Final Report: Phase II
July 1, 1997 to June 30, 1998

Identification of Large Grassland Ecosystems in Illinois

IDNR WP 359714

by
Lloyd B. McKinney, Mark G. Joselyn,
Jocelyn L. Aycrigg, and Patrick W. Brown
Center for Wildlife Ecology
Illinois Natural History Survey
607 Peabody Drive
Champaign, IL 61820

15 July 1998

Submitted to James Herkert
Illinois Department of Natural Resources
Division of Natural Heritage
524 South Second Street
Springfield, IL 62701-1787

Table of Contents

List of Tables.....ii

List of Figures.....iv

Abstract.....1

Introduction.....1

Materials and Methods.....1

Results.....3

Landscape metrics.....4

Class metrics.....5

Patch metrics.....5

Discussion.....5

Literature Cited.....8

Tables.....10

Figures.....49

Appendix A.....51

List of Tables

Table 1. Area, percent, number and range of sizes for all grasslands and grassland tracts >40 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >40 ha class. Some grassland tracts cross county lines and create tracts <40 ha, which effects some of these values, especially the range of sizes.....10

Table 2. Area, percent, number, and range of sizes for all grasslands and grassland tracts >100 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >100 ha class. Some grassland tracts cross county lines and create tracts <100 ha, which effects some of these values, especially the range of sizes.....12

Table 3. Landscape metrics for grassland tracts >40 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >40 ha class. Entries of 'inf' indicate values that were not possible to calculate.....13

Table 4. Landscape metrics for grassland tracts >100 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >100 ha class. Entries of 'inf' indicate values that were not possible to calculate.....15

Table 5. Class metrics for grassland tracts >40 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >40 ha class. Classes are 1 = urban/barren, 2 = agricultural lands, 3 = grasslands, 4 = forested areas, 5 = open water, 6 = wetlands, and 7 = grassland tracts >40 ha. Entries with 'inf' or '.' indicate values that were not possible to calculate.....16

Table 6. Class metrics for grassland tracts >100 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >100 ha class. Classes are 1 = urban/barren, 2 = agricultural lands, 3 = grasslands, 4 = forested areas, 5 = open water, 6 = wetlands, and 7 = grassland tracts >100 ha. Entries with 'inf' or '.' indicate values that were not possible to calculate.....25

Table 7. Patch metrics for grassland tracts >40 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These

values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >40 ha class. Entries with '.' indicate values that were not possible to calculate.....31

Table 8. Patch metrics for grassland tracts >100 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >100 ha class. Entries with '.' indicate values that were not possible to calculate.....46

List of Figures

Fig. 1. Grasslands in Illinois based on the Land Cover database (IDNR 1996) include pastures, hay meadows, and idle fields as well as some non-agricultural land (i.e., mined areas, road and railroad right-of-ways, remnant prairies, and cemeteries). Grasslands comprise approximately 19.6% of Illinois. These 3 grassland classes were combined to create a single grassland class for this study.....49

Fig. 2. Areas with a high density of grasslands were identified by aggregating the 28.5 x 28.5-m cells up to 5 x 5-km cells (25 km^2) and summing the number of cells for >40 ha (a) and >100 ha (b) grassland classes.....50

Abstract

Native prairies in Illinois have been nearly extirpated; reduced to fragmented islands in a landscape dominated by managed agricultural lands. Non-native grasslands, which are affected by agricultural practices, have replaced native prairies in many portions of the state and now constitute the habitats available to prairie fauna. Our objective was to identify grasslands throughout Illinois and to examine their spatial pattern in the broader landscape. We evaluated the landscape-level management potential of areas with relatively high concentrations of grasslands, and their importance as habitat for grassland species. We used Geographic Information System (GIS) technology to conduct our spatial analyses. We also examined landscape metrics of grasslands on a county basis using Fragstats 2.0 (McGarigal and Marks 1995). Grasslands occur throughout Illinois, but occur in higher densities and in larger patches in specific areas of the state including Union, Johnson, Jo Daviess, and Will counties.

Introduction

Expanding agricultural practices as well as urban sprawl have virtually wiped out the native prairies in Illinois (Herkert 1991 and IDENR 1994). In many areas grassland habitat composed of non-native vegetation has replaced native prairie habitat. Prairie fauna have adapted to these grassland habitats, but some, such as the state threatened Henslow's sparrow require large grassland areas (J. Herkert, pers. comm.). We sought to identify large grasslands throughout Illinois and evaluate their density and abundance as a resource for prairie fauna, specifically avifauna.

Analysis of grassland resources for an area as extensive as Illinois (56,000 mi^2) requires Geographic Information System (GIS) technology. This technology serves as the key to integrate data for analyses of broad landscapes and investigate spatial relationships. GIS is capable of representing landscape features for evaluation across extensive areas, which may be more meaningful for the population management of rare grassland birds. This analysis and representation of quantitative spatial and tabular data will help direct fieldwork and identify areas that have management potential for grassland birds.

Materials and Methods

Our primary source of data for this project was the Critical Trends Assessment Project (CTAP) Land Cover database (IDNR, 1996), produced by the Illinois Natural History Survey. The source of this database is satellite imagery consisting of a series of Landsat Thematic Mapper scenes for Illinois acquired from 1991 to 1995 with a spatial resolution of 28.5 x 28.5 meters. The Land Cover database consists of 19 broad classes identifying urban lands, croplands, forested lands, and grasslands.

GIS technology was used to analyze data and generate maps for this report using a Sun Sparc Ultra 143 at the Illinois Natural History Survey, Champaign, Illinois. Arc/Info (Environmental Systems Research Institute, Redlands, CA) and EASI (PCI Remote

Sensing Corp., Arlington, VA) software were used to manipulate the Land Cover database and extract areas classified as grassland.

The grassland classes in the Land Cover database include pastures, hay meadows, and idle fields as well as some non-agricultural land (i.e., mined areas, road and railroad right-of-ways, remnant prairies, and cemeteries). The following three classes were combined to create a single grassland class for our study; non-urban grasslands, urban grasslands, and wet meadows. A binary representation (0, 1) of these combined classes was used as our base map for these analyses. Various spatial algorithms and filters were applied to perform exploratory analysis for specific counties (Joselyn et al. 1997).

To perform our analysis, linear tracts of grasslands along roads and railways that connect larger patches were removed to isolate and identify separate patches or tracts. Our method involved passing a window consisting of a 3 x 3 matrix over the entire state. This window summed the number of grassland cells in the 3 x 3 matrix to a maximum value of 9. Cells with a value of 9 identified interior grassland while values <9 identified cells on or near the edge of grassland patches. All cells with a value of 9 were extracted to create the large grassland database used in the remainder of this study.

Additional cells were removed to equal a 100-meter edge buffer for each patch based on habitat requirements for grassland songbirds (S. Robinson, pers. comm.) and to isolate contiguous interior habitat. The resulting patches were then categorized into three size classes for separate analysis: >10 ha, >40 ha, and >100 ha. The size classes are nested within each other (i.e., the >100 ha patches are contained in both the >10 ha and >40 ha patches). Finally, grassland cells were restored to each interior patch by size class to recreate as much of the original grassland landscape from the Land Cover database as possible.

We attempted to correct for potential misclassification by converting small areas (< 0.5 ha) classified as cropland and contained within large grassland tracts. These areas may have been confused as cropland due to biophysical or phenological conditions. We restored these small areas to grassland since both classes are structurally similar. These corrections reduced the degree of fragmentation within large tracts and simplified the configuration of the grassland database.

To examine grasslands within a landscape context using Fragstats 2.0 (McGarigal and Marks 1995), the original 19 class Land Cover database was generalized into six categories, urban/barren, agricultural lands, grasslands, forested areas, wetlands, and open water. We then merged the large grassland patches (>40 ha and >100 ha) with this simplified landscape.

We chose to use counties as the unit of analysis for Fragstats since they represent familiar geographic units in Illinois. We selected counties that contained areas with ≥75% grassland within 1 km^2 and at least 10 ha of grassland for further analysis. We also limited this analysis to the largest 2 size classes (>40 ha and >100 ha) based on Herkert (1991, 1994a, and 1994b). We created four separate landscapes for use in our analyses:

1) grassland tracts >40 ha, 2) grassland tracts >100 ha, 3) grassland tracts >40 ha in a generalized landscape, and 4) grassland tracts >100 ha in a generalized landscape. The later two landscapes were used in our Fragstats analysis while the former two landscapes were used for all other analyses.

To compare the density of the large grassland tracts (>40 and >100 ha) across the state the amount of grassland in each 25 km^2 area was determined. Areas with a high density of grasslands were identified by counting the number of 28.5 x 28.5-m cells occupied by grasslands within each 5 x 5-km cell for both size classes. We chose 25 km^2 because it best represented the density of grasslands statewide. Areas with high grassland density will have higher values for the 25- km^2 area.

In our Fragstats analysis, we defined the landscape as a county, the classes as the 6 generalized land cover categories described above plus the grassland tracts >40 ha or >100 ha (7 classes total), and the patch as an individual grassland tract. Patch, class, and landscape indices from Fragstats discussed in this report include edge density, nearest neighbor, Simpson's Diversity Index and Evenness Index, contagion, and interspersion and juxtaposition (see appendix A for all Fragstat indices). Edge density measures total edge length of all patch types and standardizes it to a per unit area so comparisons between landscapes can be made (McGarigal and Marks 1995). We measured mean nearest neighbor distances at the class level. This distance is based on nearest edge-to-edge distance, for each patch of the corresponding patch type, divided by the number of patches of the same type (McGarigal and Marks 1995). To measure the diversity and evenness of patch types within each county, we used the Simpson's Diversity Index and the Simpson's Evenness Index. The Simpson's Diversity Index is the probability that any 2 patches selected at random will be different while Simpson's Evenness Index measures the distribution of areas among patch types or the evenness of the diversity. Higher values indicate greater landscape diversity (McGarigal and Marks 1995). The contagion index measures raster cell adjacencies and the extent to which patch types are aggregated or clumped. While interspersion and juxtaposition measures patch adjancies and the extent to which patch types are interspersed. Higher contagion values usually correspond with lower interspersion and juxtaposition values and vice versa (McGarigal and Marks 1995).

