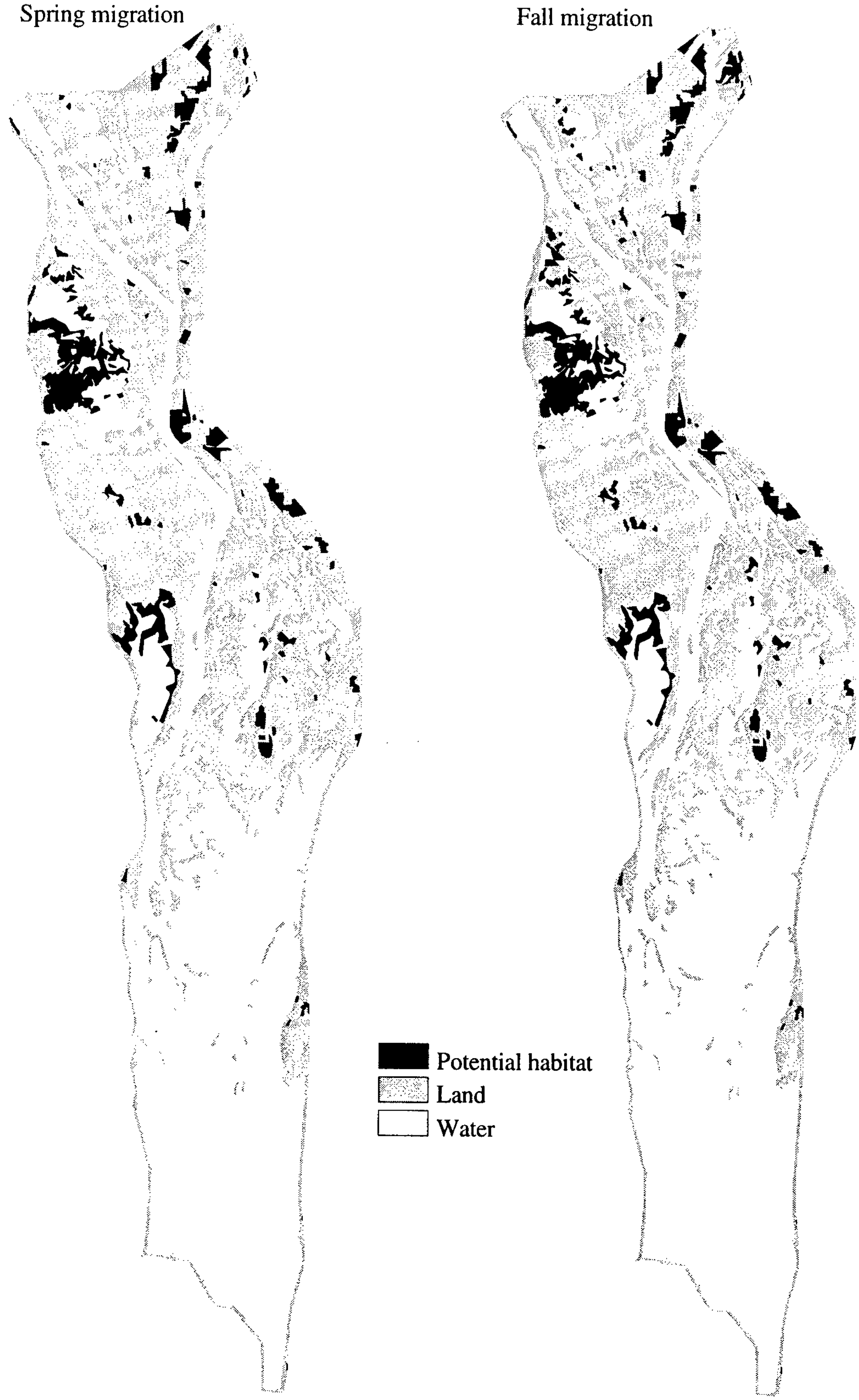


Figure E-1. Potential 1975 spring and fall migration habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 8.

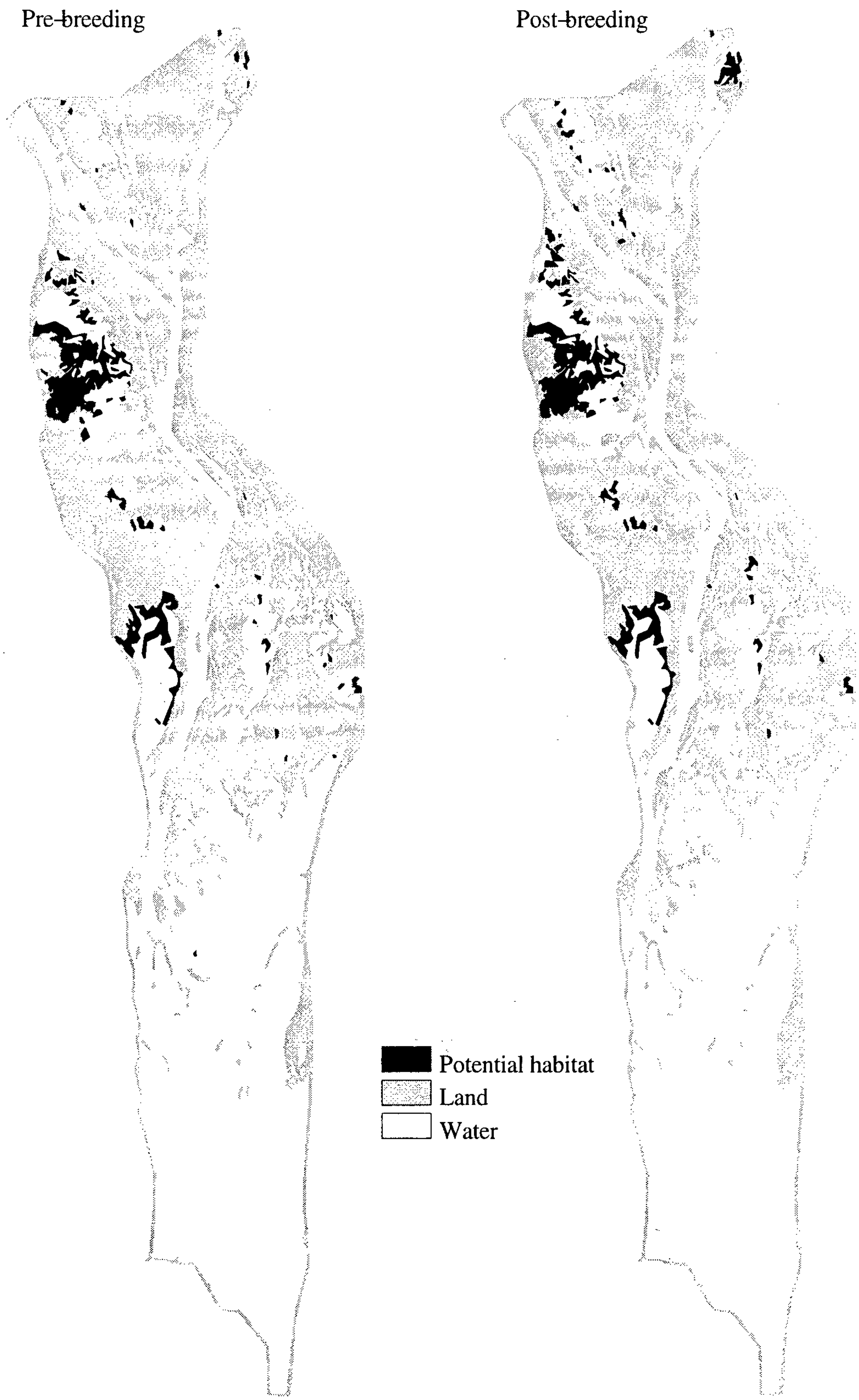


Figure E-2. Potential 1975 pre- and post-breeding habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 8.

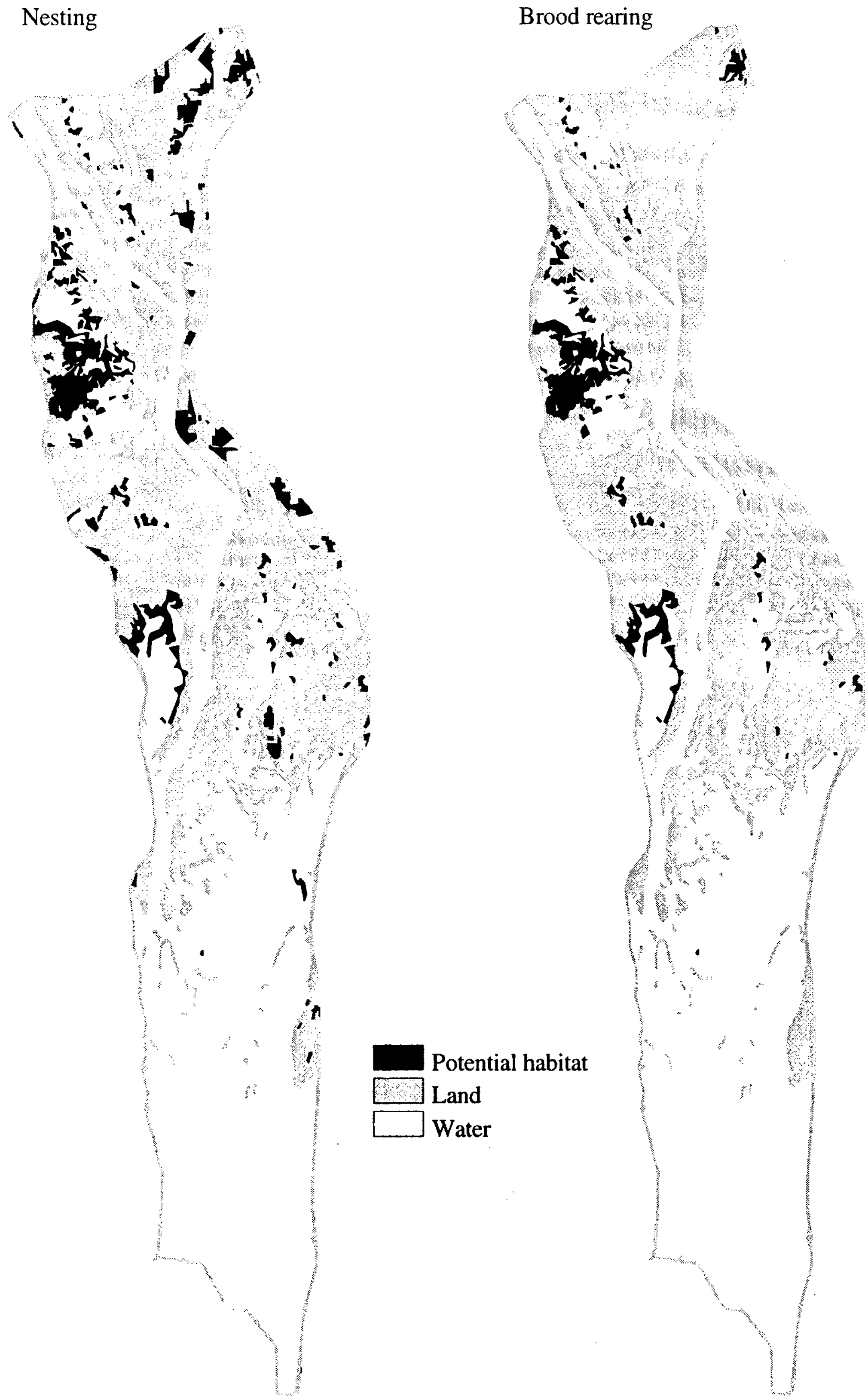


Figure E-3. Potential 1975 nesting and brood rearing habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 8.

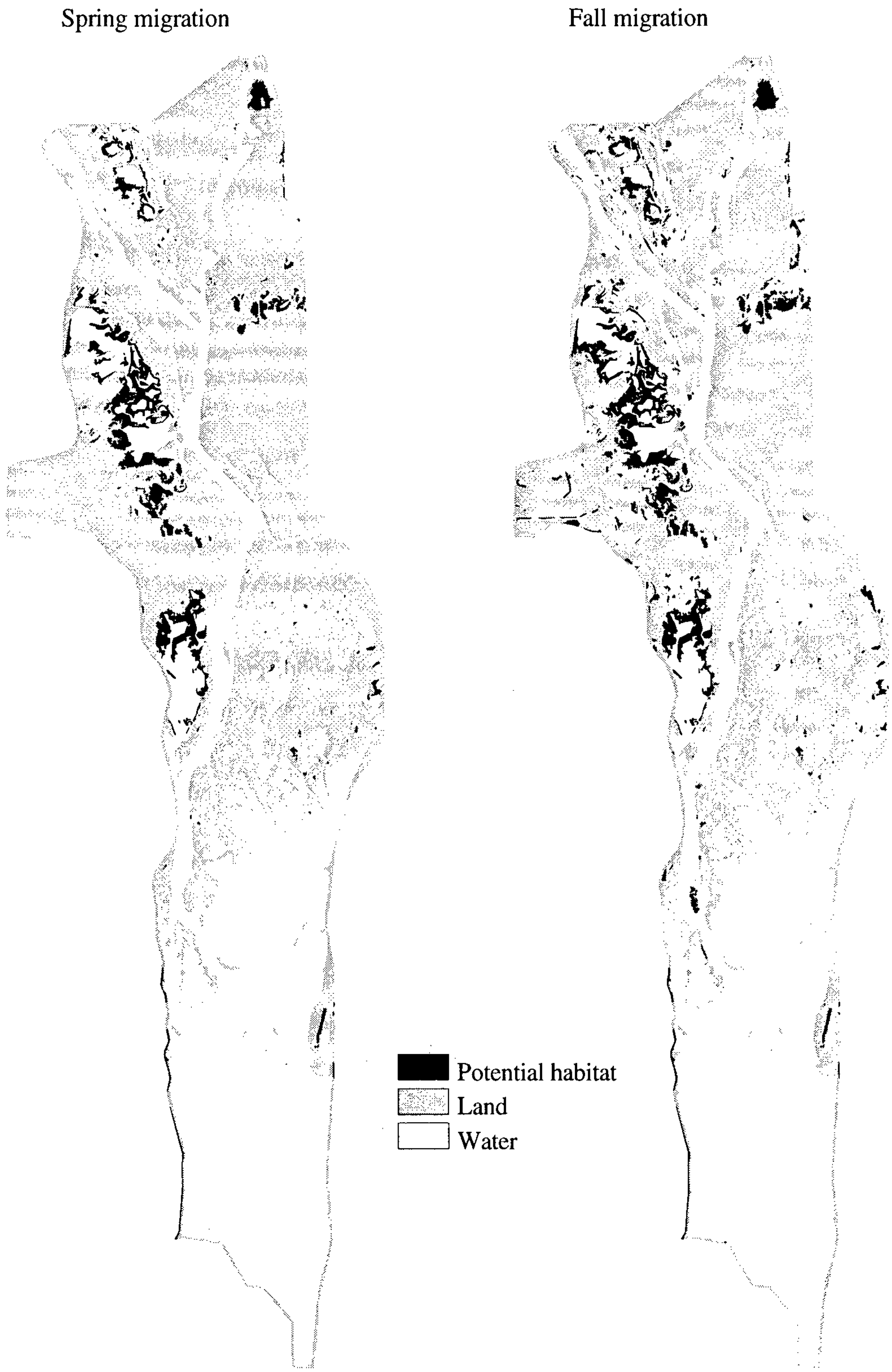


Figure E-4. Potential 1989 spring and fall migration habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 8.

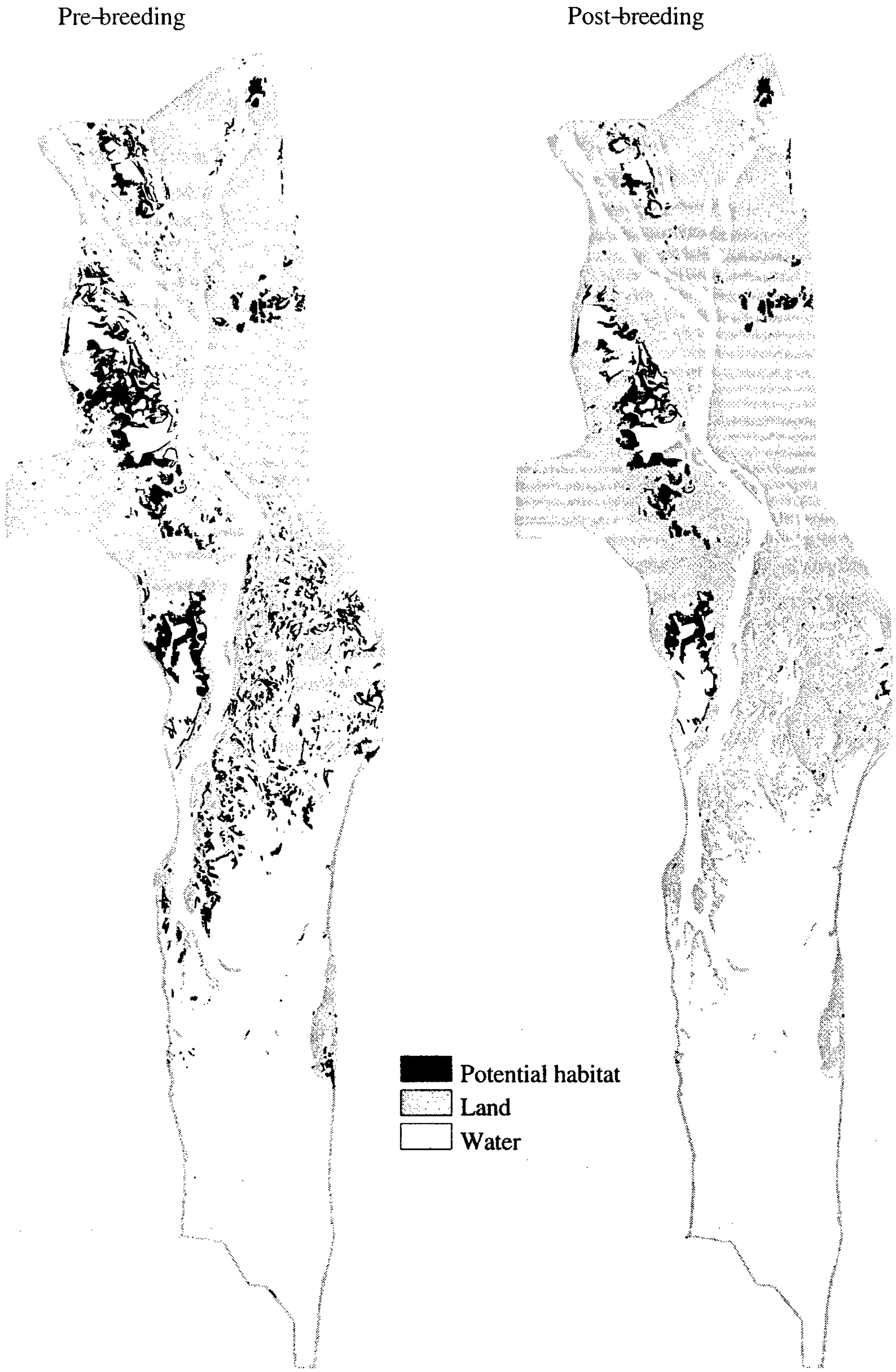


Figure E-5. Potential 1989 pre- and post-breeding habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 8.

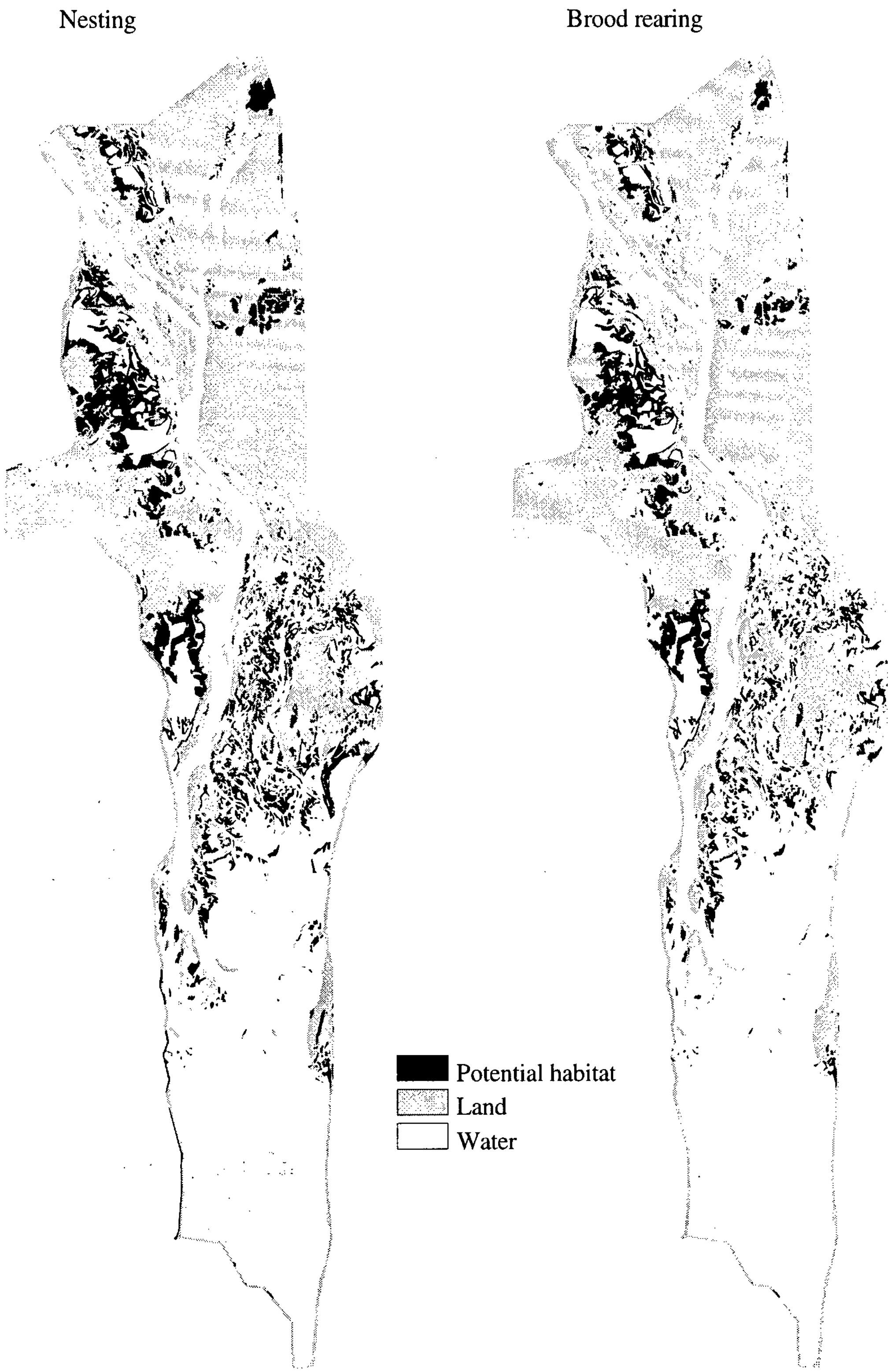


Figure E-6. Potential 1989 nesting and brood rearing habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 8.

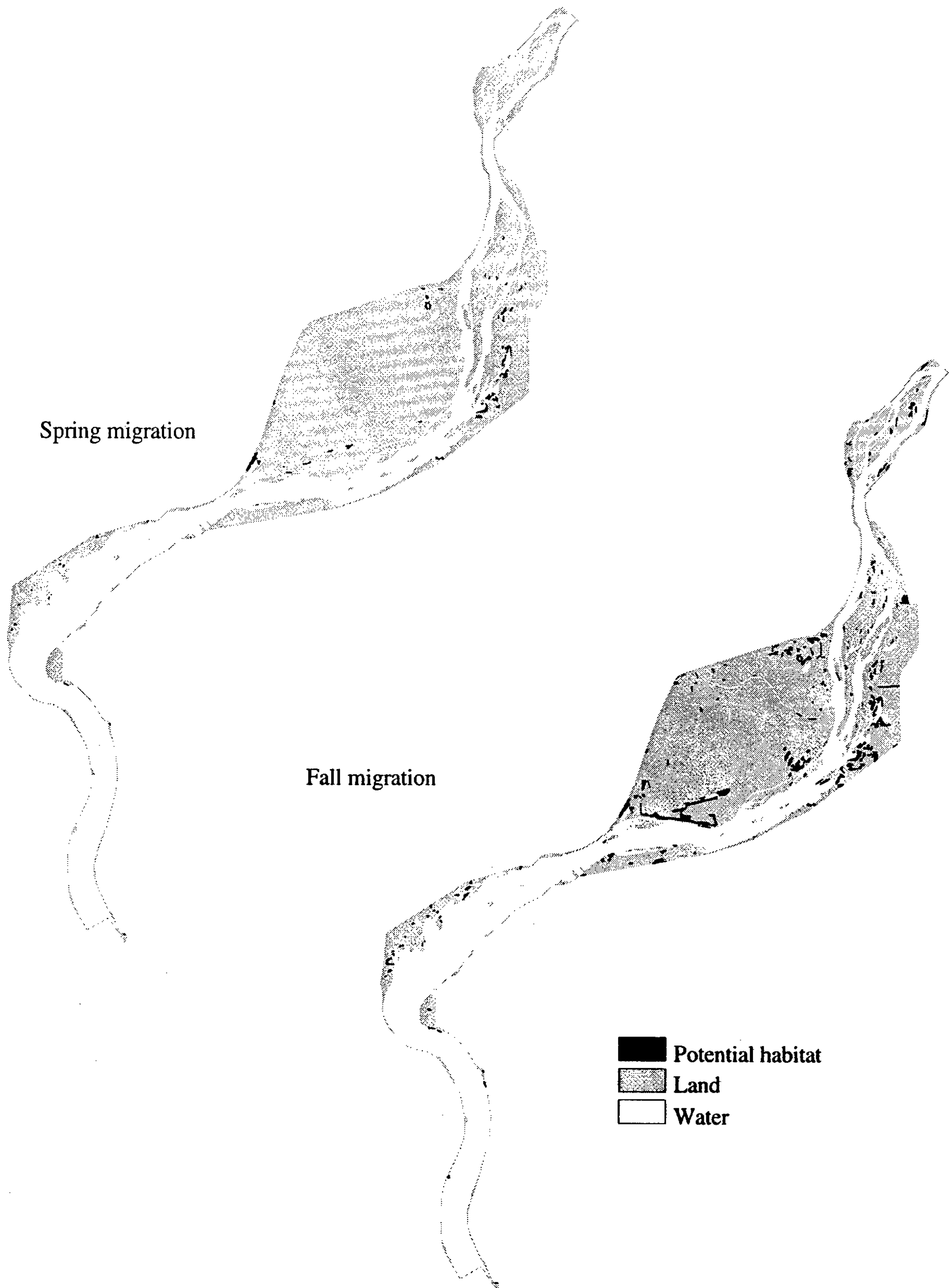


Figure E-7. Potential 1975 spring and fall migration habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 19.

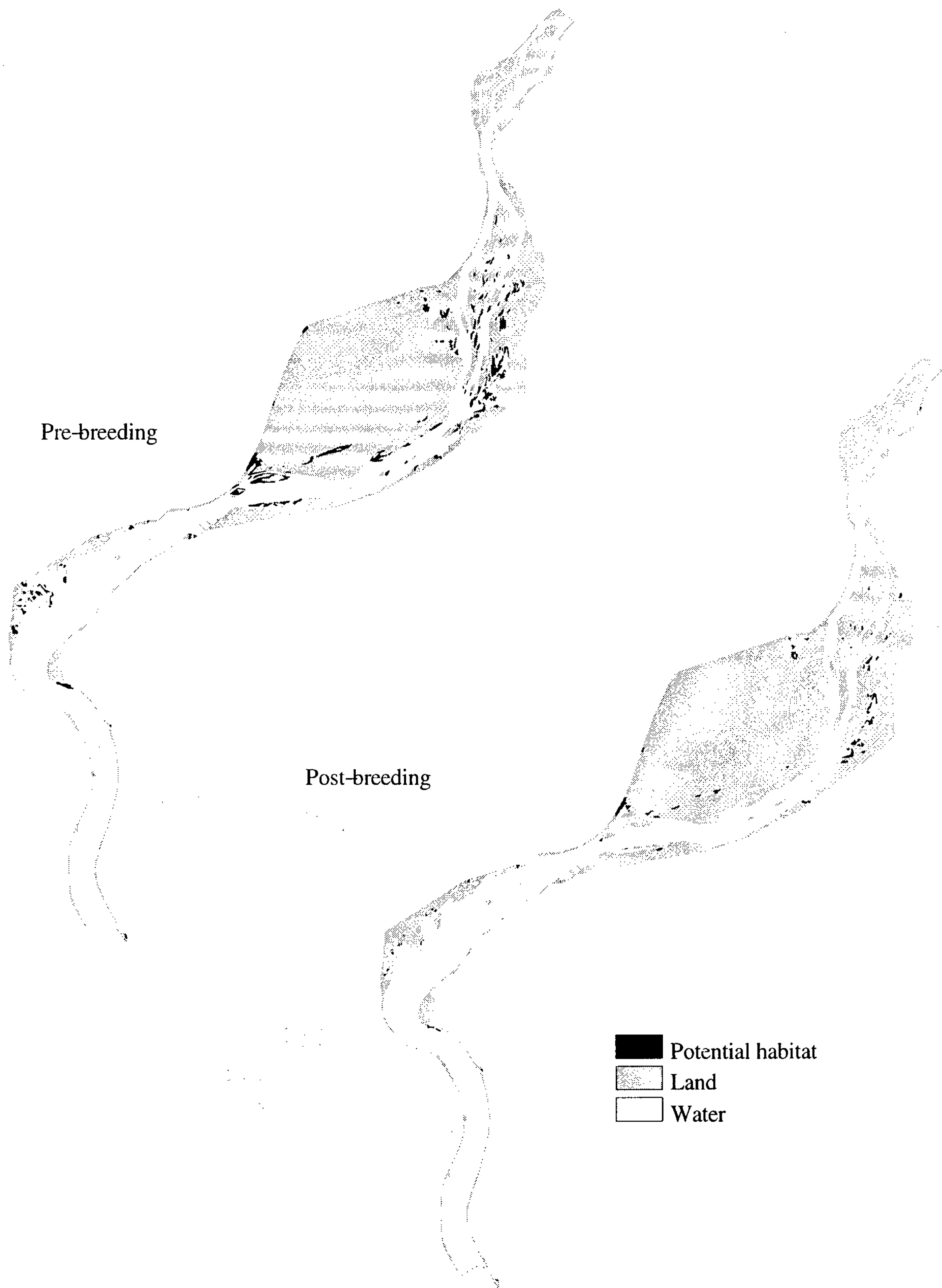


Figure E-8. Potential 1975 pre- and post-breeding habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 19.

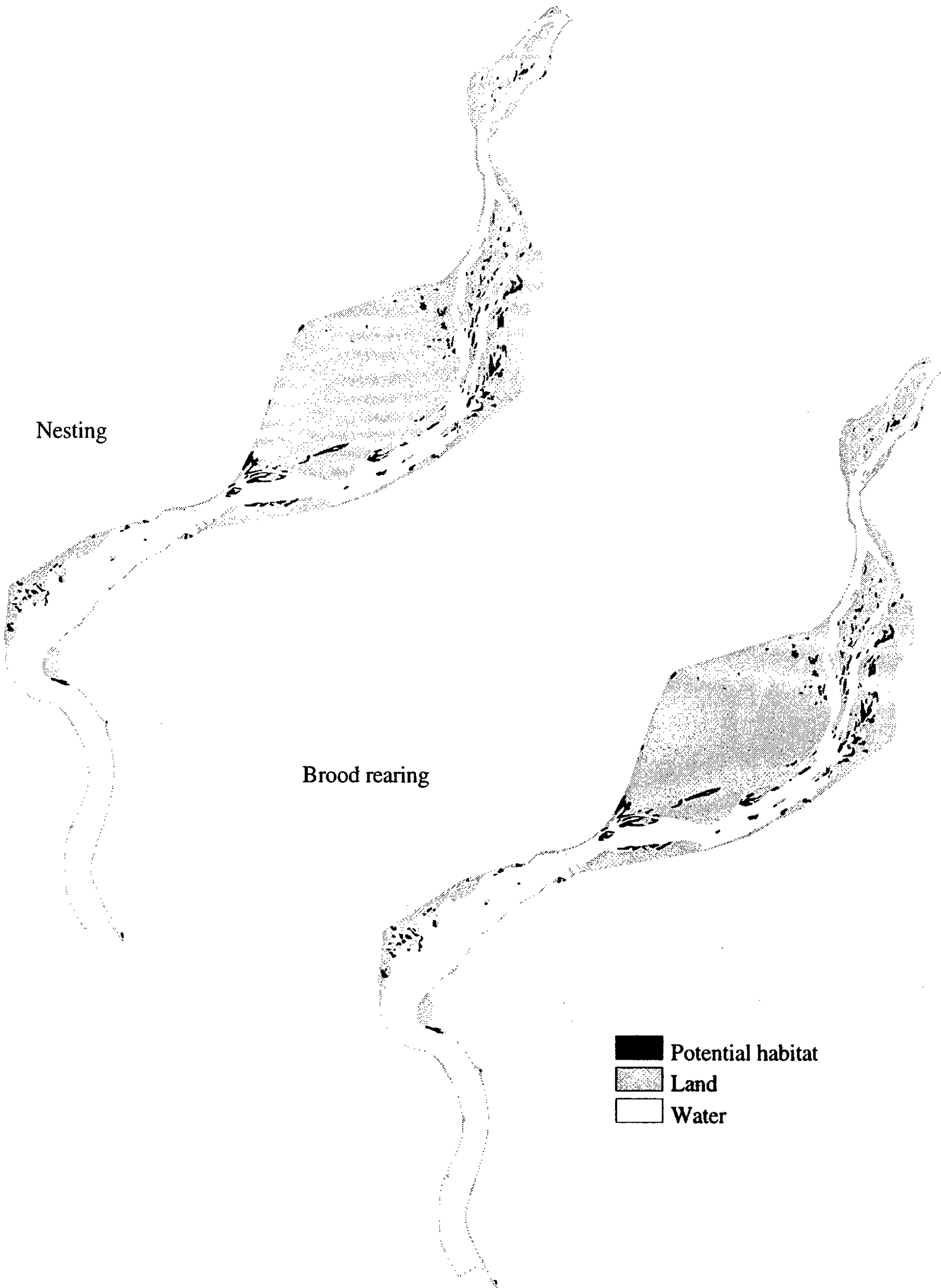


Figure E-9. Potential 1975 nesting and brood rearing habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 19.

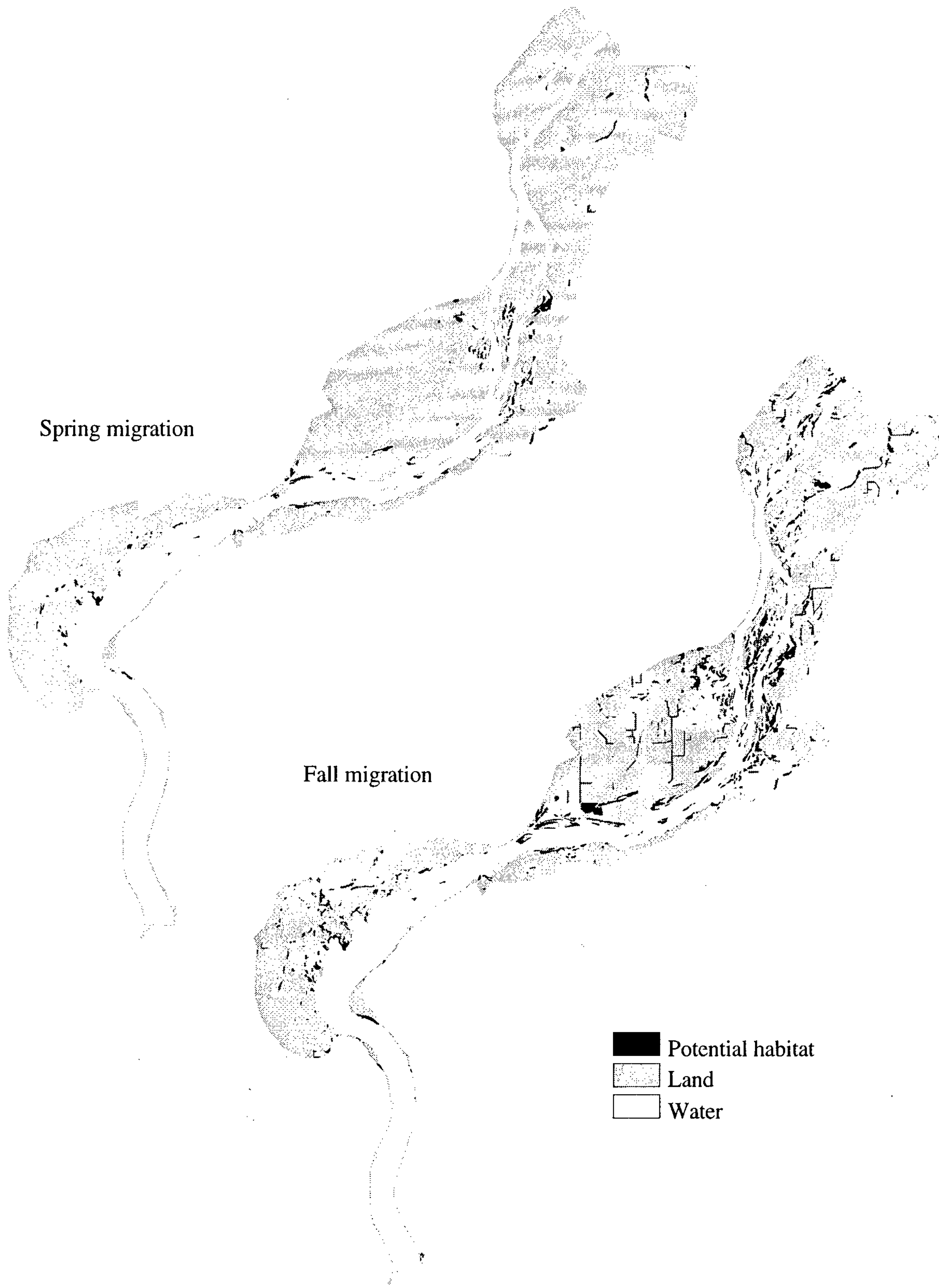


Figure E-10. Potential 1989 spring and fall migration habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 19.

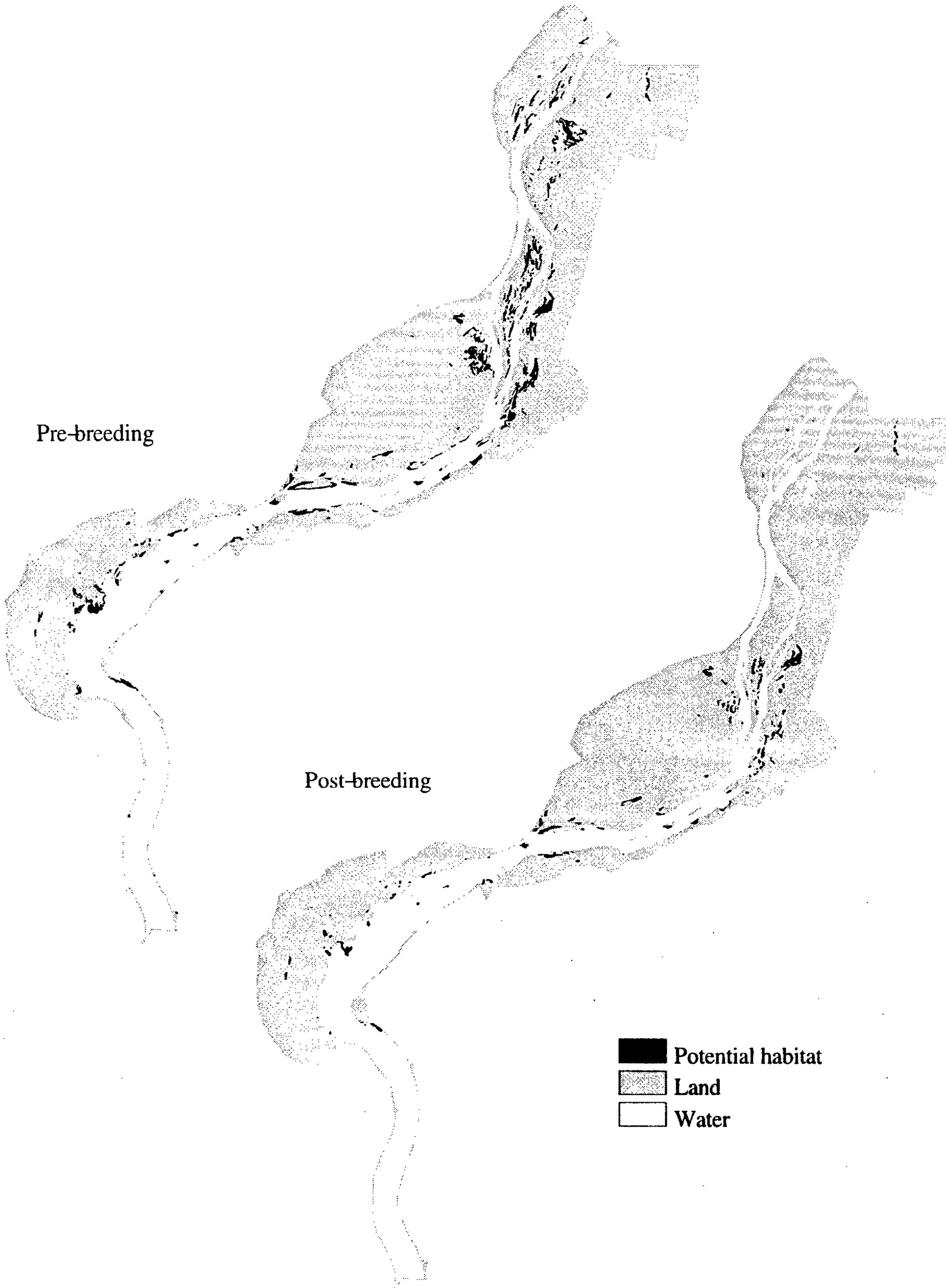


Figure E-11. Potential 1989 pre- and post-breeding habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 19.

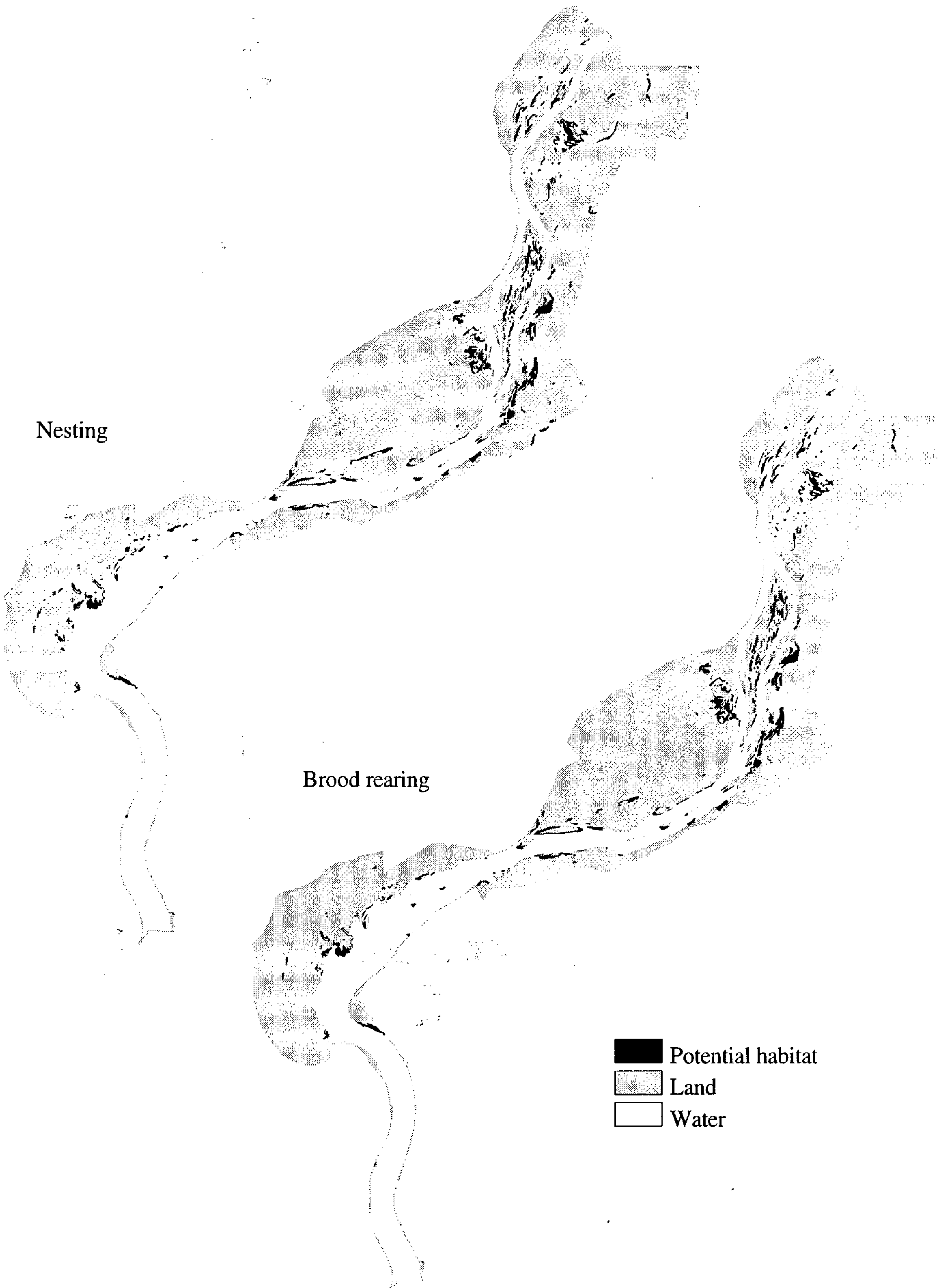


Figure E-12. Potential 1989 nesting and brood rearing habitat for the sora (*Porzana carolina*), Upper Mississippi River Pool 19.

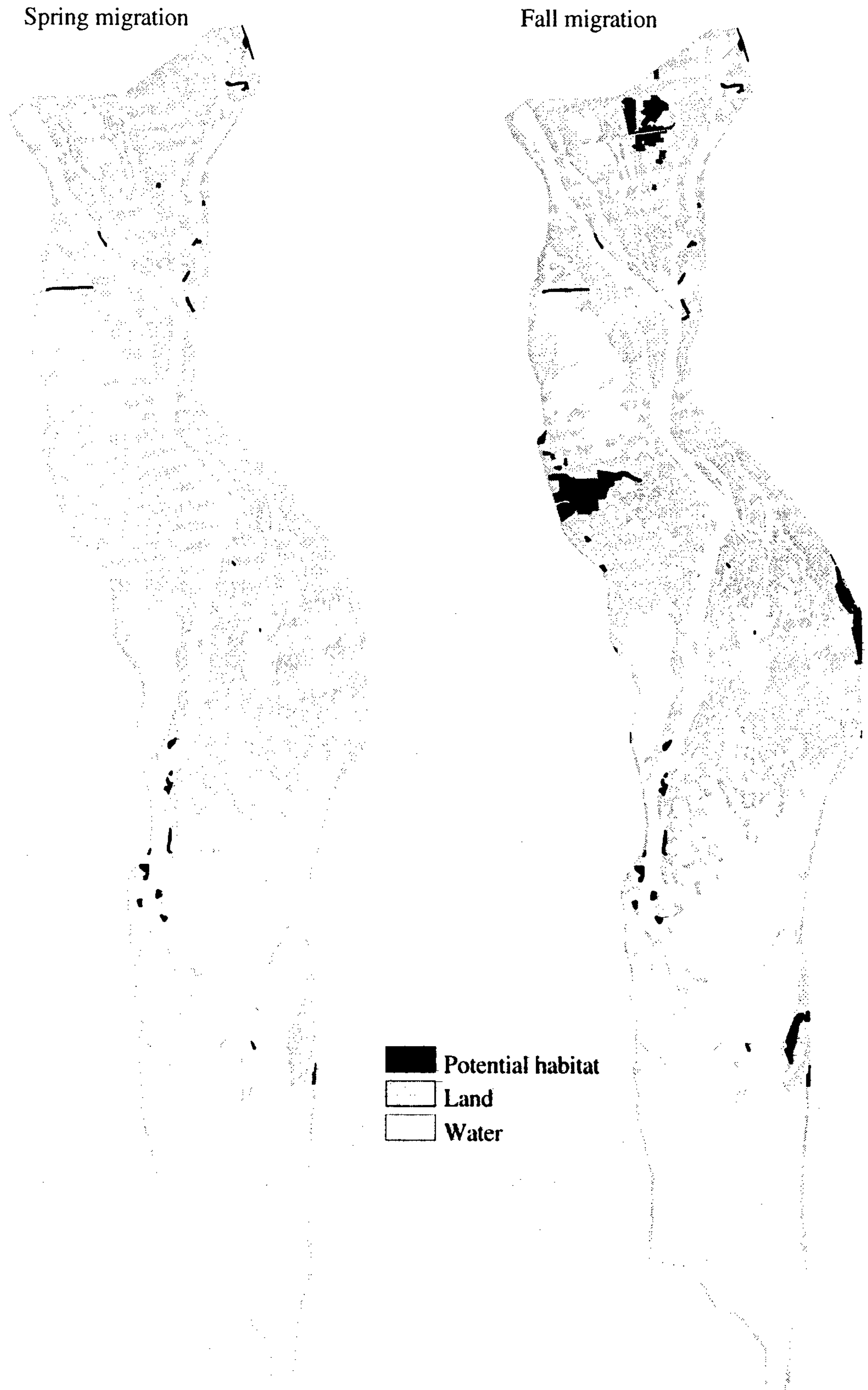


Figure E-13. Potential 1975 spring and fall migration habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 8.

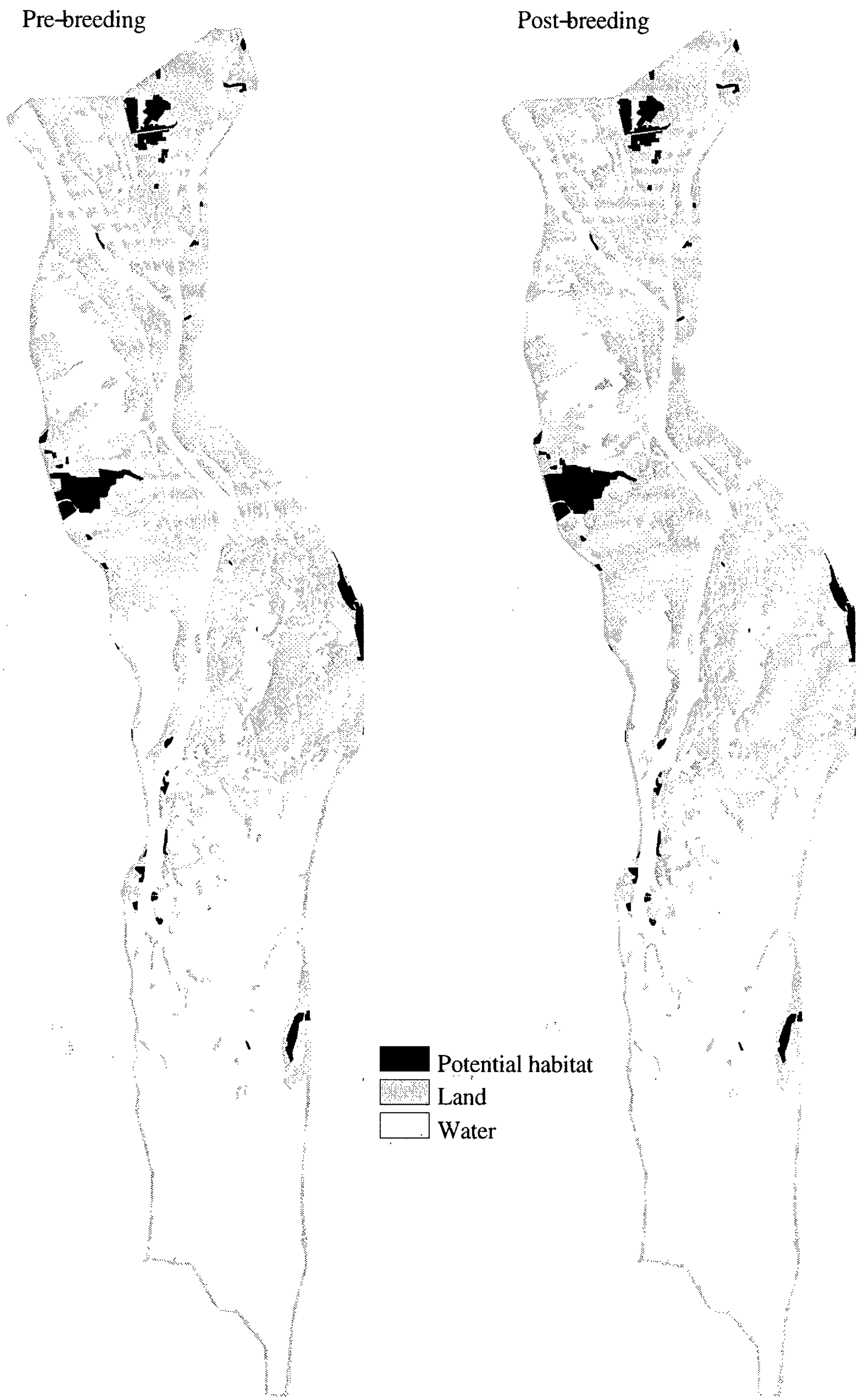


Figure E-14. Potential 1975 pre- and post-breeding habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 8.

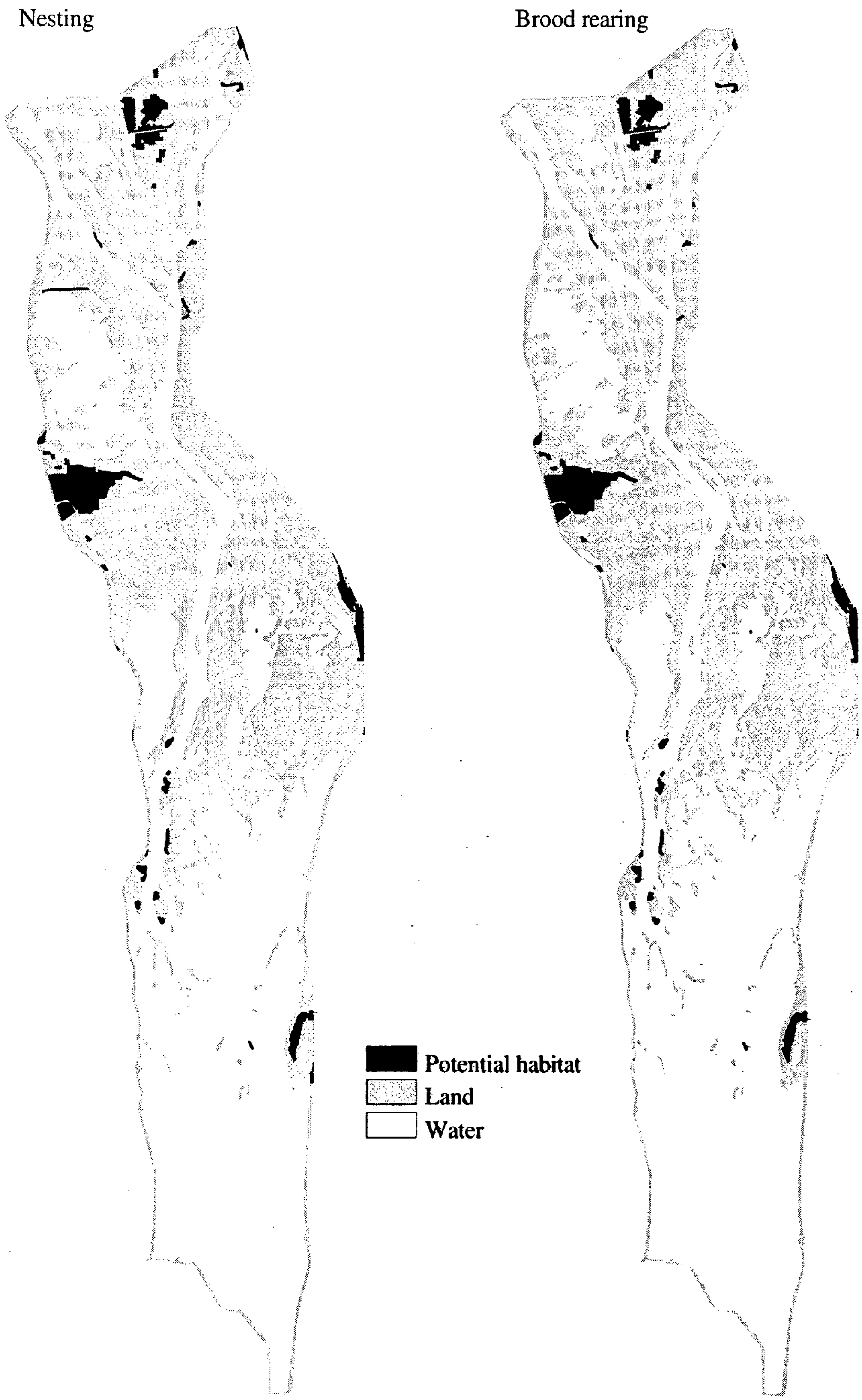


Figure E-15. Potential 1975 nesting and brood rearing habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 8.

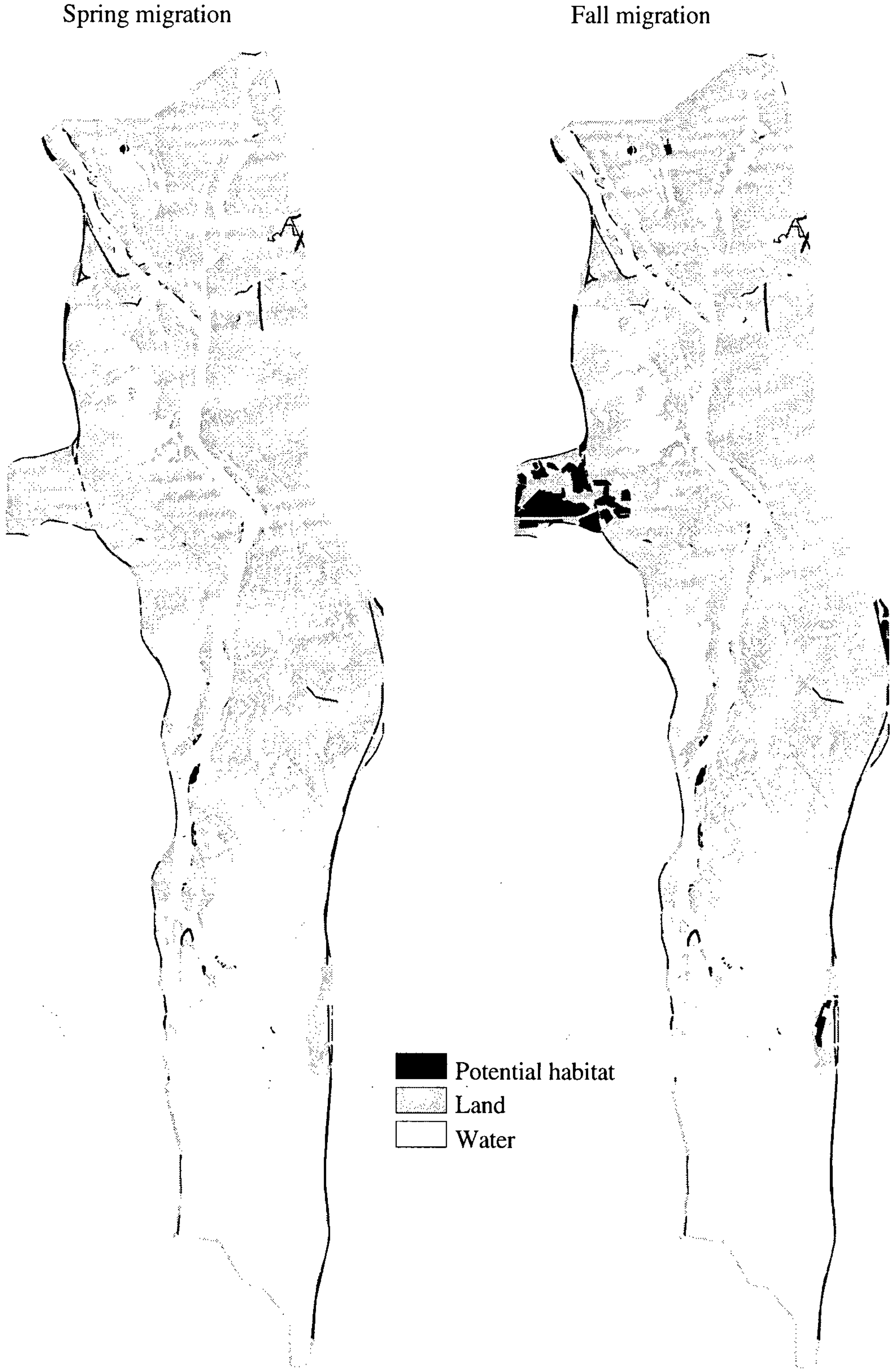


Figure E-16. Potential 1989 spring and fall migration habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 8.

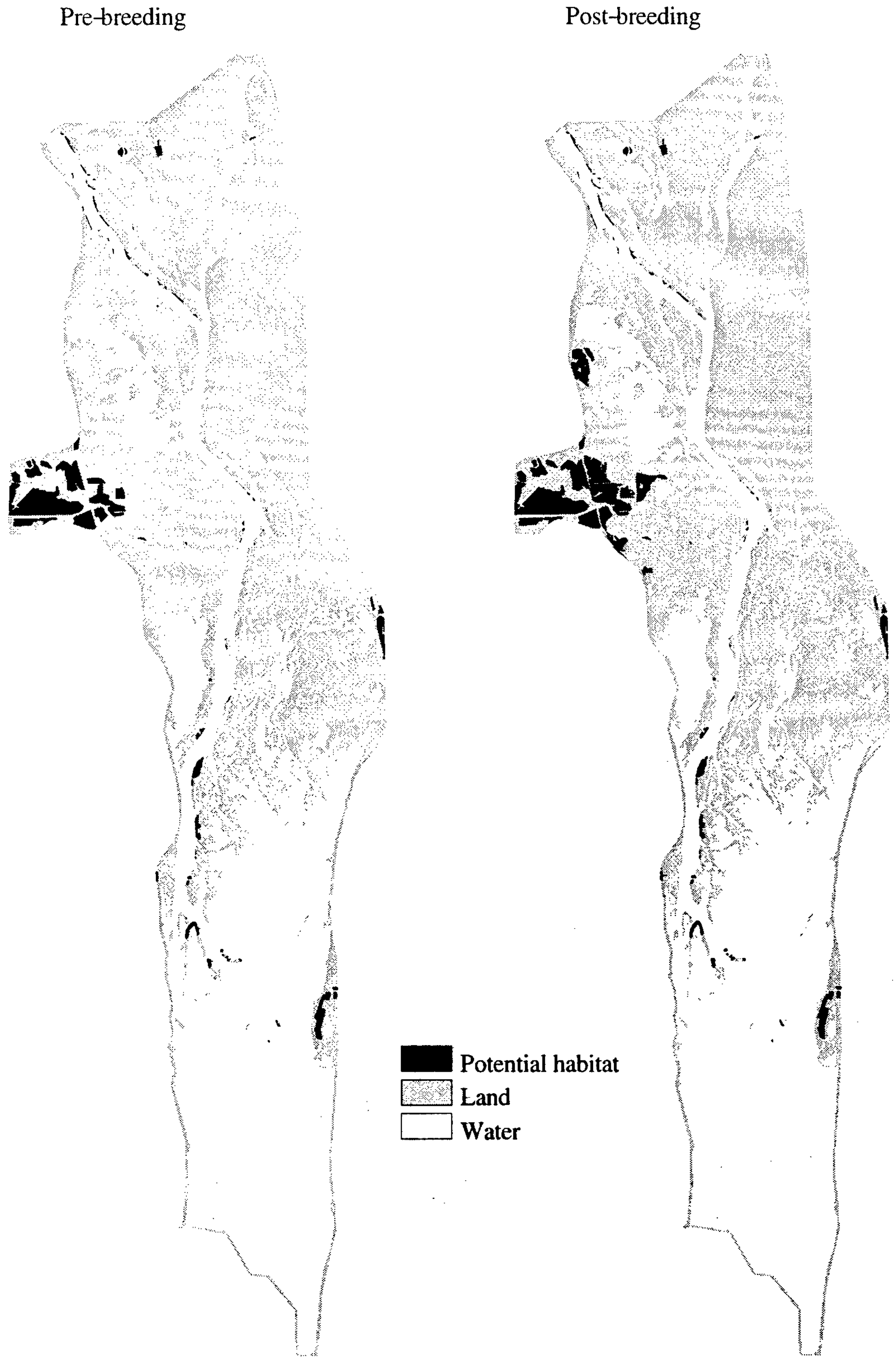


Figure E-17. Potential 1989 pre- and post-breeding habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 8.

Figure E-18. Potential 1989 nesting and brood rearing habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 8.

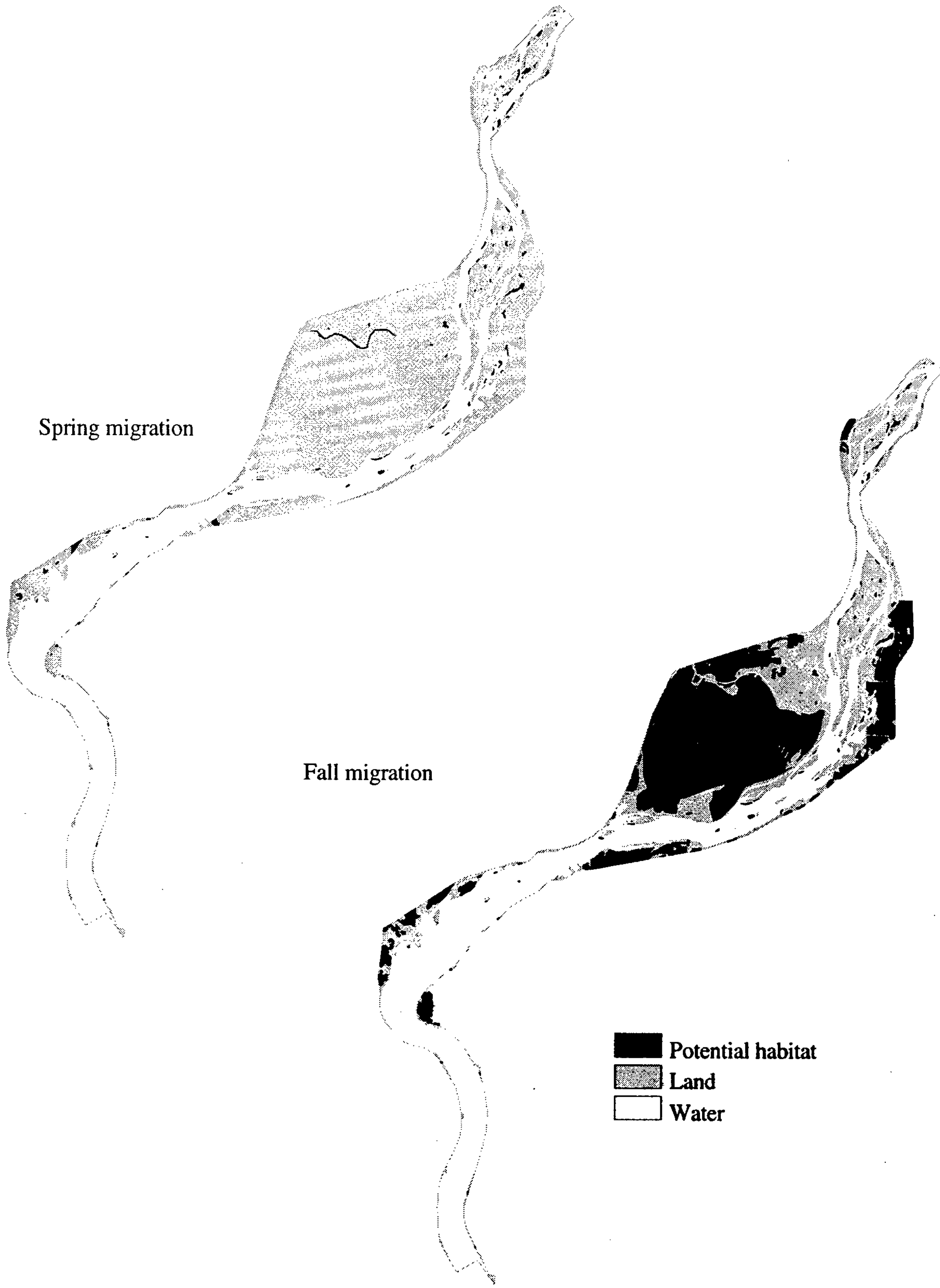


Figure E-19. Potential 1975 spring and fall migration habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 19.

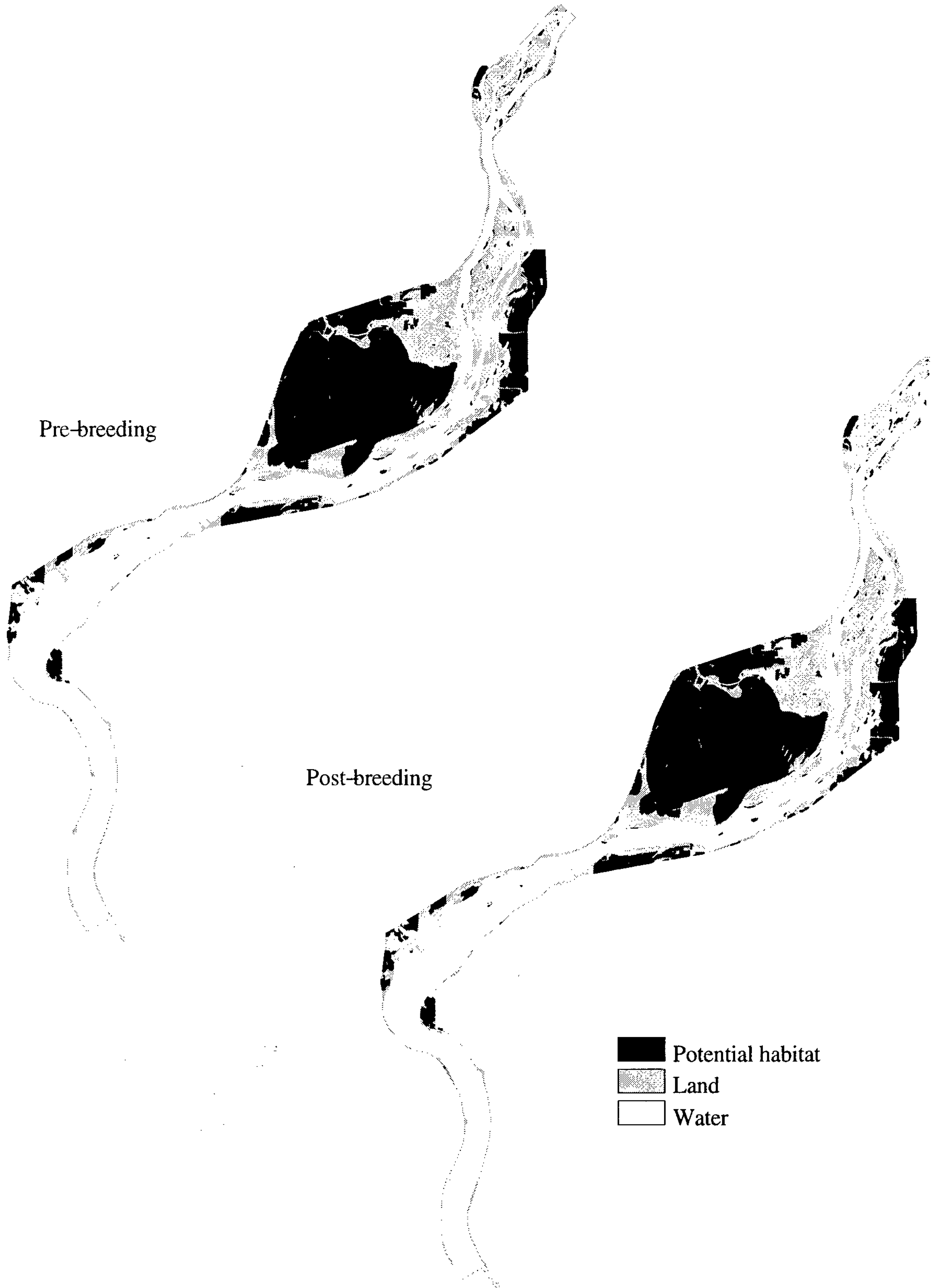


Figure E-20. Potential 1975 pre- and post-breeding habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 19.

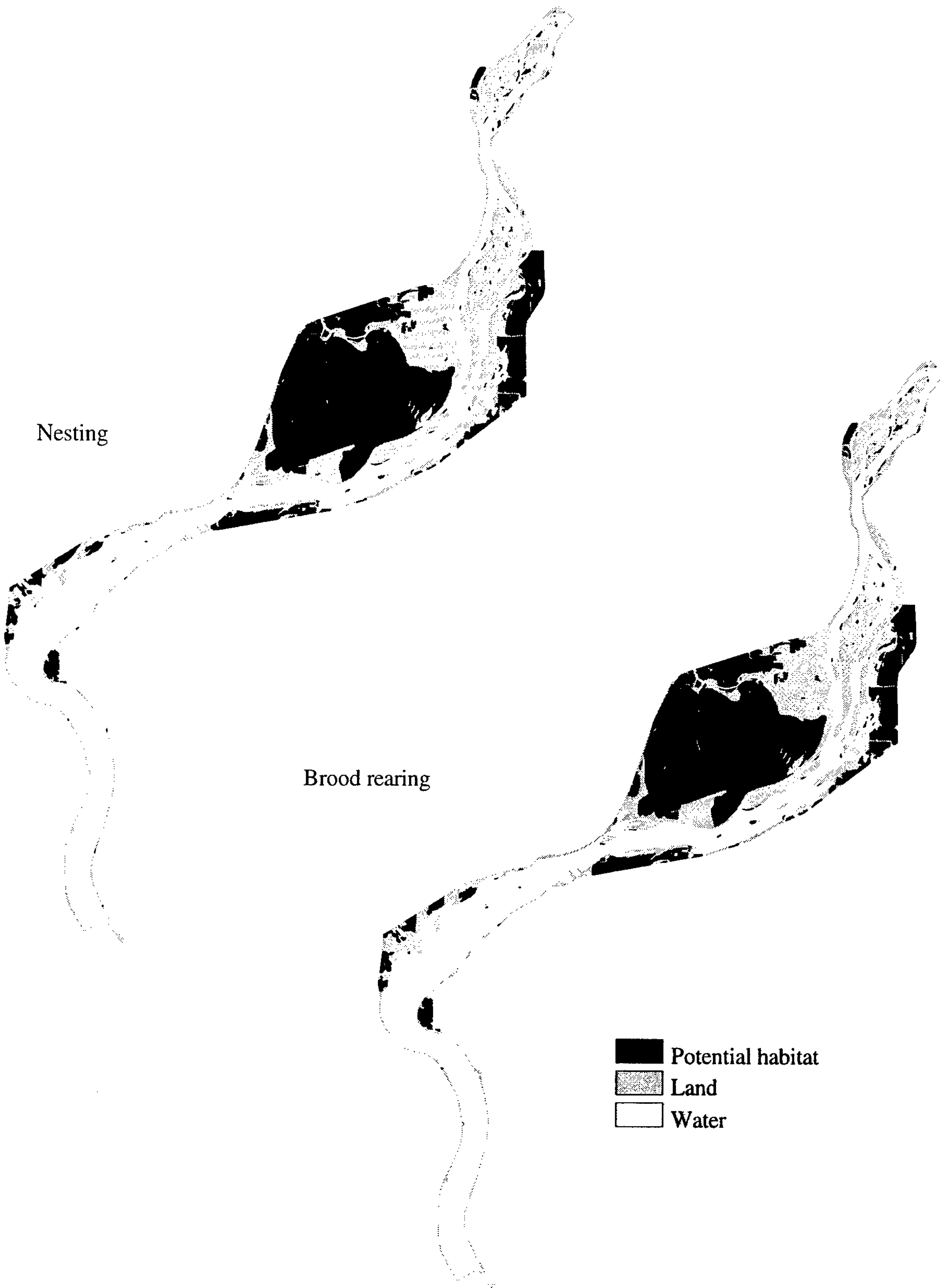


Figure E-21. Potential 1975 nesting and brood rearing habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 19.

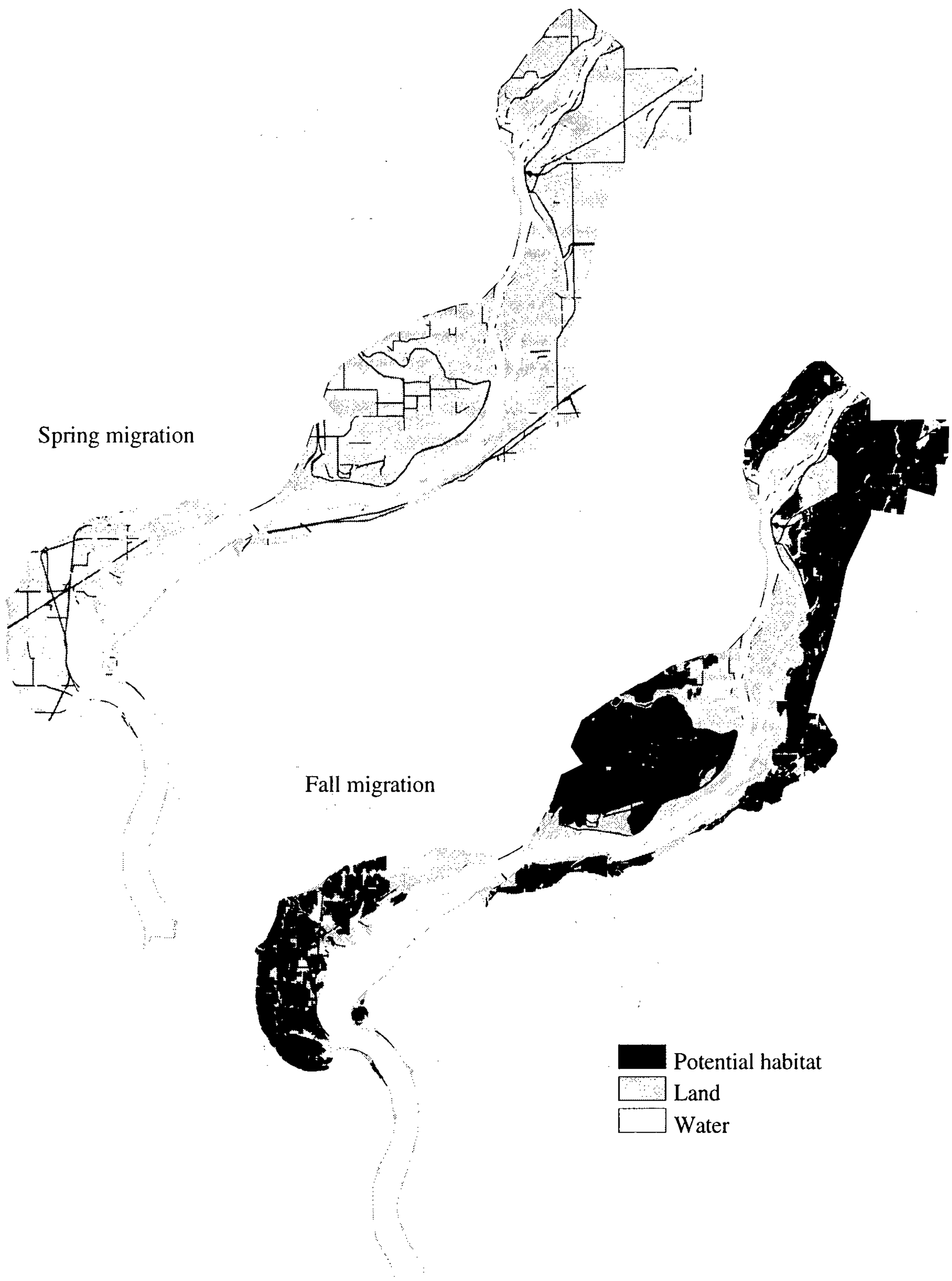


Figure E-22. Potential 1989 spring and fall migration habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 19.

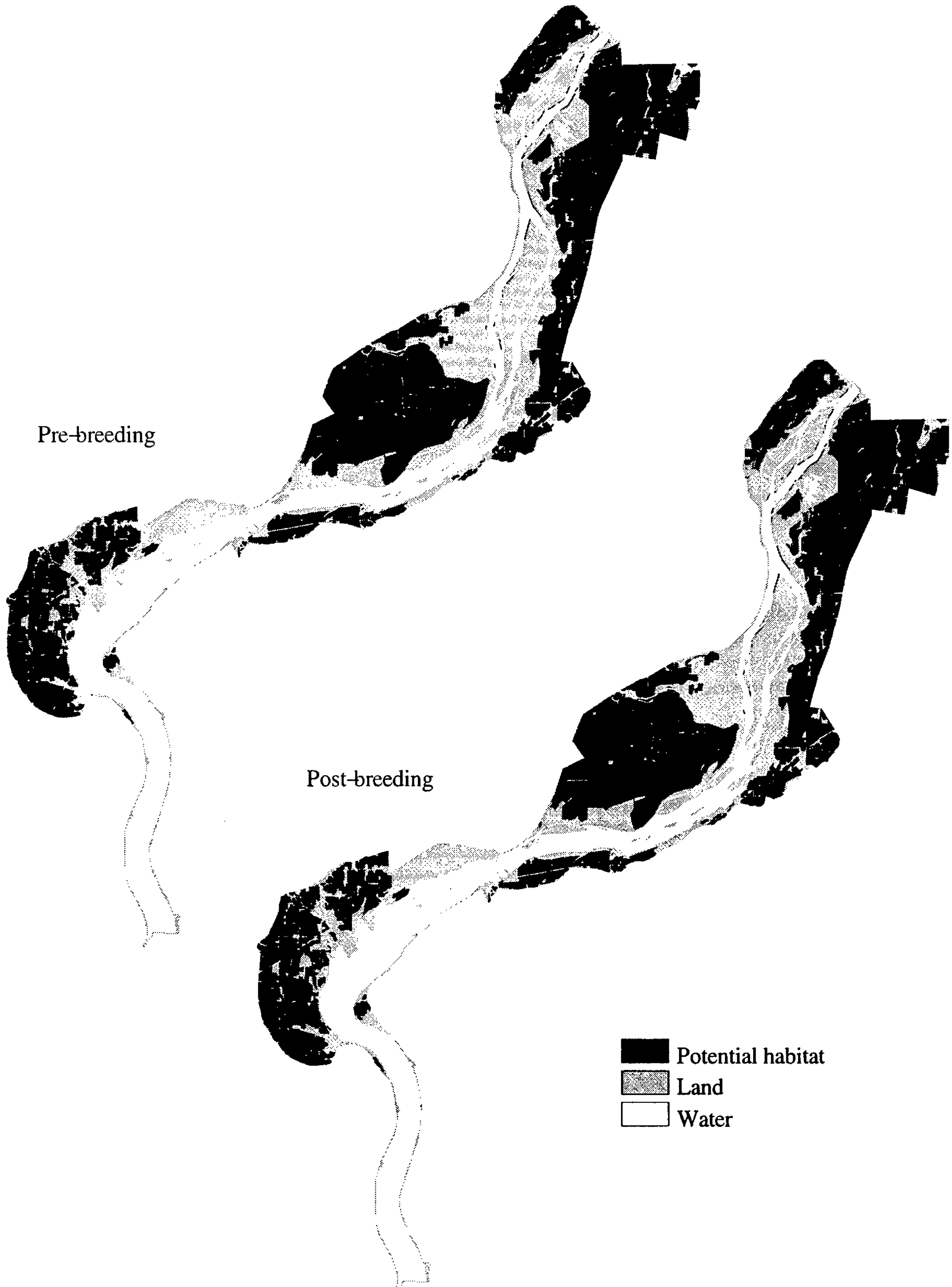


Figure E-23. Potential 1989 pre- and post-breeding habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 19.

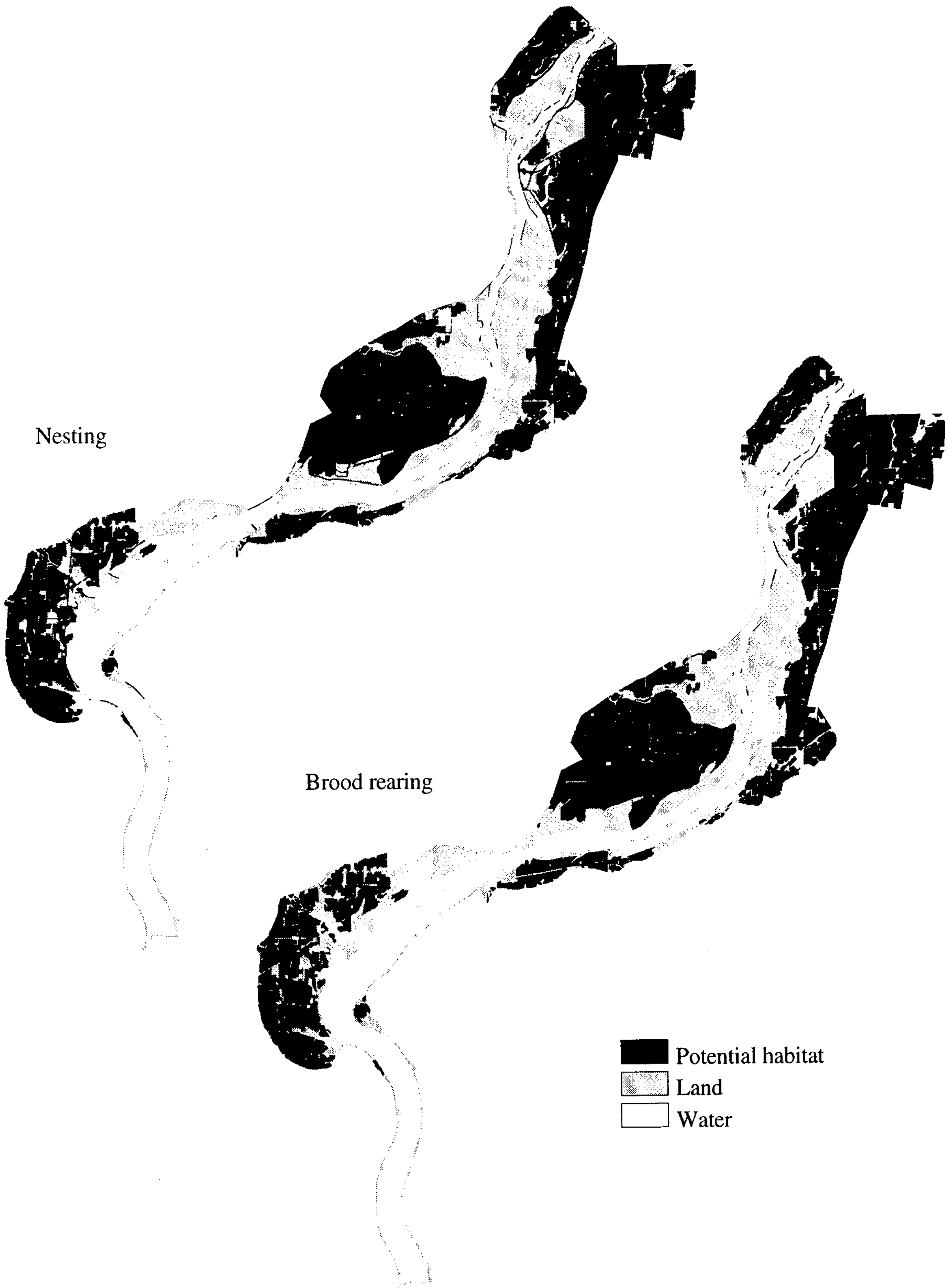


Figure E-24. Potential 1989 nesting and brood rearing habitat for the spotted sandpiper (*Actitis macularia*), Upper Mississippi River Pool 19.

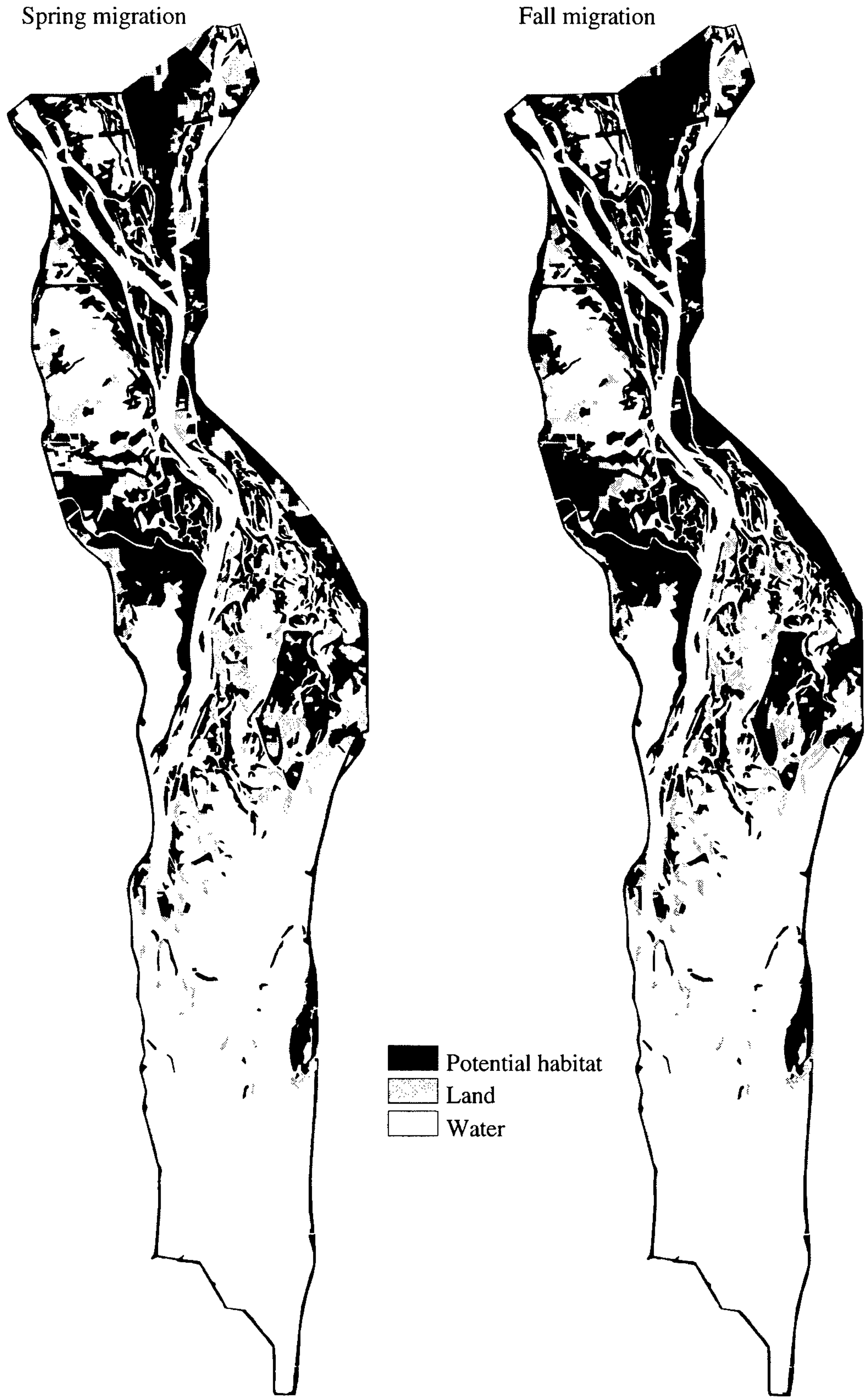


Figure E-25. Potential 1975 spring and fall migration habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 8.

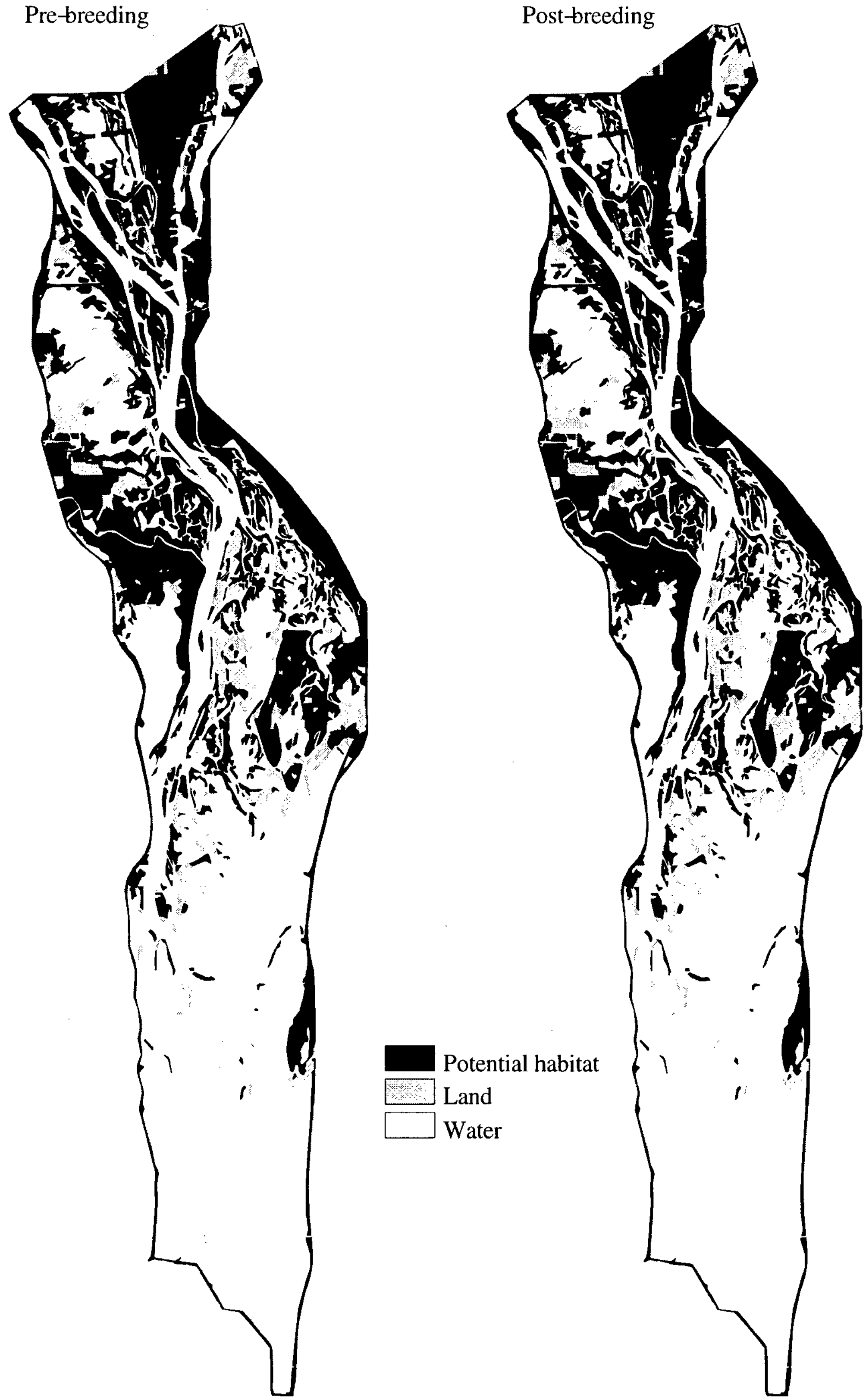


Figure E-26. Potential 1975 pre- and post-breeding habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 8.

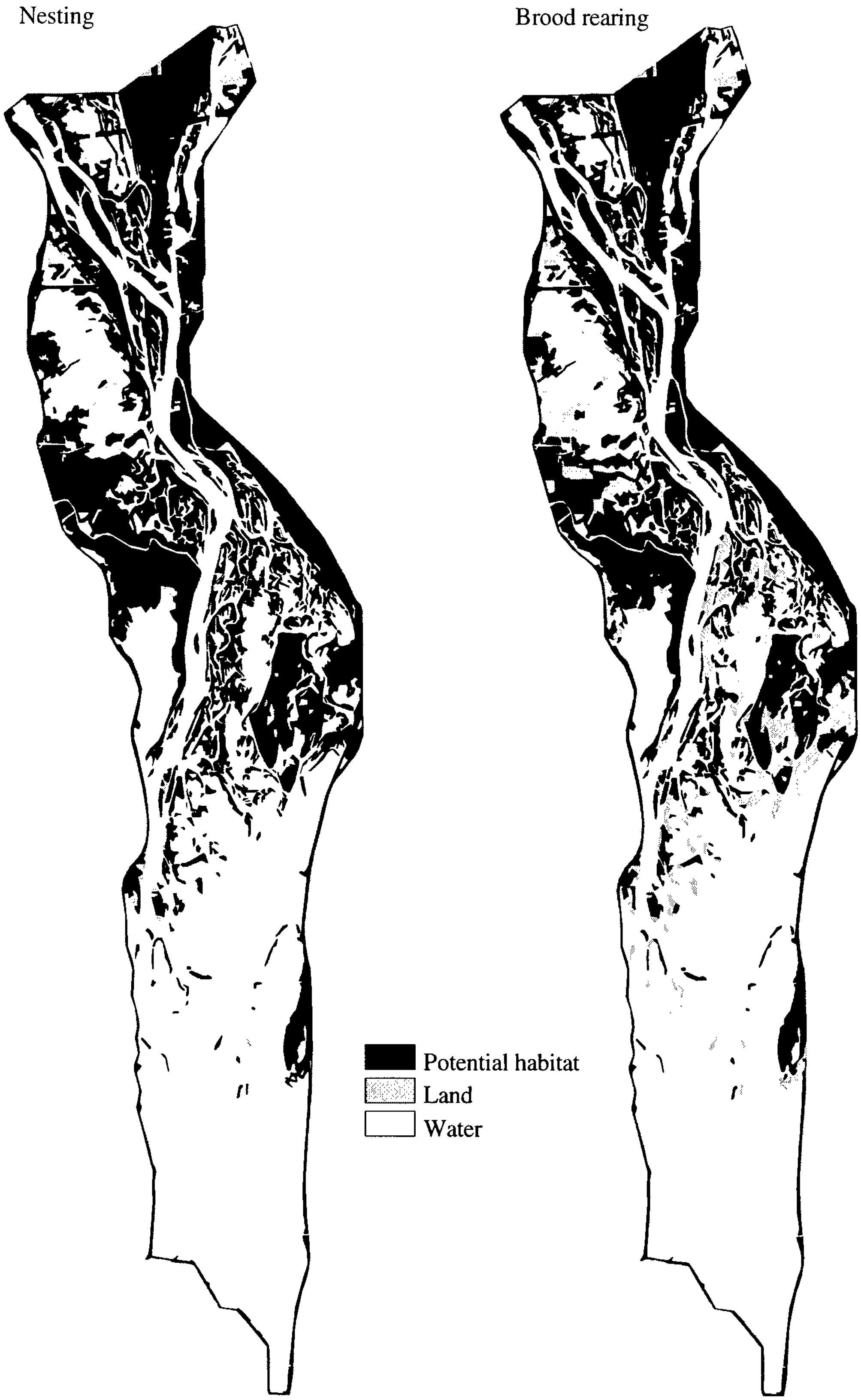


Figure E-27. Potential 1975 nesting and brood rearing habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 8.