Results

Based on the Land Cover database, grasslands comprise approximately 19.6% of Illinois. Of the total grasslands, non-urban grasslands constitute 89%, urban grasslands 9%, and wet meadows, 2% (Fig. 1).

Before the filtering process there were approximately 2,950,807 ha of grasslands across the state. After filtering there were 314,929 ha of >10 ha grasslands (89% reduction), 112,463 ha of >40 ha grasslands (96% reduction), and 34,942 ha of >100 ha grasslands (99% reduction). Based on the land cover database, the majority of grasslands in Illinois are small, fragmented tracts or long linear strips along roads.

The highest density of grassland tracts >40 ha, based on our aggregation to 25 km^2, occurred in Will, Johnson, Union, and Franklin counties and the highest density of grassland tracts >100 ha occurred in Will and Union counties (Fig. 2). However, the highest density of grasslands for any 25 km^2 area was only 43% for grassland tracts >100 ha and 49% for grassland tracts >40 ha.

The largest amount of grassland occurred in Will County for grassland tracts >40 ha (9,917 ha) and >100 ha (69,168 ha) (Tables 1 and 2). Furthermore, the single largest grassland tract, Midewin N.T.P. for both >40 ha and >100 ha occurred in Will County (Tables 7 and 8). For grassland tracts >40 ha, Union County had the largest percentage of grasslands (7.3%) while for grassland tracts >100 ha, it was Johnson County that had the largest percentage (3.7%). The largest number of grassland tracts >40 ha occurred in Johnson (54) and Union (52) counties (Table 1). For grassland tracts >100 ha, Johnson County had the highest number of grasslands (14), but they were all smaller tracts (<390 ha) (Table 2). Union County had a large area of grassland as well as a large number of grasslands, but similar to Johnson County most were small tracts. Prior to filtering, Jo Daviess County had 47.1% grassland, only 1.1% of that is in grassland tracts >100 ha, a 98% difference.

Landscape metrics

To run Fragstats 2.0 (McGarigal and Marks 1995), we had to define a landscape in which to calculate various landscape, class and patch metrics. We chose county boundaries for our landscape unit because they are familiar geographic units in Illinois. In our analysis of grassland tracts >40 ha and >100 ha, we used 42 and 27 counties, respectively. We used edge density to measure fragmentation at the landscape level, or in our case, the county level. All counties in our analysis had edge density values >50 m/ha which reflected the amount of fragmentation among patch types within a county. The counties with the highest edge density values for both the >40 ha and >100 ha grassland tracts were DuPage (121 m/ha), Jo Daviess (127 m/ha), and Lake (128 m/ha) (Tables 3 and 4). Will and Johnson counties both had values >90 m/ha for edge density while Union County had <90 m/ha (Tables 3 and 4).

Williamson and Lake counties had the highest Simpson's Diversity and Simpson's Evenness values for grassland tracts >40 ha and >100 ha (Tables 3 and 4). Will, Johnson, Jo Daviess, and Union counties had high values for these indices as well (>0.6). High values indicate high landscape diversity (McGarigal and Marks 1995).

Additionally, we determined interspersion and juxtaposition to measure patch adjacency across the landscape (McGarigal and Marks 1995). Values approaching 100% indicate when all patch types are equally adjacent to all other patch types. The highest values for interspersion and juxtaposition were in Williamson (68%), Jackson (69%), and St. Clair (68%) counties for grassland tracts >40 ha and in Williamson (65%), Jackson (67%), and Lake (70%) counties for grassland tracts >100 ha (Tables 3 and 4). Will, Johnson, and Union counties had values of 62%, 57%, and 63%, respectively, for grassland tracts >40 ha, and 60%, 54%, and 60%, respectively, for grassland tracts >100 ha. Jo Daviess

County had low interspersion and juxtaposition values suggesting that patch types were poorly interspersed.

A landscape with patch types aggregated into larger contiguous patches will have greater contagion than a landscape with patch types fragmented into many small patches (McGarigal and Marks 1995) . Contagion values for grassland tracts >40 ha indicated that Stark (75%), Kendall (68%), Henry (68%), and LaSalle (68%) counties had larger contiguous patches while Lake (42%) and Williamson (42%) counties had many smaller patches. For >100 ha grasslands, Lake (39%) and Williamson (44%) counties had low contagion values indicating numerous smaller patches while the contagion values for Kankakee (68%) and La Salle (69%) counties indicated fewer large patches. Contagion values for Johnson, Will, Union, and Jo Daviess counties, ranged from 48% to 52% for both >40 ha and >100 ha grasslands.

Class metrics

At the class level, we used edge density, mean nearest neighbor distance, mean proximity index, and interspersion and juxtaposition to examine fragmentation, aggregation, and diversity of patches within classes (Tables 5 and 6). Compared to other patch types, grasslands tracts > 40 ha and >100 ha have low edge density values, but have high mean nearest neighbor distances. The mean proximity index is based on a selected distance of 400 m. High values indicate counties with highly aggregated grassland patches and low values imply the patches are widely distributed. Will and Jo Daviess counties have large aggregated grasslands tracts which are indicated by the high mean proximity index values and Union and Johnson counties have smaller dispersed grasslands tracts (Tables 5 and 6). Interspersion and juxtaposition values suggest that the grassland patches are well interspersed with the other patch types.

Patch metrics

We also examined individual grassland patches within various counties. The largest single grassland, `Midewin N.T.P.` , is in Will County (Tables 7 and 8). Its size ranged from 2990 to 3151 ha due to differences between >40 ha and >100 ha filters. Its nearest neighbor was within 28.5 m or 1 raster cell. Many of the nearest neighbor values between patches were >1000 m which implies that many of the large grasslands may not be of biological importance to grassland birds (Herkert 1991). The proximity index is useful to identify sparsely distributed, small patches from complex clusters (McGarigal and Marks 1995). We used a 400-m search distance, which was low enough to identify tightly grouped grassland tracts.

Discussion

Illinois' prairies are a climax vegetation type which include big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), panic grass (*Panicum* spp.), cord grass (*Spartina pectinata*), prairie dropseed (*Sporobolus heterolepis*), and upland sedges (*Carex* spp.) (Graber and Graber 1976 and Herkert 1994a). These native prairies now occupy a very small portion of the state (<1%) (Graber and Graber 1976). Grasslands,

comprised mostly of non-native species, such as Kentucky bluegrass (*Poa pratensis*), meadow fescue (*Festuca pratensis*), smooth brome grass (*Bromus inermis*), timothy grass (*Phleum pratense*), orchard grass (*Dactylis glomerata*), and red-top (*Agrostis alba*) have replaced prairie communities in many areas. Grassland species such as Bobolink (*Dolichonyx oryzivorus*), Western Meadowlark (*Sturnella neglecta*), Grasshopper Sparrow (*Ammodramus savannarum*) and Henslow's Sparrow (*Ammodramus henslowii*) inhabit these non-native grasslands. Species such as the Bobolink and Henslow's Sparrow require large areas of grasslands, but these areas are also declining (Herkert 1991, 1994a, and 1994b). Grasslands composed of hayfields and pastures have been lost to row-crop agriculture (Herkert 1994a). Our objective was to identify large grasslands throughout Illinois and evaluate the management potential of these areas for grassland birds based on landscape metrics.

Based on the Land Cover database for Illinois, grasslands occur throughout the state, but the vast majority of these grasslands are small fragments that may have little biological value to grassland avifauna (Hanski 1985 and Burger et al. 1994). Herkert (1994a) found that grassland bird species avoided suitable habitat on small grassland fragments. Once these small fragments are filtered out, the distribution of large contiguous grasslands is more sparse. This sparse distribution increases the relative importance of grassland areas with a high density of large grassland tracts. Grassland densities within 25 km^2 areas were greatest in Will and Union counties, but the highest density was 43%. This may be a sufficient amount on the landscape scale, but if all patches are small then potential edge effects may influence population viability (Galli et al. 1976, Ambuel and Temple 1983, Kroodsma 1984, Herkert 1991).

Contagion also measures aggregation, but measures it for all patch types within the landscape instead of only the grassland class. The counties with high contagion values (Stark, Kendall, La Salle, and Henry) are dominated by agricultural lands, which occur in large contiguous blocks. High contagion values, when viewed with agricultural patch values, may indicate the negative effect agricultural lands have on the distribution of grassland species (Freemark 1988).

By using counties as our unit of analysis, we were able to do comparisons between counties with high values for fragmentation, diversity, interspersion and juxtaposition, and contagion. Even though the shape and size of a county can influence the landscape metrics, we can use these values to measure the management potential of a county. Edge density values indicate the degree of fragmentation within all counties. These values also reflect the resolution of the raster map (McGarigal and Marks 1995). In general, the finer the resolution, the greater the edge length. Edge can be an important biological factor because it may influence the amount of internal habitat available within the patch, whether it be forest or grassland, and thereby potentially reduce the risk of nest predation. High edge density values may indicate less available interior and higher amounts of edge habitat within the county.

Landscape diversity is a measure of richness (Simpson's Diversity Index) and evenness (Simpson's Evenness Index). Richness refers to the number of patch types present and

evenness refers to the distribution of area among different patch types (McGarigal and Marks 1995). Simpson's Diversity Index places more weight on the common patches present. The value of Simpson's Diversity Index represents the probability that any 2 patches selected at random will be different patch types. Williamson and Lake counties both have high values for these indices, which indicates that the 7 patch types are evenly distributed. These indices are not useful in evaluating large grasslands, but if habitat diversity is important in conjunction with large grasslands then these indices would be helpful.