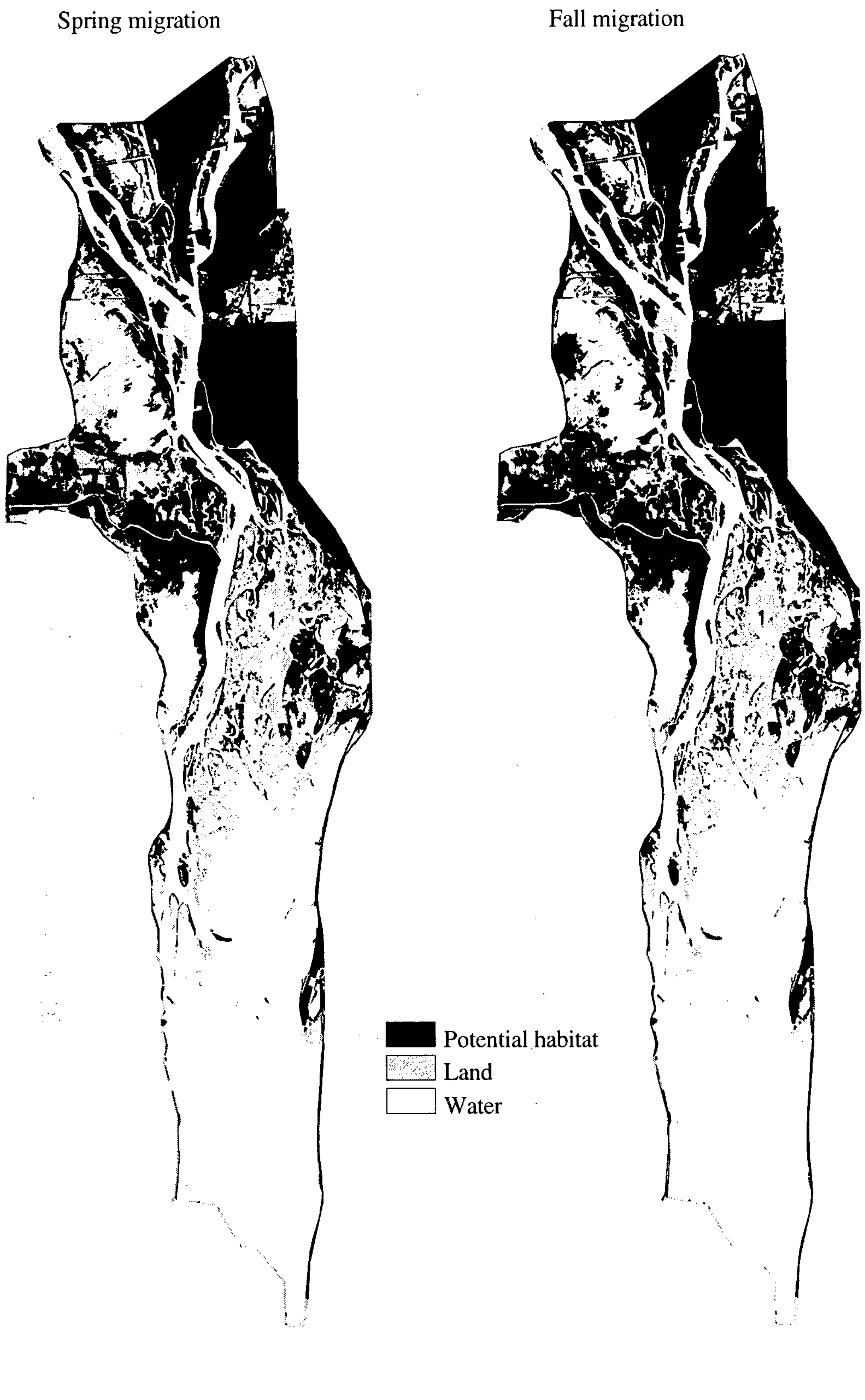


Figure E-28. Potential 1989 spring and fall migration habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 8.

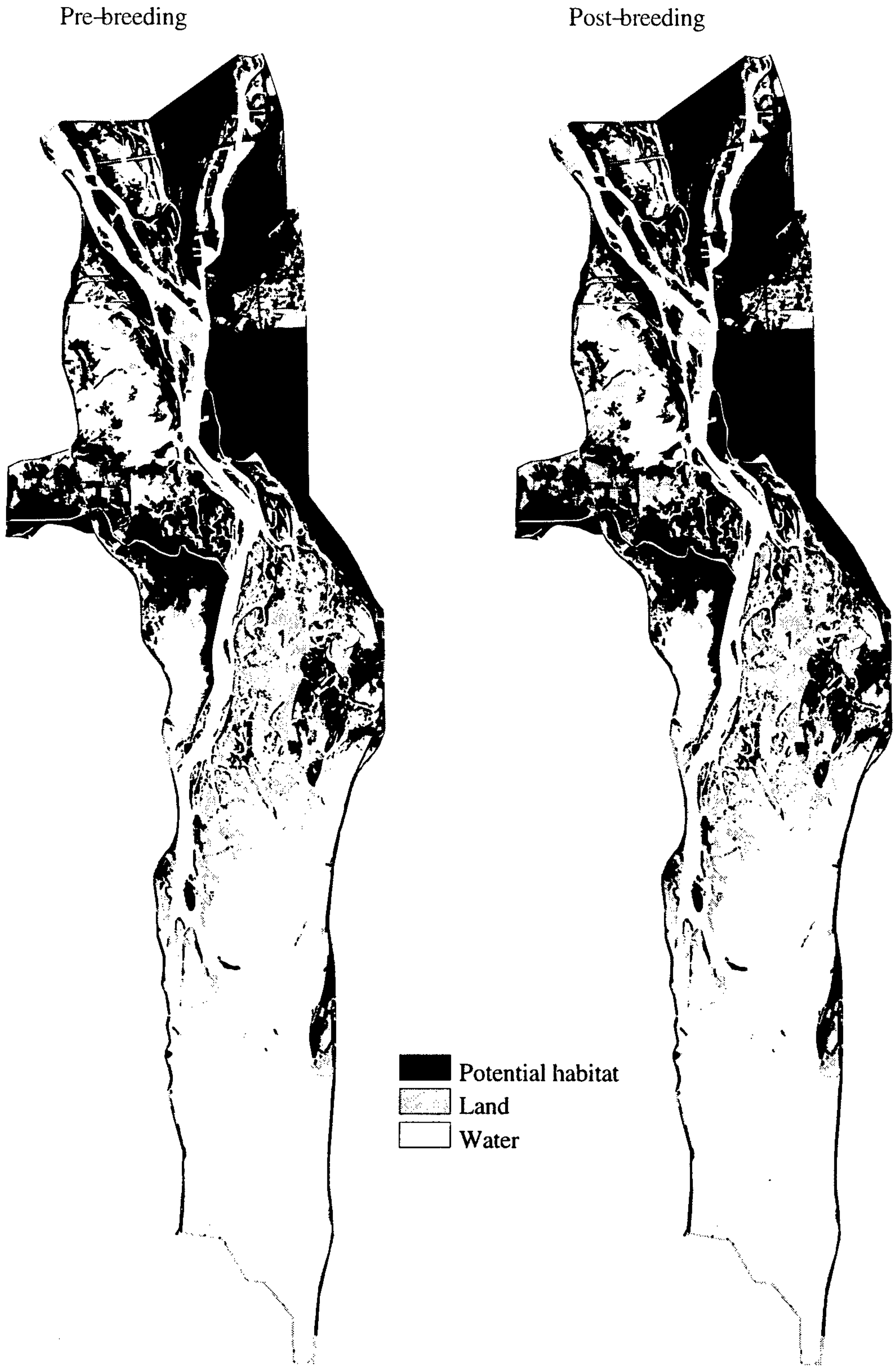


Figure E-29. Potential 1989 pre- and post-breeding habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 8.

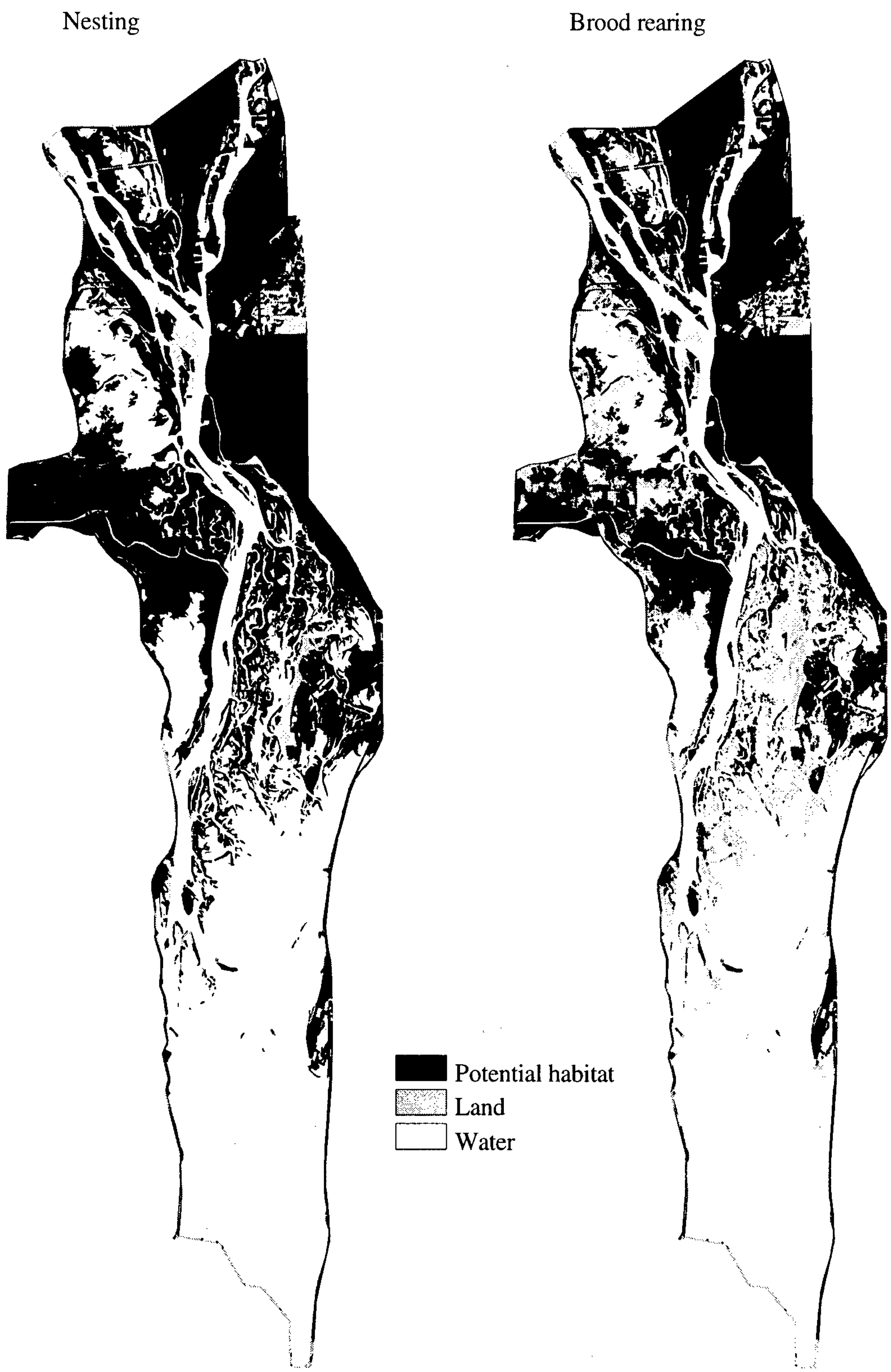


Figure E-30. Potential 1989 nesting and brood rearing habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 8.

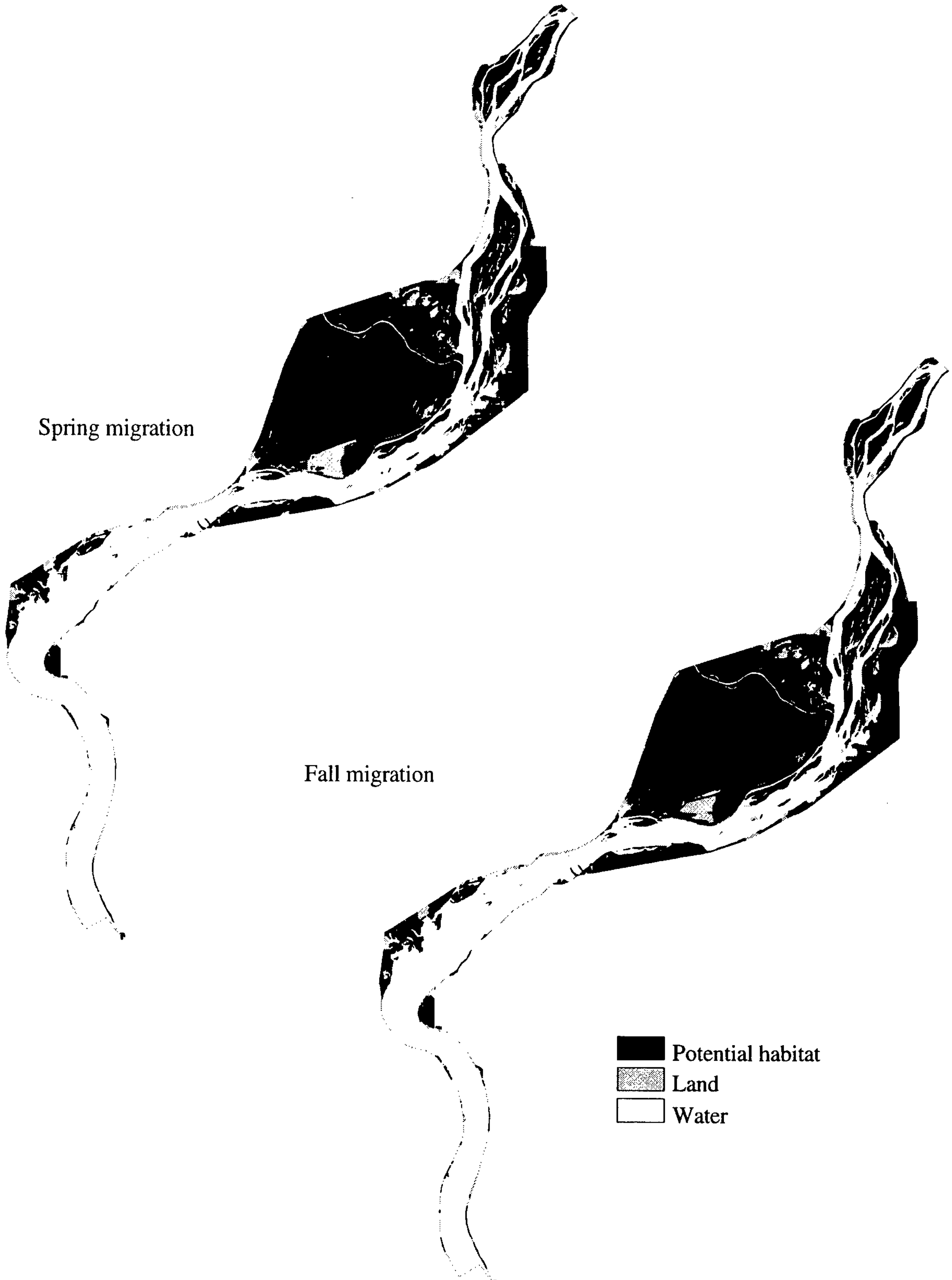


Figure E-31. Potential 1975 spring and fall migration habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 19.

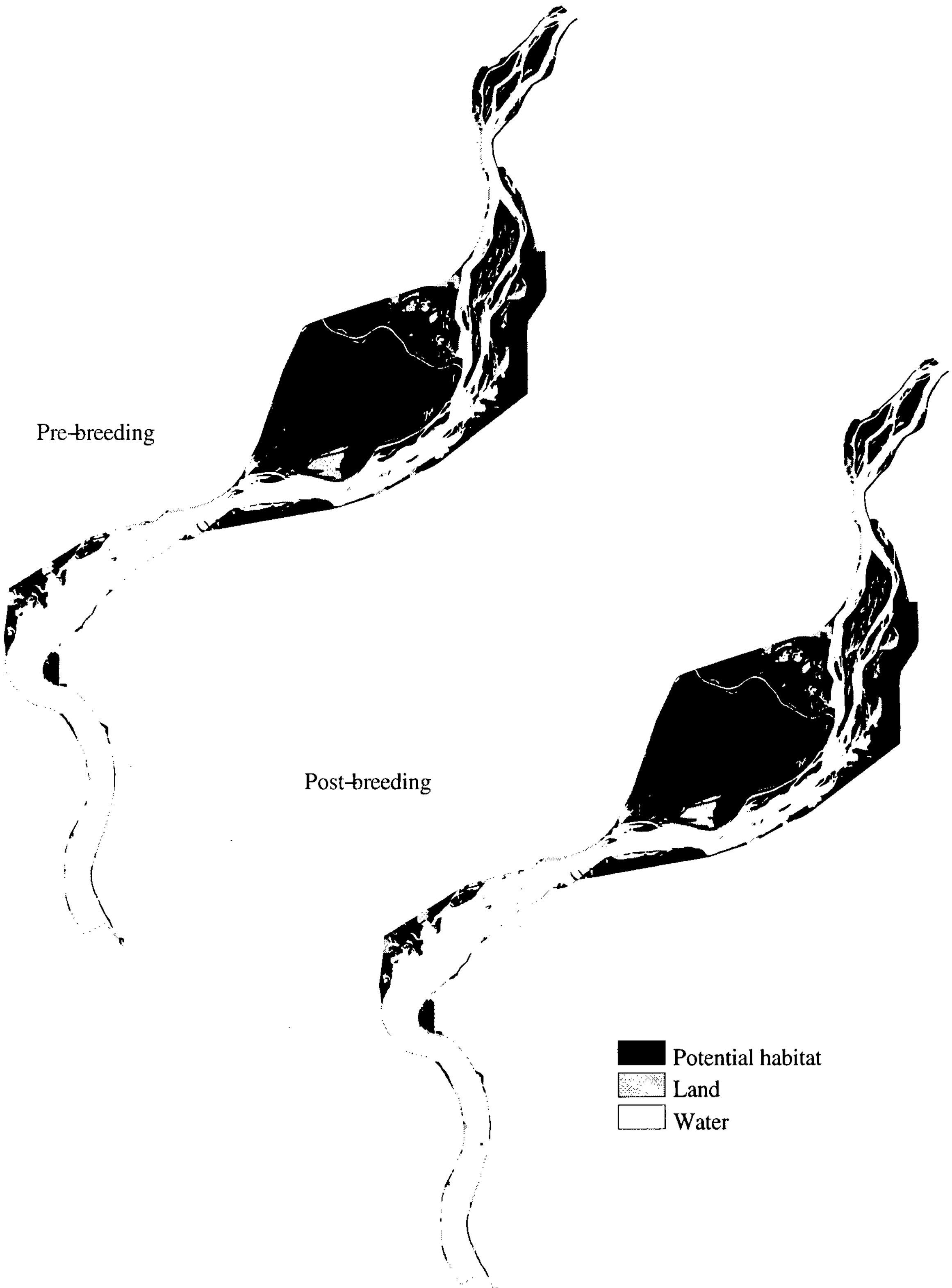


Figure E-32. Potential 1975 pre- and post-breeding habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 19.

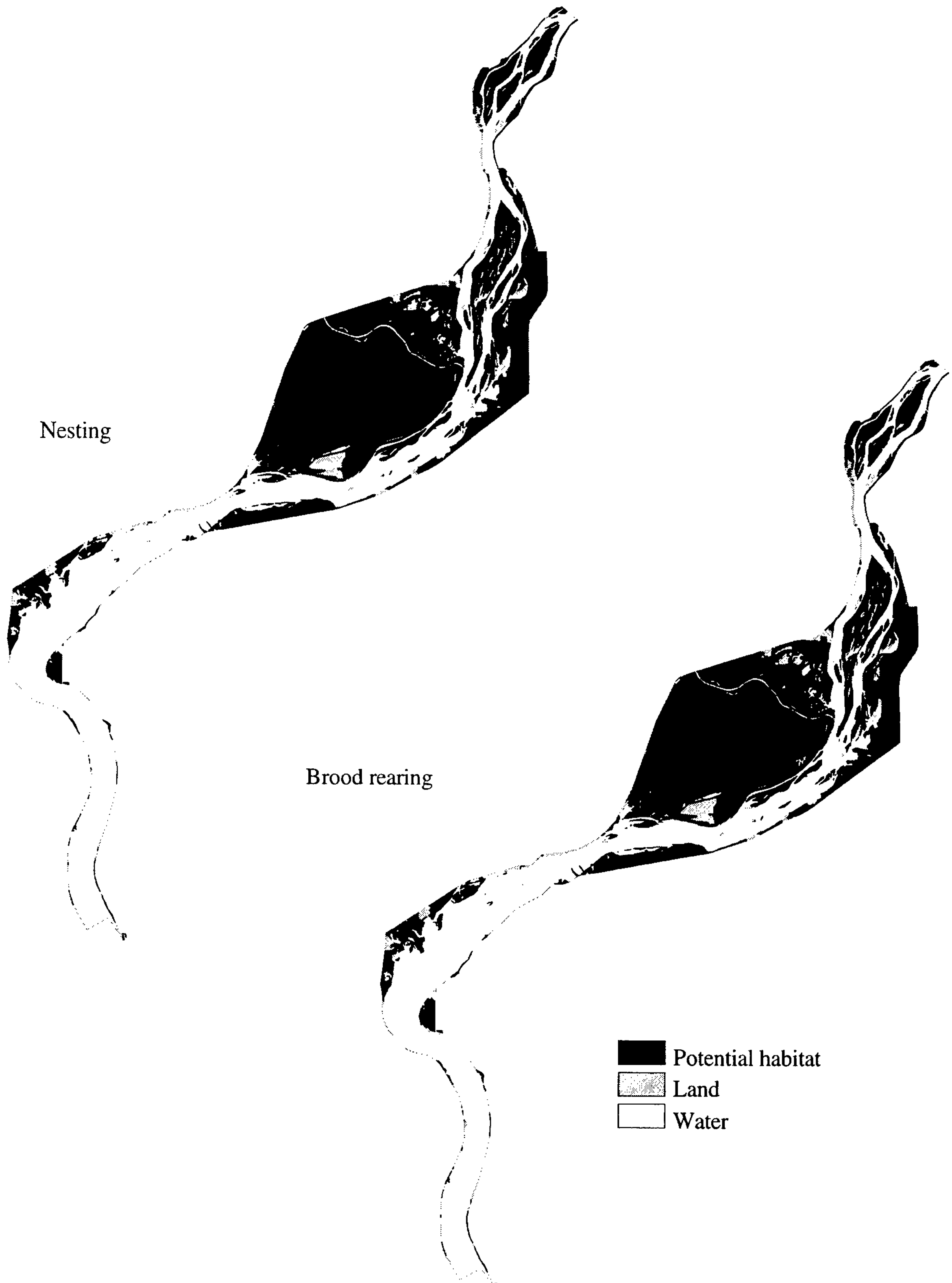


Figure E-33. Potential 1975 nesting and brood rearing habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 19.

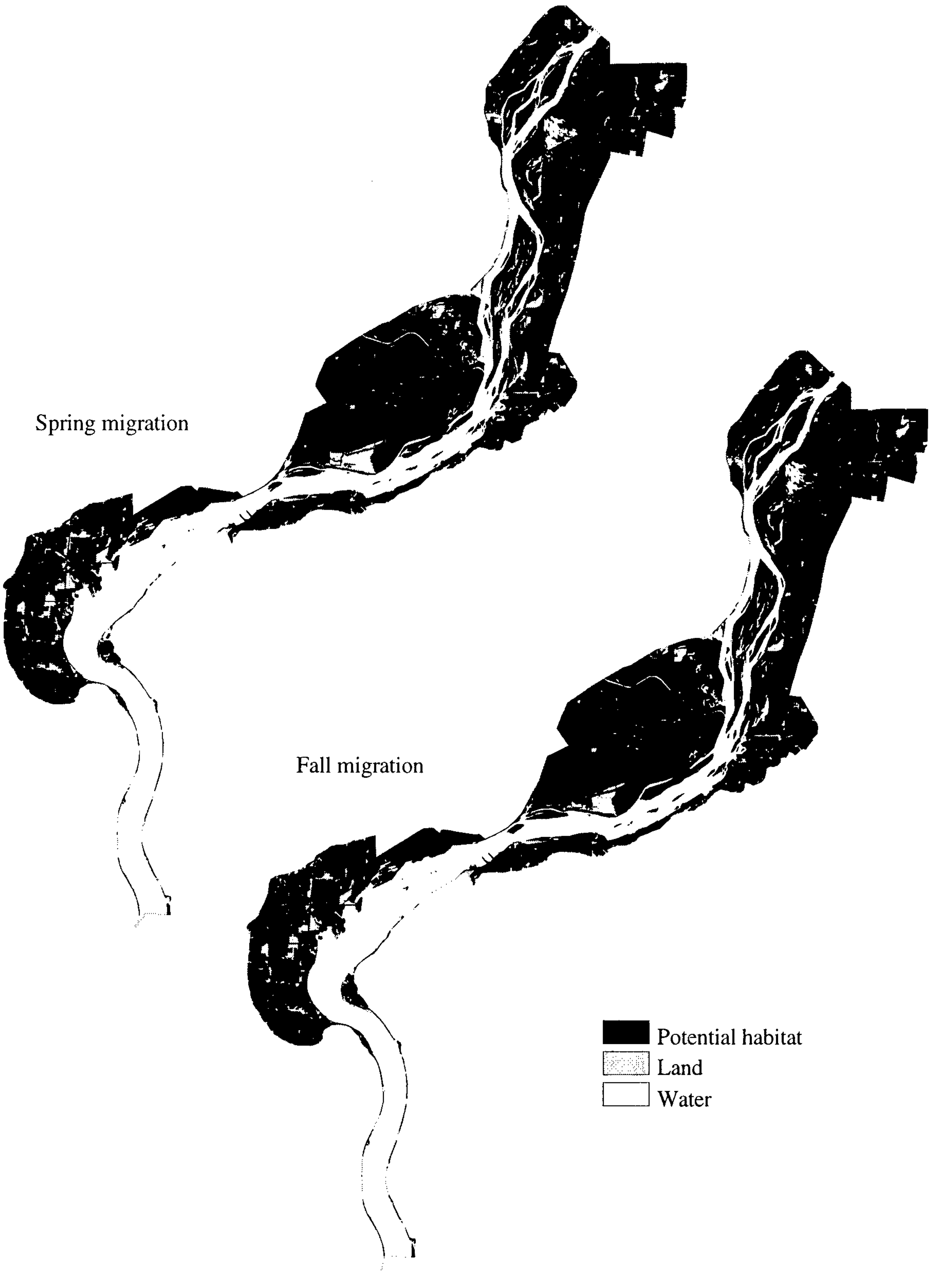


Figure E-34. Potential 1989 spring and fall migration habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 19.

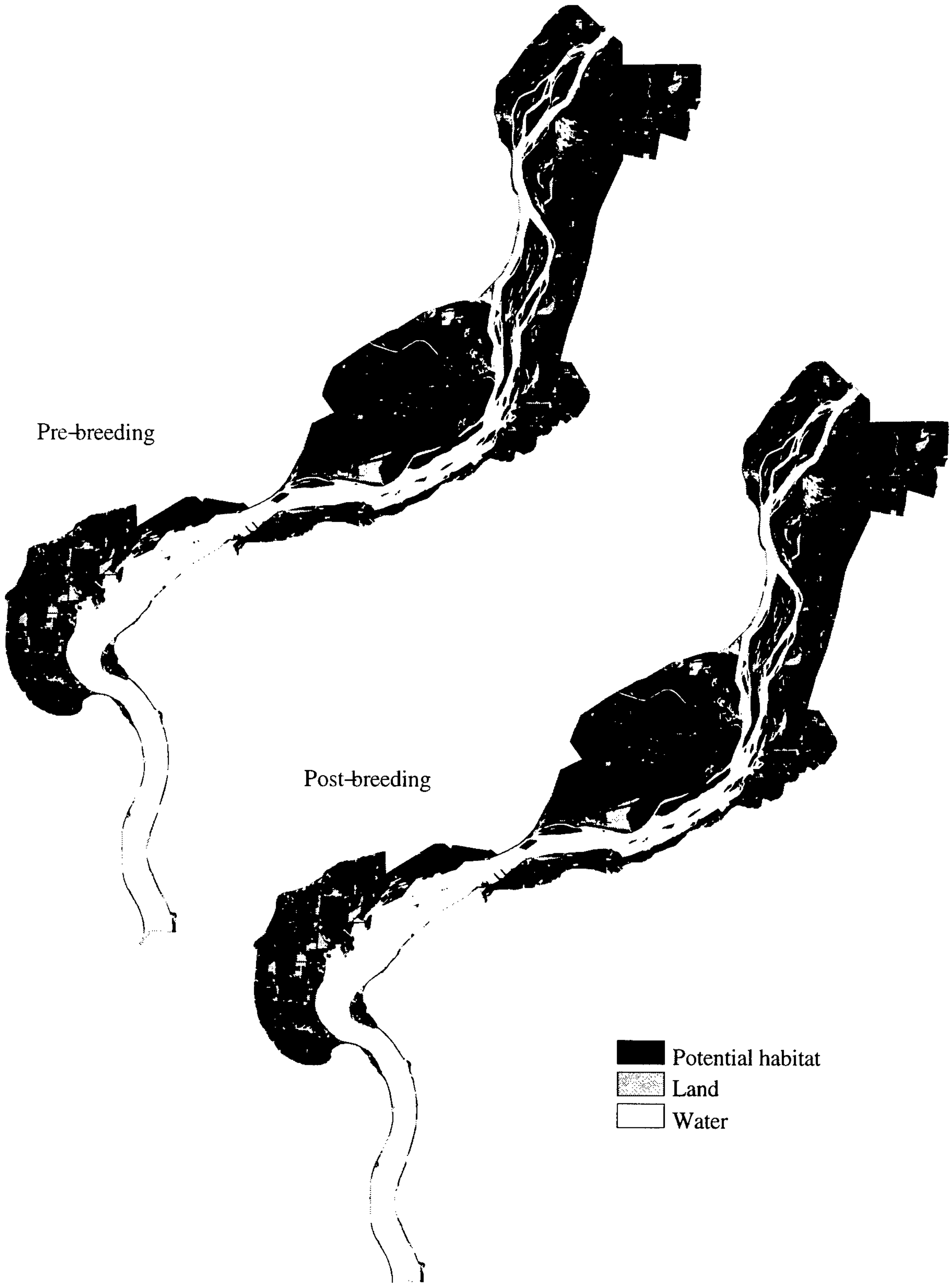


Figure E-35. Potential 1989 pre- and post-breeding habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 19.

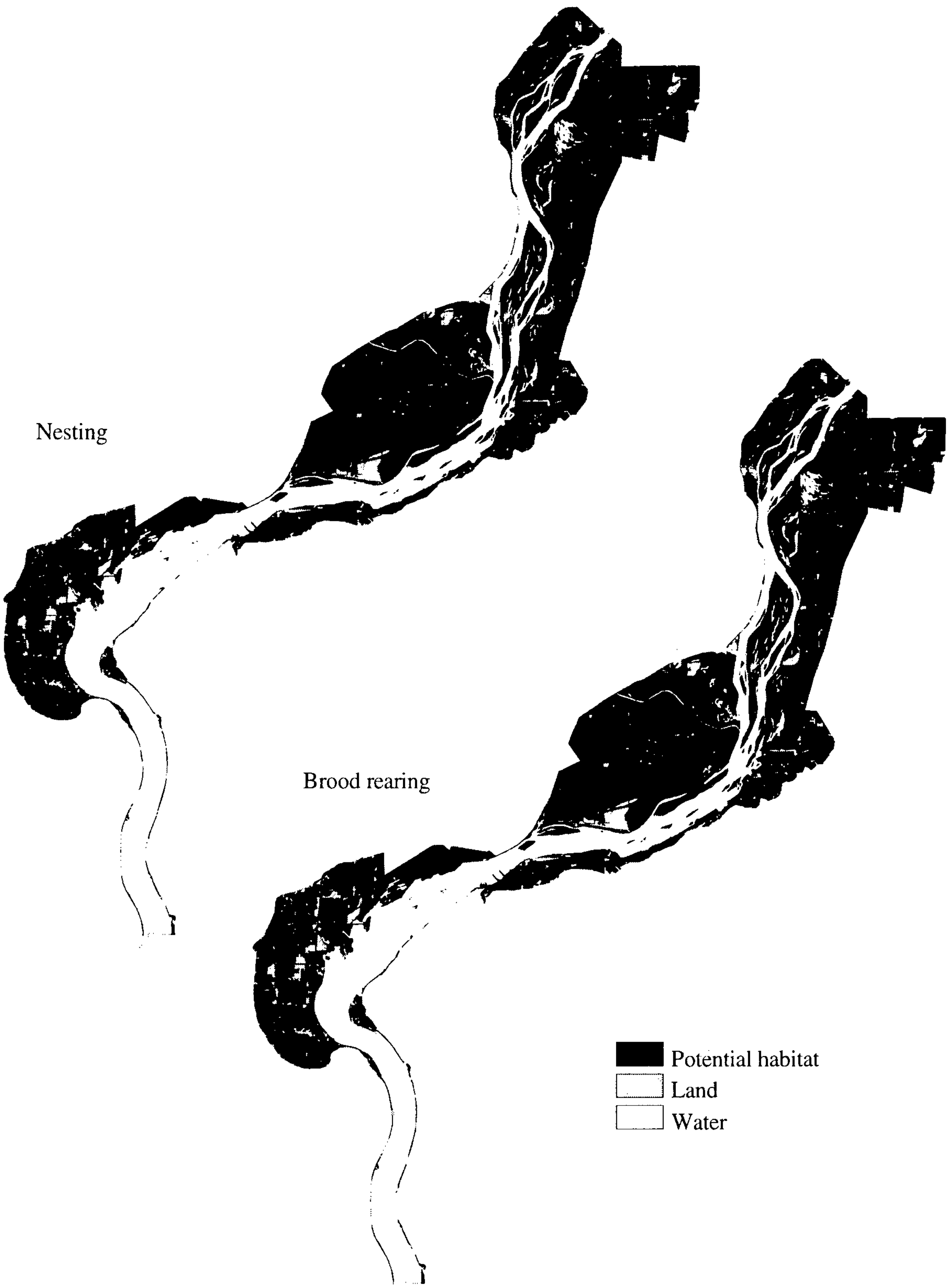


Figure E-36. Potential 1989 nesting and brood rearing habitat for the brown-headed cowbird (*Molothrus ater*), Upper Mississippi River Pool 19.

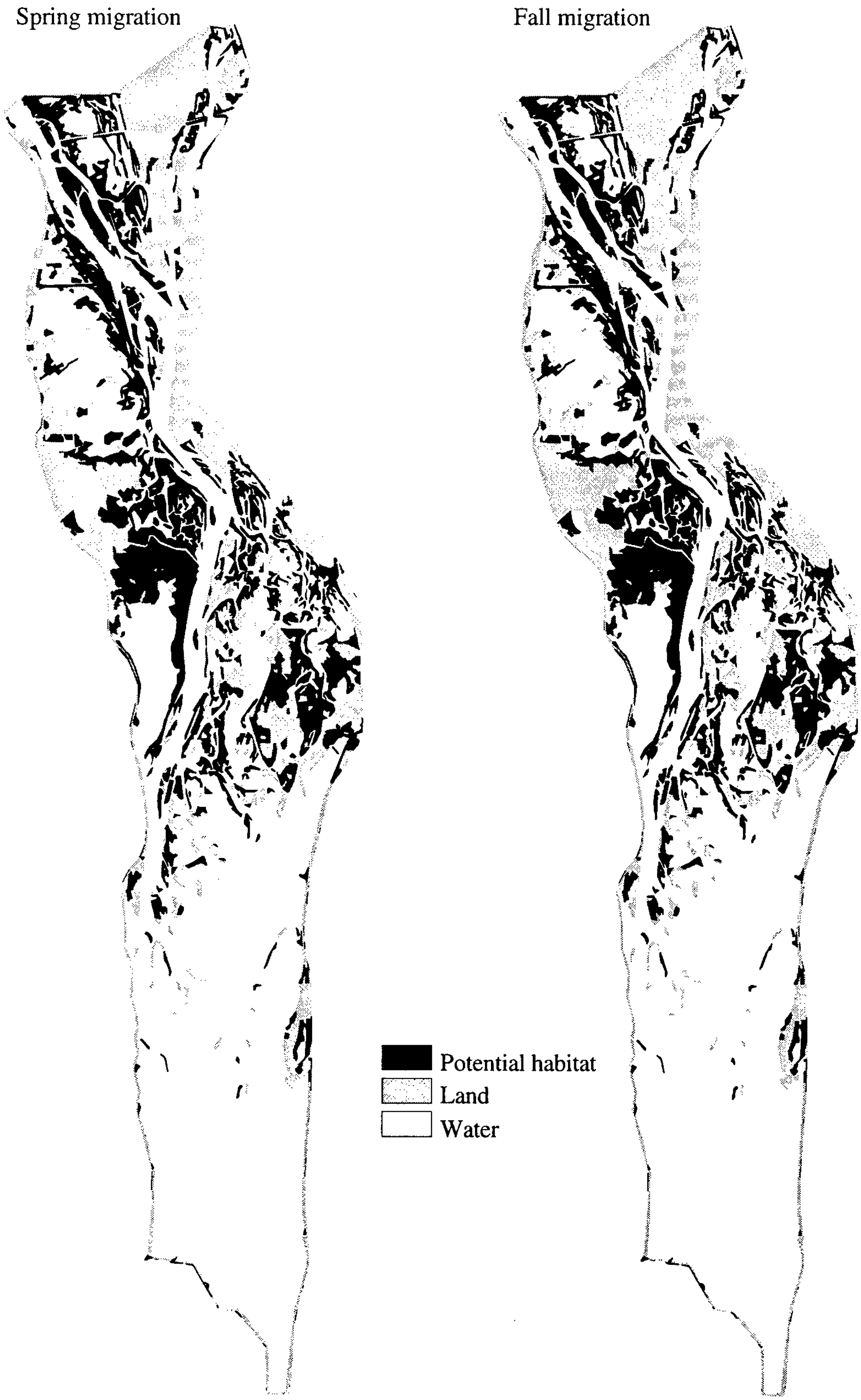


Figure E-37. Potential 1975 spring and fall migration habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 8.

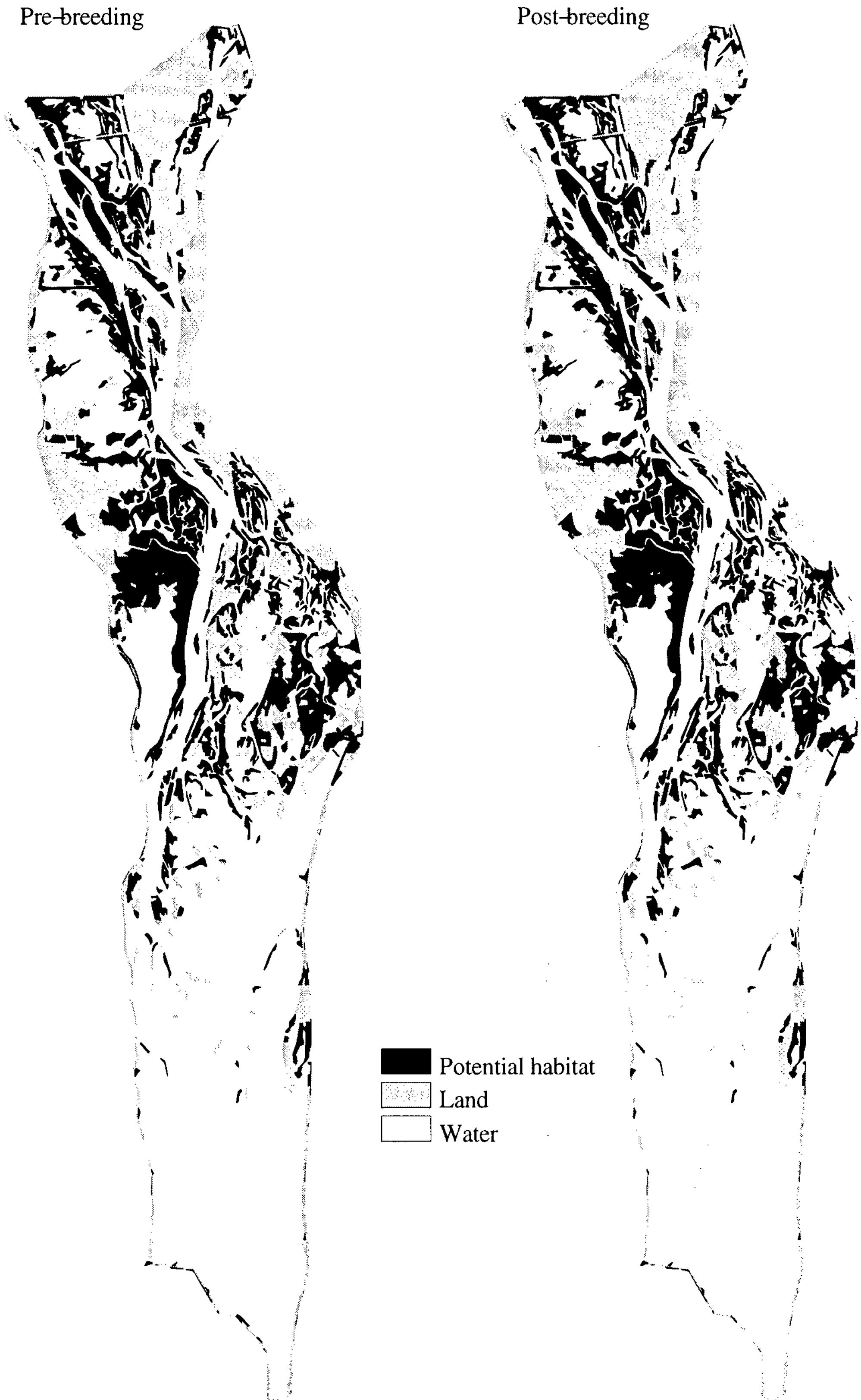


Figure E-38. Potential 1975 pre- and post-breeding habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 8.

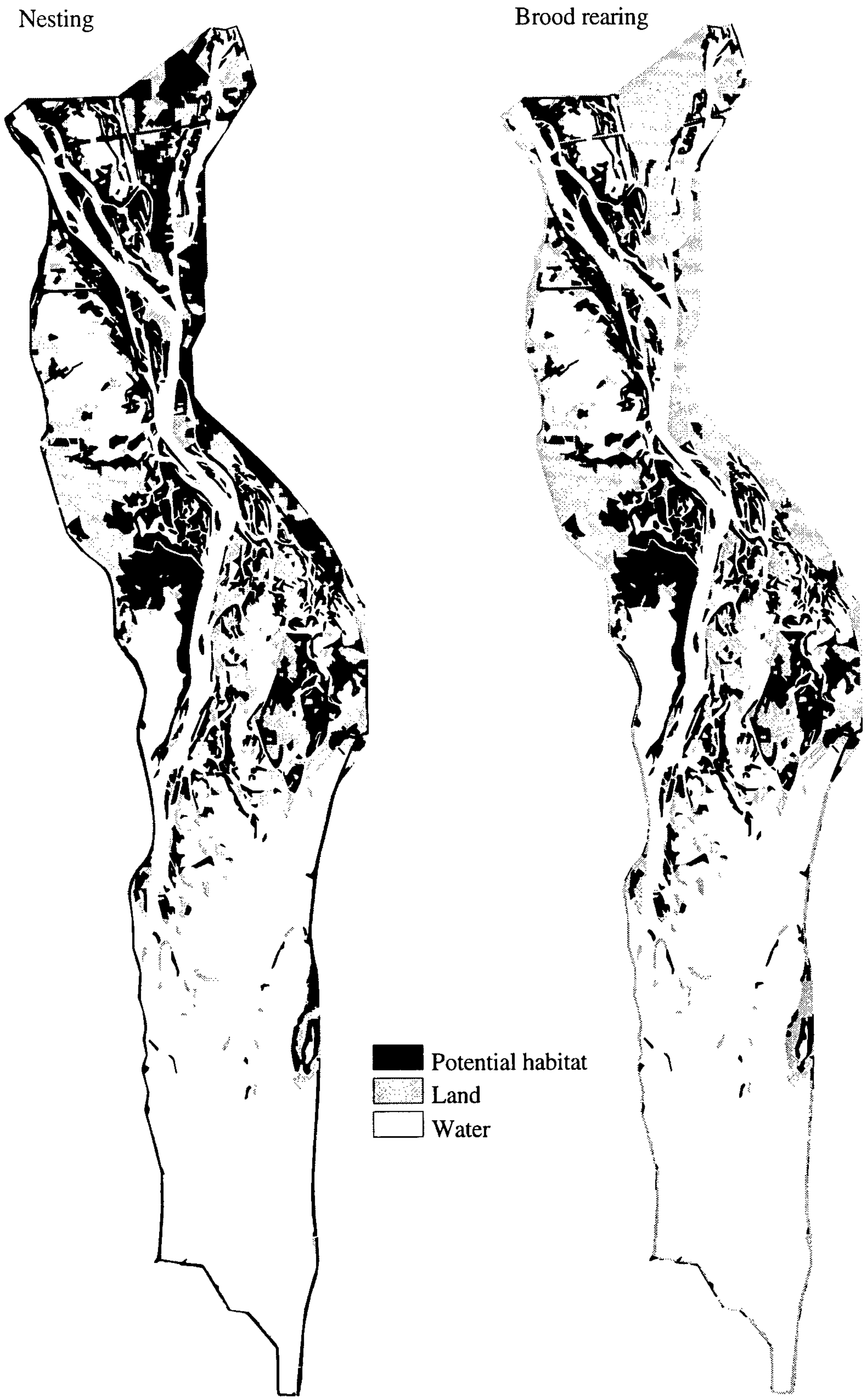


Figure E-39. Potential 1975 nesting and brood rearing habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 8.

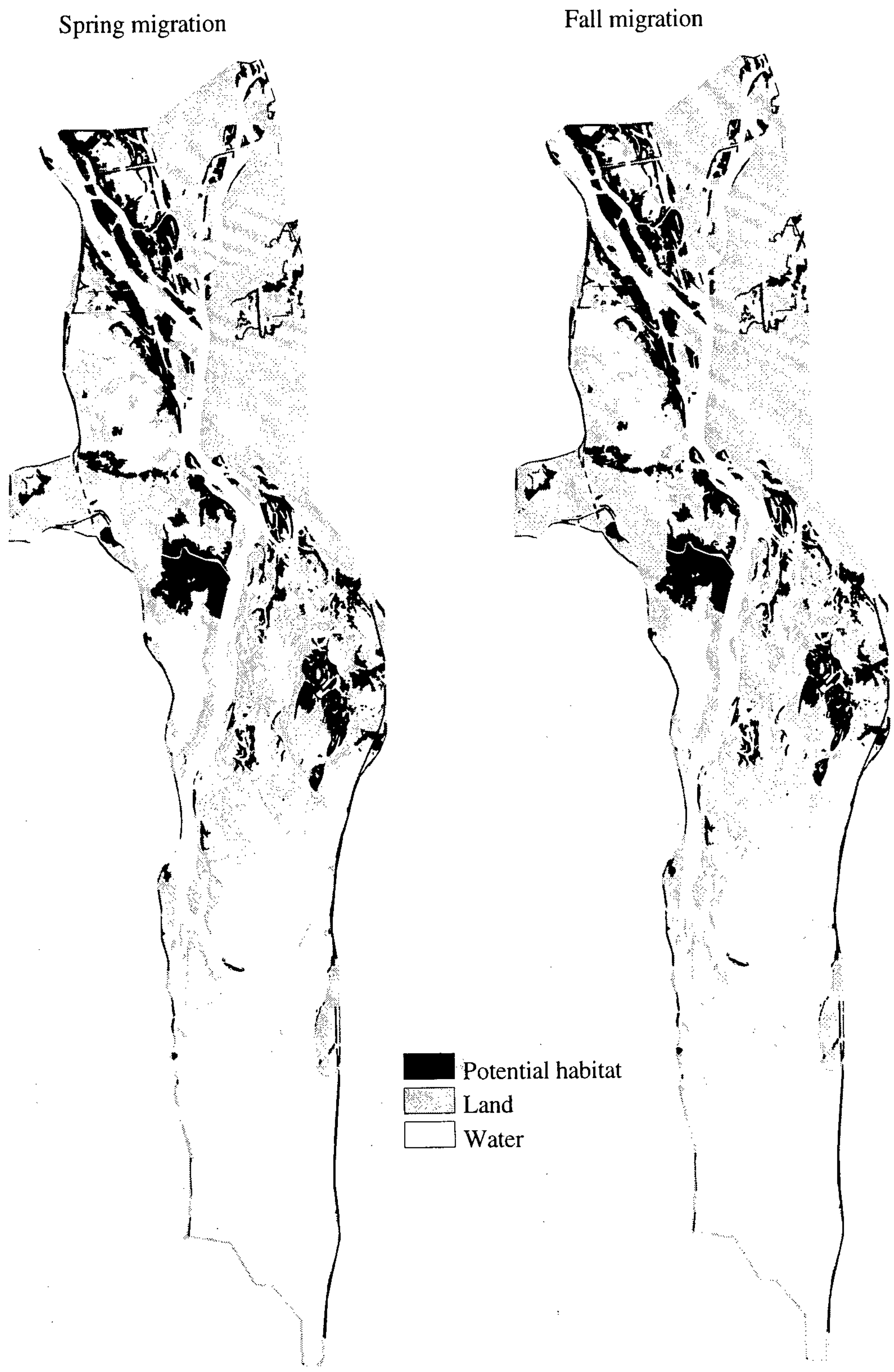


Figure E-40. Potential 1989 spring and fall migration habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 8.

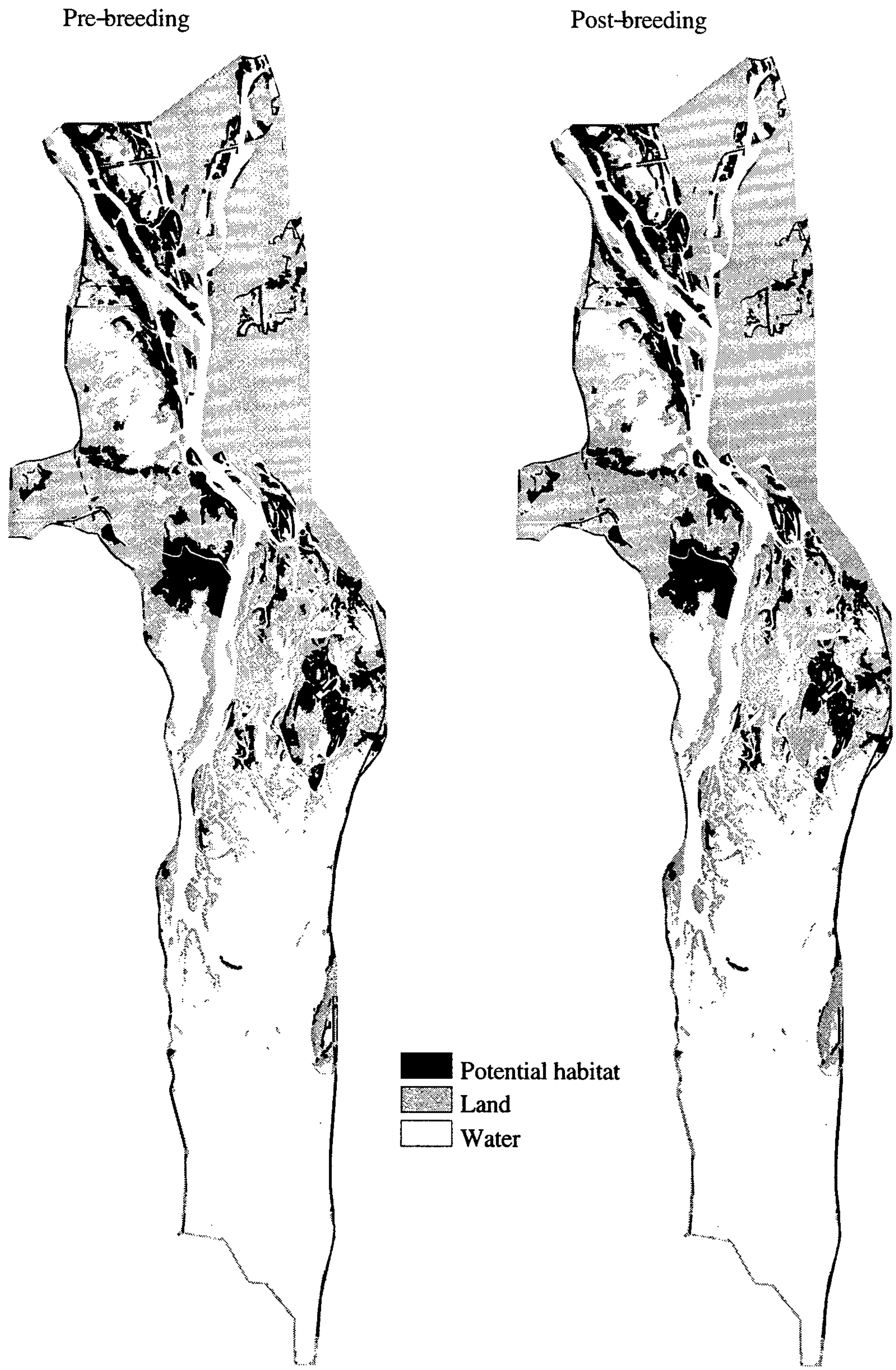


Figure E-41. Potential 1989 pre- and post-breeding habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 8.

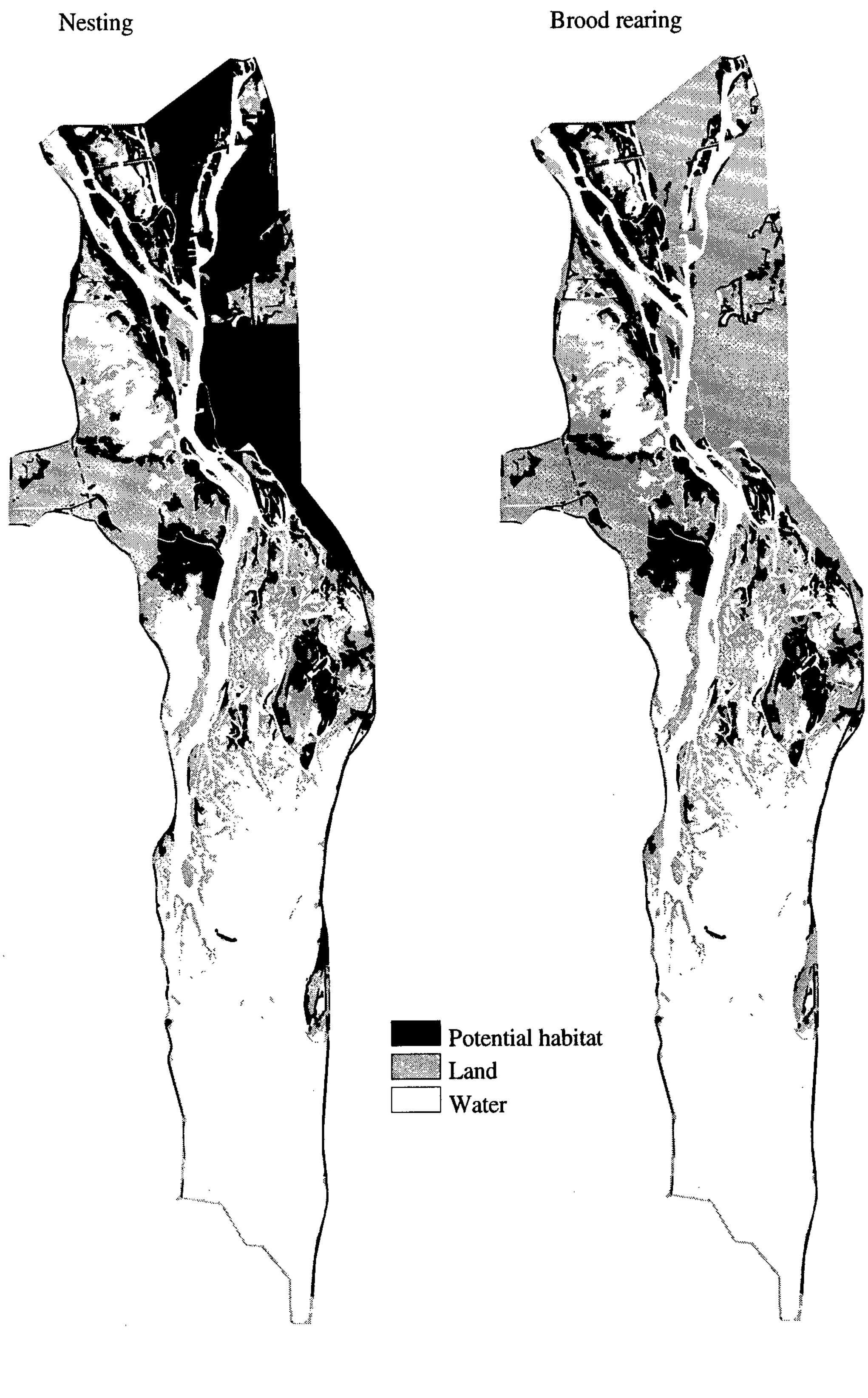


Figure E-42. Potential 1989 nesting and brood rearing habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 8.

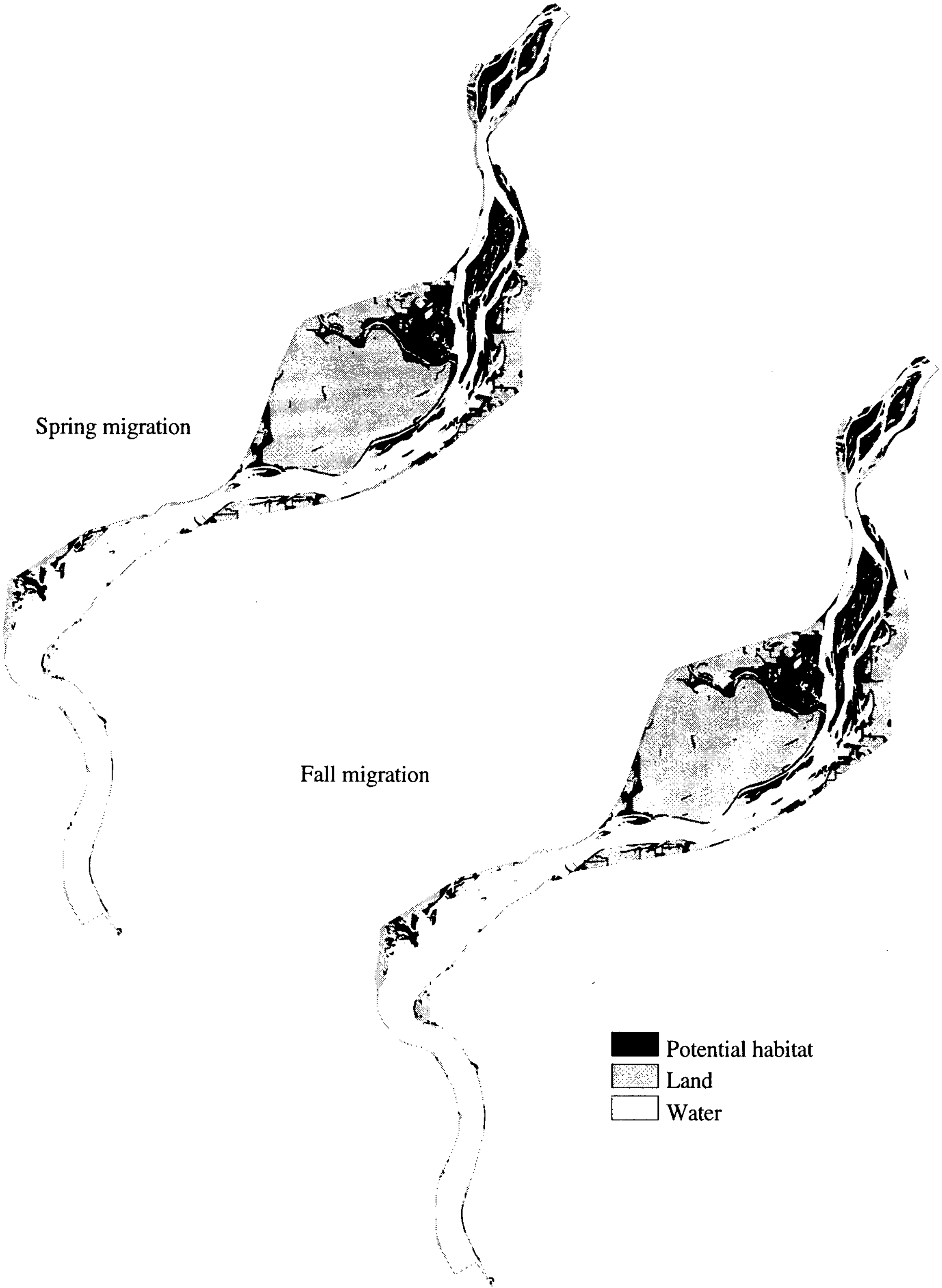


Figure E-43. Potential 1975 spring and fall migration habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 19.

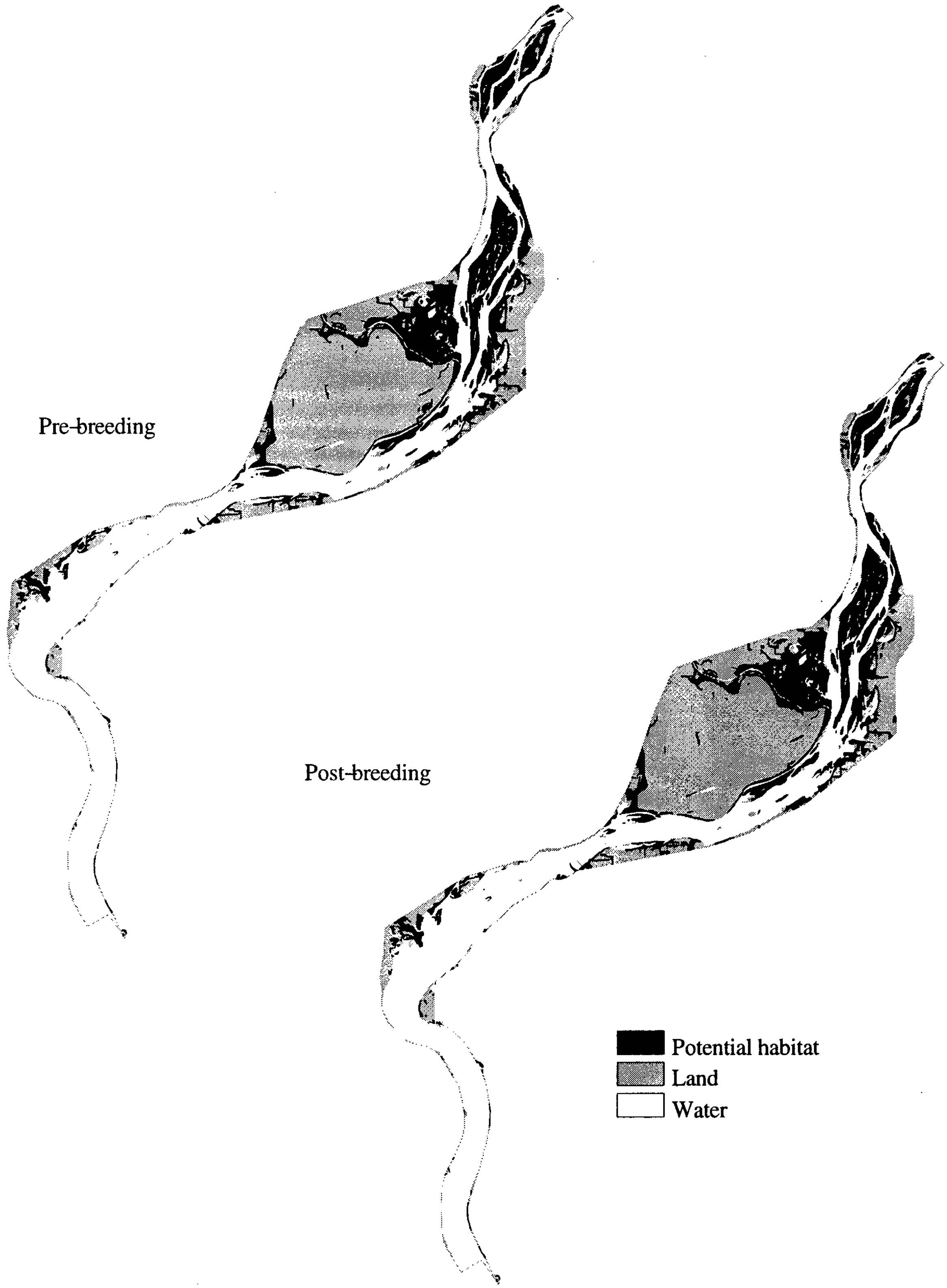


Figure E-44. Potential 1975 pre- and post-breeding habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 19.

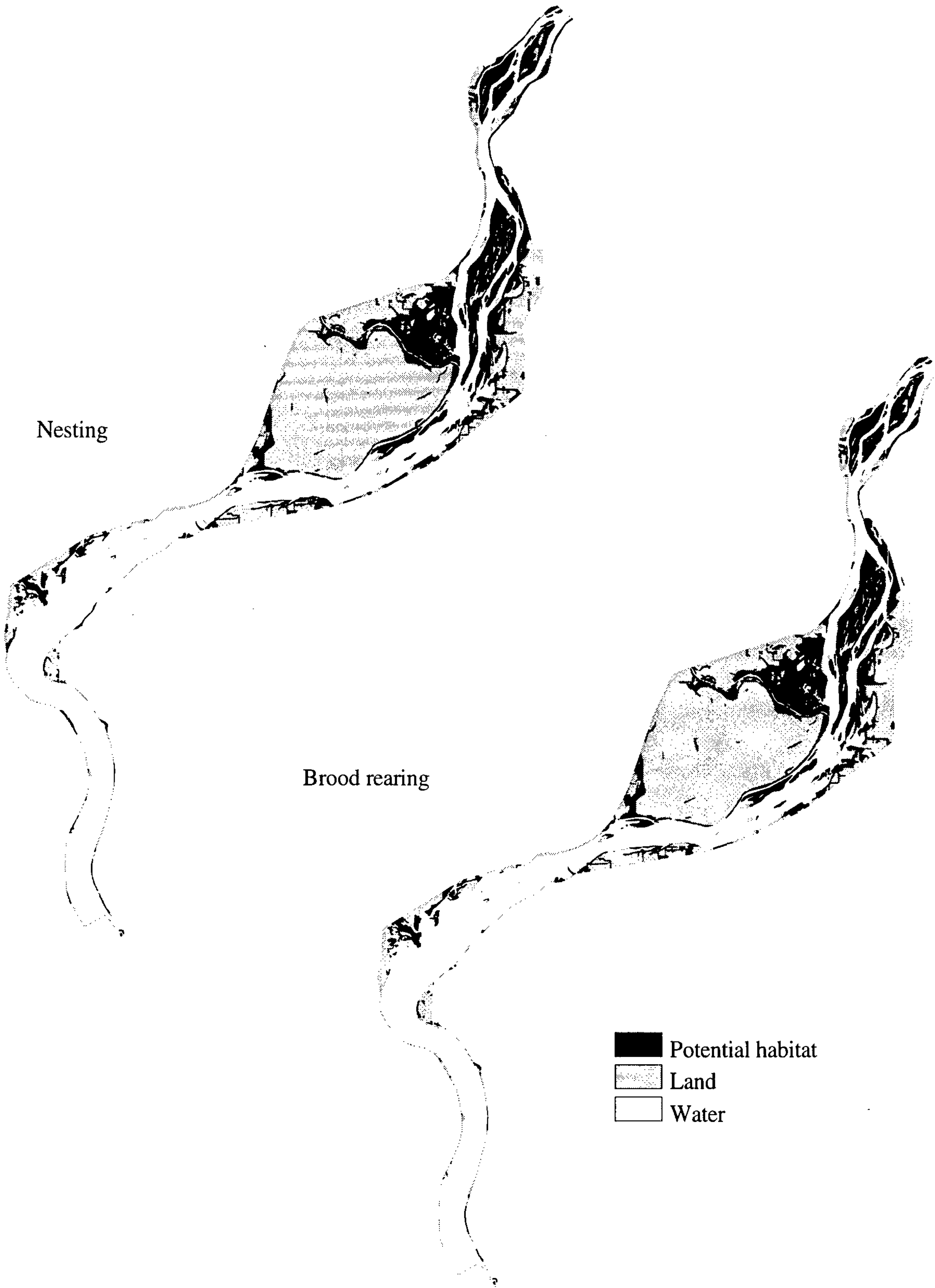


Figure E-45. Potential 1975 nesting and brood rearing habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 19.

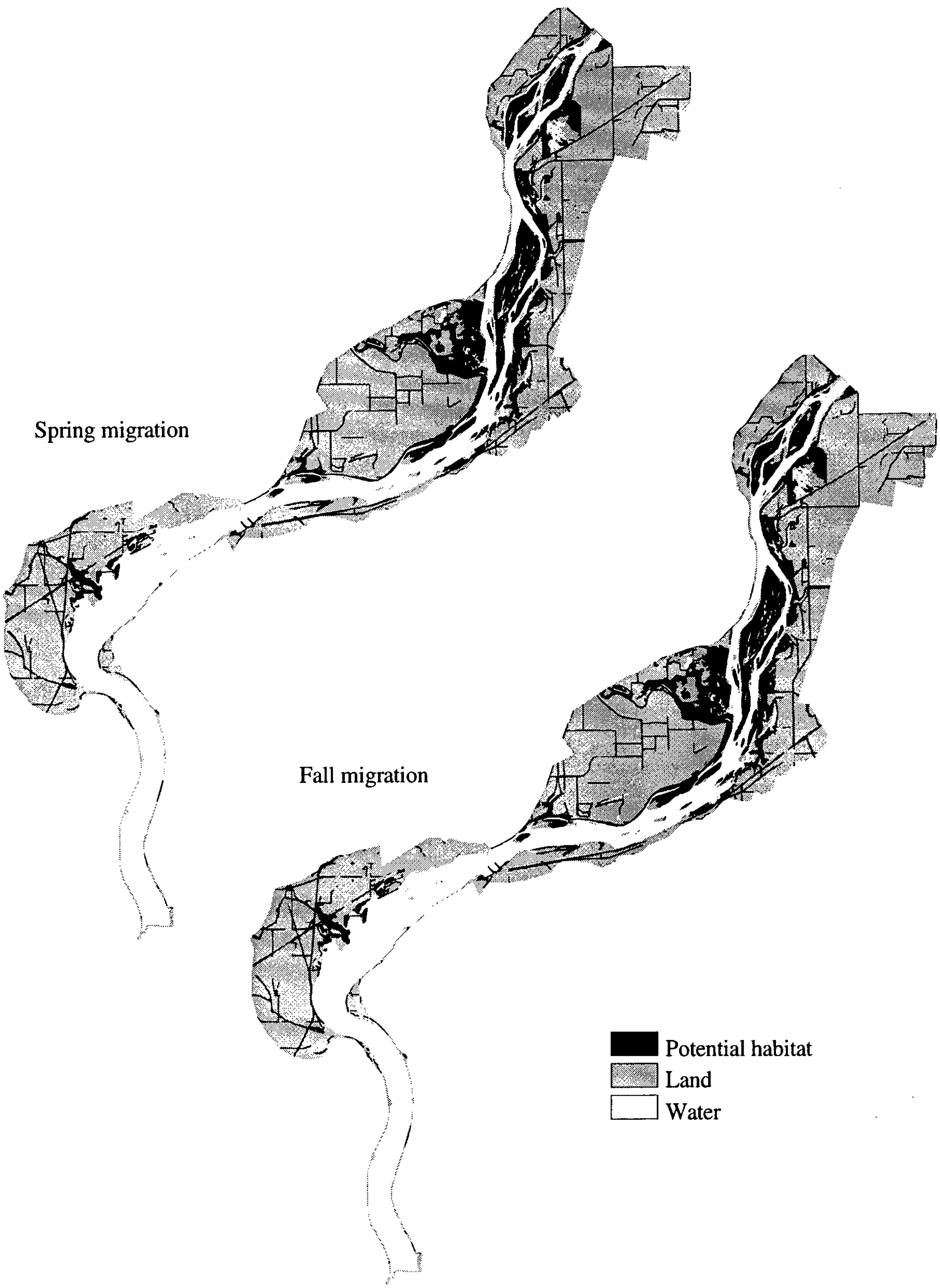


Figure E-46. Potential 1989 spring and fall migration habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 19.

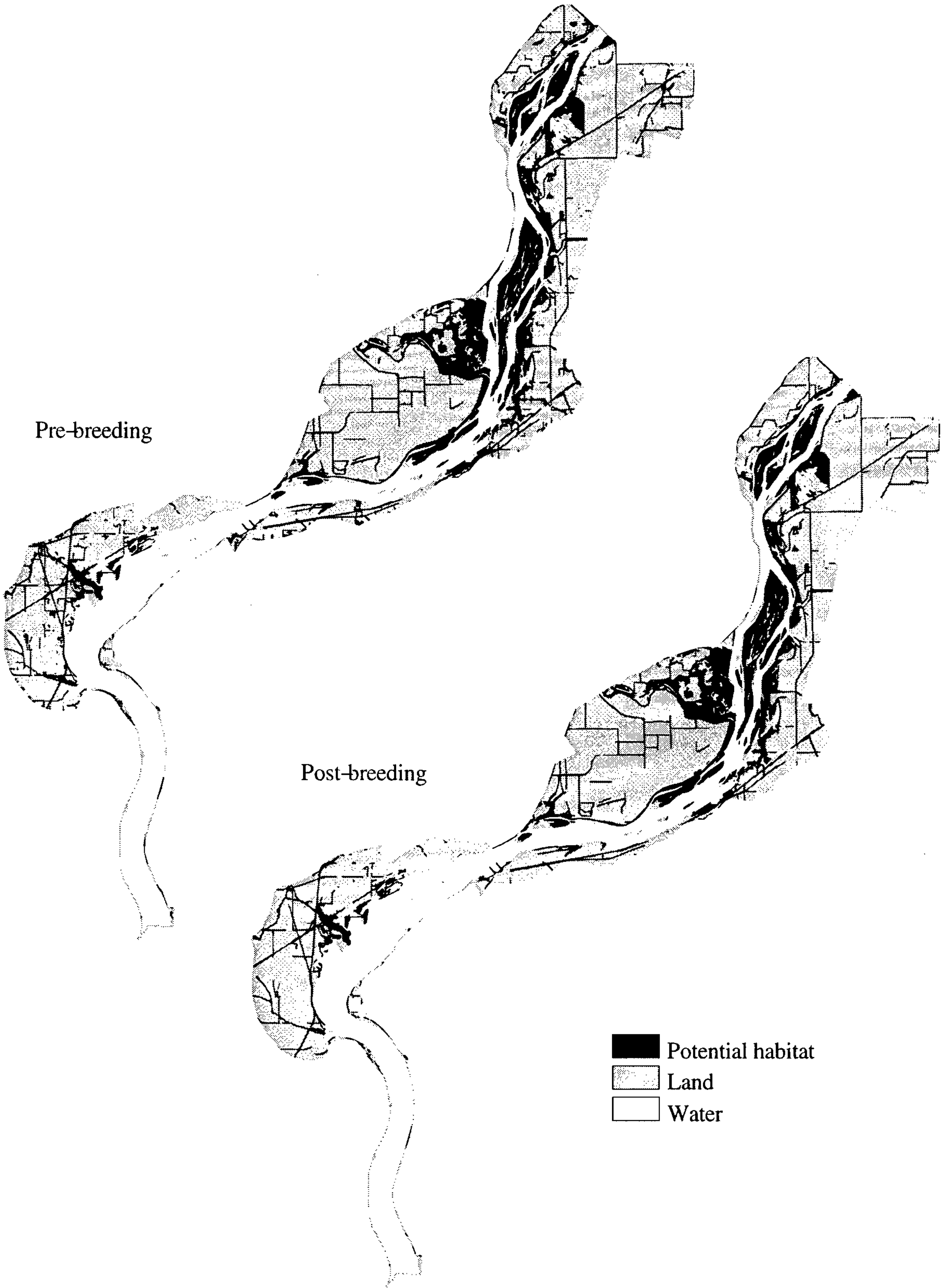


Figure E-47. Potential 1989 pre- and post-breeding habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 19.

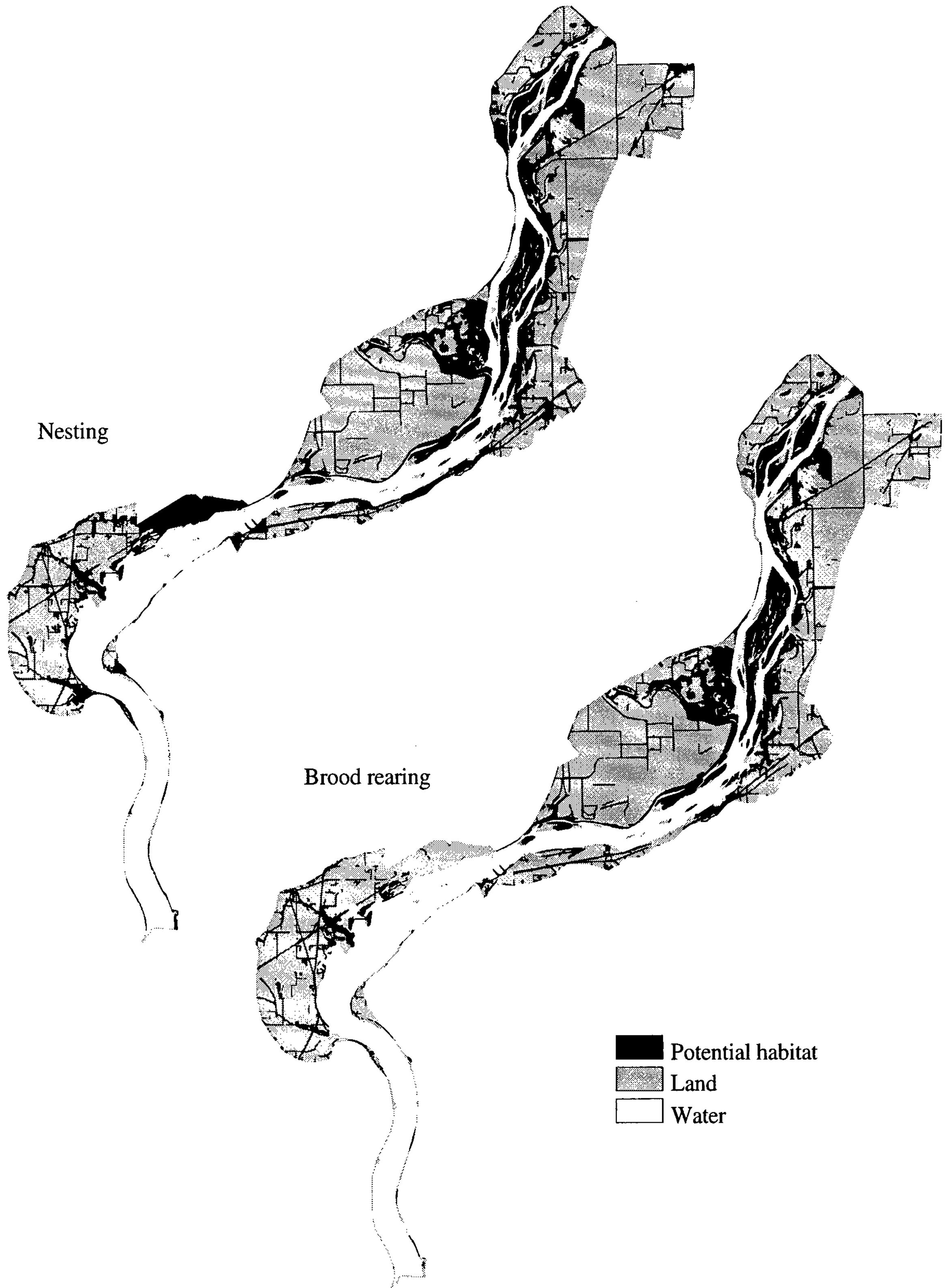


Figure E-48. Potential 1989 nesting and brood rearing habitat for the pileated woodpecker (*Dryocopus pileatus*), Upper Mississippi River Pool 19.

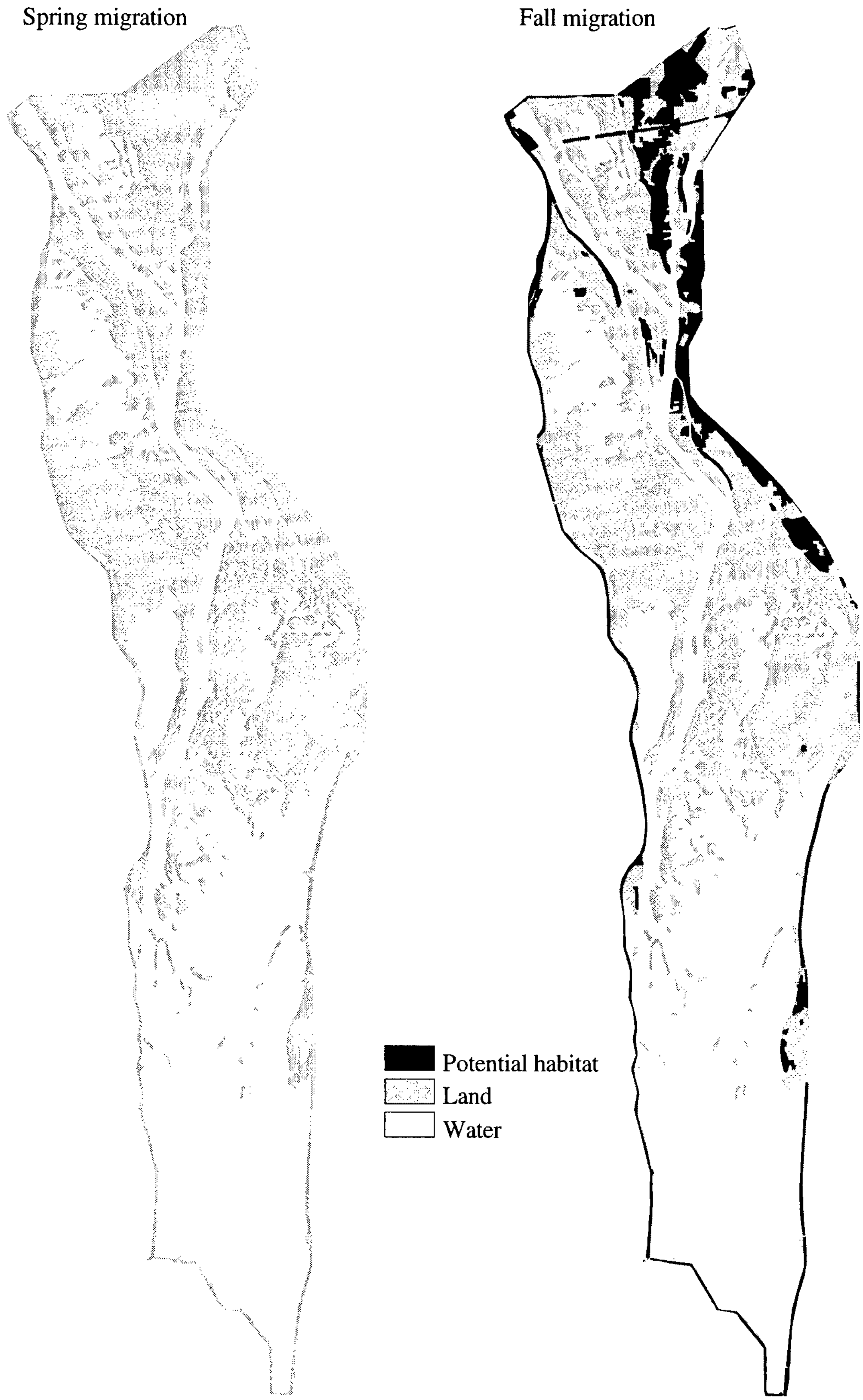


Figure E-49. Potential 1975 spring and fall migration habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 8.

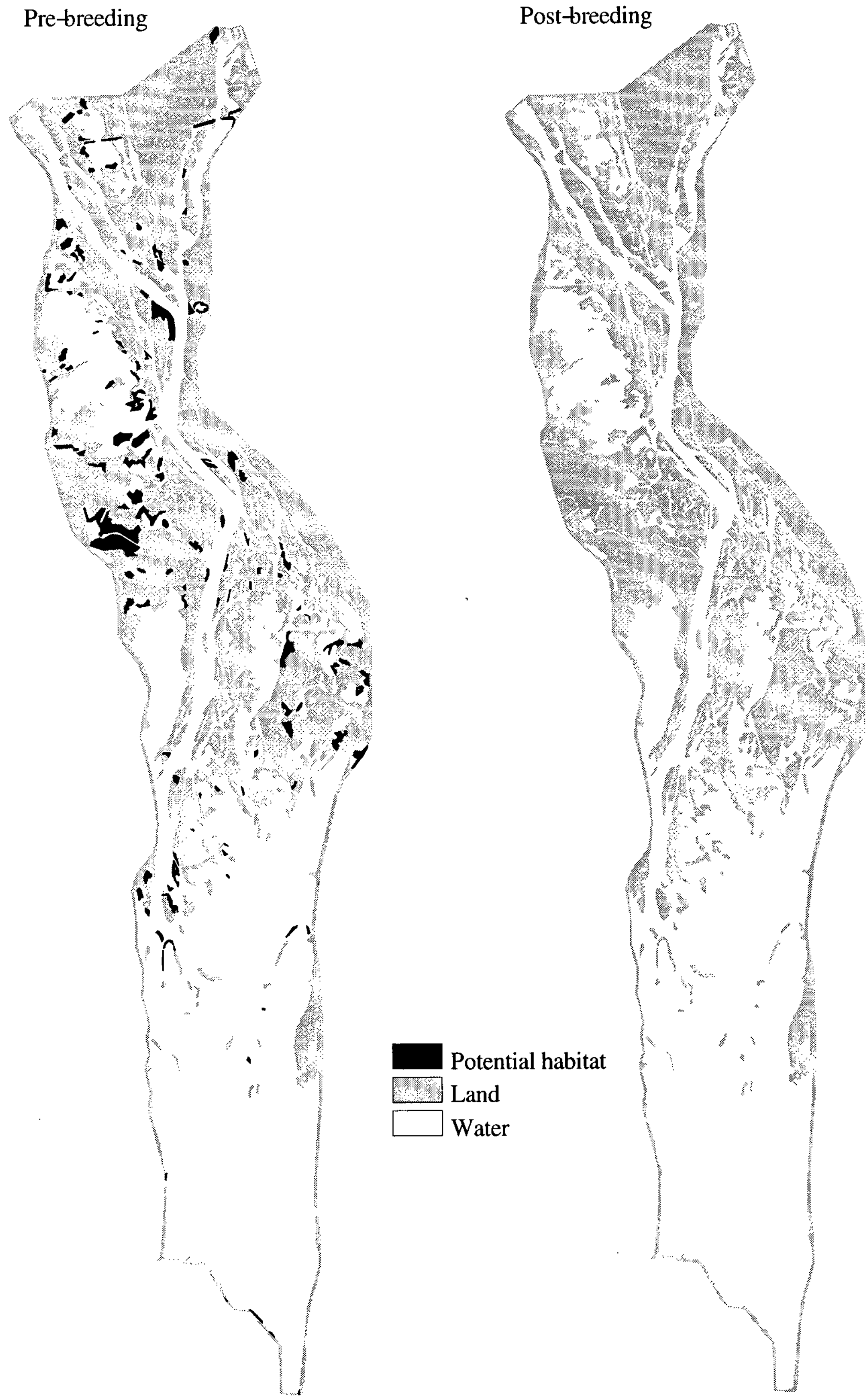


Figure E-50. Potential 1975 pre- and post-breeding habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 8.

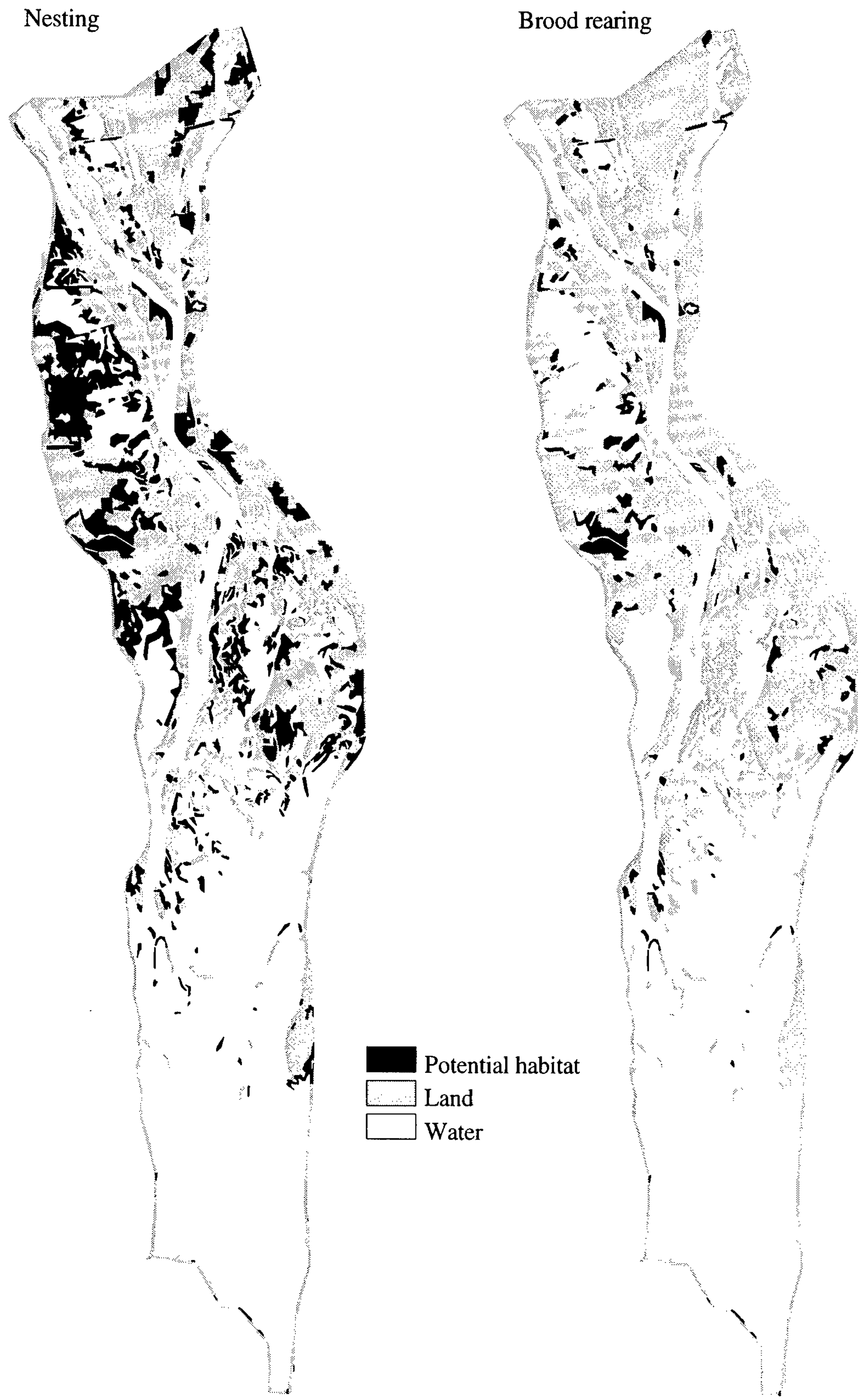


Figure E-51. Potential 1975 nesting and brood rearing habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 8.

Figure E-52. Potential 1989 spring and fall migration habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 8.

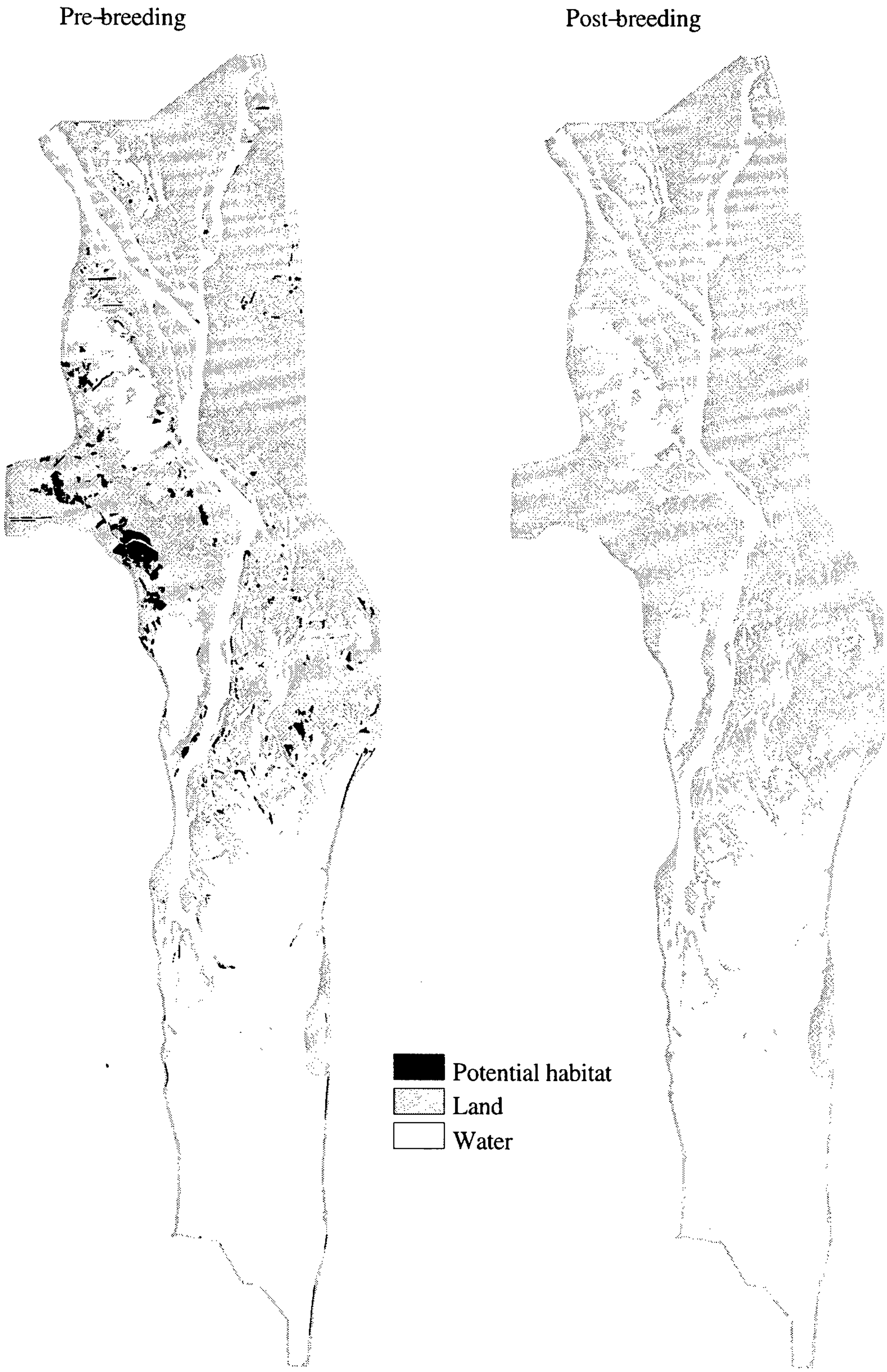


Figure E-53. Potential 1989 pre- and post-breeding habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 8.

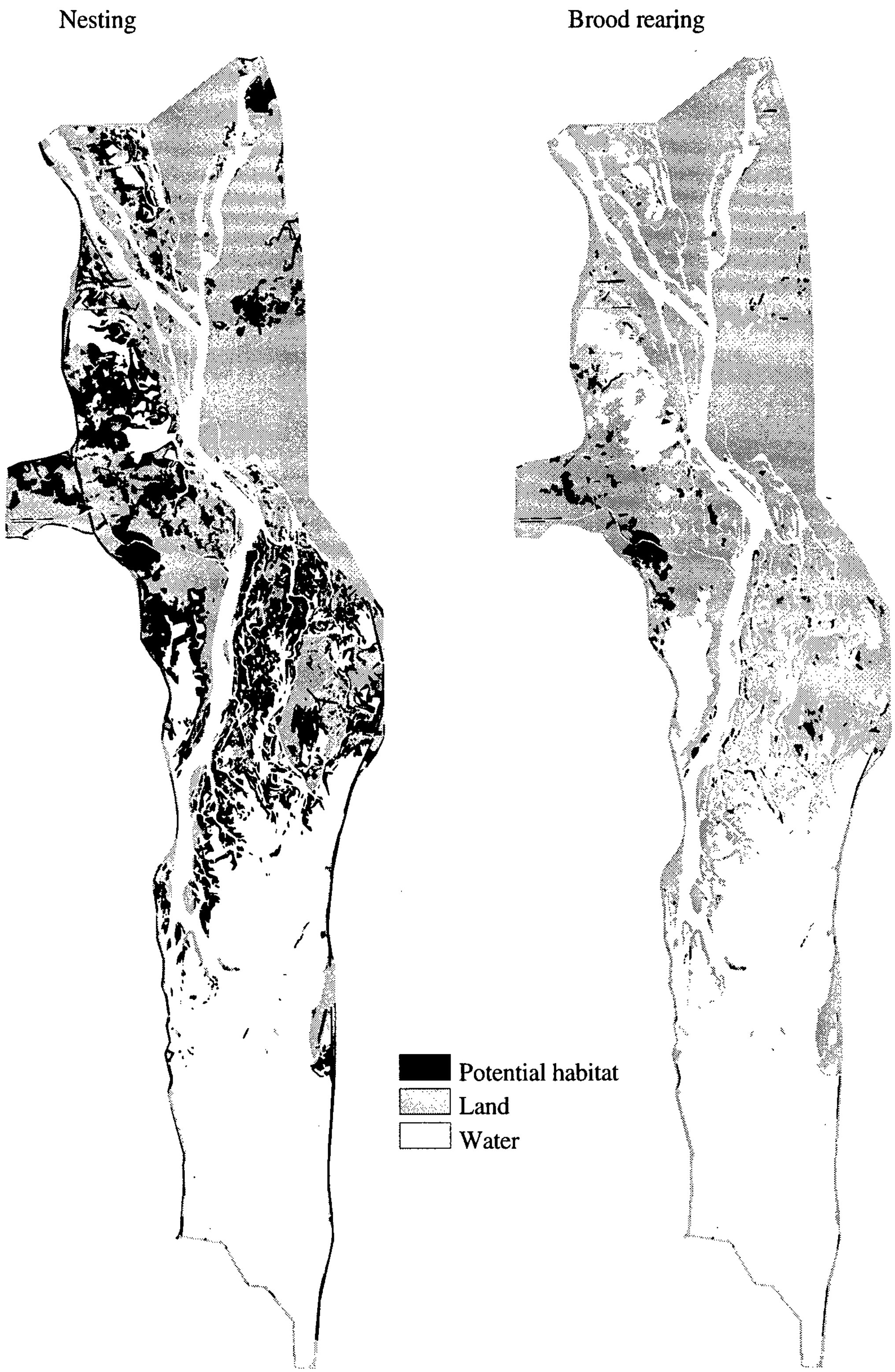


Figure E-54. Potential 1989 nesting and brood rearing habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 8.