For class metrics, mean nearest neighbor values indicate that grassland patches are widely distributed. The mean proximity index is useful in determining grassland aggregates. The 400-m search distance was used to identify tightly grouped patches. Tightly grouped grassland tracts >100 ha occur in Will and Jo Daviess counties, identifying the 2 largest grasslands (Midewin N.T.P. and Savanna Army Depot, respectively). Each of these grasslands has smaller grassland tracts closely associated with it. A larger search distance might be useful to identify groups at distances relative to mean daily movement distances. However large search distances do not provide information about closely grouped grassland tracts.

The management potential of grassland tracts >40 ha and >100 ha is high when there are larger grassland tracts in proximity to each other. This occurs in Will, Jo Daviess, Johnson, and Union counties to varying degrees. Will County contains Goose Lake Prairie, a large grassland that is adjacent to another large grassland that increases its management potential. Jo Daviess County is similar, but there are many smaller fragments surrounding the larger patches. It is possible that the management potential for the large grassland is enhanced due to the overall patch density. Jo Daviess has the largest mean proximity index value for grasslands, which indicates it has the largest amount of aggregated grassland tracts. Johnson and Union counties do not have a single large grassland, but instead many moderately sized patches. These patches have lower proximity values overall than Will and Jo Daviess counties, indicating that these grasslands are less aggregated.

These landscape, class, and patch metrics for the grasslands based on the Land Cover database, were helpful in determining the management potential of various grassland areas across the state. The landscape metrics enabled us to examine individual counties on a landscape scale. Grasslands are probably better evaluated at the class level, which we examined and were able to determine which patches had management potential. Individual patch metrics allowed us to identify large grasslands such as Midewin N.T.P,.but also allowed us to evaluate aggregates in Union and Johnson counties. The biological significance of large isolated grassland tracts versus high density moderate-sized grassland tracts is not clear, but these areas should merit further investigation based on our analyses. These results will help guide future fieldwork in existing grassland tracts and in turn will validate our analysis. This initial effort of using the Land Cover database to identify large grassland tracts will help evaluate its suitability for other statewide analyses.

Literature Cited

Ambuel, B. and S. A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forest. Ecology 64(5):1057-1068.

Burger, L. D., L. W. Burger Jr., and J. Faaborg. 1994. Effects of prairie fragmentation on predation on artificial nests. Journal of Wildlife Management 58(2):249-254.

Freemark, K. 1988. Agricultural disturbance, wildlife, and landscape management. Pp. 77-84 in M. R. Moss, ed., Landscape Ecology and Management. Polyscience Publications, Inc. Montreal, Quebec.

Galli, A. E., C. F. Leck, and R. T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93:356-364.

Graber, J. W. and R. R. Graber. 1976. Environmental evaluations using birds and their habitats. Biological Notes No. 97 Illinois Natural History Survey, Urbana, Illinois. 39 pp.

Hanski, I. 1985. Single-species spatial dynamics may contribute to long-term rarity and commonness. Ecology 66(2):335-343.

Herkert, J. R. 1991. Prairie birds of Illinois: population response to two centuries of habitat change. Illinois Natural History Survey Bulletin 34:393-399.

Herkert, J. R. 1994a. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications. 4(3):461-471.

Herkert, J. R. 1994b. Status and habitat selection of Henslow's sparrow in Illinois. Wilson Bulletin. 106:35-45.

Kroodsma, R. L. 1984. Effect of edge on breeding forest bird species. Wilson Bulletin 96(3):426-436.

Illinois Department of Energy and Natural Resources, 1994. The changing Illinois environment critical trends. Technical report of the Cricitcal Trends Assessment Project Vol. 3: Ecological Resources. Illinois Department of Energy and Natural Resources, Springfield, IL, ILENR/RE-EA-94/05.

Illinois Department of Natural Resources, 1996. Illinois Land Cover, an atlas. Compact Disk. Illinois Department of Natural Resources, Springfield, IL.

Joselyn, M. J., L. B. McKinney, and P. W. Brown. 1997. Identification of large grassland ecosystems in Illinois, Progress Report Phase I. Illinois Natural History Survey, Champaign, IL, IDNR WP 359714.

McGarigal, K. and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Gen. Tech. Rep. PNW-GTR-351. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122 p.

Table 1. Area, percent, number and range of sizes for all grasslands and grassland tracts >40 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >40 ha class. Some grassland tracts cross county lines and create tracts <40 ha, which effects some of these values, especially the range of sizes.

County	Total area of county (ha)	Total area of grasslands (ha)	Percent grasslands (%)	Total area of >40 ha grasslands (ha)	Percent >40 ha grasslands	No. of >40 ha grassland patches	Range of sizes of >40 ha grasslands (ha)
Bond	99182.63	25330.99	25.54	793.81	0.8	7	88.94 - 278.36
Carroll	120902.92	35399.72	29.28	908.83	0.75	9	83.5 - 205.42
Cook	247797.33	40568.39	16.38	508.55	0.21	3	62.14 - 279.58
Dupage	87072.06	21838.07	25.08	1484.79	1.71	9	88.29 - 393.94
Fayette	187913.39	48377.2	25.74	1910.74	1.02	19	70.5 - 295.5
Franklin	111790.54	29966.99	26.81	4151.9	3.71	32	42.4 - 415.87
Grundy	111462.23	17915.23	16.07	1216.67	1.09	10	57.51 - 695.61
Hamilton	112852.31	28940.22	25.64	4232.72	3.75	42	60.03 - 266.42
Hardin	46942.28	13678.78	29.14	1560.82	3.32	10	75.95 - 430.17
Henry	213842.92	49670.22	23.23	472.65	0.22	6	62.06 - 139.87
Jackson	156871.95	29283.97	18.67	4170.09	2.66	30	63.6 - 488.89
Jefferson	151194.66	51916.83	34.34	5693.22	3.77	46	49.55 - 294.93
Jo Daviess	160289.66	75464.68	47.08	3771.6	2.35	24	55.15 - 1078.26
Johnson	90275.09	32364.02	35.85	7191.26	7.97	54	46.46 - 384.36
Kane	135666.78	40168.52	29.61	1701.18	1.25	19	59.78 - 236.85
Kankakee	176309.75	32821.97	18.62	1676.97	0.95	12	71.97 - 355.68
Kendall	83447.8	16434.17	19.69	598.14	0.72	6	76.6 - 150.59
Knox	186531.67	38513.81	20.65	299.96	0.16	2	96.01 - 203.96
Lake	121861.13	34632.63	28.43	1253.79	1.03	16	40.45 - 180.4
LaSalle	297310.47	51039.84	17.17	2353.17	0.79	21	56.21 - 243.27
Madison	191847.52	37888.78	19.75	65.63	0.03	1	n/a
Marion	149147.12	43020.66	28.84	1064.45	0.71	12	61.16 - 143.77
Massac	62581.1	20742.1	33.14	4202.26	6.71	30	71.72 - 313.9
McHenry	158128.42	49616.94	31.38	5455.72	3.45	40	58.48 - 609.03
Mercer	147227.95	40538.58	27.53	744.59	0.51	6	65.95 - 267.23
Ogle	197742.75	51957.19	26.28	480.12	0.24	6	65.87 - 103.81
Perry	115815.16	31525.37	27.22	3954.03	3.41	33	42.07 - 568.82
Pike	219683.33	51199.45	23.31	568.74	0.26	7	72.62 - 112.17
Pope	96891.27	21887.21	22.59	2678.48	2.76	21	64.66 - 348.78
Pulaski	52630.96	13639.63	25.92	1507.78	2.86	12	55.88 - 234.98

County	Total area of county (ha)	Total area of grasslands (ha)	Percent grasslands (%)	Total area of >40 ha grasslands (ha)	Percent >40 ha grasslands	No. of >40 ha grassland patches	Range of sizes of >40 ha grasslands (ha)
Randolph	154210.7	42739.05	27.71	3158.92	2.05	25	74.73 - 667.1
Rock Island	117095.99	36515.84	31.18	641.11	0.55	7	71.8 - 119.08
Saline	100189.82	21220.52	21.18	1616.62	1.61	14	60.51 - 209.48
Sangamon	227462.73	43249.06	19.01	625.92	0.28	6	67.82 - 185.84
St. Clair	174691.42	32323.33	18.5	515.62	0.3	5	79.84 - 170.33
Stark	74753.64	12123.89	16.22	335.13	0.45	5	49.06 - 196.73
Stephenson	146216.12	58196.9	39.8	937.66	0.64	10	83.26 - 128.58
Union	109355.01	31312.89	28.63	7978.41	7.3	52	61.49 - 466.64
Washington	146090.31	33559.81	22.97	816.15	0.56	8	69.85 - 158.96
Will	219773.48	69168.12	31.47	9917.25	4.51	47	63.92 - 3151.37
Williamson	115016.55	38148.7	33.17	5793.29	5.04	37	41.83 - 928.89
Winnebago	134460.44	44427.15	33.04	1830.16	1.36	21	74.97 - 295.01

Table 2. Area, percent, number, and range of sizes for all grasslands and grassland tracts >100 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >100 ha class. Some grassland tracts cross county lines and create tracts <100 ha, which effects some of these values, especially the range of sizes.