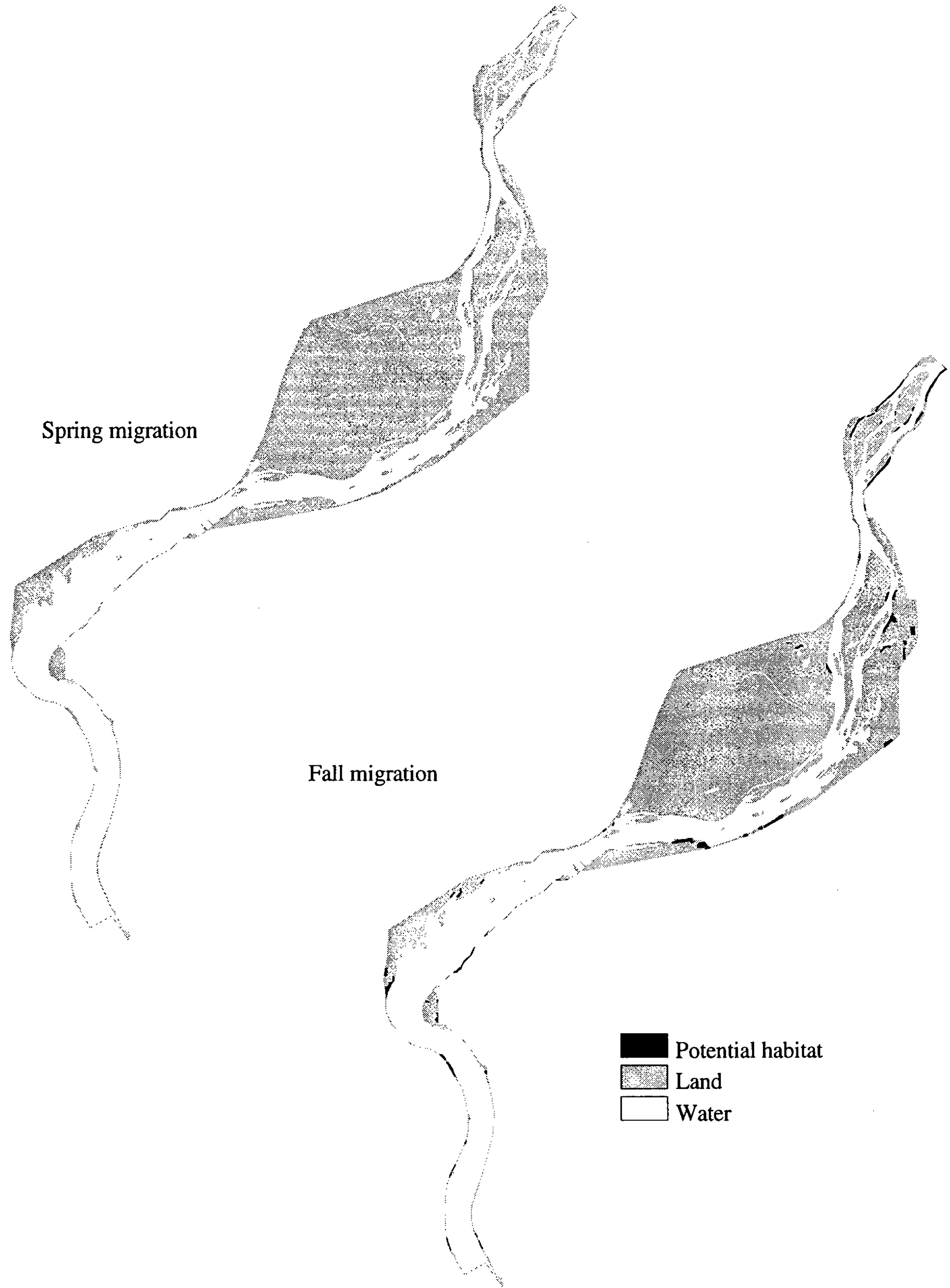


Figure E-55. Potential 1975 spring and fall migration habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 19.

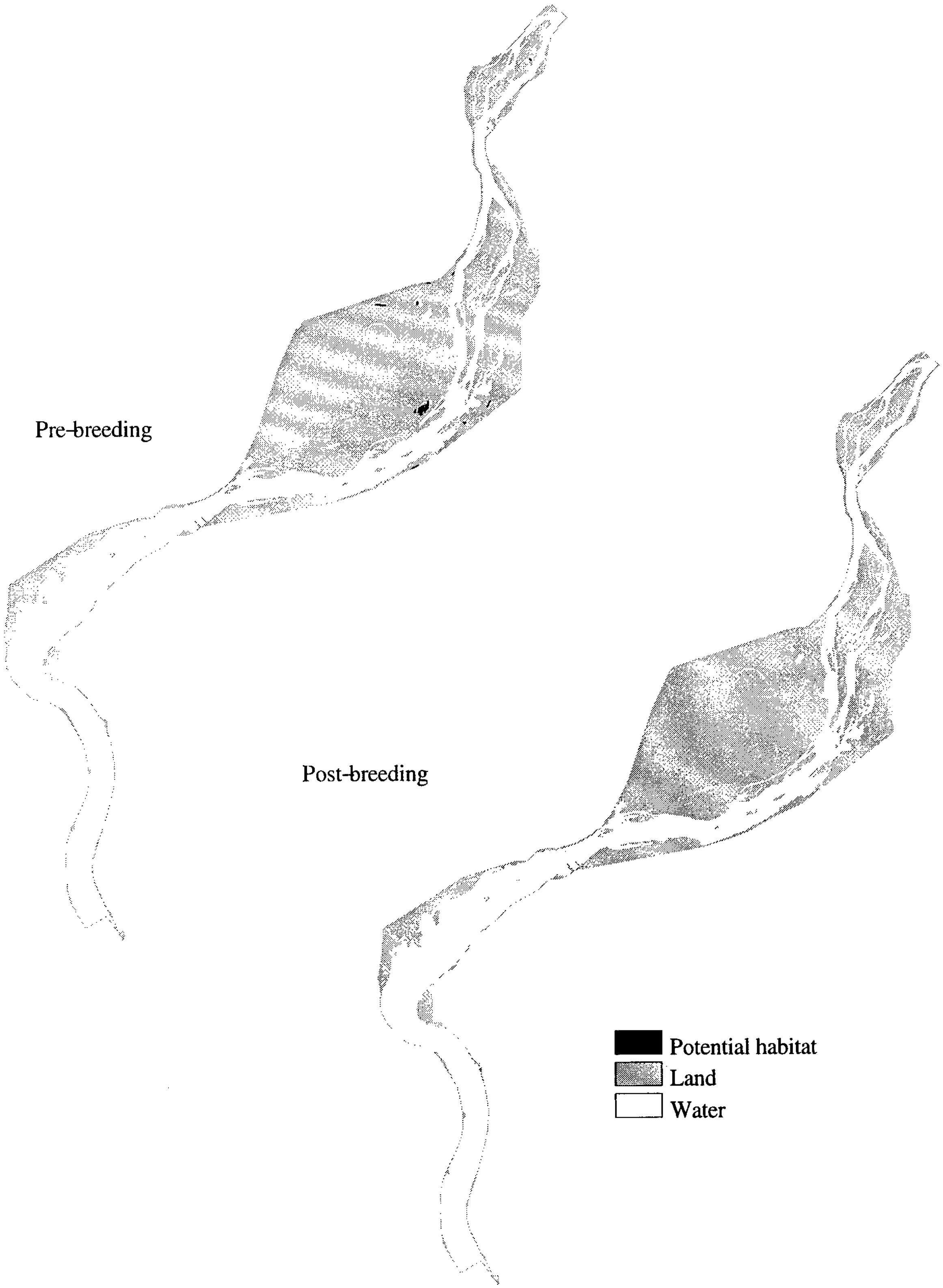


Figure E-56. Potential 1975 pre- and post-breeding habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 19.

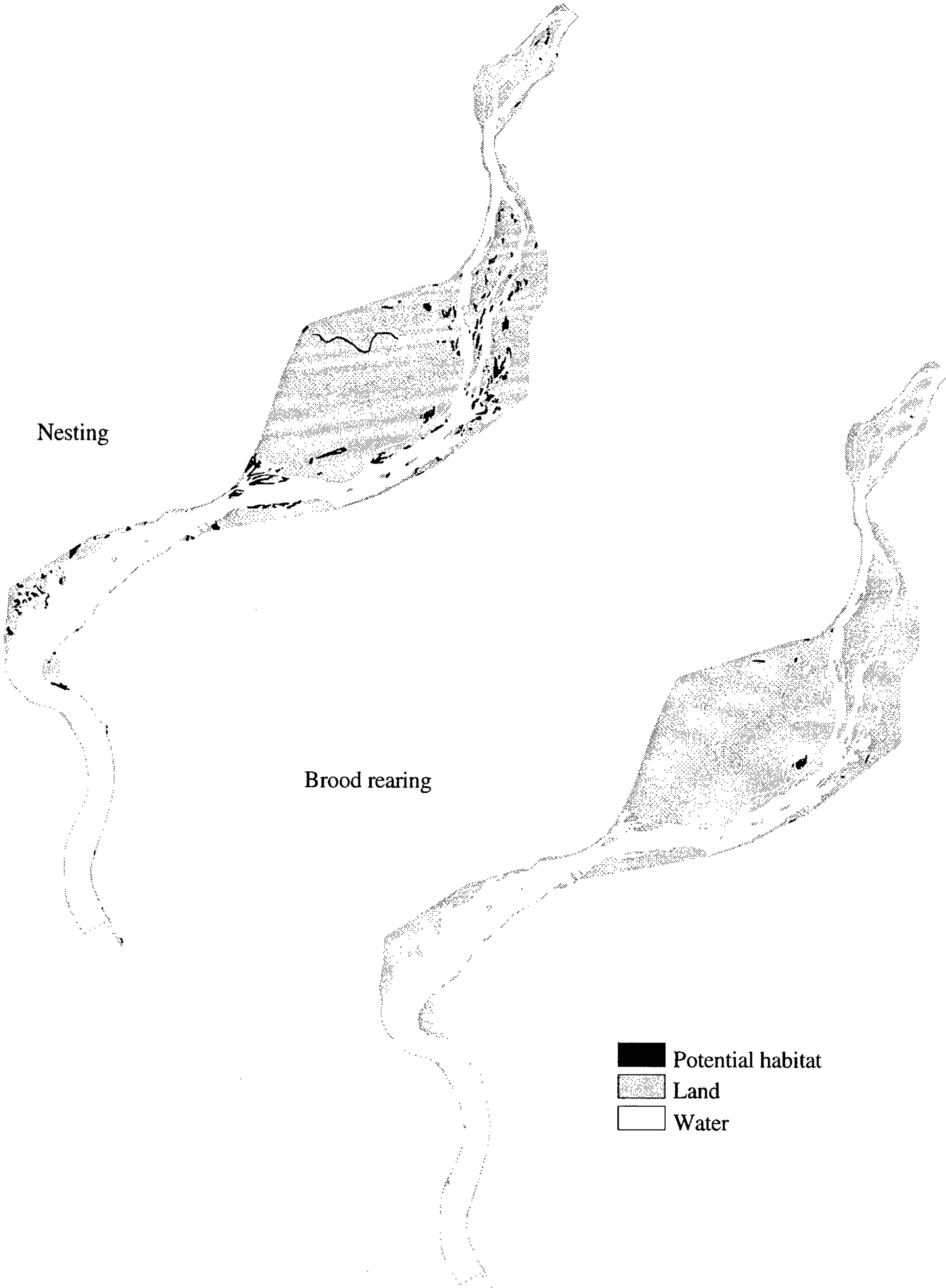


Figure E-57. Potential 1975 nesting and brood rearing habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 19.

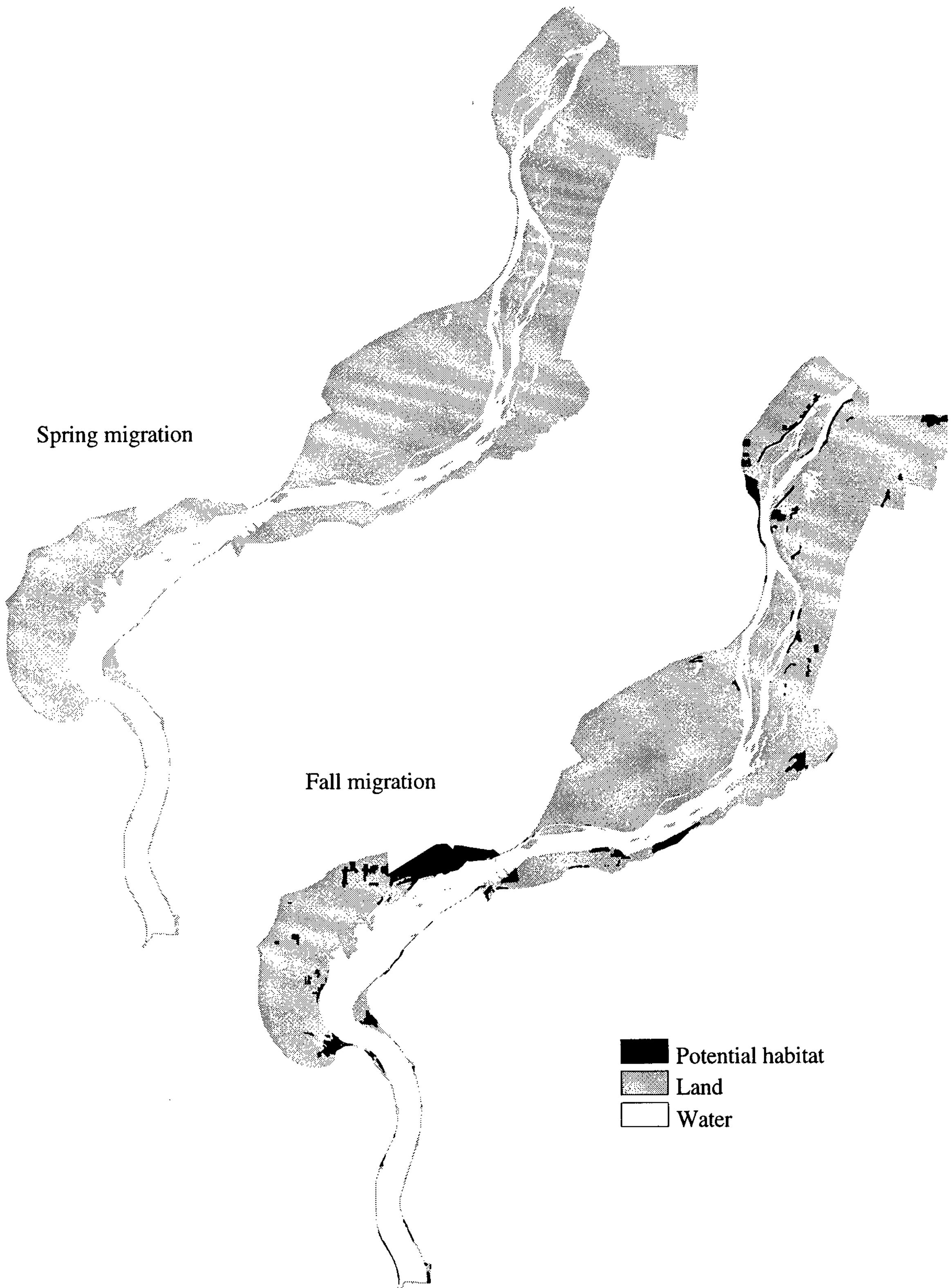


Figure E-58. Potential 1989 spring and fall migration habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 19.

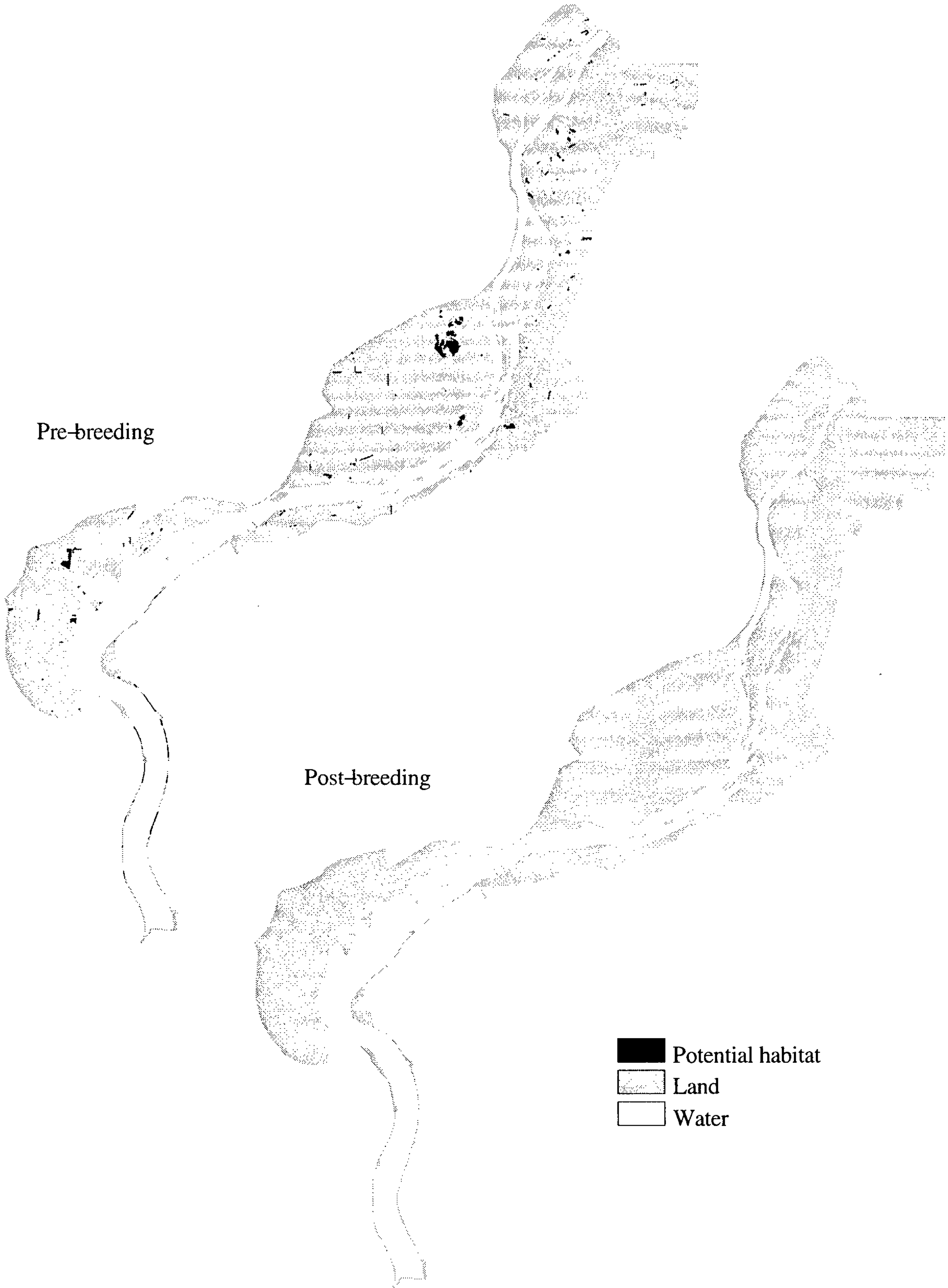


Figure E-59. Potential 1989 pre- and post-breeding habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 19.

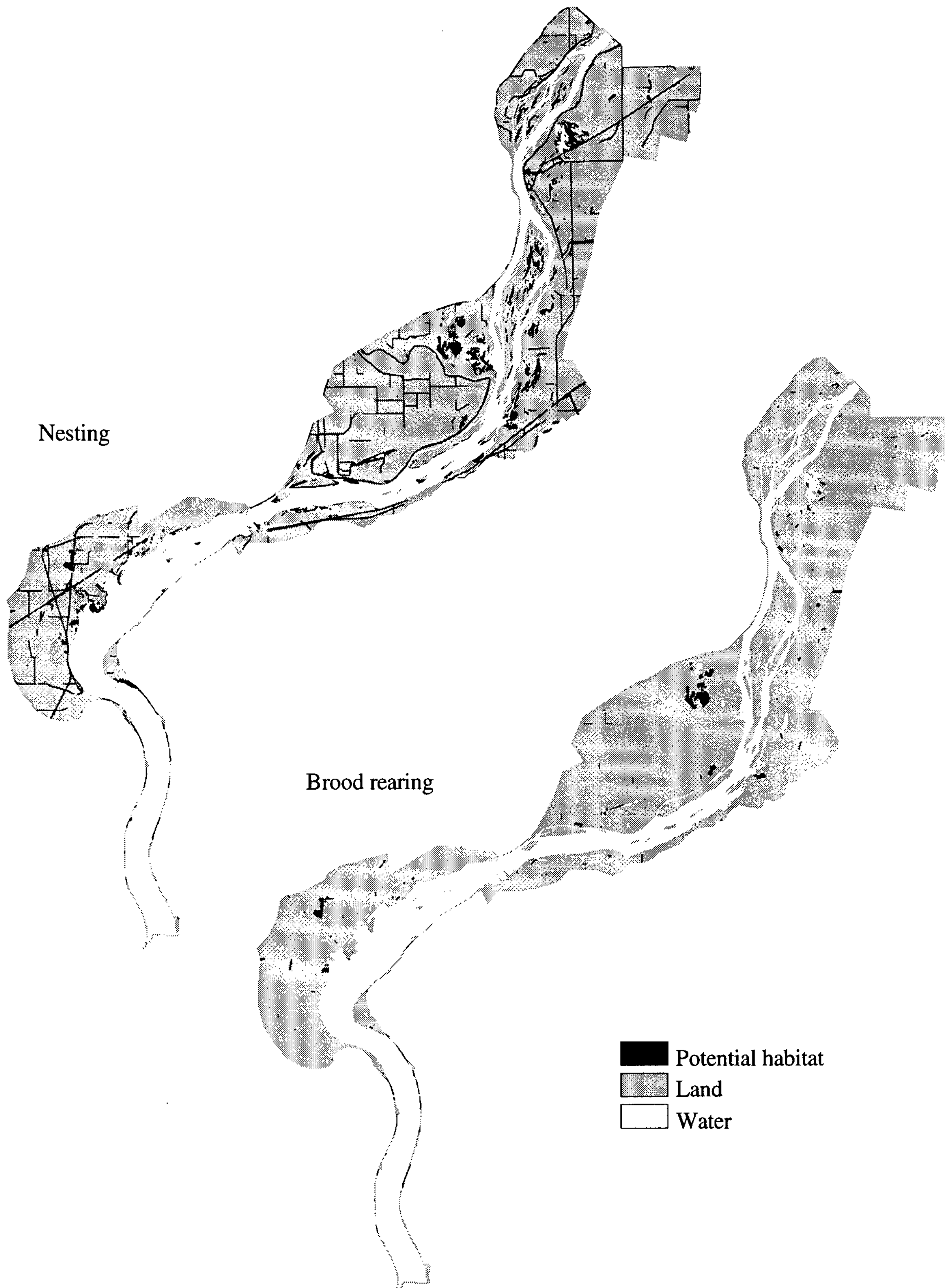


Figure E-60. Potential 1989 nesting and brood rearing habitat for the swamp sparrow (*Melospiza georgiana*), Upper Mississippi River Pool 19.

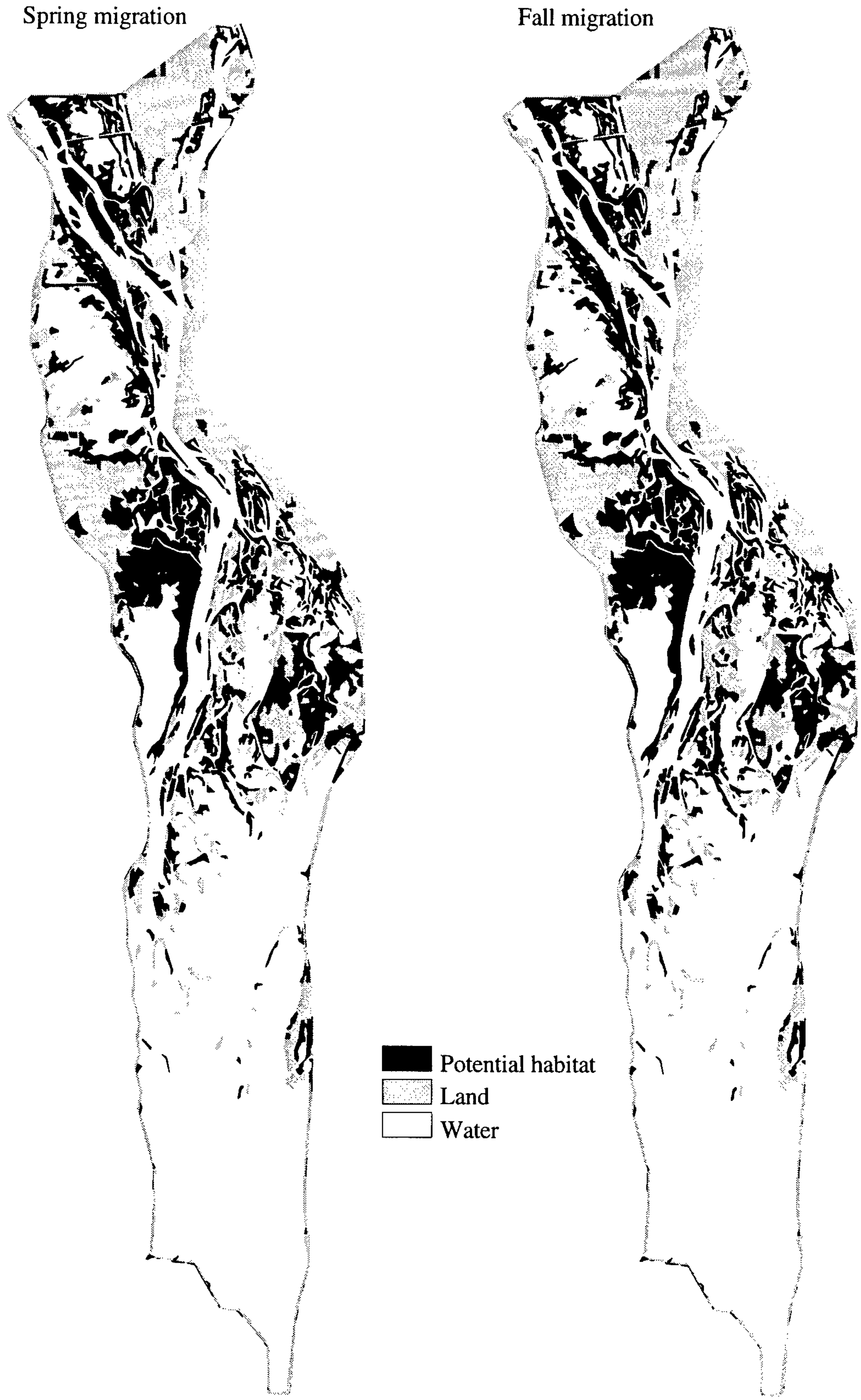


Figure E-61. Potential 1975 spring and fall migration habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 8.

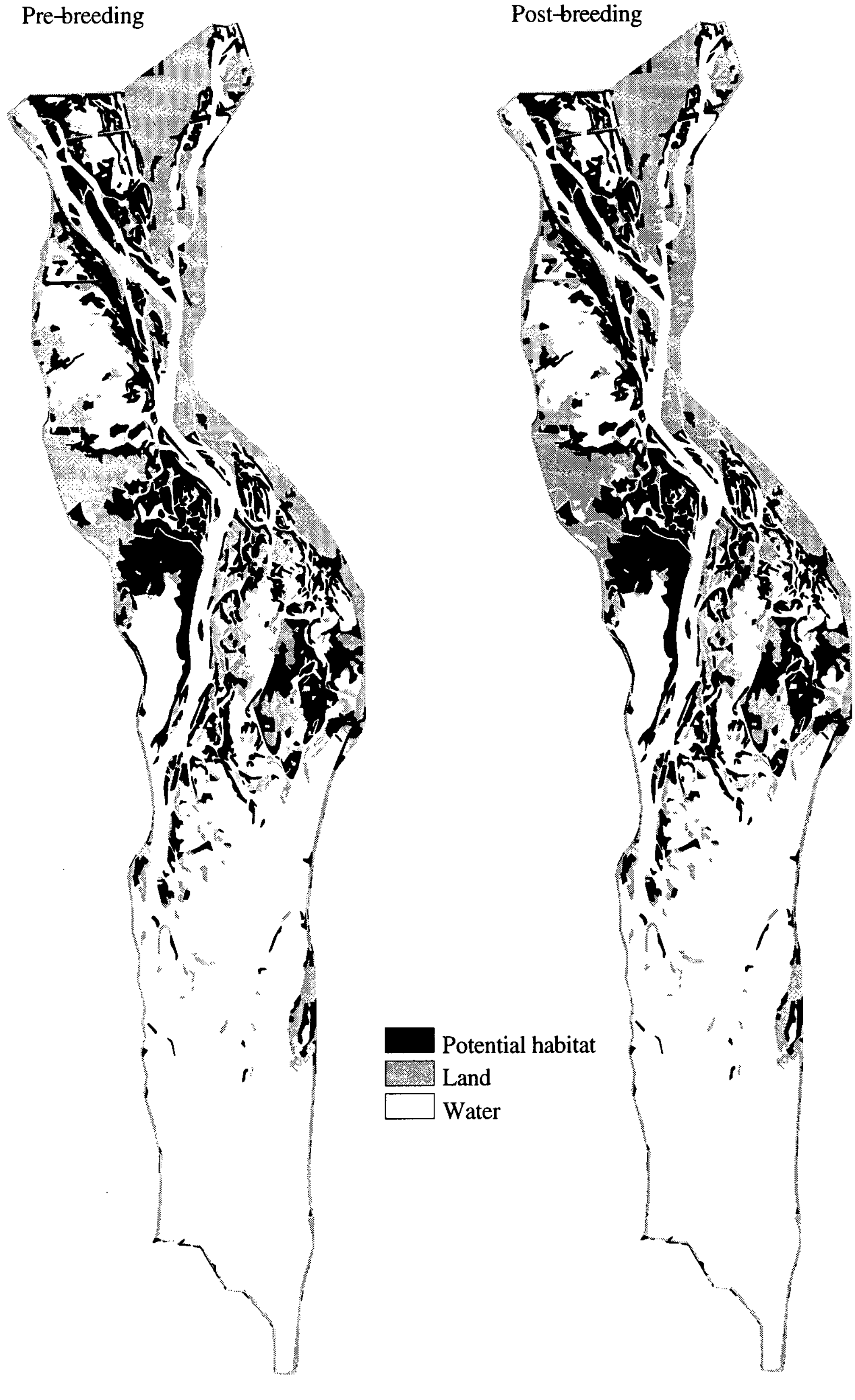


Figure E-62. Potential 1975 pre- and post-breeding habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 8.

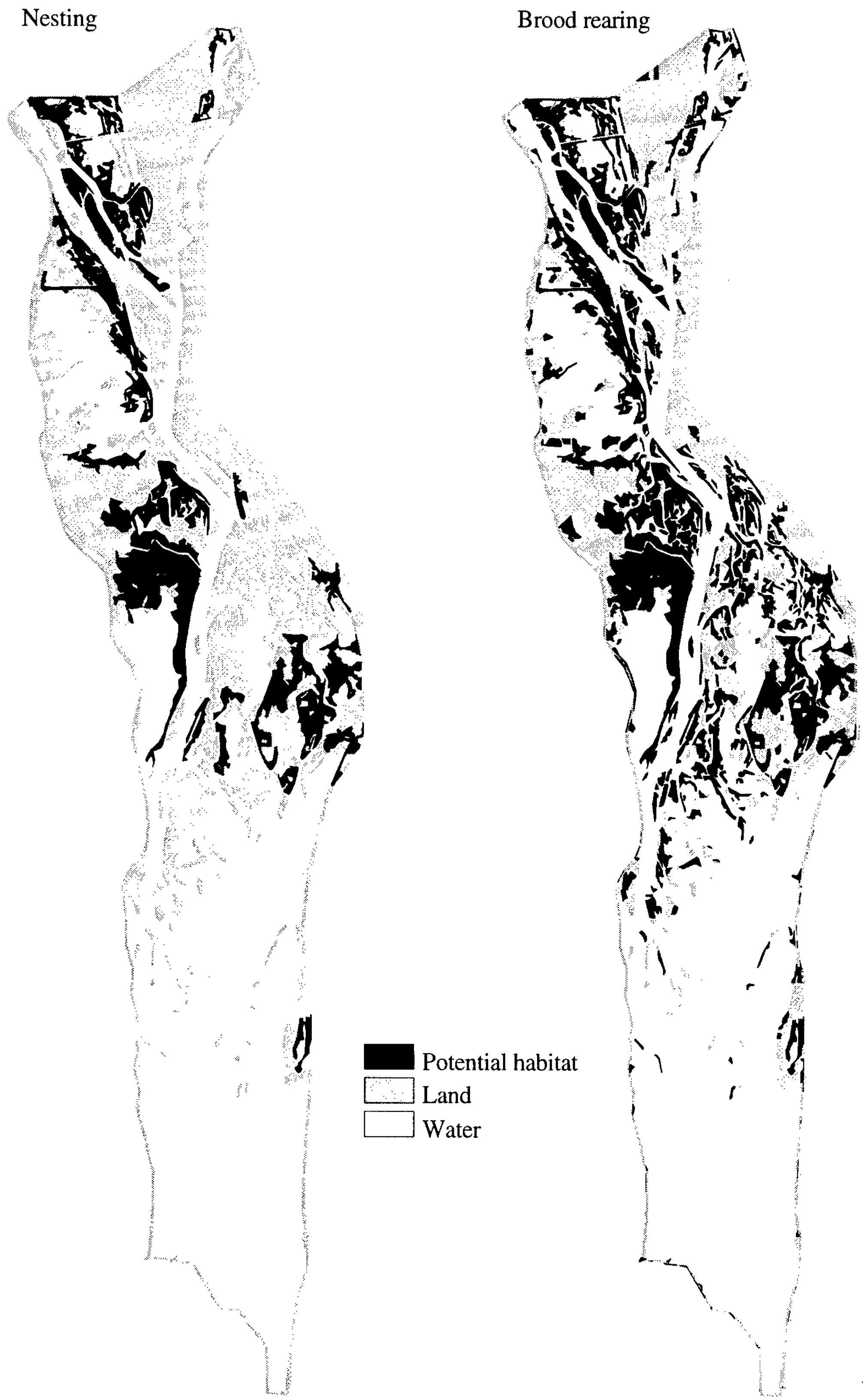


Figure E-63. Potential 1975 nesting and brood rearing habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 8.

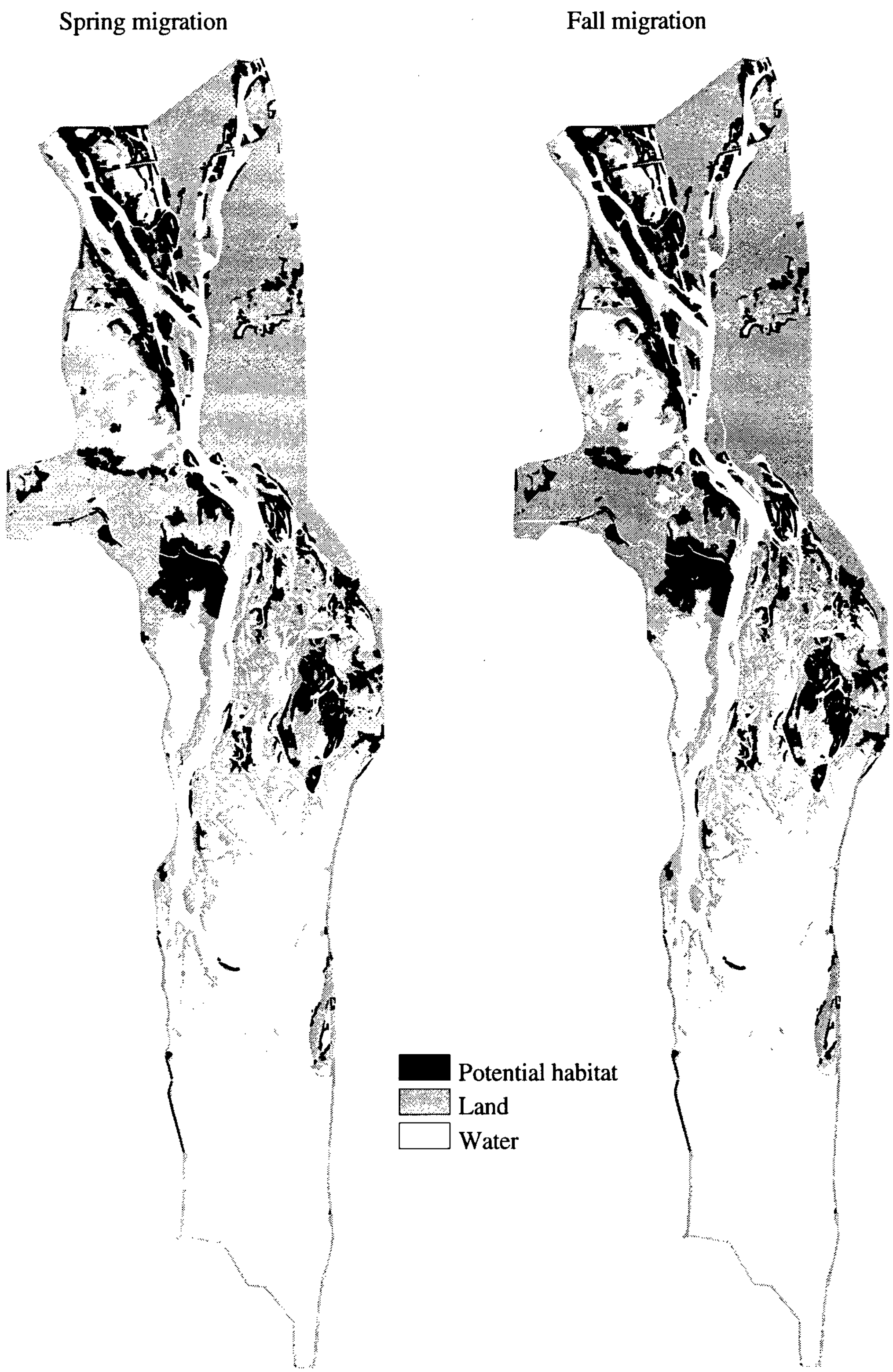


Figure E-64. Potential 1989 spring and fall migration habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 8.

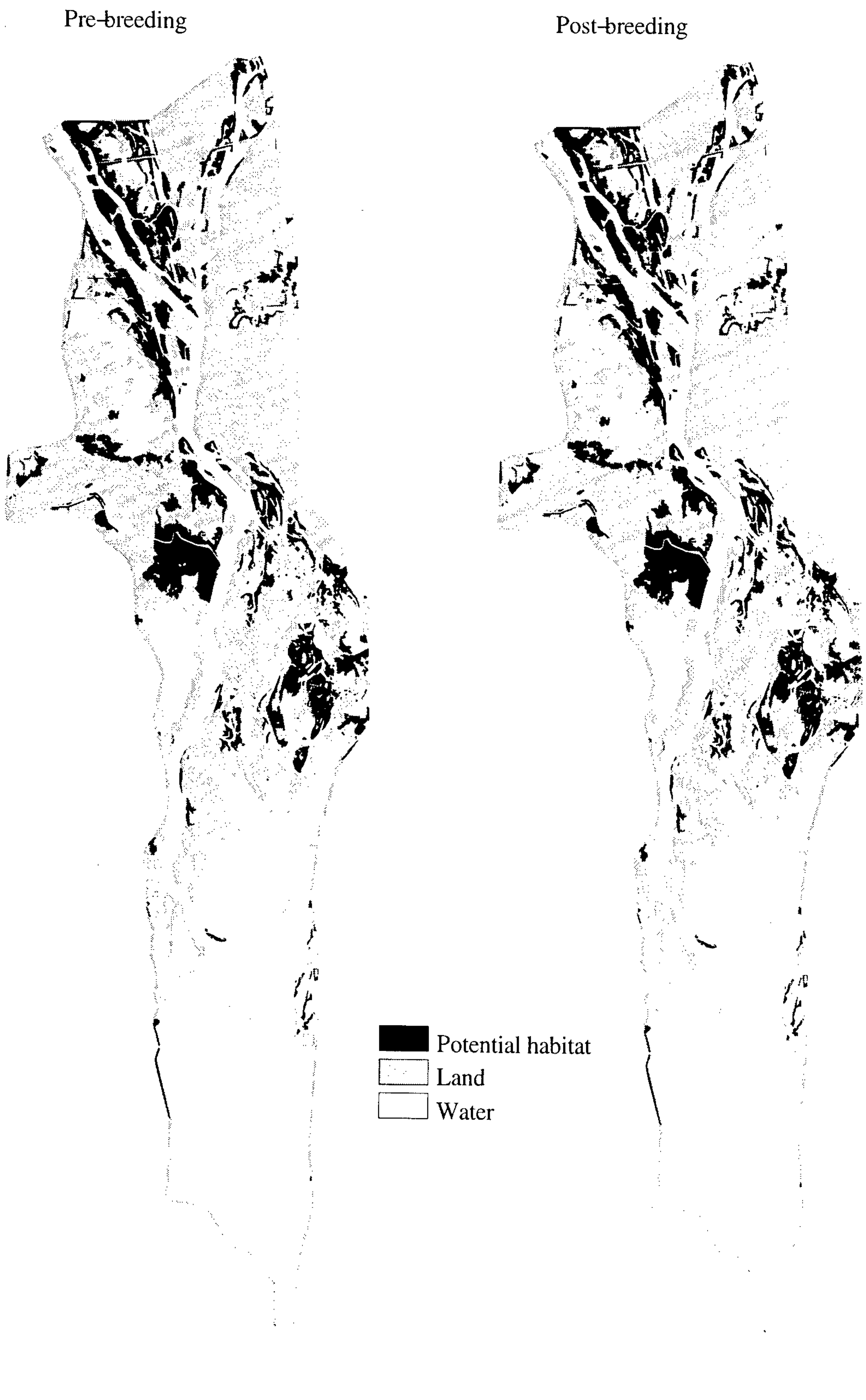


Figure E-65. Potential 1989 pre- and post-breeding habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 8.

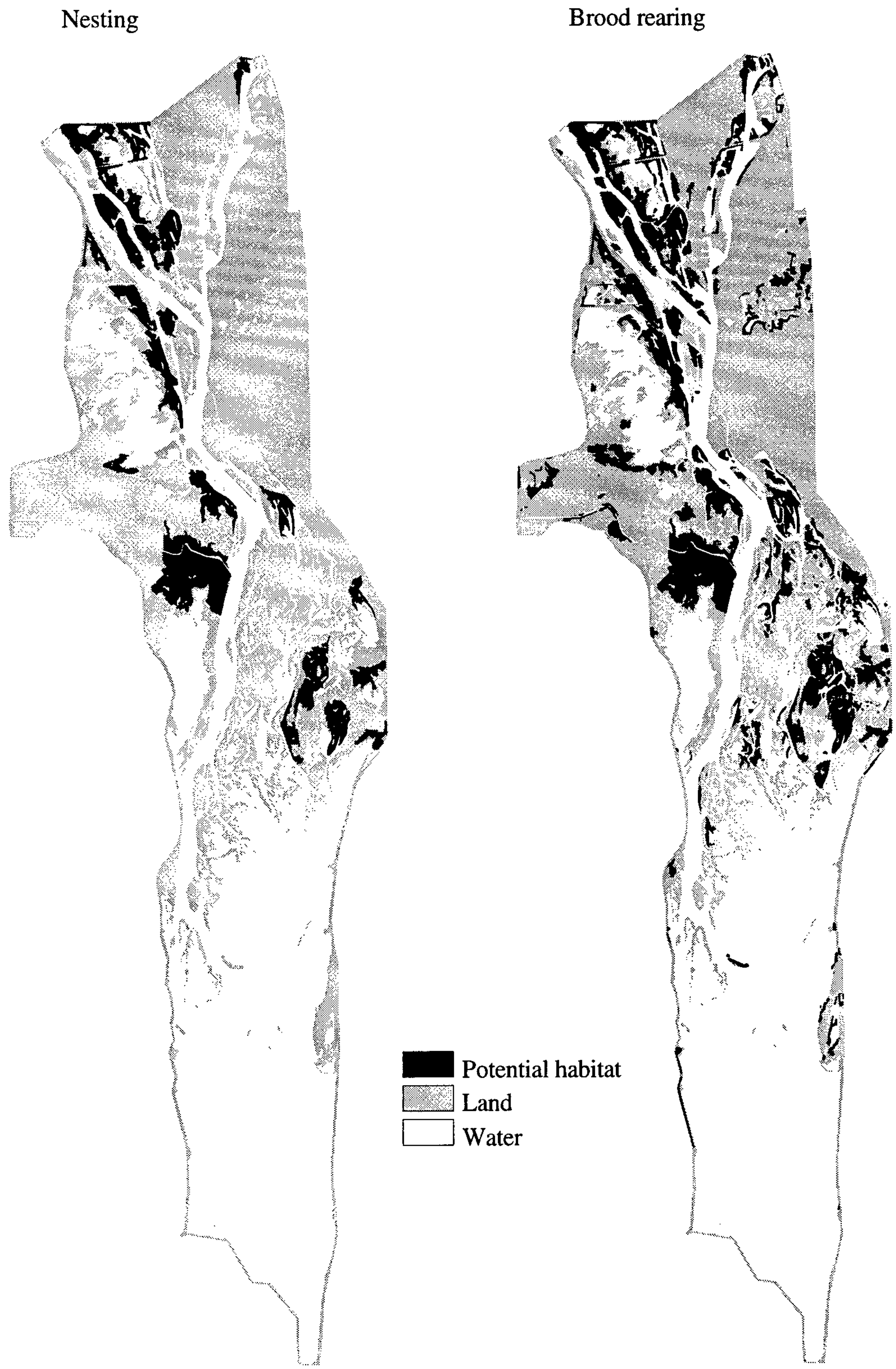


Figure E-66. Potential 1989 nesting and brood rearing habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 8.

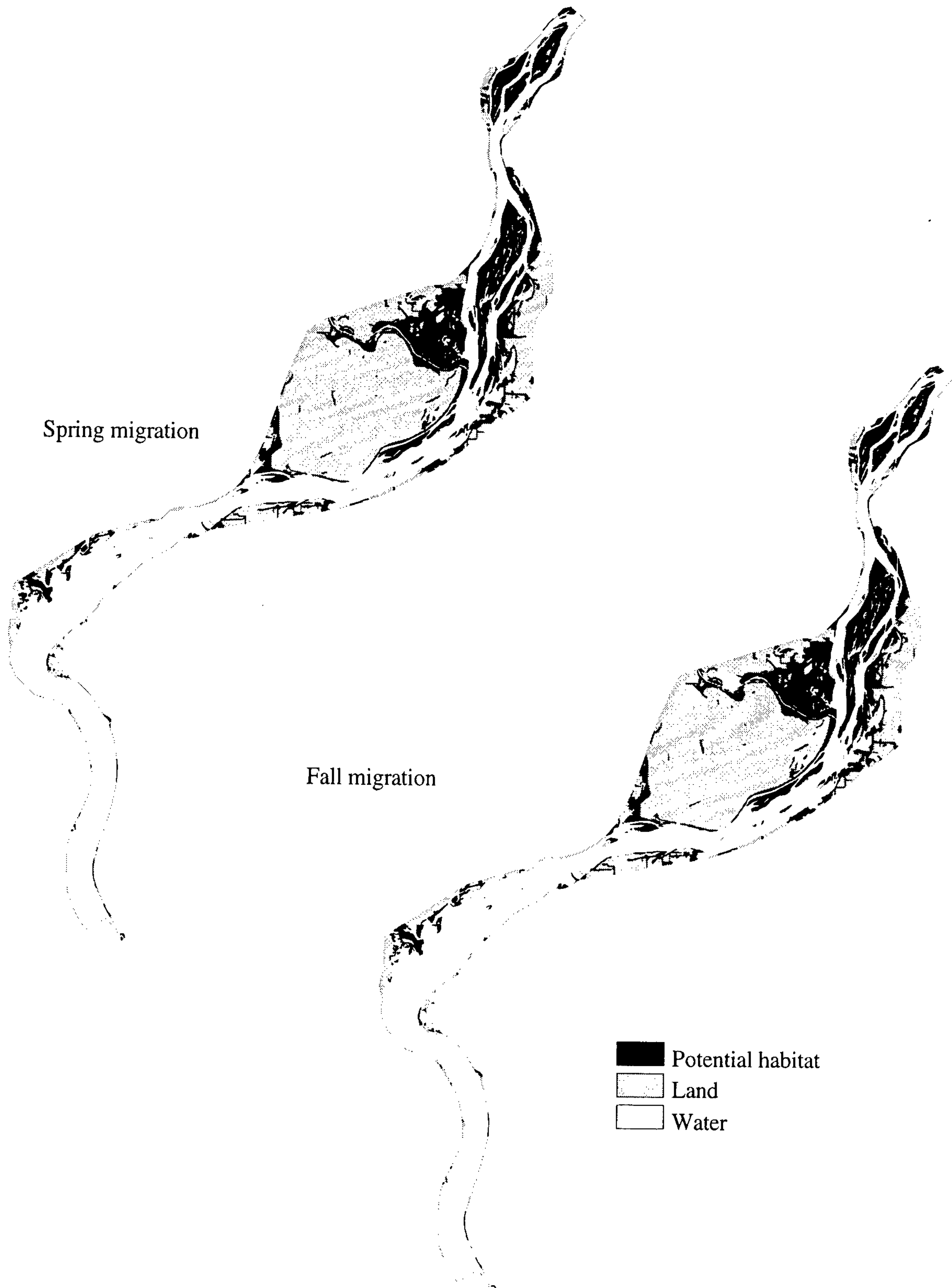


Figure E-67. Potential 1975 spring and fall migration habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 19.

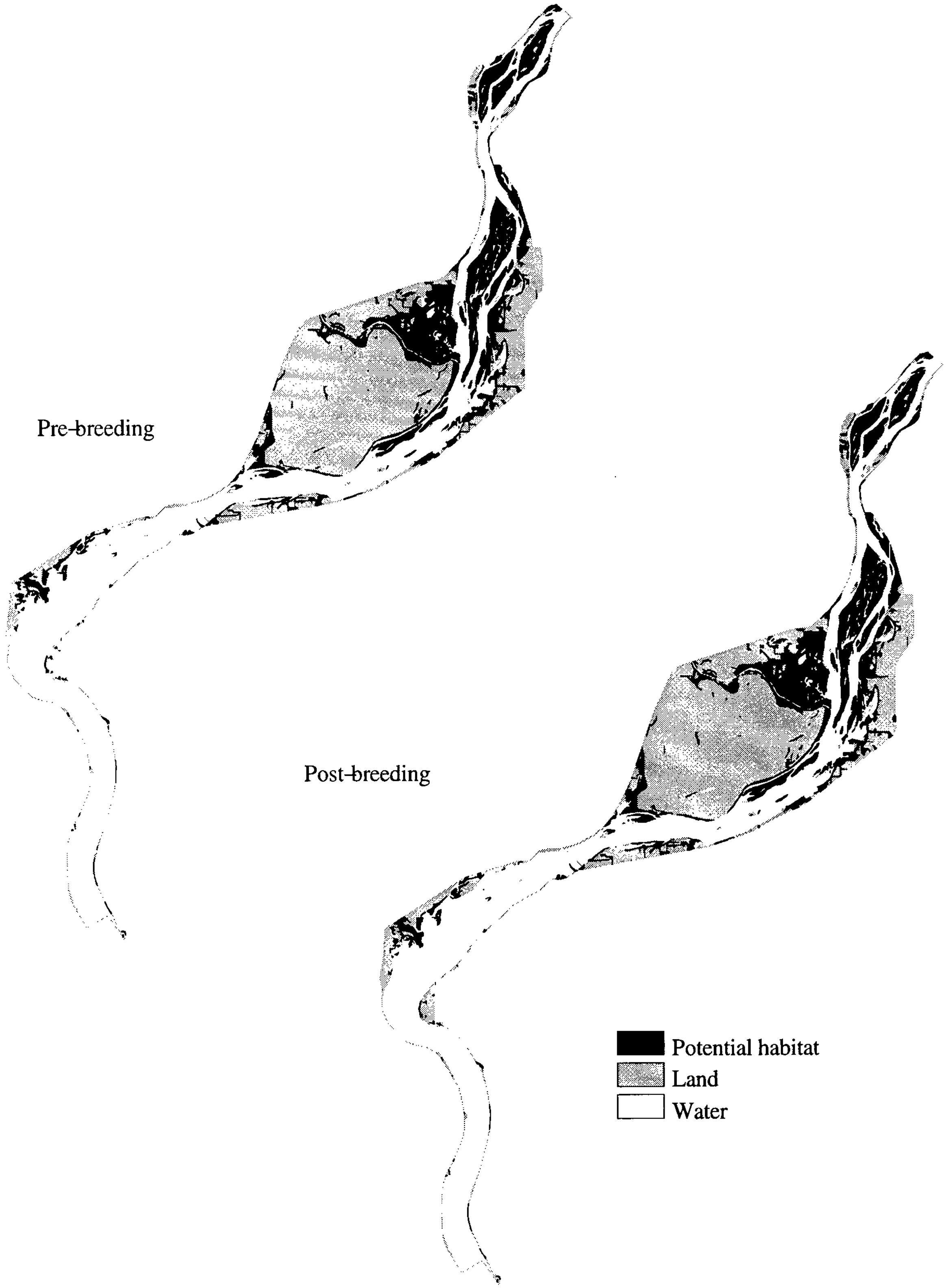


Figure E-68. Potential 1975 pre- and post-breeding habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 19.

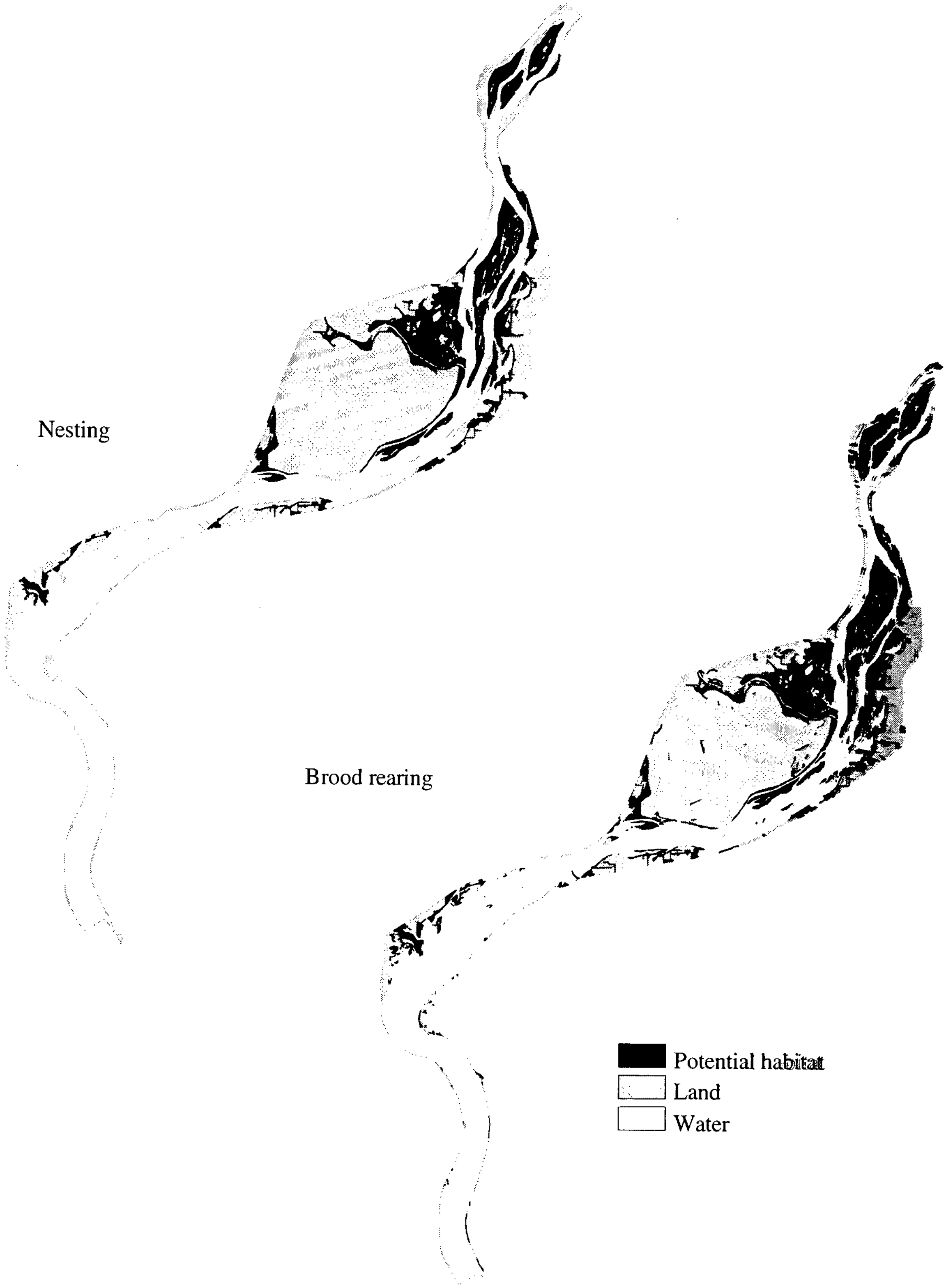


Figure E-69. Potential 1975 nesting and brood rearing habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 19.

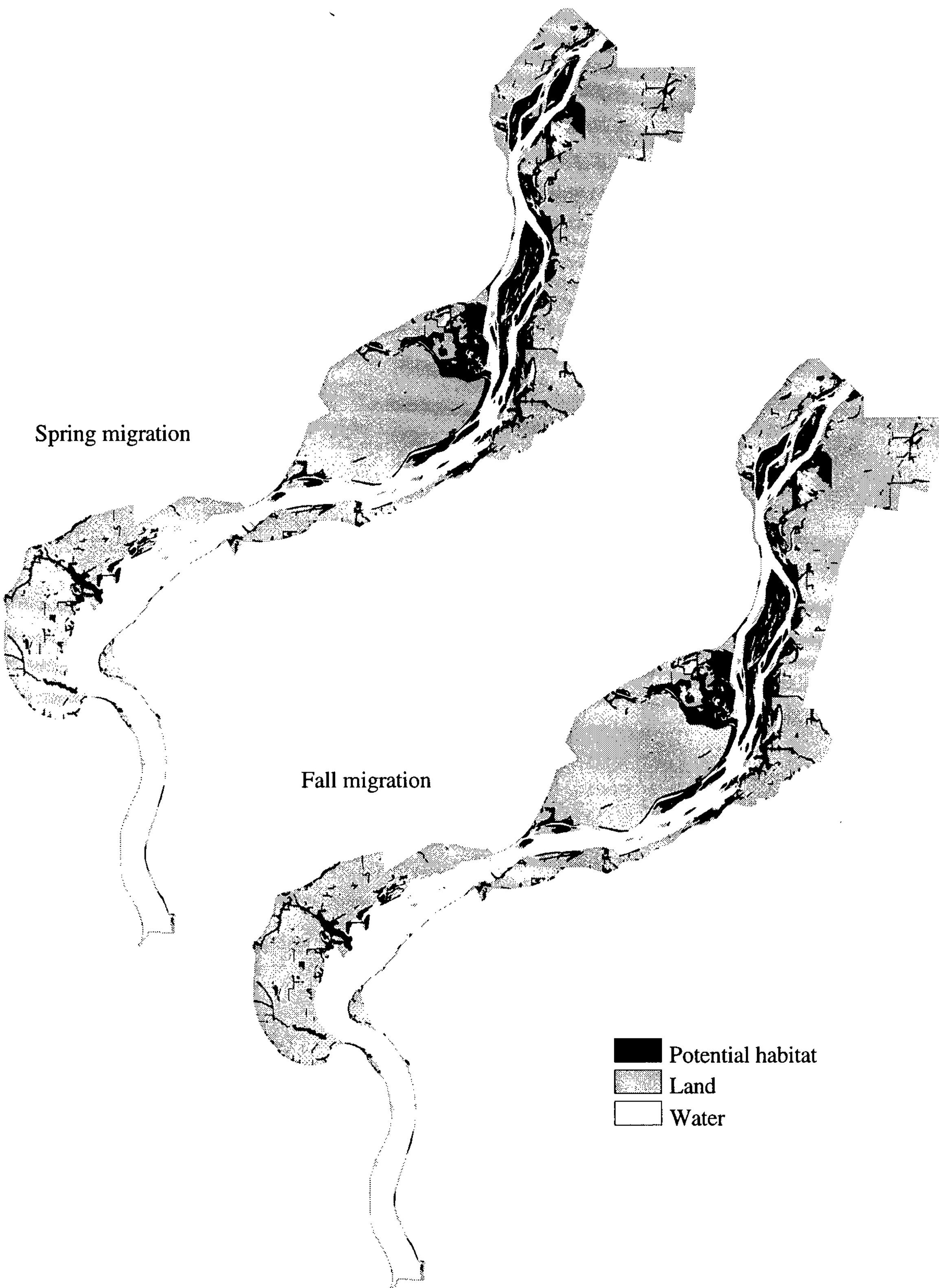


Figure E-70. Potential 1989 spring and fall migration habitat for the cerulean warbler (*Dendroica cerulea)*, Upper Mississippi River Pool 19.

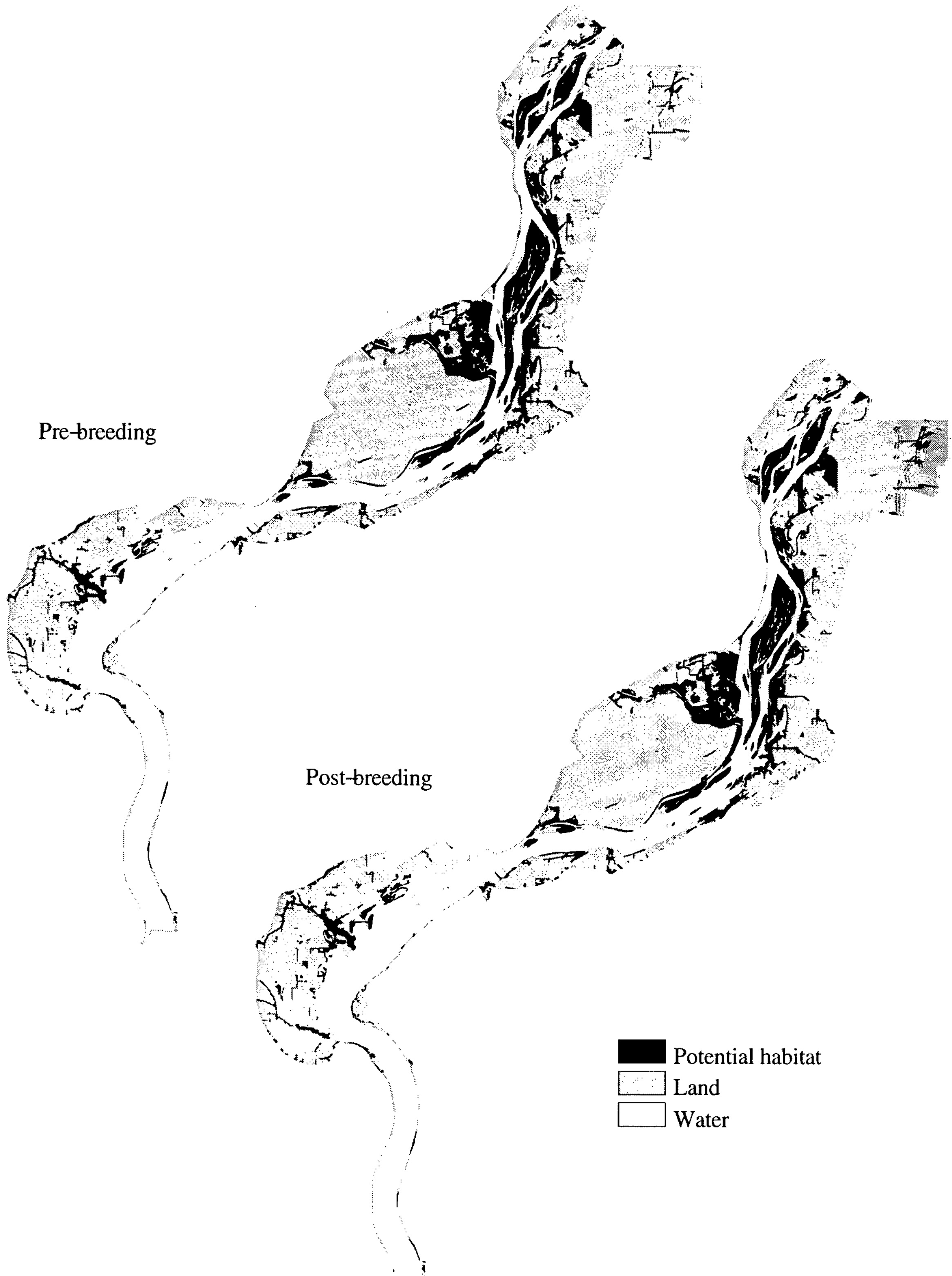


Figure E-71. Potential 1989 pre- and post-breeding habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 19.

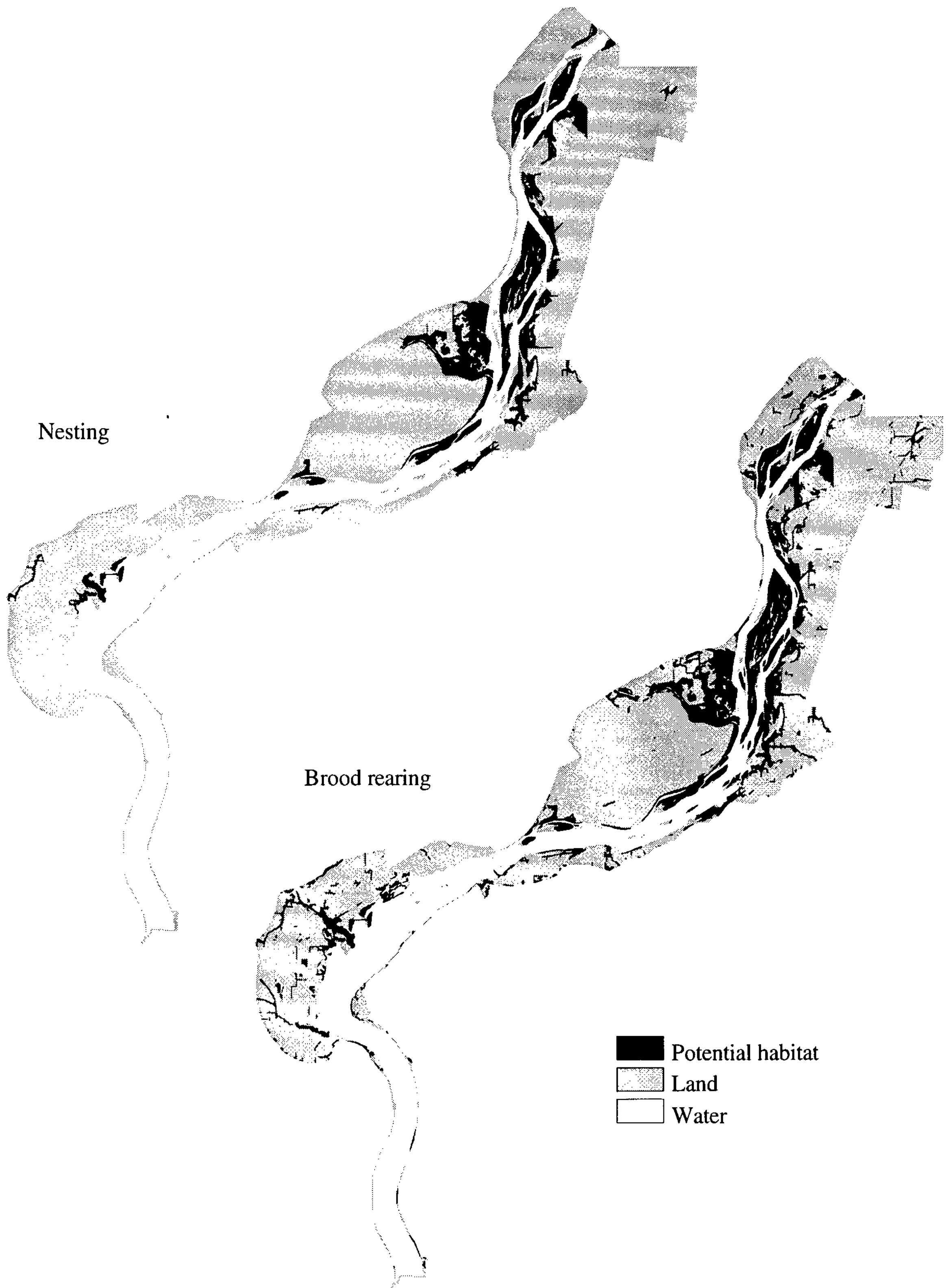


Figure E-72. Potential 1989 nesting and brood rearing habitat for the cerulean warbler (*Dendroica cerulea*), Upper Mississippi River Pool 19.

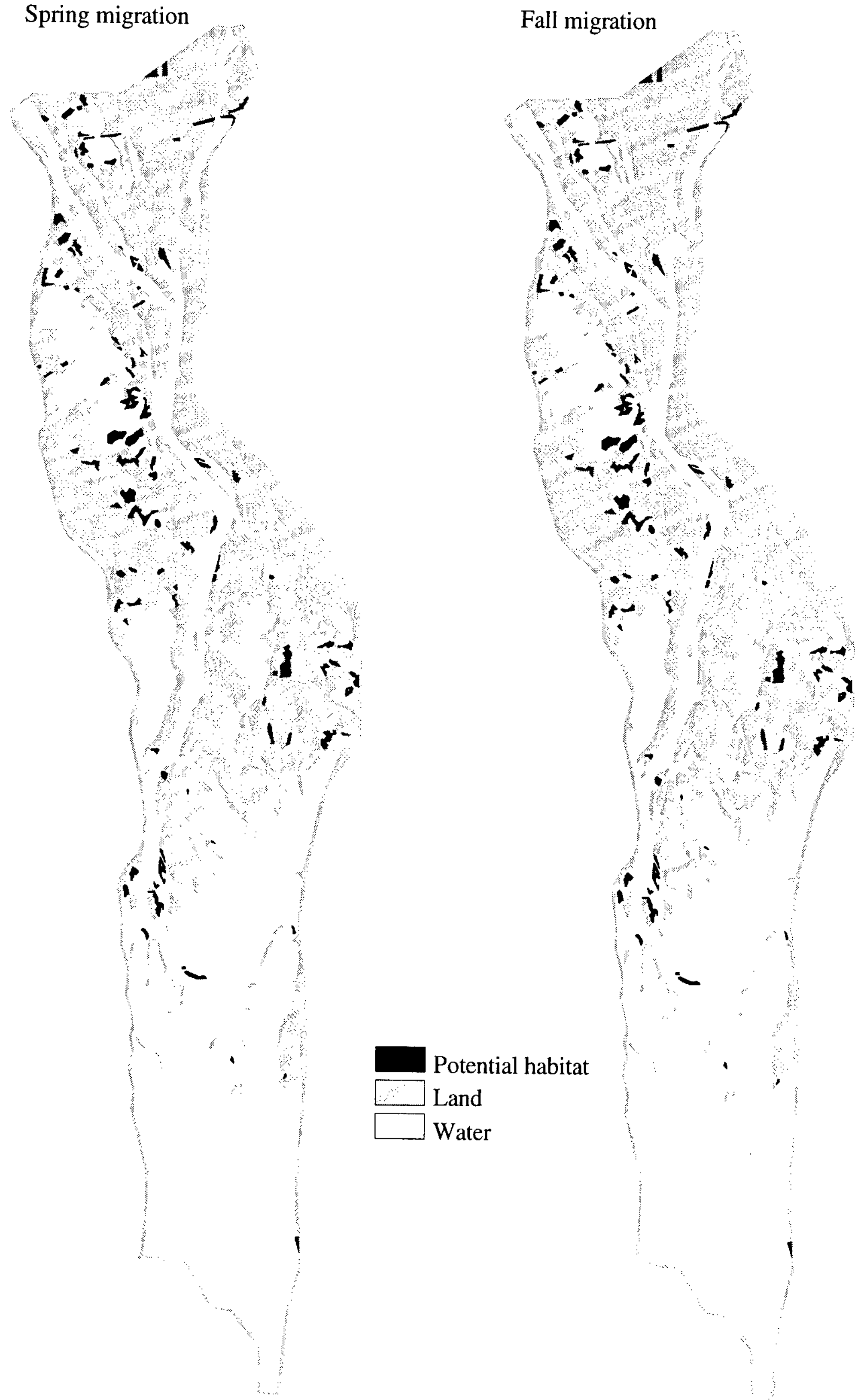


Figure E-73. Potential 1975 spring and fall migration habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 8.

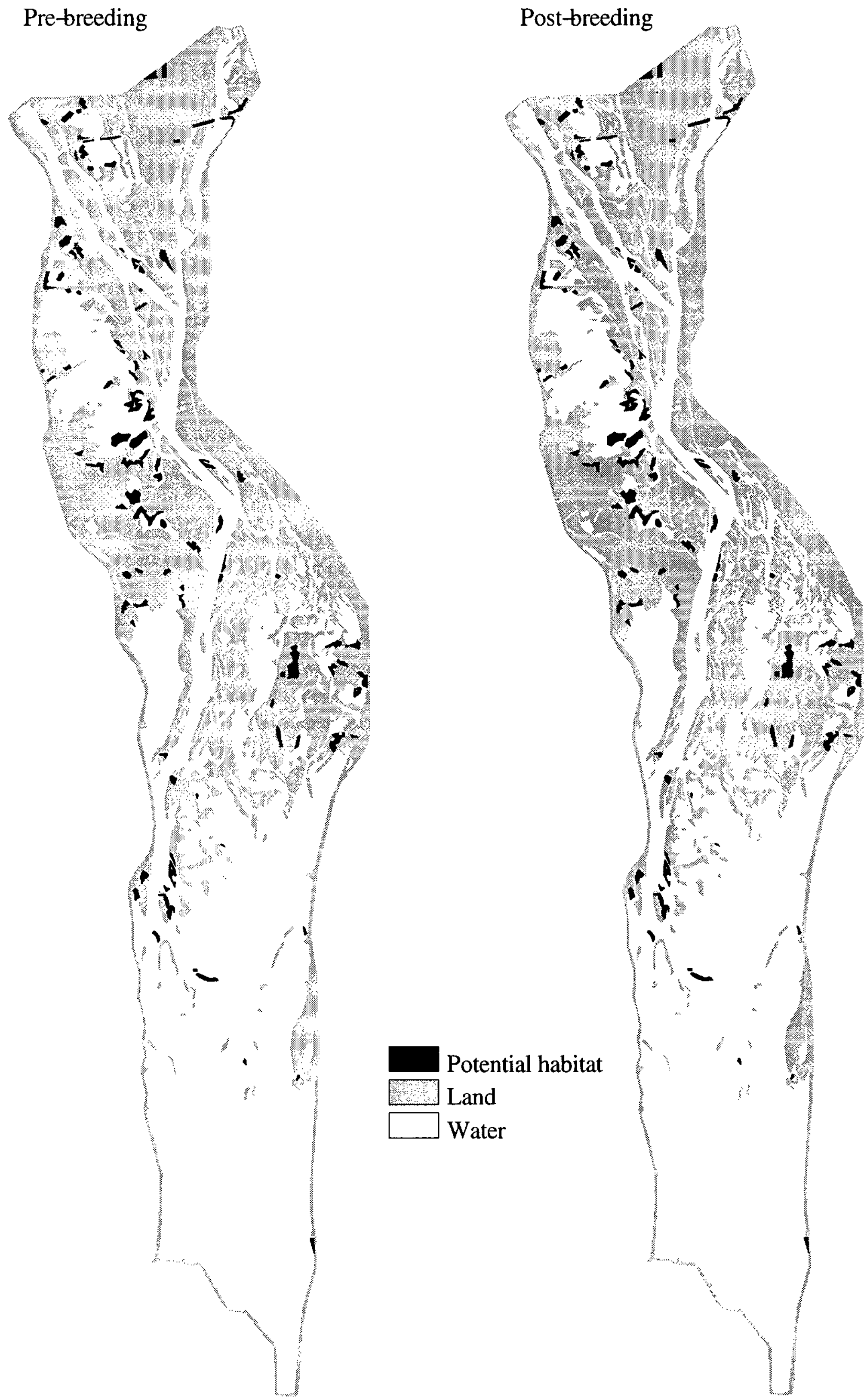


Figure E-74. Potential 1975 pre- and post-breeding habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 8.

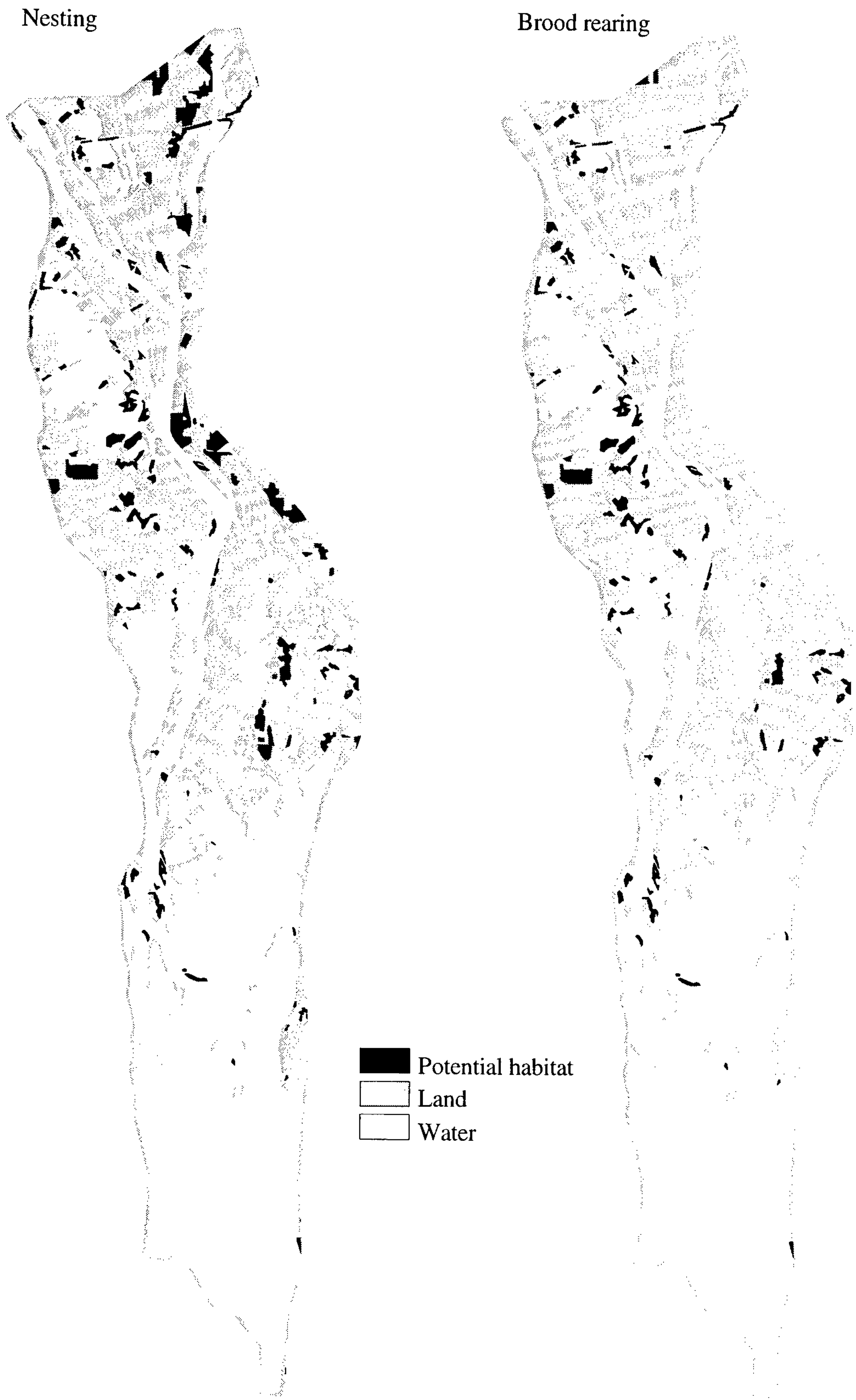


Figure E-75. Potential 1975 nesting and brood rearing habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 8.

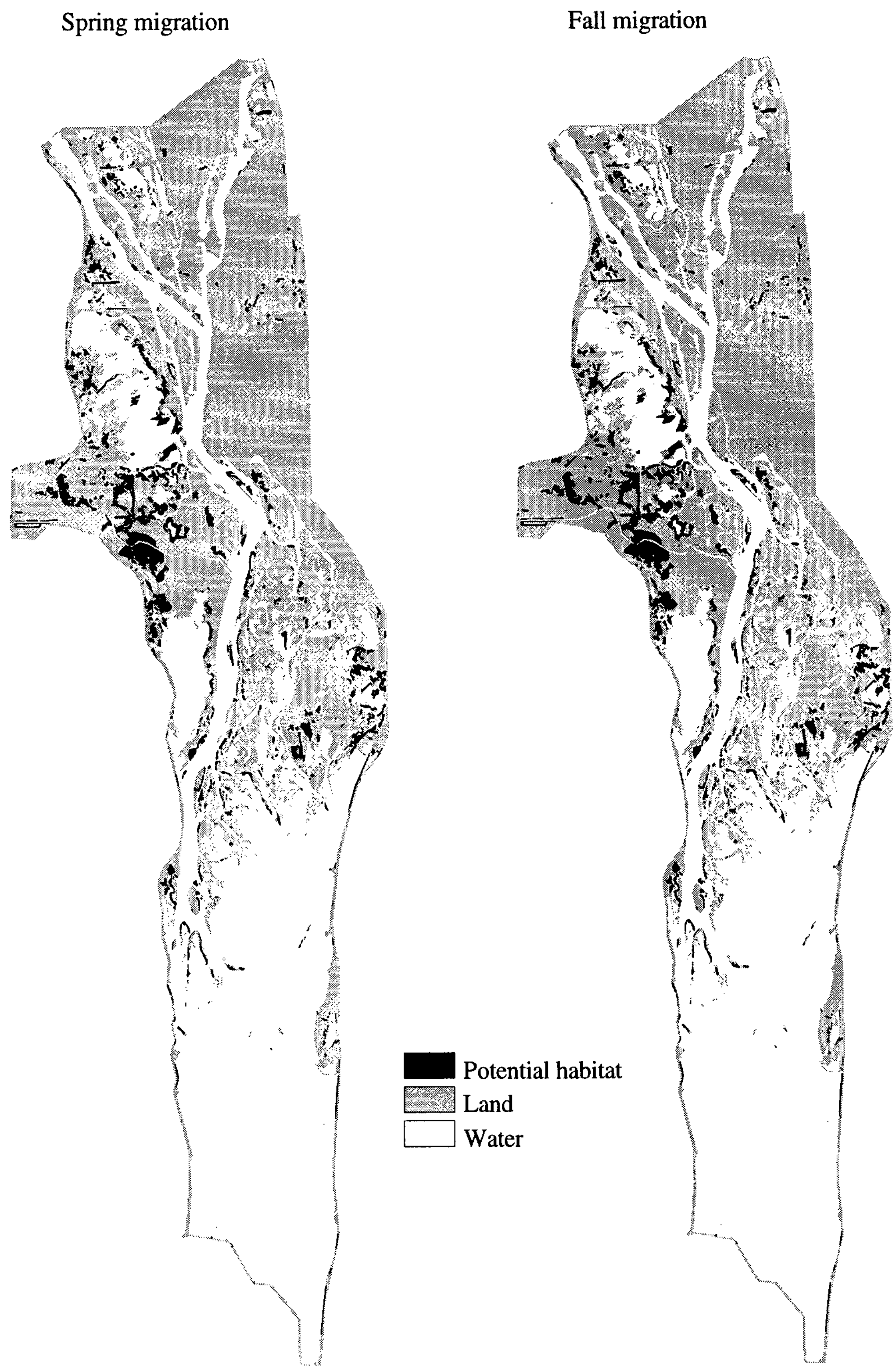


Figure E-76. Potential 1989 spring and fall migration habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 8.

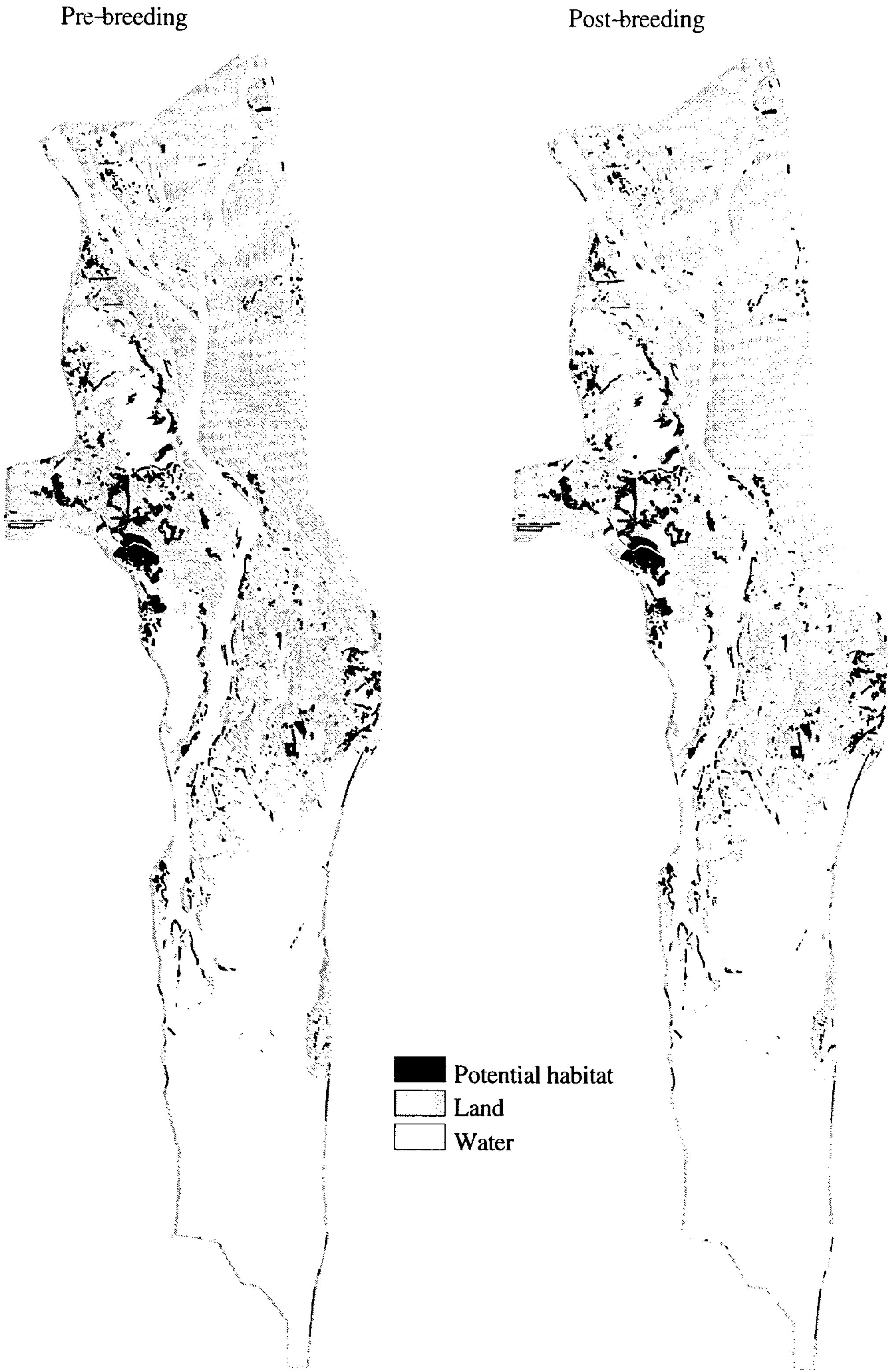


Figure E-77. Potential 1989 pre- and post-breeding habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 8.

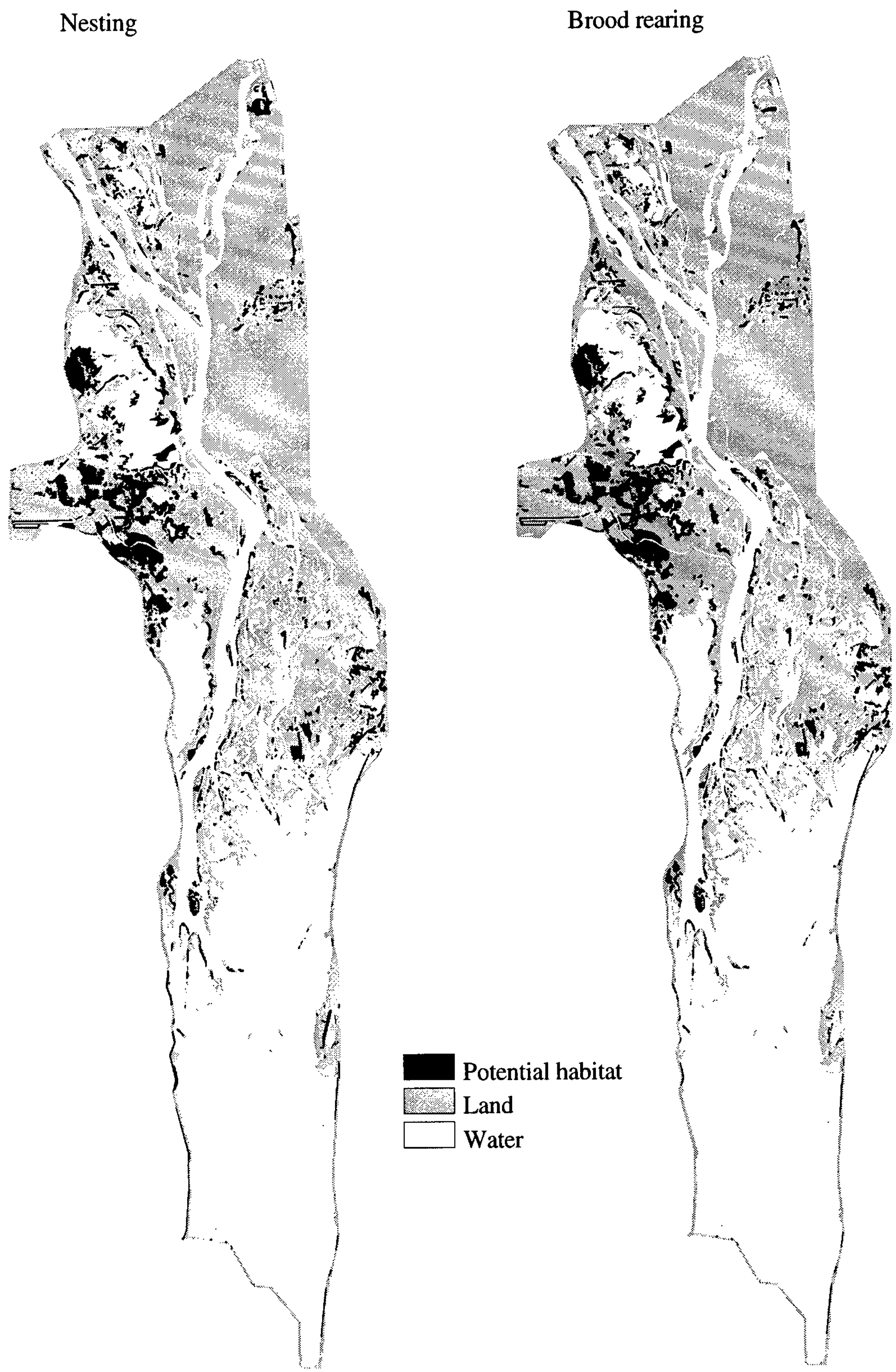


Figure E-78. Potential 1989 nesting and brood rearing habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 8.

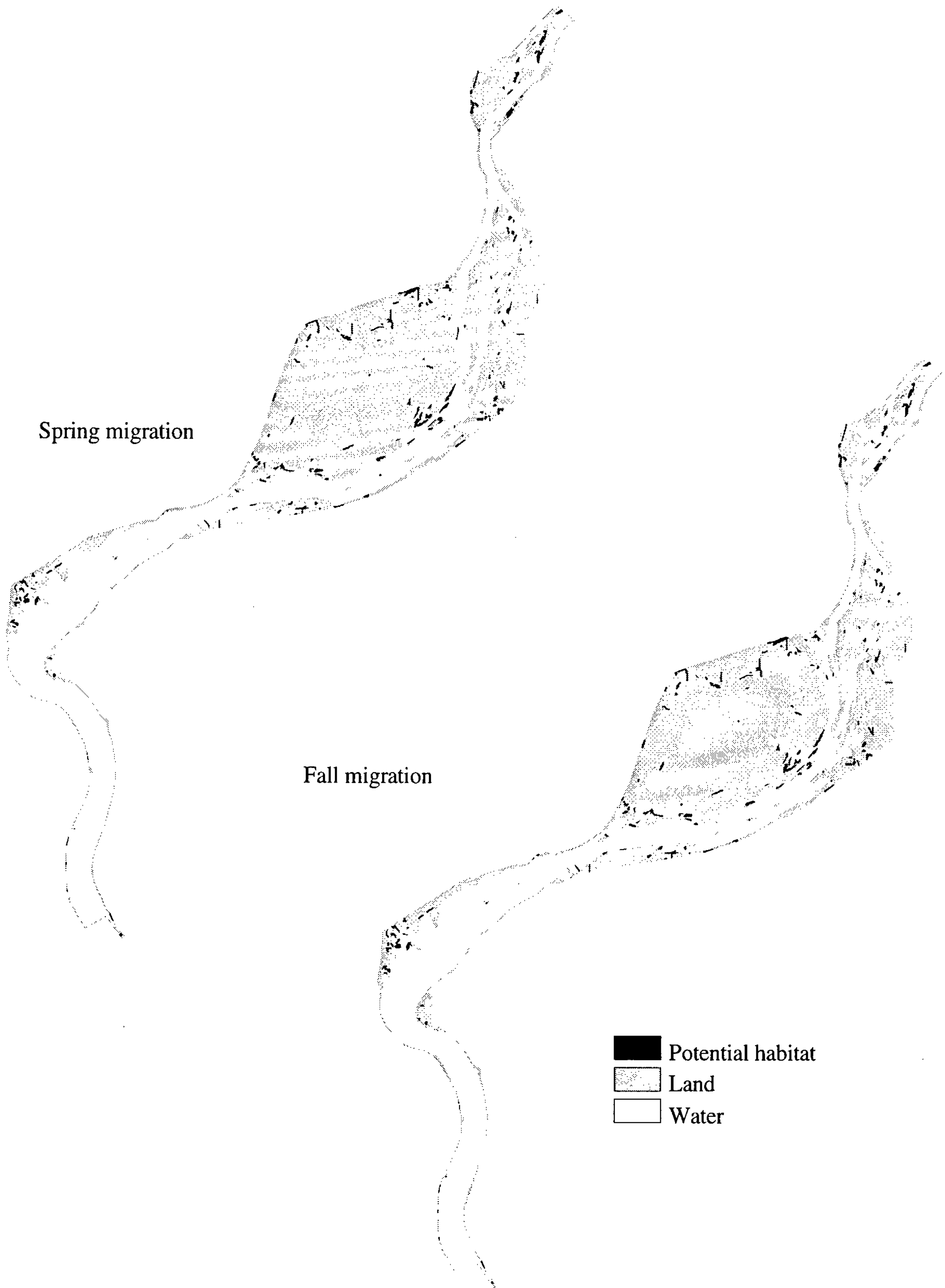


Figure E-79. Potential 1975 spring and fall migration habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 19.

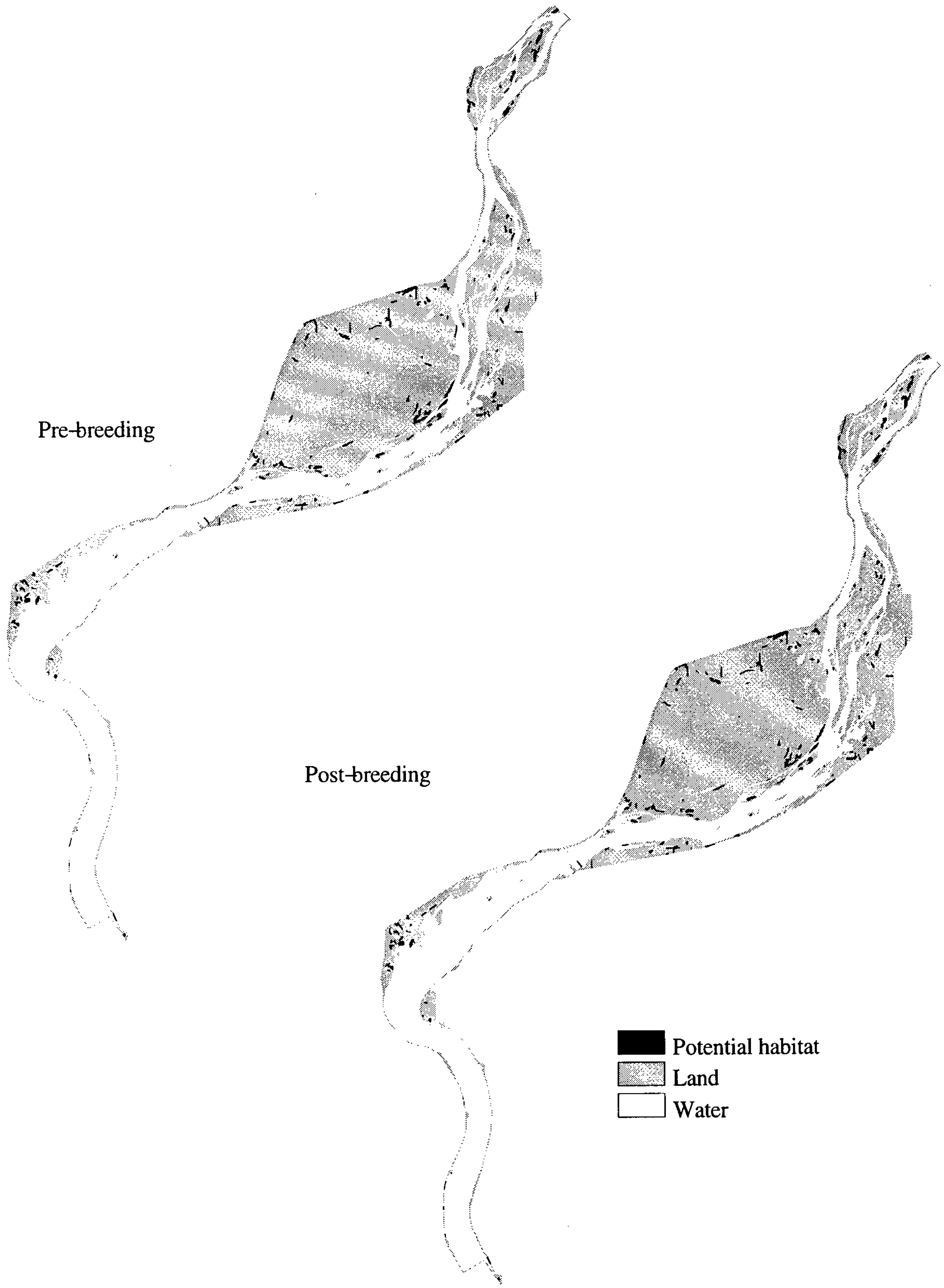


Figure E-80. Potential 1975 pre- and post-breeding habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 19.