County	Total area of county (ha)	Total area of grasslands (ha)	Percent grasslands (%)	Total area of >100 ha grasslands (ha)	Percent >100 ha grasslands	No. of >100 ha grassland patches	Range of sizes of >100 ha grasslands (ha)
Bond	99182.63	25330.99	25.54	278.36	0.28	1	n/a
Boone	73028.18	20838.2	28.53	214.76	0.29	2	n/a
Carroll	120902.93	35399.72	29.28	239.69	0.2	3	n/a
Cook	247736.57	40568.39	16.38	446.41	0.18	2	166.84 - 279.58
Dupage	87072.06	21838.07	25.08	1028.63	1.18	3	302.97 - 393.94
Fayette	187913.39	48377.2	25.74	231.82	0.12	1	n/a
Franklin	111790.54	29966.99	26.81	1598.91	1.43	7	213.78 - 415.87
Grundy	111462.22	17915.23	16.07	630.87	0.57	6	n/a
Hamilton	112852.31	28940.22	25.64	727.45	0.64	4	160.09 - 228.73
Hardin	46942.28	13678.78	29.14	338.79	0.72	1	n/a
Jackson	156871.87	29283.97	18.67	1389.19	0.89	6	220.44 - 488.89
Jefferson	151194.65	51916.83	34.34	1312.68	0.87	6	167.73 - 294.85
Jo Daviess	160289.66	75464.68	47.08	1741.79	1.09	4	217.44 - 1078.26
Johnson	90275.09	32364.02	35.85	3340.13	3.7	14	148.89 - 384.36
Kane	135666.79	40168.52	29.61	235.07	0.17	1	n/a
Kankakee	176309.75	32821.97	18.62	690.33	0.39	3	208.42 - 248.71
Lake	121819.96	34632.63	28.43	268.94	0.22	3	n/a
LaSalle	297310.39	51039.84	17.17	970.80	0.33	5	151.48 - 243.27
Massac	62581.1	20742.1	33.14	1099.95	1.76	4	212.97 - 313.69
McHenry	158128.42	49616.94	31.38	1390.82	0.88	4	205.01 - 529.51
Perry	115815.15	31525.37	27.22	1771.76	1.53	9	113.47 - 568.82
Pope	96891.27	21887.21	22.59	963.98	0.99	5	118.59 - 284.69
Randolph	154210.7	42739.05	27.71	1153.64	0.75	4	139.54 - 667.1
Union	109355	31312.89	28.63	3707.27	3.39	11	169.6 - 466.64
Will	219773.49	69168.12	31.47	5986.28	2.72	9	154.98 - 2990.05
Williamson	115016.55	38148.7	33.17	1617.35	1.41	4	188.28 - 815.17
Winnebago	134460.19	44427.15	33.04	33.30	0.02	3	n/a

Table 3. Landscape metrics for grassland tracts >40 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >40 ha class. Entries of 'inf' indicate values that were not possible to calculate.

County	Edge density (m/ha)	Mean Proximity Index	Simpson's diversity index	Simpson's evenness index	Interspersion and juxtaposition index (%)	Contagion (%)
Bond	77.39	9159.59	0.59	0.69	46.69	59.87
Carroll	100.21	46098.91	0.63	0.74	37.94	55.78
Cook	80.37	inf	0.58	0.66	57.36	60.43
Dupage	120.82	inf	0.7	0.82	64	46.19
Fayette	79.99	inf	0.63	0.74	48.5	56.95
Franklin	90.33	inf	0.73	0.85	66.54	46.43
Grundy	60.05	12546.01	0.46	0.54	54.38	65.86
Hamilton	75.47	17604.21	0.59	0.69	49.8	59.34
Hardin	83.78	inf	0.62	0.72	55.04	56.22
Henry	76.05	53649.24	0.45	0.53	33.69	68.36
Jackson	74.65	5523.2	0.74	0.86	68.91	49.14
Jefferson	101.09	9105.45	0.71	0.83	54.49	48.47
Jo Daviess	126.79	103117.71	0.68	0.8	40.11	50.39
Johnson	93.86	1438.41	0.73	0.86	57.23	48.14
Kane	92.43	inf	0.67	0.79	58.22	52.3
Kankakee	68.98	23947.68	0.43	0.51	42.6	67.77
Kendall	63.44	inf	0.45	0.52	41.5	68.3
Knox	101.8	inf	0.56	0.65	47.3	59.63
Lake	128.35	inf	0.8	0.91	65.08	42.22
LaSalle	58.93	inf	0.44	0.52	43.39	68.12
Madison	91.43	5961.14	0.67	0.79	64.79	51.02
Marion	94.57	9350.39	0.65	0.76	47.28	55.16
Massac	89.6	2278.28	0.74	0.86	59.69	47.67
McHenry	99.27	4602.11	0.71	0.82	62.98	48.13
Mercer	91.87	32305.87	0.56	0.66	39.88	60.49
Ogle	88.75	inf	0.52	0.61	33.45	63.86
Perry	89.53	5879.58	0.7	0.81	63.12	49.81
Pike	105.59	7007.83	0.66	0.77	51.02	53.42
Pope	67.23	10845.22	0.59	0.69	54.51	59.37
Pulaski	87.31	4878.05	0.69	0.81	59.03	50.81
Randolph	100.27	inf	0.71	0.83	59.3	48.22

County	Edge density (m/ha)	Mean Proximity Index	Simpson's diversity index	Simpson's evenness index	Interspersion and juxtaposition index (%)	Contagion (%)
Rock Island	109.39	inf	0.74	0.86	56.36	46.07
Saline	79.32	inf	0.67	0.78	63.61	52.7
Sangamon	70.27	16625.35	0.48	0.56	50.75	65.02
St. Clair	88.94	8344.49	0.67	0.78	68.07	50.83
Stark	61.18	40859.86	0.34	0.4	34.79	74.76
Stephenson	116.28	74812.63	0.57	0.67	31.47	59.79
Union	79.86	8350.99	0.73	0.85	63.01	49.32
Washington	76.15	inf	0.54	0.63	42.06	62.33
Will	91.6	inf	0.69	0.81	61.68	49.6
Williamson	105.76	1089.45	0.78	0.91	68.07	42.07
Winnebago	113.04	16045.39	0.7	0.81	55.59	48.82

Table 4. Landscape metrics for grassland tracts >100 ha in select counties of Illinois containing ≥75% grasslands within 1 km^2 and having at least 10 ha of grasslands. These values were calculated using Fragstats 2.0 and the Land Cover database with 6 general landcover classes overlaid with the grassland tracts >100 ha class. Entries of 'inf' indicate values that were not possible to calculate.

County	Edge density (m/ha)	Mean proximity index	Simpson's diversity index	Simpson's evenness index	Interspersion and juxtaposition index (%)	Contagion (%)
Bond	77.23	9415.34	0.59	0.69	45.78	60.43
Boone	83.66	15052.32	0.52	0.61	36.54	64.29
Carroll	100.05	46919.56	0.63	0.73	37.11	56.42
Cook	80.28	52416.94	0.58	0.67	62.46	57.81
Dupage	120.77	12562.78	0.7	0.82	63.57	46.48
Fayette	79.75	8735.03	0.63	0.73	47	57.91
Franklin	89.78	inf	0.72	0.84	64.24	47.91
Grundy	59.92	12852.13	0.46	0.53	53.41	66.29
Hamilton	74.69	19553.72	0.58	0.68	45.72	61.51
Hardin	83.05	inf	0.6	0.71	51.9	58.19
Jackson	74.14	6003.87	0.73	0.85	66.65	50.32
Jefferson	100.33	10678.86	0.7	0.81	51.49	50.68
Jo Daviess	126.36	104089.98	0.67	0.79	38.79	51.57
Johnson	92.73	2409.56	0.71	0.83	53.8	50.21
Kane	92.32	inf	0.67	0.78	56.79	53.35
Kankakee	68.85	24862.23	0.43	0.51	41.7	68.27
Lake	128.21	2132.04	0.79	0.92	70.25	39.13
LaSalle	58.81	inf	0.44	0.52	42.45	68.56
Massac	88.18	3833.87	0.72	0.84	54.95	50.53
McHenry	99.02	5491.44	0.69	0.81	60.53	49.76
Perry	89.09	6341.9	0.69	0.8	61.22	51.06
Pope	66.76	11522.31	0.58	0.68	51.99	60.6
Randolph	99.89	inf	0.71	0.82	57.85	49.3
Union	78.7	11069.02	0.71	0.83	59.55	51.05
Will	91.26	inf	0.69	0.8	60.1	50.54
Williamson	104.82	1718.68	0.76	0.88	65.01	44.42
Winnebago	112.88	17201.22	0.69	0.8	54.06	50.19

Progress Report: Phase I
May 1, 1997 to June 30, 1997

IDENTIFICATION OF LARGE GRASSLAND ECOSYSTEMS IN ILLINOIS

IDNR WP 359714

Submitted to James Herkert
Illinois Department of Natural Resources
Division of Natural Heritage

By

Mark G. Joselyn, Lloyd B. McKinney, and Patrick W. Brown
Center for Wildlife Ecology
Illinois Natural History Survey

Joelyn Ayerigg
ayerigg@waxwing.igis.uiuc.edu

31 July 1997

Abstract: Native prairies in Illinois have been nearly extirpated, reduced to fragmented islands in a landscape dominated by managed agricultural lands. Non-native grasslands, which are affected by agricultural practices, have replaced native prairies in many portions of the state and now constitute the habitats inhabited by prairie fauna. The purpose of this project is to identify existing grassland blocks in Illinois and to examine their spatial pattern in the broader landscape. The landscape-scale management potential of areas with relatively high concentrations of grassland blocks, and their importance as habitat for grassland species, will be evaluated. Geographic Information System (GIS) technology was used to analyze and generate maps for this report (Arc/Info version 7.0.1 on a Sun Sparc Ultra 1 at the Illinois Natural History Survey, Champaign, IL).

Materials and Methods

The primary source of data for this project is the Critical Trends Assessment Project (CTAP) Land Cover database (IDNR 1996), produced by the Illinois Natural History Survey. The source of this database is satellite imagery consisting of a series of Landsat Thematic Mapper scenes for Illinois acquired from 1991 to 1995 with a spatial resolution of 28.5 x 28.5 meters. The Land Cover database consists of 19 broad classes identifying urban lands, croplands, forested lands and grasslands. The following three classes were used as the basis for this analysis: 1) rural grasslands; 2) urban grasslands; and 3) barren lands.

Arc/Info (Environmental Systems Research Institute, Redlands, CA) software was used to manipulate the Land Cover database and extract areas classified as grassland. This representation of grasslands was used as a base map. Various methods of spatial analysis were applied to evaluate their applicability to this project and to perform exploratory analysis for a specific county. The information provided below presents various ways of modeling Illinois' grassland distribution. These analyses fall into two broad categories: local factors, such as size (large, contiguous blocks), and regional factors, such as proximity and connectivity.

Analysis and Discussion

Grasslands currently comprise approximately 19.3 percent of the land cover of Illinois (IDNR 1996). Figure 1 illustrates the grassland distribution in Illinois, although the scale of this map causes the extent of grasslands to be exaggerated. Ninety-one percent of all grassland is classified as non-urban. Urban grassland comprises about 9 percent and barren land accounts for less than 1 percent of the total. We have focused our analysis on Fulton County to explore various spatial analysis techniques. Fulton County lies in central Illinois along the Illinois River. It is 47% agriculture and 22% grassland. Much of the county has been extensively strip mined. The four regions of the county that rank high in grassland density and have large grassland patches are all formerly strip mined and reclaimed areas. Wooded riparian corridors cover much of the county, providing a highly connected grassland mosaic. The floodplain of the Illinois River is predominated by agriculture and contains few grasslands or grassland corridors. The largest town in the county is Canton, population 14,000.

Various methods were applied in order to model the local and regional distribution, or relative density, of grasslands throughout Fulton County. Proximity to grassland was also considered. A focalsum routine was performed on a binary map (0,1) of all grasslands. Each location (cell) is visited and the question posed 'How many cells that have been classified as grassland lie within a specified distance?' This routine assigns a value to each focal cell based upon the number of grassland cells in the search radius. A continuous surface is created with values of 0 indicating no grassland within the specified radial distance and the maximum value representing interior sites. Only grasslands with a large aerial extent will have the highest value. Figures 2 and 3 show maps generated in this way for 85.5 and 142.5 meter search radii, respectively, and demonstrate local effects. The regional effect of the grassland distribution is shown in Figure 4. Using a search radius of 1 km creates a surface based on the percentage of grassland within the immediate 3.14 km^2. If any location met the criteria of being surrounded by nothing but grassland cells, it would have a value exceeding 3,800. The highest values calculated for Fulton County were approximately 2,600, indicating that the area within a 1 km radius is 67% grassland. These areas possess the greatest regional density of grassland for this radial distance. Figures 2-4 also identify non-grassland cells that are assigned a value based on their proximity to grasslands.

Grassland concentrations were determined using a routine which calculated the Euclidean (straight line) distance between grassland cells (Figure 5). Areas where grasslands are absent and areas of grassland concentration clearly stand out. This map over represents the total amount of grasslands because the numerous small grassland tracts skew the Euclidean distances to the shorter end of the scale. Figure 6 represents the connection of Fulton County grasslands based on minimum distance to nearest cells. It may be used to describe the movement or percolation of a species through the county based on the minimum distance.

Much of the grassland lies in linear strips along railroad rights-of-way, roadways and forest edges. Areas can be classified based on the distance from each cell to the nearest non-grassland cell, or the thickness of the grassland (Figures 7 and 8). Grassland interiors will have high values while values for linear strips will be very low. However, as calculated, the distribution of all classes may be overstated. Any linear strip contiguous to large patches will be included in that size class. If not eliminated with pre-processing, these linear strips may skew the data to favor larger classes.

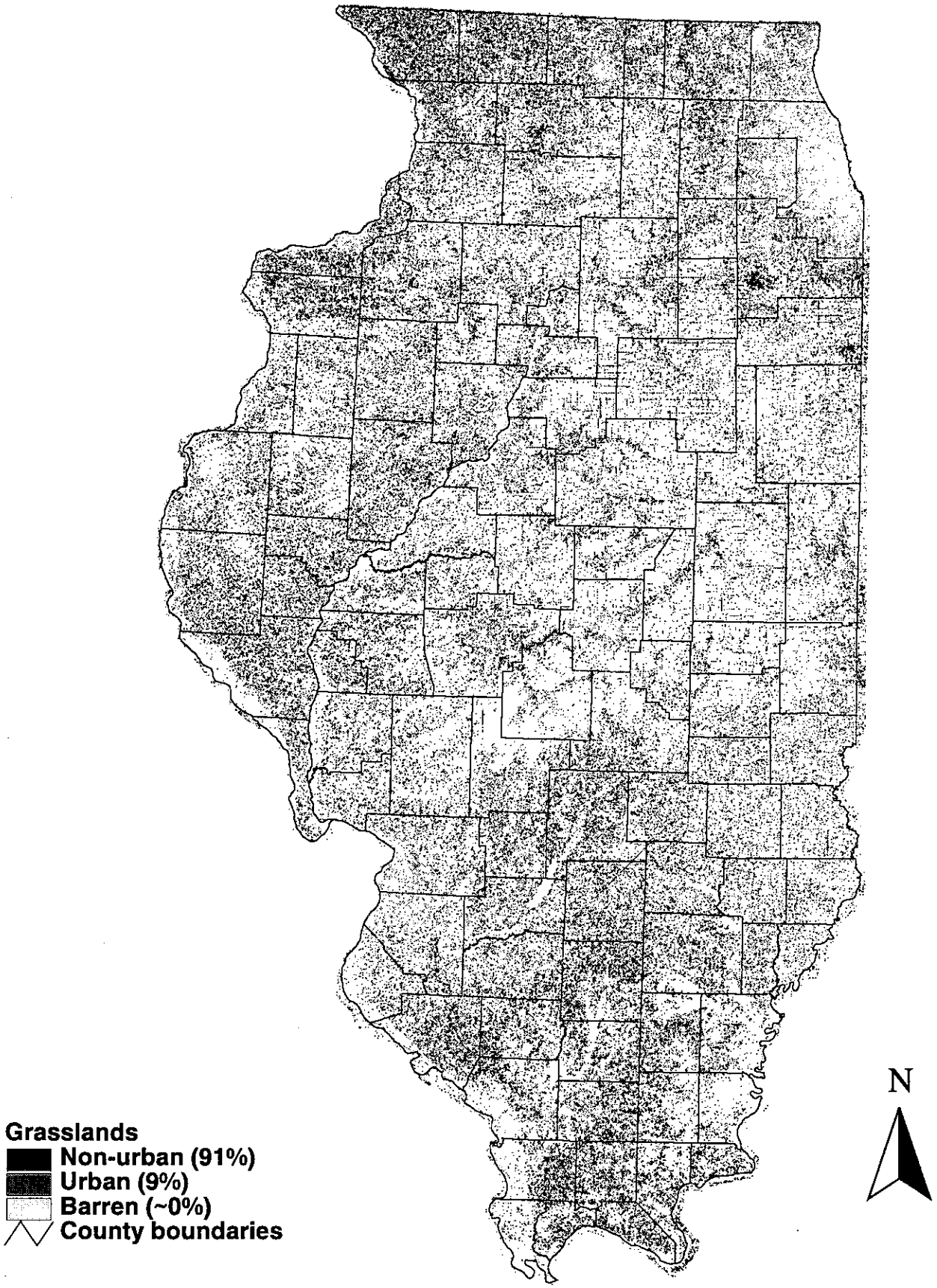
Similar information is obtained by generating an explicit cost surface. While this analysis is typically used with economic data, we believe this approach may yield interesting results if modeled for individual species. Figure 9 represents the degree of effort needed to move across the landscape. This was generated using the Euclidean distance map (Figure 5) as a cost surface, and combining it with the map of contiguous grasslands (Figure 7). Lavender represents the areas that require the least cost (effort, etc) to move from one cell to a grassland cell. Red pixels represent cities, large croplands or barren areas and have the highest associated cost; i.e. from any red pixel a species must expend more energy, or travel the farthest, to reach a grassland cell.

Summary

Our spatial analysis of grasslands has been performed only on Fulton County, but they can be extended to other areas of the state, or the entire state. We need to determine which approach is best suited to meet the needs of the project. Rules need to be identified which will define our decision-based modeling approach. Development of appropriate parameters will enable the development of species and landscape specific models. For example, grassland strips may provide suitable habitat for meadowlarks or red-winged blackbirds, but may not be ecologically significant for interior grassland species. Further work will seek to explicitly identify large tracts, the focus of this project, and to extract them from the broader grassland mosaic. These tracts and their spatial arrangement will then be evaluated, independent of and in conjunction with smaller tracts. With careful definition, decision rules can be developed and implemented to help identify unique grasslands with relatively high habitat value.

Illinois Department of Natural Resources, 1996. Illinois Land Cover, An Atlas. Compact Disk. Illinois Department of Natural Resources, Springfield, IL.