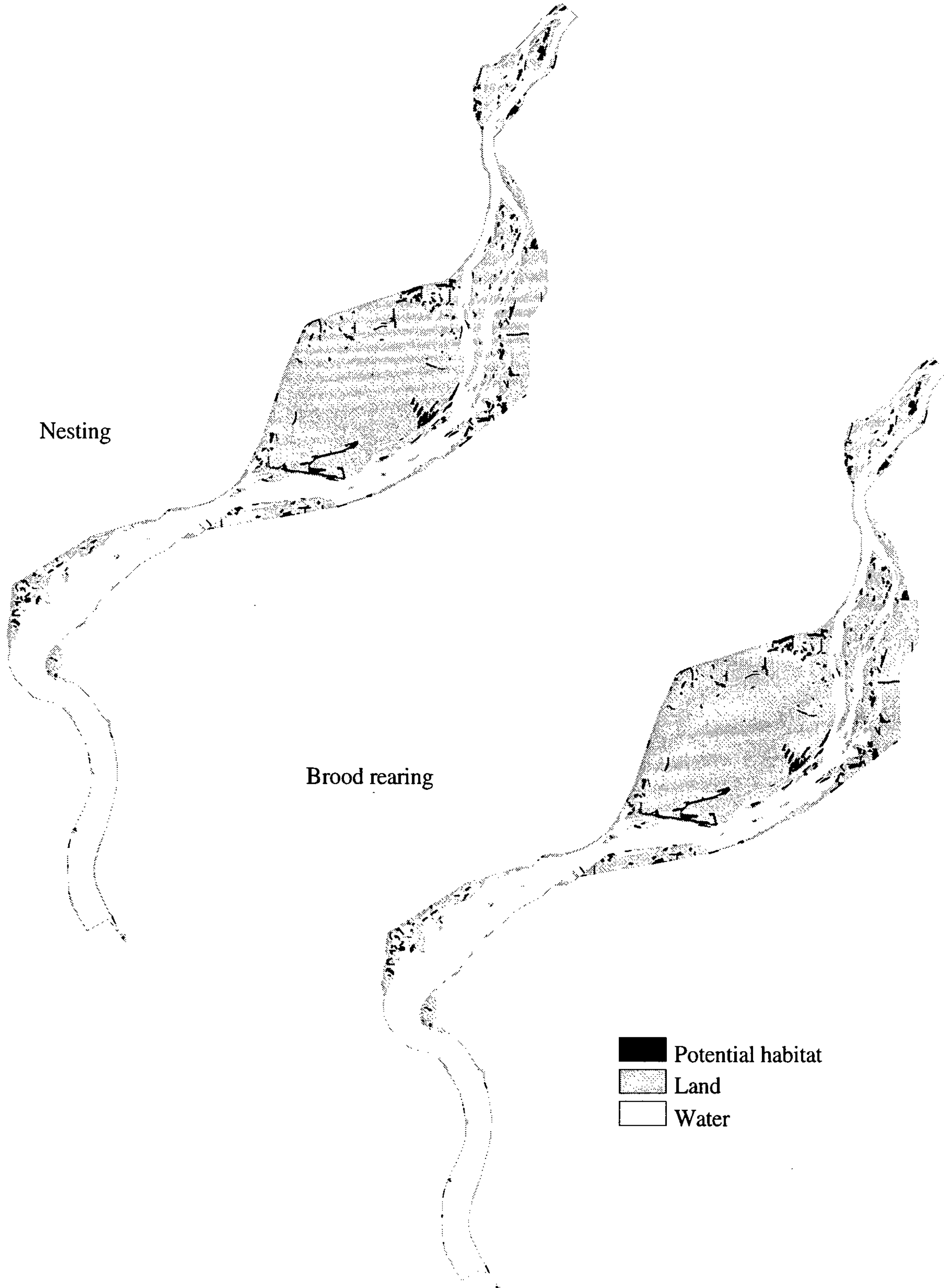


Figure E-81. Potential 1975 nesting and brood rearing habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 19.

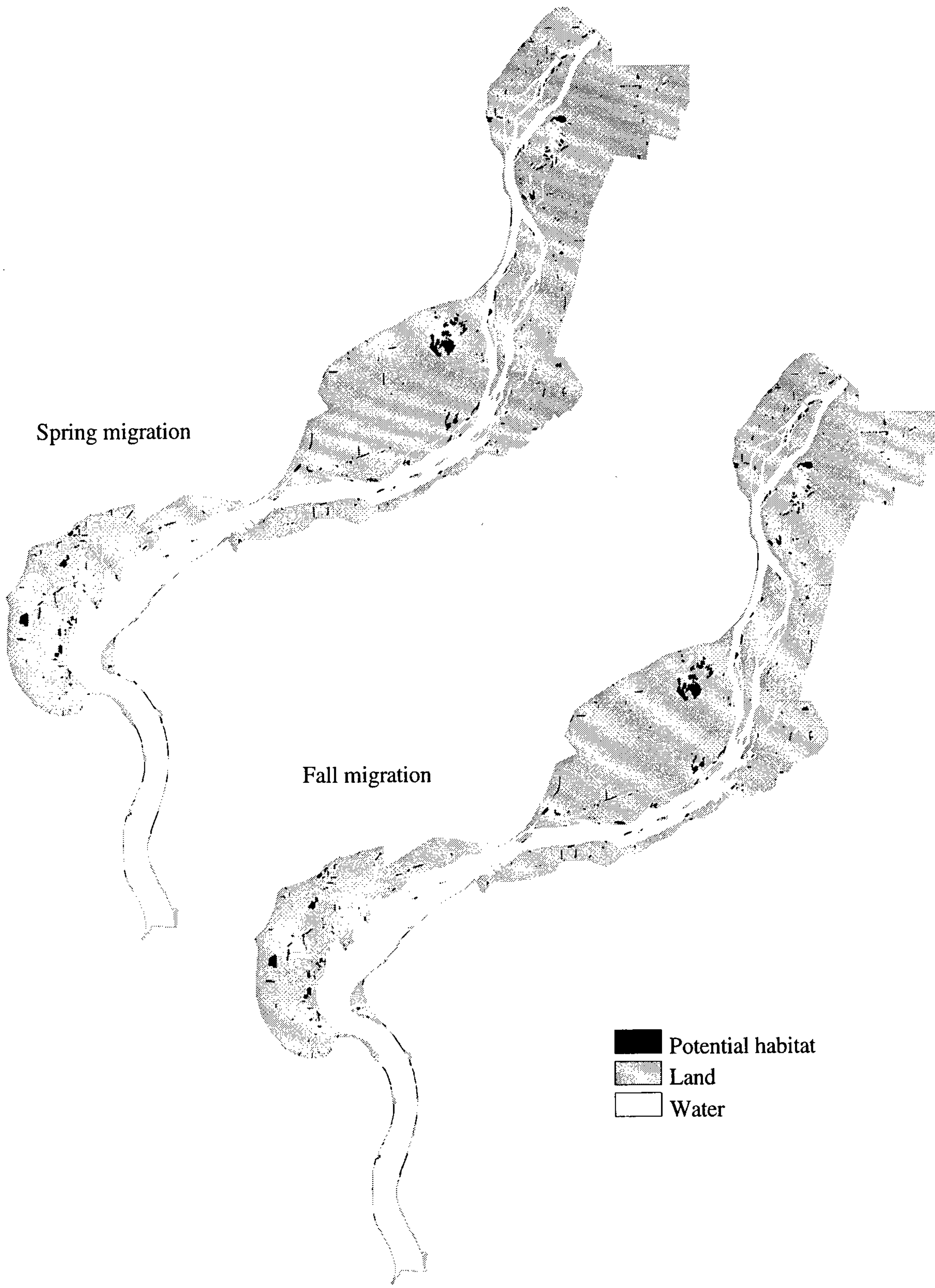


Figure E-82. Potential 1989 spring and fall migration habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 19.

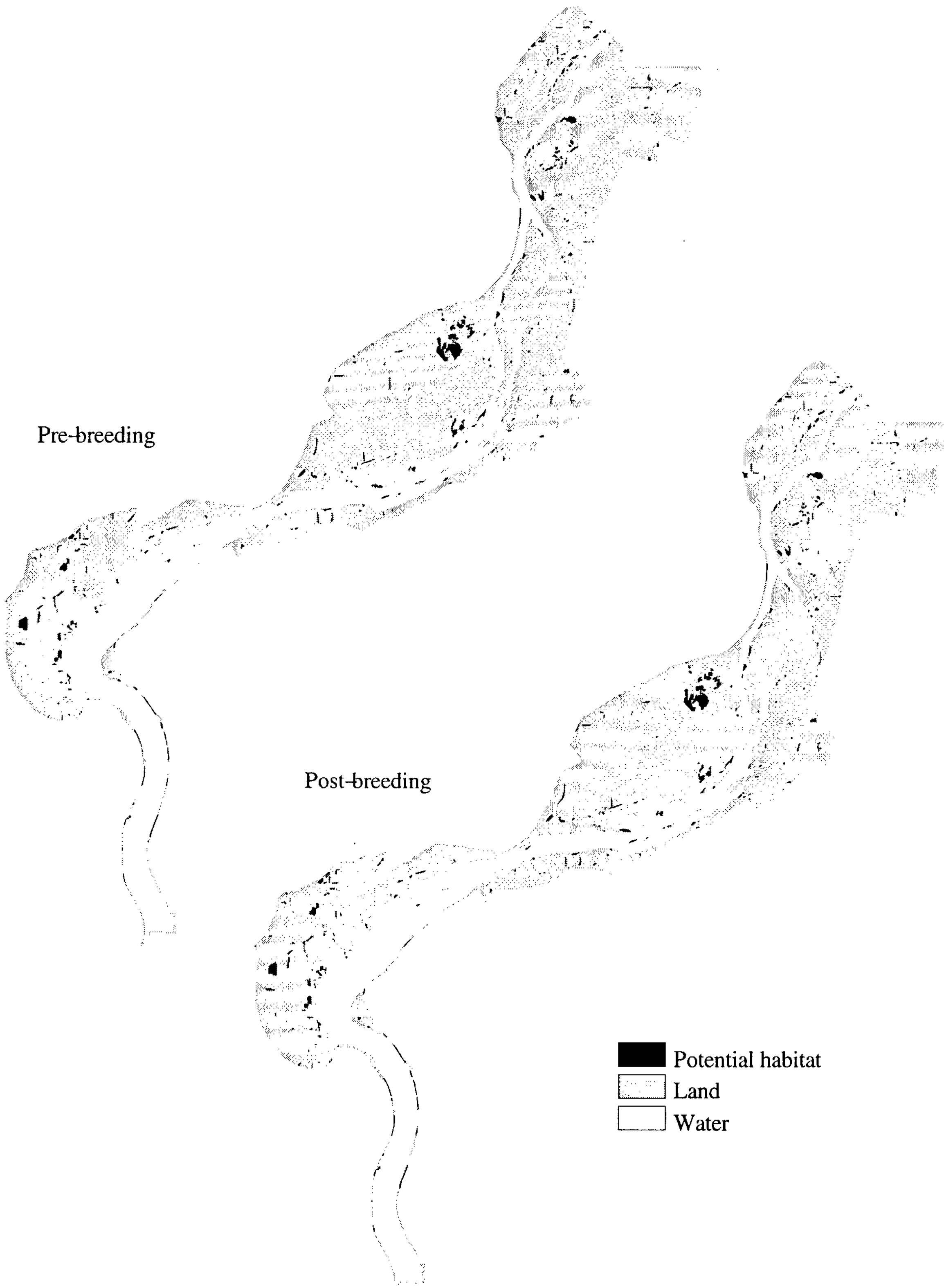


Figure E-83. Potential 1989 pre- and post-breeding habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 19.

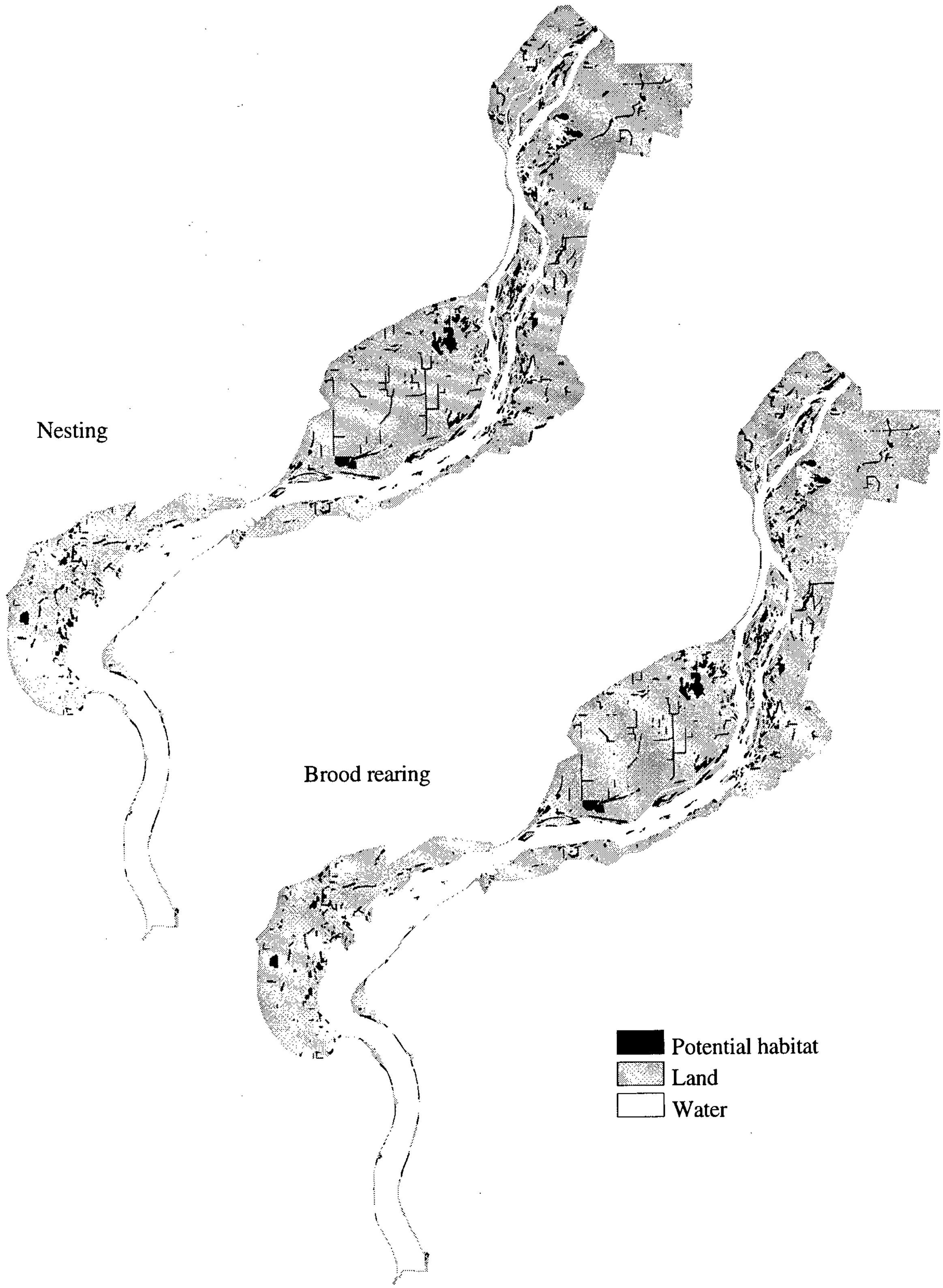


Figure E-84. Potential 1989 nesting and brood rearing habitat for the golden-winged warbler (*Vermivora chrysoptera*), Upper Mississippi River Pool 19.

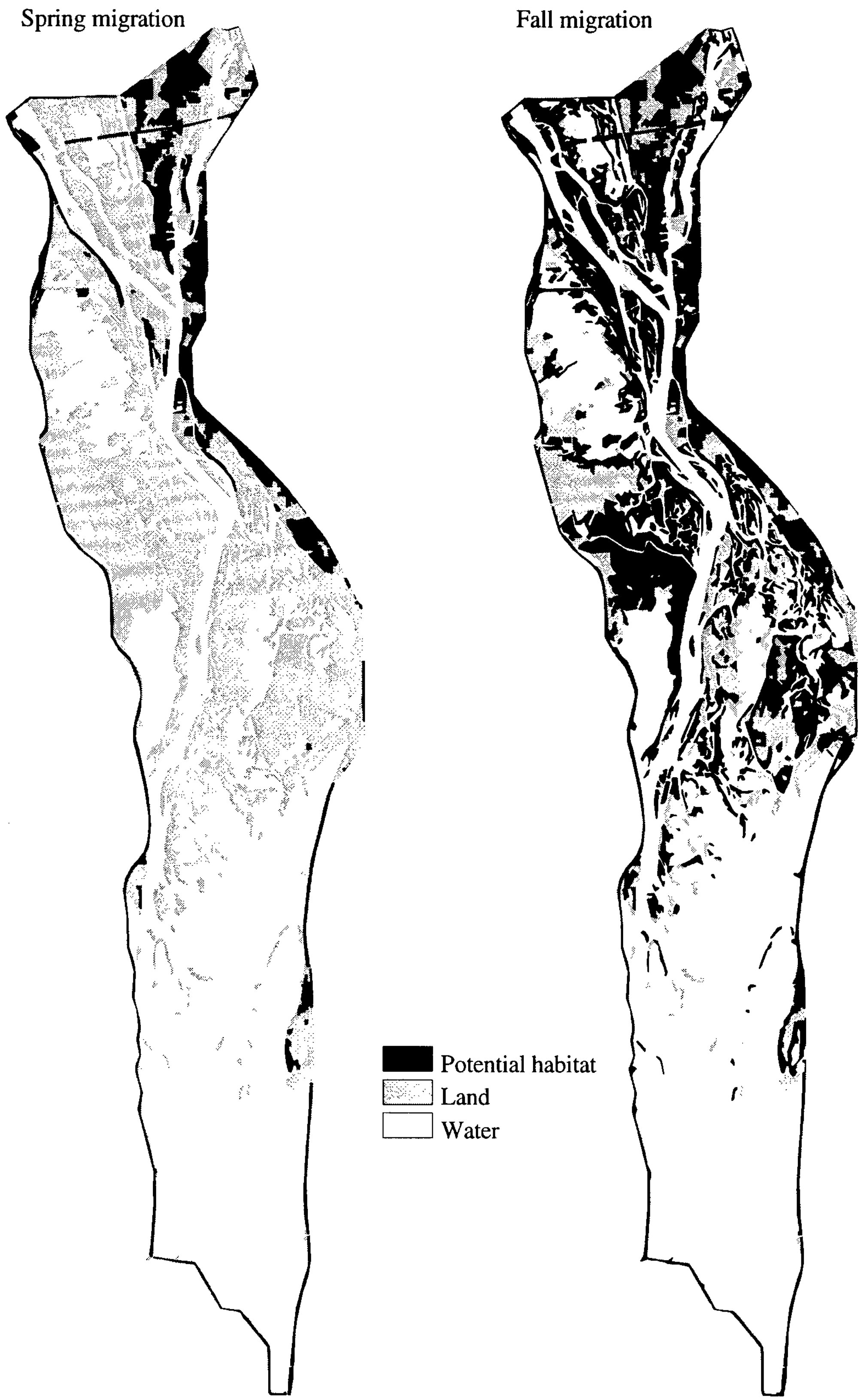


Figure E-85. Potential 1975 spring and fall migration habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 8.

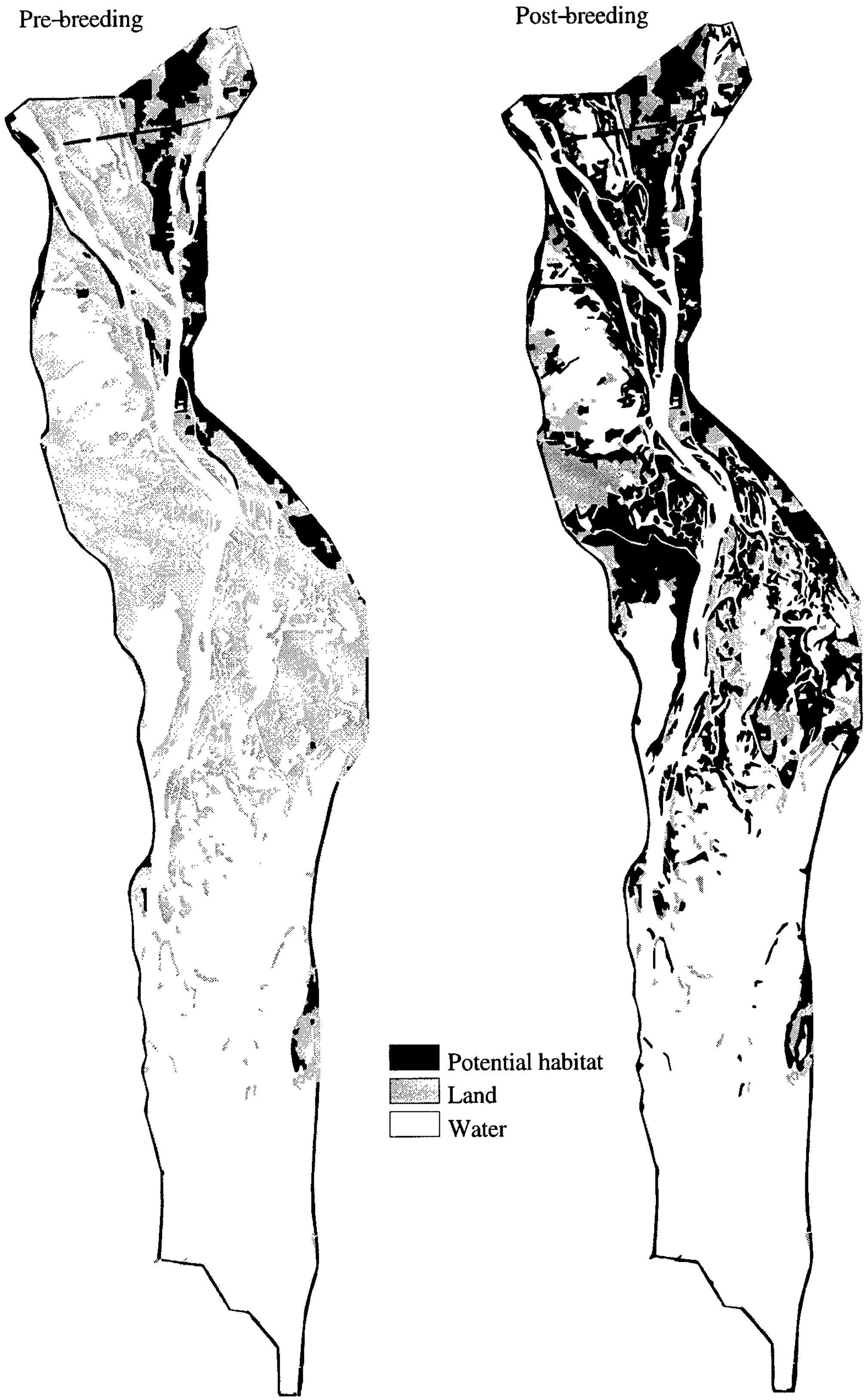


Figure E-86. Potential 1975 pre- and post-breeding habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 8.

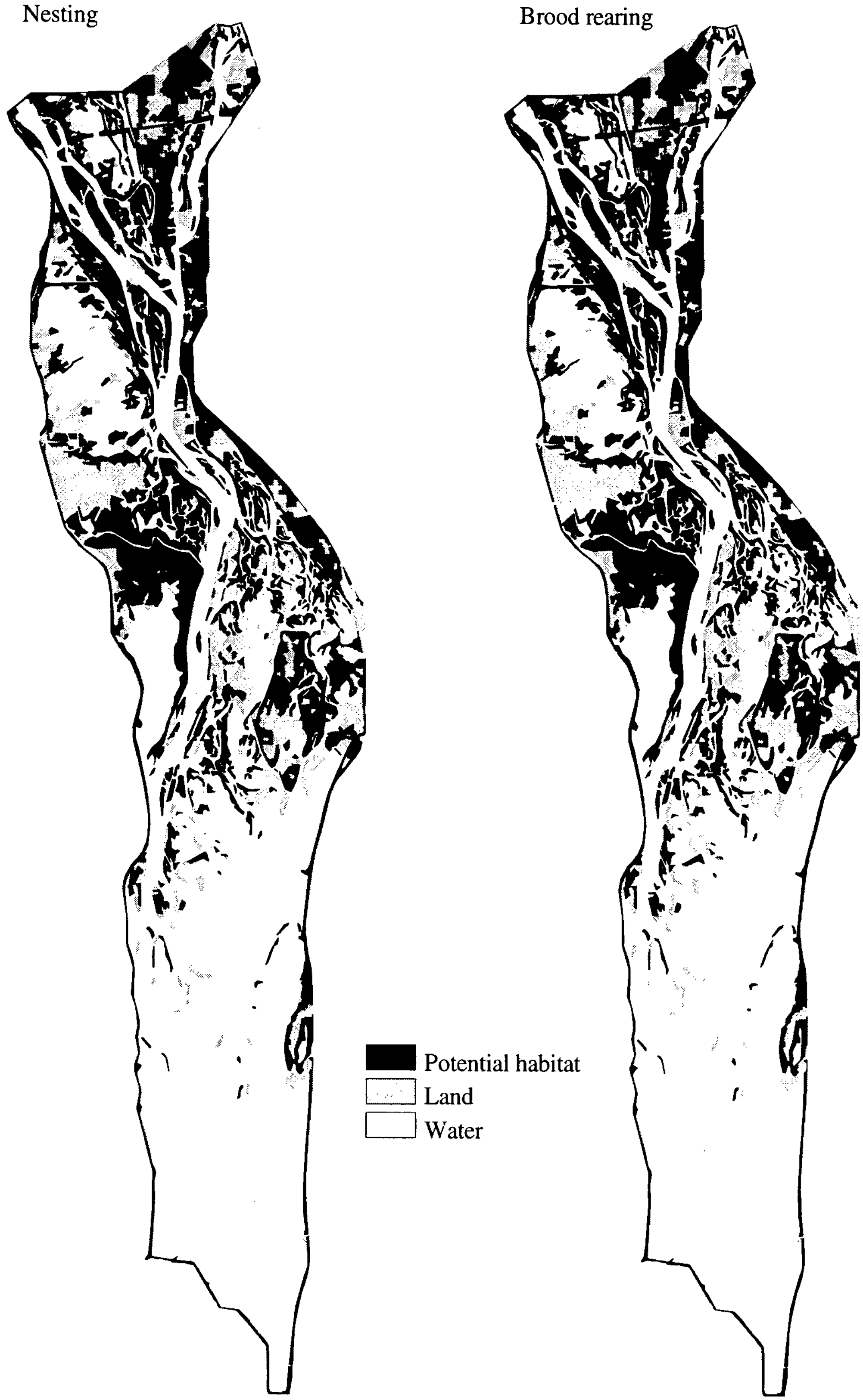


Figure E-87. Potential 1975 nesting and brood rearing habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 8.

Figure E-88. Potential 1989 spring and fall migration habitat for the wood thrush, (*Hylocichla mustelina*) Upper Mississippi River Pool 8.

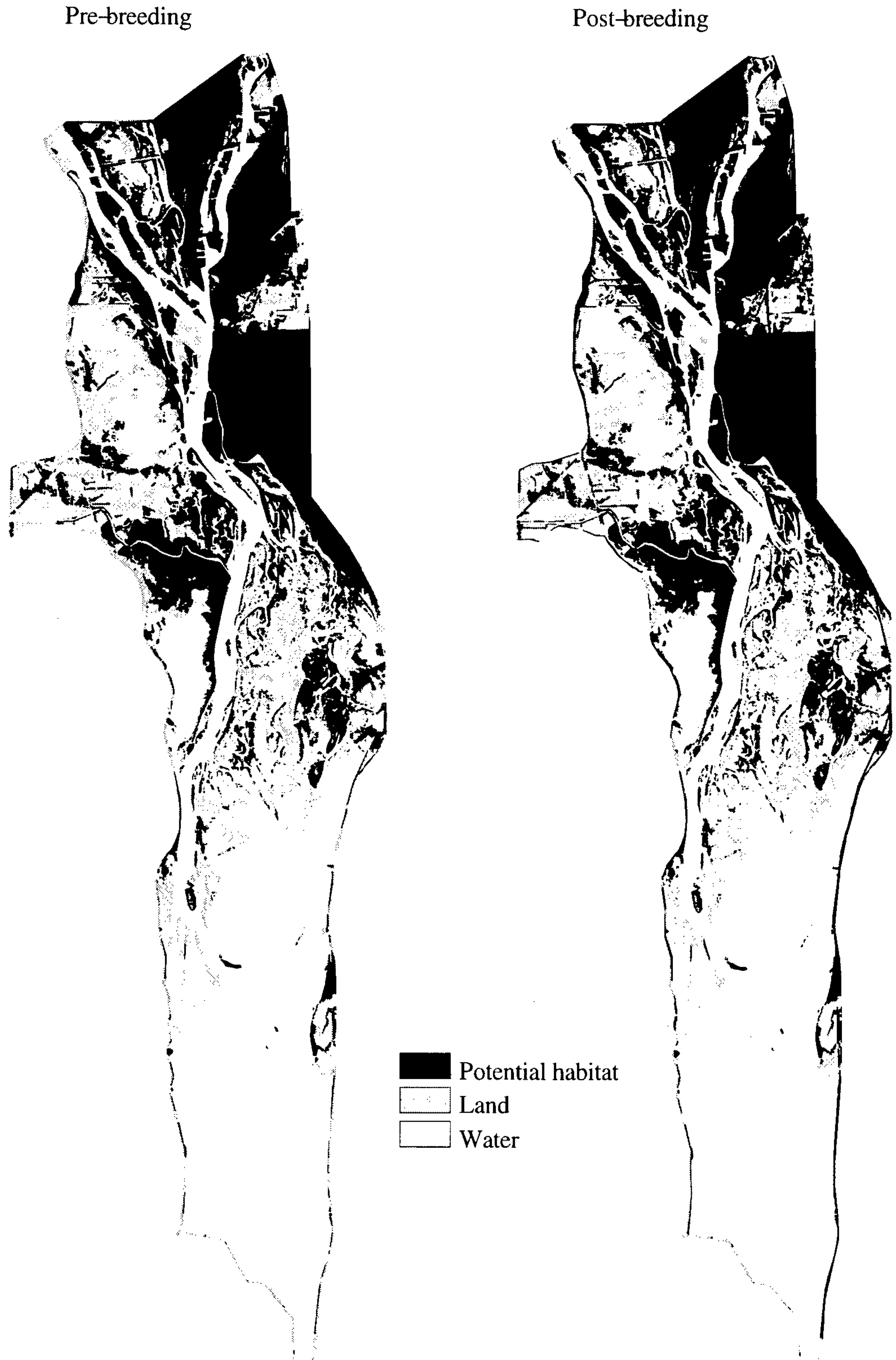


Figure E-89. Potential 1989 pre- and post-breeding habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 8.

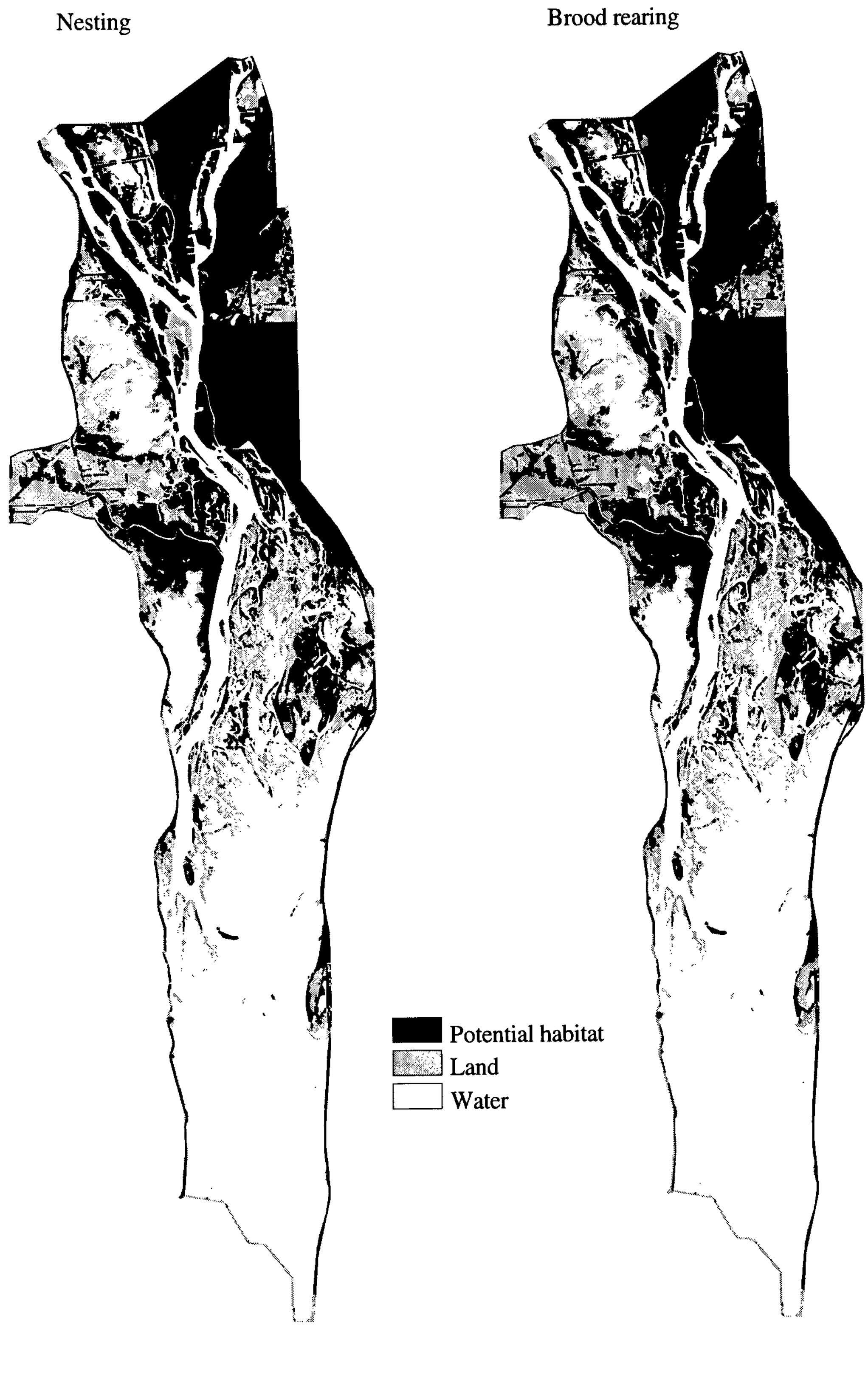


Figure E-90. Potential 1989 nesting and brood rearing habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 8.

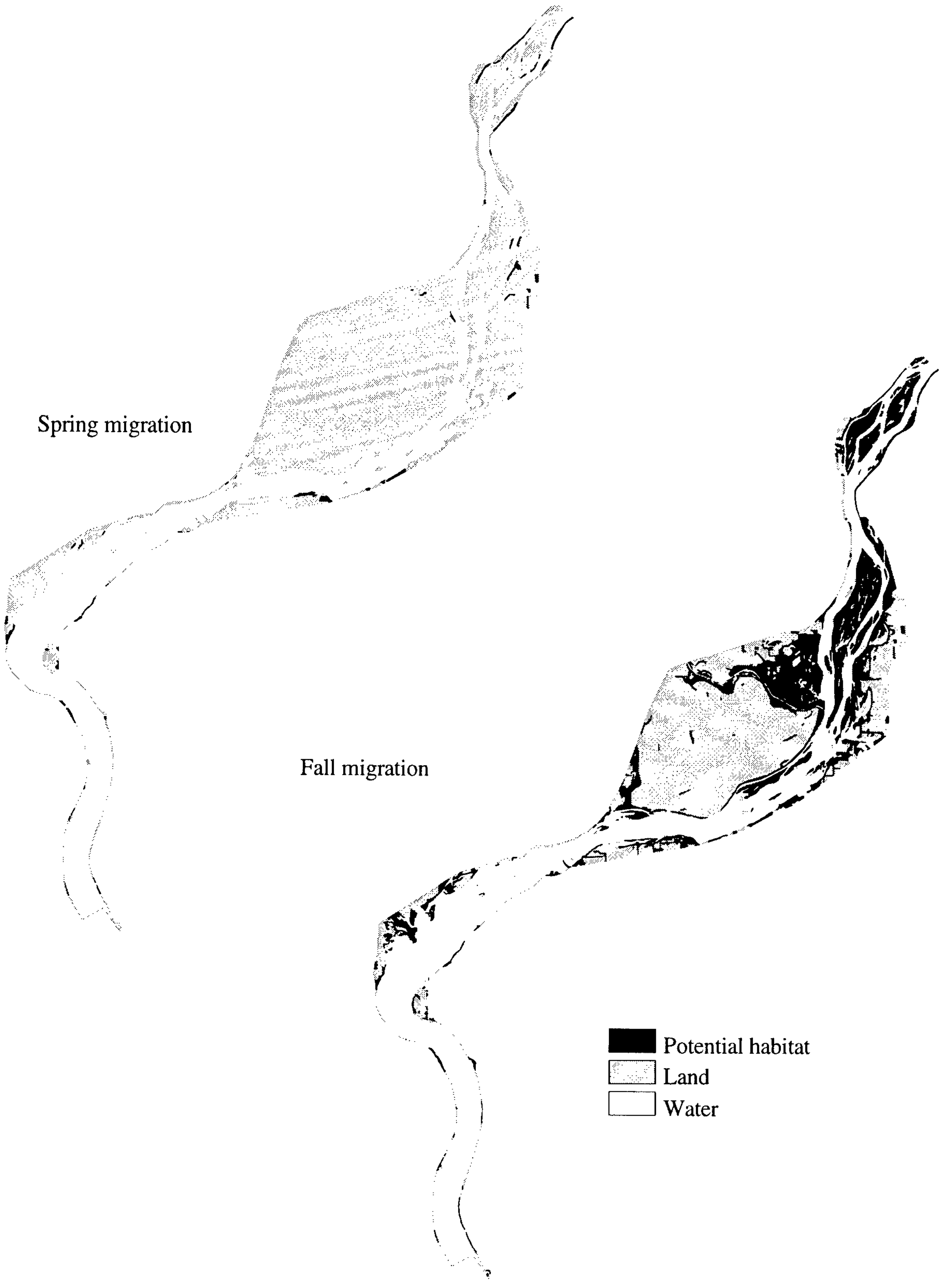


Figure E-91. Potential 1975 spring and fall migration habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 19.

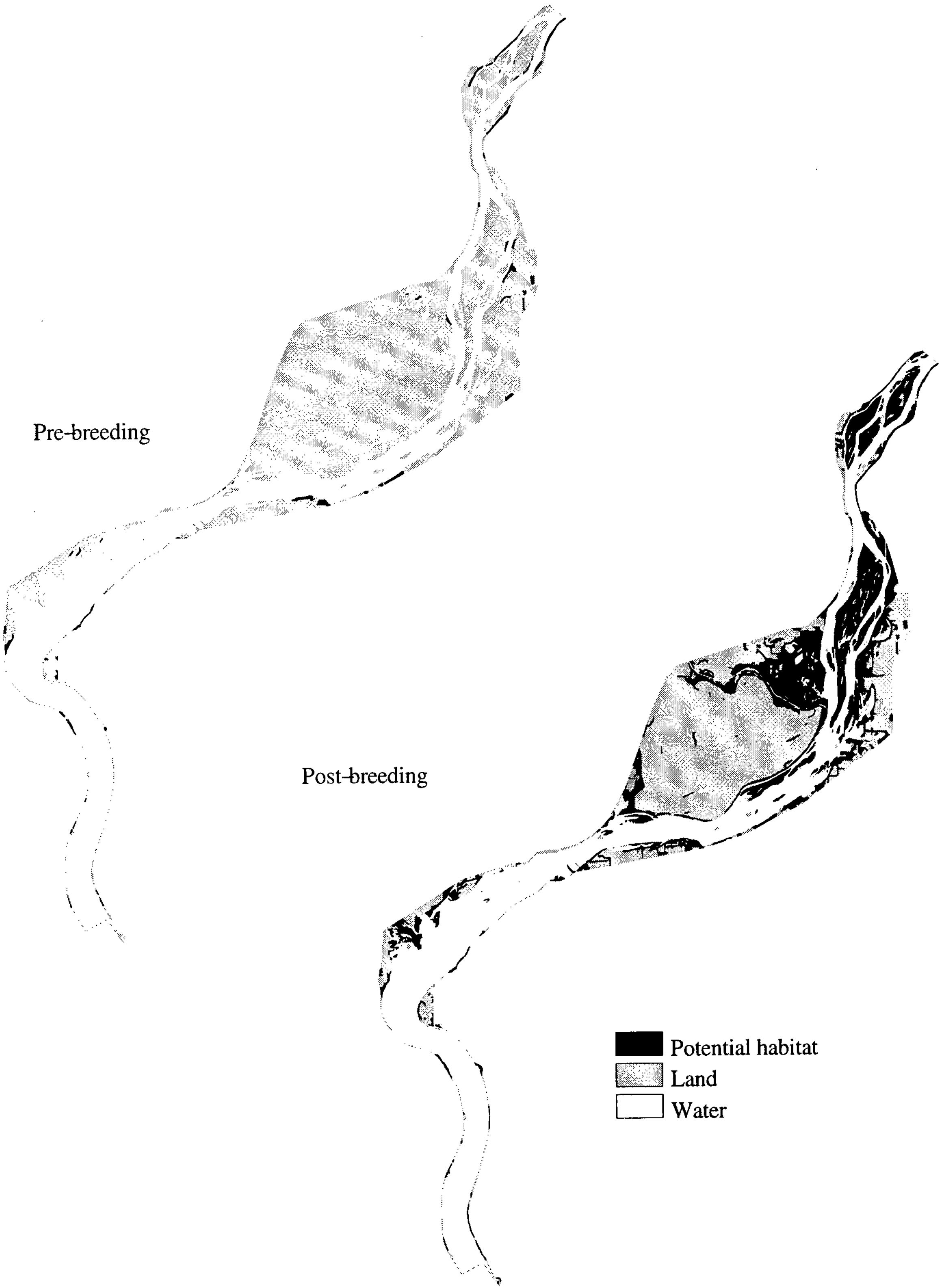


Figure E-92. Potential 1975 pre- and post-breeding habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 19.

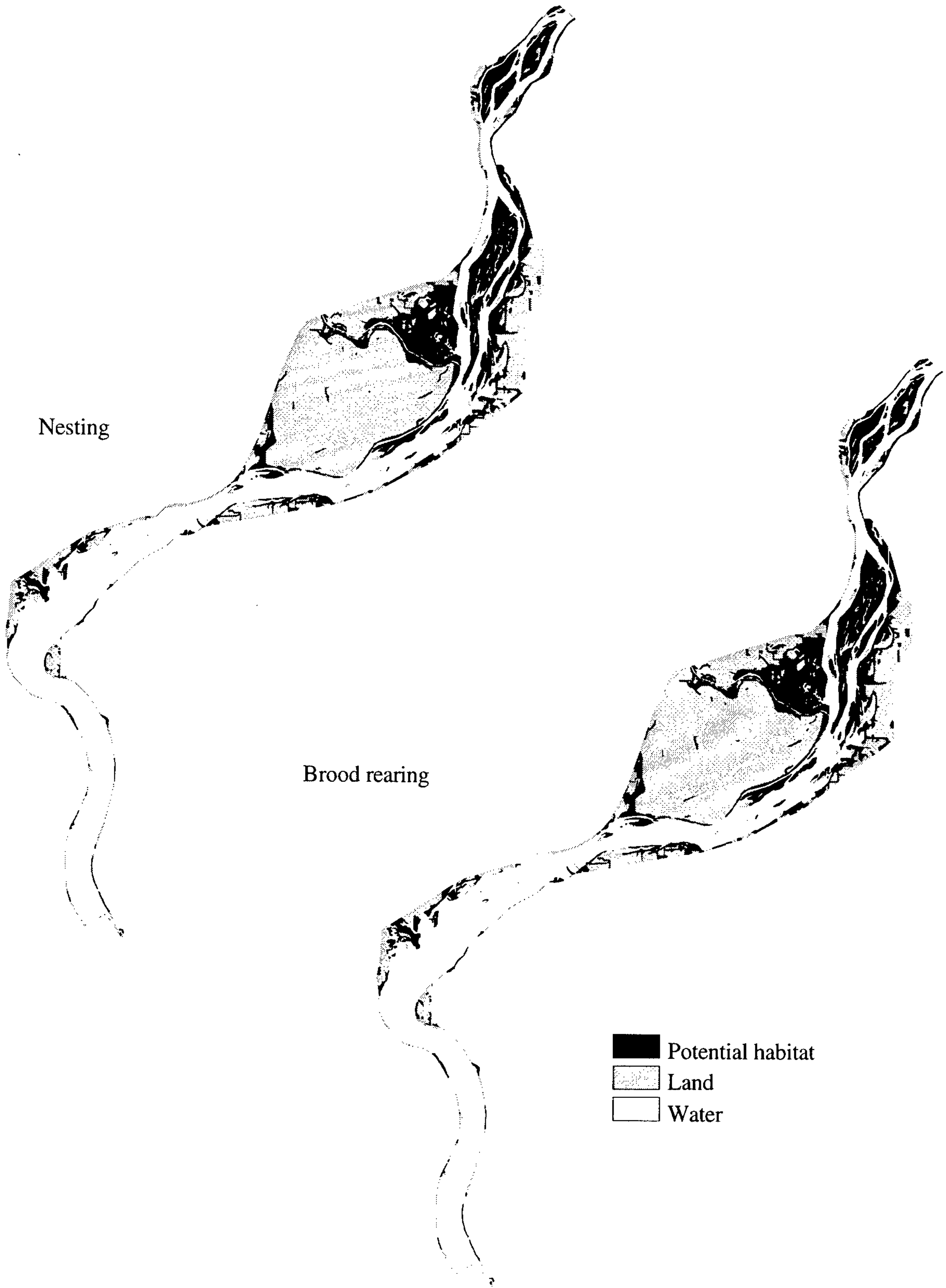


Figure E-93. Potential 1975 nesting and brood rearing habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 19.

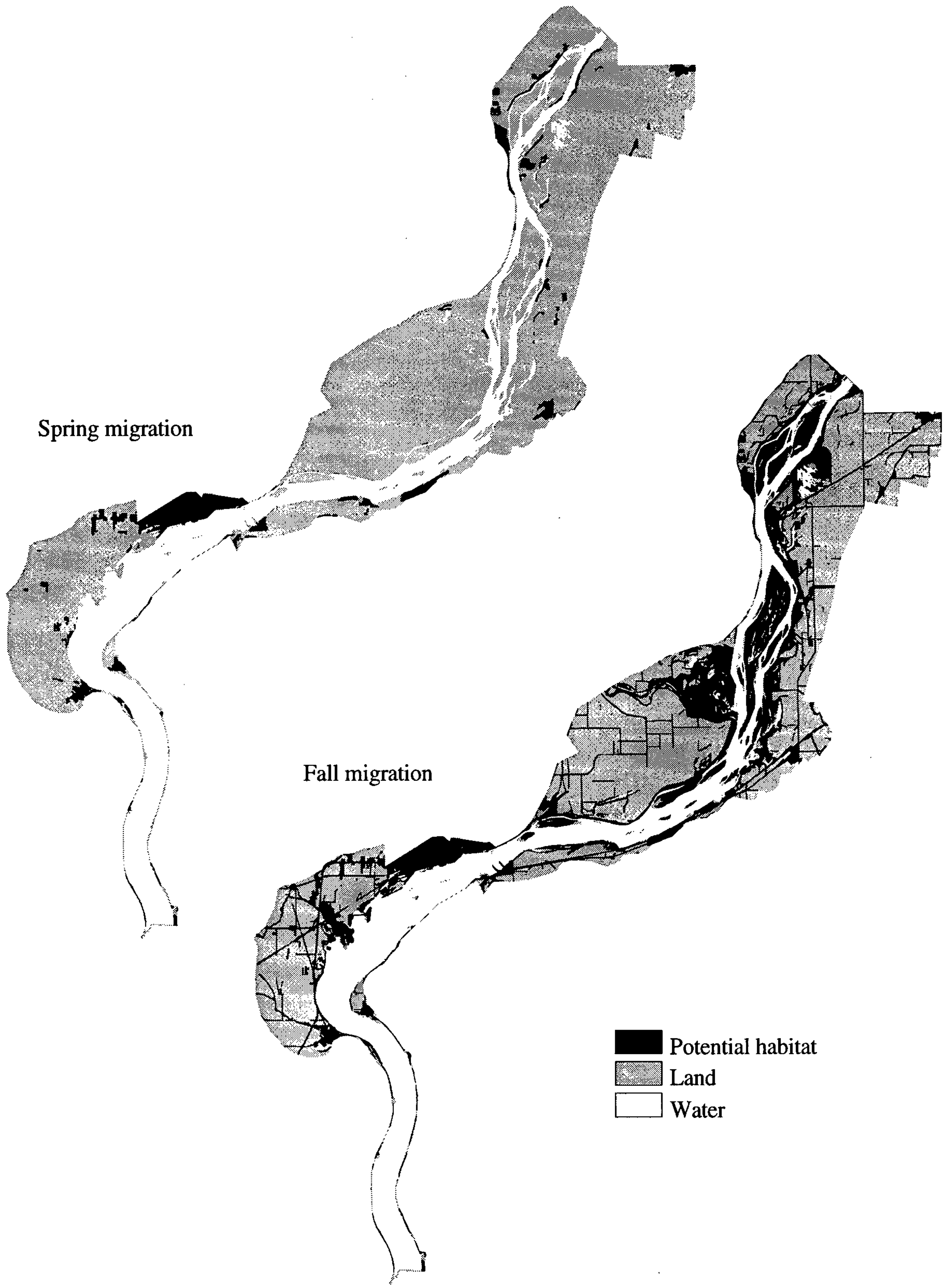


Figure E-94. Potential 1989 spring and fall migration habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 19.

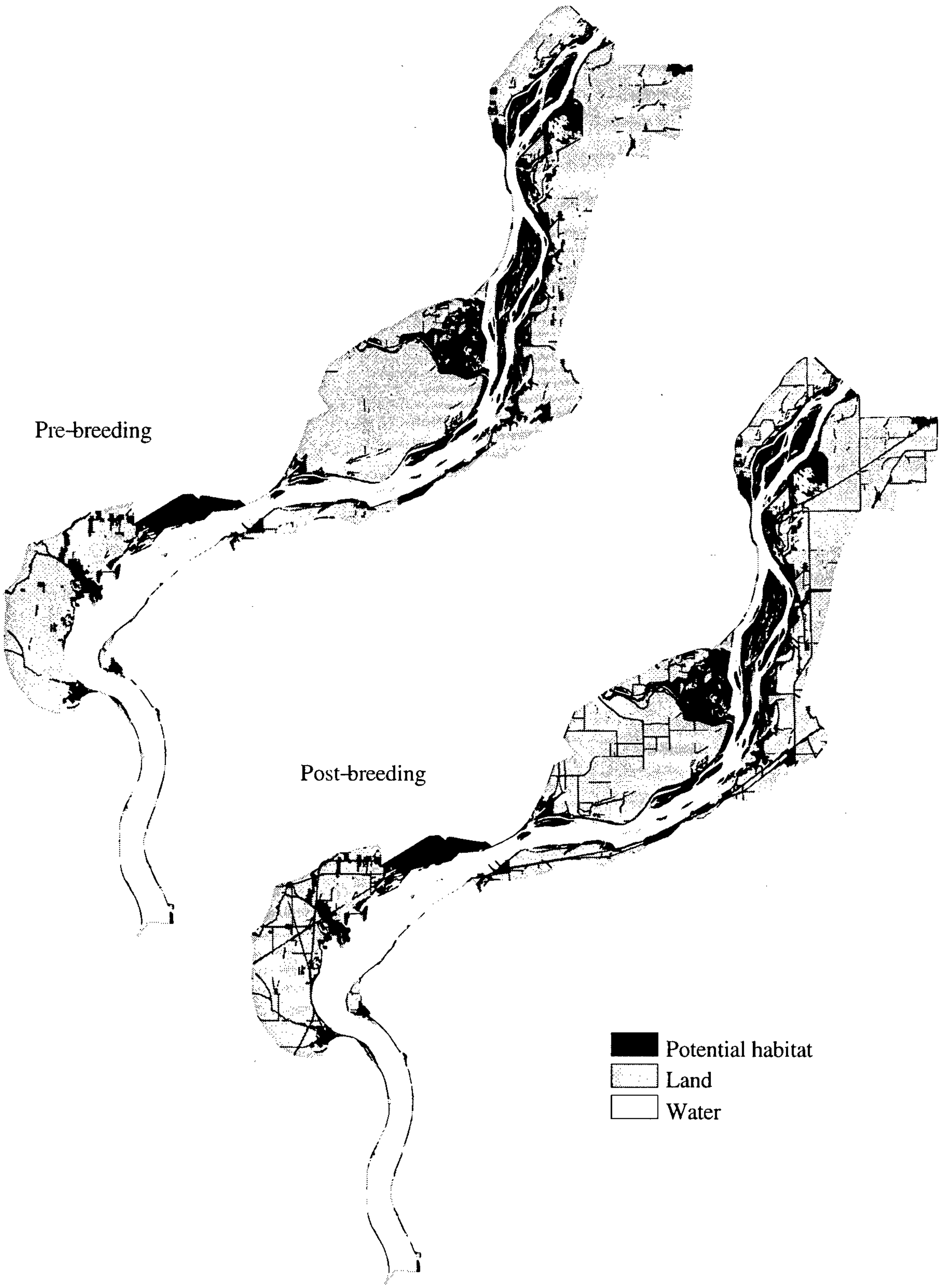


Figure E-95. Potential 1989 pre- and post-breeding habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 19.

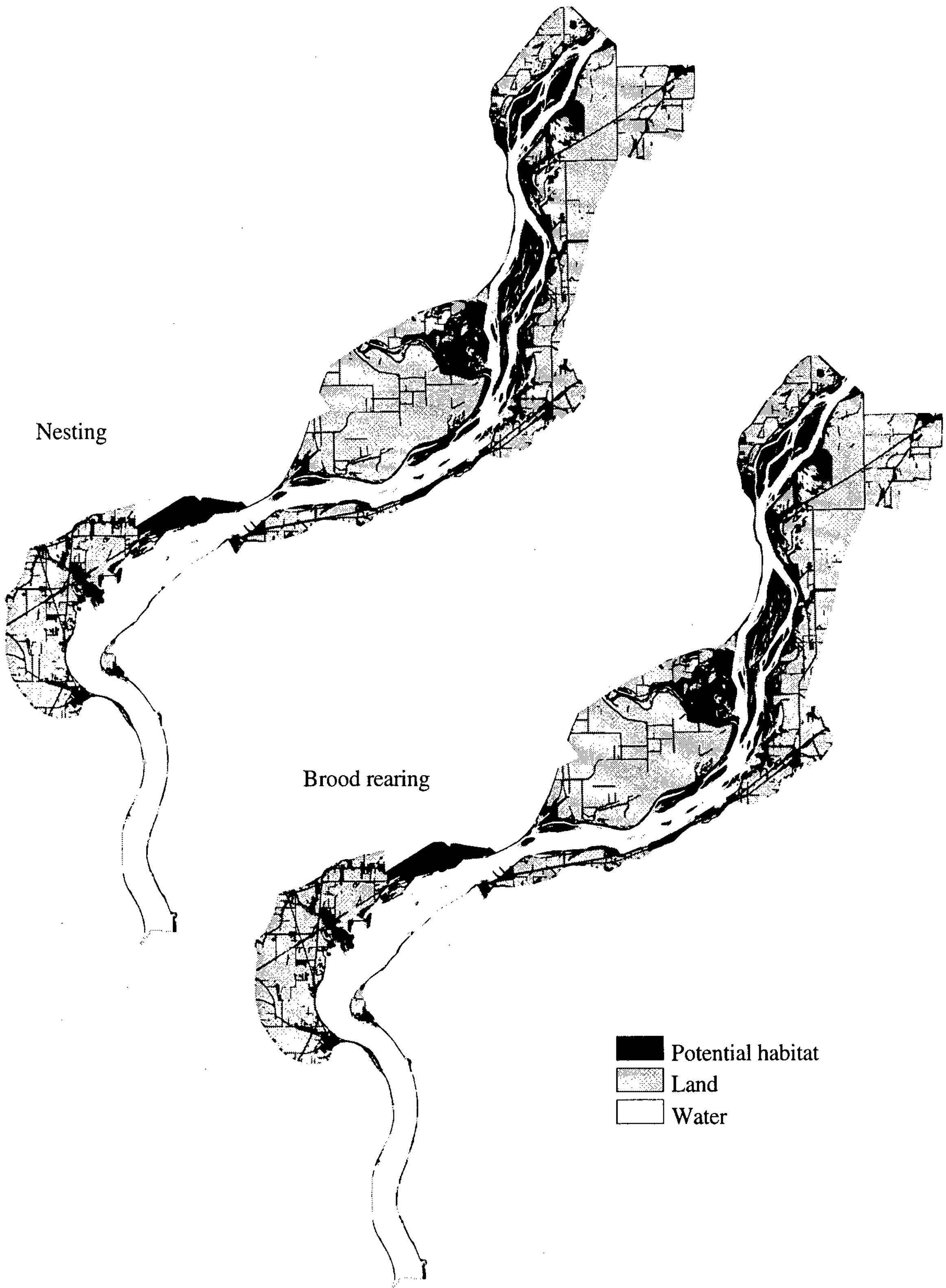


Figure E-96. Potential 1989 nesting and brood rearing habitat for the wood thrush (*Hylocichla mustelina*), Upper Mississippi River Pool 19.

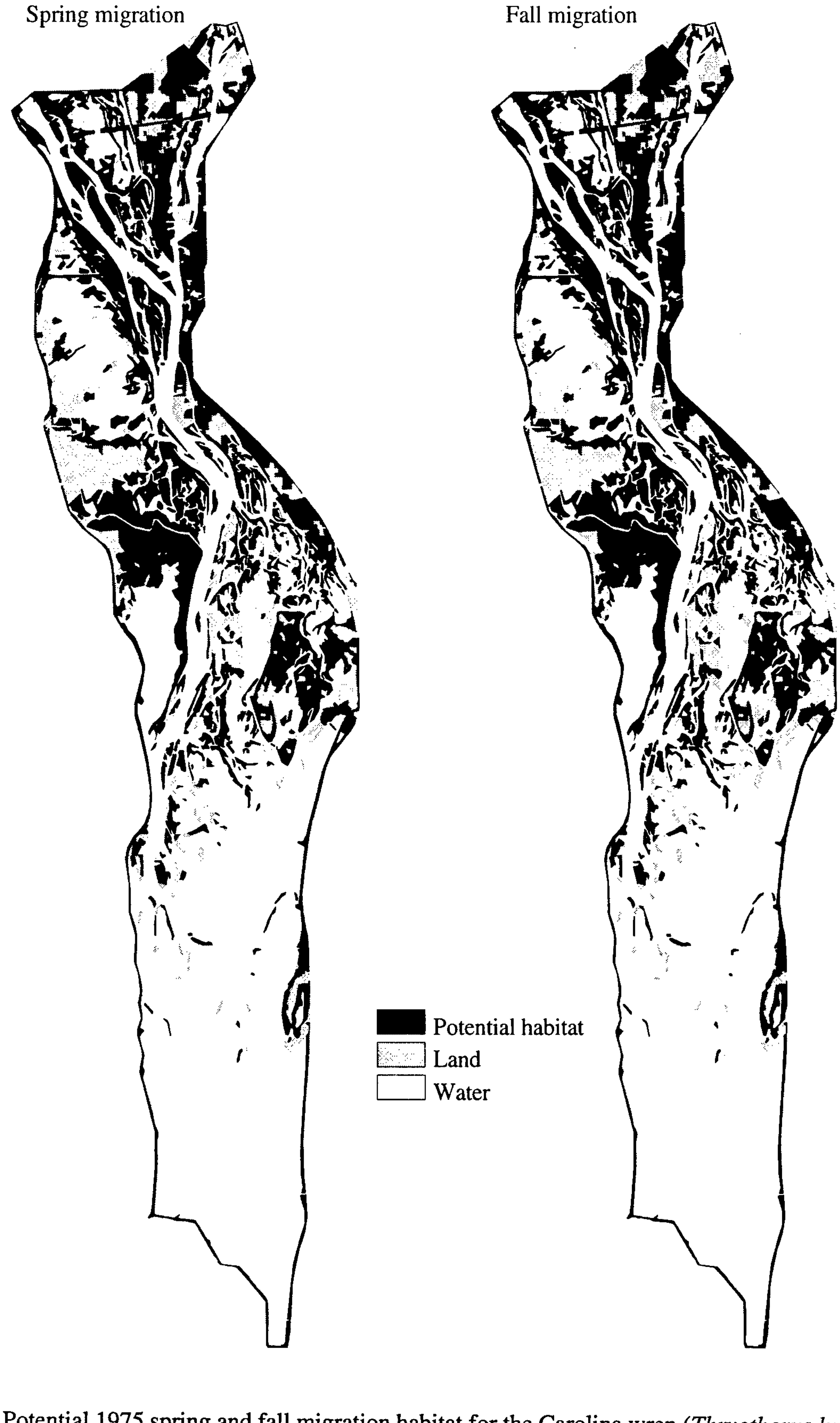


Figure E-97. Potential 1975 spring and fall migration habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 8.

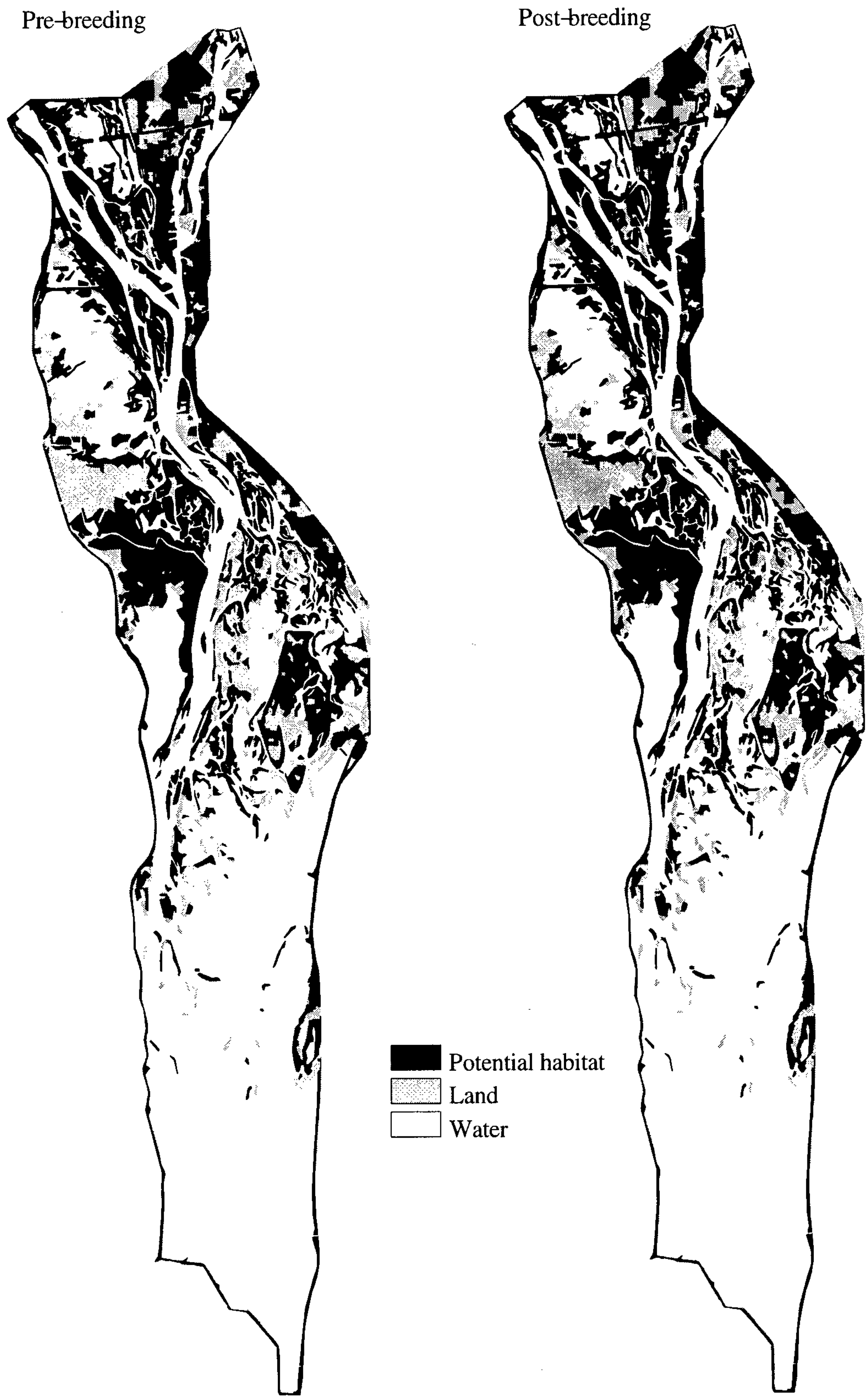


Figure E-98. Potential 1975 pre- and post-breeding habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 8.

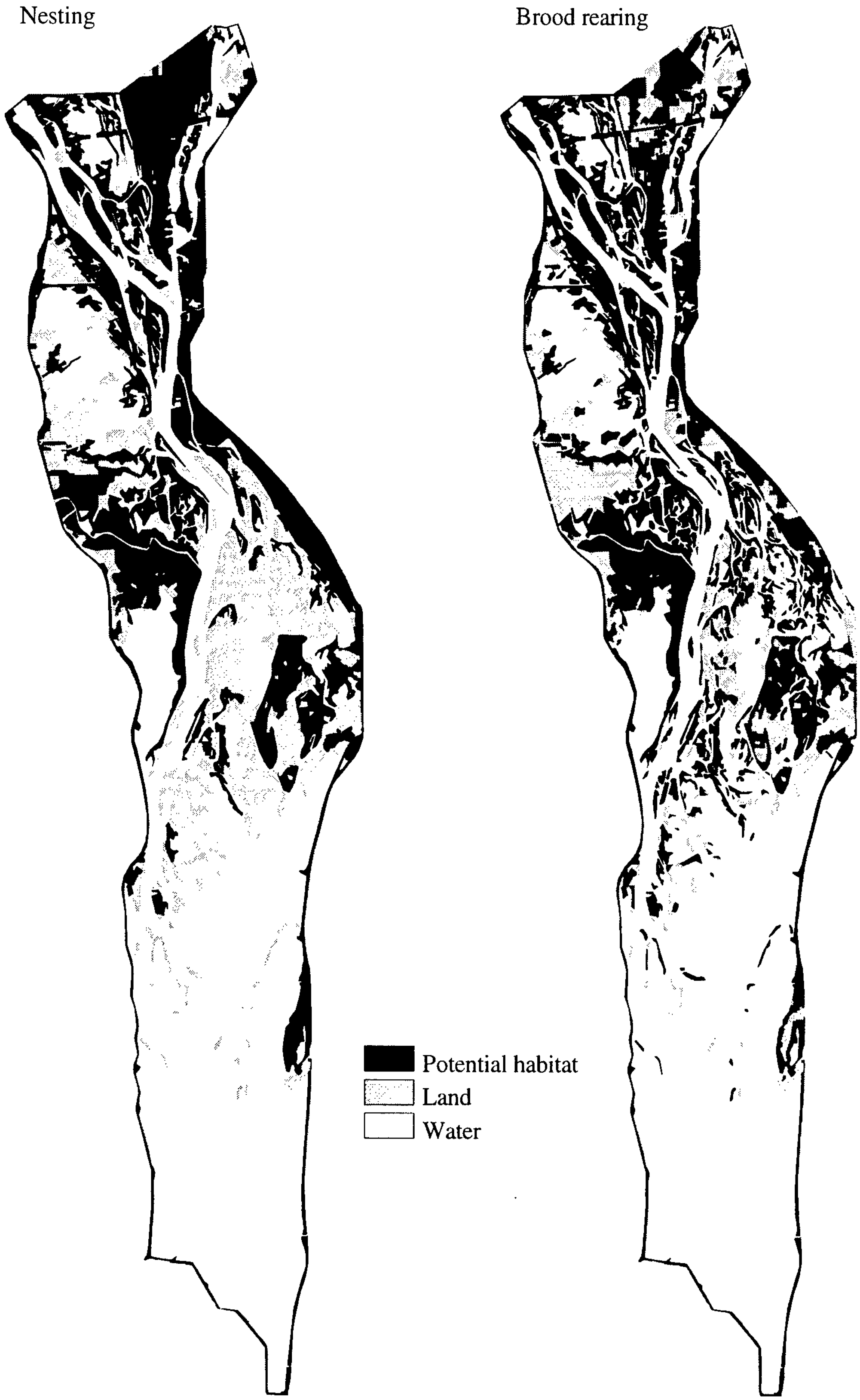


Figure E-99. Potential 1975 nesting and brood rearing habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 8.

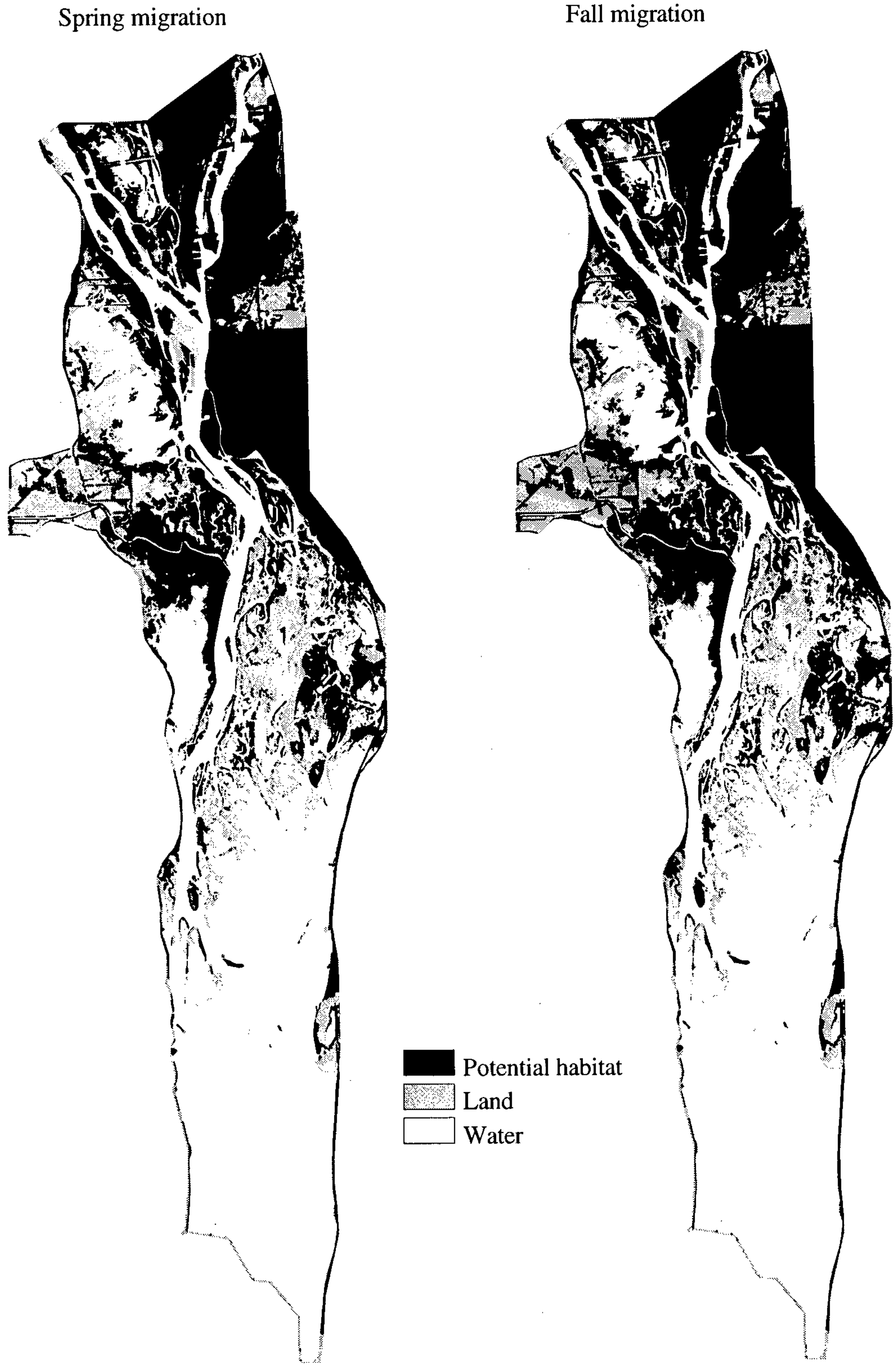


Figure E-100. Potential 1989 spring and fall migration habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 8.

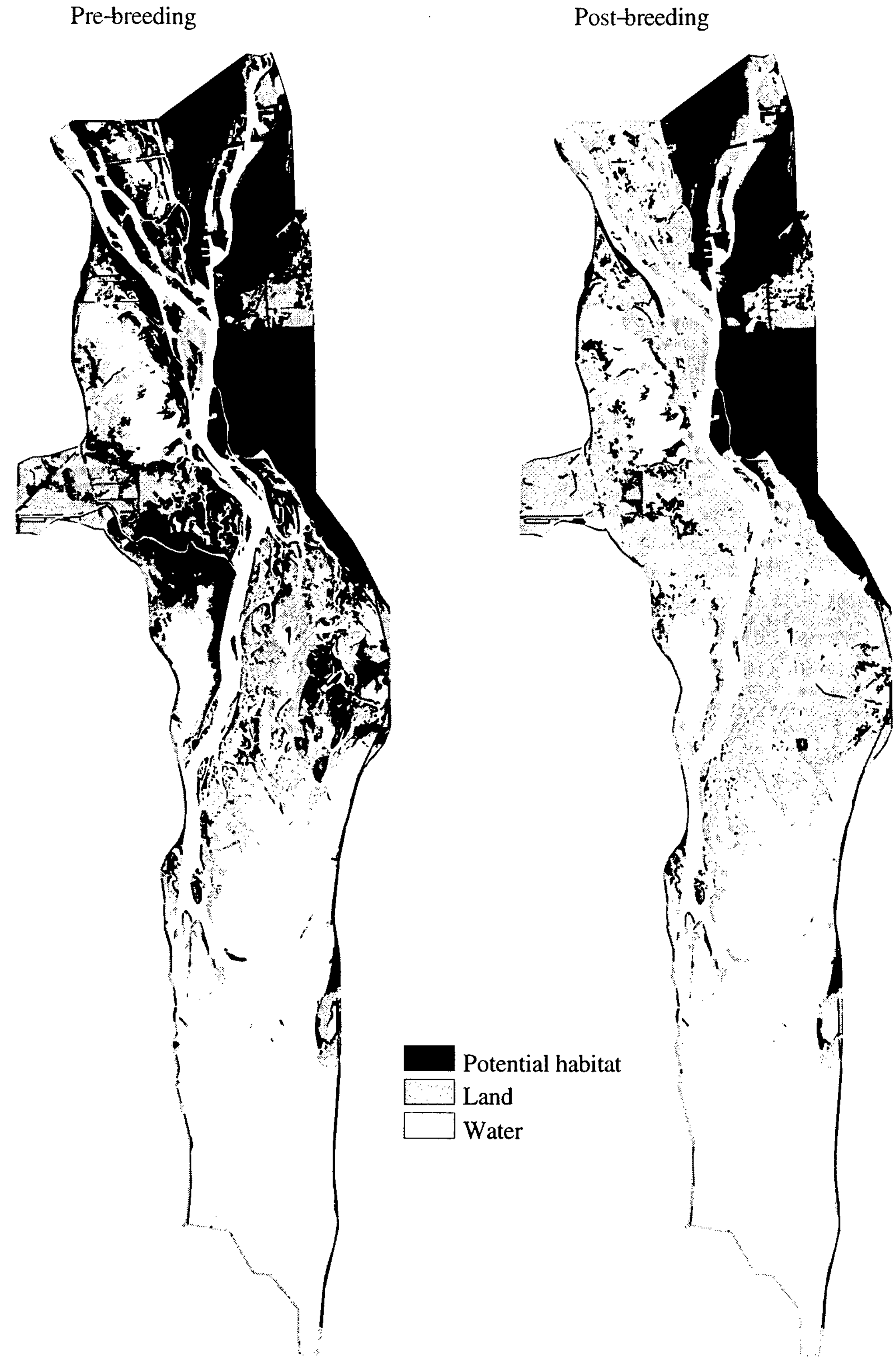


Figure E-101. Potential 1989 pre- and post-breeding habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 8.

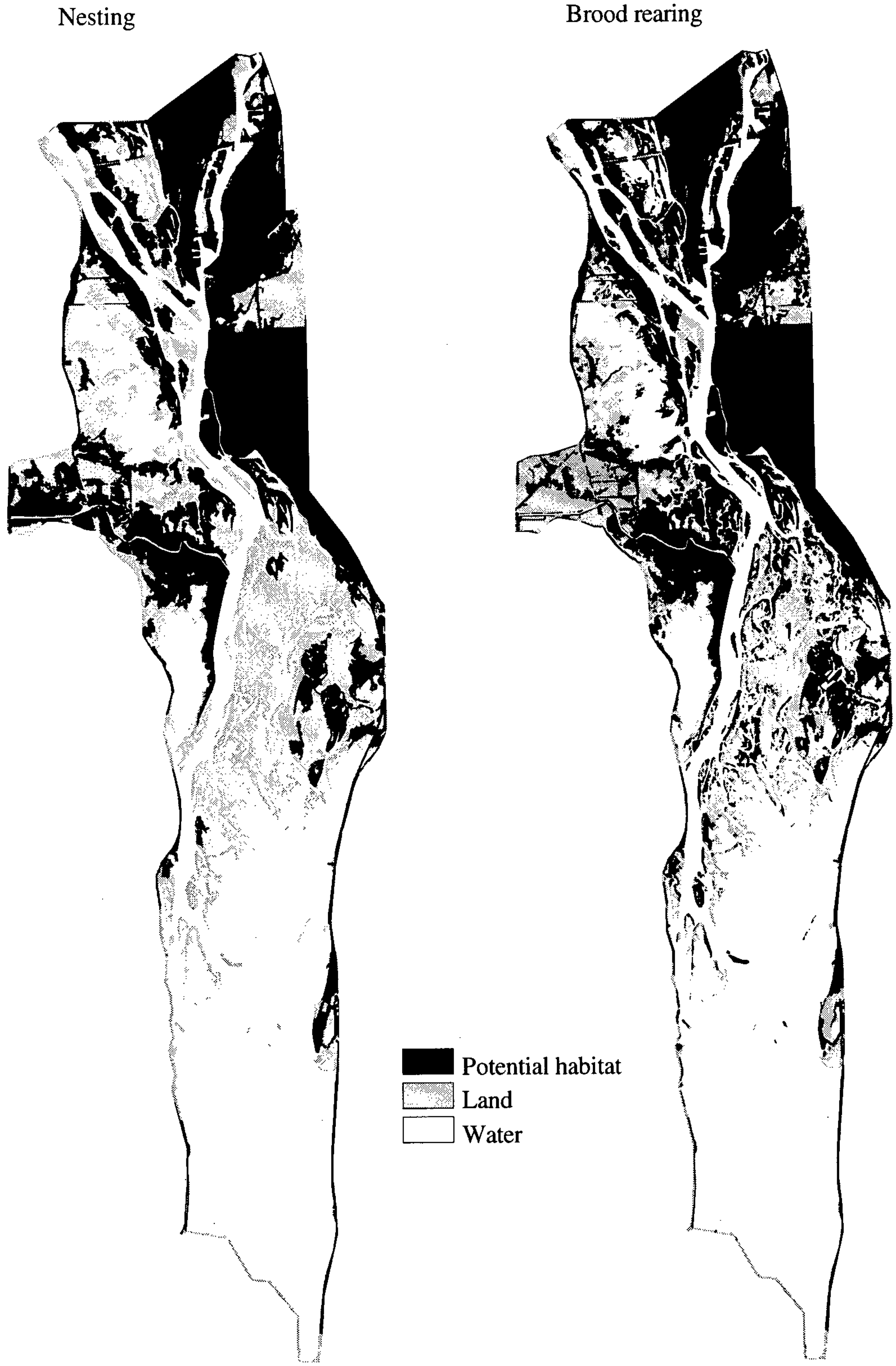


Figure E-102. Potential 1989 nesting and brood rearing habitat for the Carolina wren, (*Thryothorus ludovicianus*) Upper Mississippi River Pool 8.

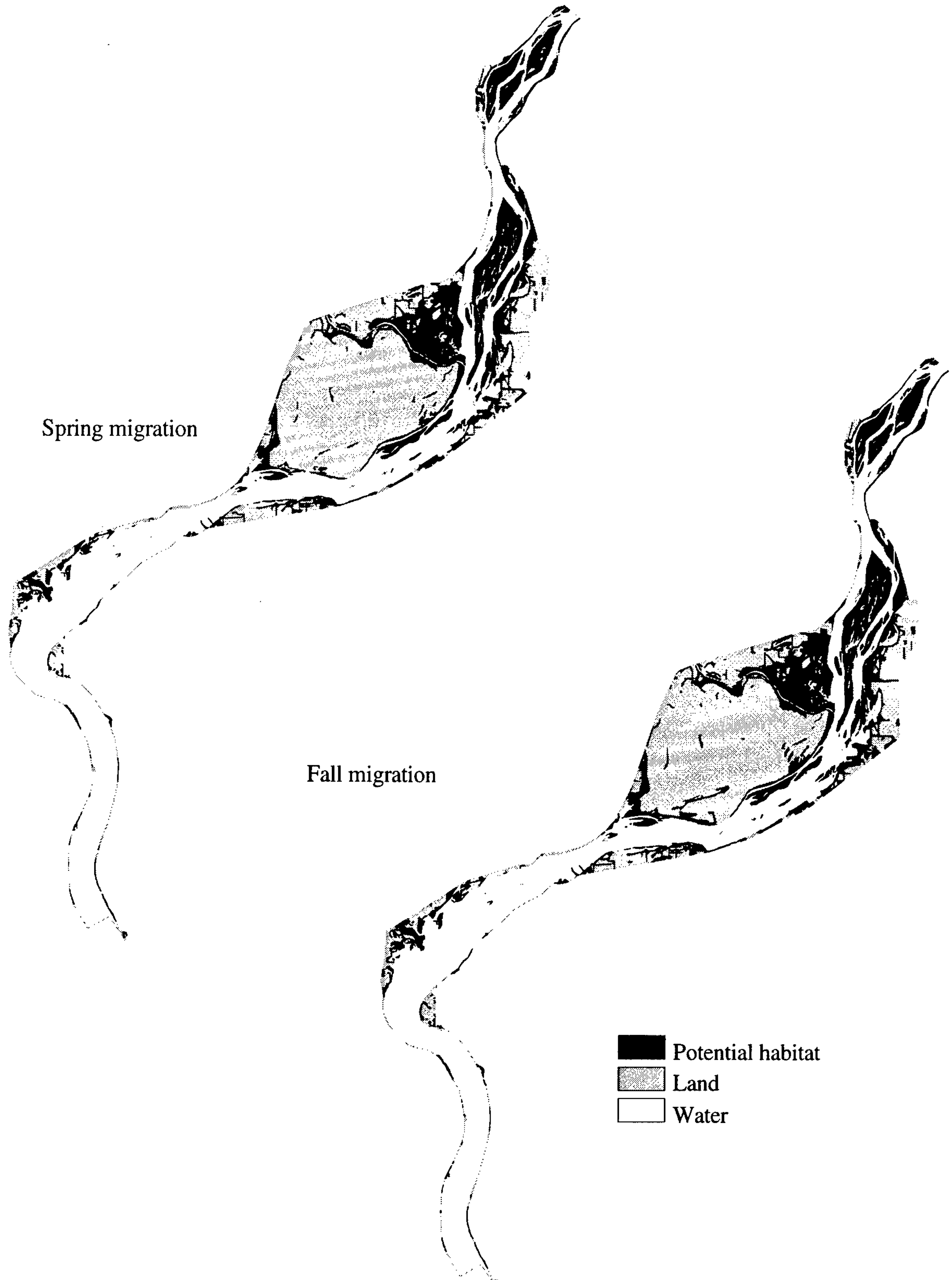


Figure E-103. Potential 1975 spring and fall migration habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 19.

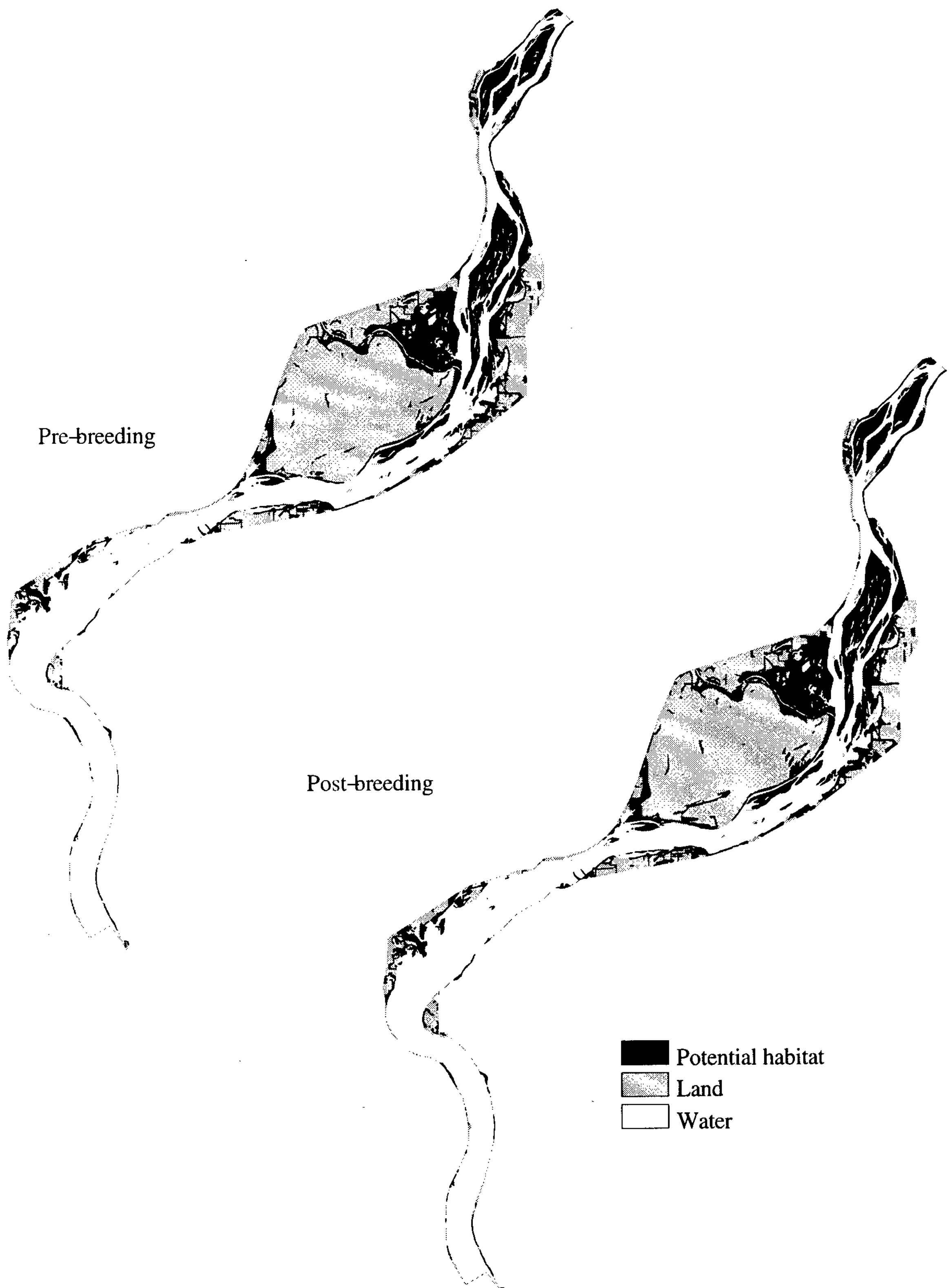


Figure E-104. Potential 1975 pre- and post-breeding habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 19.

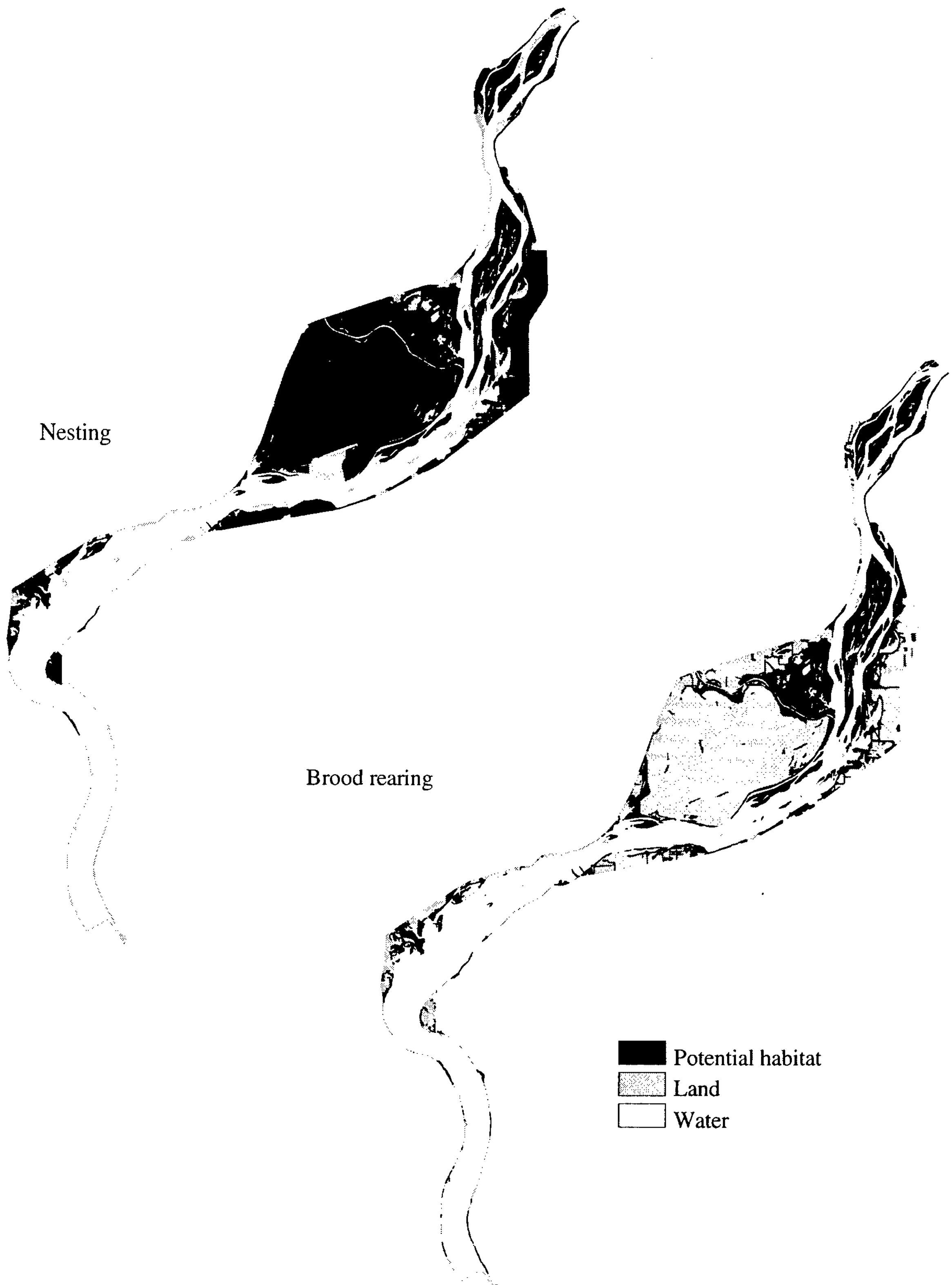


Figure E-105. Potential 1975 nesting and brood rearing habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 19.

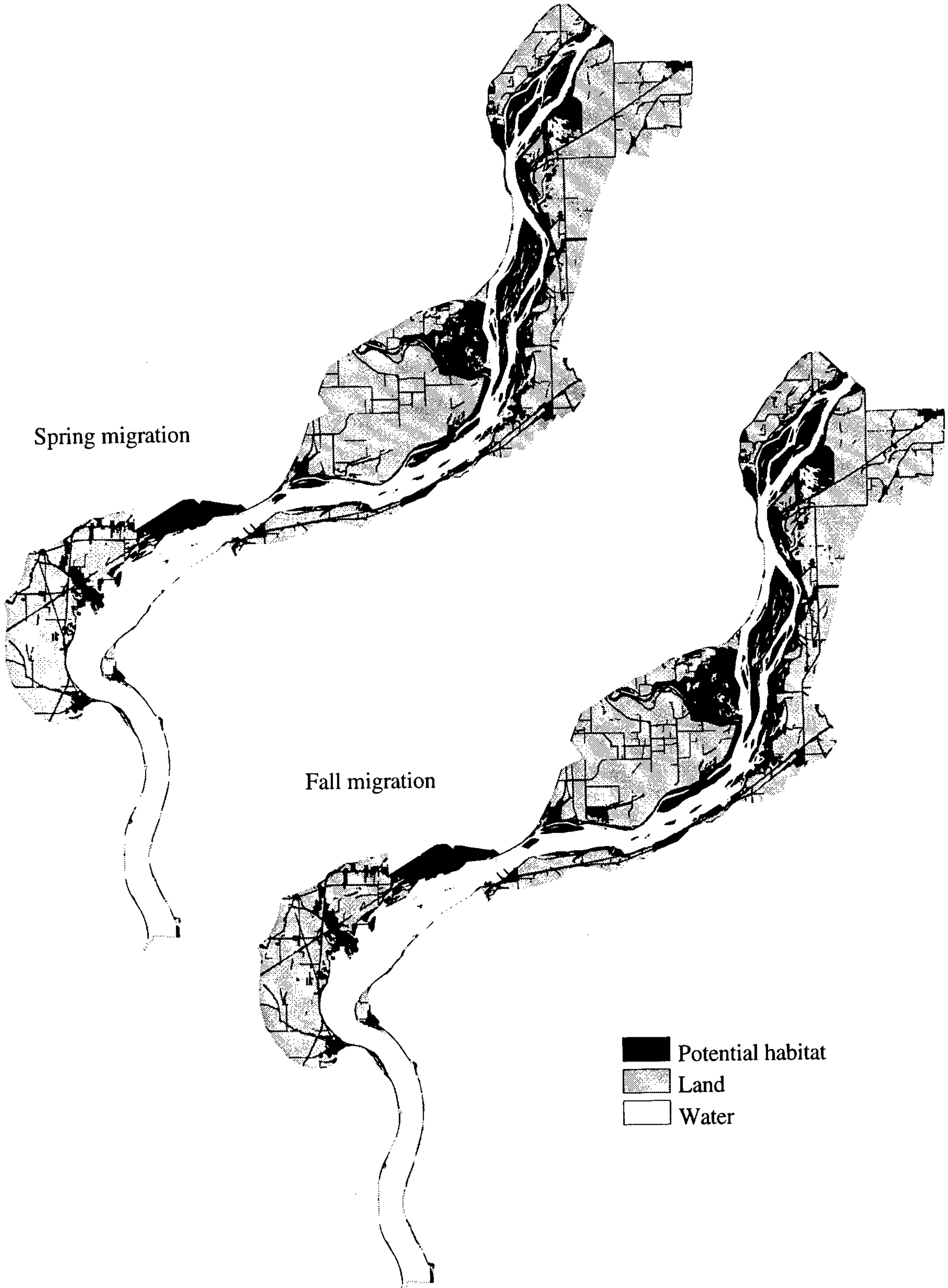


Figure E-106. Potential 1989 spring and fall migration habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 19.

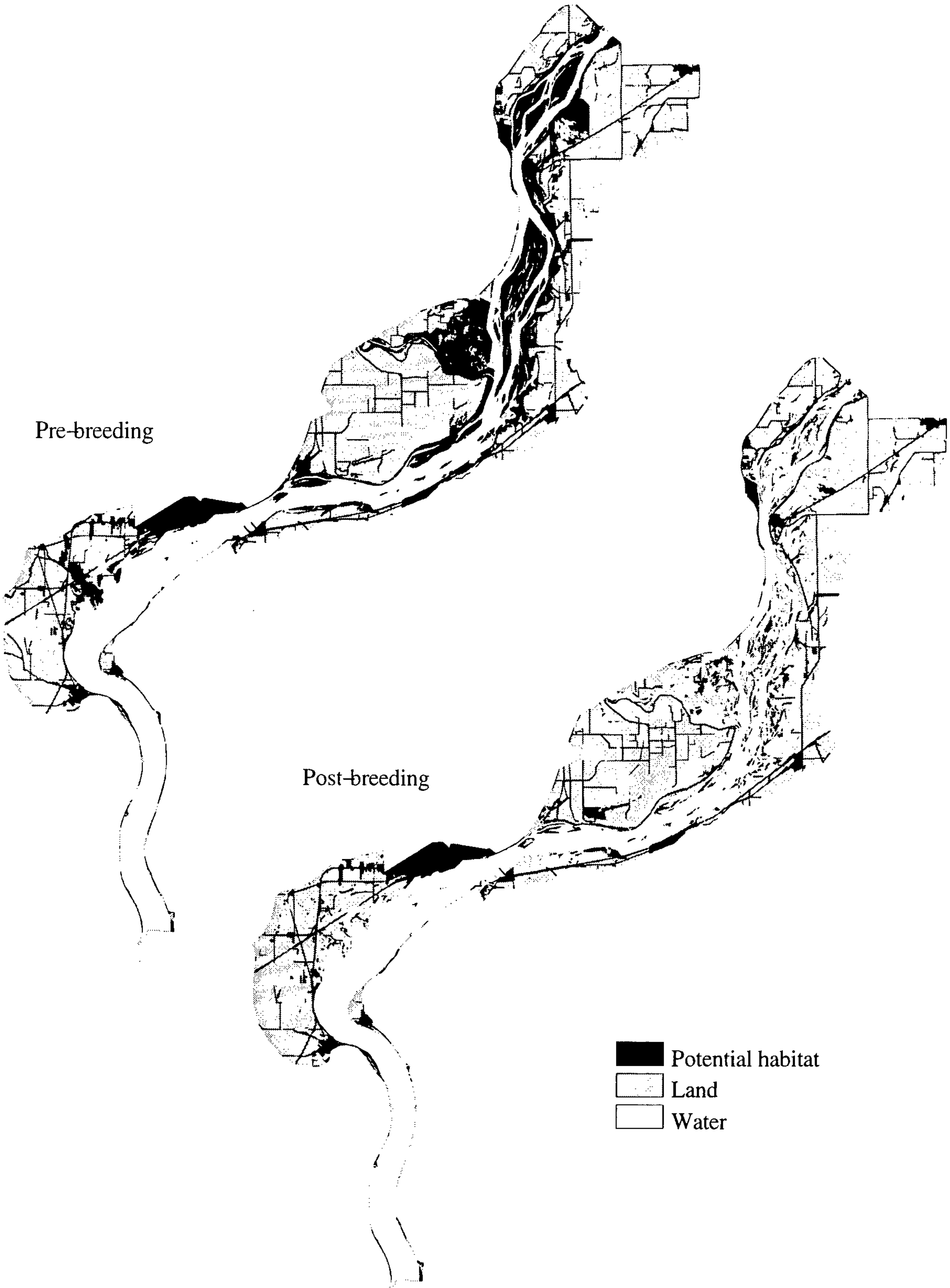


Figure E-107. Potential 1989 pre- and post-breeding habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 19.