Fig. 1. Grassland distribution in Illinois



Based on Illinois landcover map

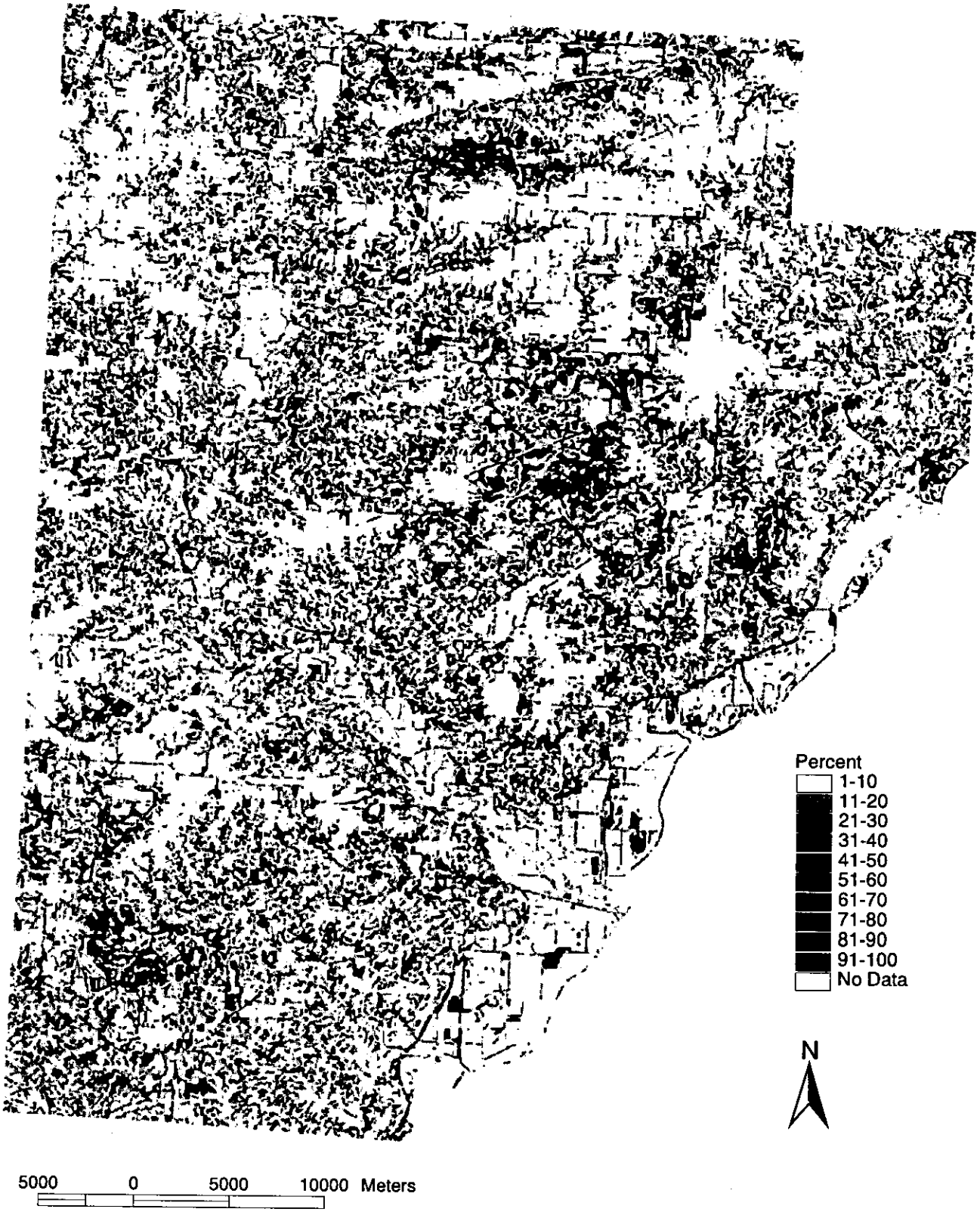


Fig. 2. Percent grasslands within an 85.5 meter radius
Fulton County, Illinois

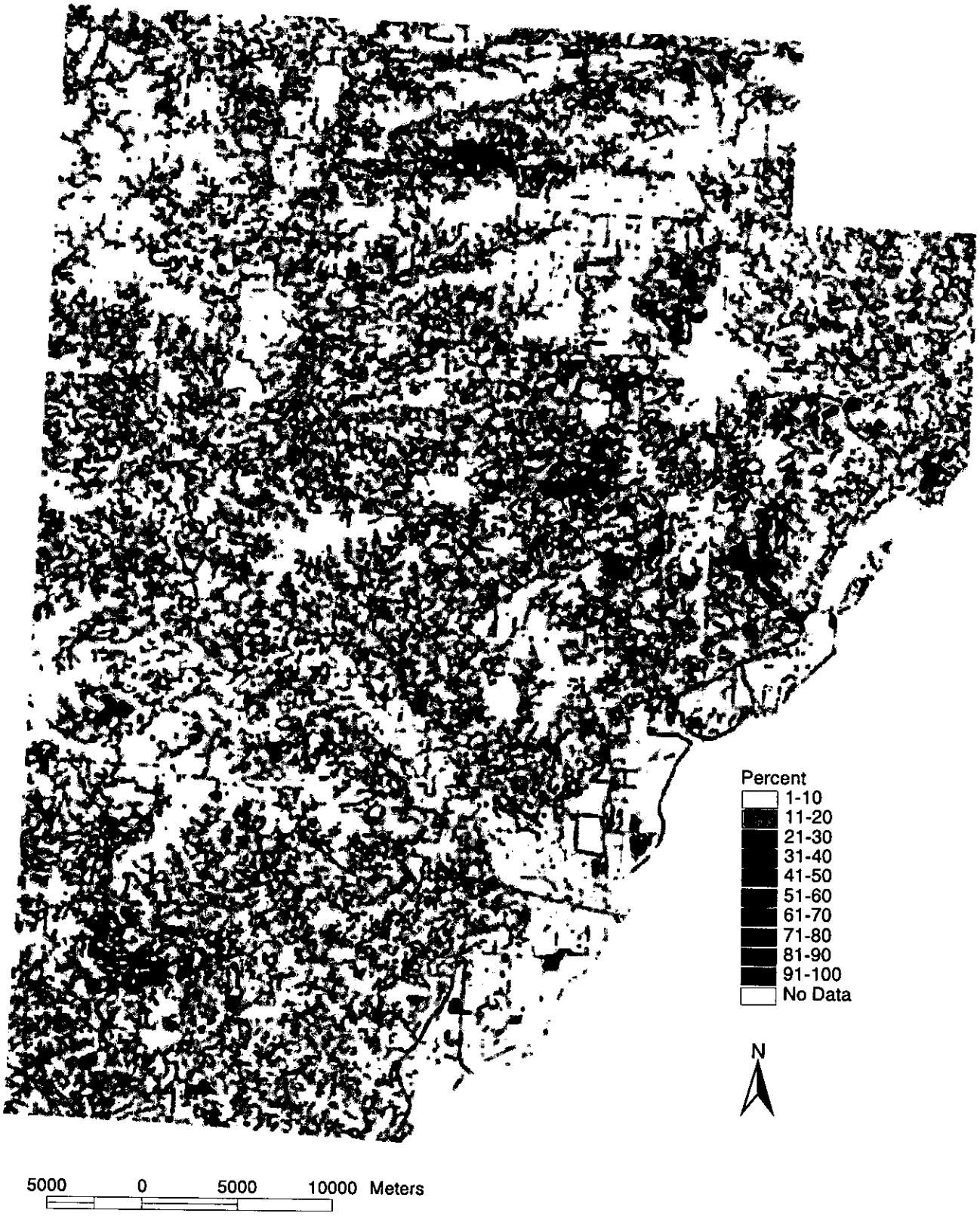


Fig. 3. Percent grassland within an 142.5 meter radius
Fulton County, Illinois

Fig. 4. Percent grassland within a 1 kilometer radius
Fulton County, Illinois

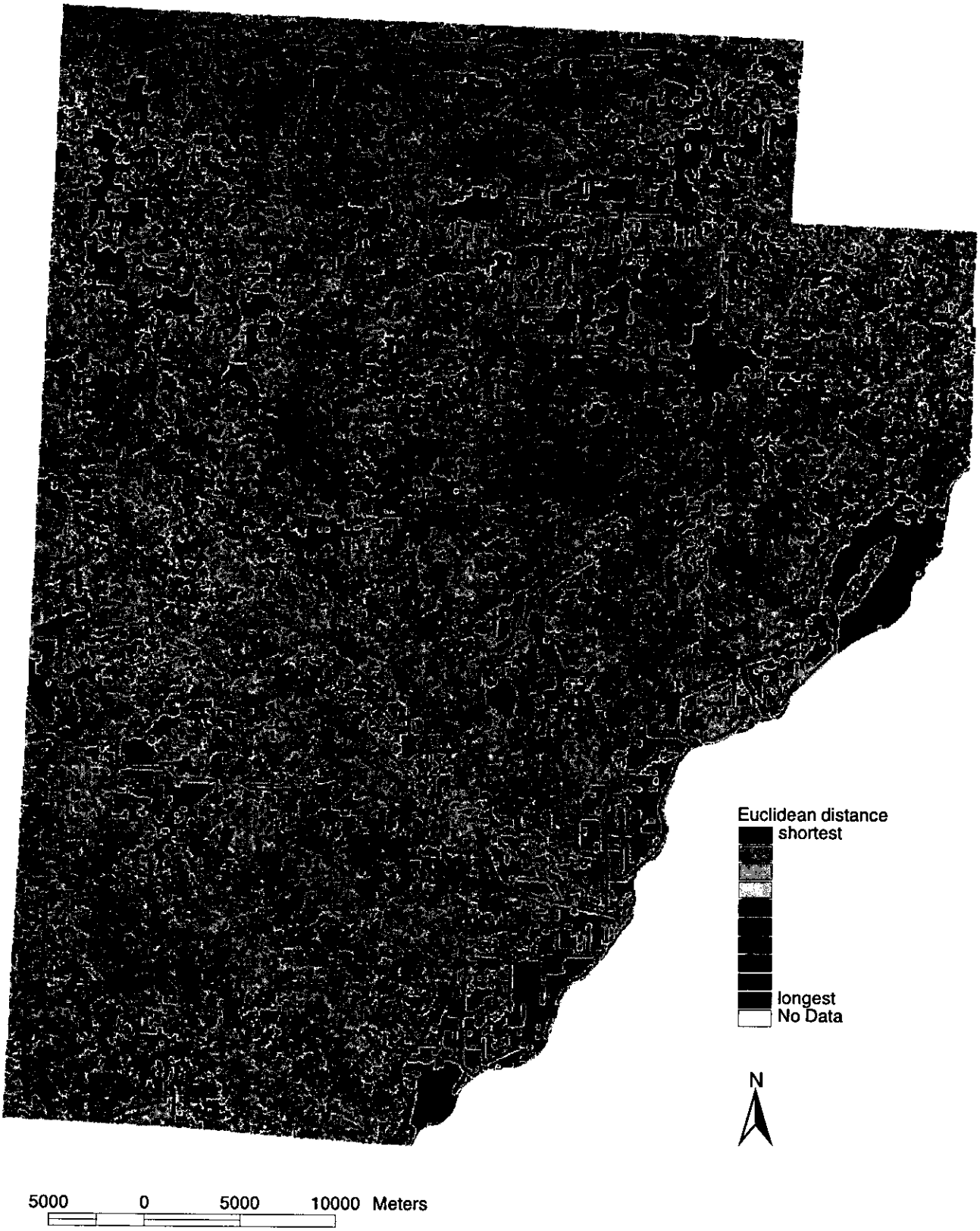


Fig. 5. Euclidean distances between grasslands
Fulton County, Illinois

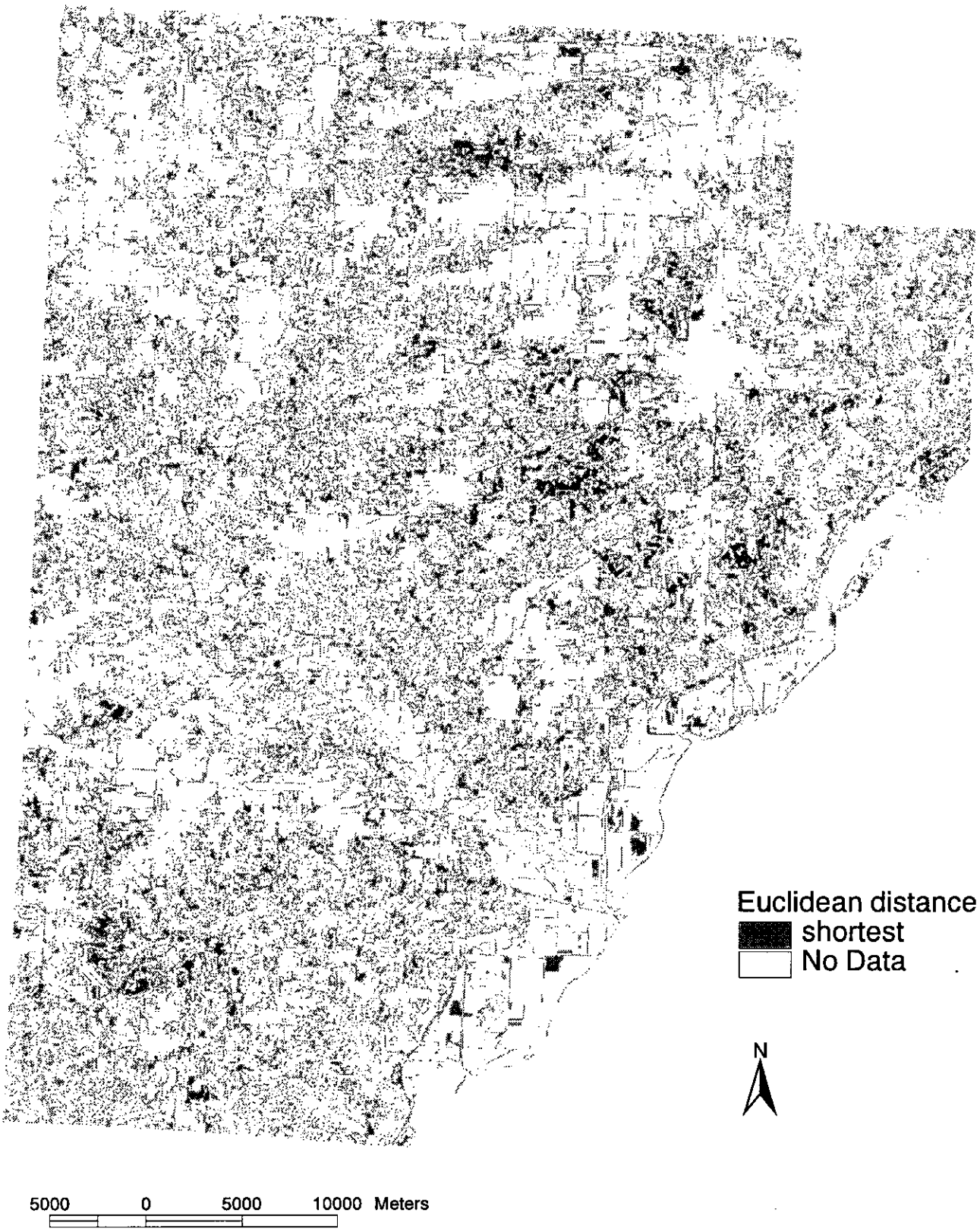


Fig. 6. Shortest euclidean distances between grasslands in Fulton County, Illinois