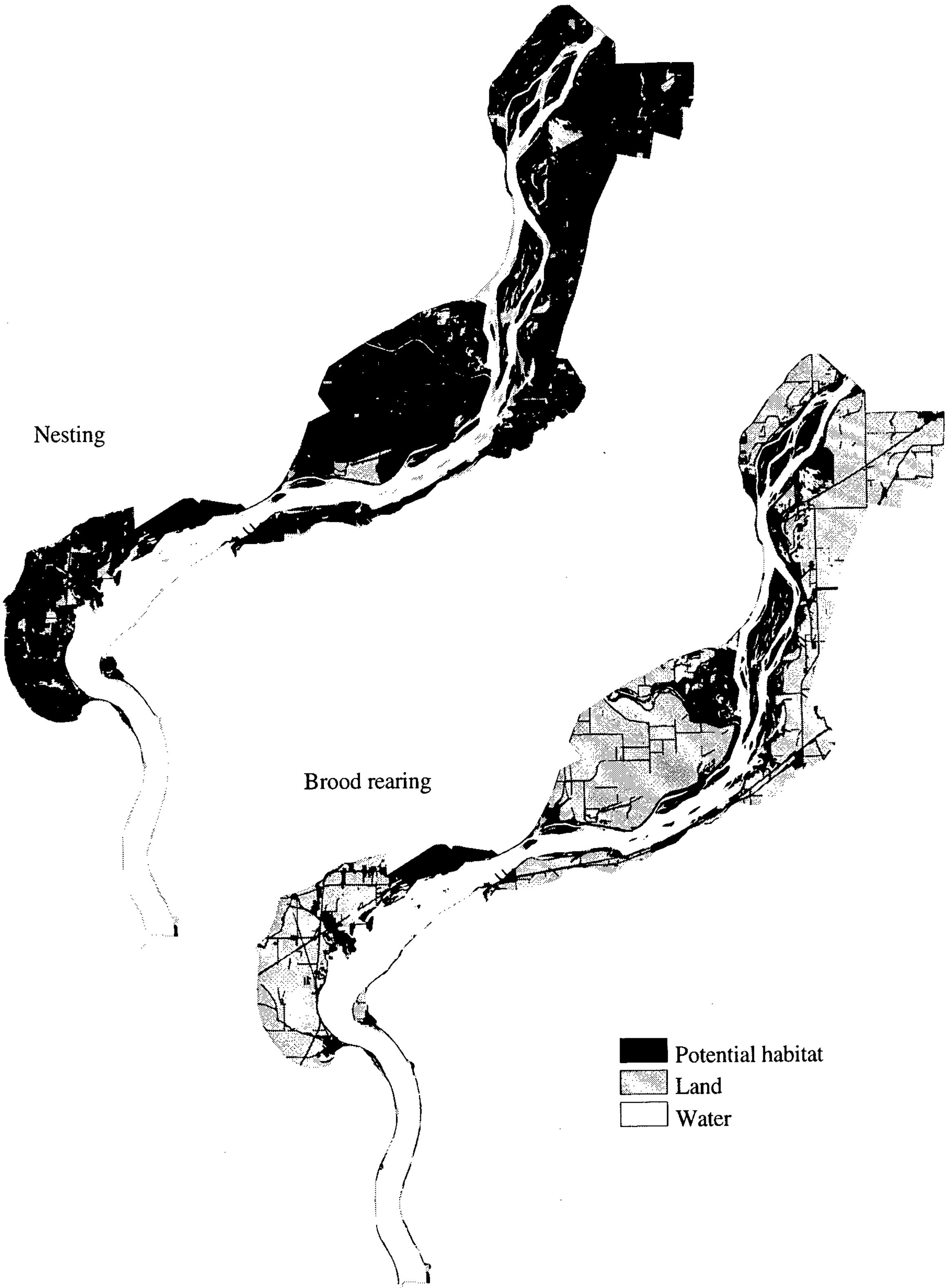


Figure E-108. Potential 1989 nesting and brood rearing habitat for the Carolina wren (*Thryothorus ludovicianus*), Upper Mississippi River Pool 19.

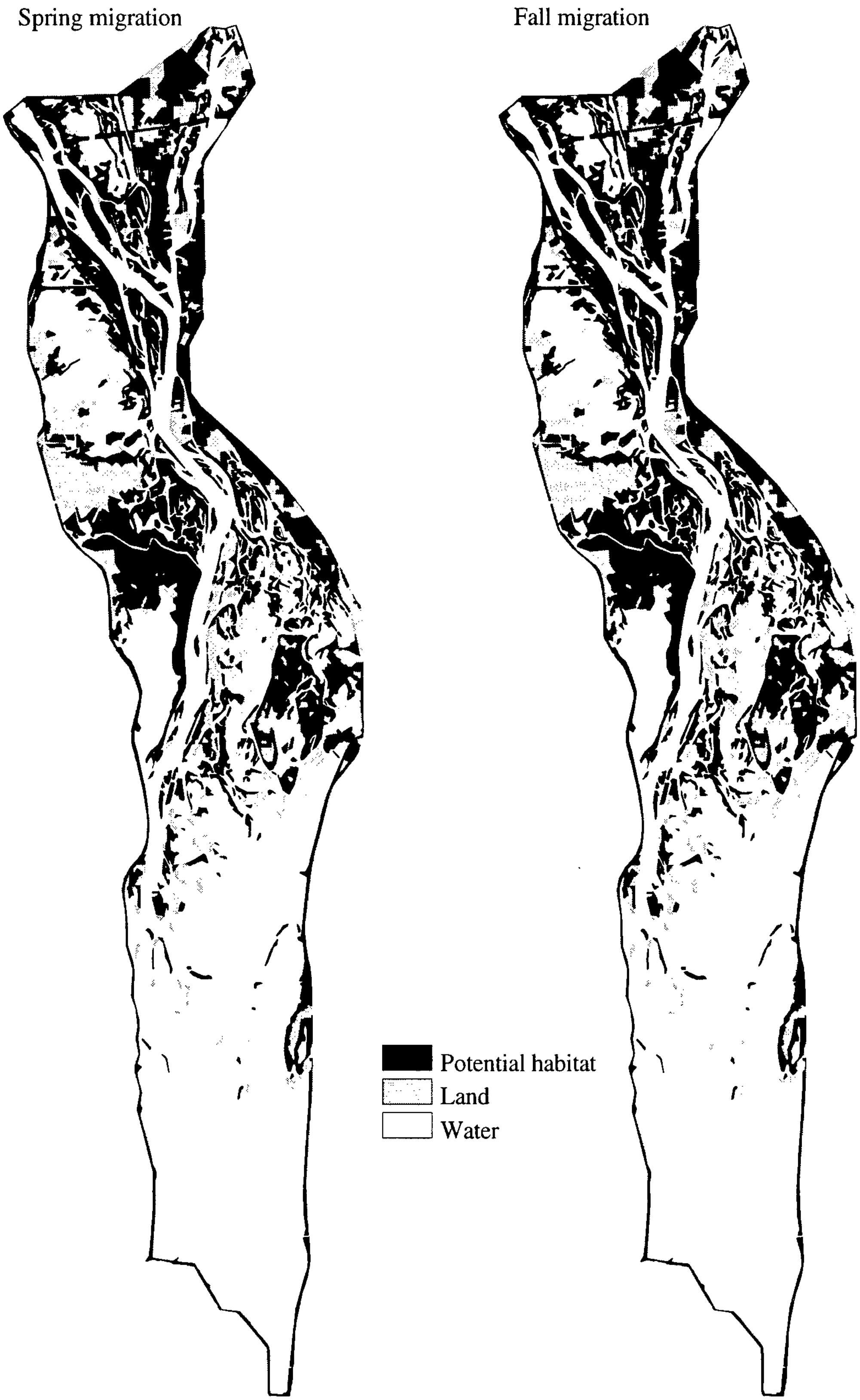


Figure E-109. Potential 1975 spring and fall migration habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 8.

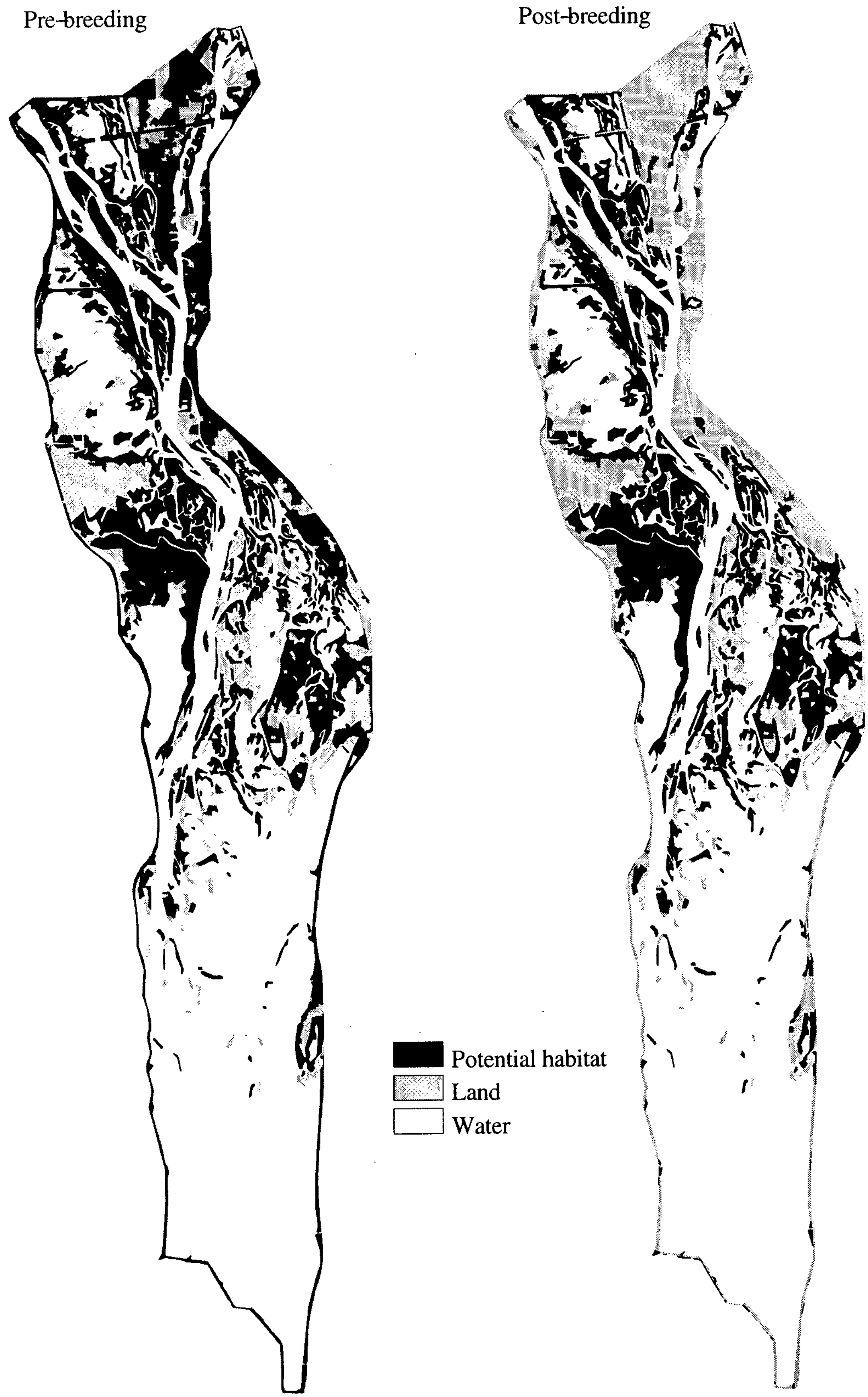


Figure E-110. Potential 1975 pre- and post-breeding habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 8.

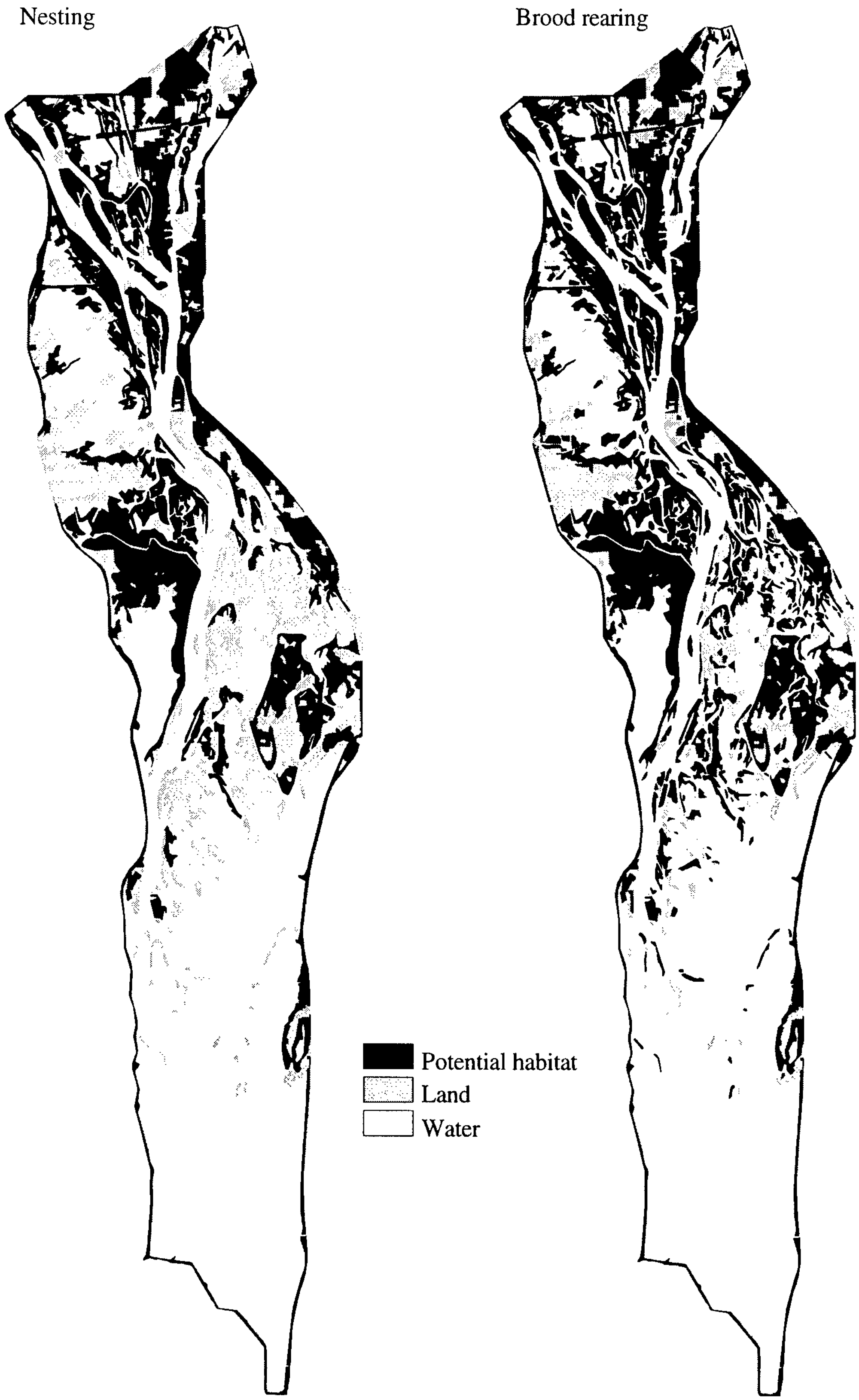


Figure E-111. Potential 1975 nesting and brood rearing habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 8.

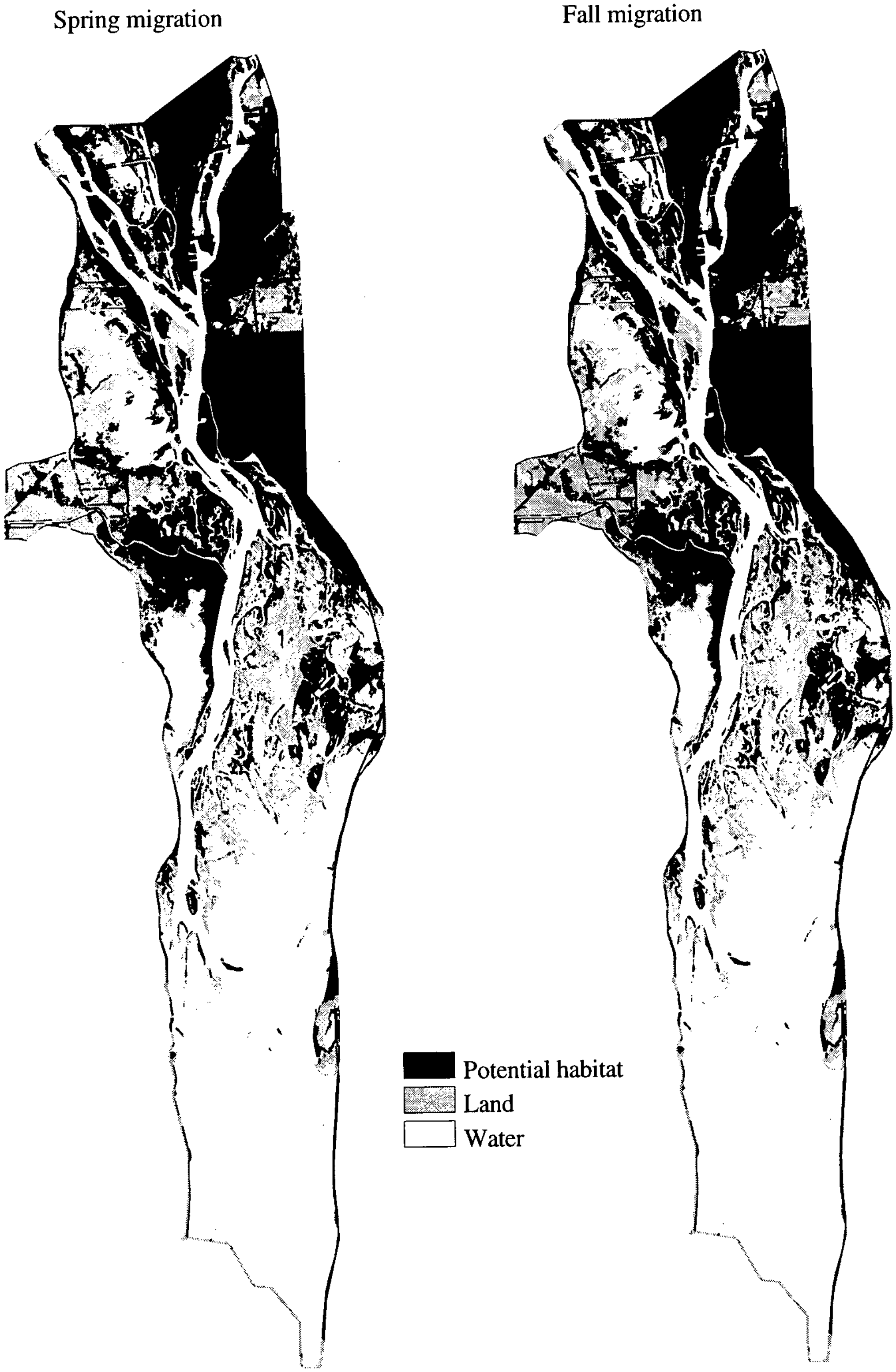


Figure E-112. Potential 1989 spring and fall migration habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 8.

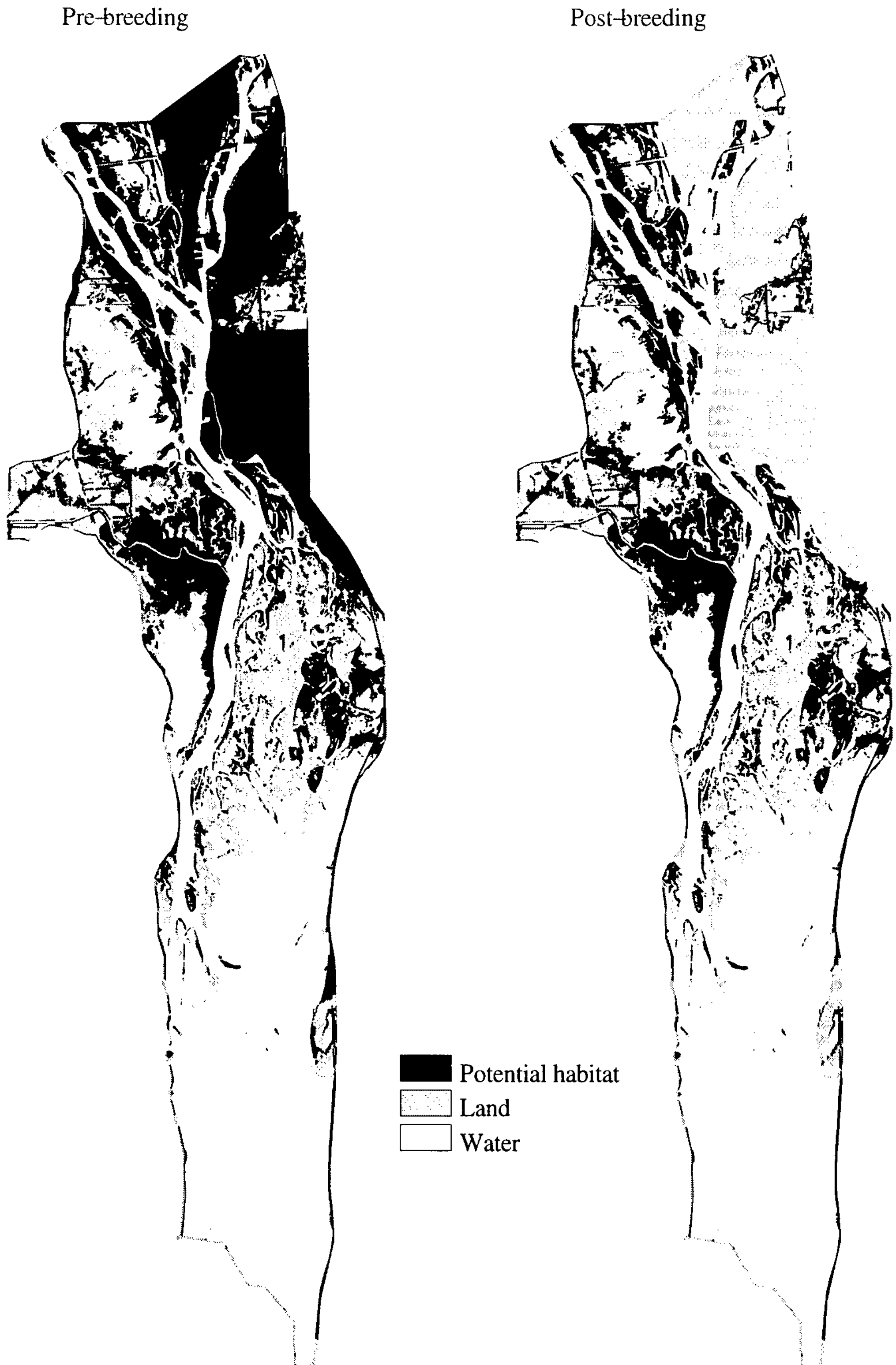


Figure E-113. Potential 1989 pre- and post-breeding habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 8.

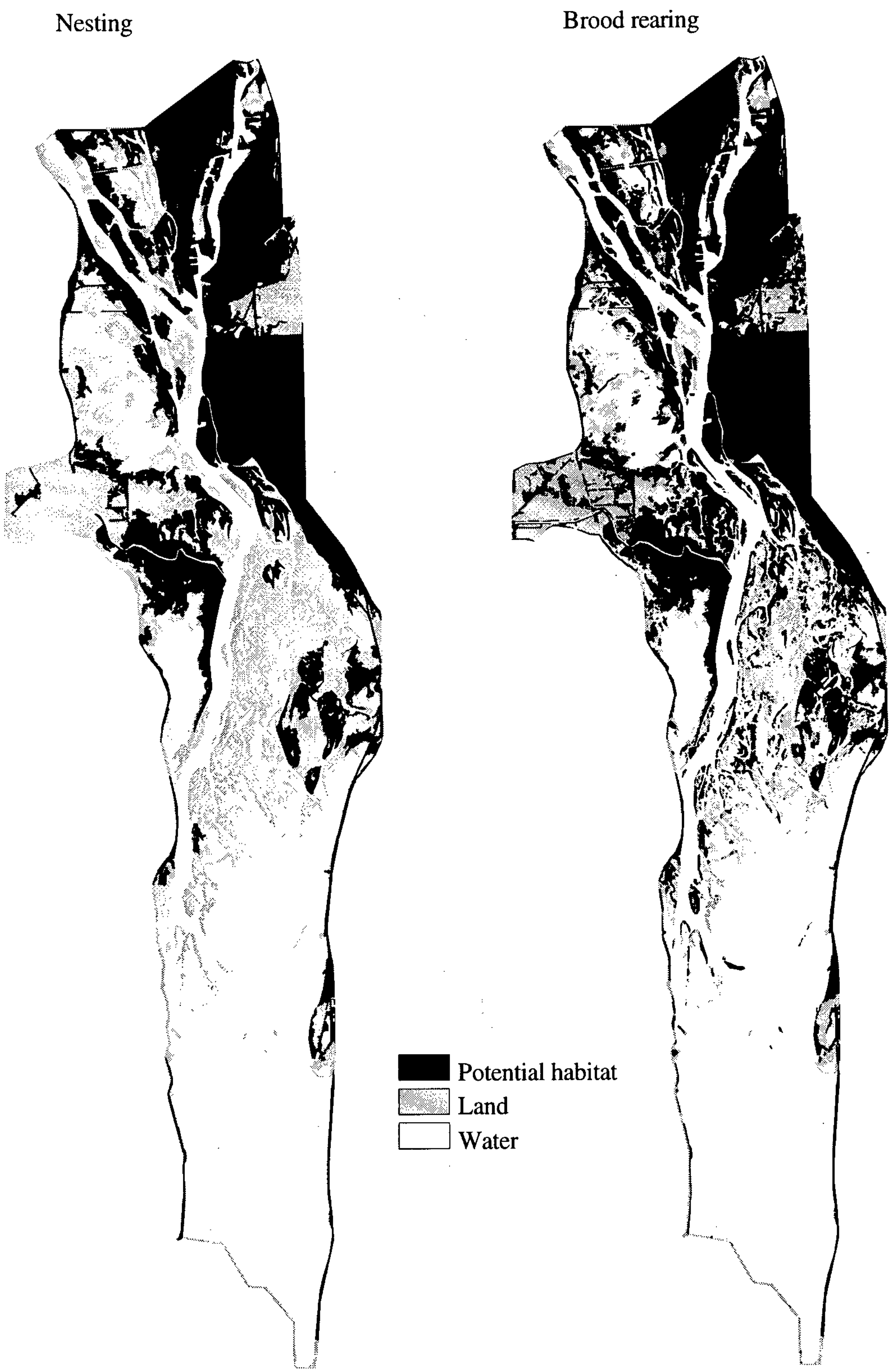


Figure E-114. Potential 1989 nesting and brood rearing habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 8.

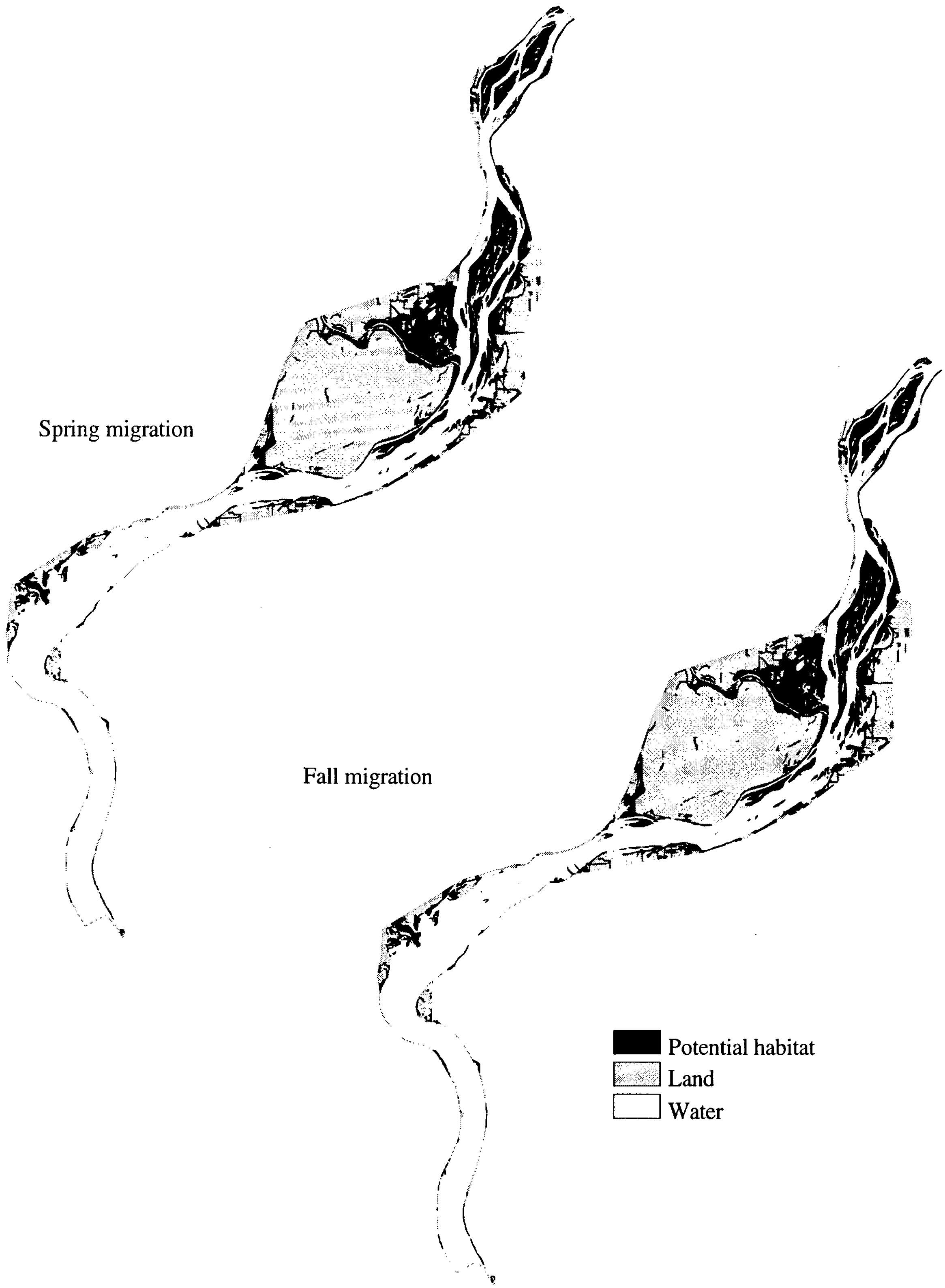


Figure E-115. Potential 1975 spring and fall migration habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 19.

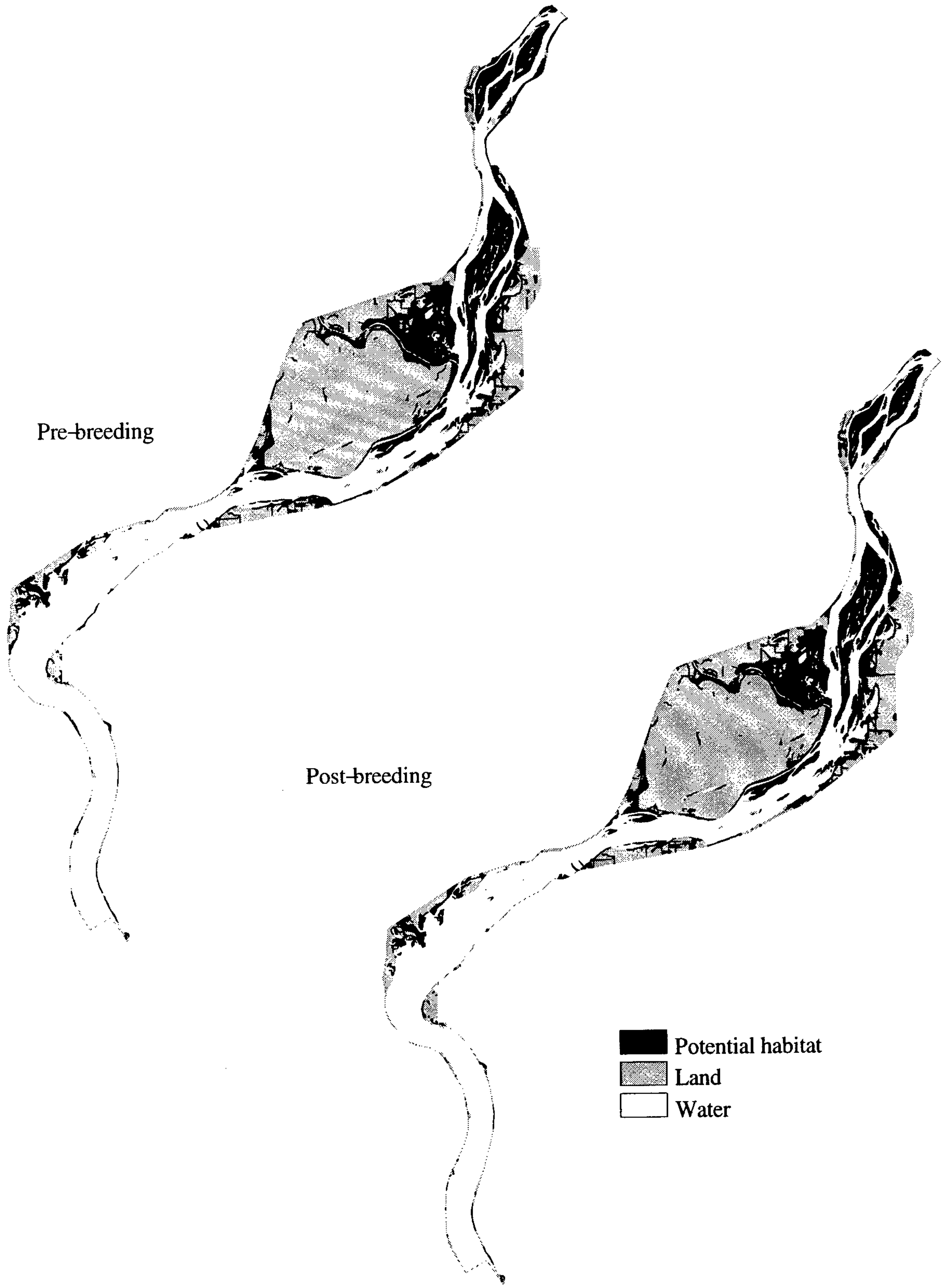


Figure E-116. Potential 1975 pre- and post-breeding habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 19.

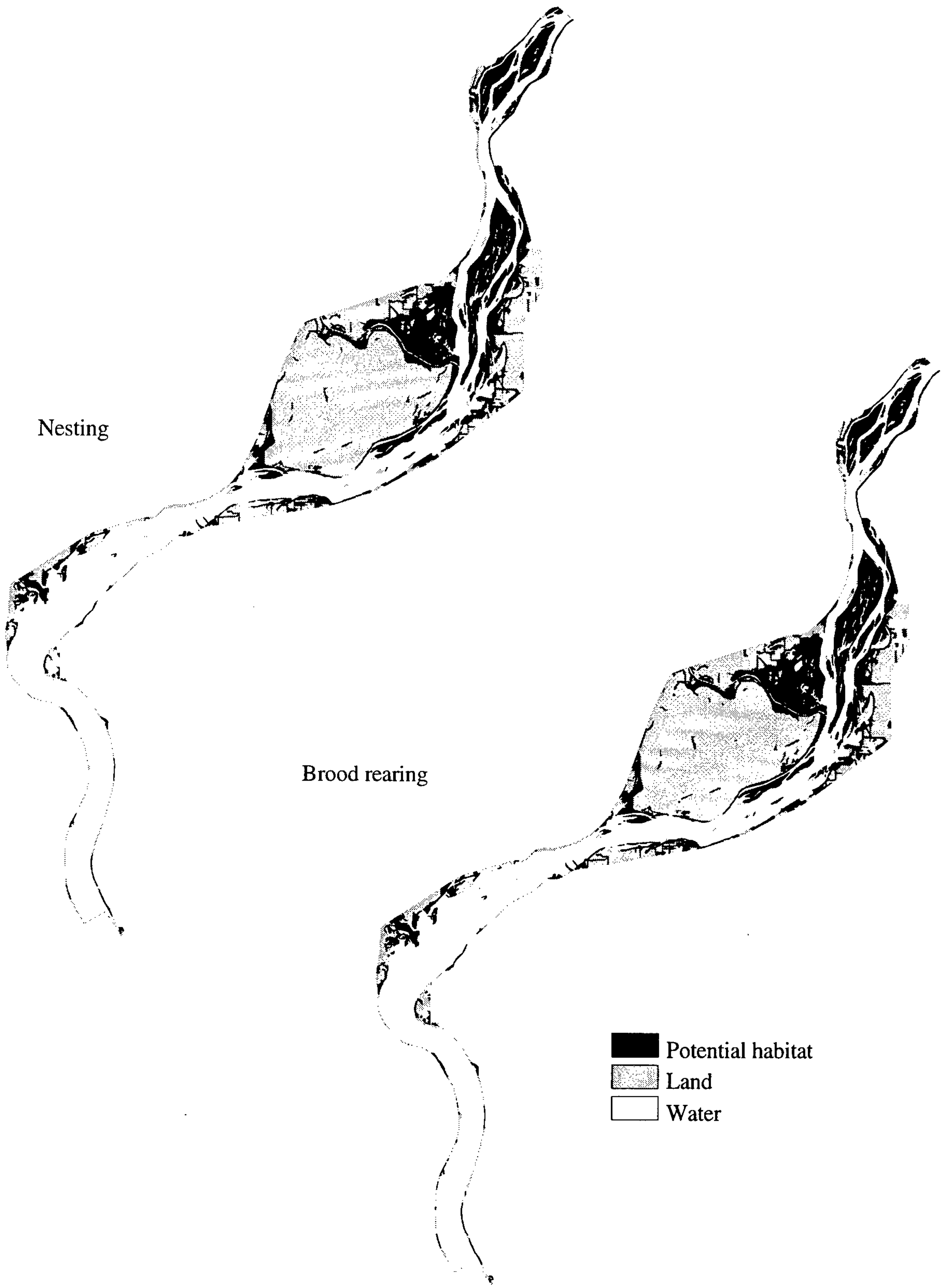


Figure E-117. Potential 1975 nesting and brood rearing habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 19.

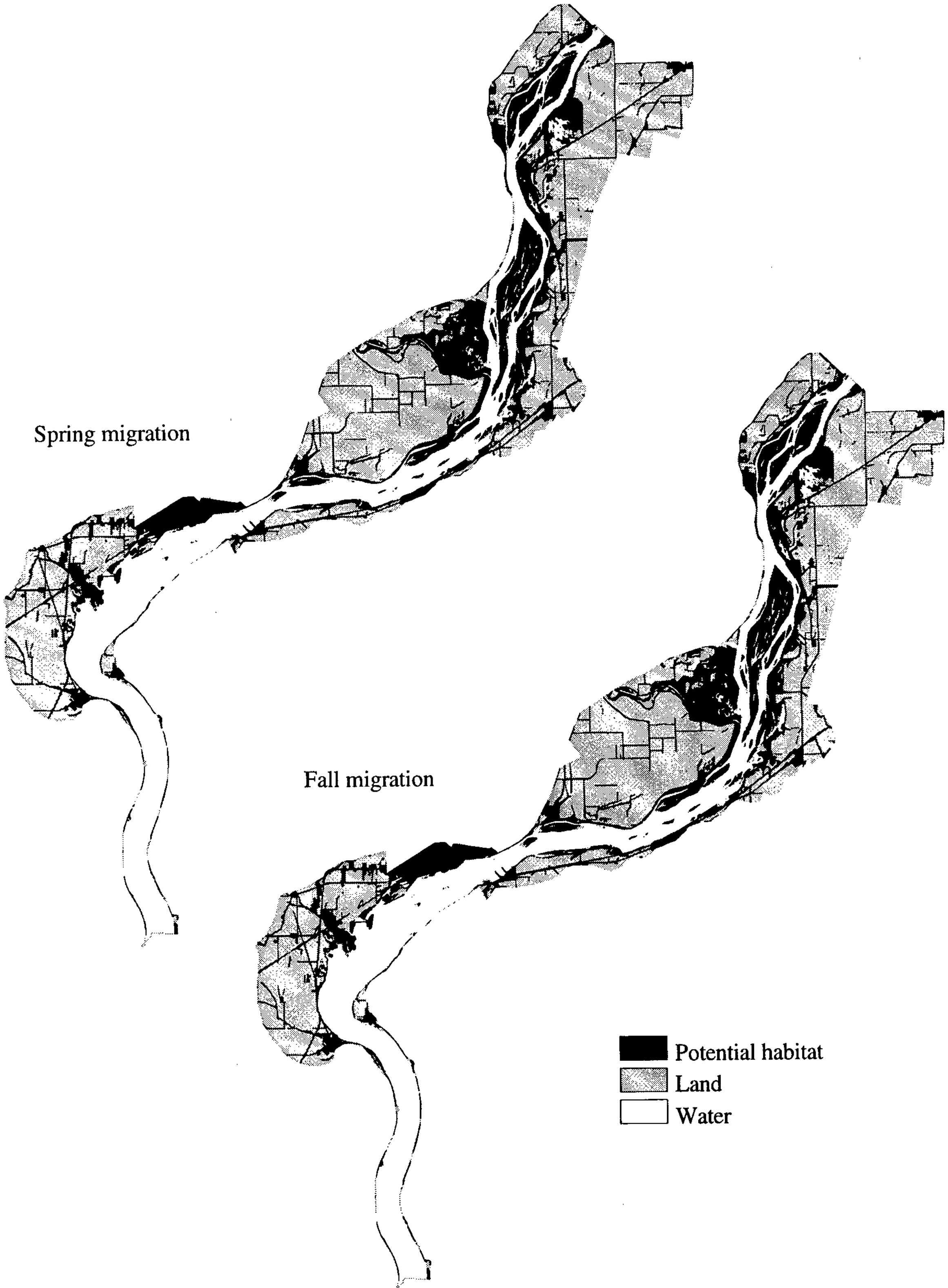


Figure E-118. Potential 1989 spring and fall migration habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 19.

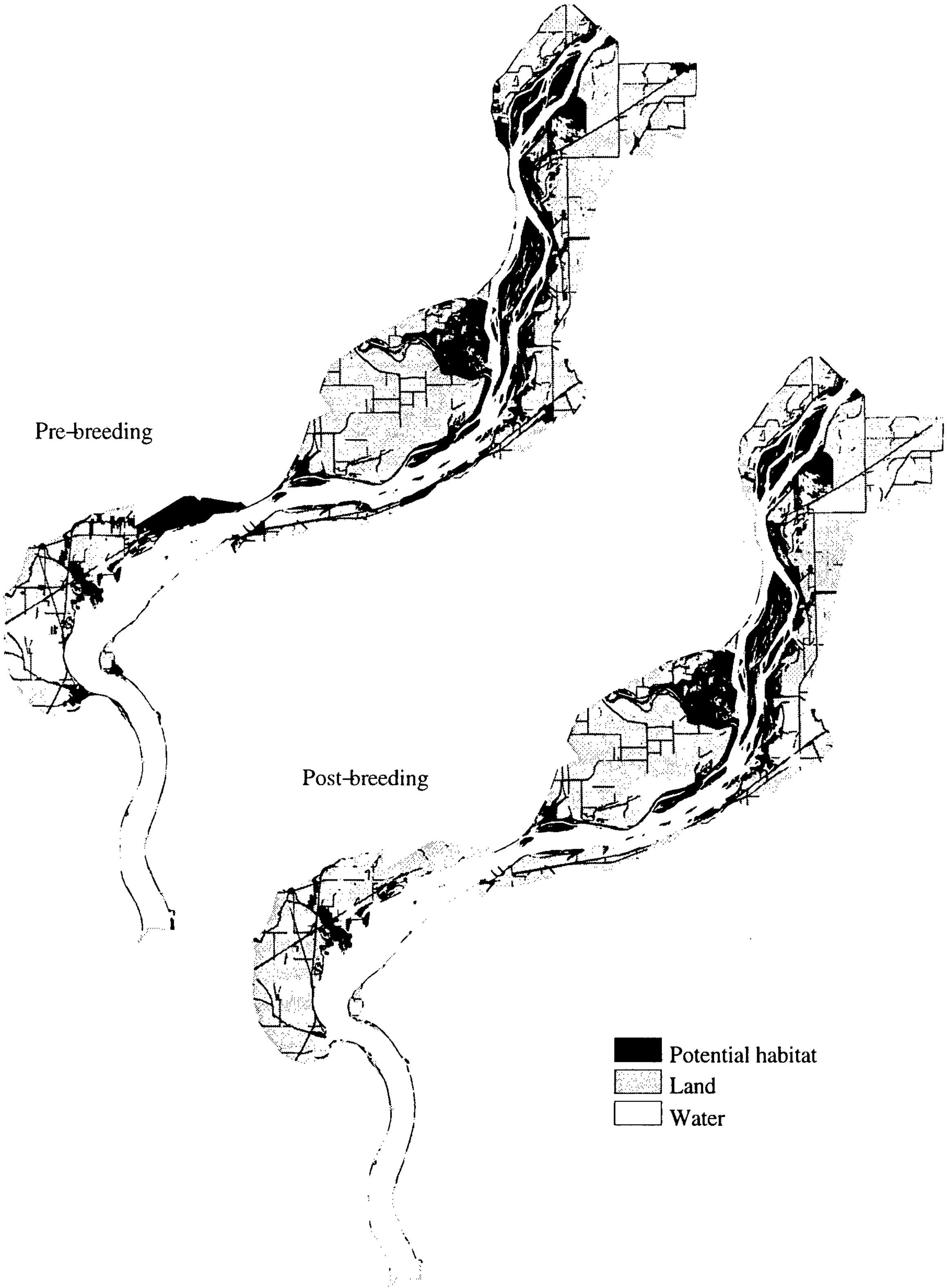


Figure E-119. Potential 1989 pre- and post-breeding habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 19.

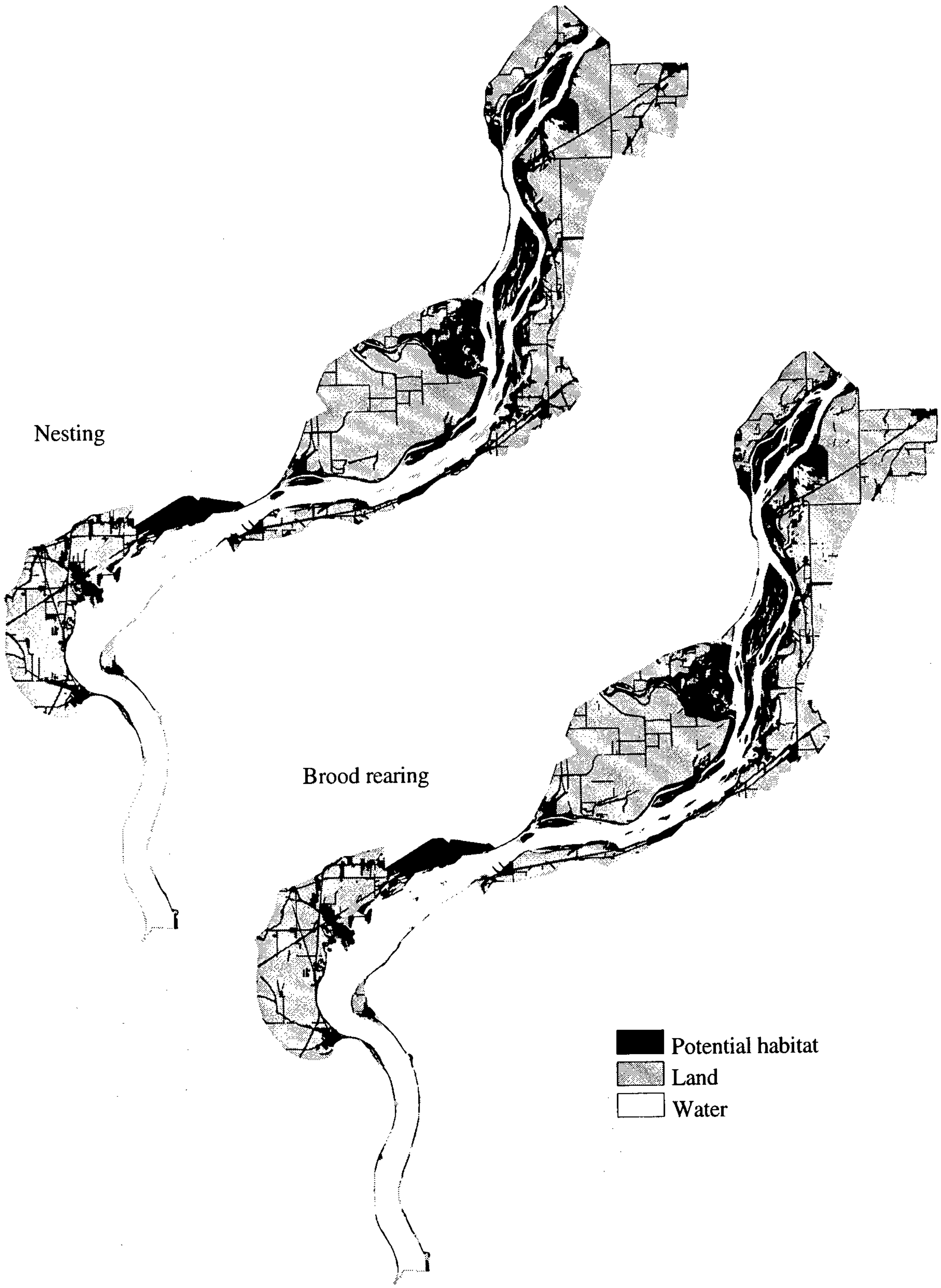


Figure E-120. Potential 1989 nesting and brood rearing habitat for the great crested flycatcher (*Myiarchus crinitus*), Upper Mississippi River Pool 19.

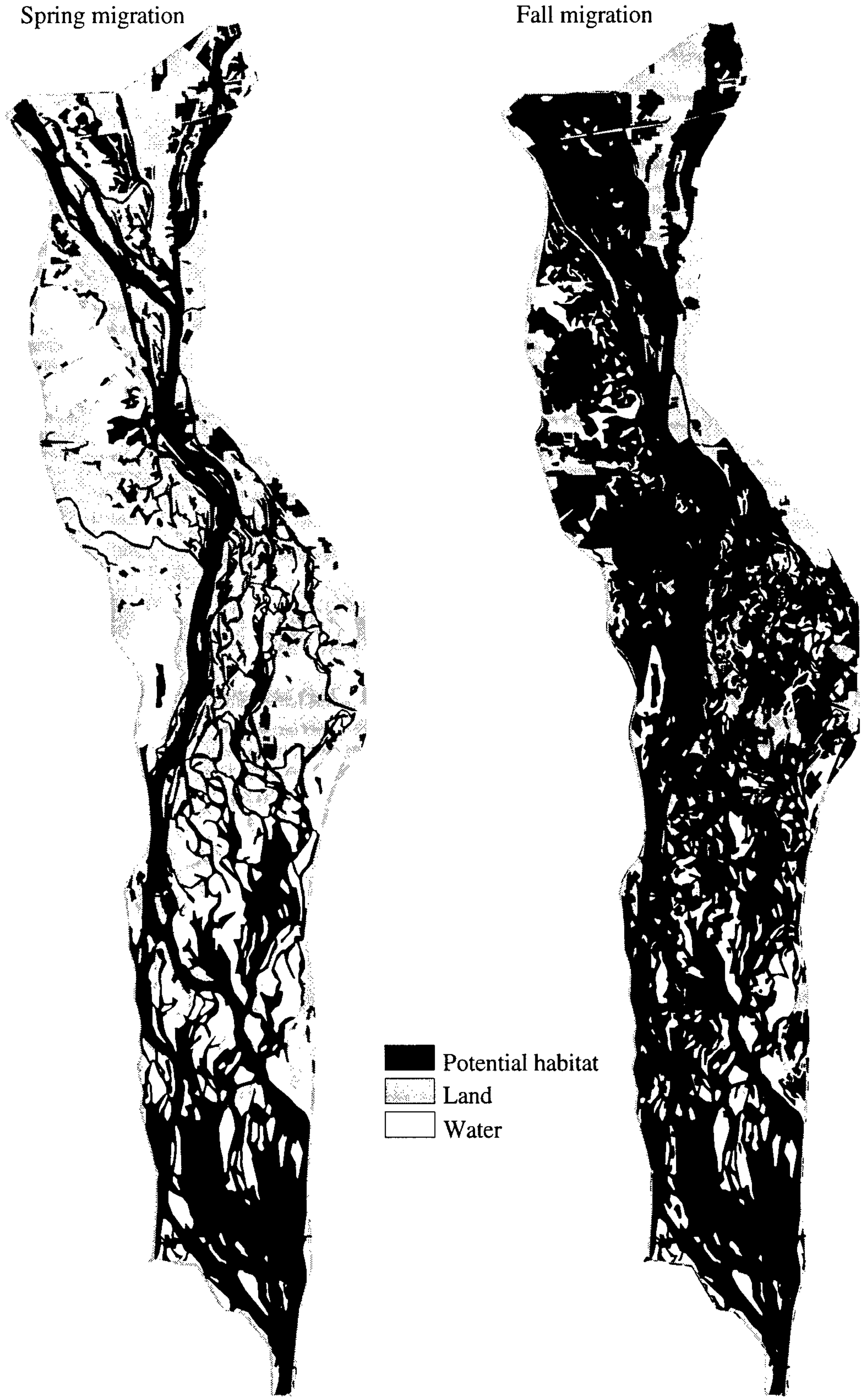


Figure E-121. Potential 1975 spring and fall migration habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 8.

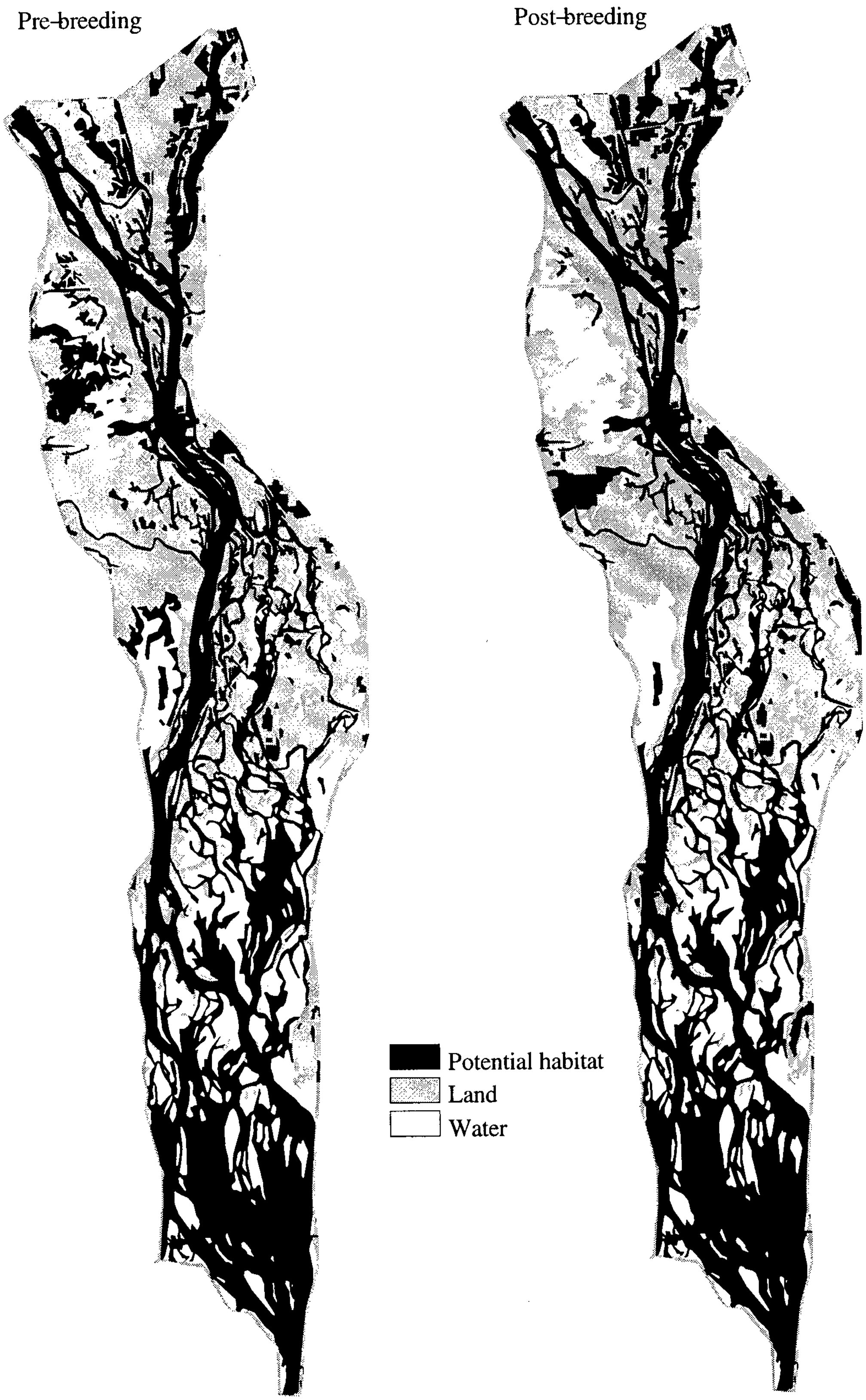


Figure E-122. Potential 1975 pre- and post-breeding habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 8.

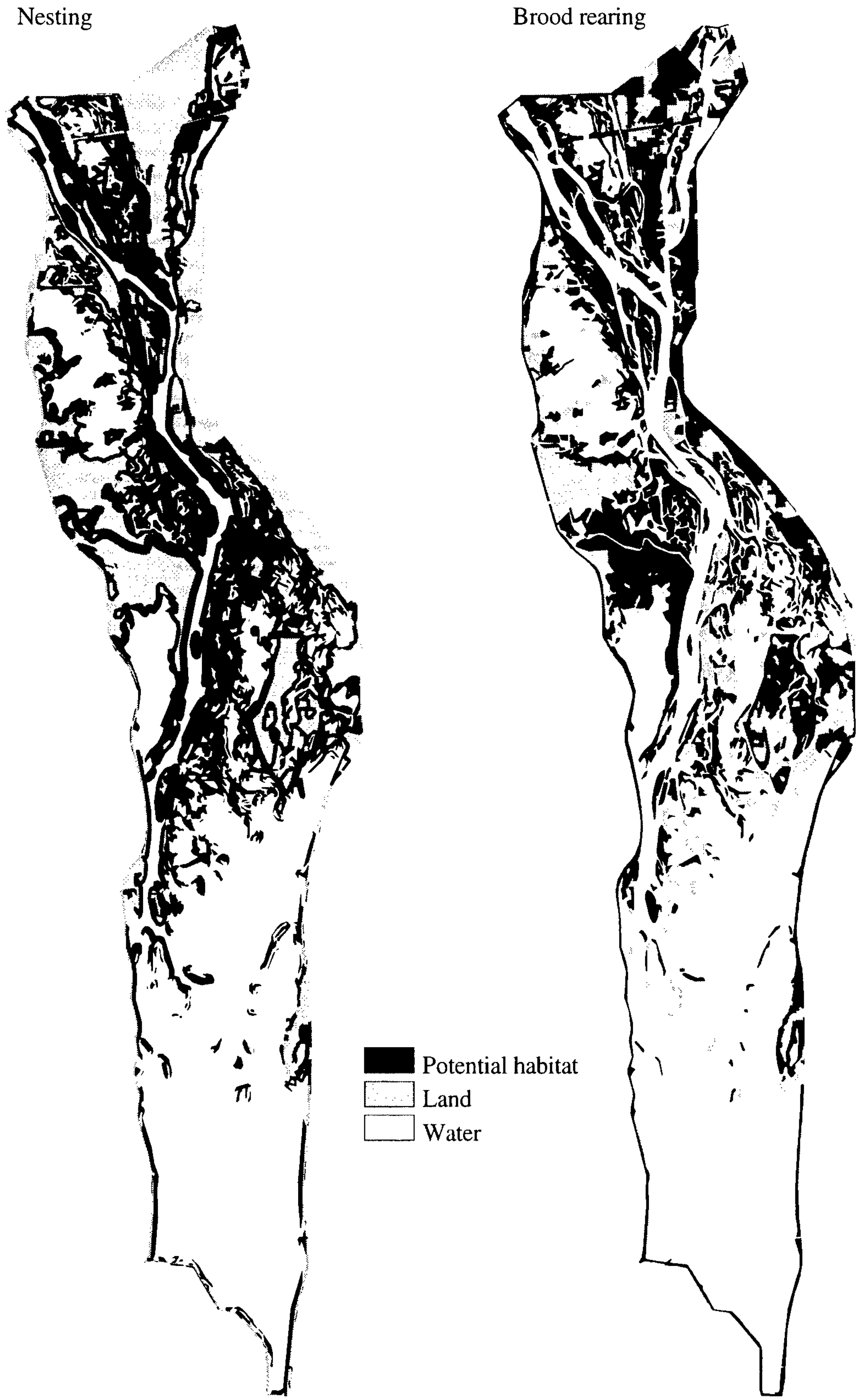


Figure E-123. Potential 1975 nesting and brood rearing habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 8.

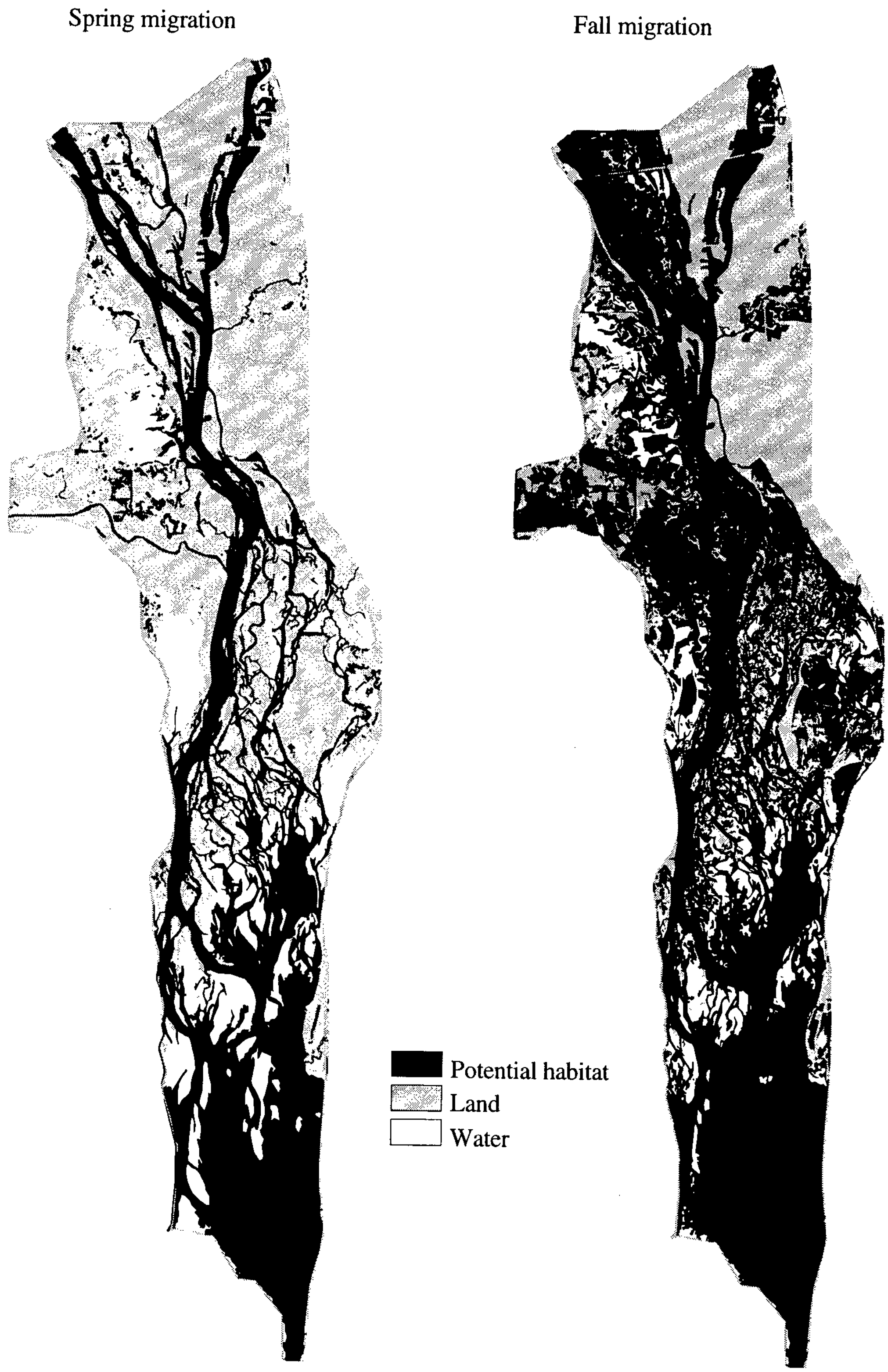


Figure E-124. Potential 1989 spring and fall migration habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 8.

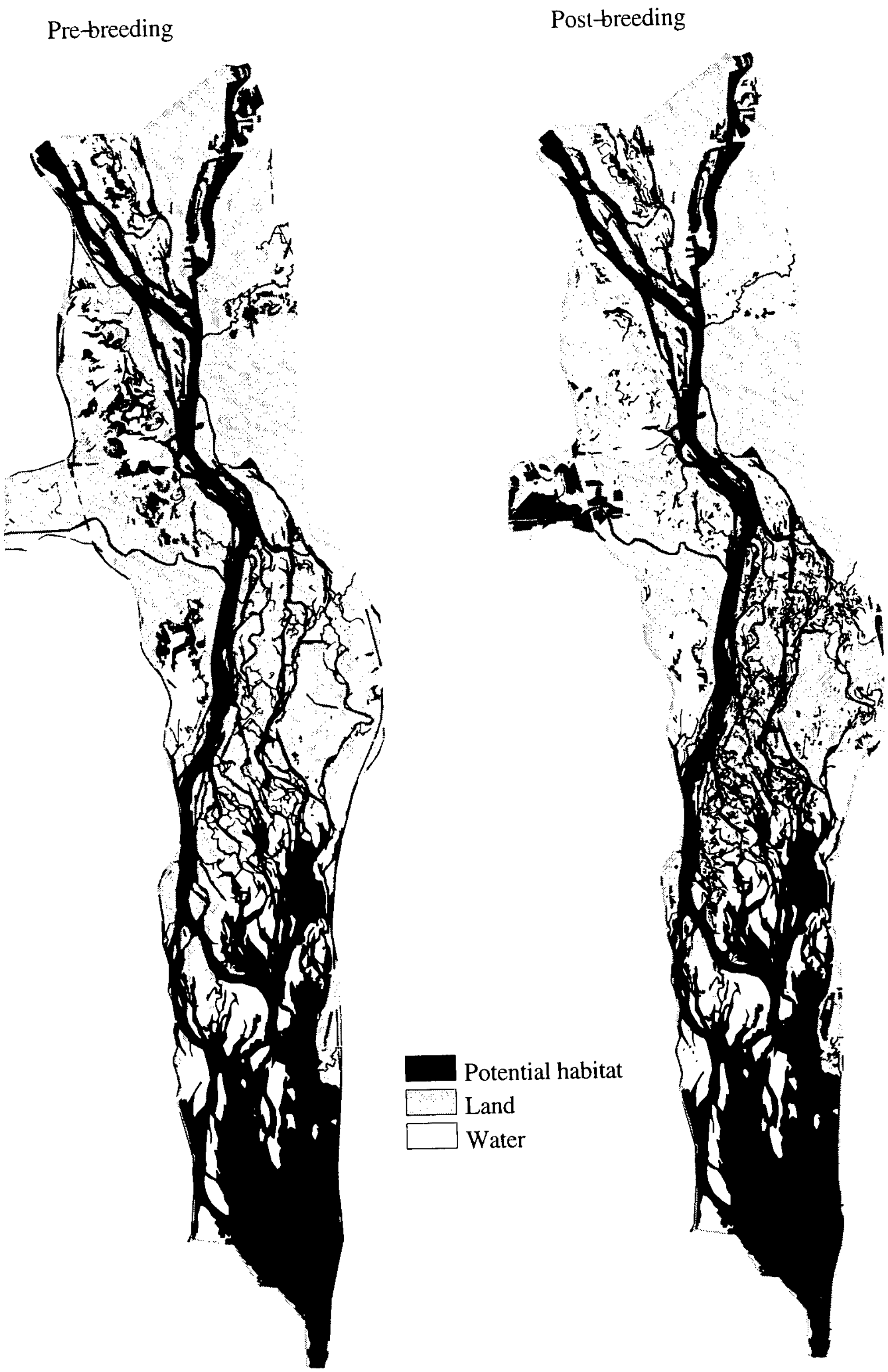


Figure E-125. Potential 1989 pre- and post-breeding habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 8.

Figure E-126. Potential 1989 nesting and brood rearing habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 8.

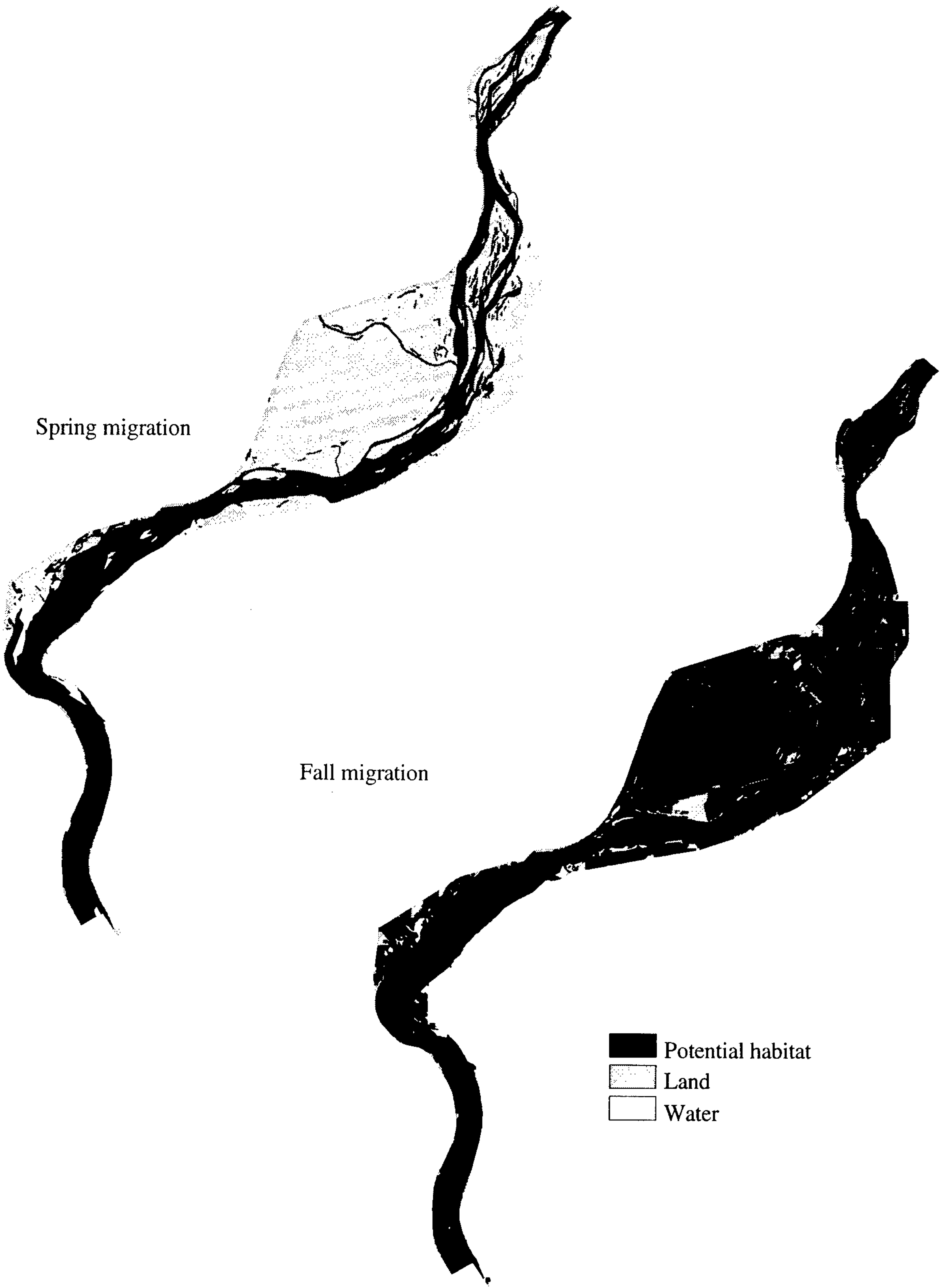


Figure E-127. Potential 1975 spring and fall migration habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 19.

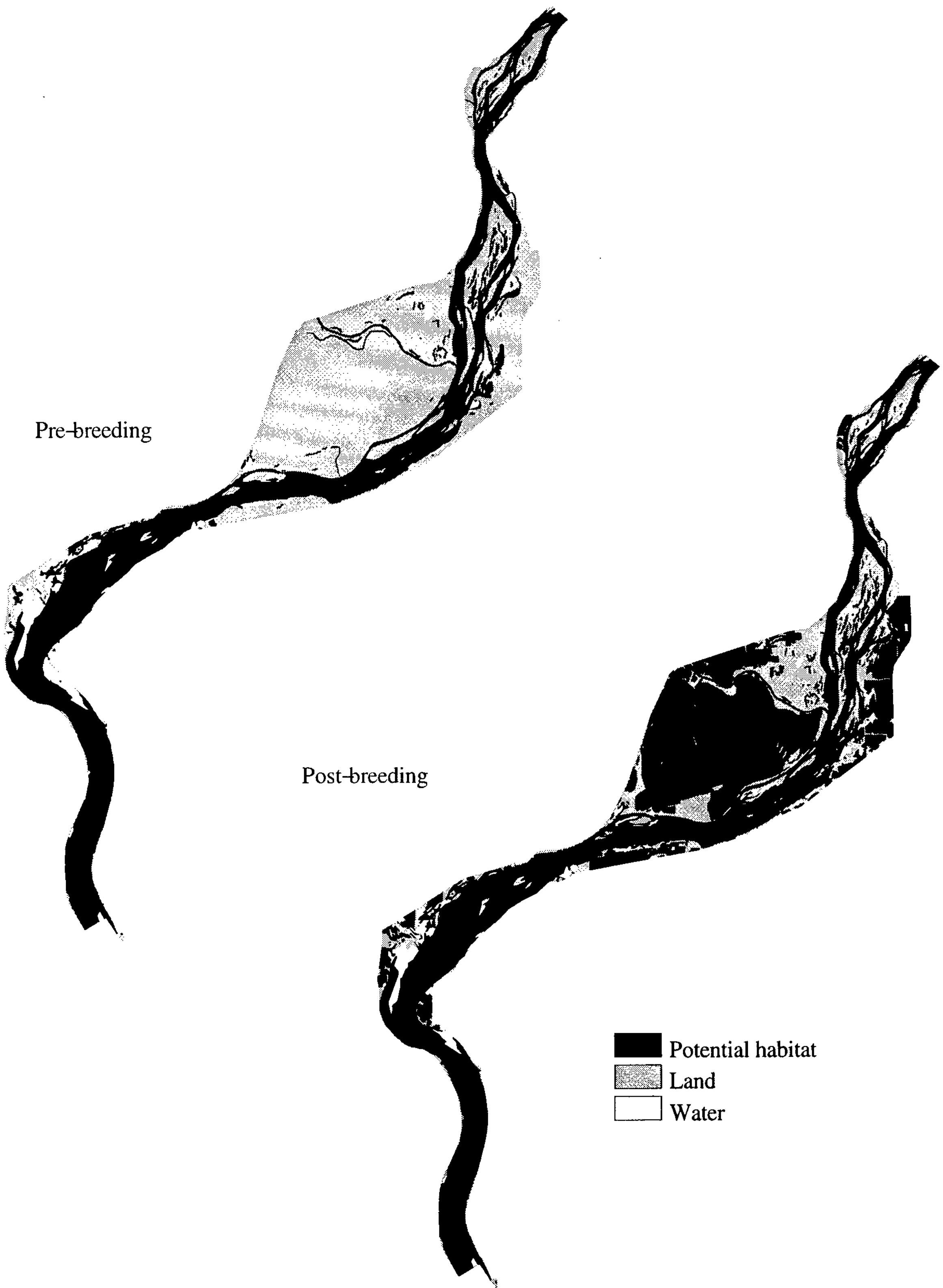


Figure E-128. Potential 1975 pre- and post-breeding habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 19.

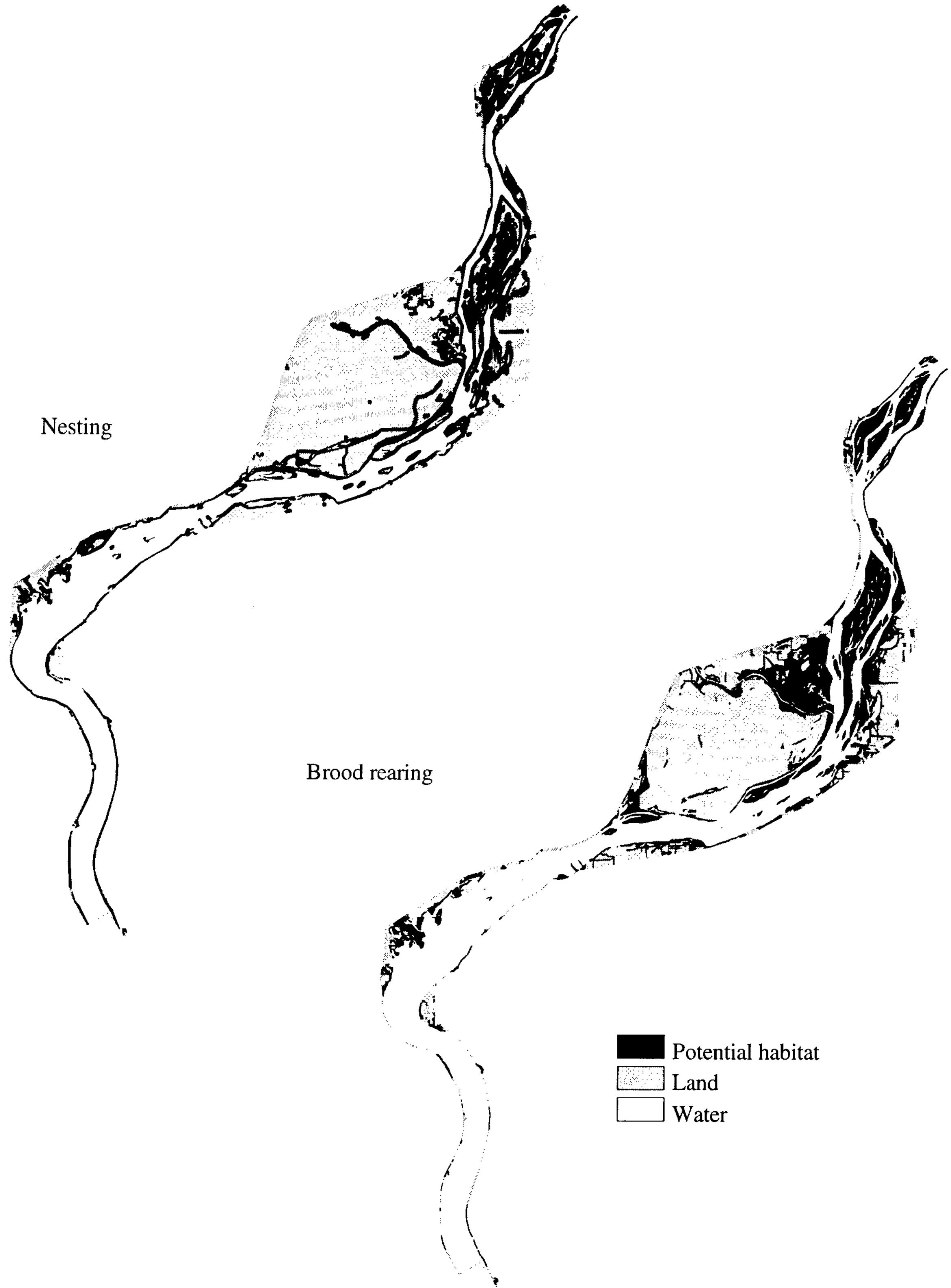


Figure E-129. Potential 1975 nesting and brood rearing habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 19.

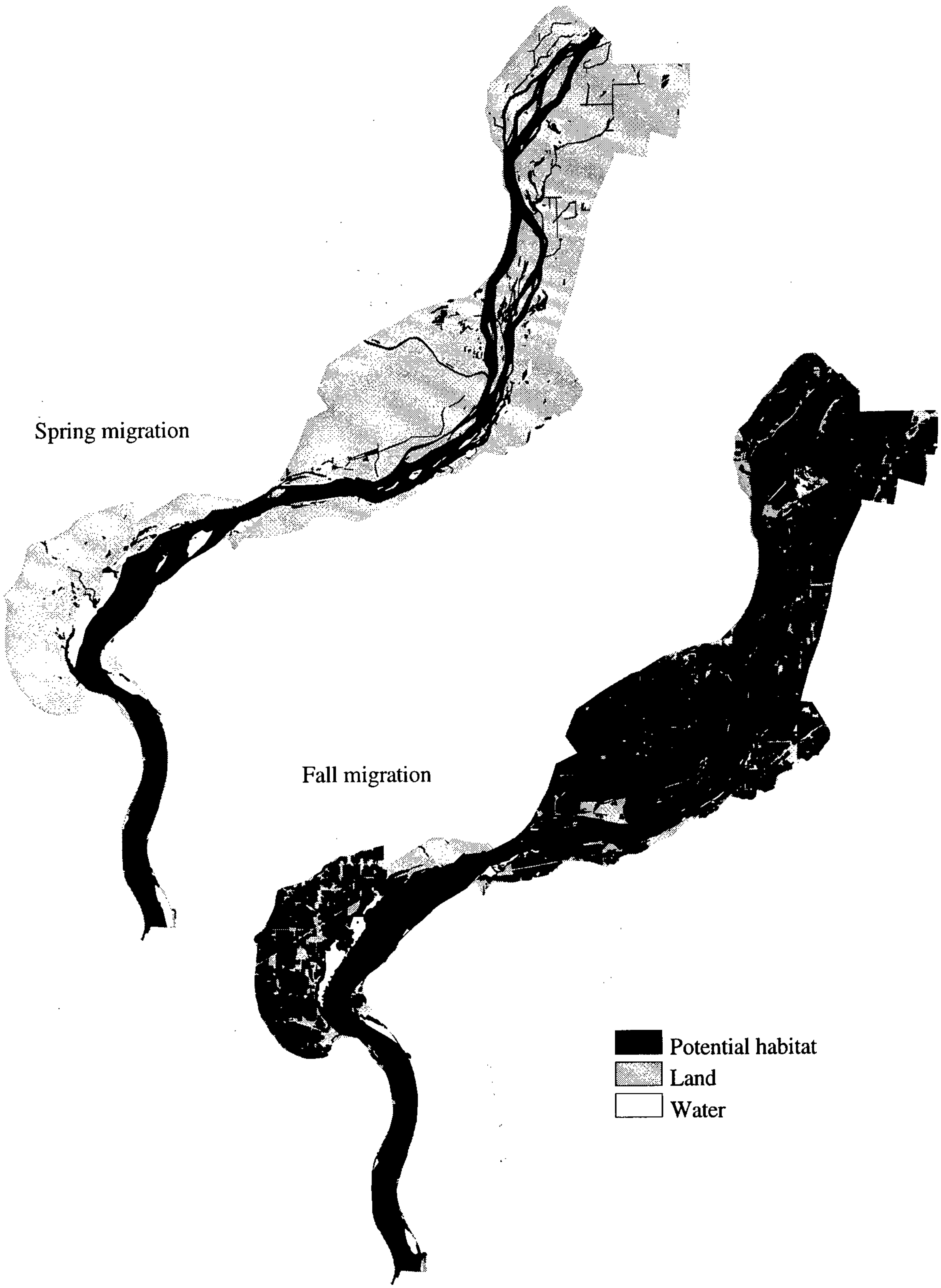


Figure E-130. Potential 1989 spring and fall migration habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 19.

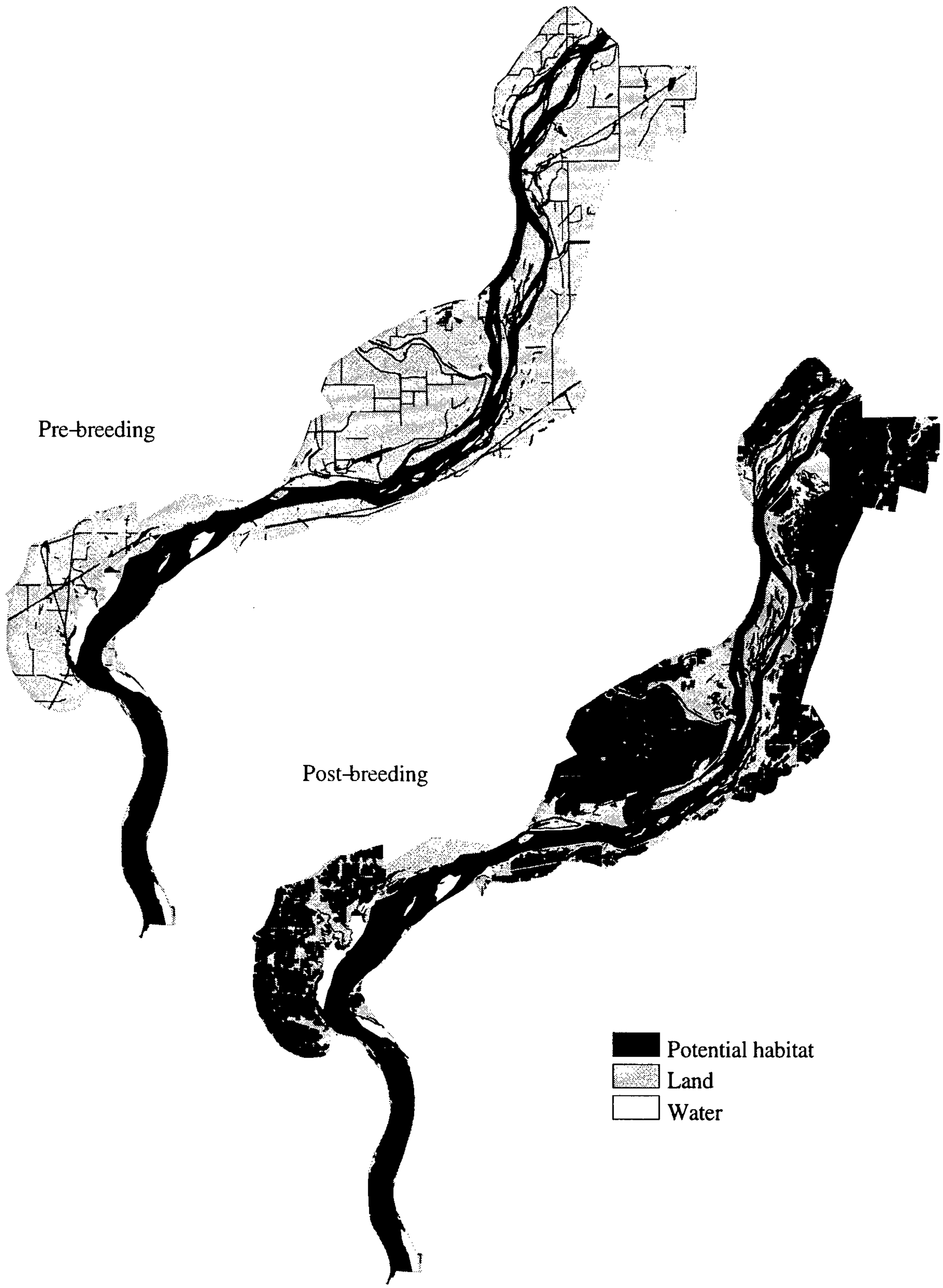


Figure E-131. Potential 1989 pre- and post-breeding habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 19.

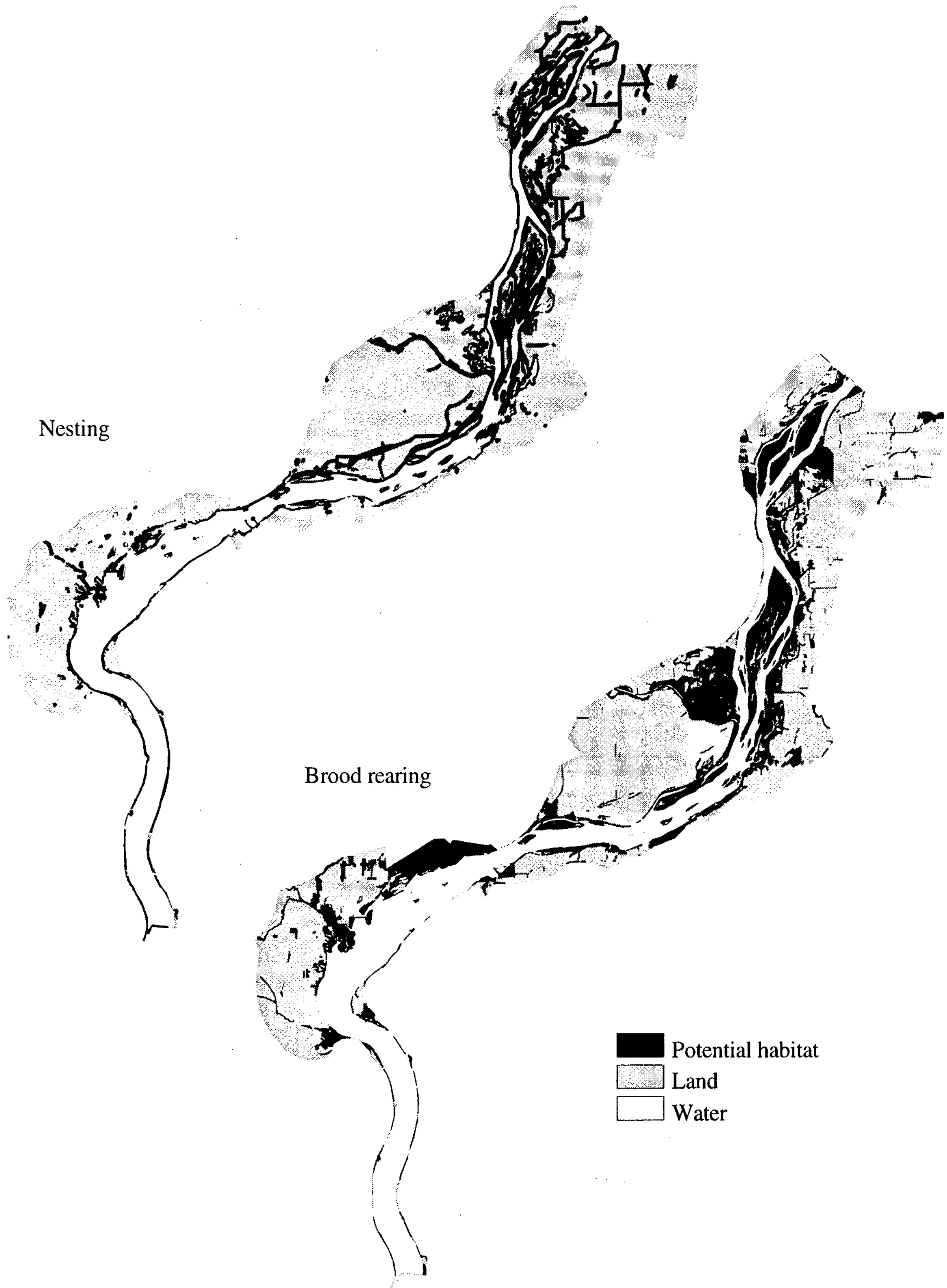


Figure E-132. Potential 1989 nesting and brood rearing habitat for the mallard (*Anas platyrhynchos*), Upper Mississippi River Pool 19.

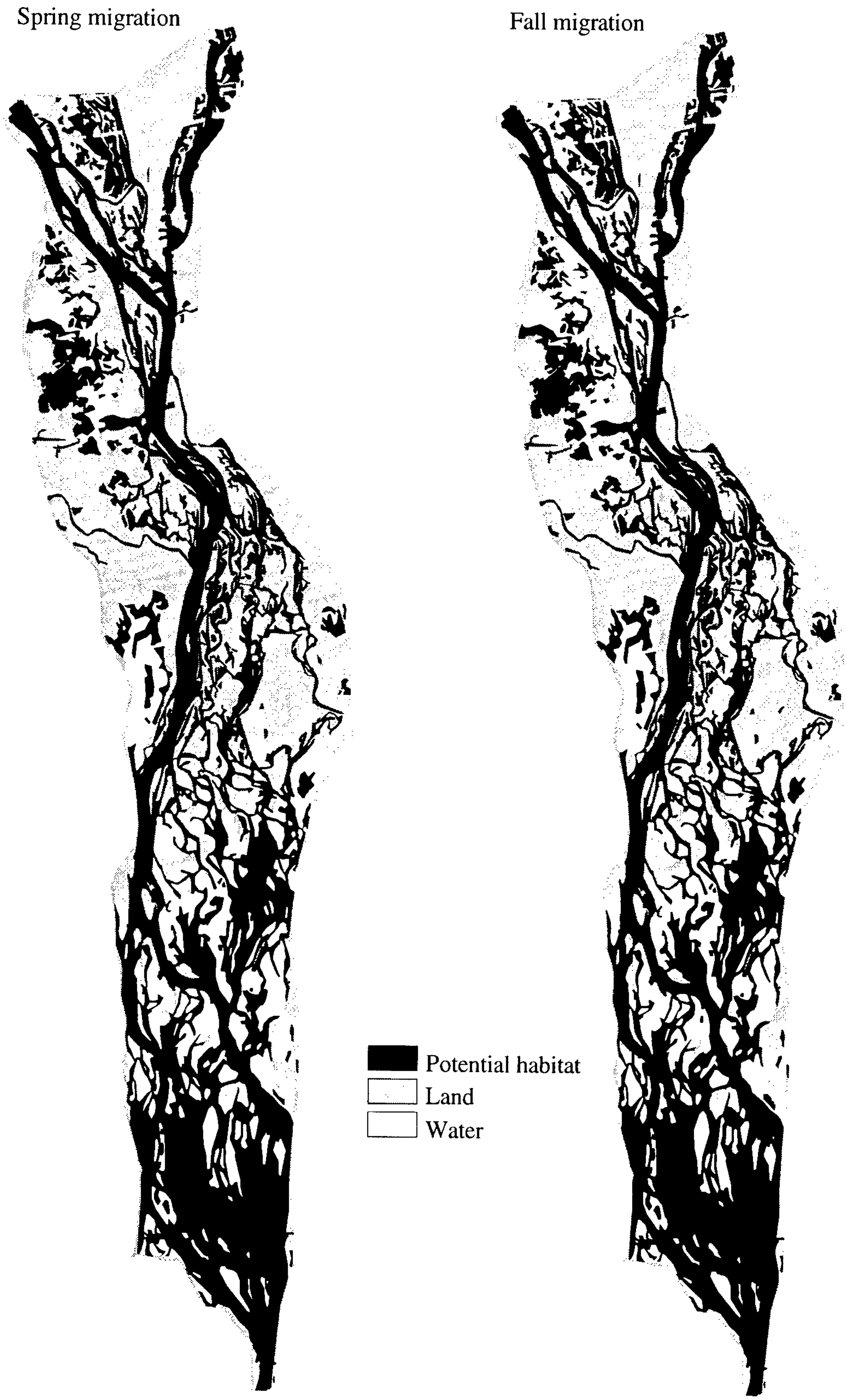


Figure E-133. Potential 1975 spring and fall migration habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 8.

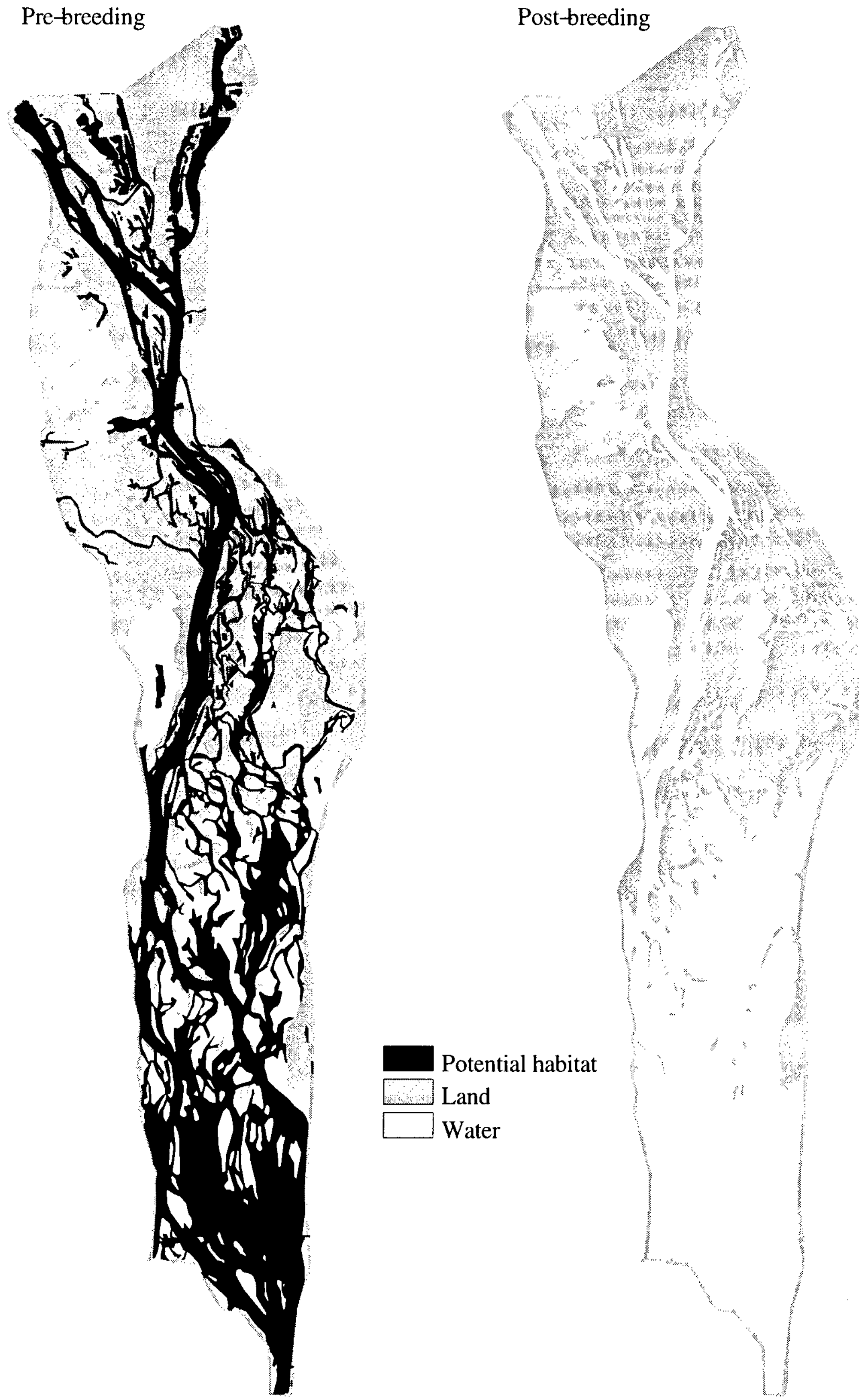


Figure E-134. Potential 1975 pre- and post-breeding habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 8.