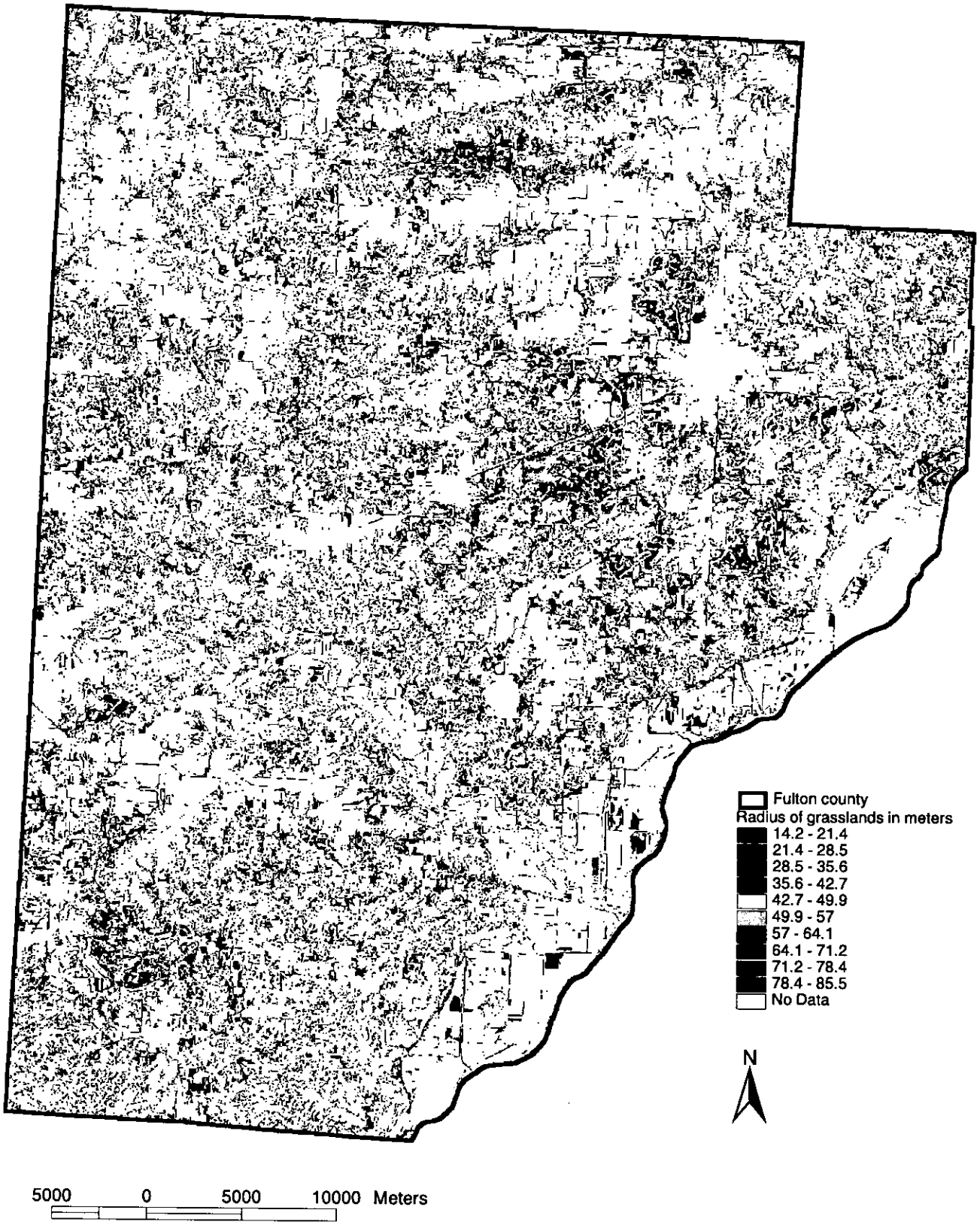


Fig. 7. Size classes of contiguous grasslands in Fulton County, Illinois

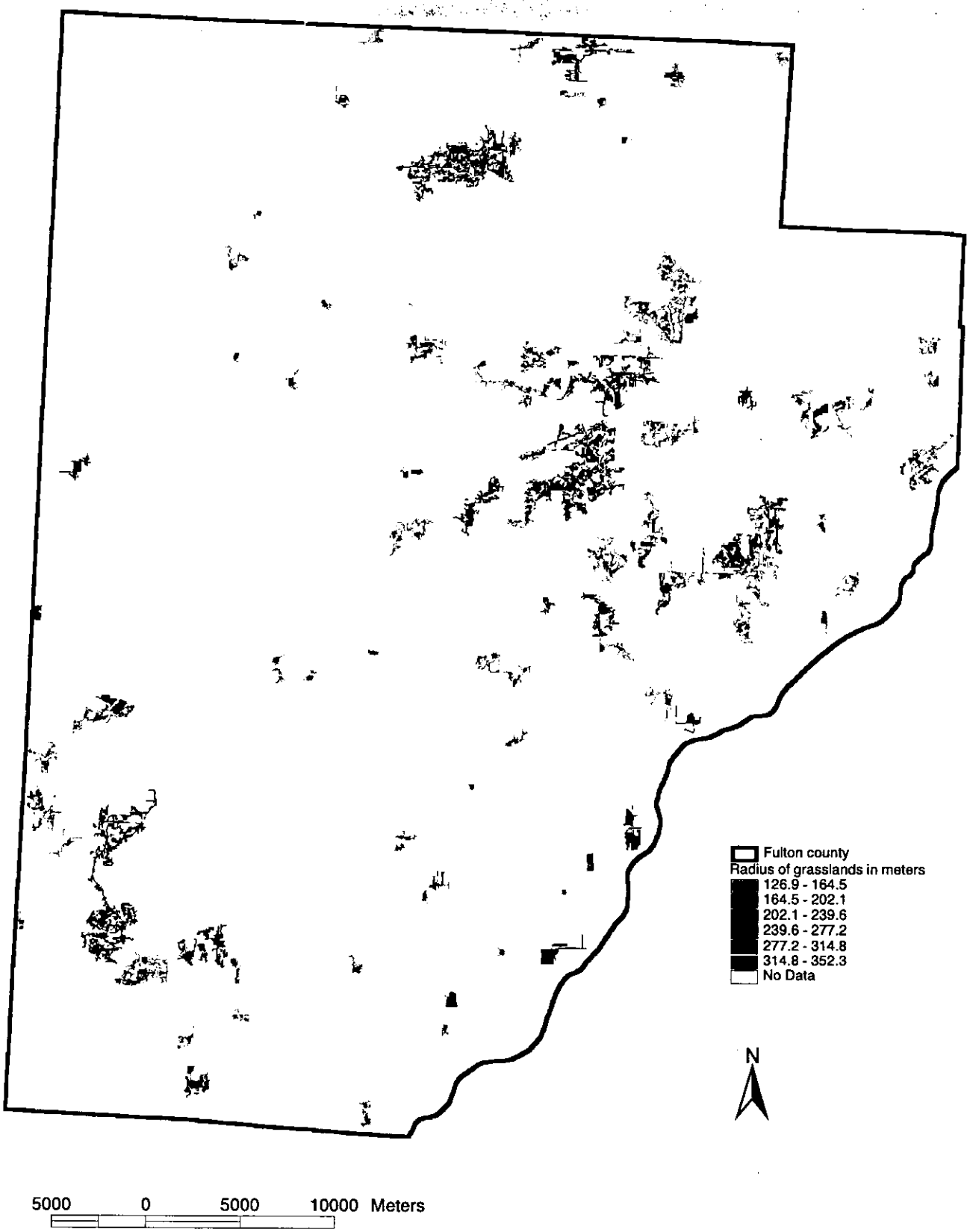


Fig. 8. Largest contiguous grasslands with minimum radius of 126.9 meters Fulton County, Illinois

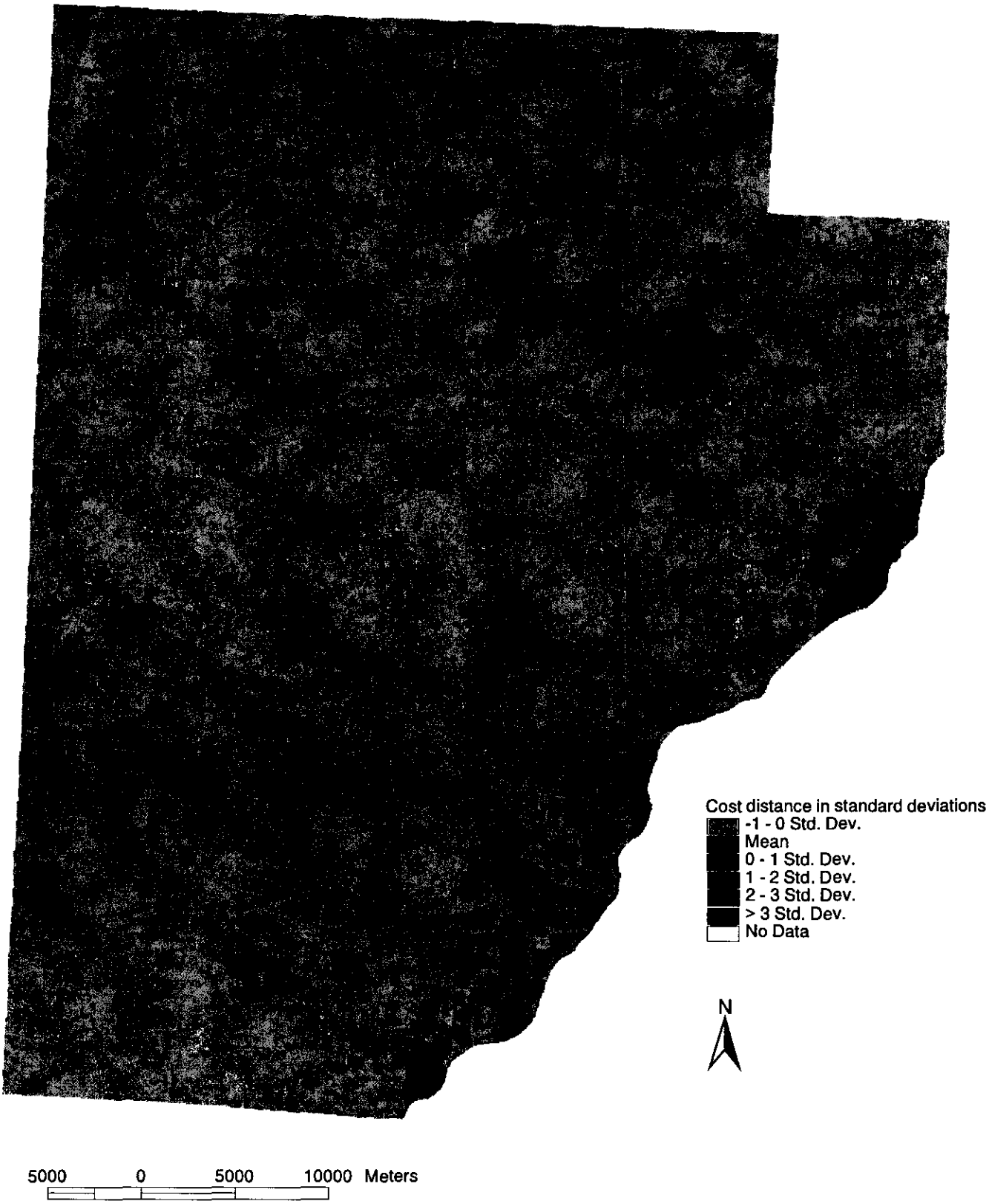
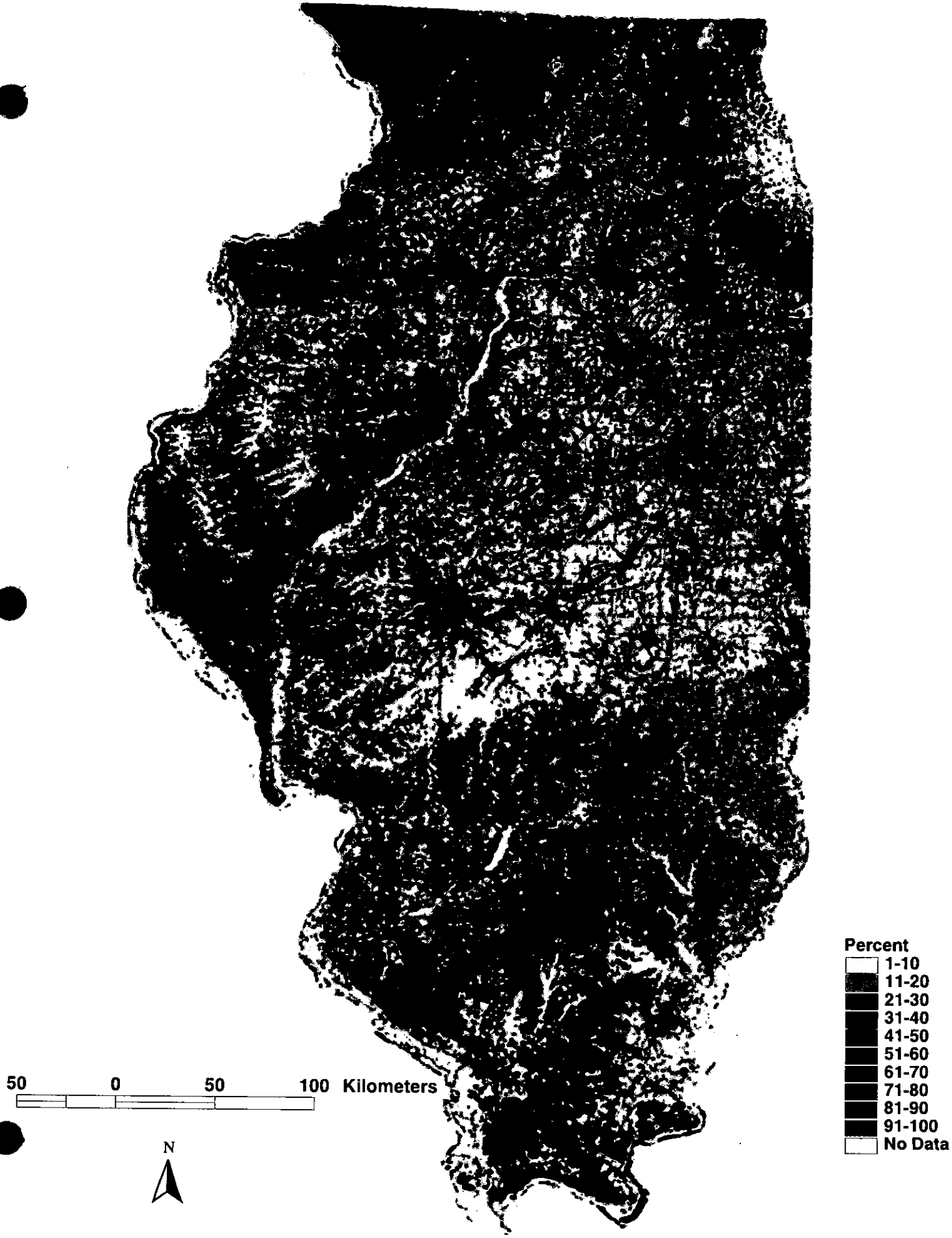


Fig. 9. Cost surface of grasslands in Fulton County, Illinois



Percent grasslands within 1 km radius, Illinois