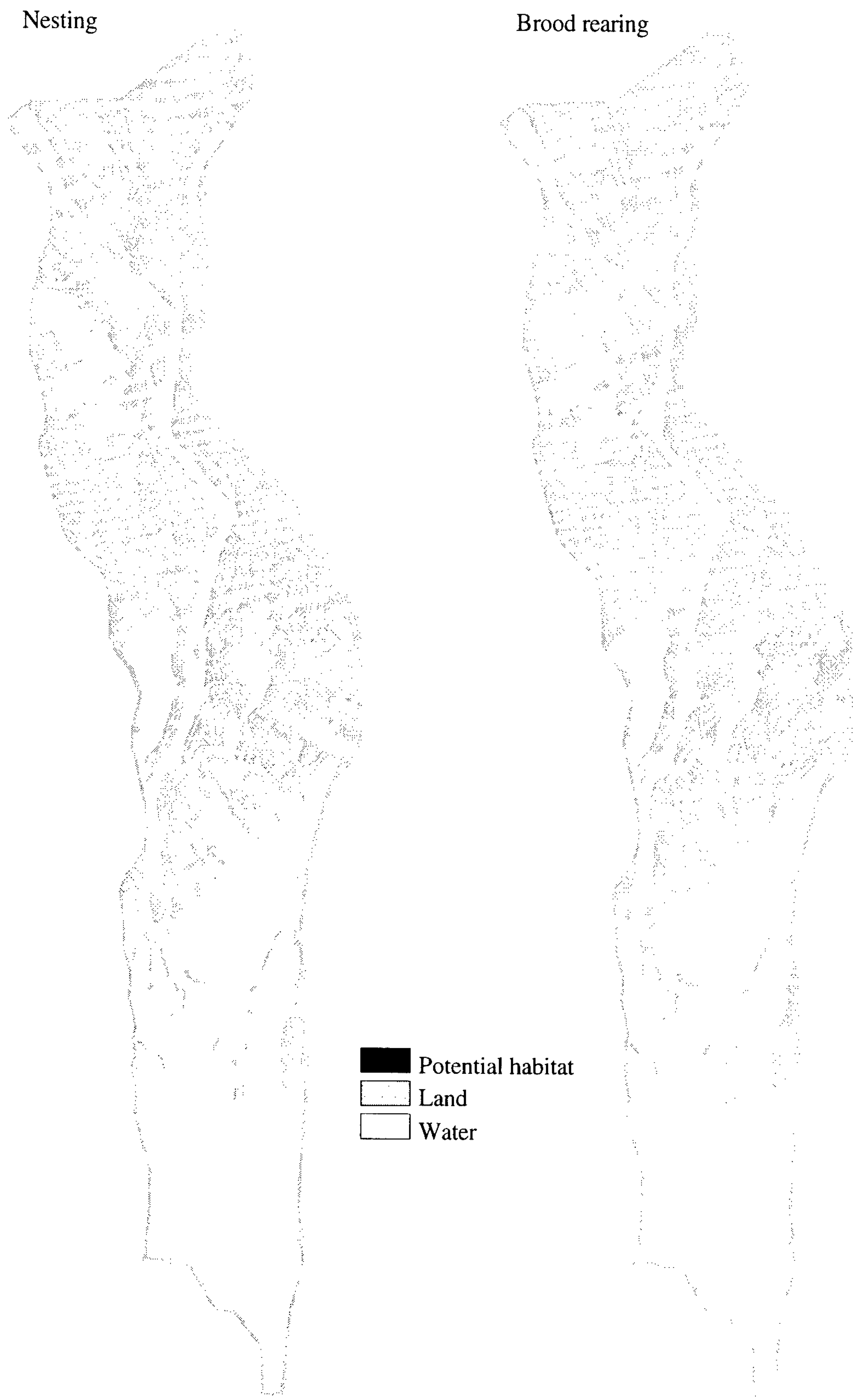


Figure E-135. Potential 1975 nesting and brood rearing habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 8.

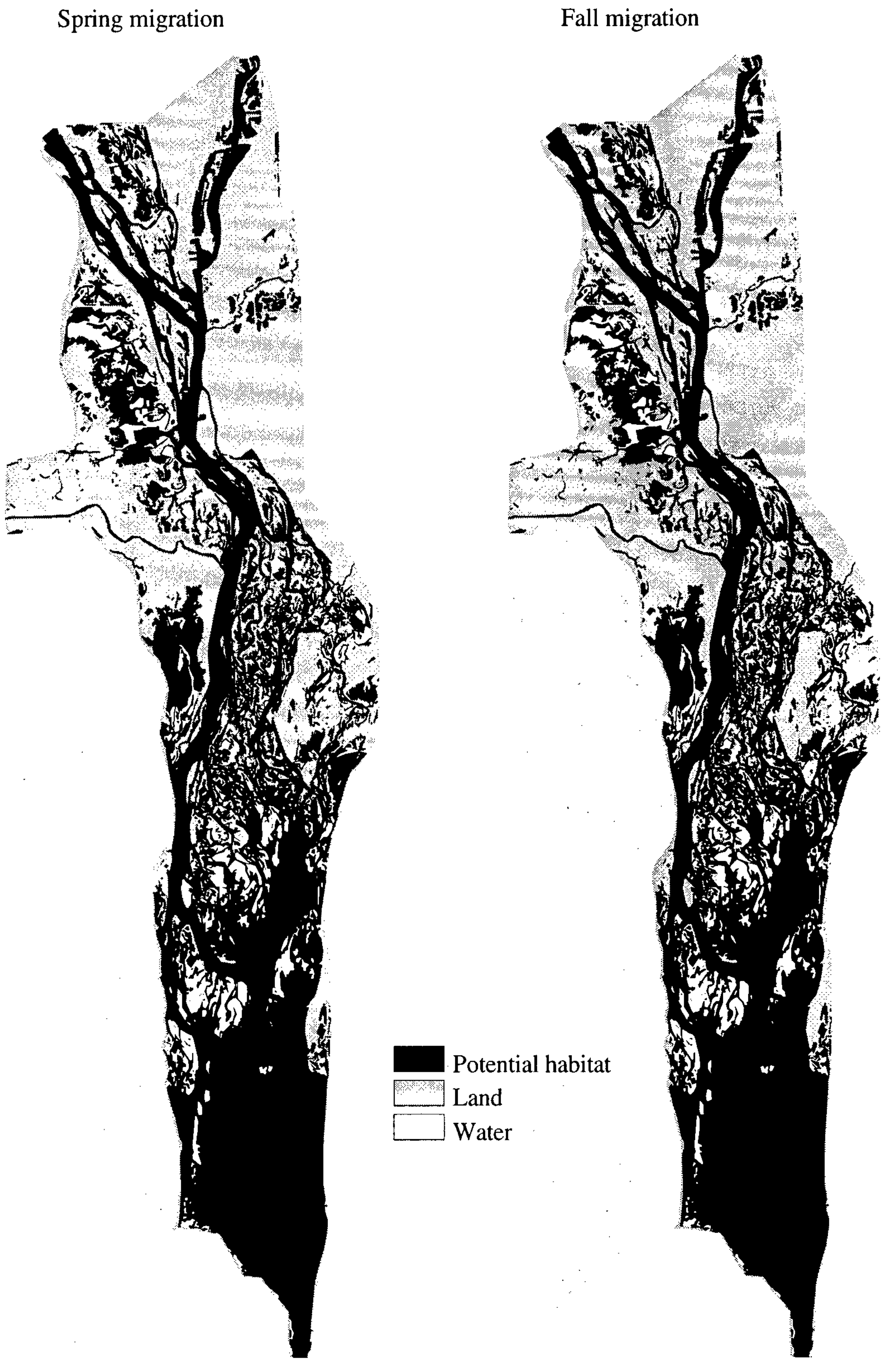


Figure E-136. Potential 1989 spring and fall migration habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 8.

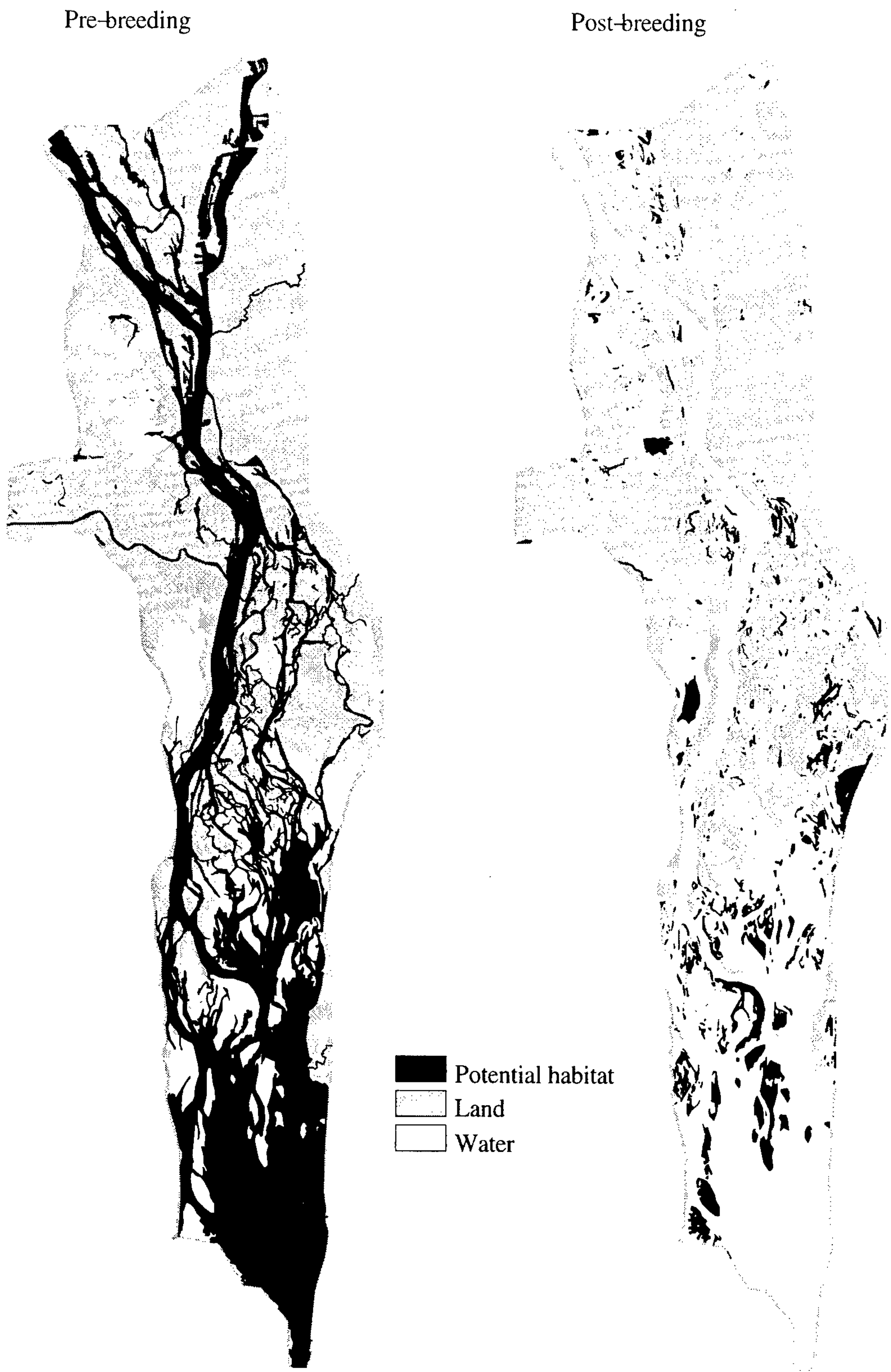


Figure E-137. Potential 1989 pre- and post-breeding habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 8.

Figure E-138. Potential 1989 nesting and brood rearing habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 8.

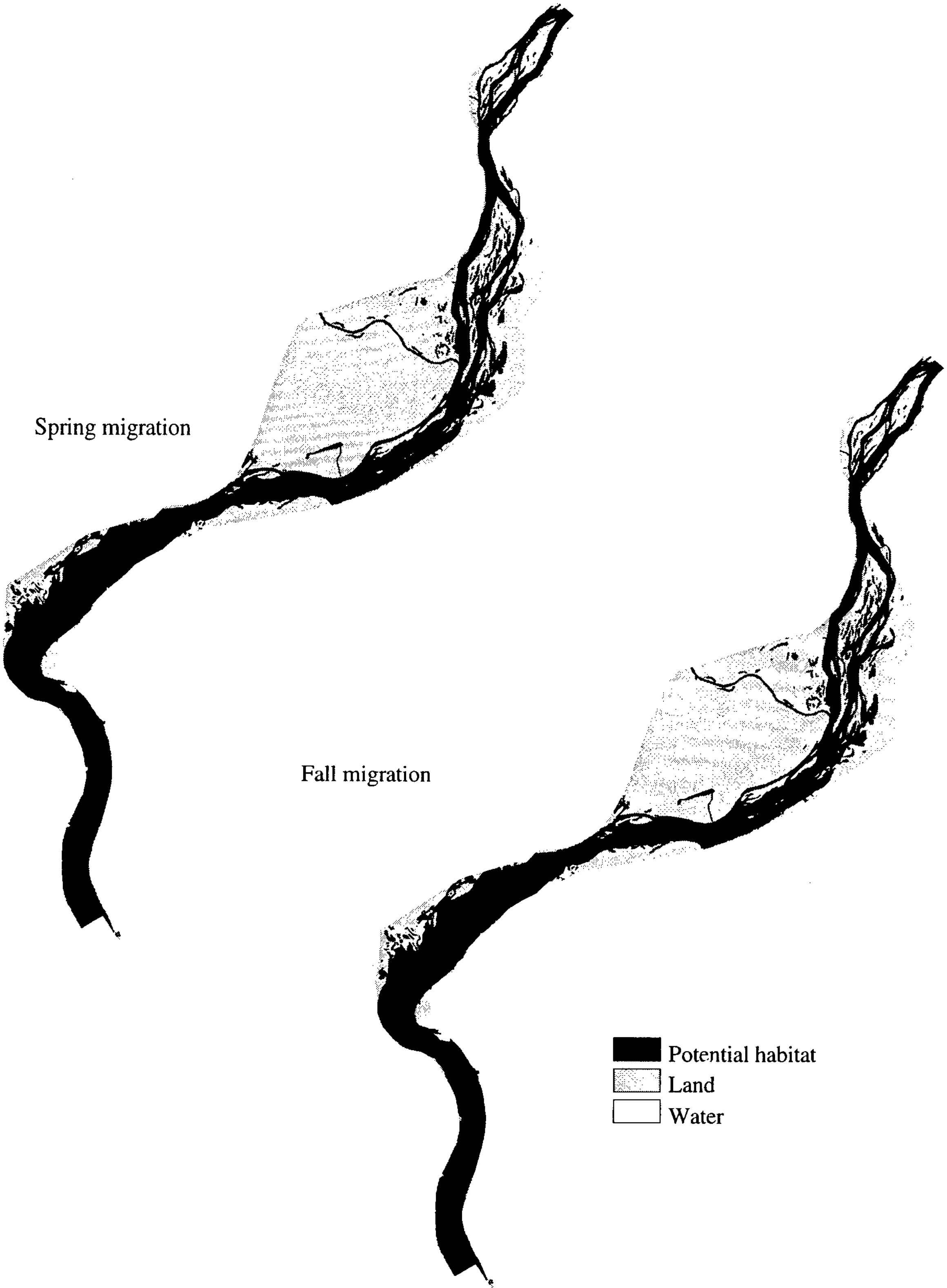


Figure E-139. Potential 1975 spring and fall migration habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 19.

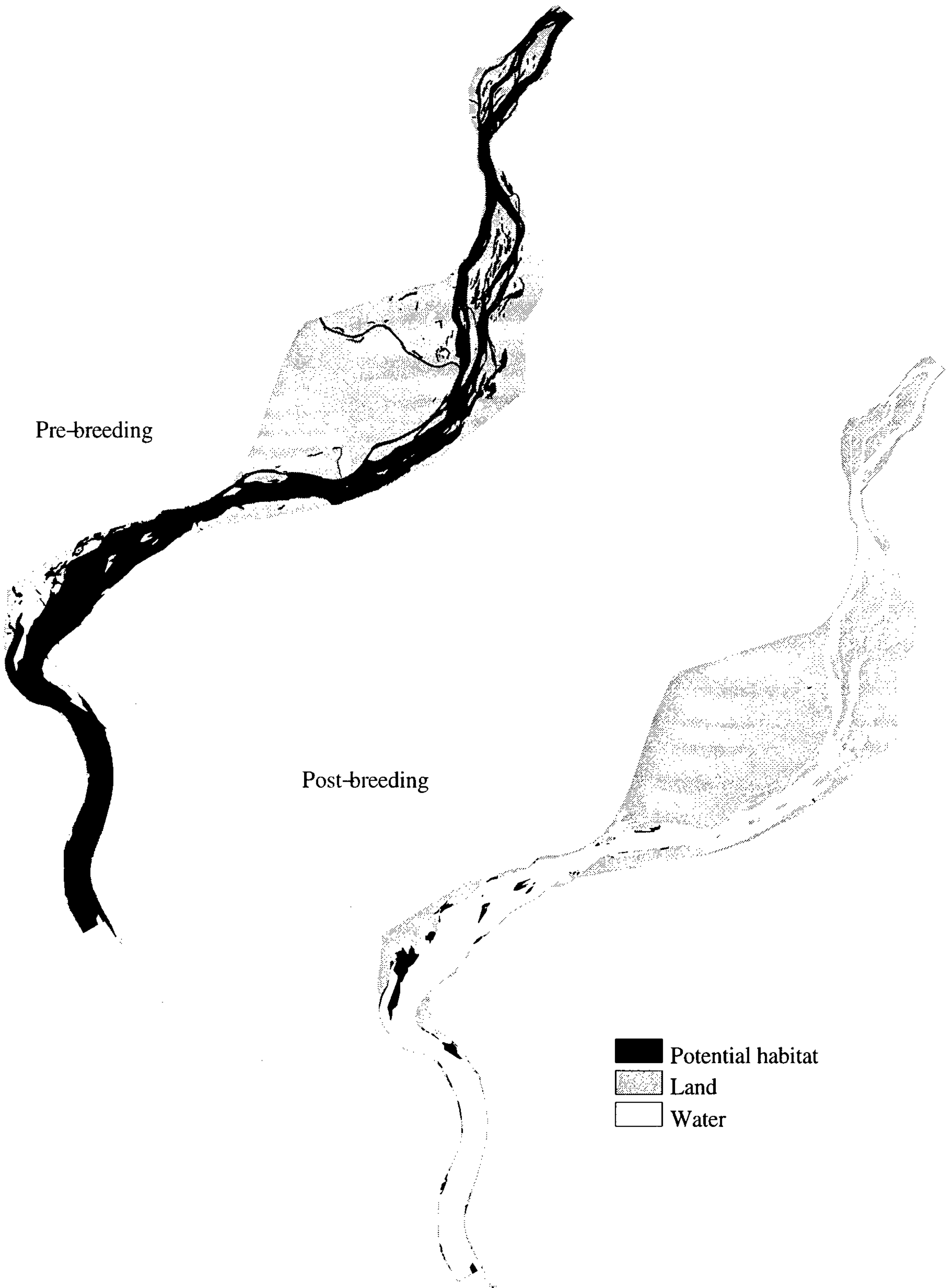


Figure E-140. Potential 1975 pre- and post-breeding habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 19.

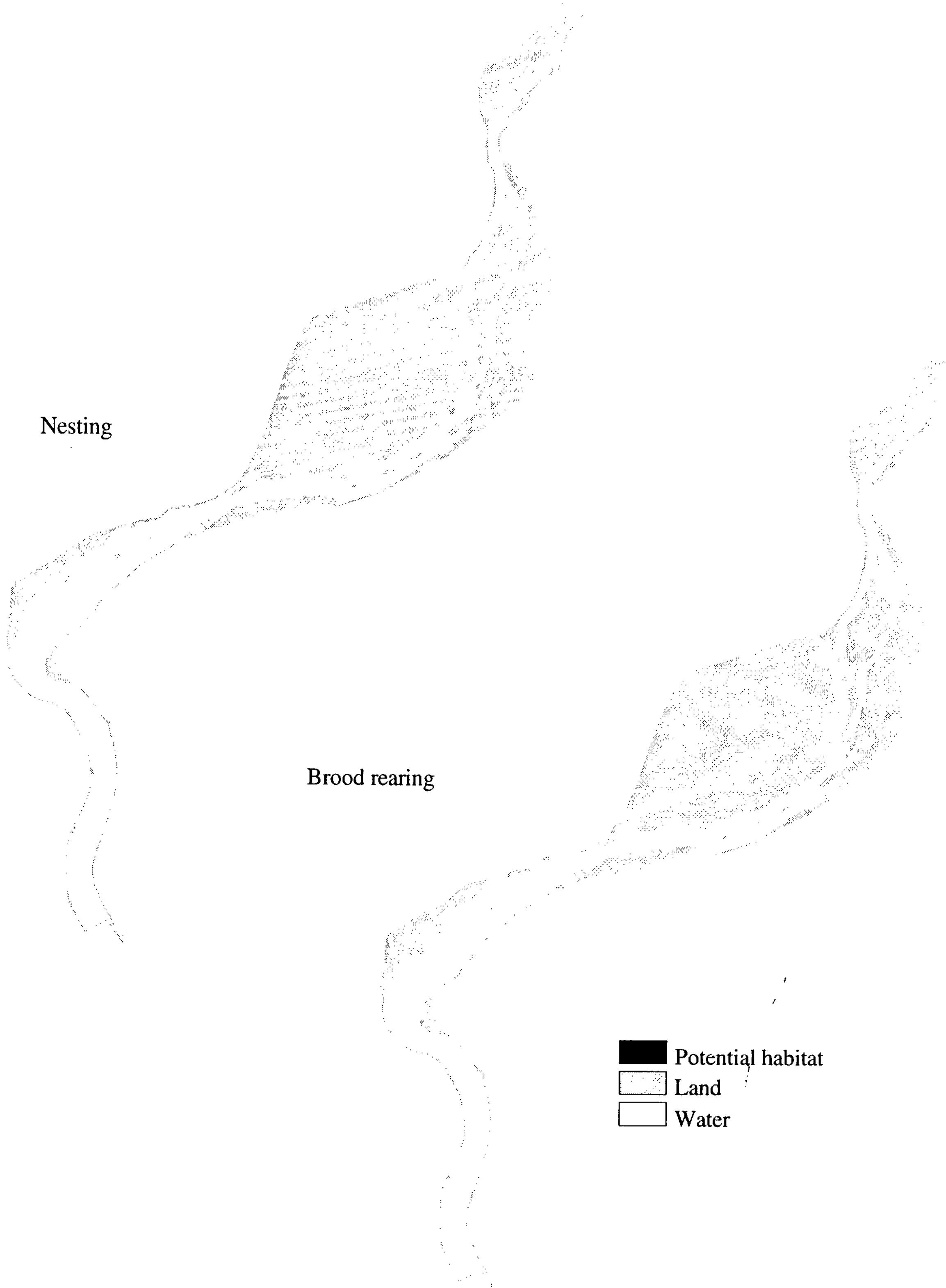


Figure E-141. Potential 1975 nesting and brood rearing habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 19.

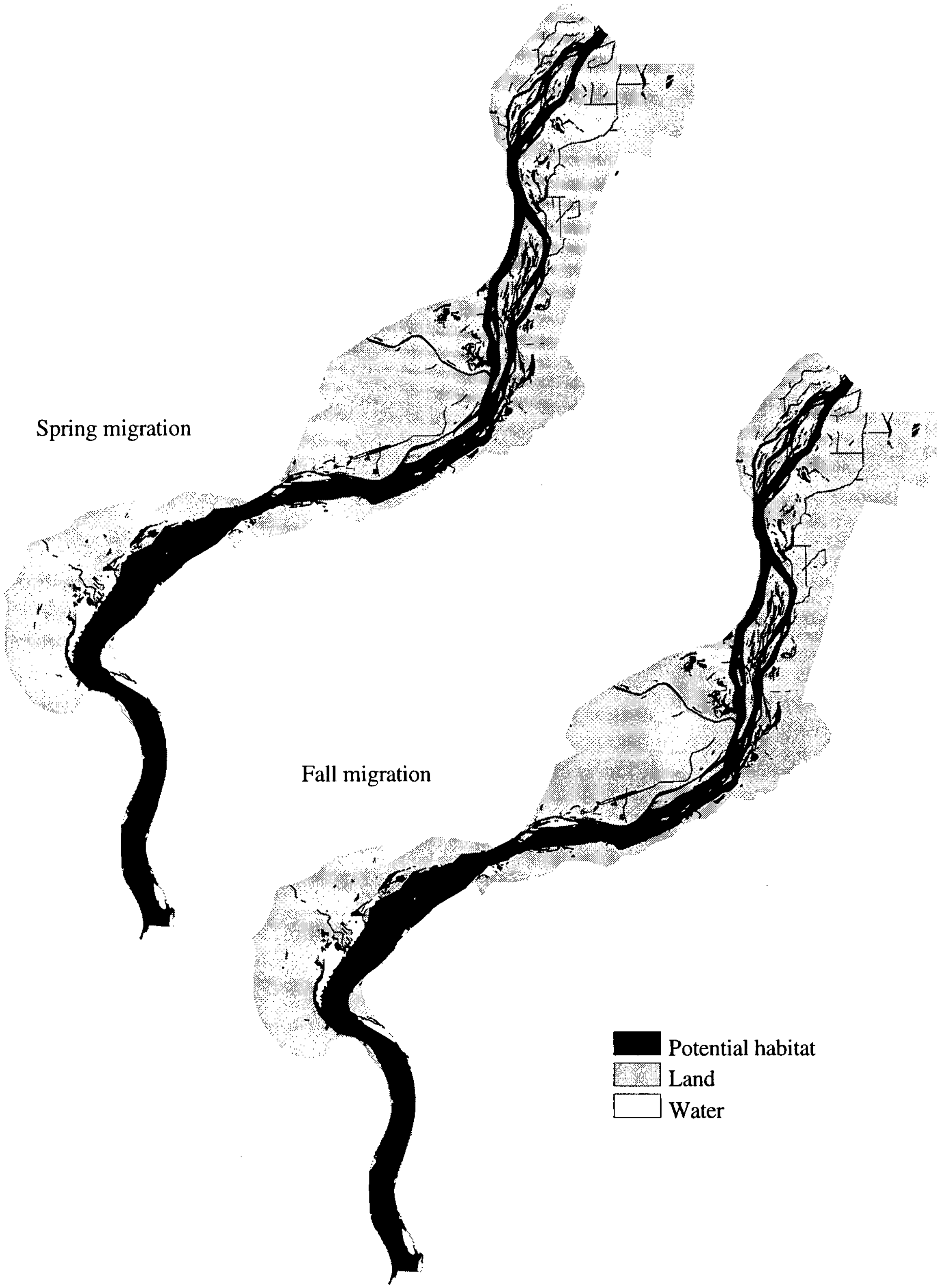


Figure E-142. Potential 1989 spring and fall migration habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 19.

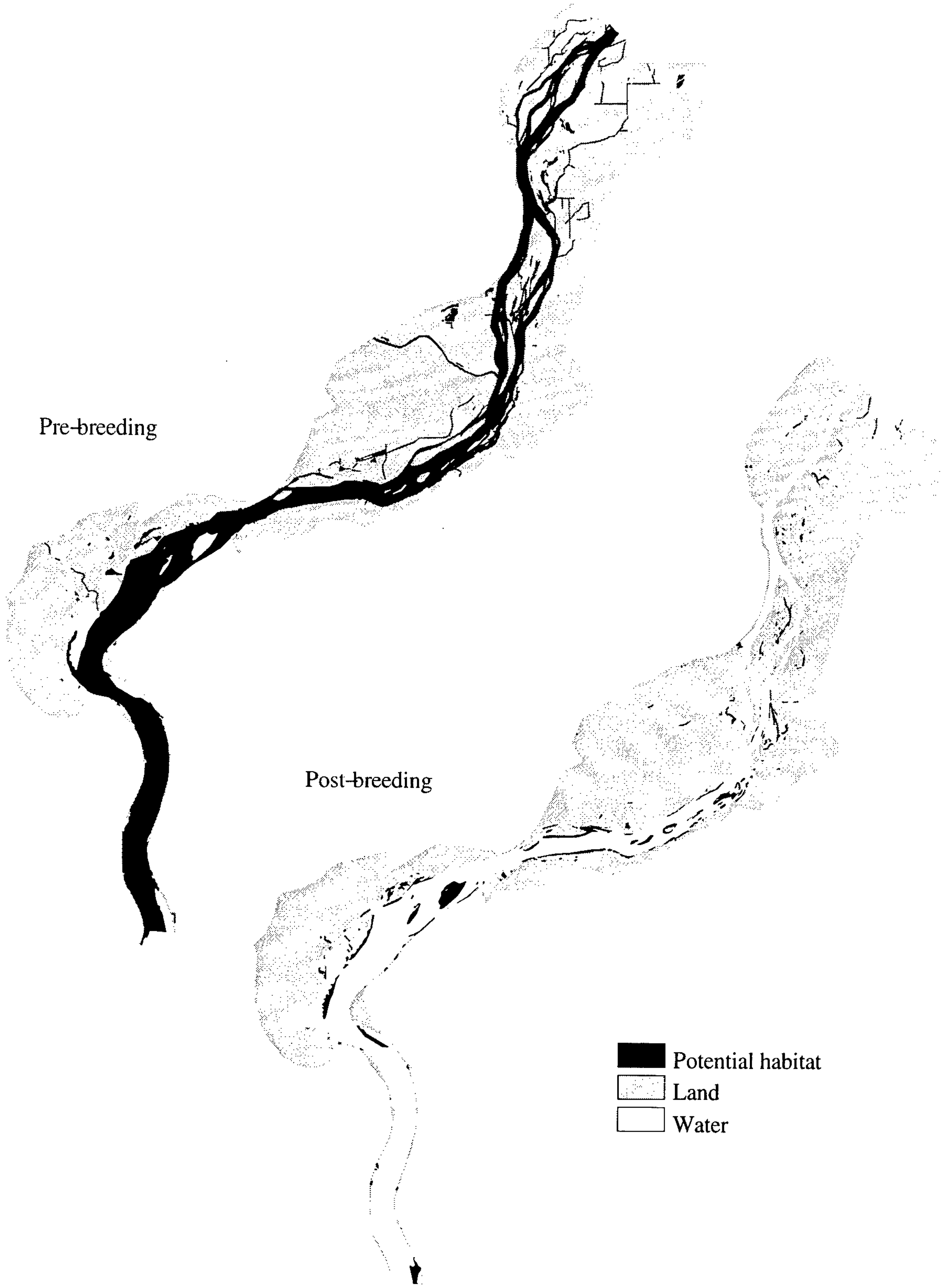


Figure E-143. Potential 1989 pre- and post-breeding habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 19.

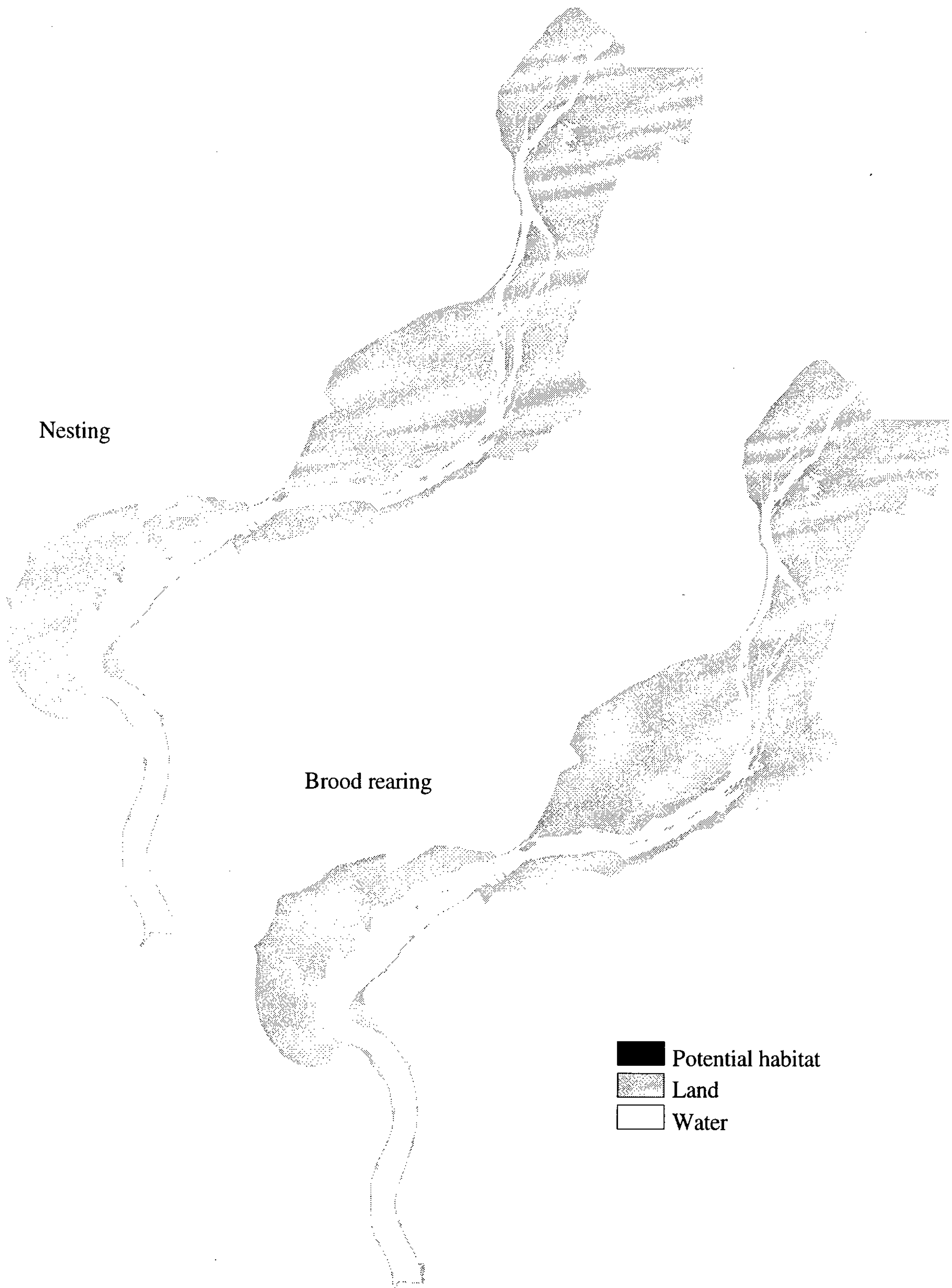


Figure E-144. Potential 1989 nesting and brood rearing habitat for the canvasback (*Aythya valisineria*), Upper Mississippi River Pool 19.

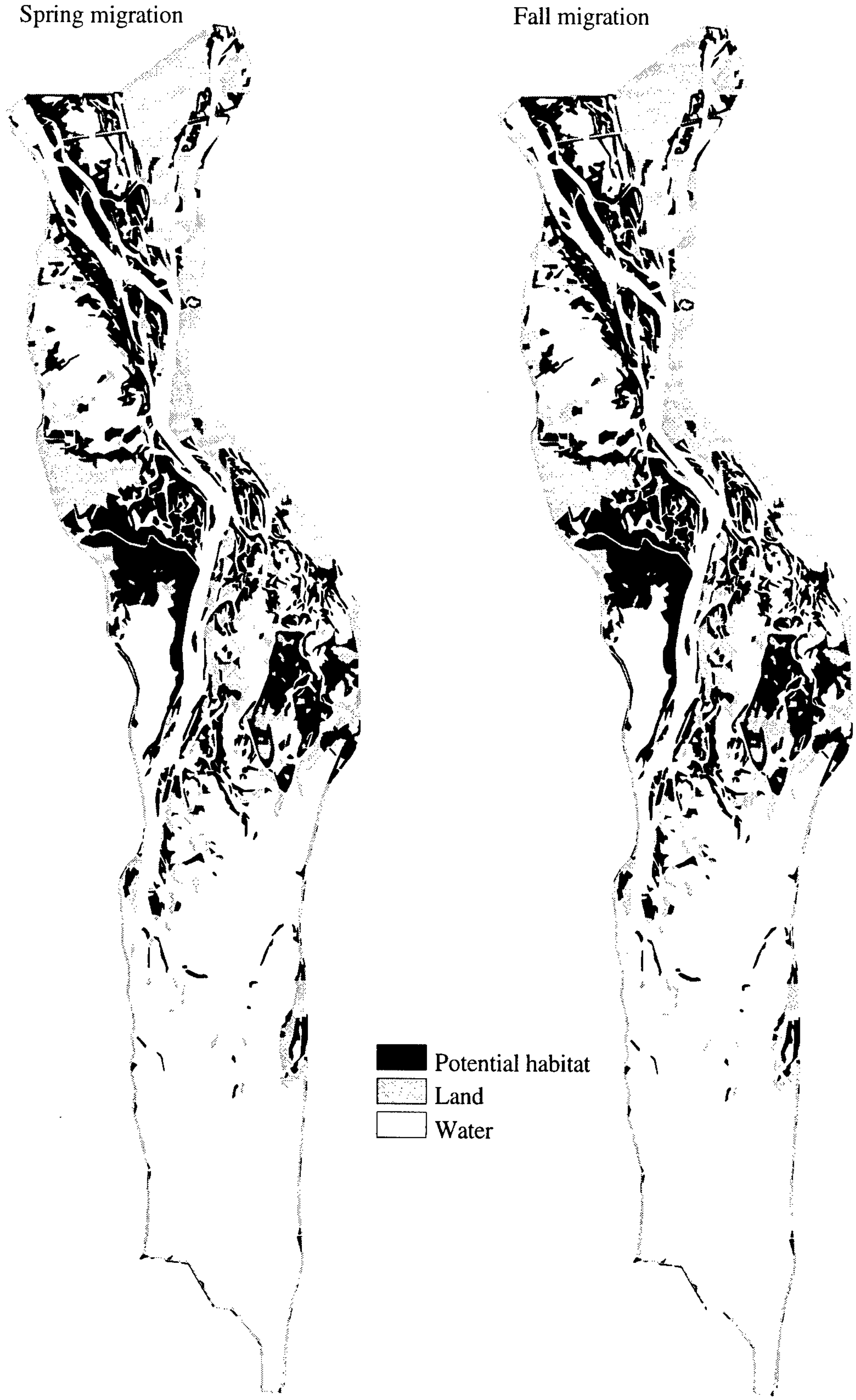


Figure E-145. Potential 1975 spring and fall migration habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 8.

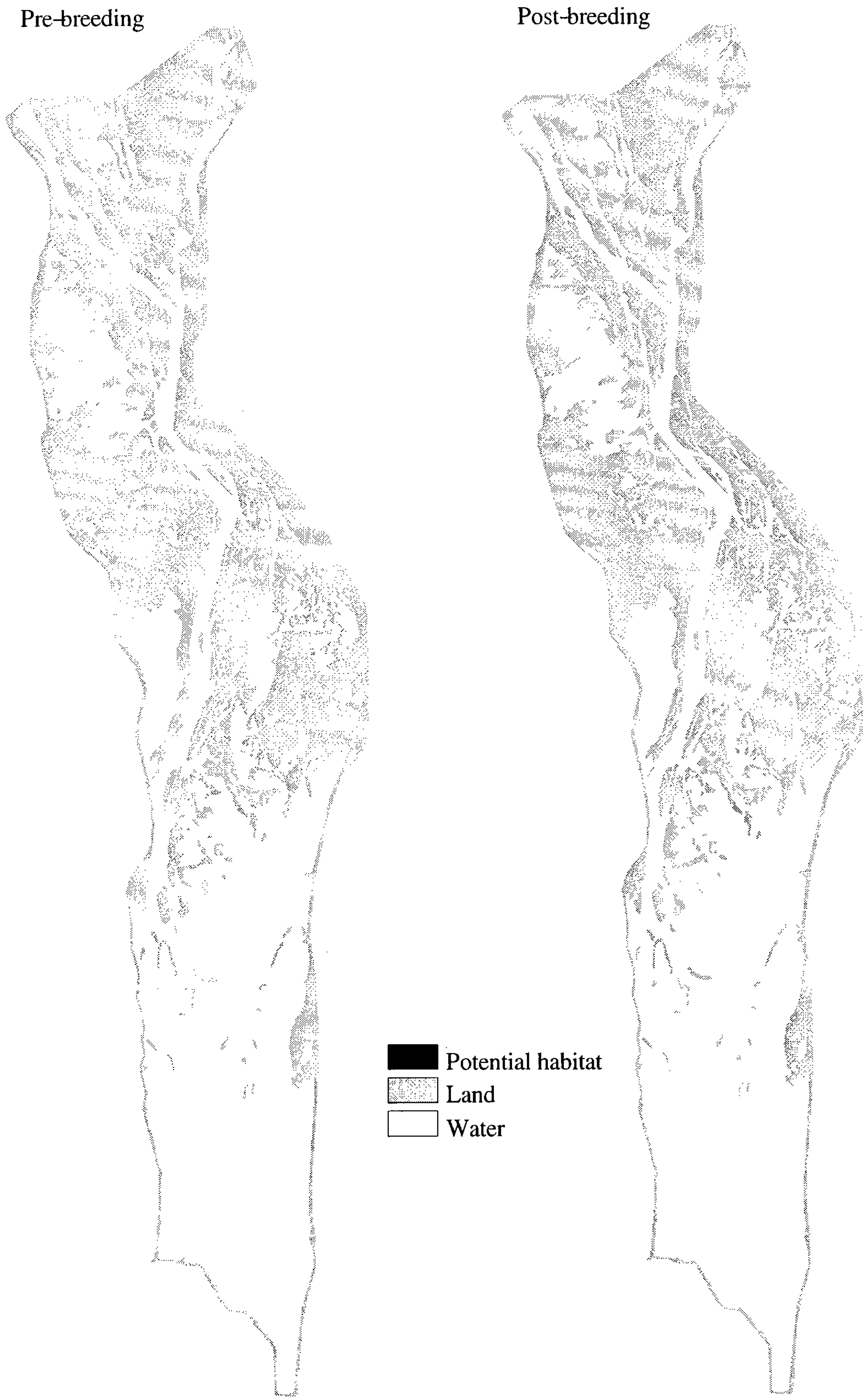


Figure E-146. Potential 1975 pre- and post-breeding habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 8.

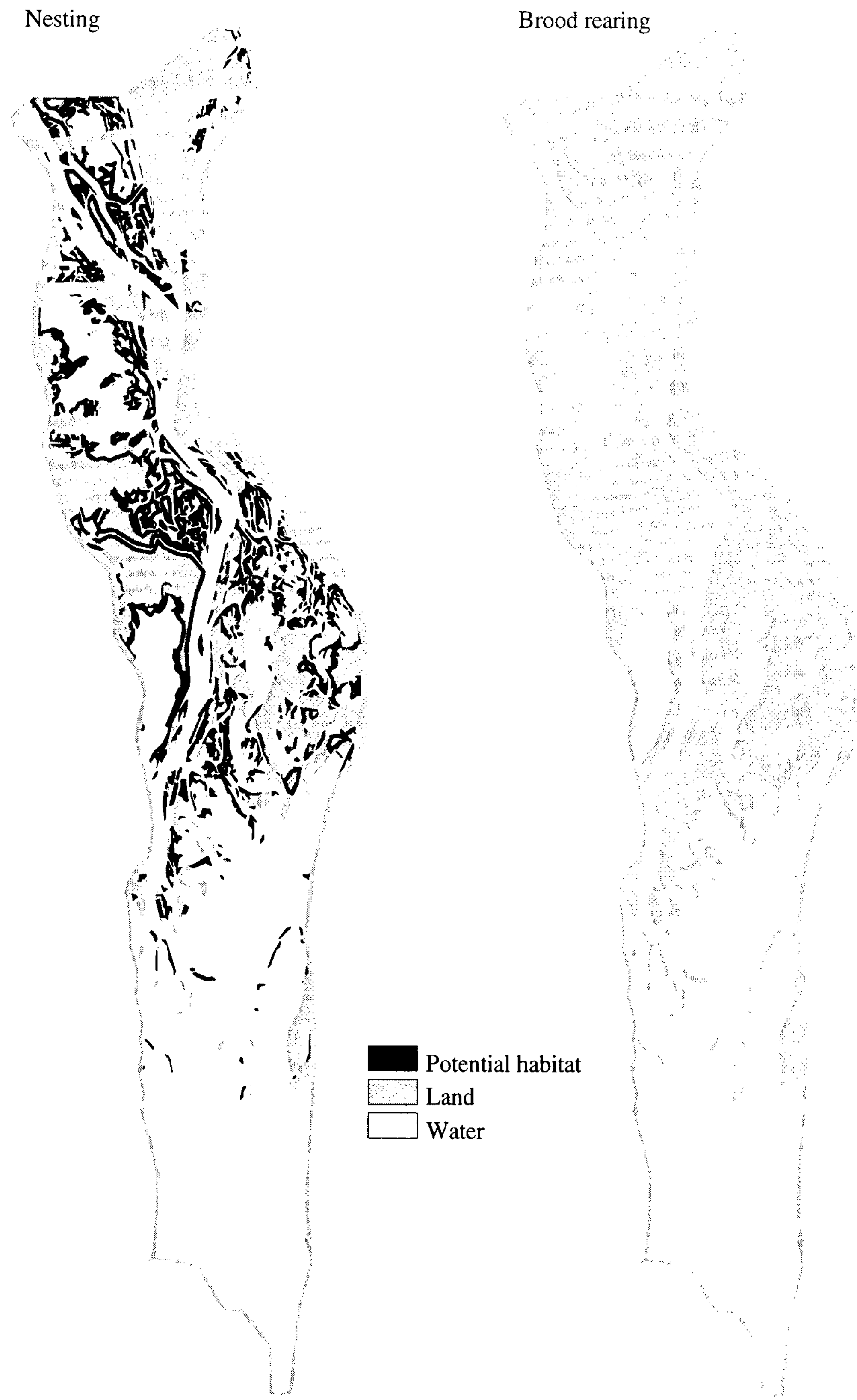


Figure E-147. Potential 1975 nesting and brood rearing habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 8.

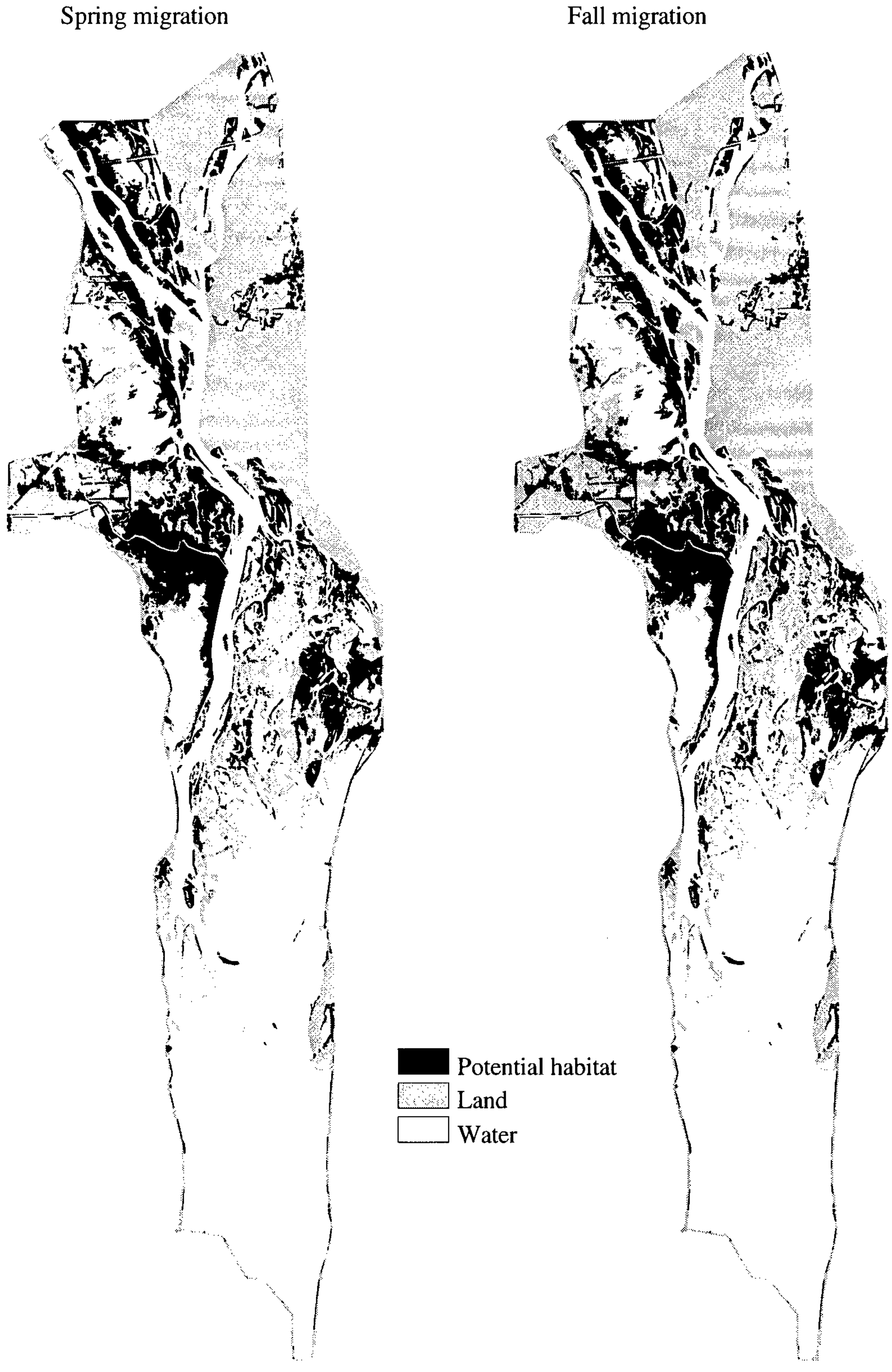


Figure E-148. Potential 1989 spring and fall migration habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 8.

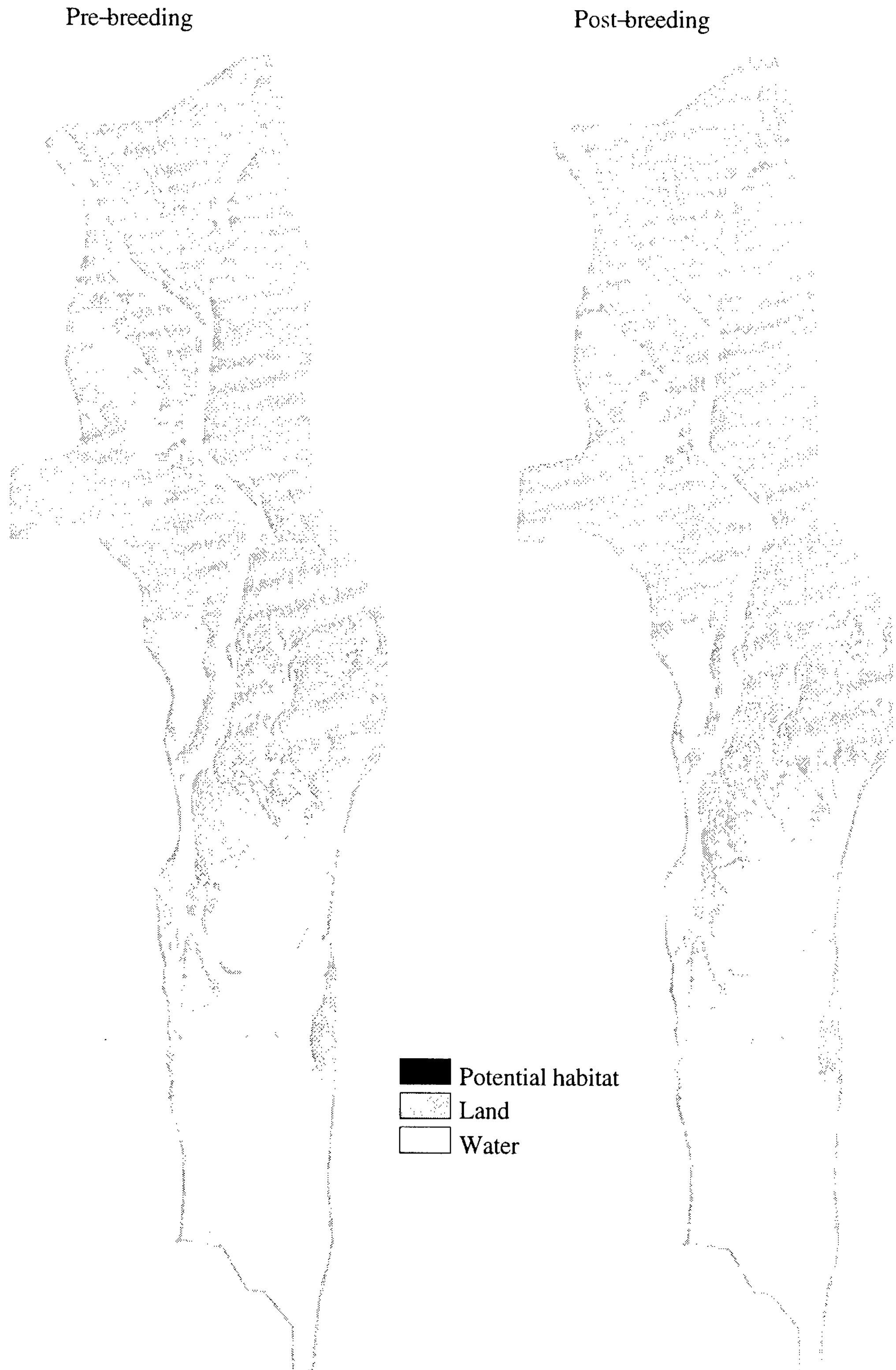


Figure E-149. Potential 1989 pre- and post-breeding habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 8.

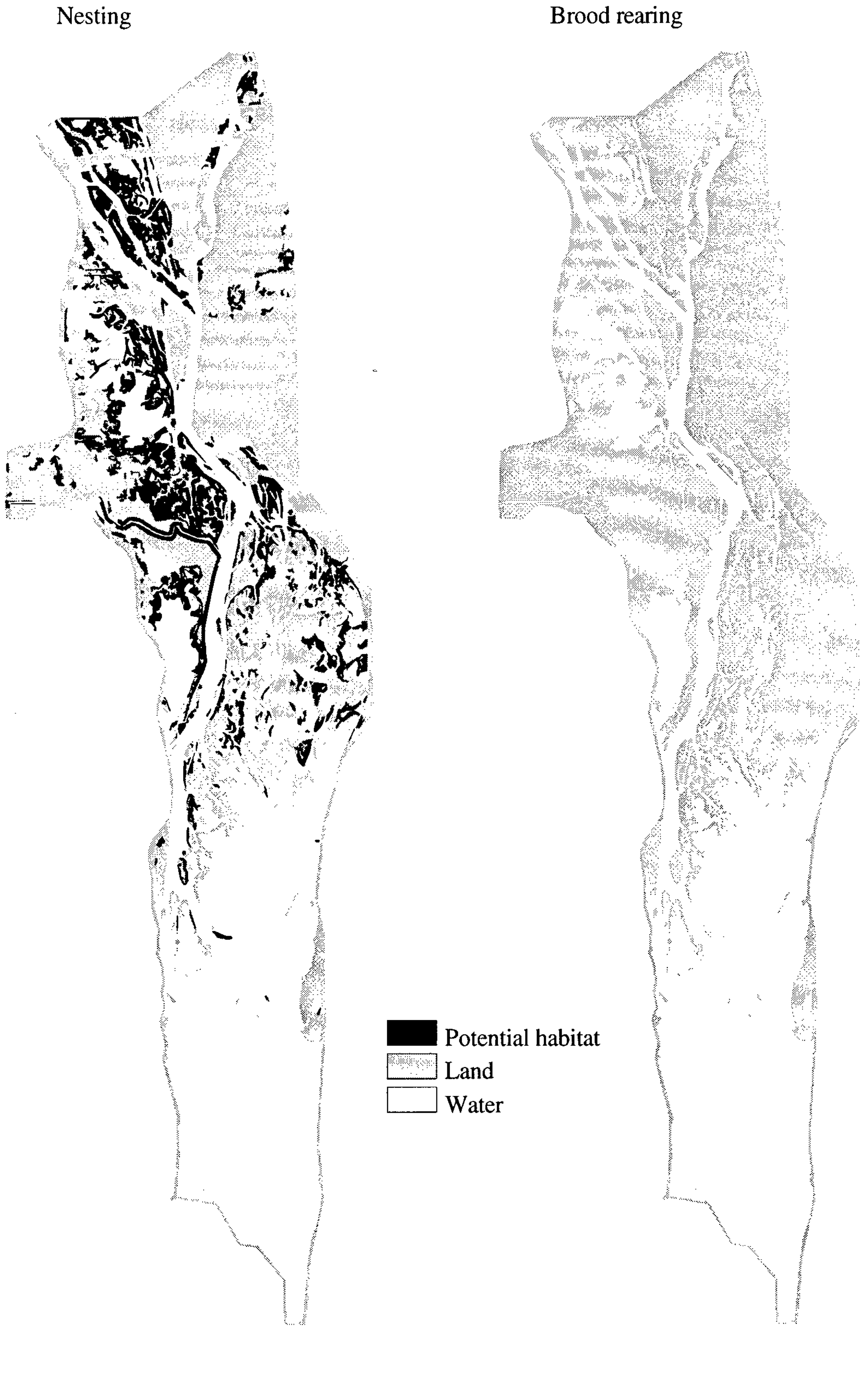


Figure E-150. Potential 1989 nesting and brood rearing habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 8.

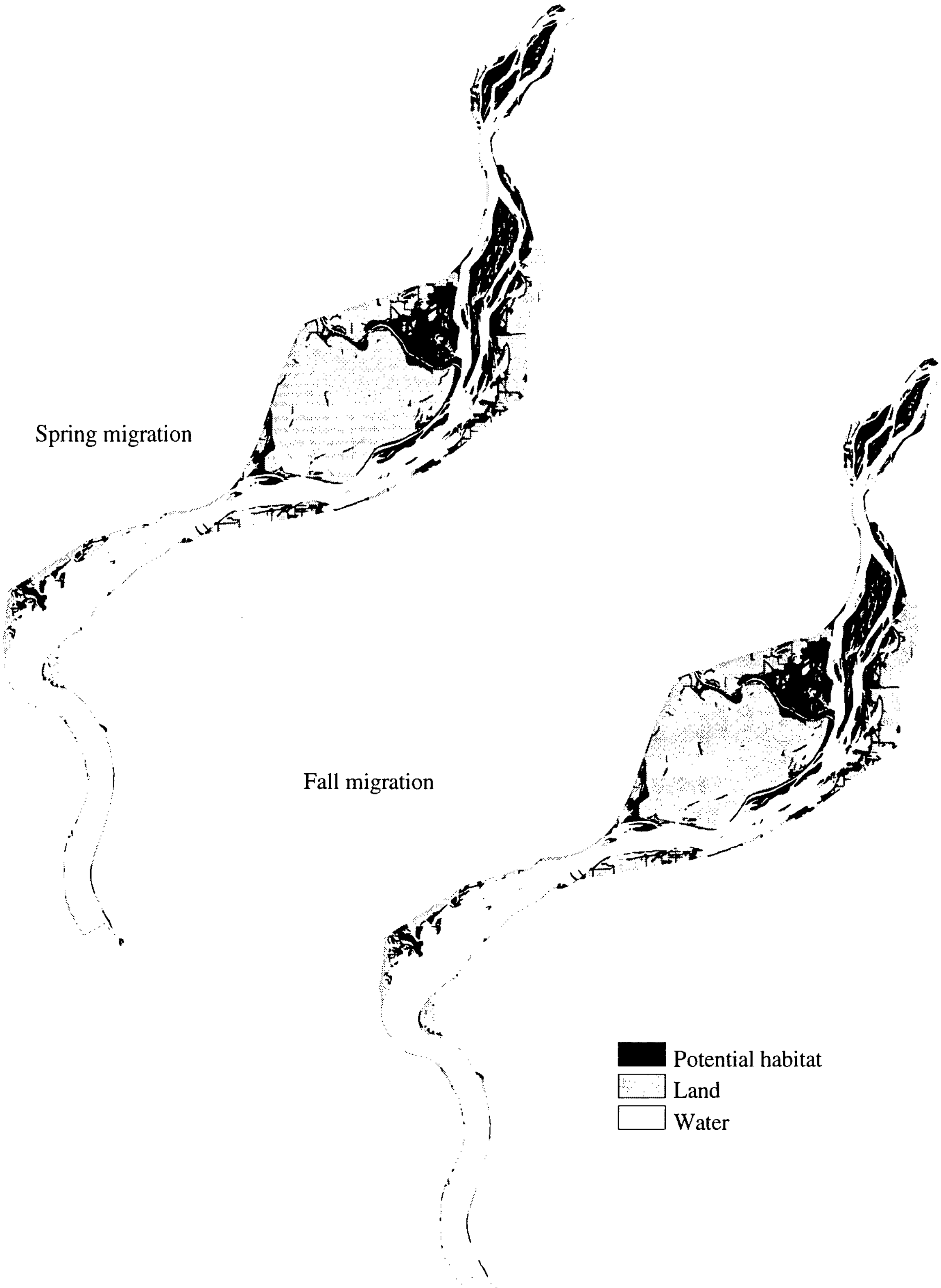


Figure E-151. Potential 1975 spring and fall migration habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 19.

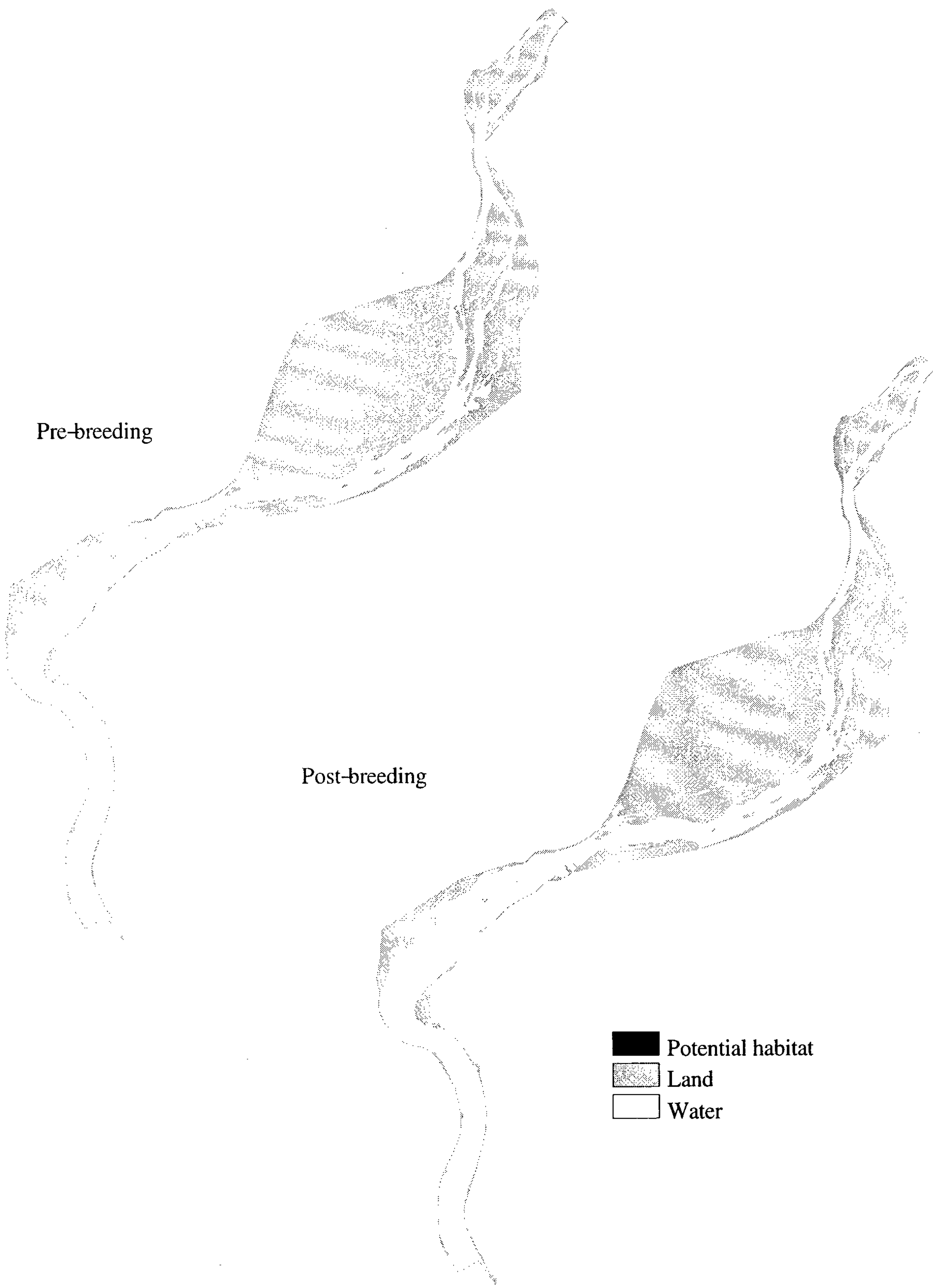


Figure E-152. Potential 1975 pre- and post-breeding habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 19.

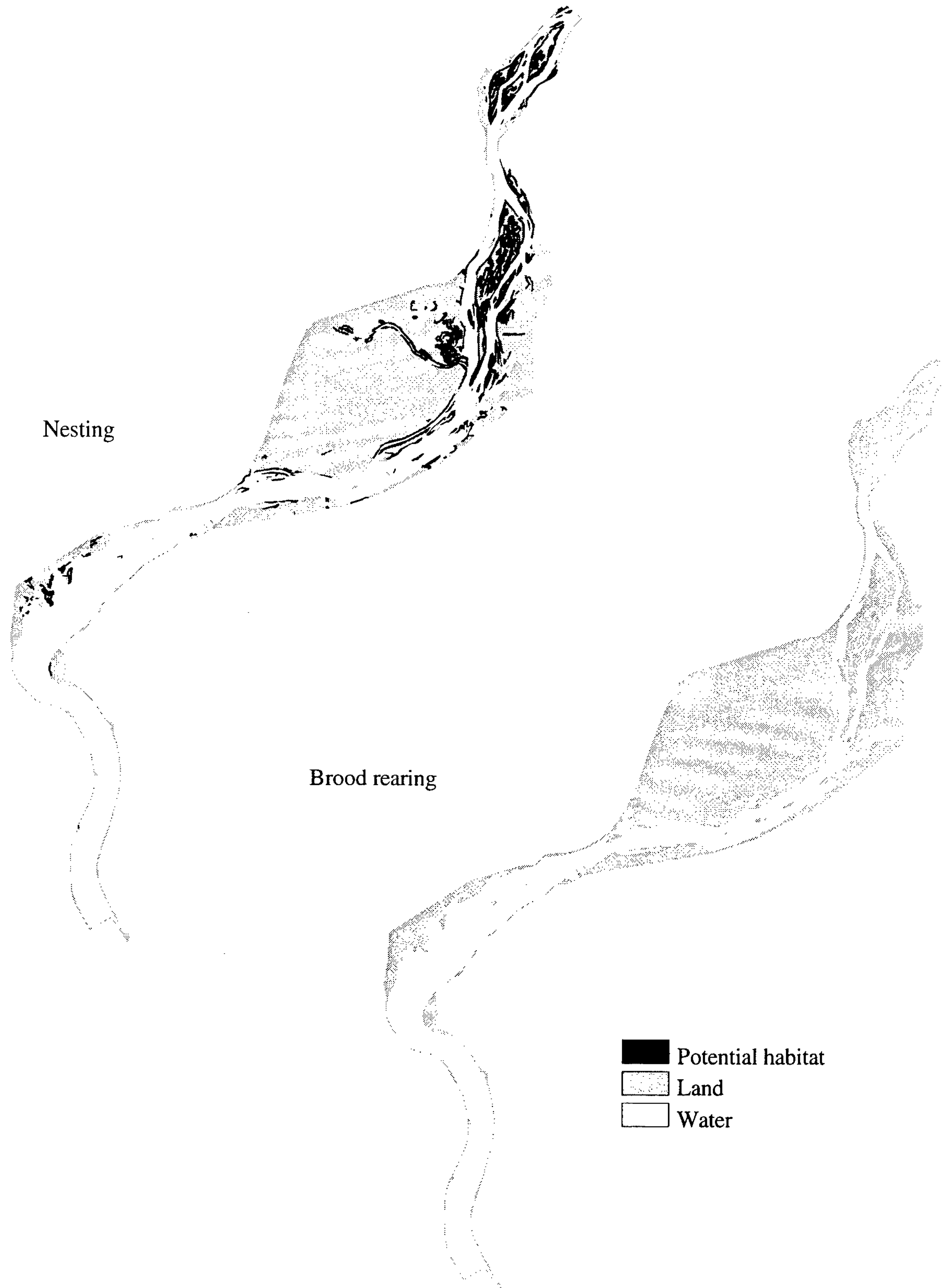


Figure E-153. Potential 1975 nesting and brood rearing habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 19.

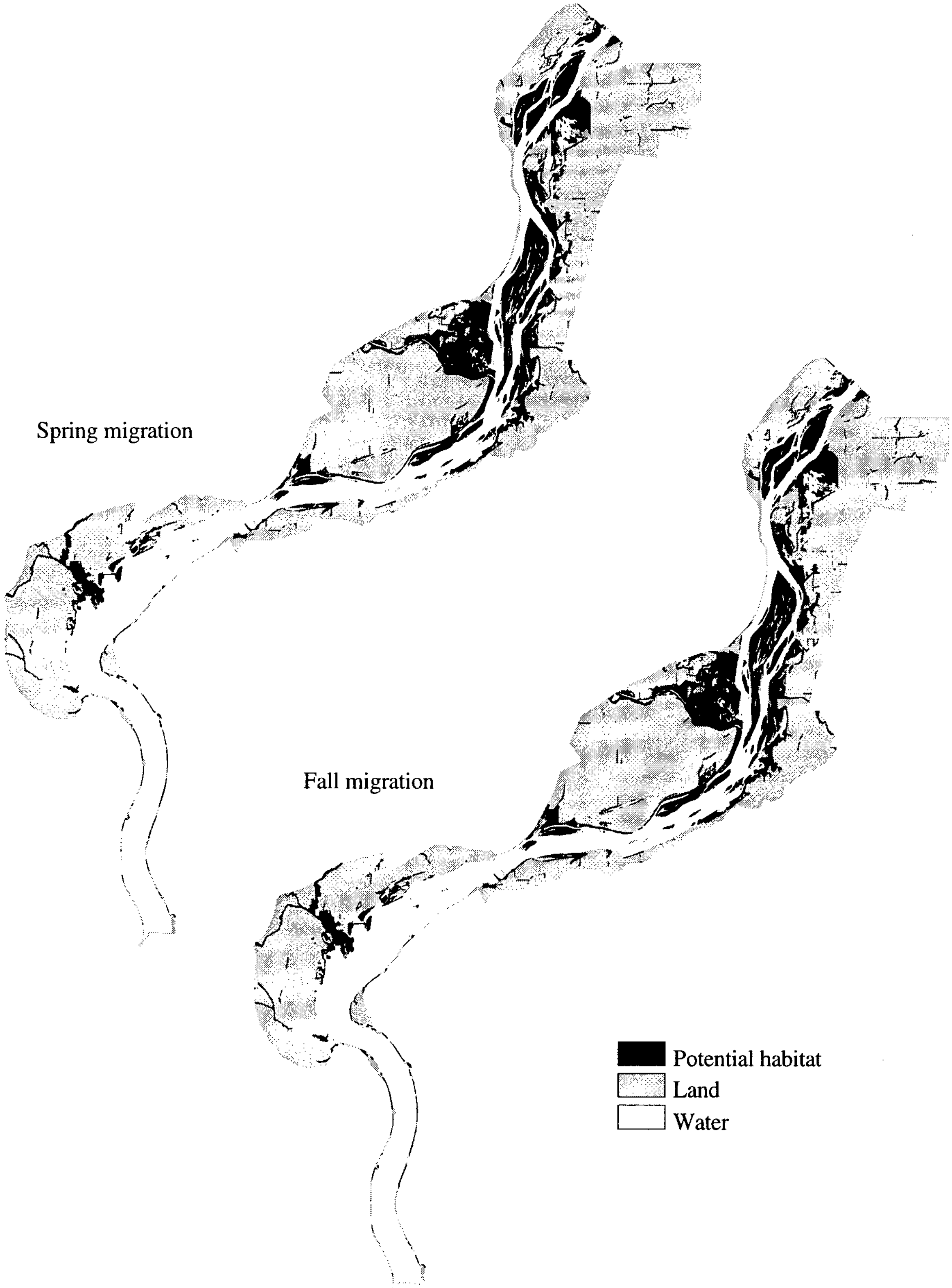


Figure E-154. Potential 1989 spring and fall migration habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 19.

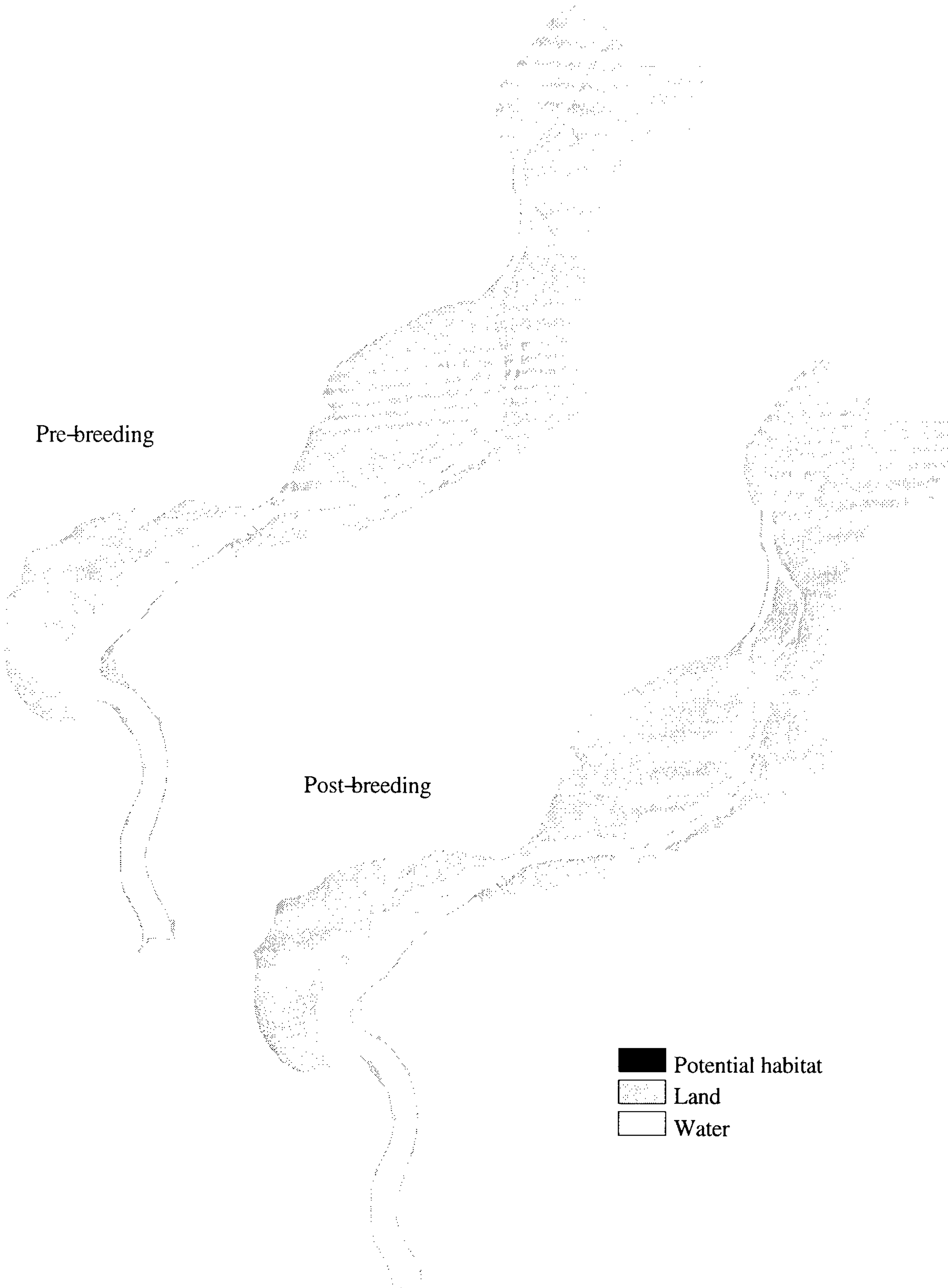


Figure E-155. Potential 1989 pre- and post-breeding habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 19.

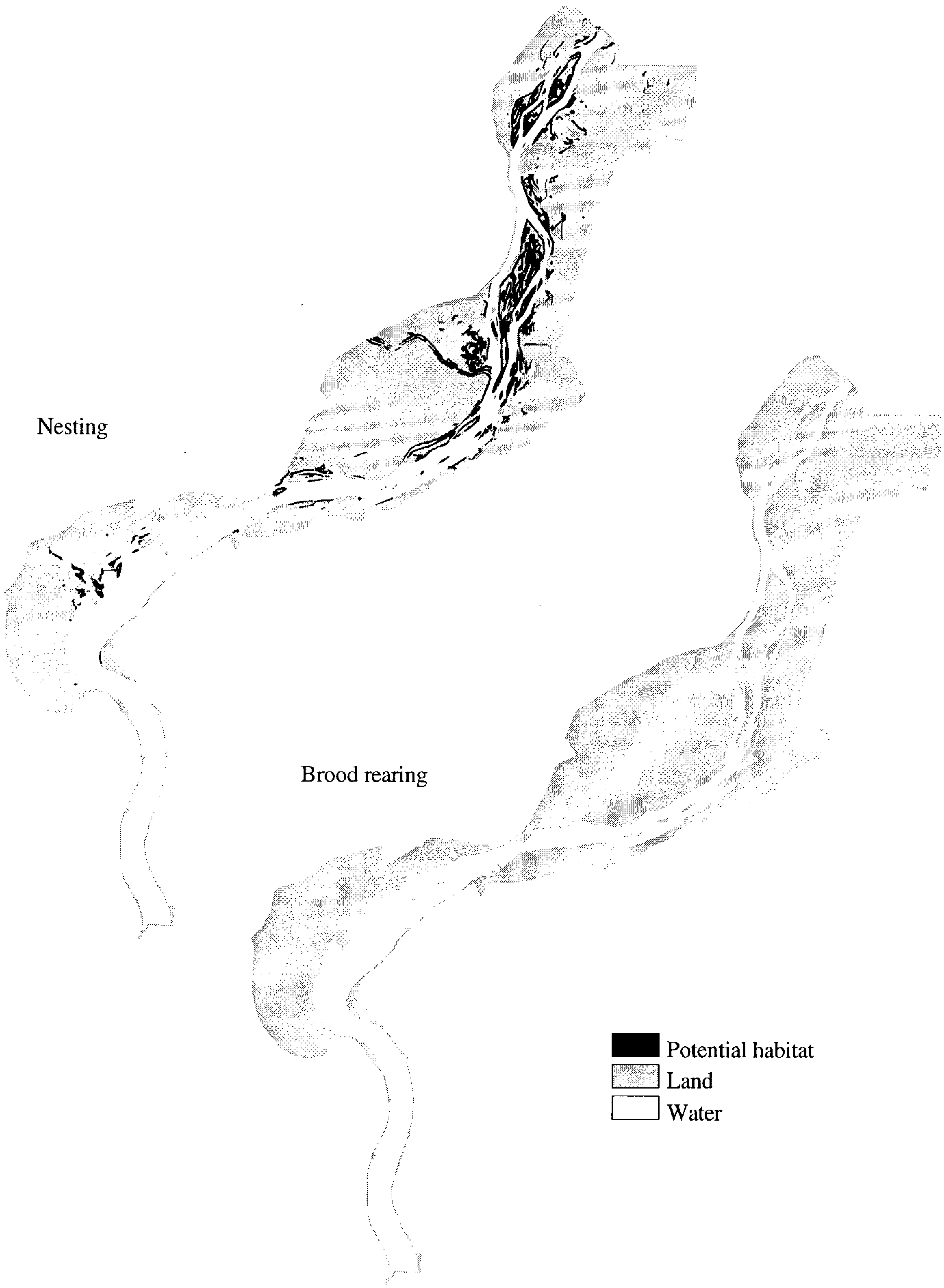


Figure E-156. Potential 1989 nesting and brood rearing habitat for the great blue heron (*Ardea herodias*), Upper Mississippi River Pool 19.

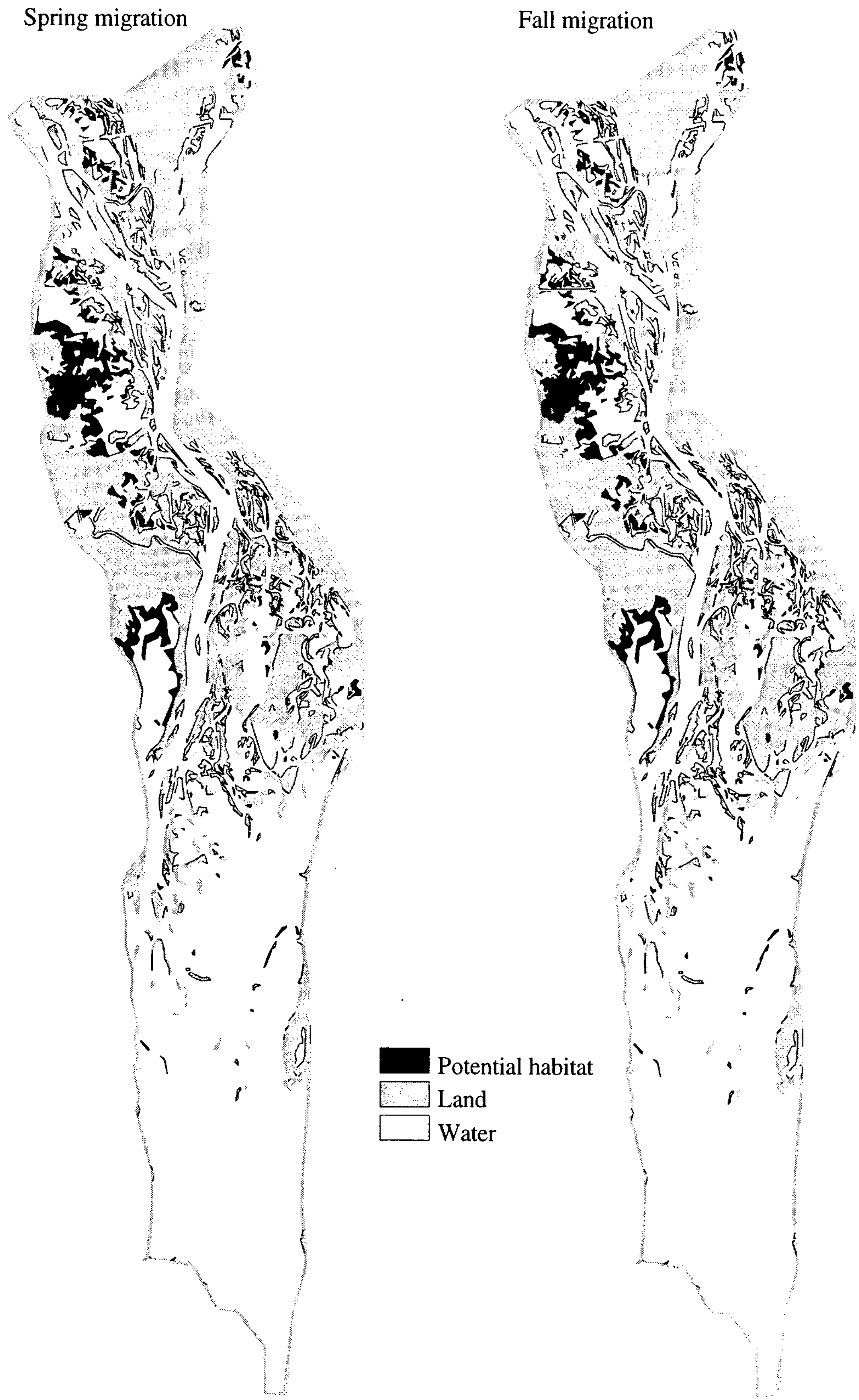


Figure E-157. Potential 1975 spring and fall migration habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 8.

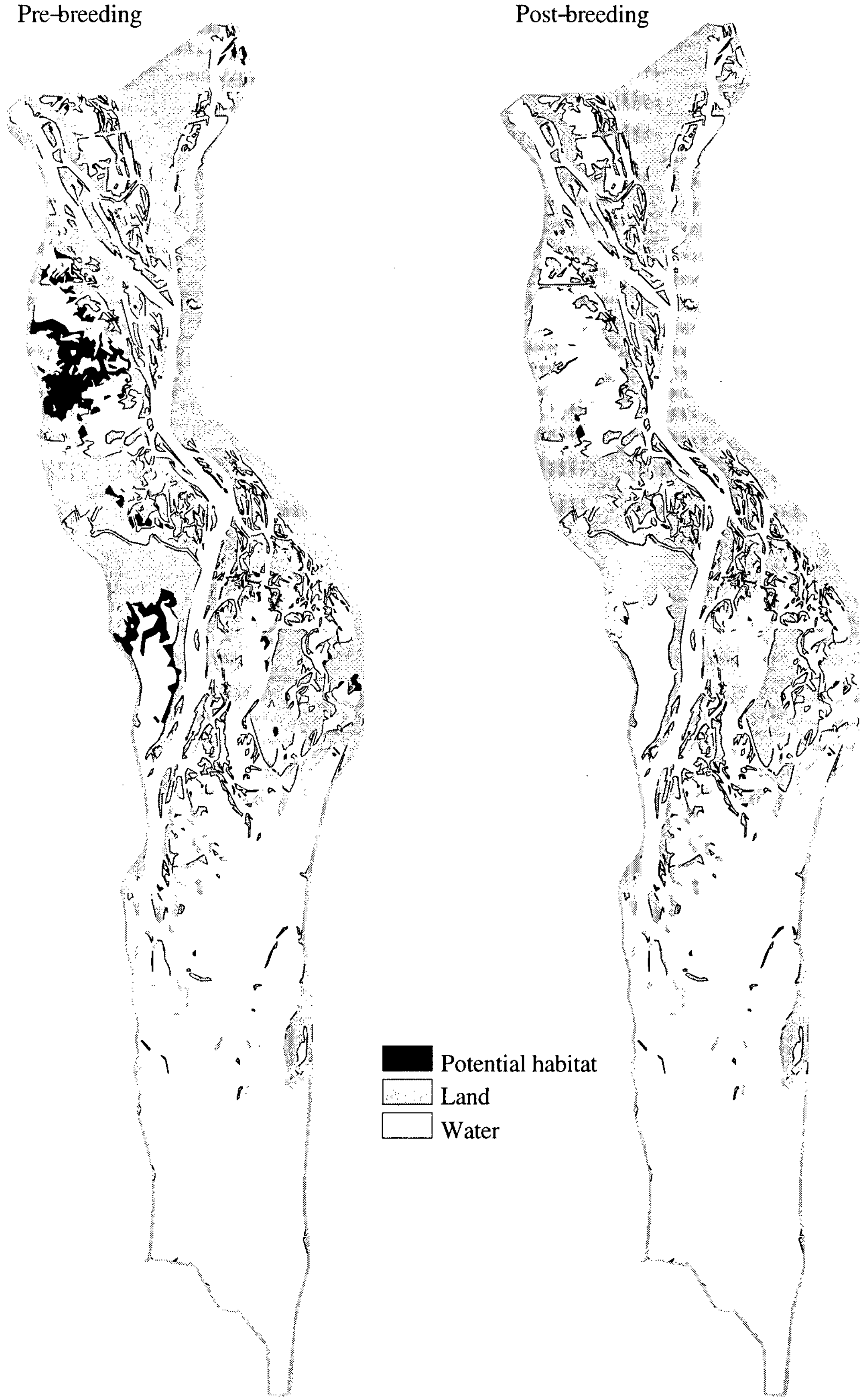


Figure E-158. Potential 1975 pre- and post-breeding habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 8.

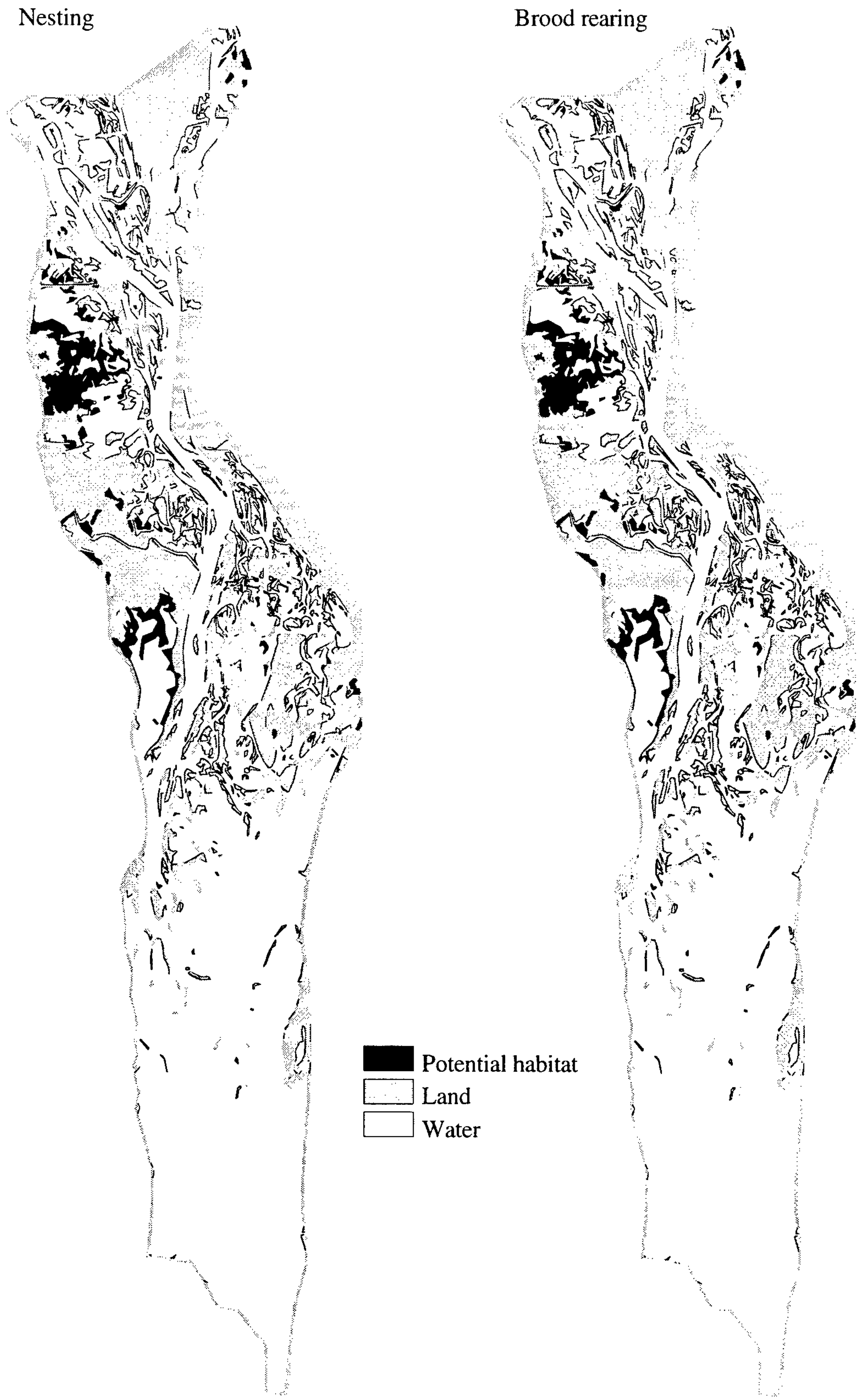


Figure E-159. Potential 1975 nesting and brood rearing habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 8.

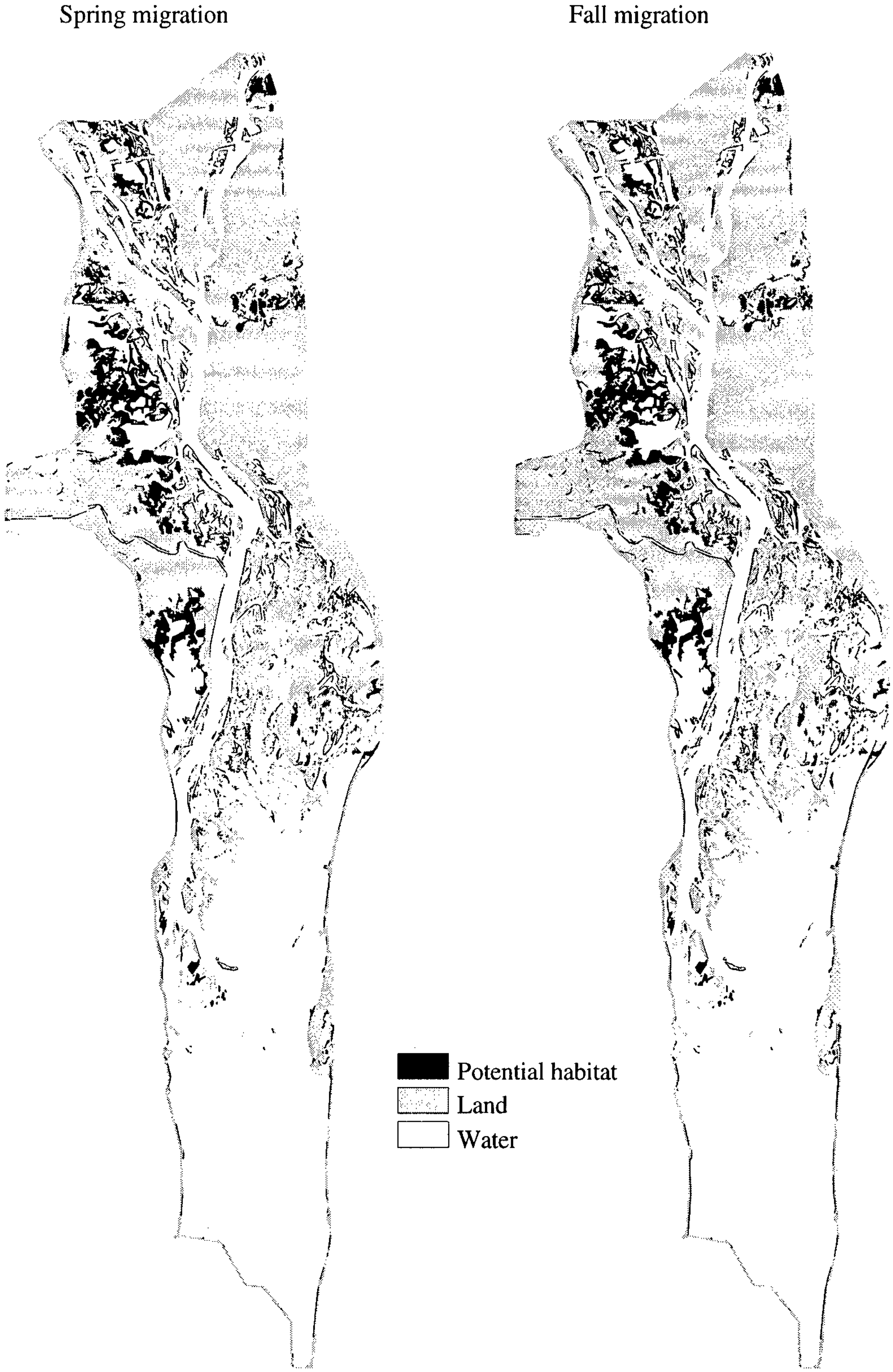


Figure E-160. Potential 1989 spring and fall migration habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 8.

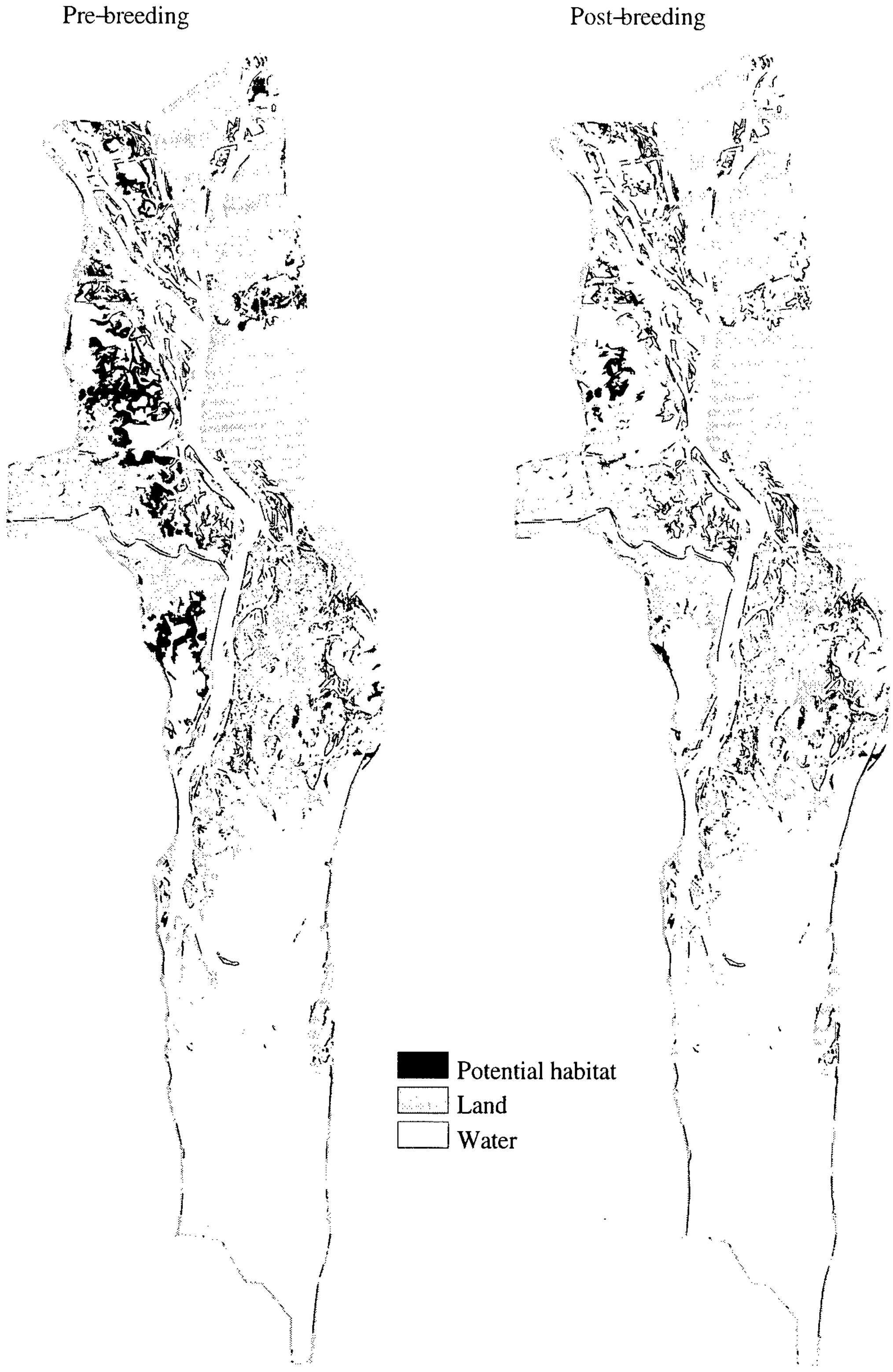


Figure E-161. Potential 1989 pre- and post-breeding habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 8.

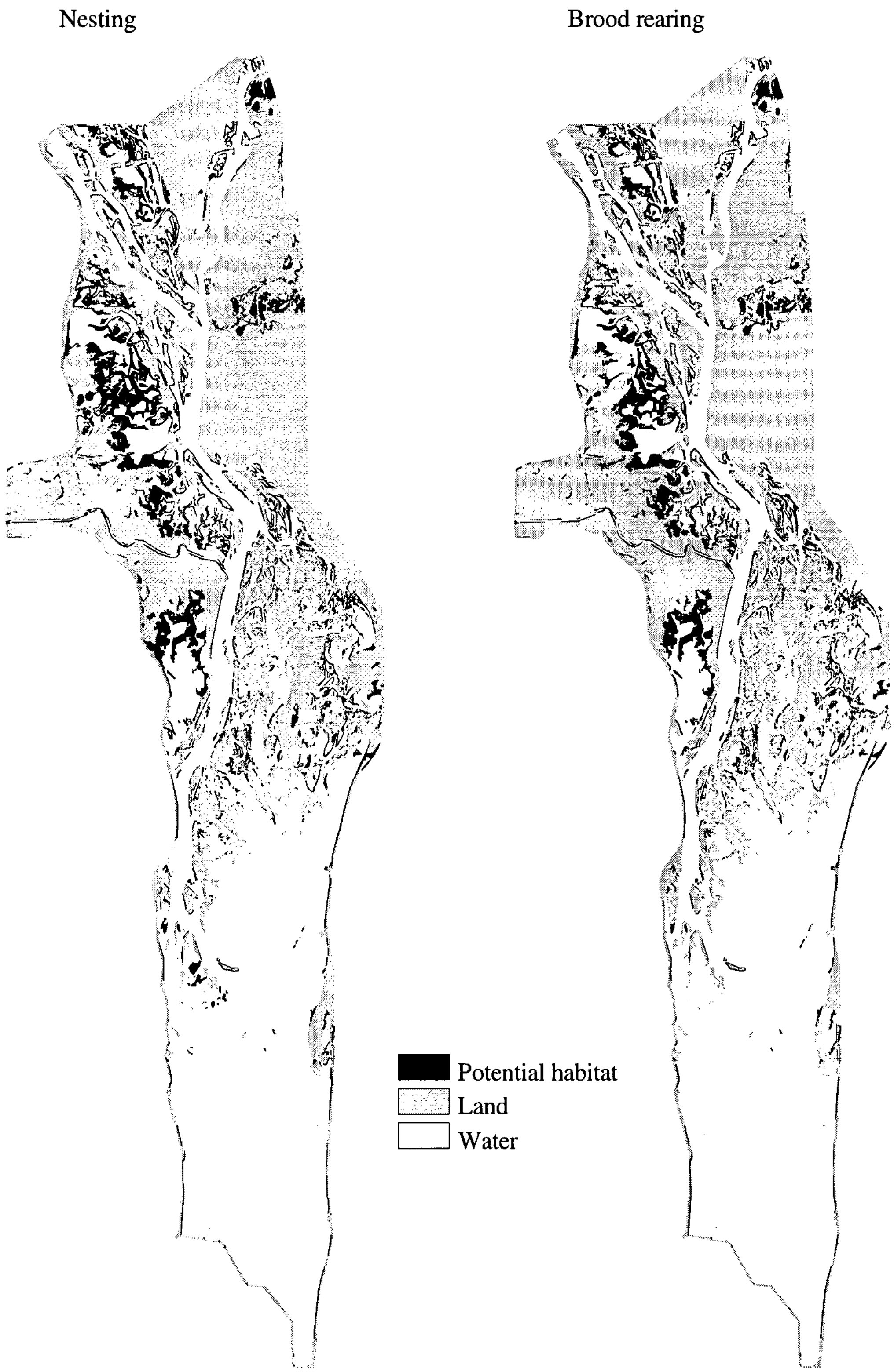


Figure E-162. Potential 1989 nesting and brood rearing habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 8.

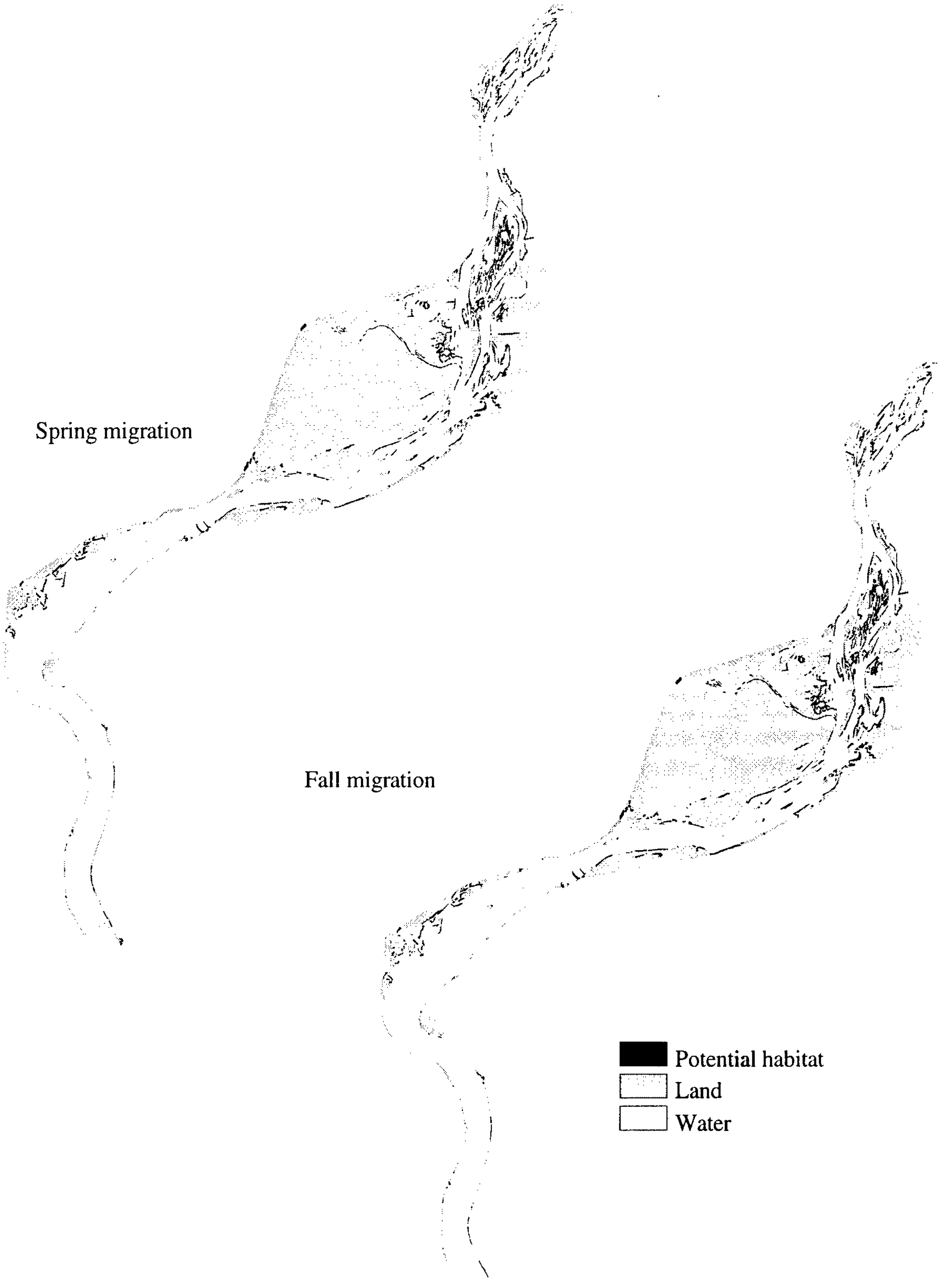


Figure E-163. Potential 1975 spring and fall migration habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 19.

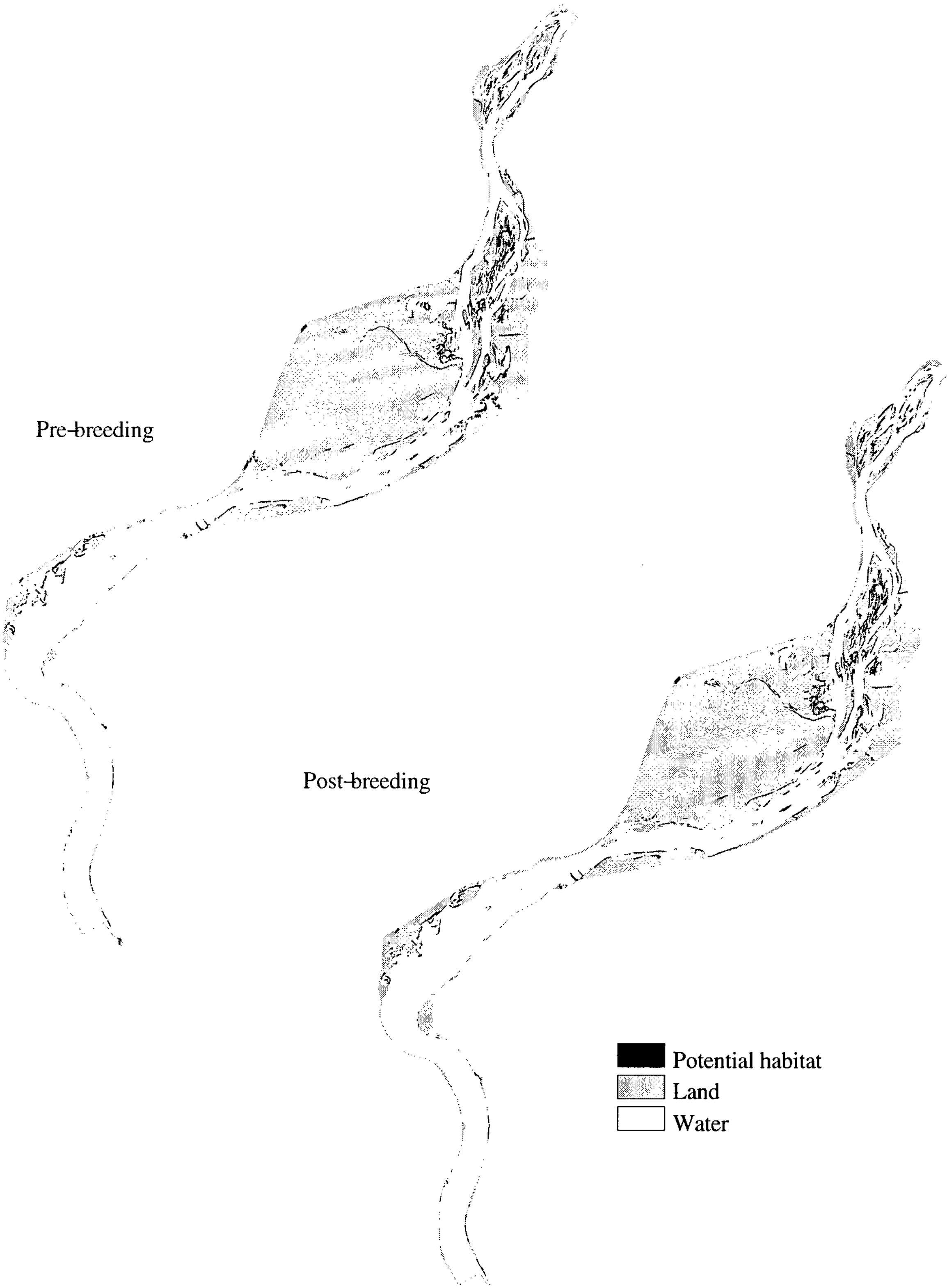


Figure E-164. Potential 1975 pre- and post-breeding habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 19.

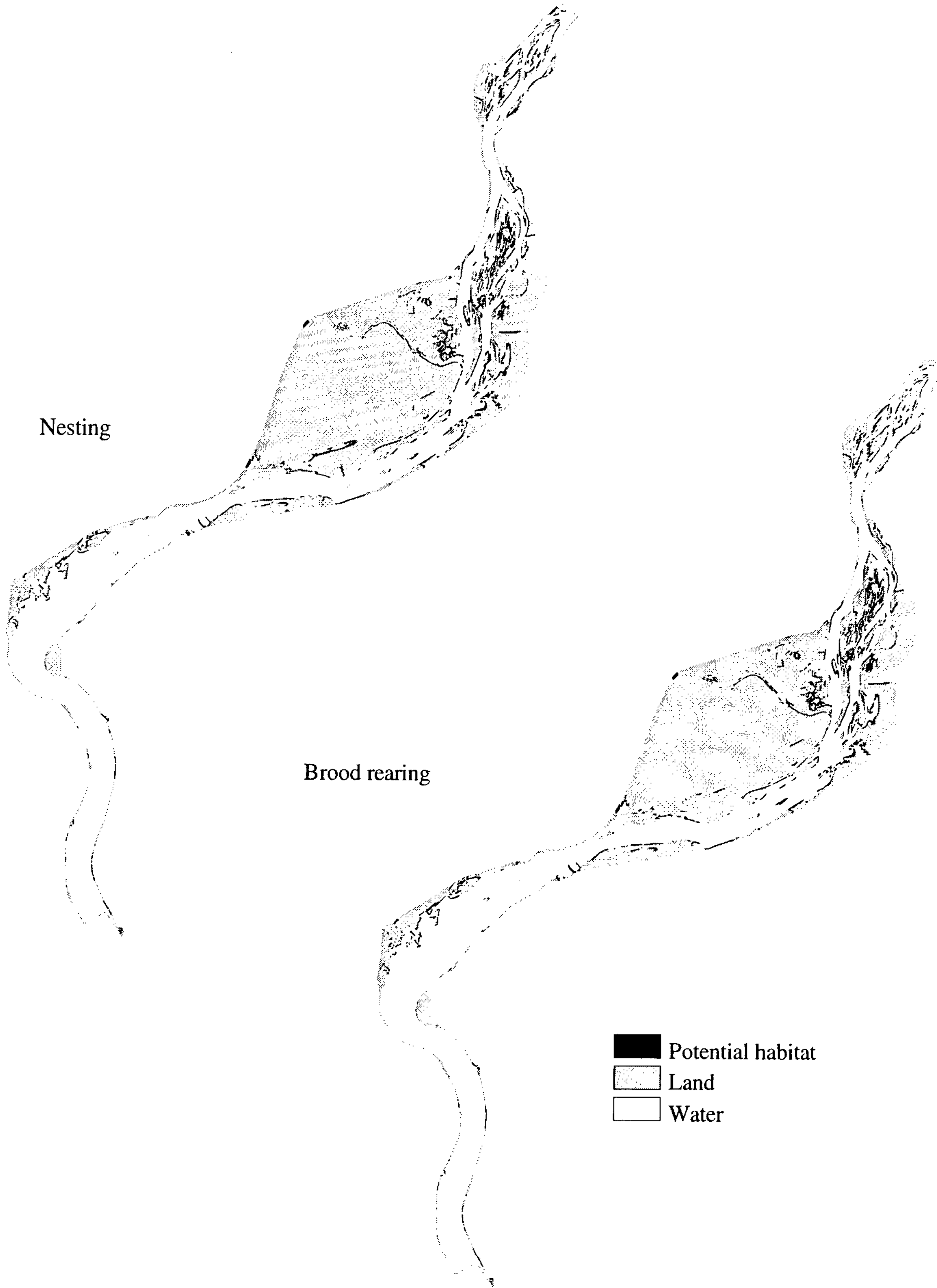


Figure E-165. Potential 1975 nesting and brood rearing habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 19.

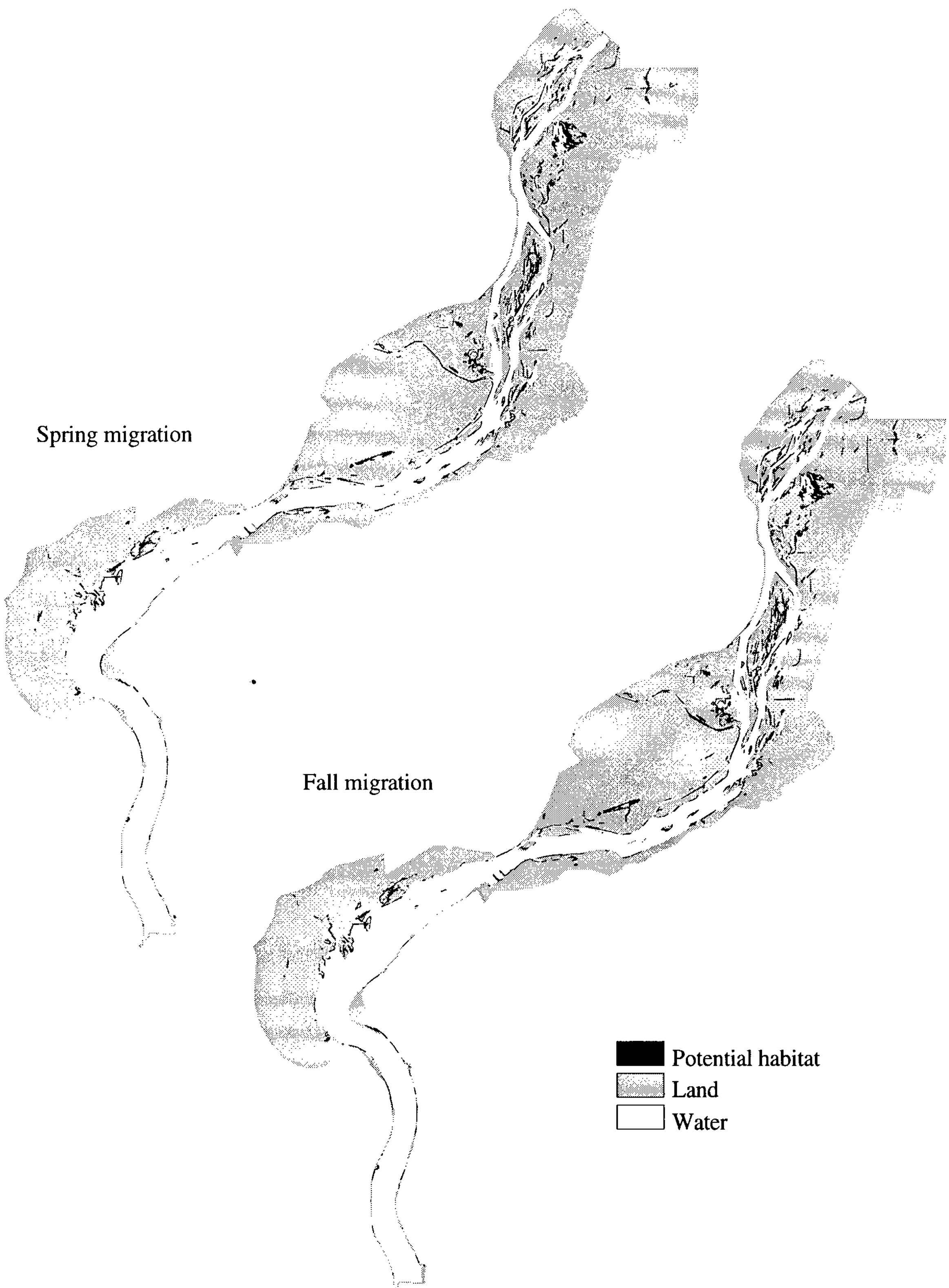


Figure E-166. Potential 1989 spring and fall migration habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 19.

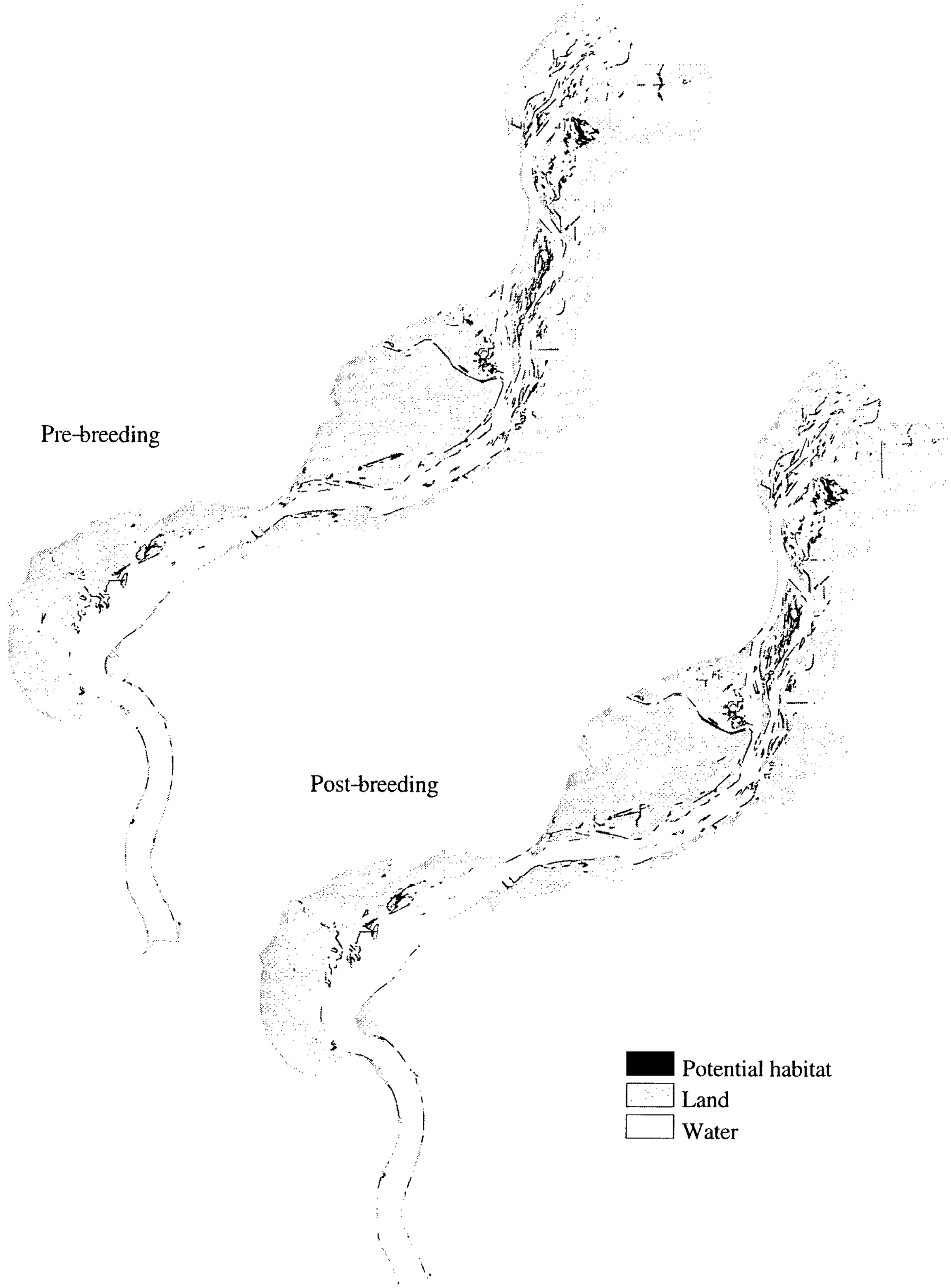


Figure E-167. Potential 1989 pre- and post-breeding habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 19.

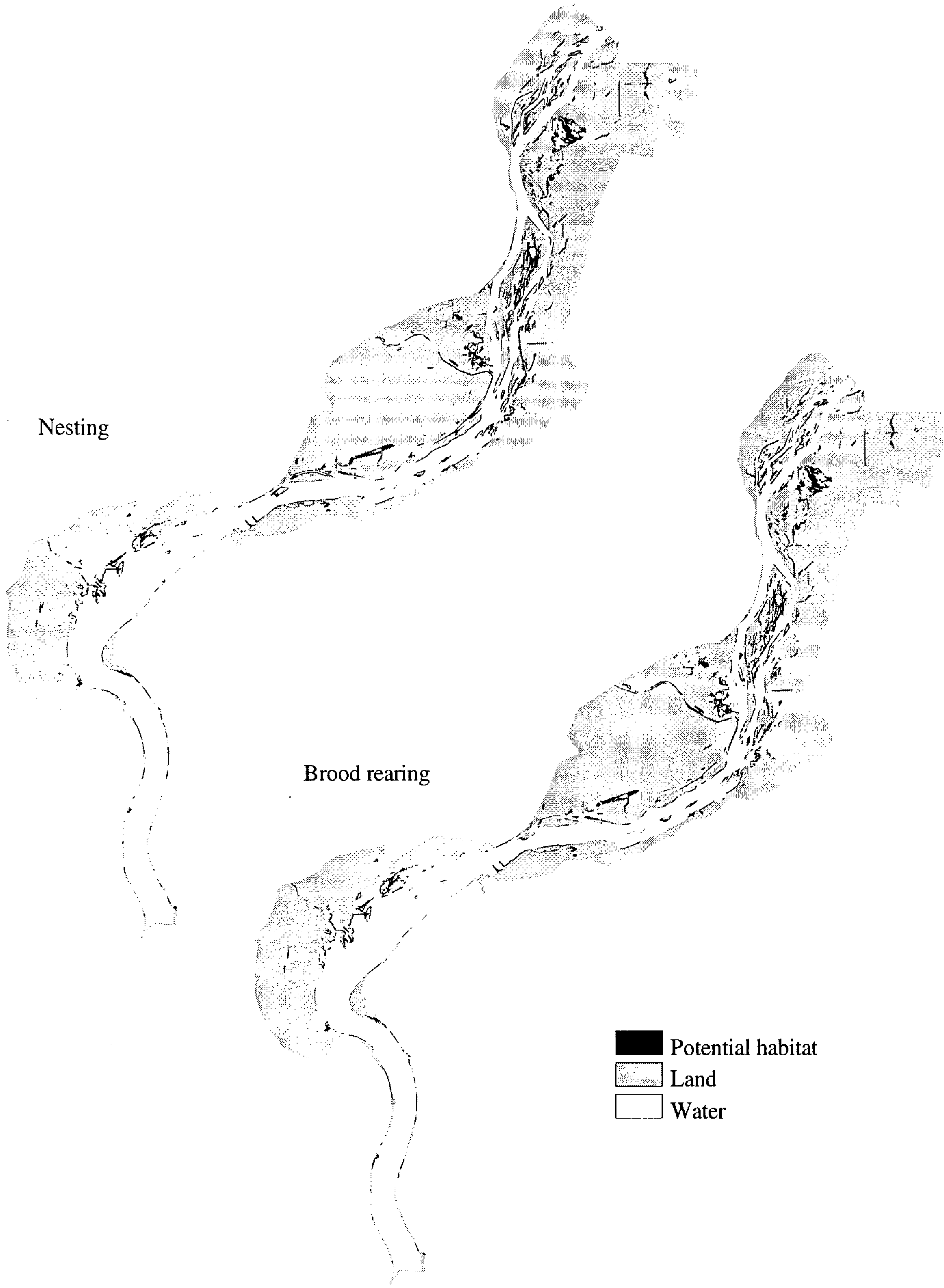


Figure E-168. Potential 1989 nesting and brood rearing habitat for the American bittern (*Botaurus lentiginosus*), Upper Mississippi River Pool 19.

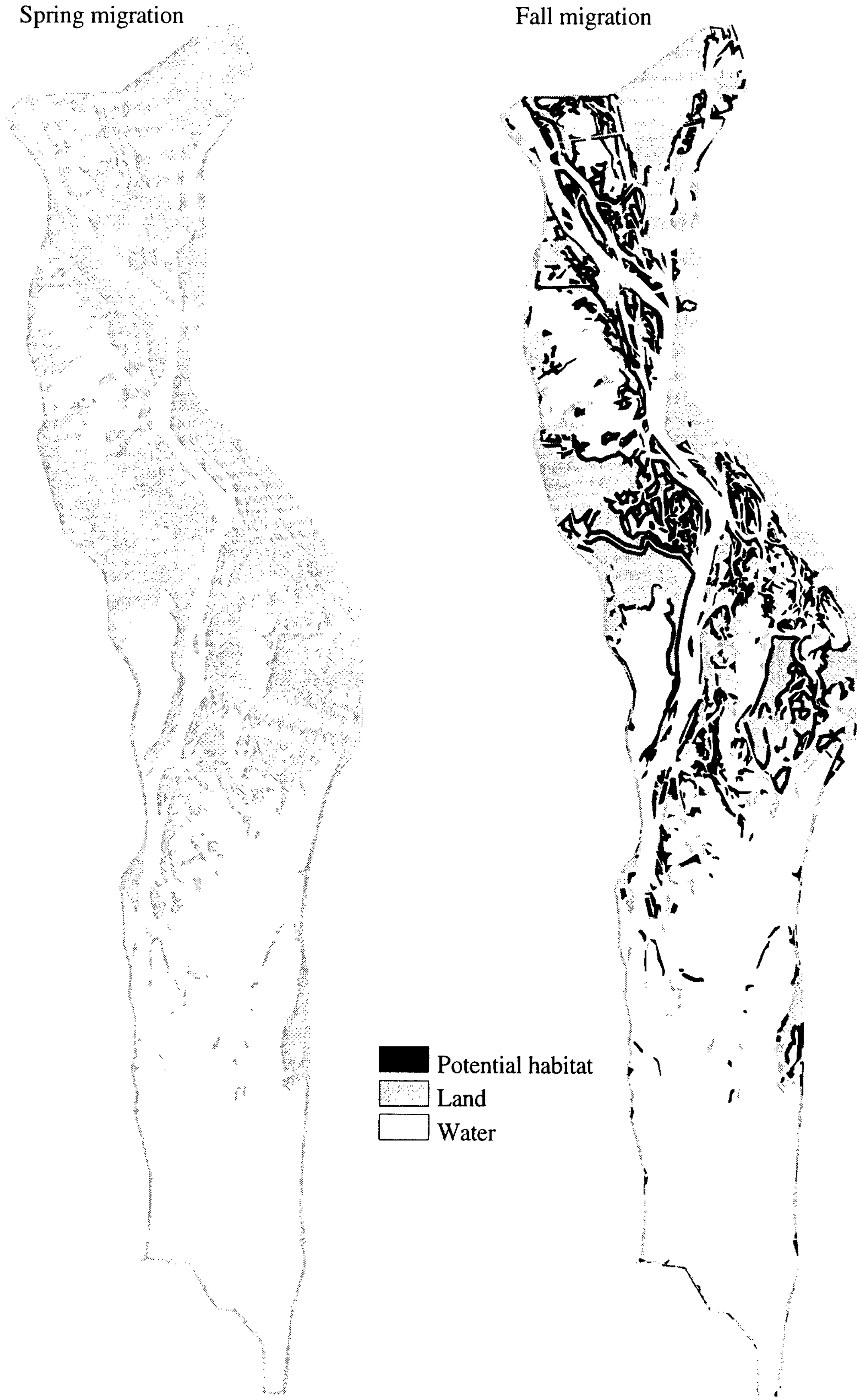


Figure E-169. Potential 1975 spring and fall migration habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 8.

Figure E-170. Potential 1975 pre- and post-breeding habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 8.

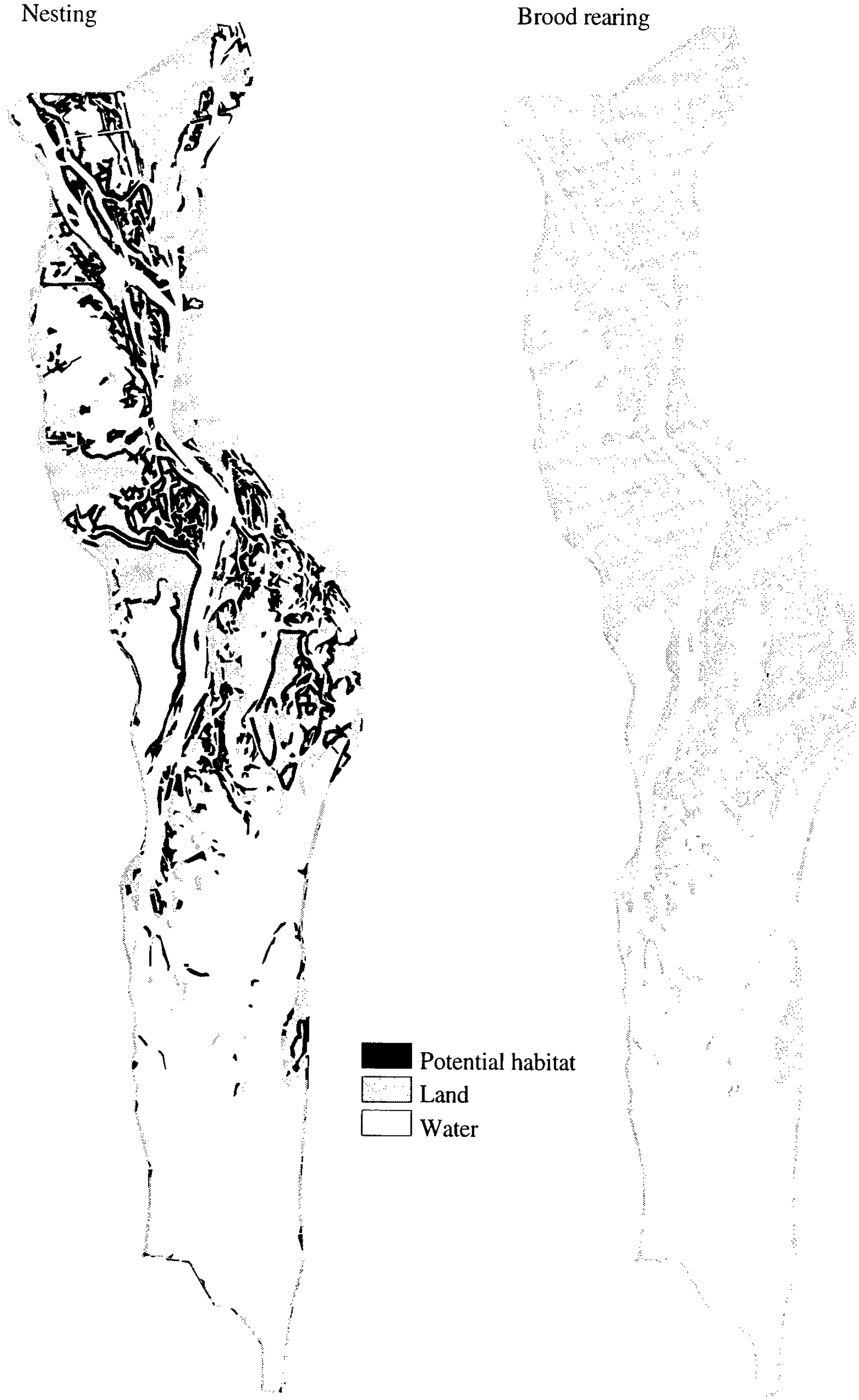


Figure E-171. Potential 1975 nesting and brood rearing habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 8.

Figure E-172. Potential 1989 spring and fall migration habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 8.

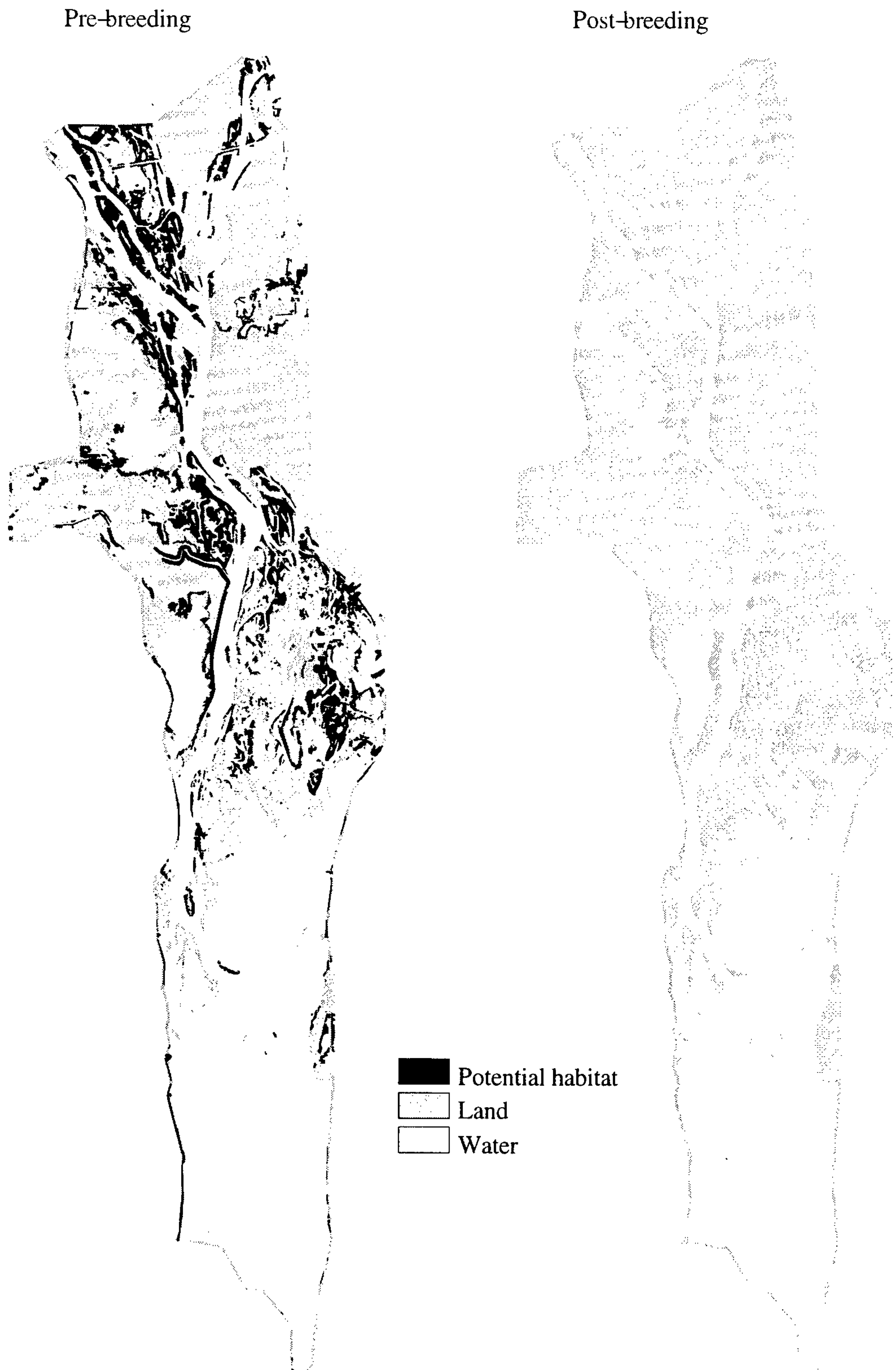


Figure E-173. Potential 1989 pre- and post-breeding habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 8.

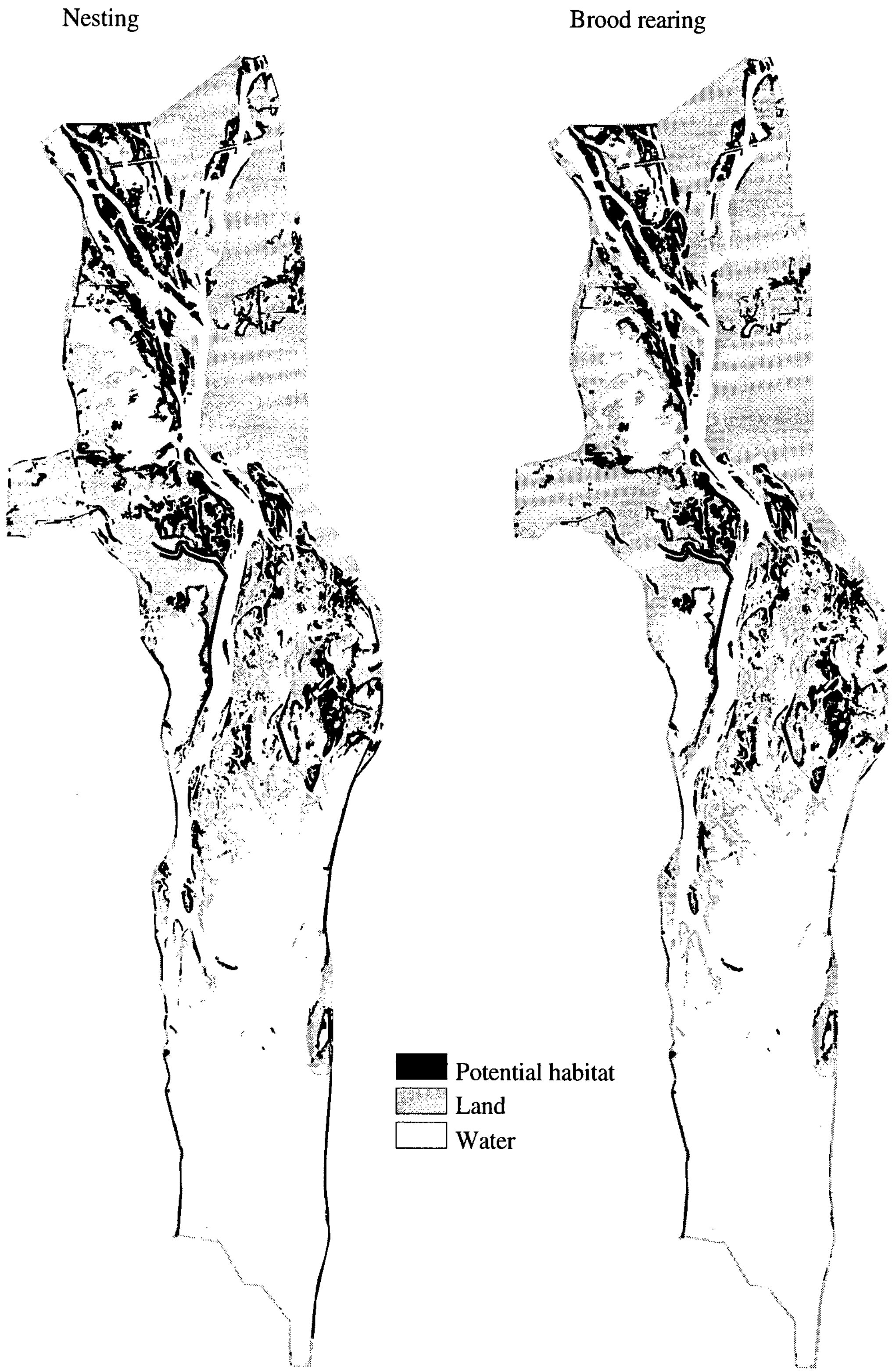


Figure E-174. Potential 1989 nesting and brood rearing habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 8.

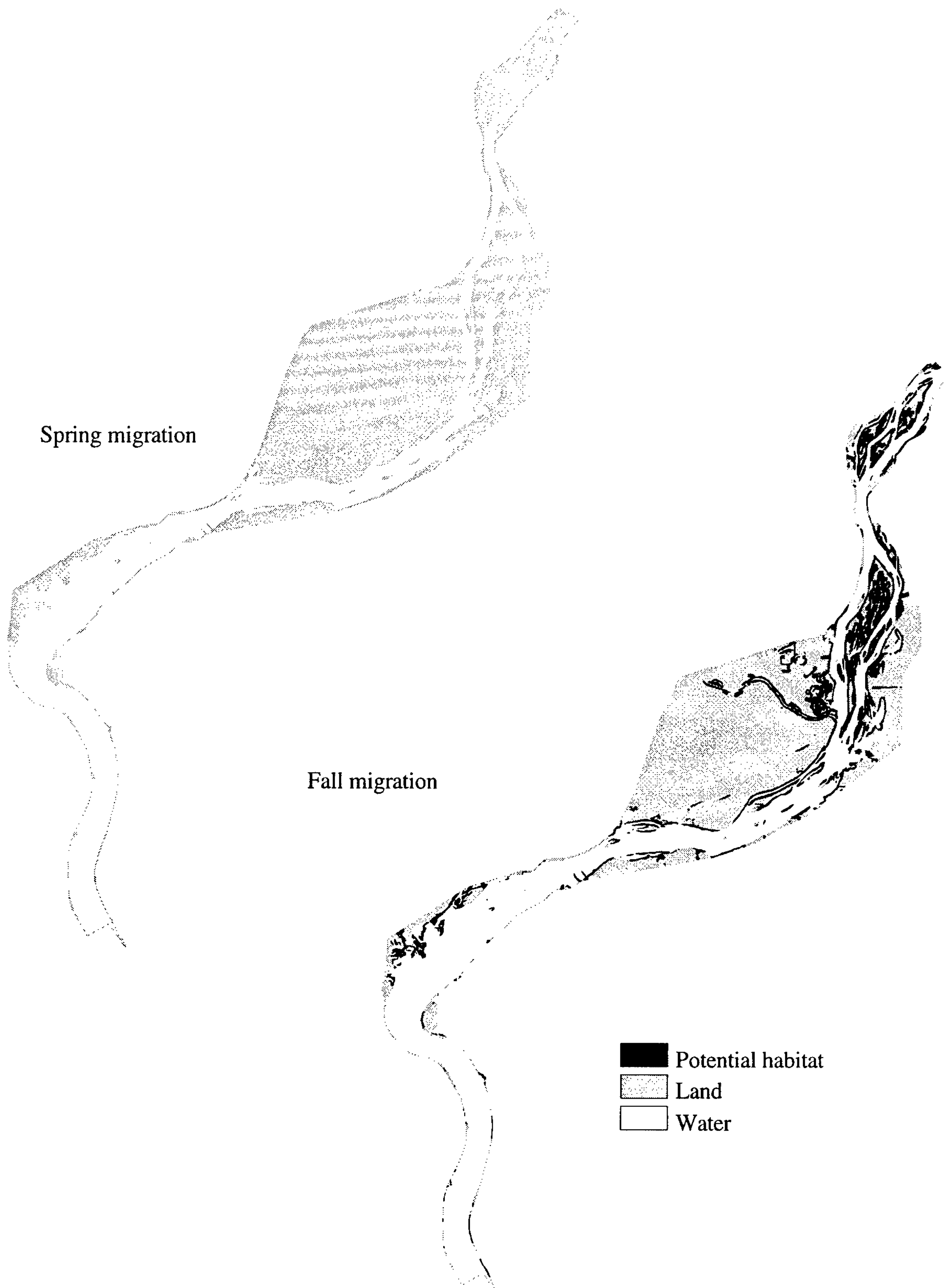


Figure E-175. Potential 1975 spring and fall migration habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 19.

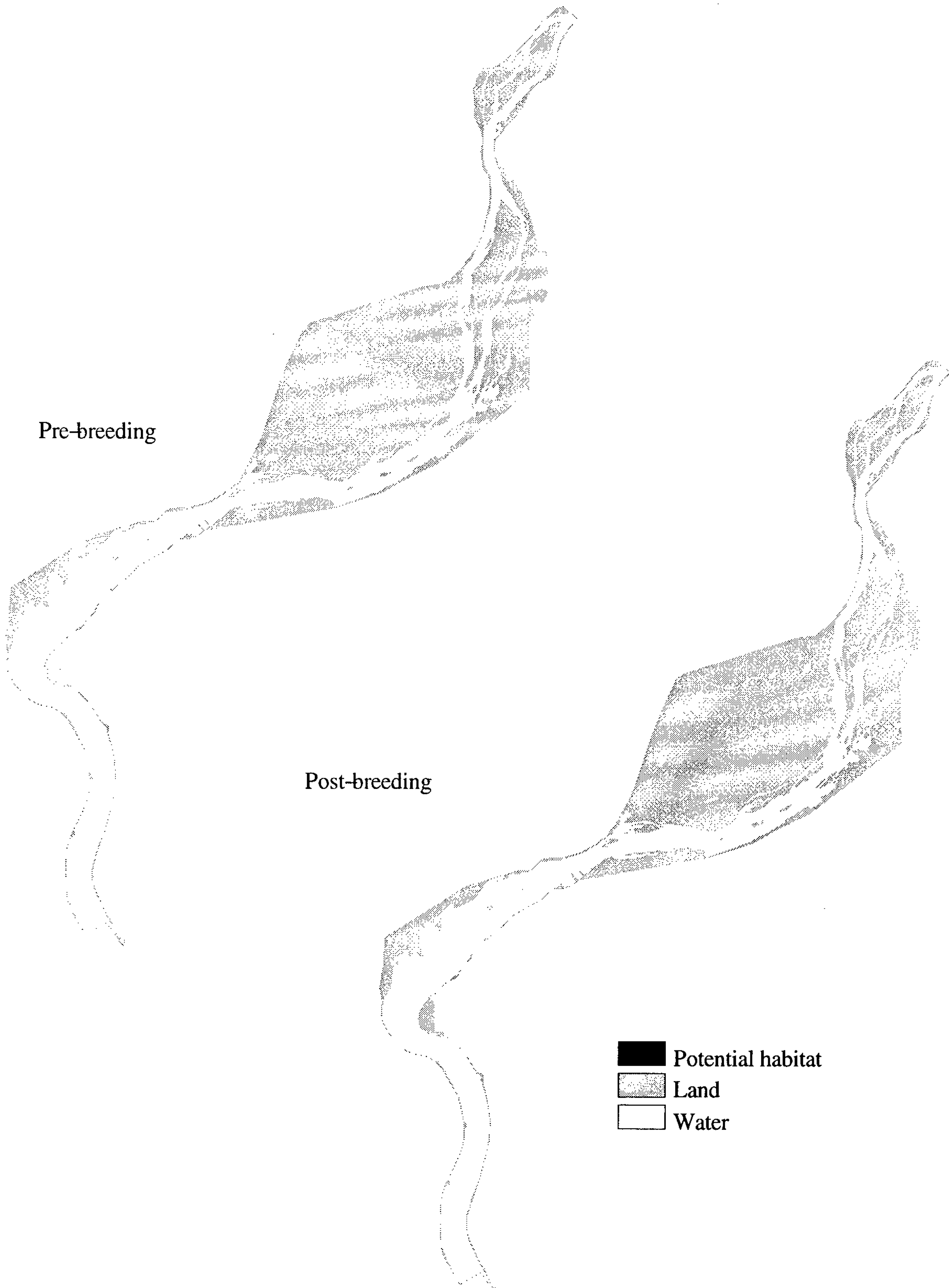


Figure E-176. Potential 1975 pre- and post-breeding habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 19.

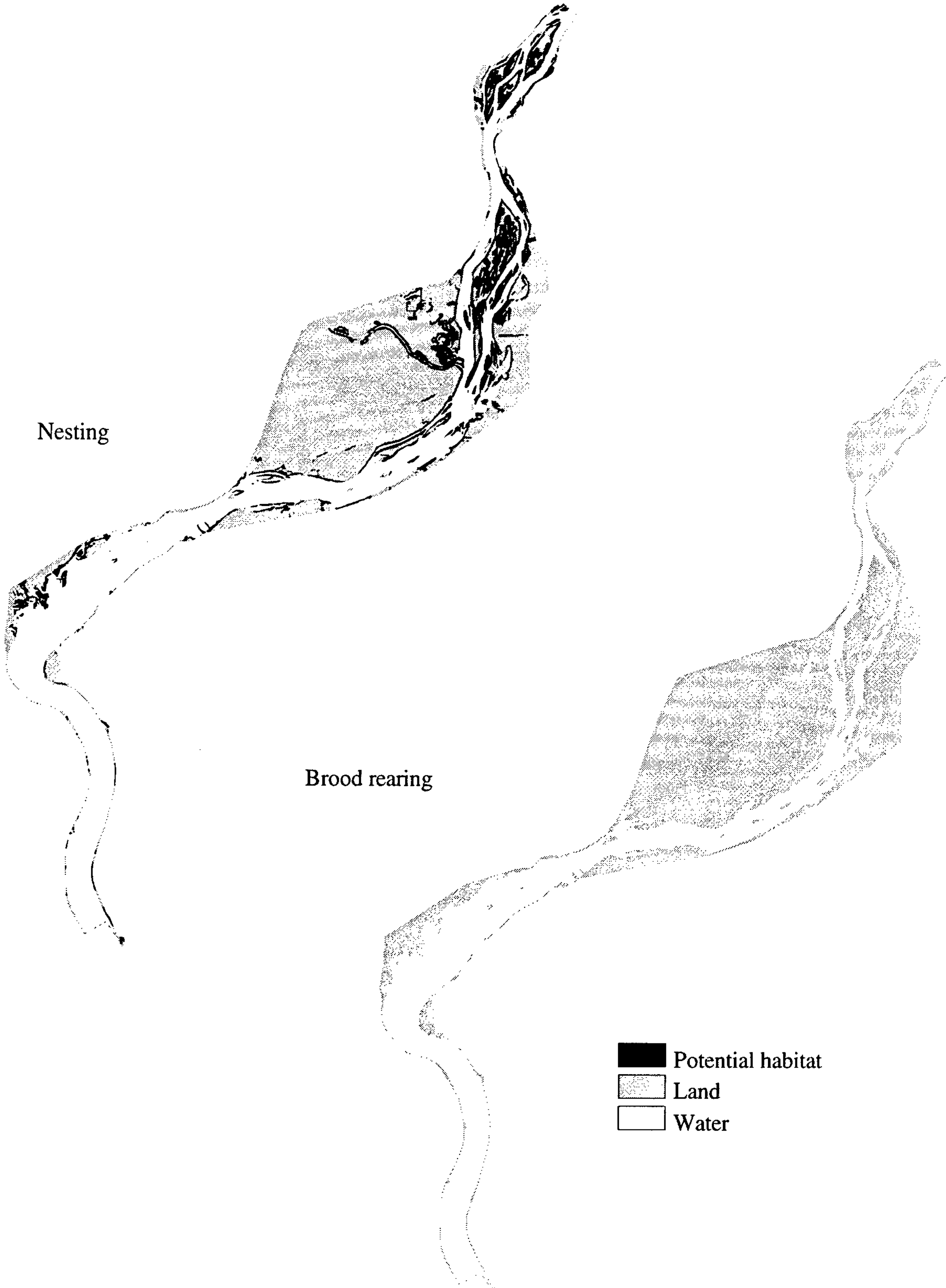


Figure E-177. Potential 1975 nesting and brood rearing habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 19.

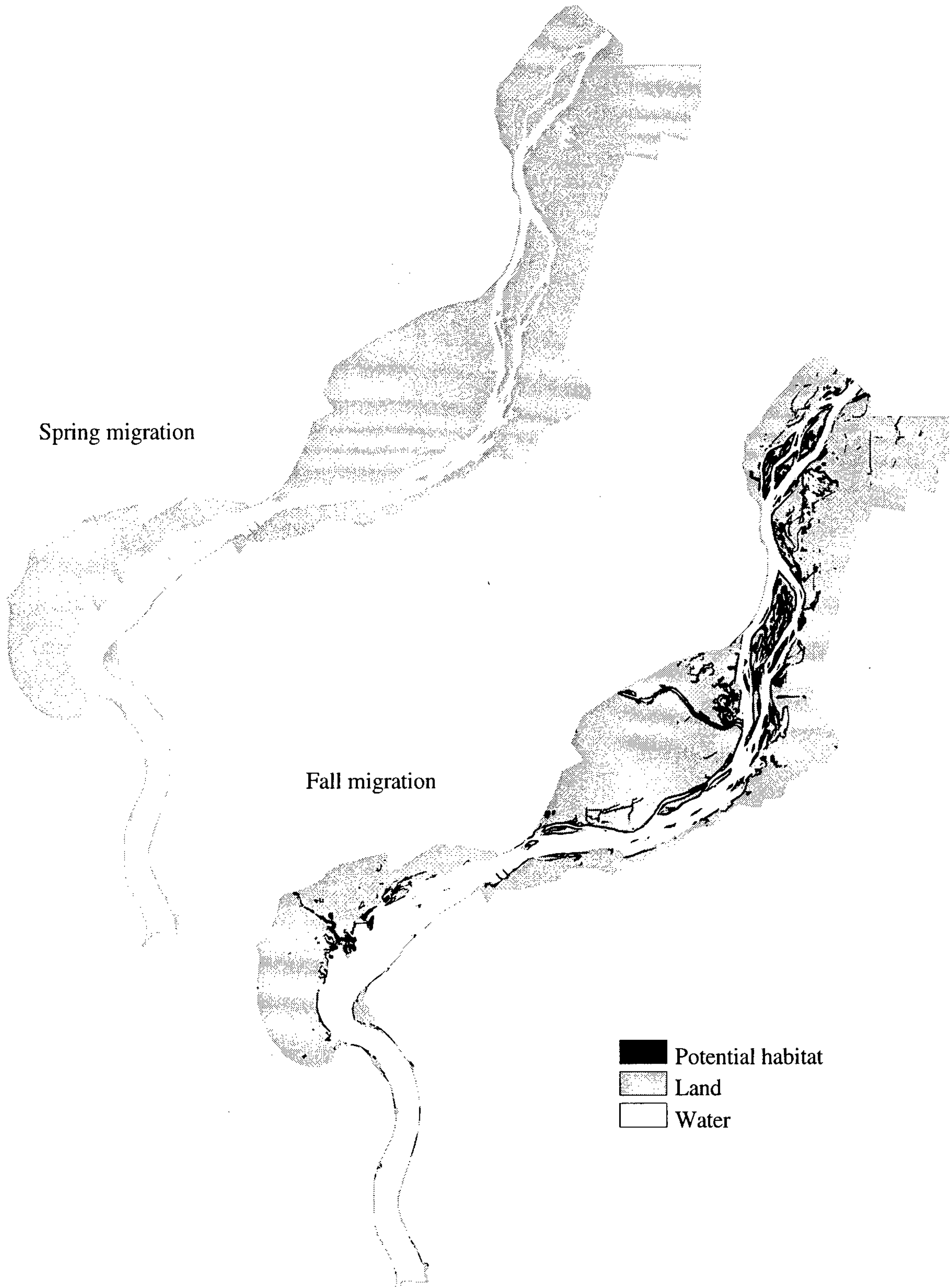


Figure E-178. Potential 1989 spring and fall migration habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 19.

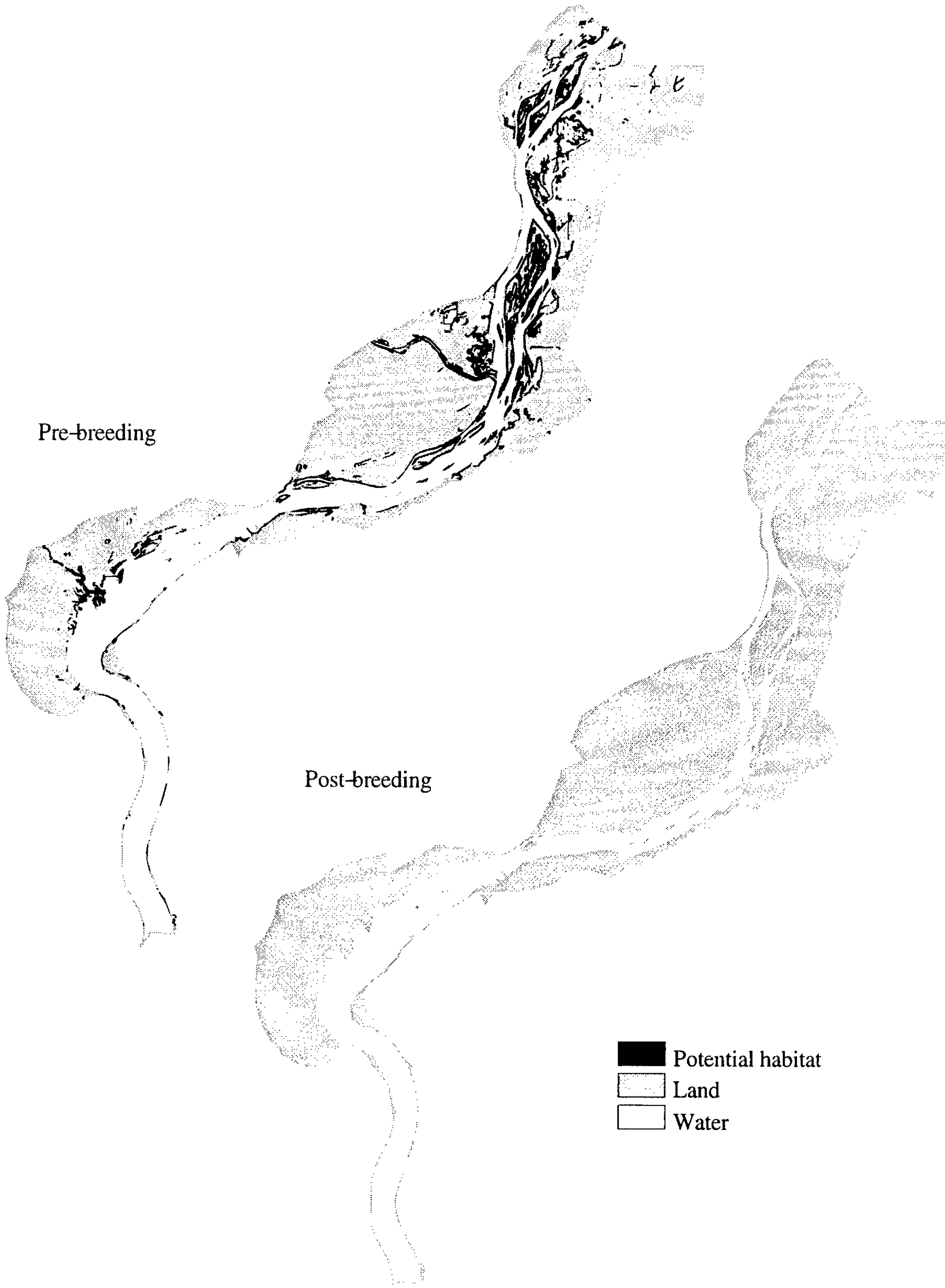


Figure E-179. Potential 1989 pre- and post-breeding habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 19.

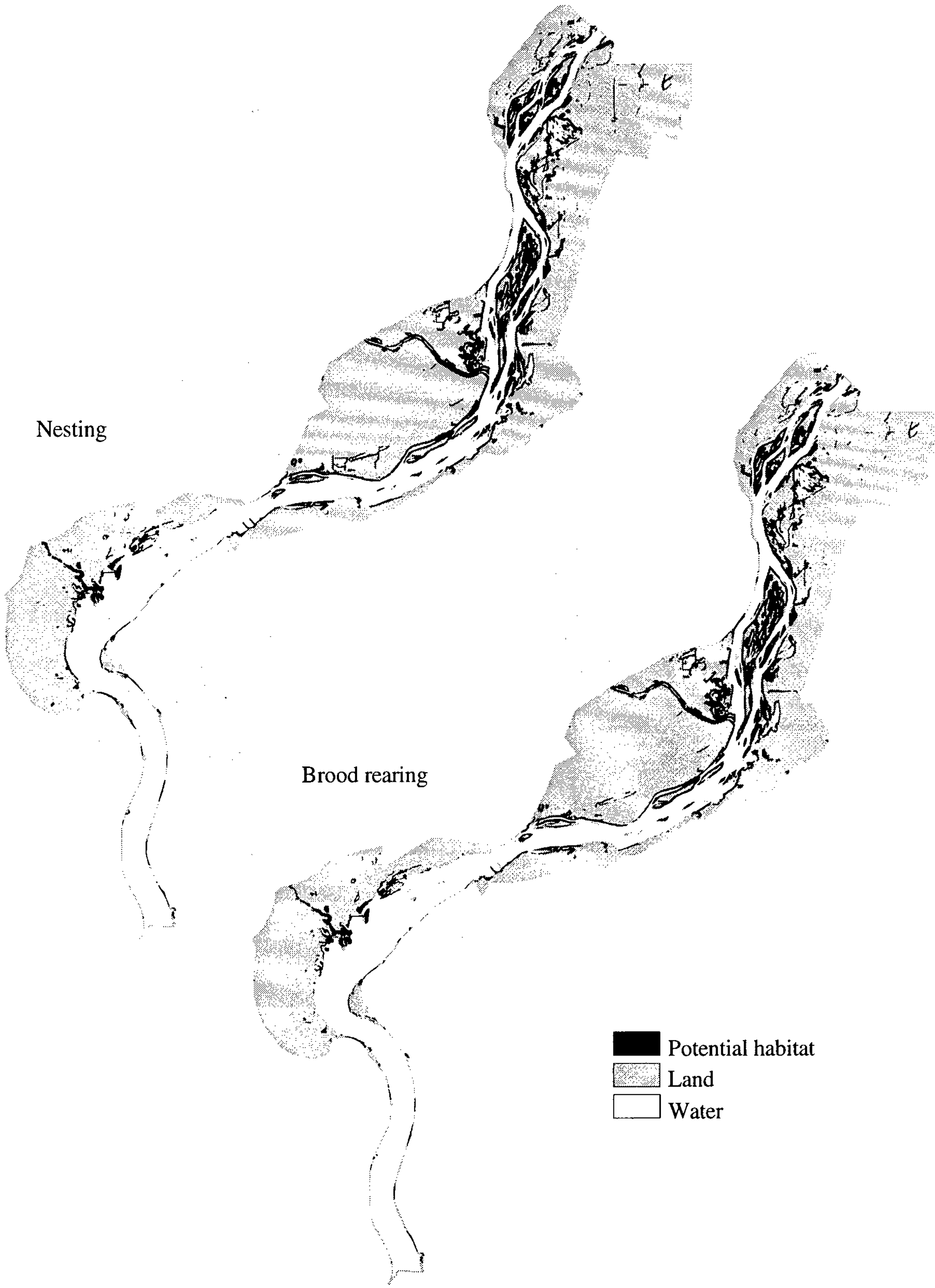


Figure E-180. Potential 1989 nesting and brood rearing habitat for the yellow-billed cuckoo (*Coccyzus americanus*), Upper Mississippi River Pool 19.

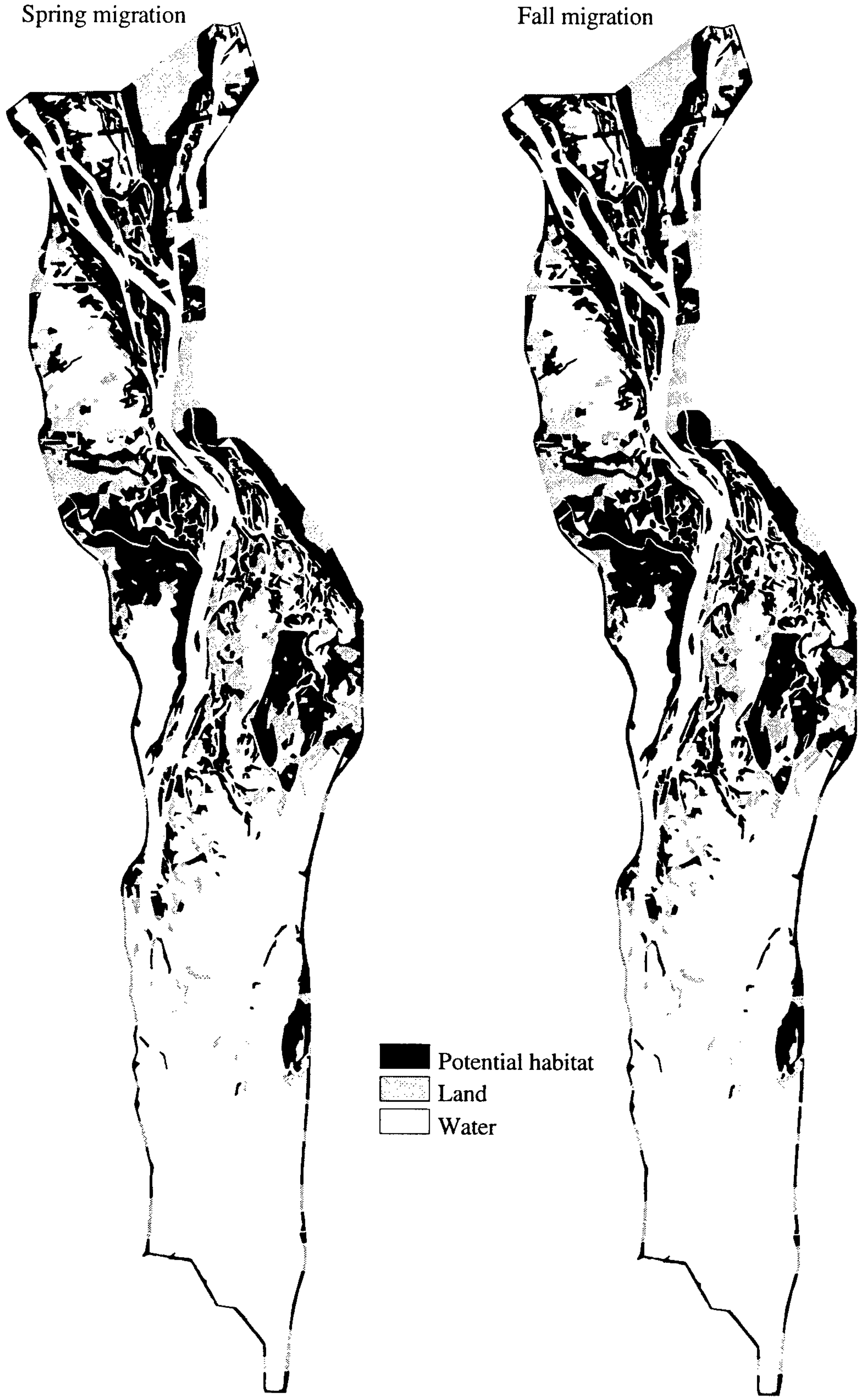


Figure E-181. Potential 1975 spring and fall migration habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 8.

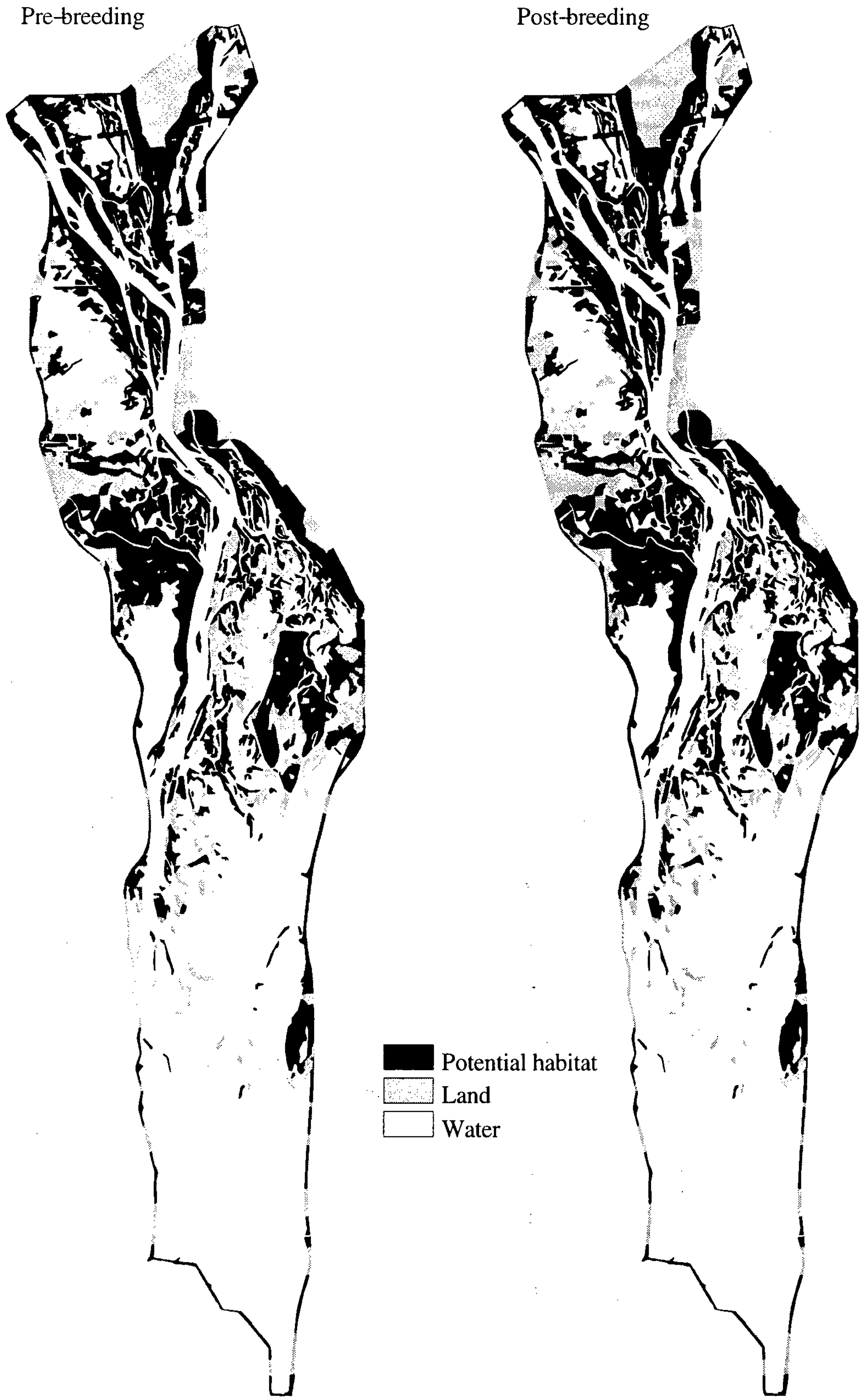


Figure E-182. Potential 1975 pre- and post-breeding habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 8.

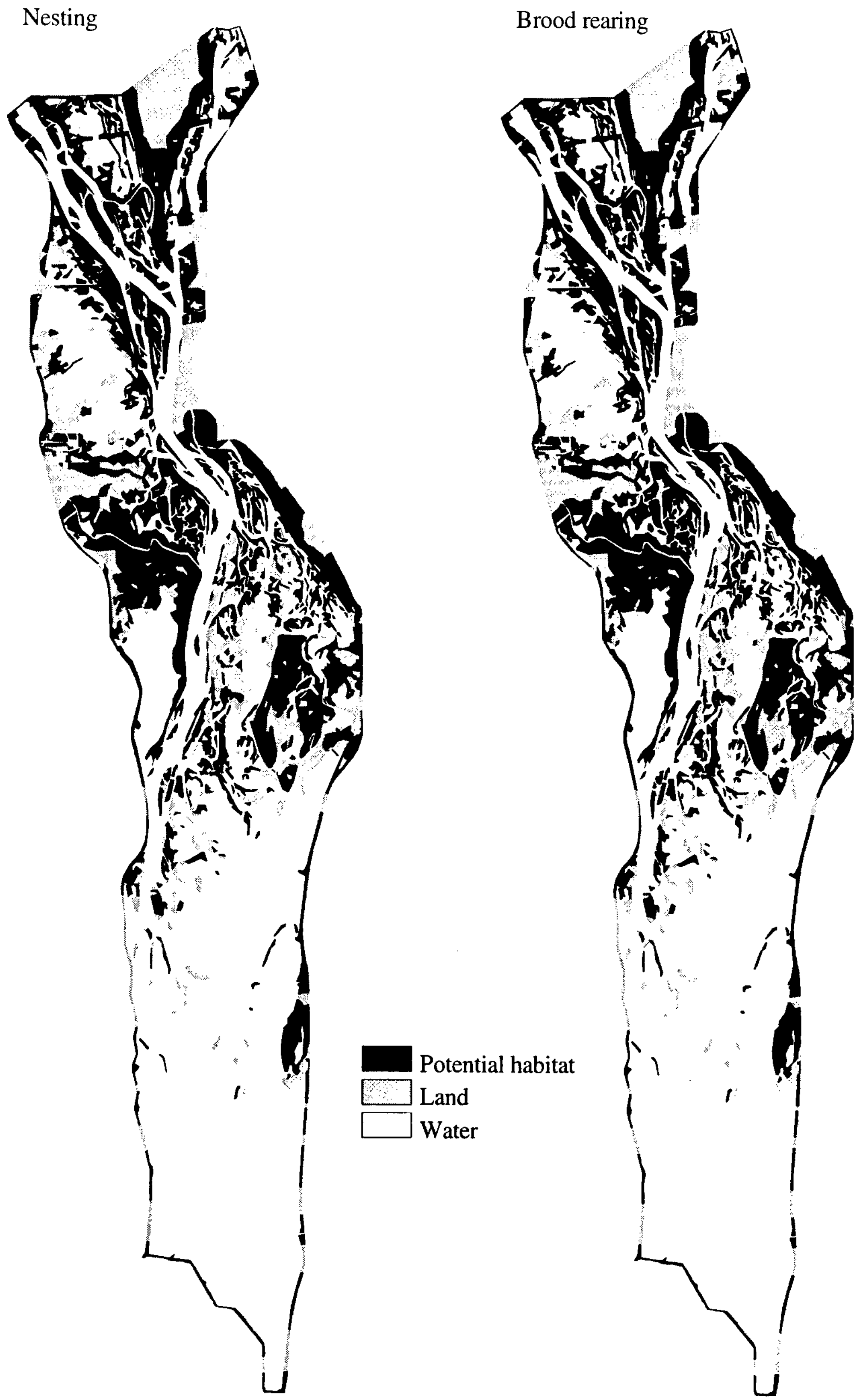


Figure E-183. Potential 1975 nesting and brood rearing habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 8.

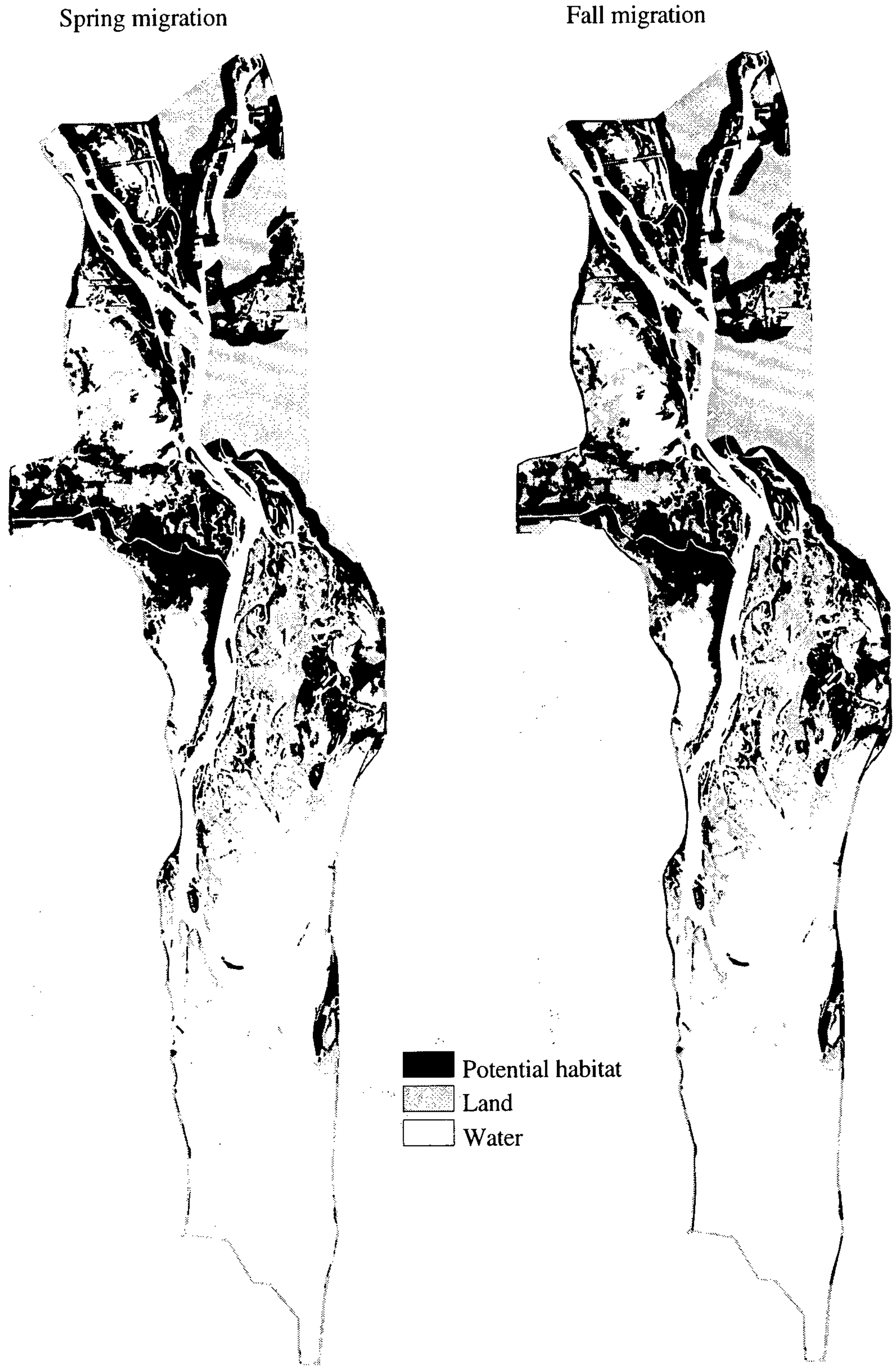


Figure E-184. Potential 1989 spring and fall migration habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 8.

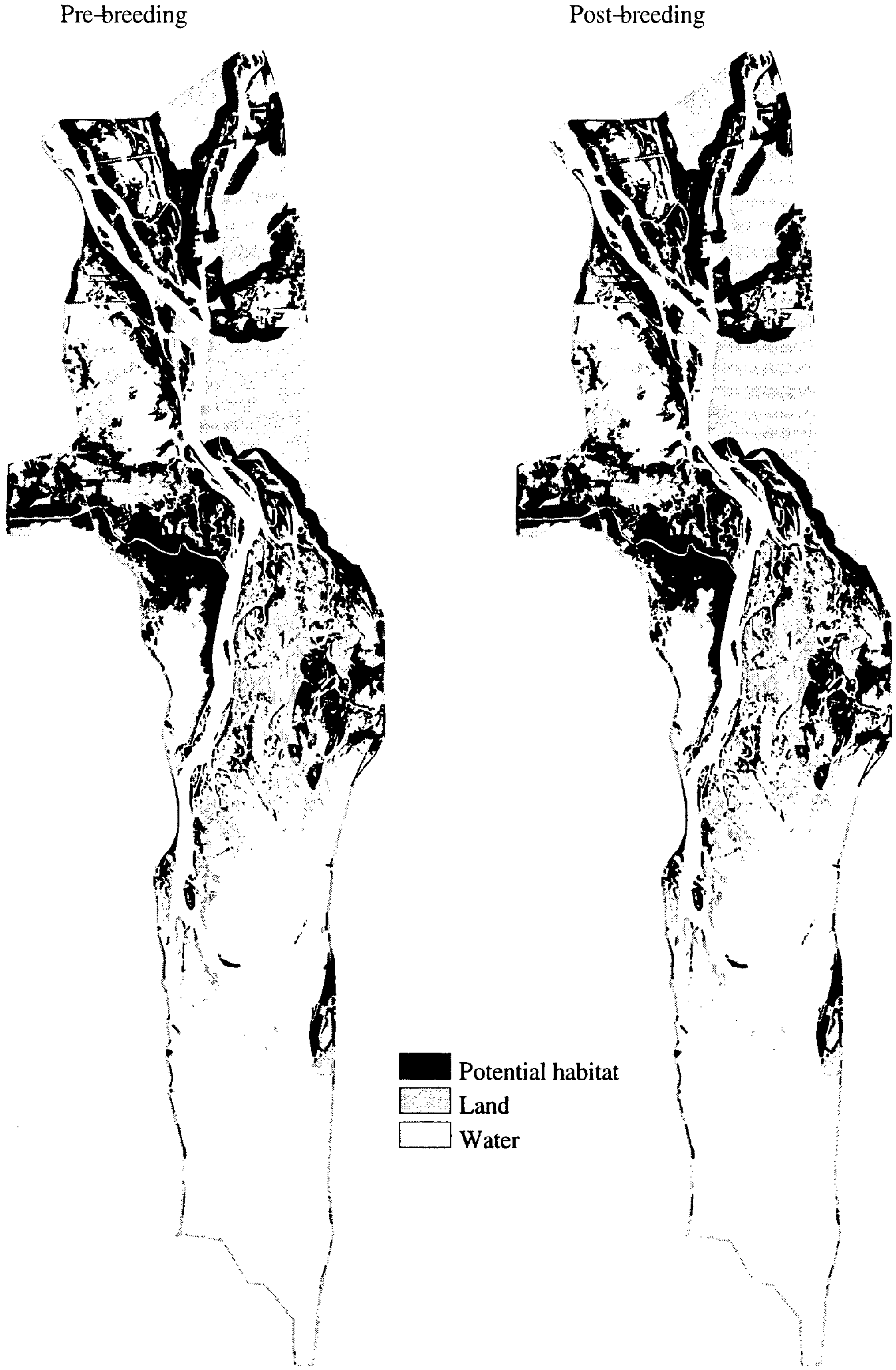


Figure E-185. Potential 1989 pre- and post-breeding habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 8.

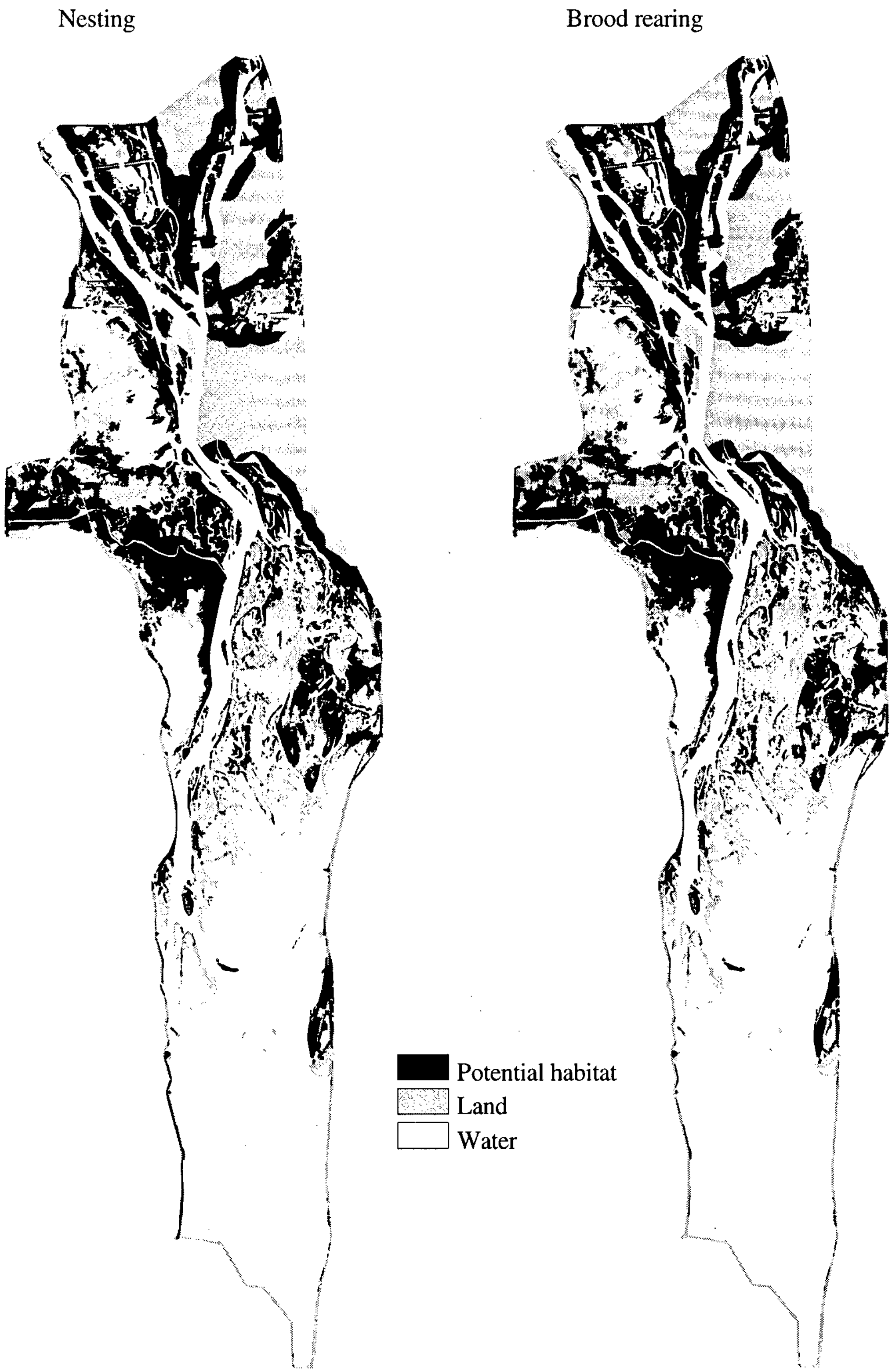


Figure E-186. Potential 1989 nesting and brood rearing habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 8.

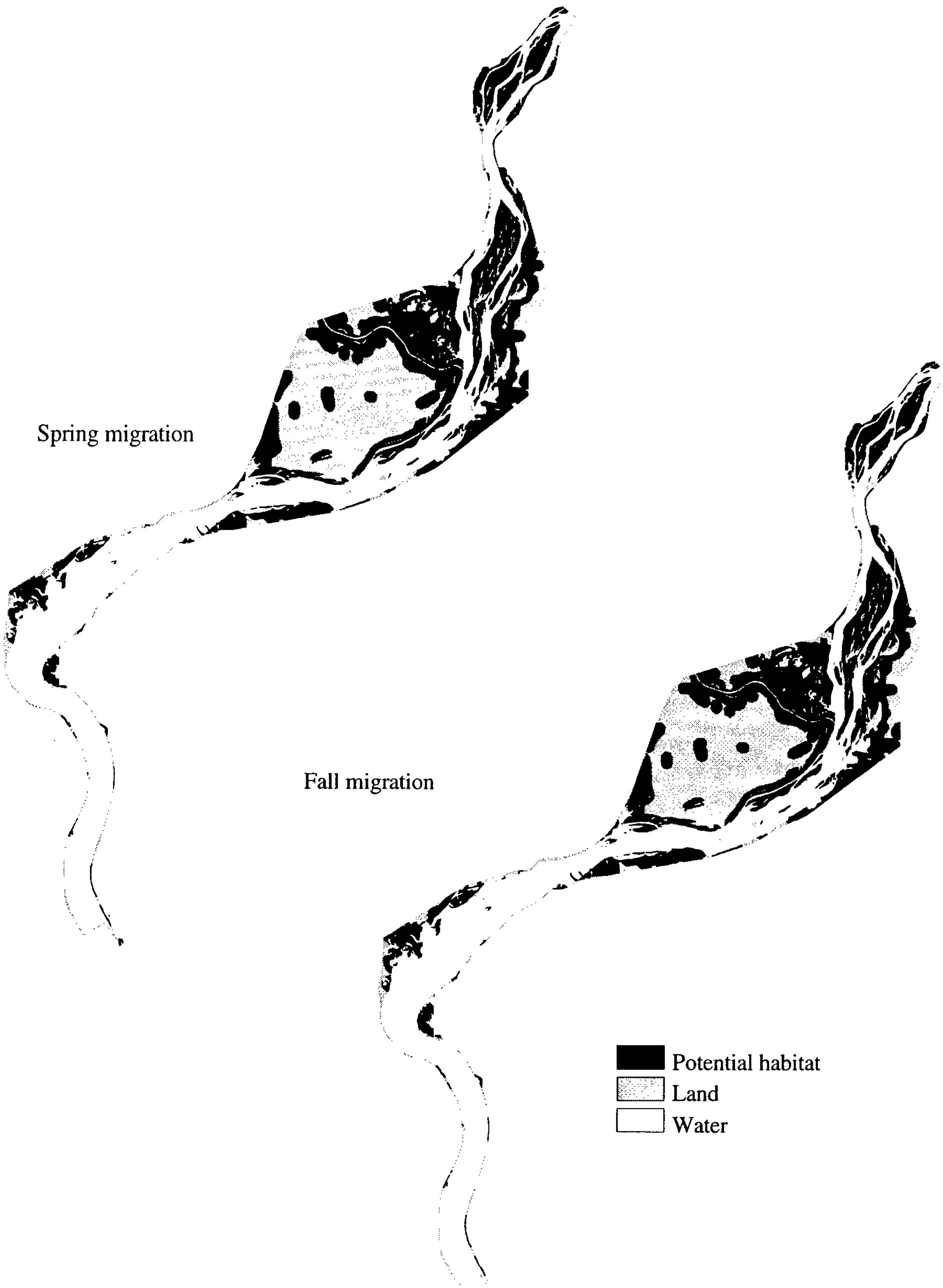


Figure E-187. Potential 1975 spring and fall migration habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 19.

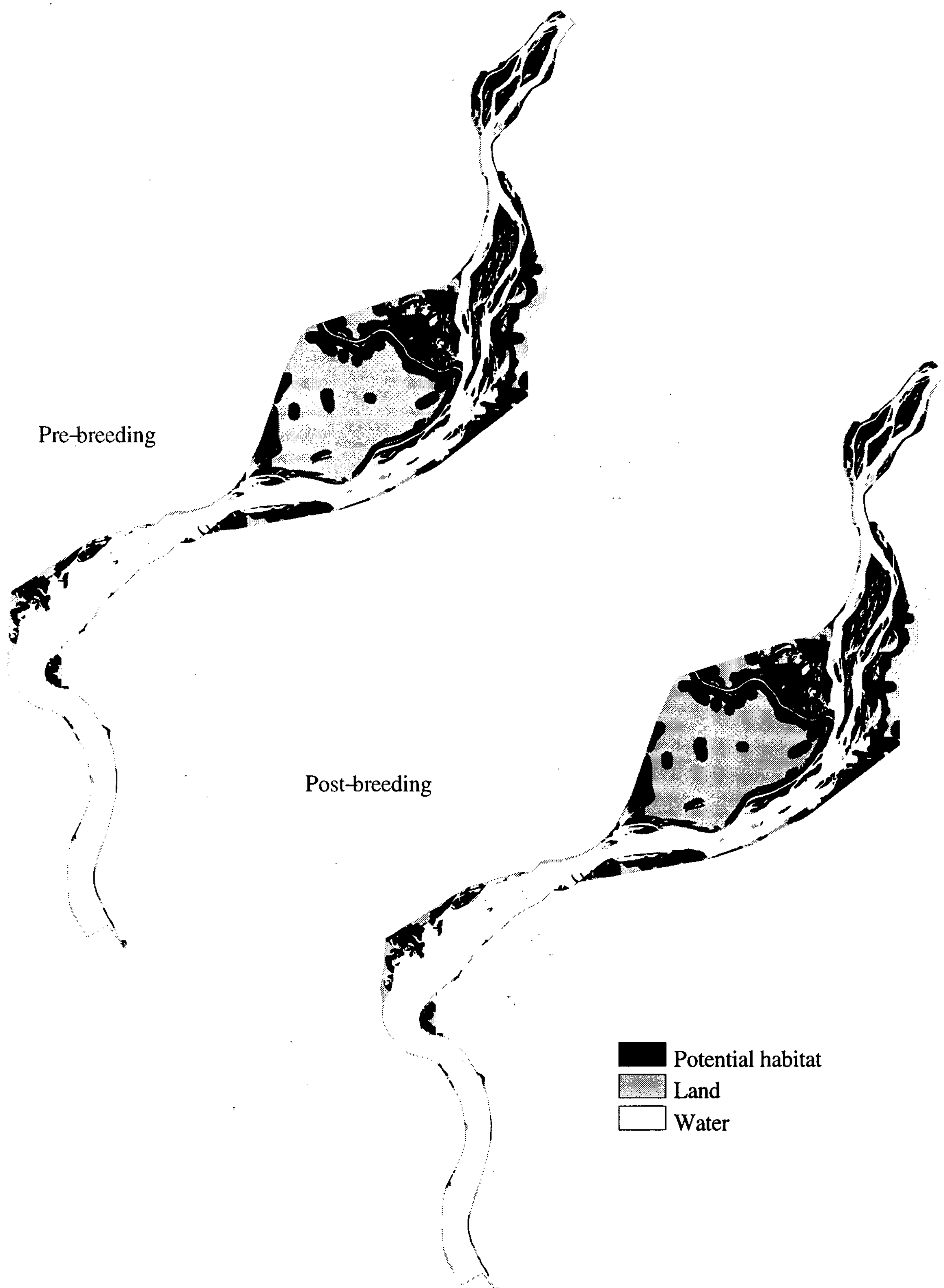


Figure E-188. Potential 1975 pre- and post-breeding habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 19.

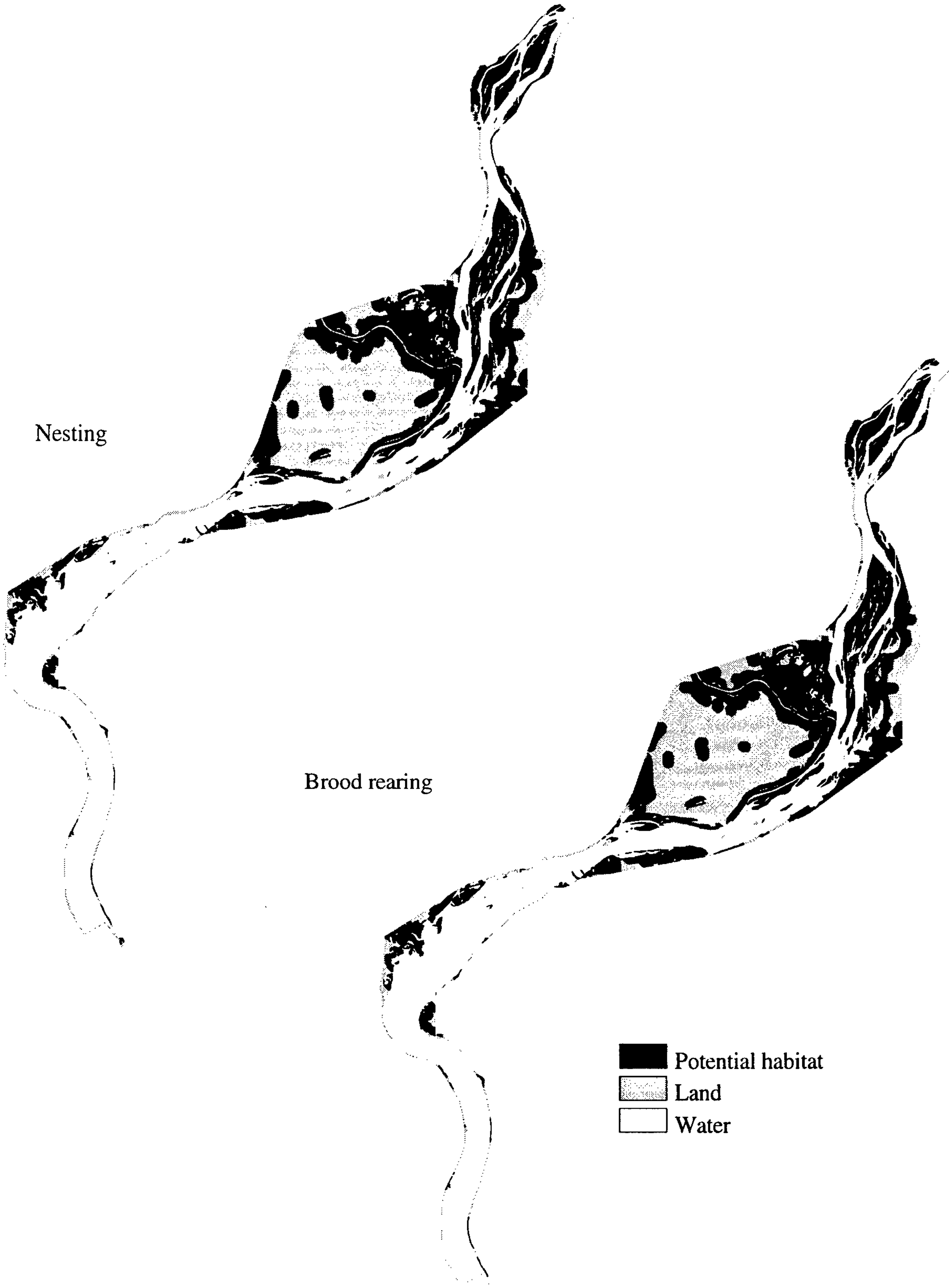


Figure E-189. Potential 1975 nesting and brood rearing habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 19.

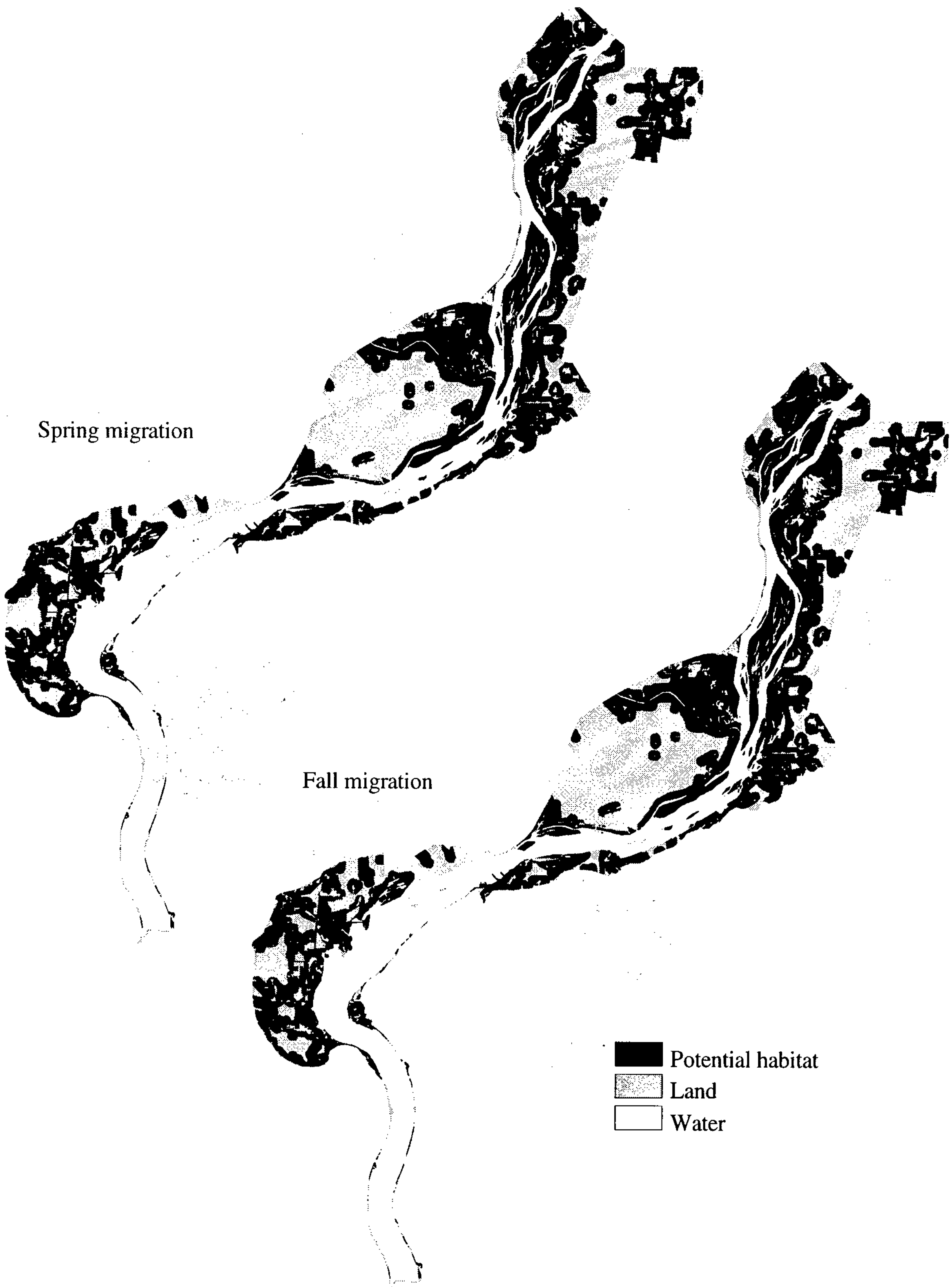


Figure E-190. Potential 1989 spring and fall migration habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 19.

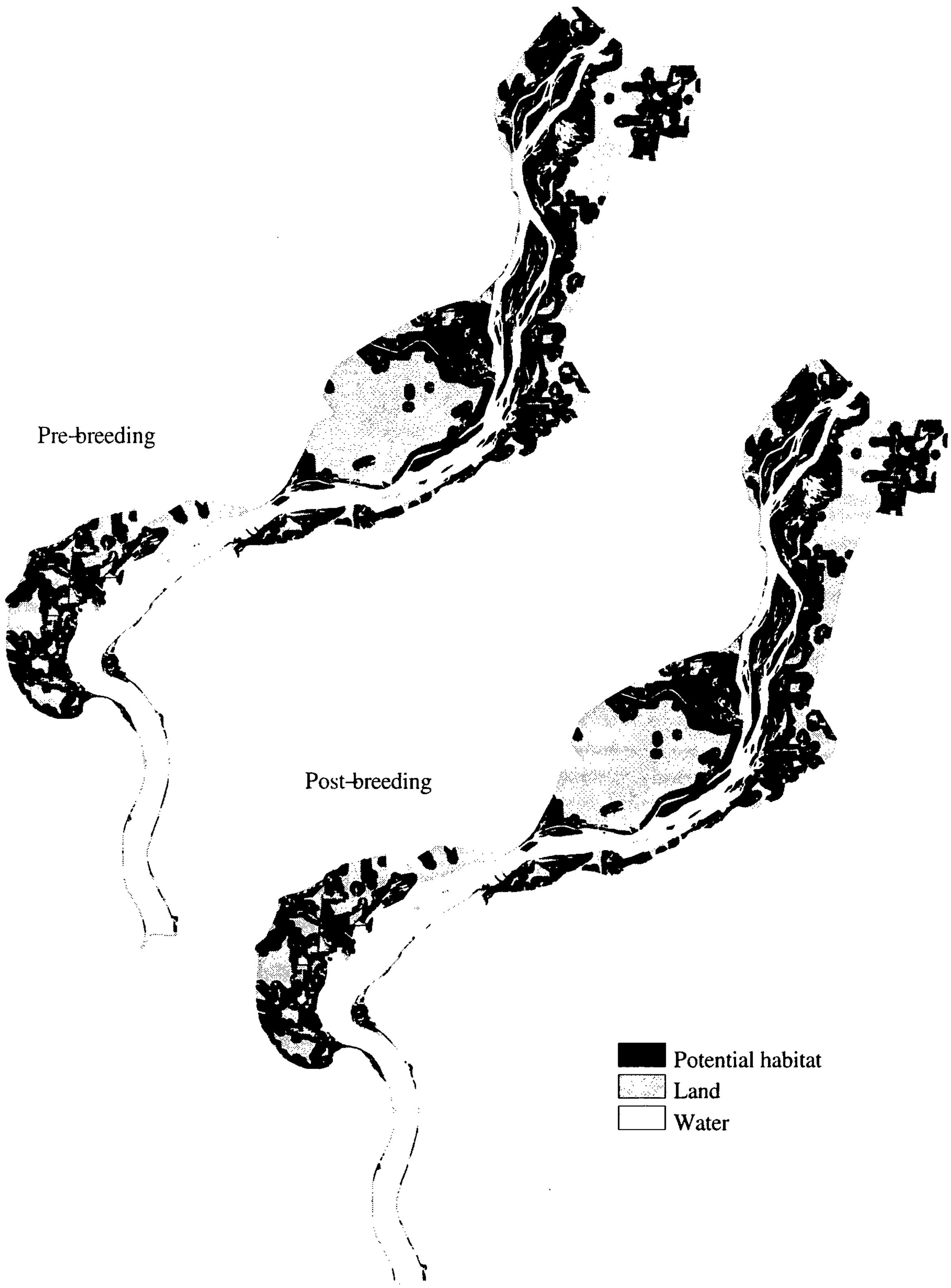


Figure E-191. Potential 1989 pre- and post-breeding habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 19.

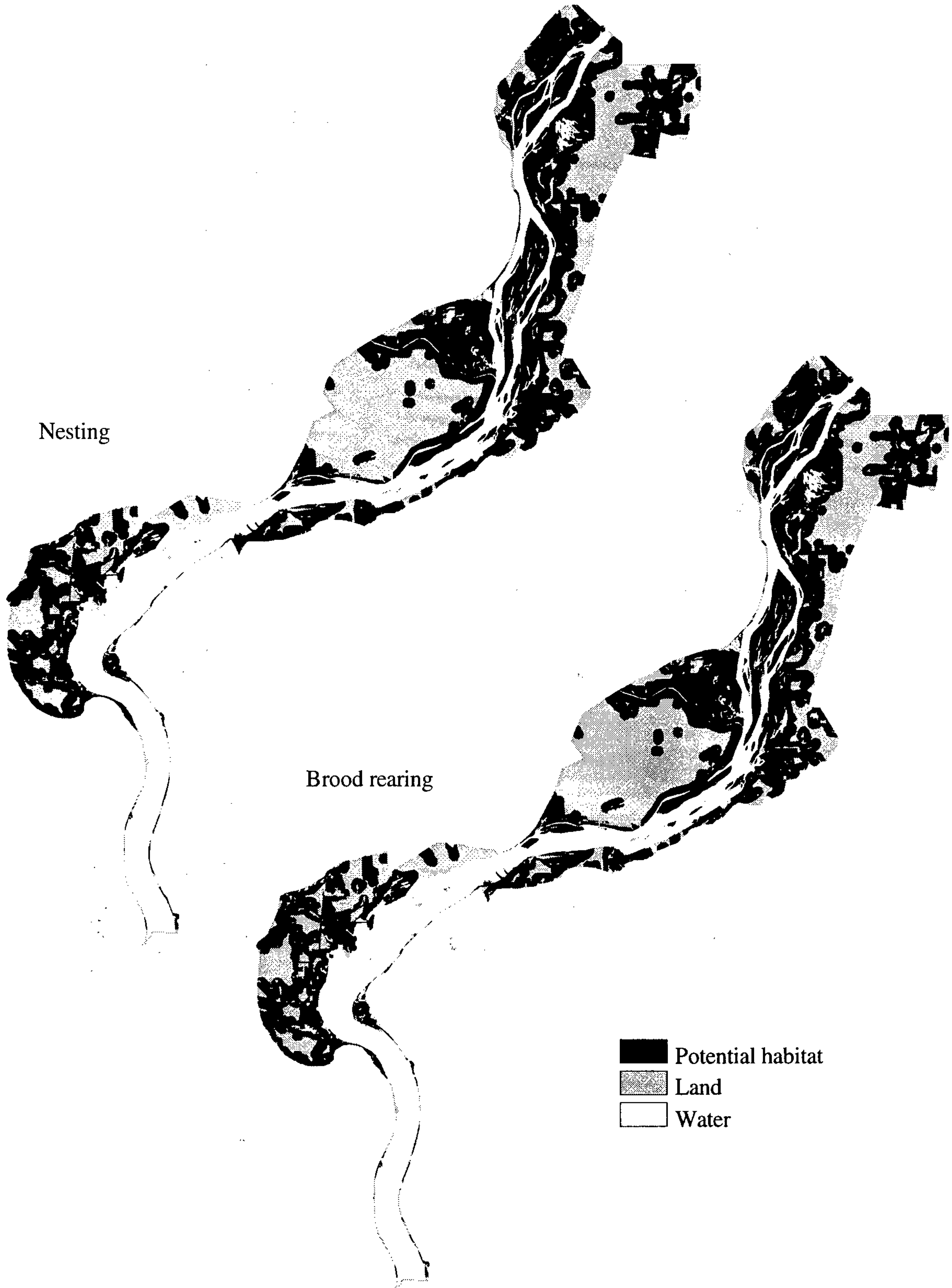


Figure E-192. Potential 1989 nesting and brood rearing habitat for the barred owl (*Strix varia*), Upper Mississippi River Pool 19.

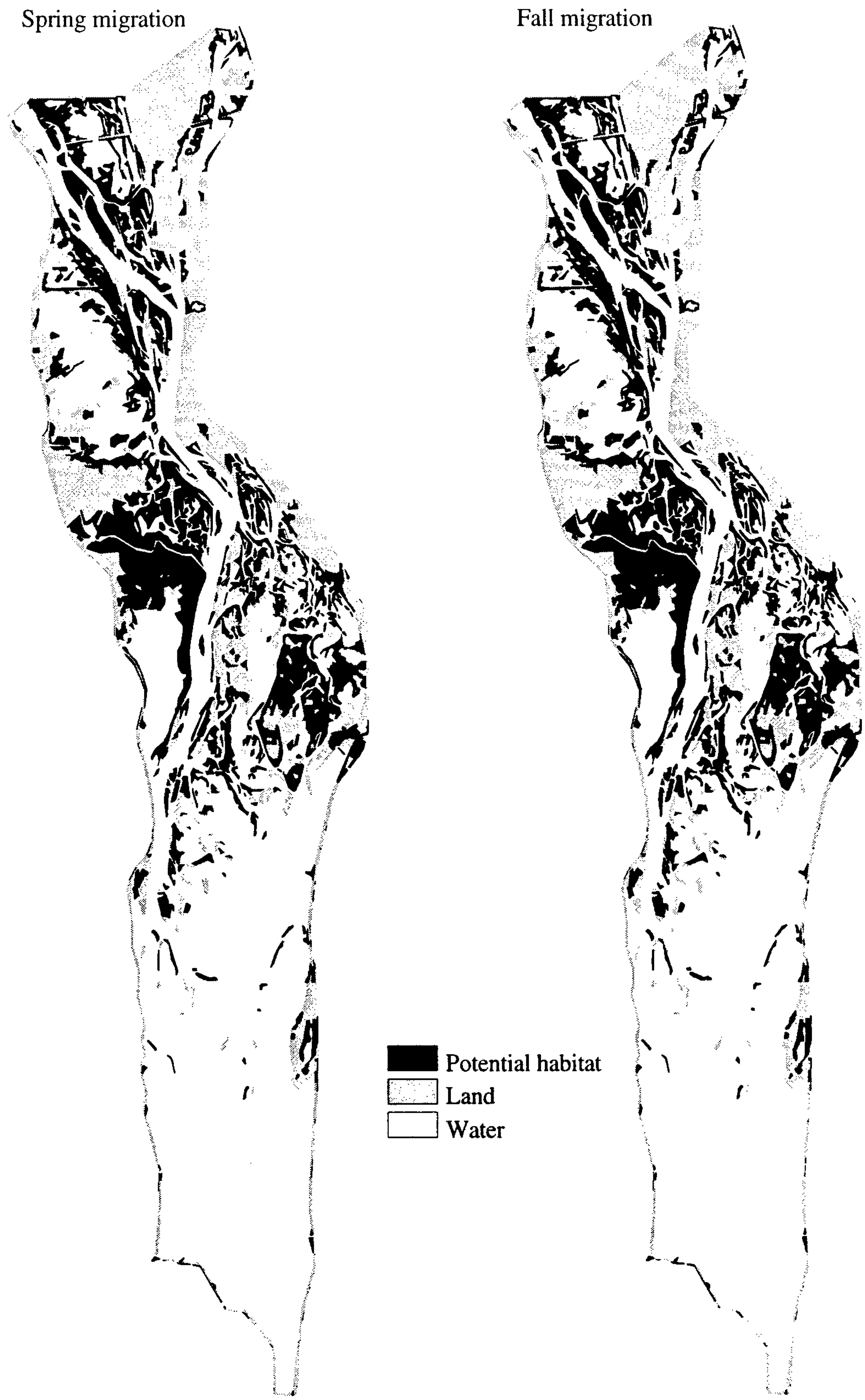
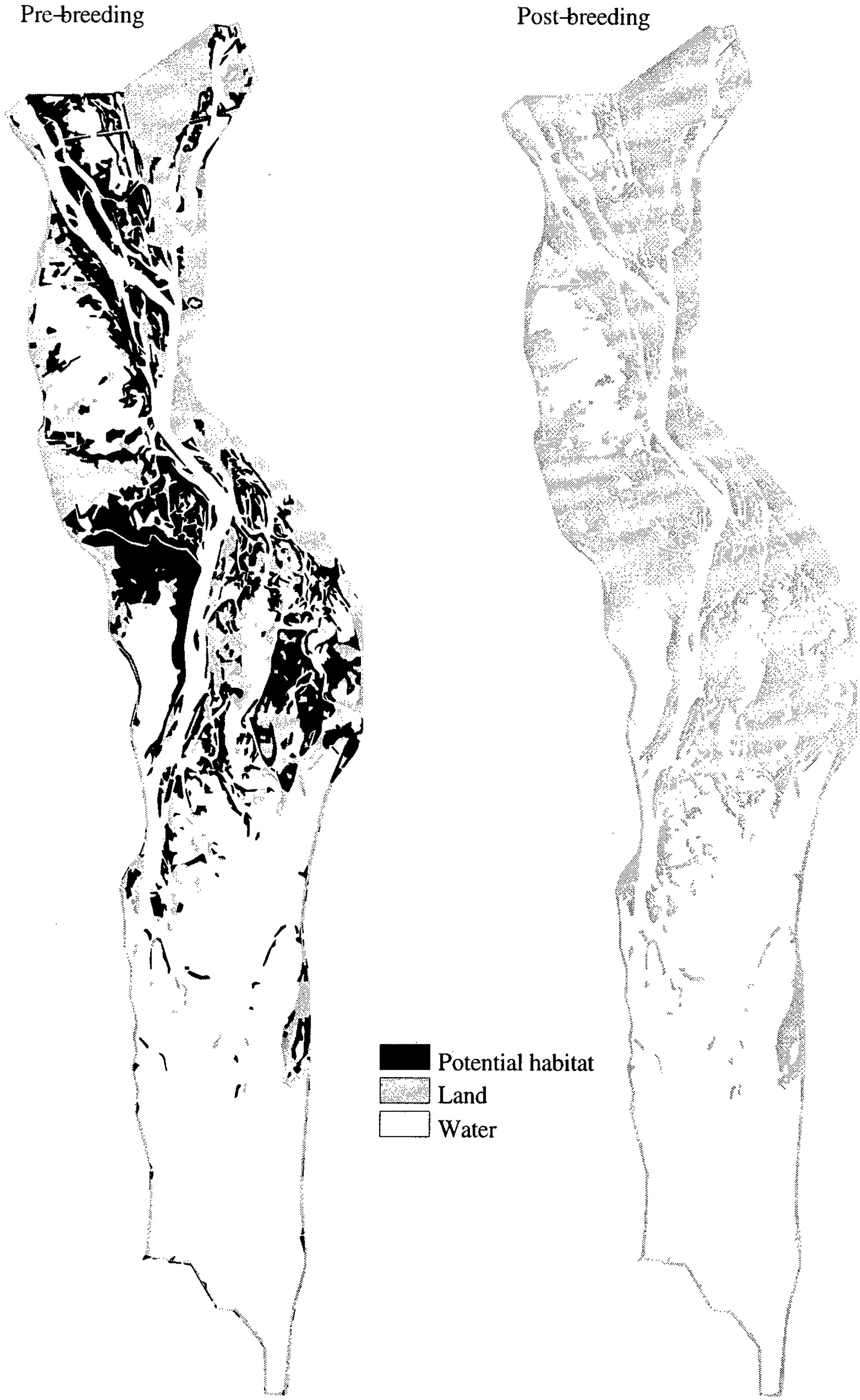


Figure E-193. Potential 1975 spring and fall migration habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 8.



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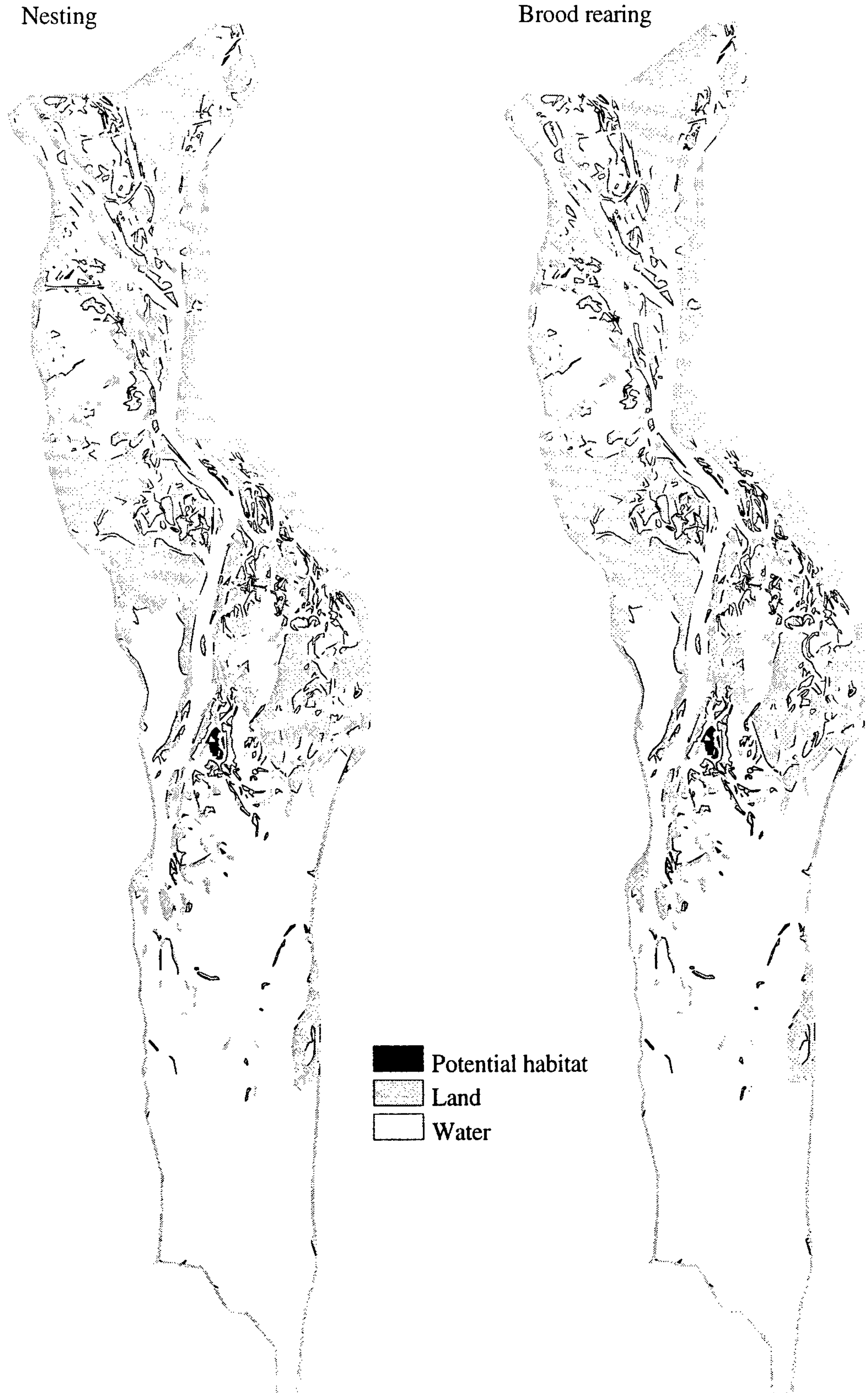

Figure E-195. Potential 1975 nesting and brood rearing habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 8.

Figure E-196. Potential 1989 spring and fall migration habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 8.

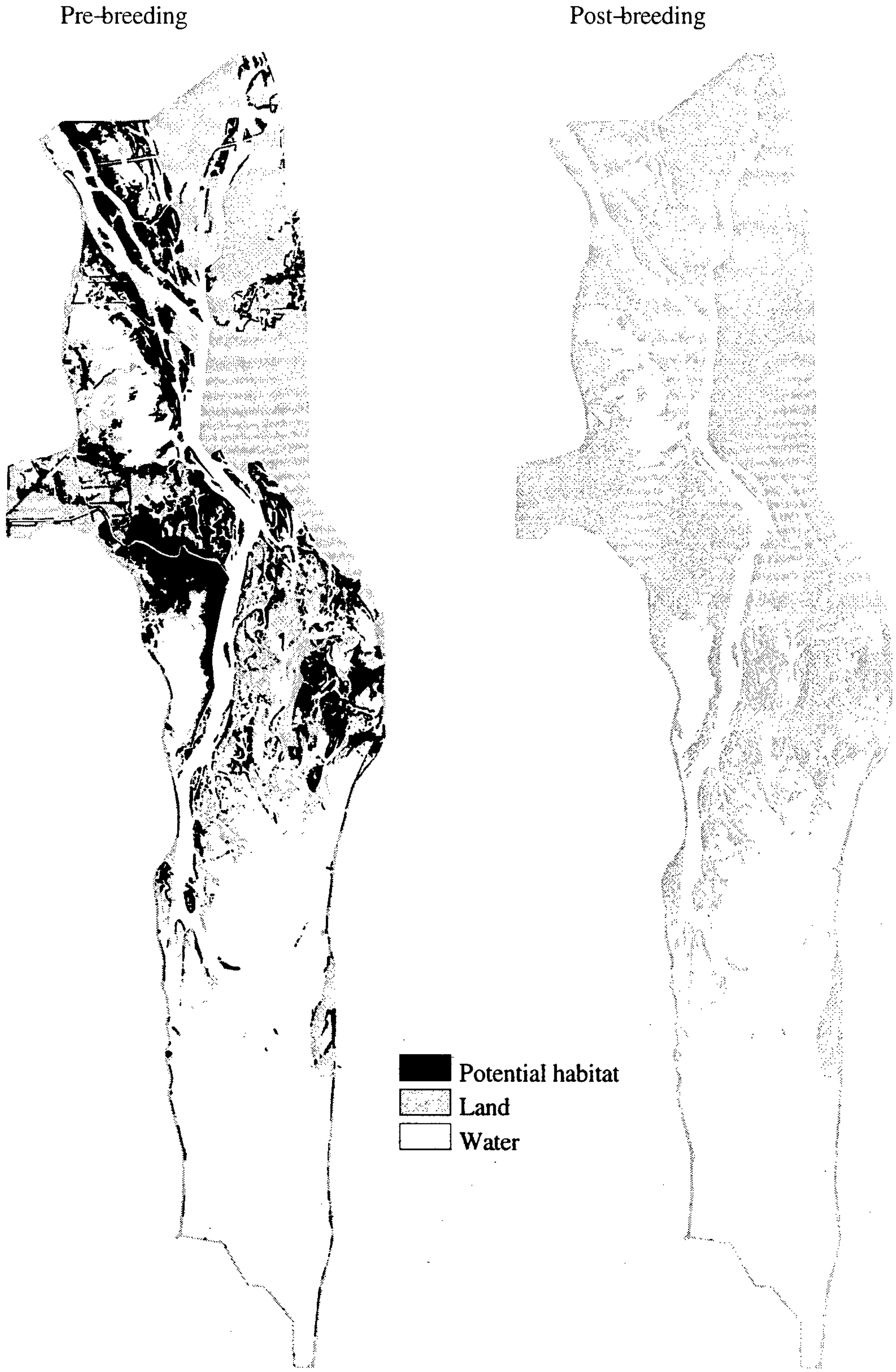

Figure E-197. Potential 1989 pre- and post-breeding habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 8.

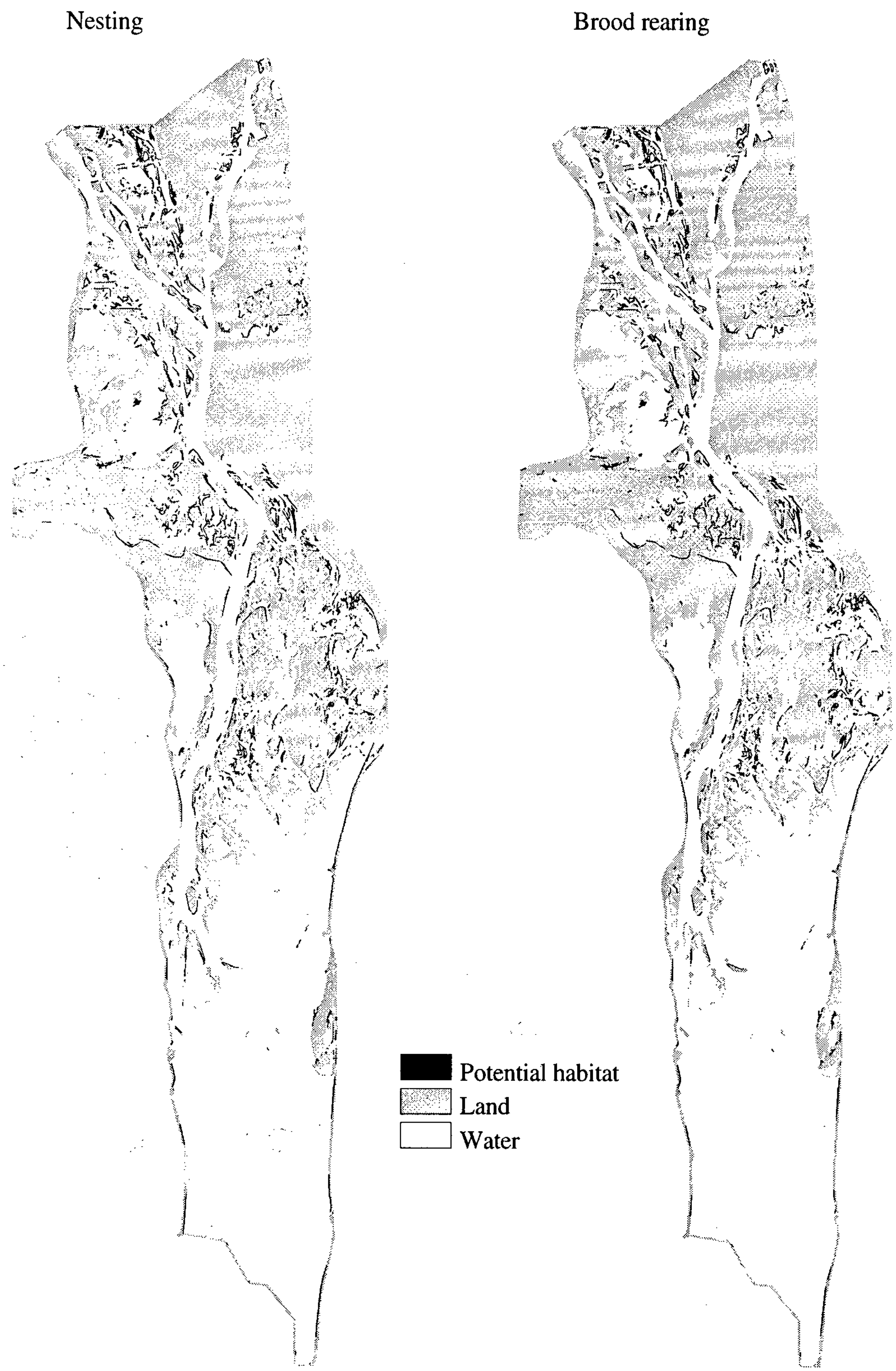

Figure E-198. Potential 1989 nesting and brood rearing habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 8.

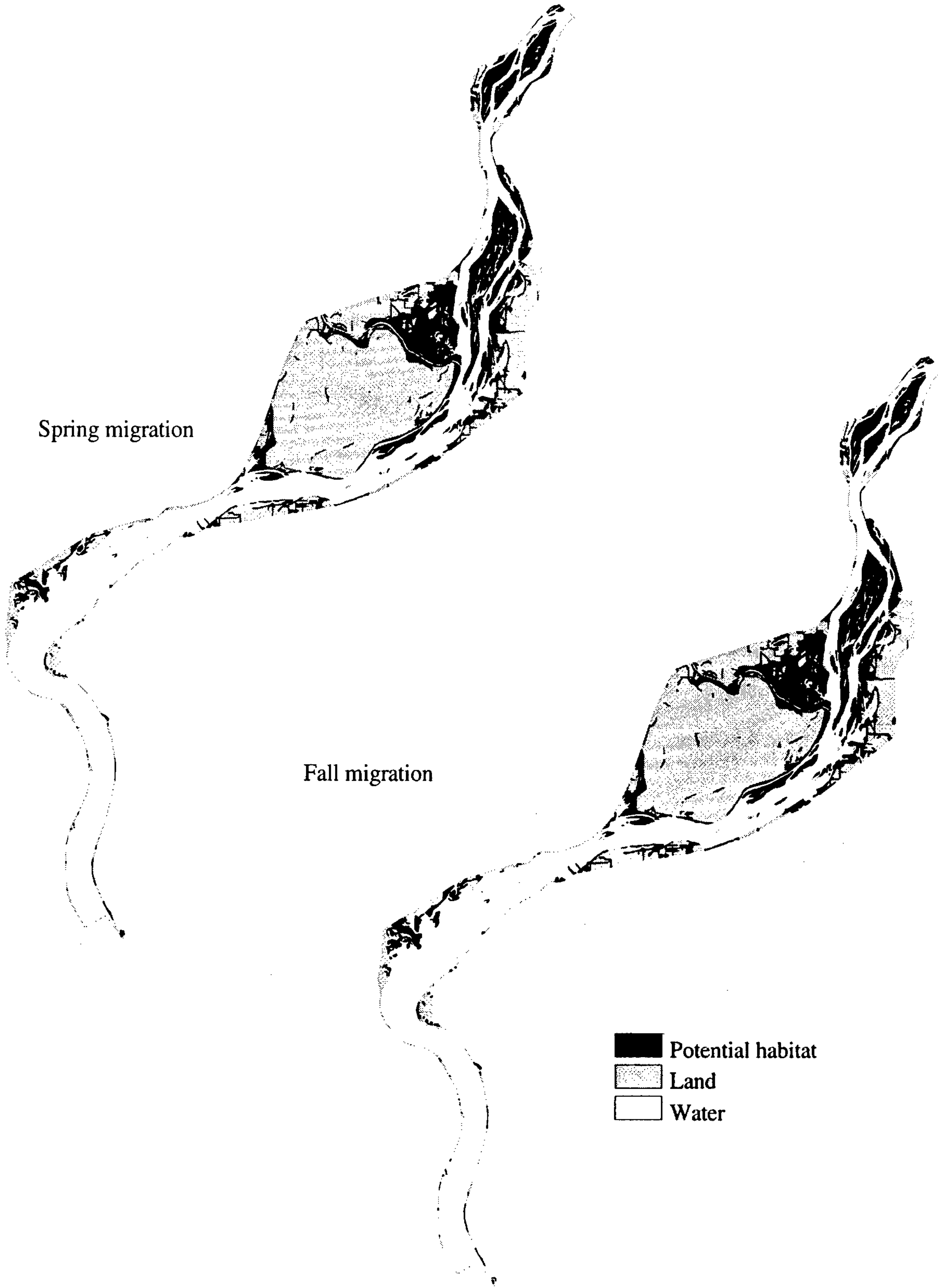

Figure E-199. Potential 1975 spring and fall migration habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 19.

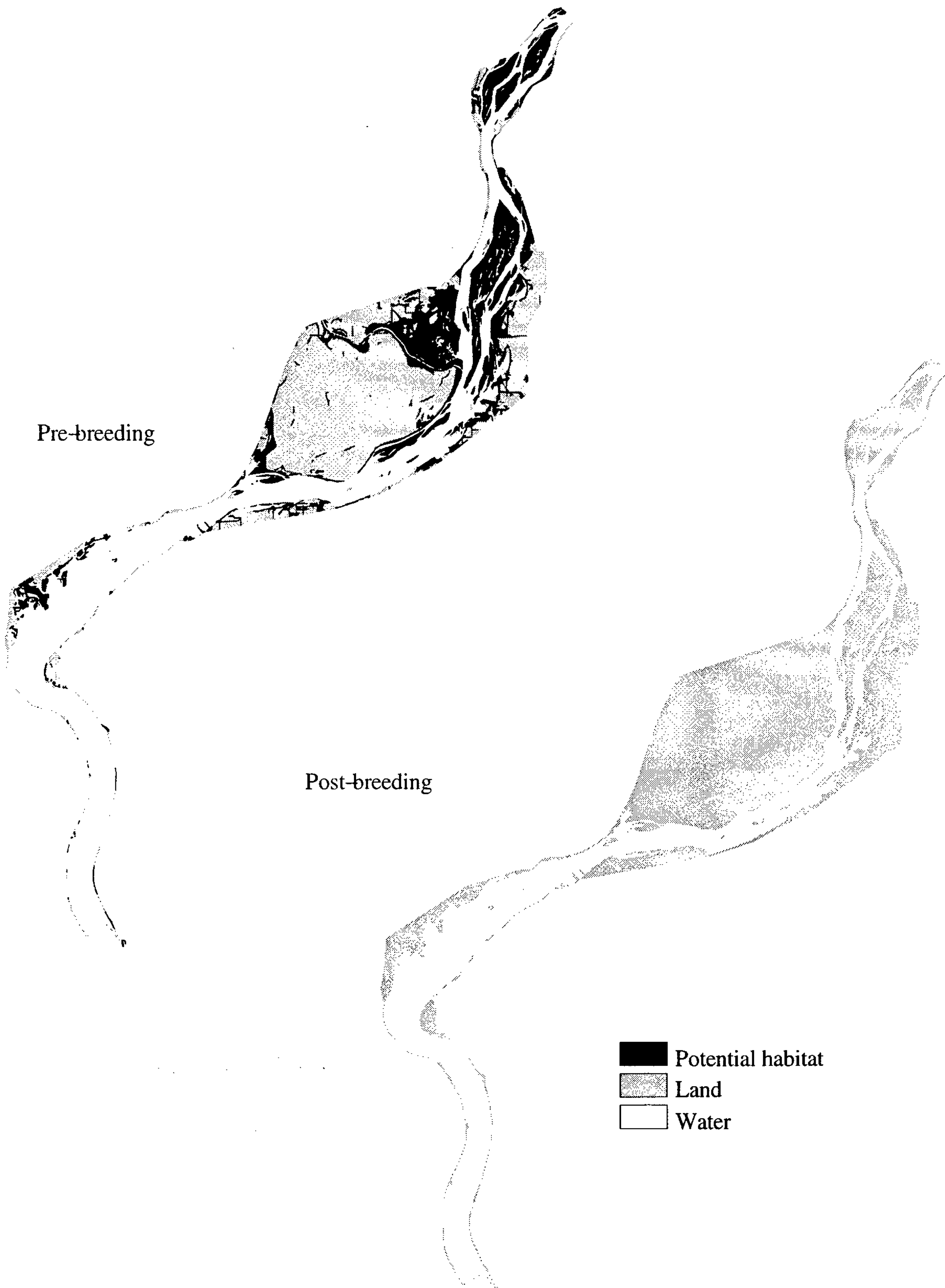

Figure E-200. Potential 1975 pre- and post-breeding habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 19.

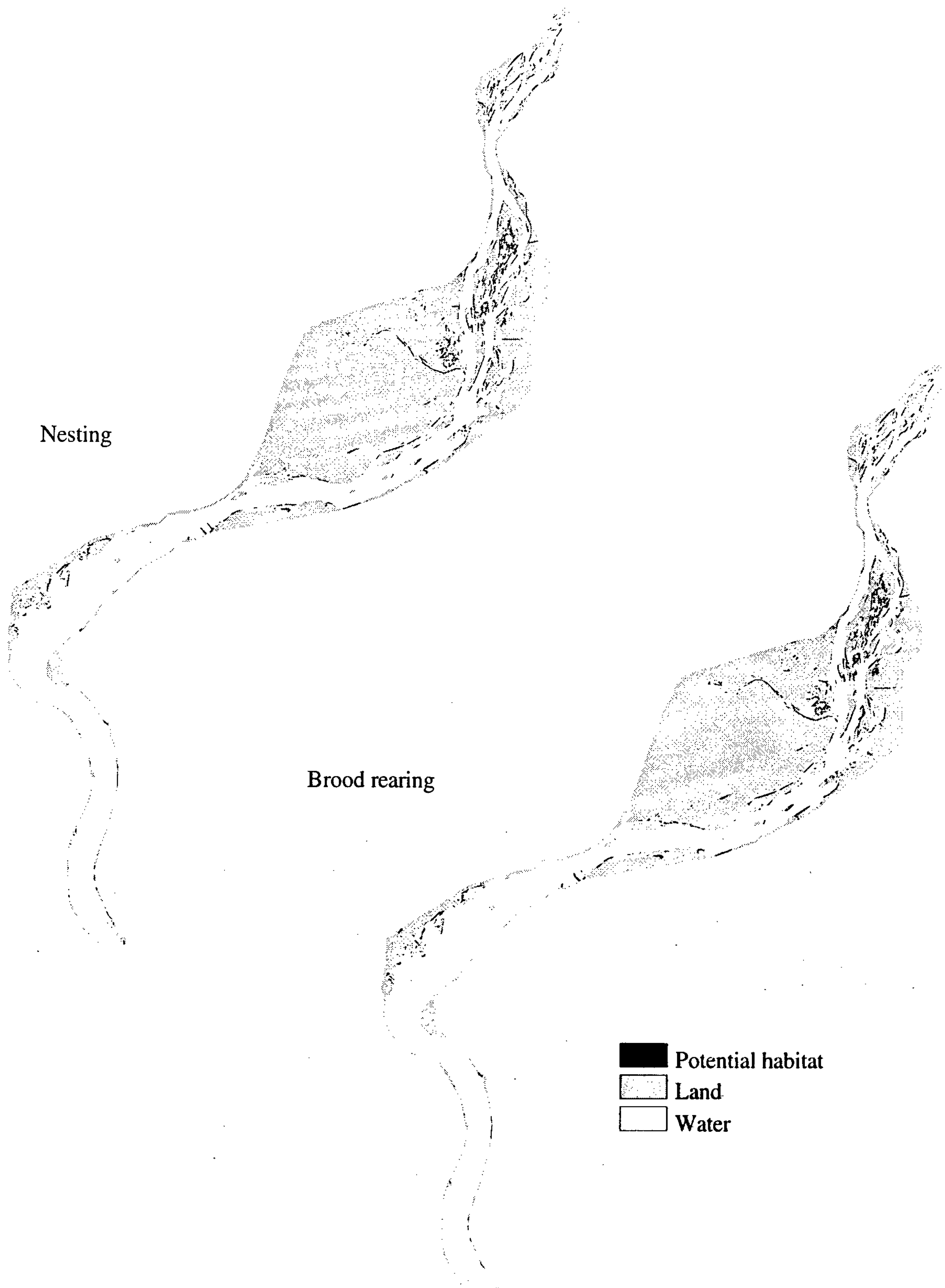

Figure E-201. Potential 1975 nesting and brood rearing habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 19.

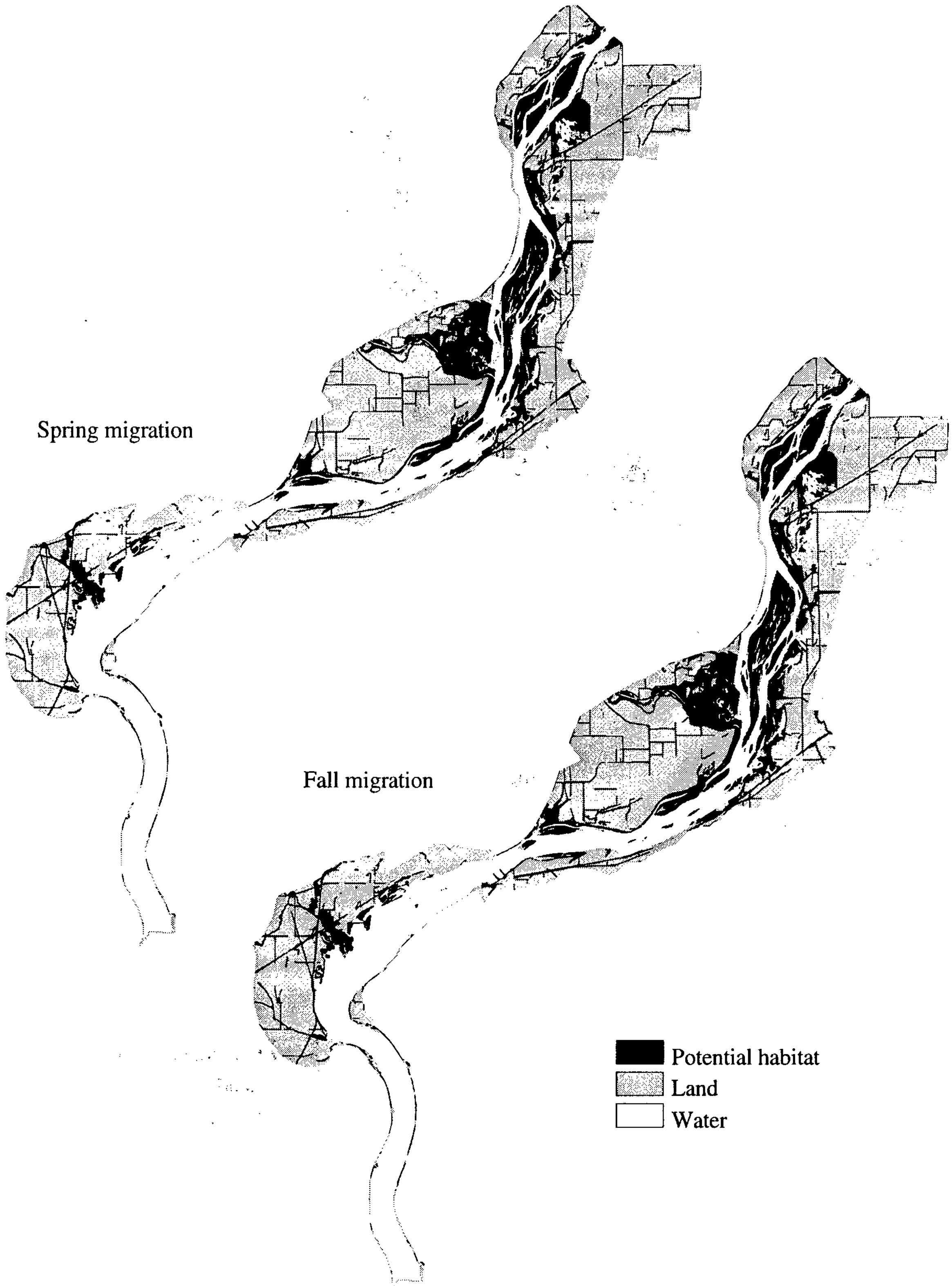

Figure E-202. Potential 1989 spring and fall migration habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 19.

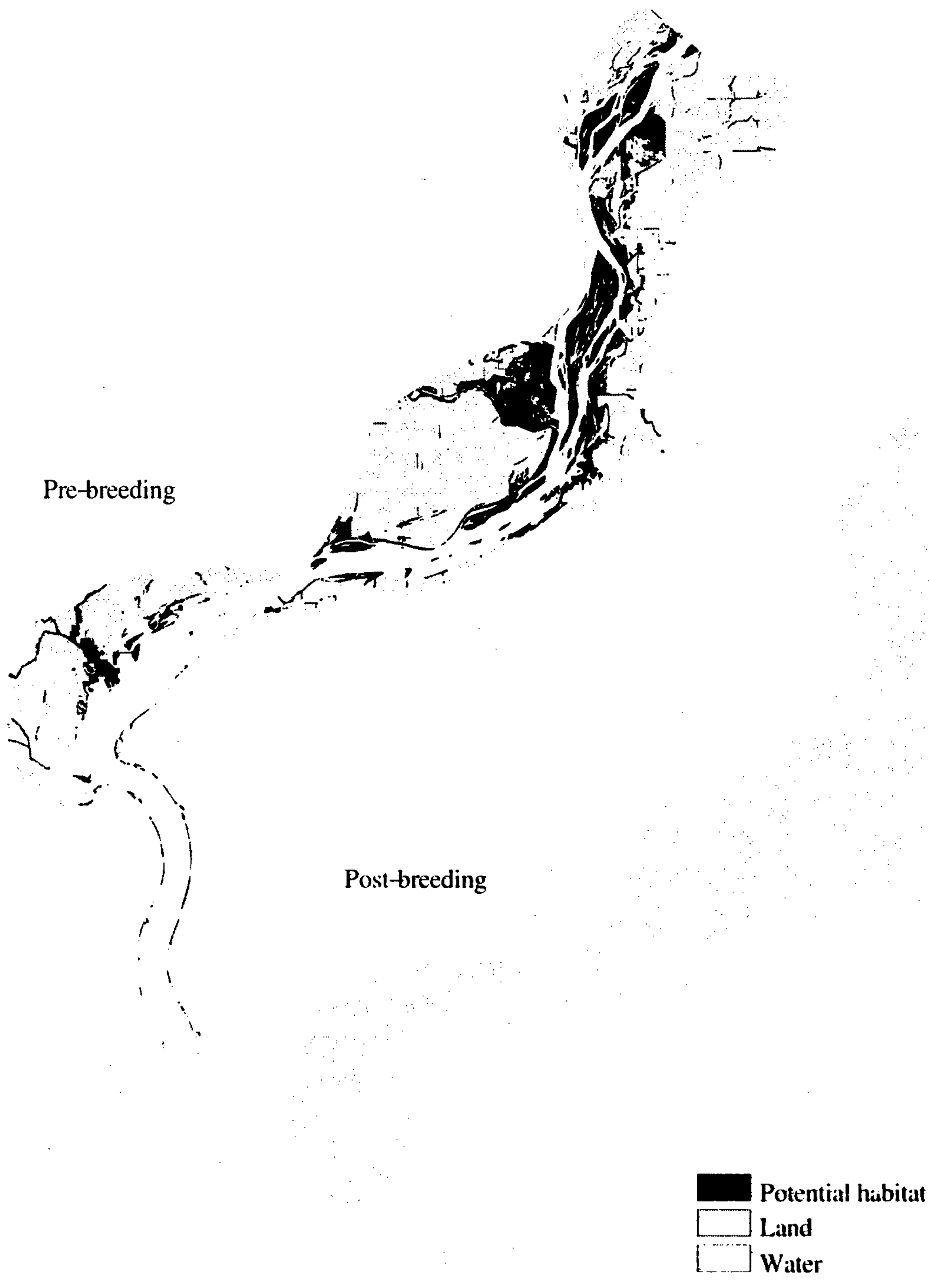

Figure E-203. Potential 1989 pre- and post-breeding habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 19.

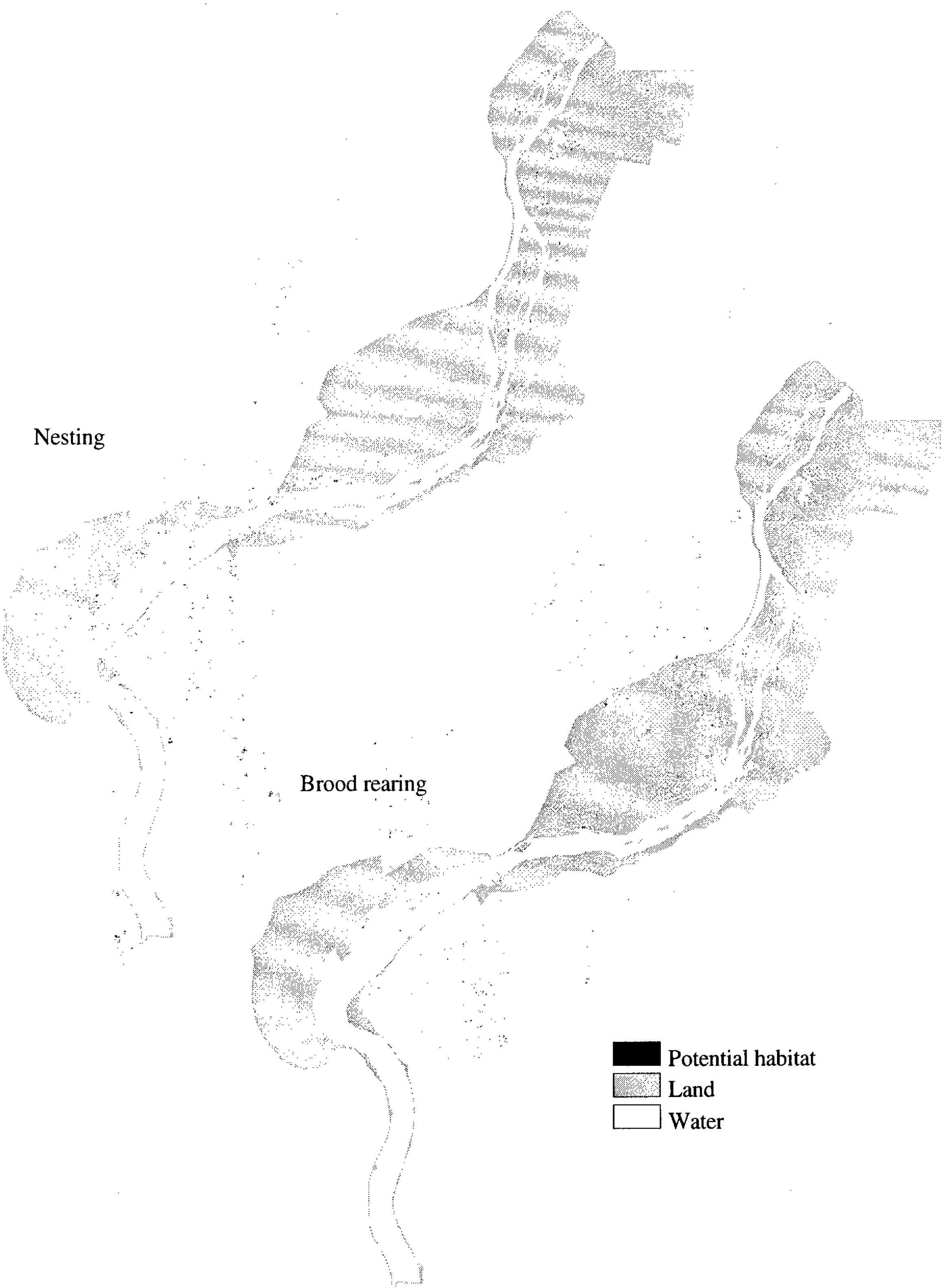

Figure E-204. Potential 1989 nesting and brood rearing habitat for the prothonotary warbler (*Protonotaria citrea*), Upper Mississippi River Pool 19.

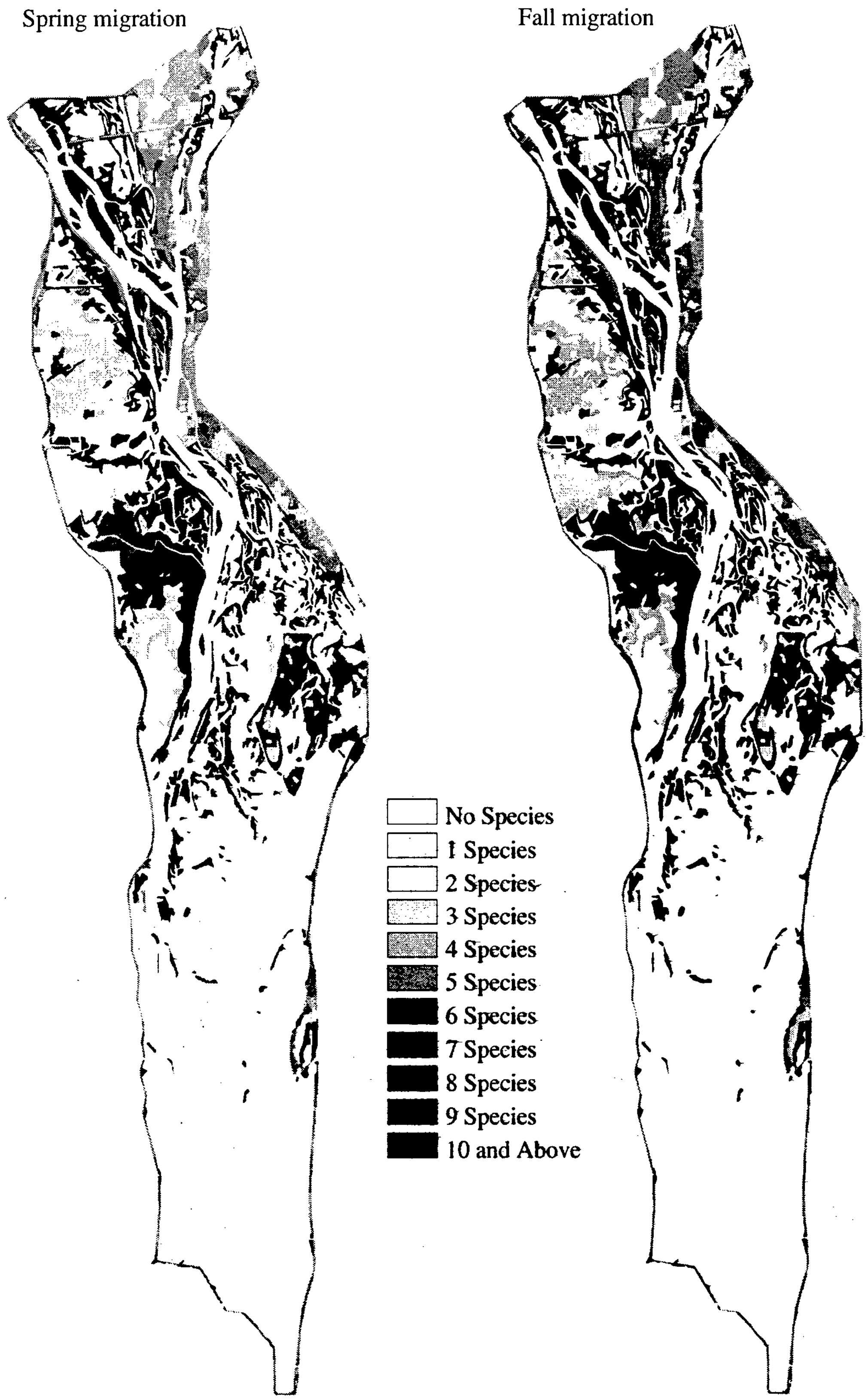

Figure E-205. Potential species richness, 1975 spring and fall migration, Upper Mississippi River Pool 8.

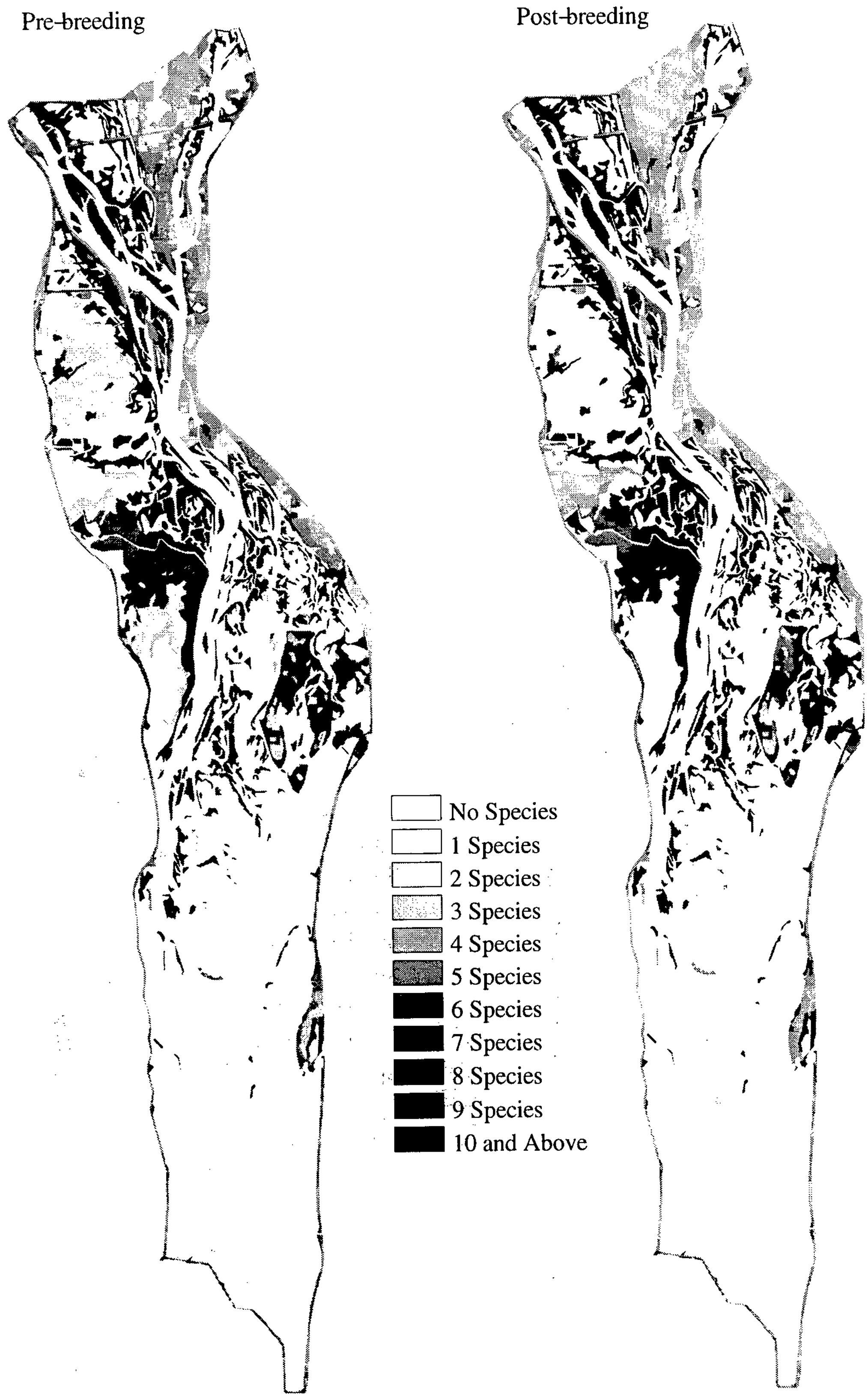

Figure E-206. Potential species richness, 1975 pre- and post-breeding, Upper Mississippi River Pool 8.

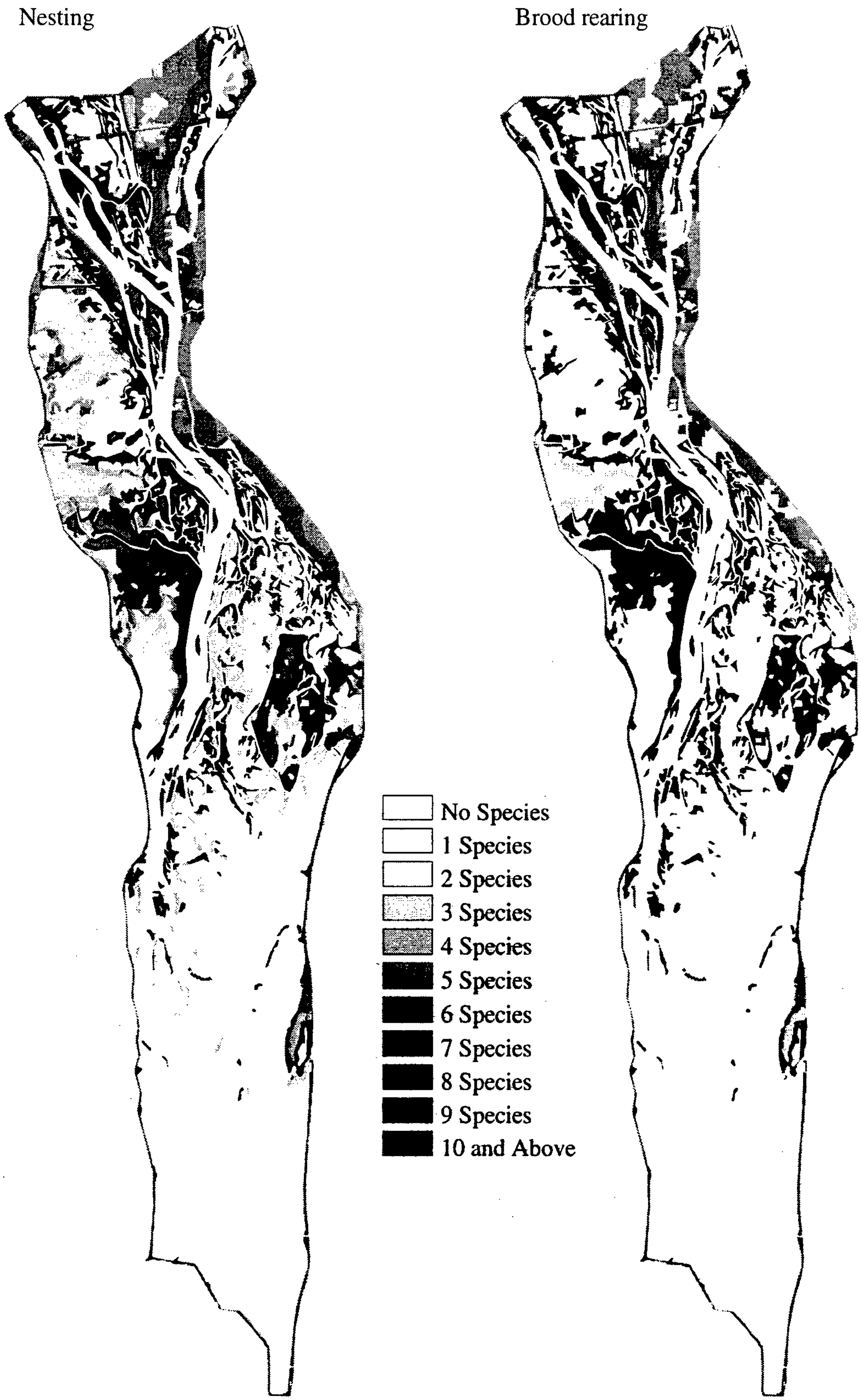

Figure E-207. Potential species richness, 1975 nesting and brood rearing, Upper Mississippi River Pool 8.

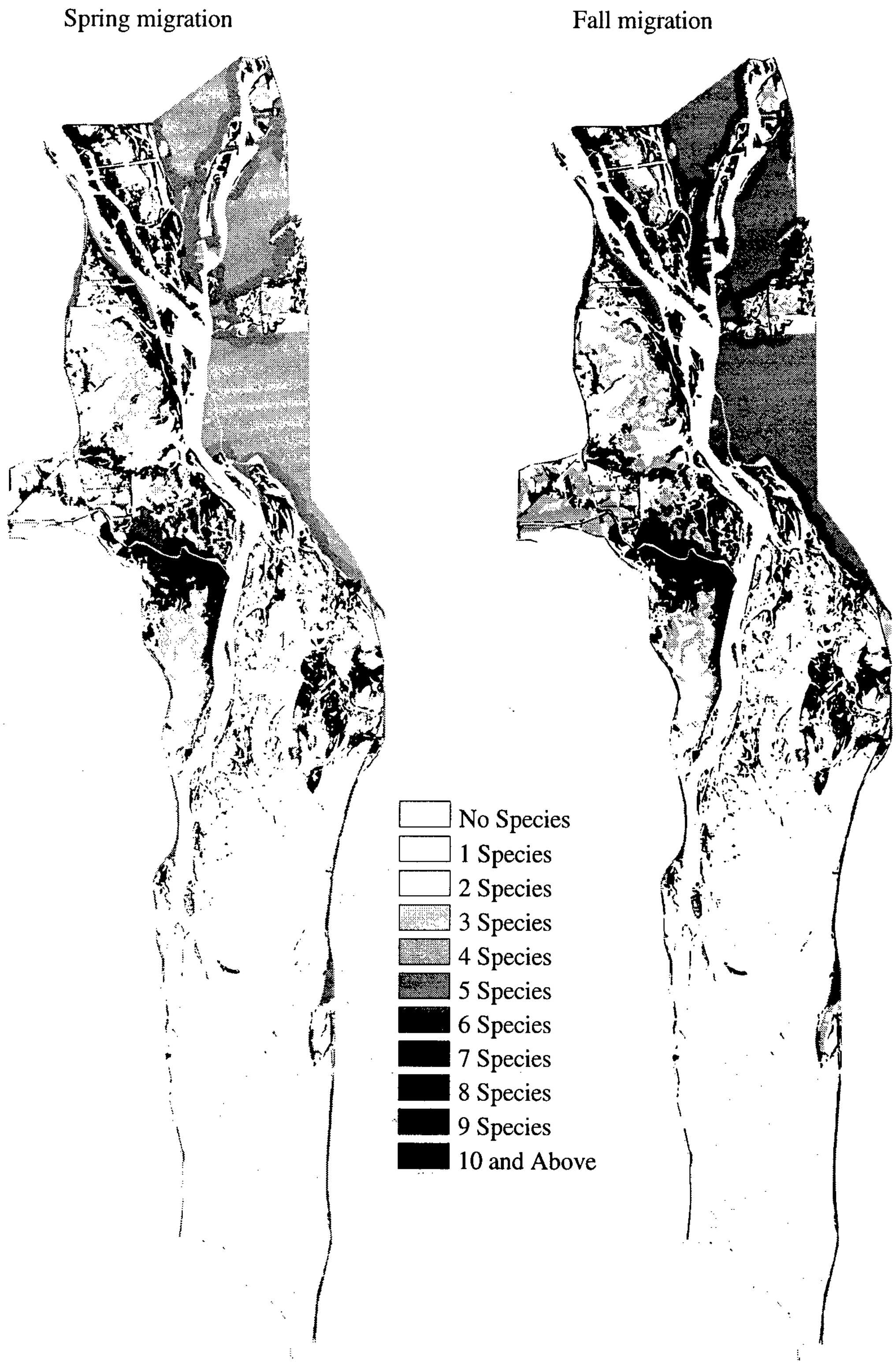

Figure E-208. Potential species richness, 1989 spring and fall migration, Upper Mississippi River Pool 8.

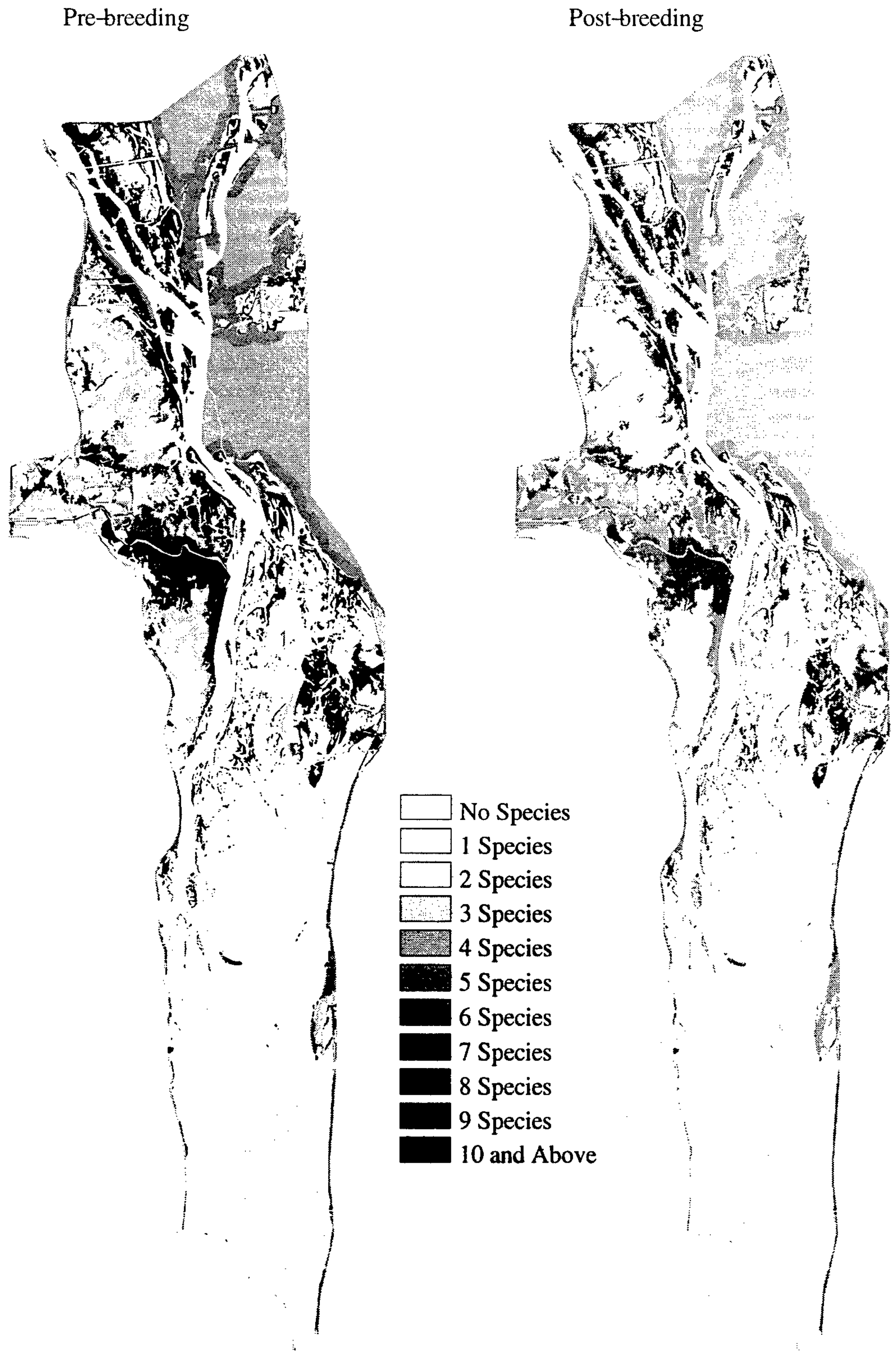

Figure E-209. Potential species richness, 1989 pre- and post-breeding, Upper Mississippi River Pool 8.

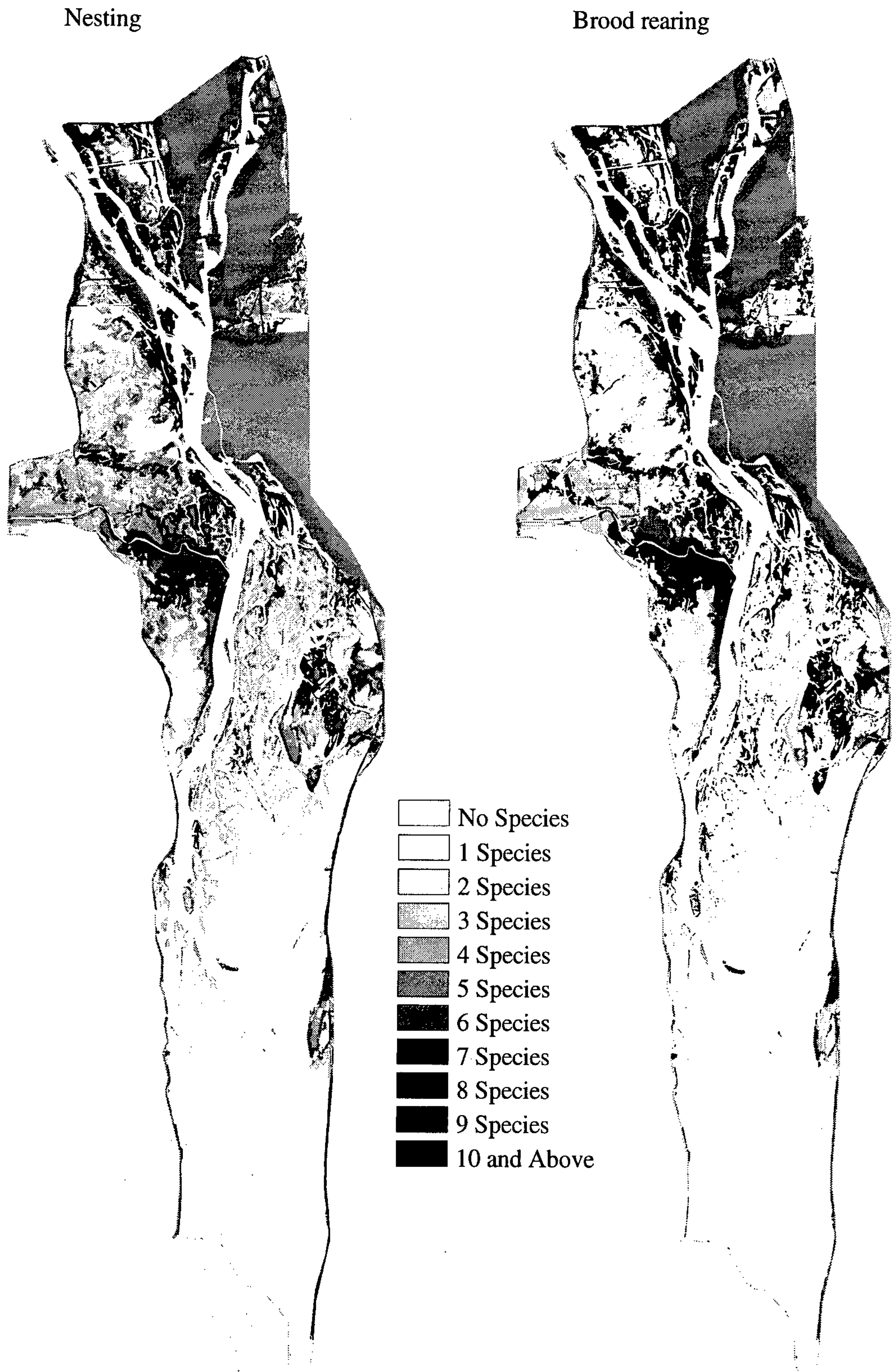

Figure E-210. Potential species richness, 1989 nesting and brood rearing, Upper Mississippi River Pool 8.

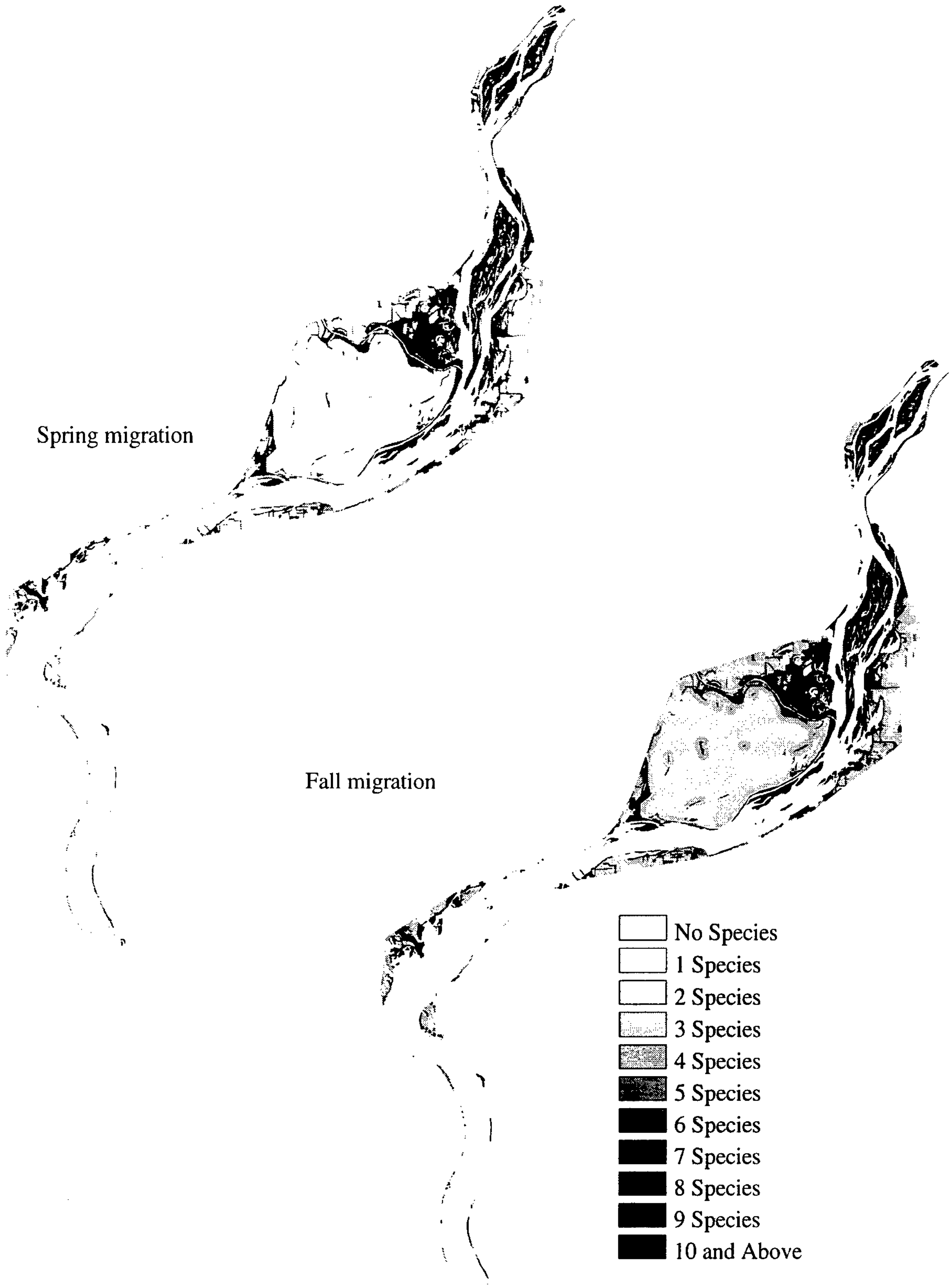

Figure E-211. Potential species richness, 1975 spring and fall migration, Upper Mississippi River Pool 19.

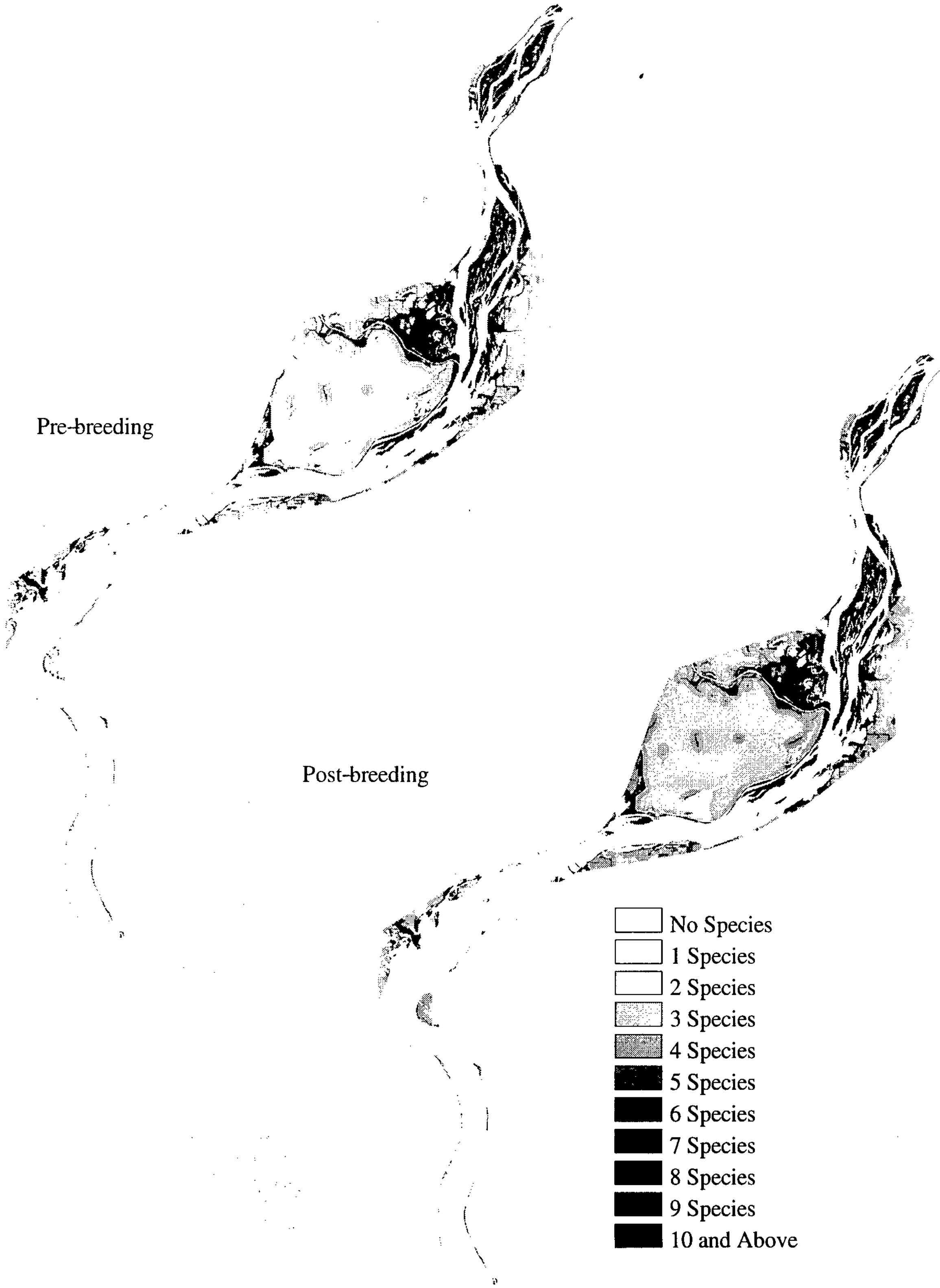

Figure E-212. Potential species richness, 1975 pre- and post-breeding, Upper Mississippi River Pool 19.

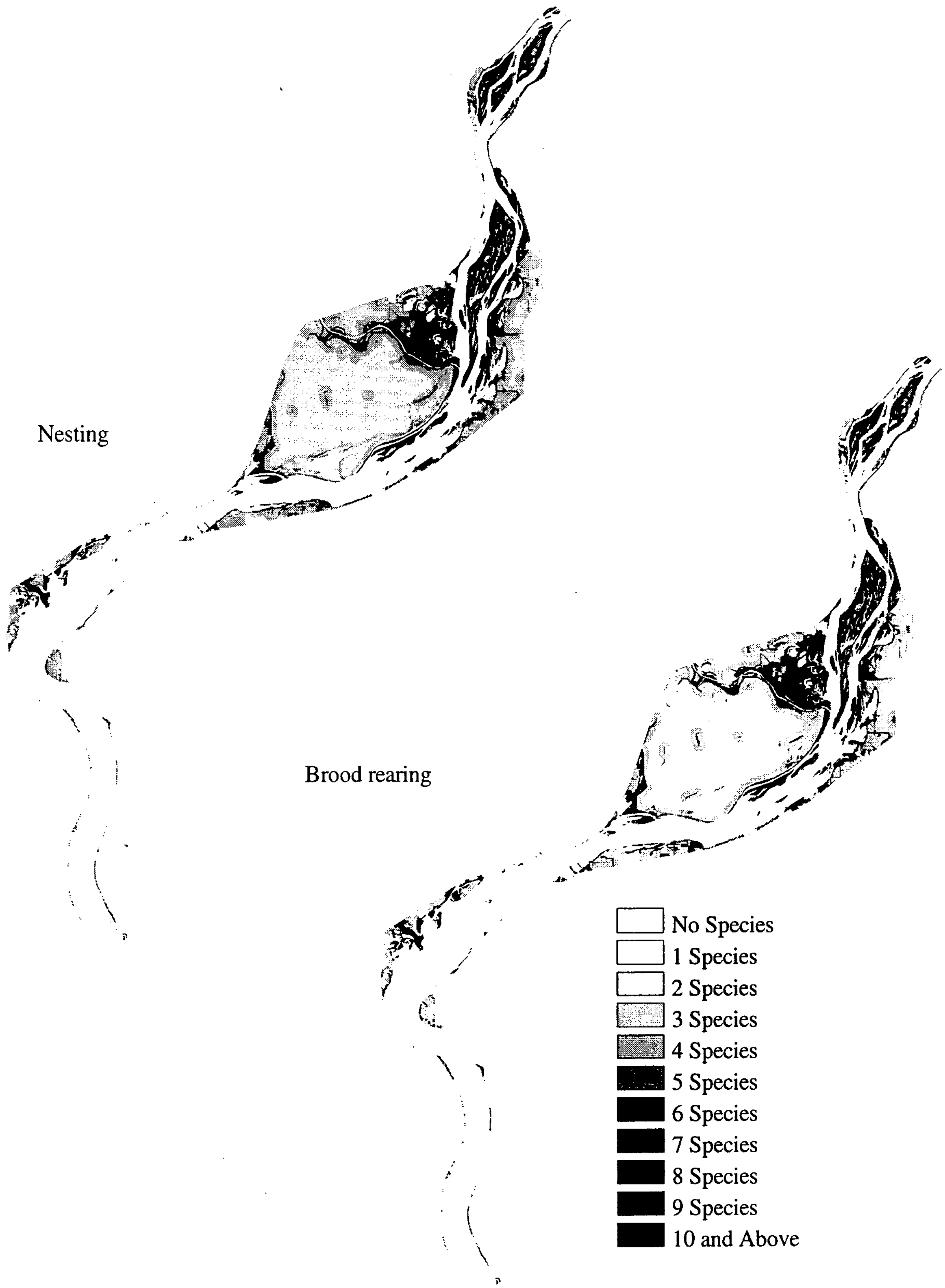

Figure E-213. Potential species richness, 1975 nesting and brood rearing, Upper Mississippi River Pool 19.

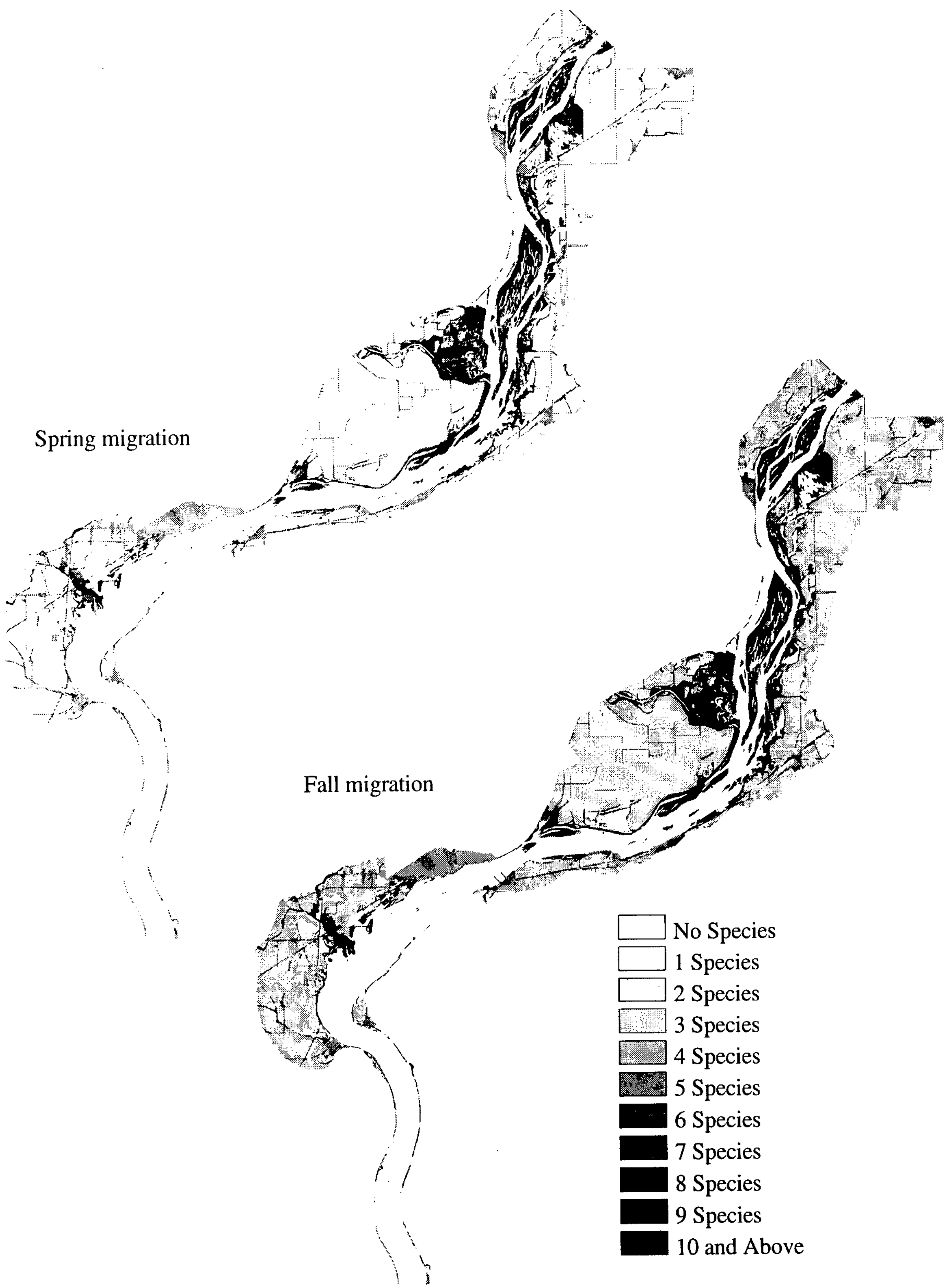

Figure E-214. Potential species richness, 1989 spring and fall migration, Upper Mississippi River Pool 19.

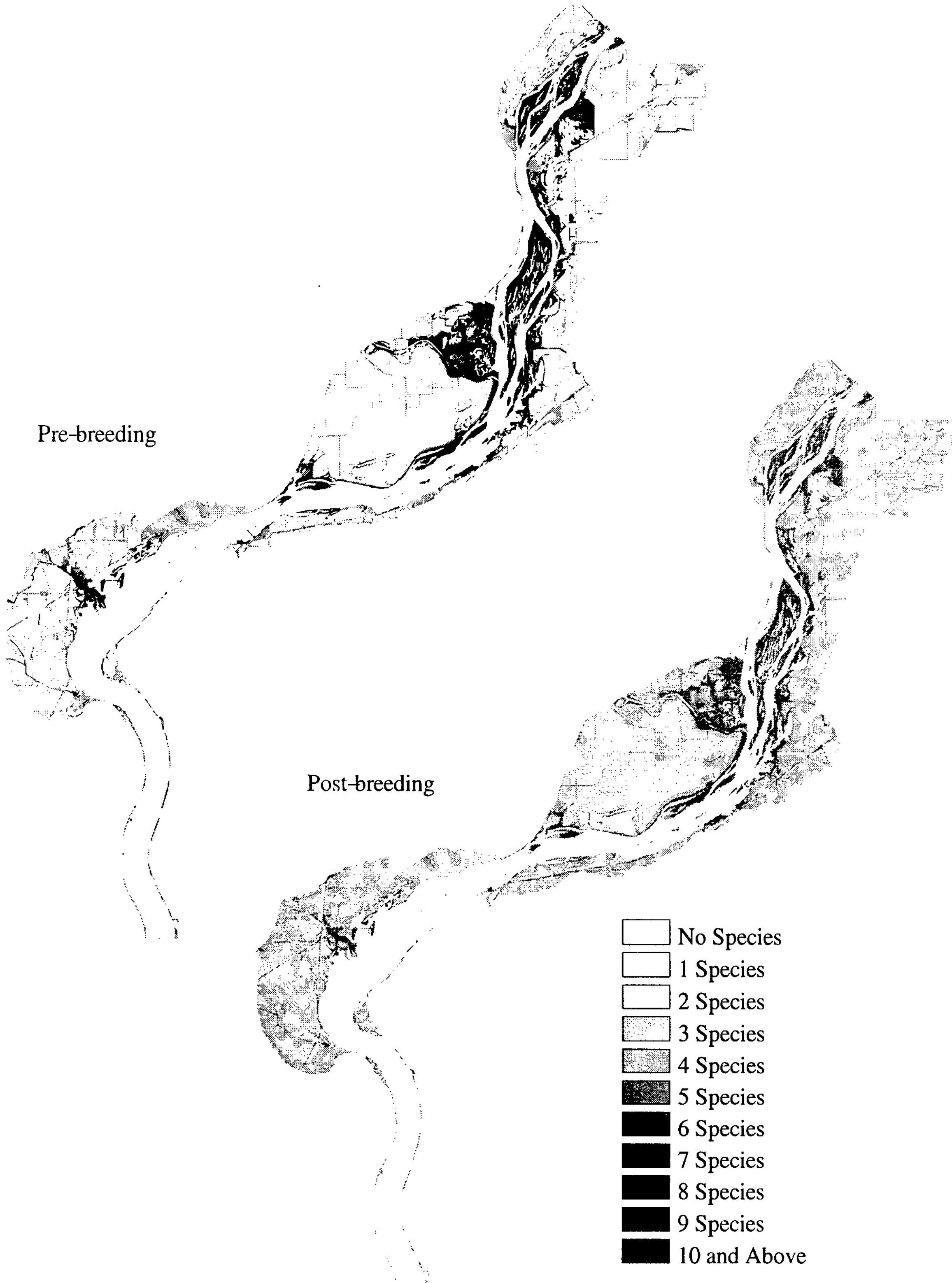

Figure E-215. Potential species richness, 1989 pre- and post-breeding, Upper Mississippi River Pool 19.

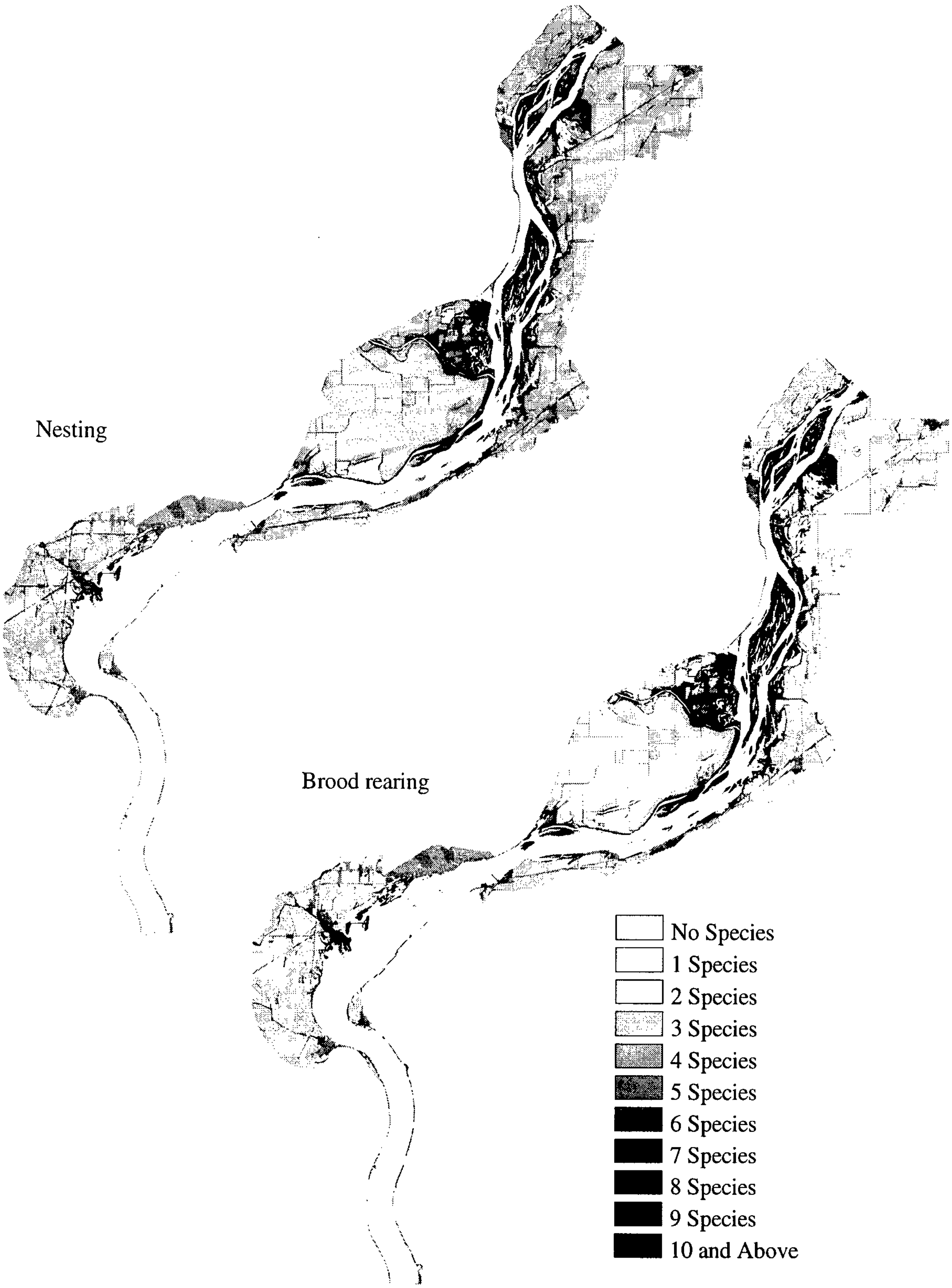

Figure E-216. Potential species richness, 1989 nesting and brood rearing, Upper Mississippi River Pool 19.

Appendix F

References

Most of the references listed in this appendix were used by the persons conducting the literature search. Several recording and abbreviation methods were used to record these data, resulting in some incomplete information. A standardized format has been used to present the data.

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13. ABSTRACT (Maximum 200 words)

The Management Strategy for Migratory Birds on the Mississippi River corridor from Wabasha, Minnesota, to St. Louis, Missouri (Strategy), is a cooperative effort of the U.S. Fish and Wildlife Service, the Biological Resources Division of the U.S. Geological Survey, the Illinois Department of Natural Resources, the Illinois Natural History Survey, the Iowa Department of Natural Resources, the Minnesota Department of Natural Resources, the Missouri Department of Conservation, and the Wisconsin Department of Natural Resources and is designed to create an "integrated, ecological, and proactive approach to management of habitats used by migratory bird populations" within the Upper Mississippi River System. The Migratory Bird Pilot Project was conducted to determine what types of products could be generated from data collected through a literature search. The initial literature search was conducted by the U.S. Fish and Wildlife Service, followed by a literature search conducted by the National Biological Service's Upper Mississippi River Science Center. These data were delivered to the Environmental Management Technical Center where they were compiled and entered into a geographic information system (GIS). The information were then processed for three study sites along the Mississippi River to determine what types of products could be produced. This report addresses technical issues associated with the creation of the potential habitat coverages. The results have garnered the support of the U.S. Fish and Wildlife Service and the five participating states as a potential and viable management tool. Follow-up will include the verification of GIS habitat coverages through ground surveys, expansion to a larger study area for an increased number of bird species, and the development of tools required for technology transfer to managers in the field. The data and analysis procedures will be valuable in assisting the U.S. Army Corps of Engineers and participating federal and state agencies in planning and constructing future Habitat Rehabilitation and Enhancement Projects as part of the Upper Mississippi River Environment Management Program.

14. SUBJECT TERMS

Environmental Management Technical Center, GIS, geographic information systems, long-term resource monitoring program, migratory birds, National Biological Service, spatial modeling, U.S. Fish and Wildlife Service

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The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.