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Forest Cover of Champaign County, Illinois in 1993

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ABSTRACT

The forest cover of Champaign County, in east-central Illinois, was mapped from 1993 aerial photography and entered in a geographical information system database. One hundred and six forest patches cover 3,380 ha. These patches have a mean area of 32 ha, a mean perimeter of 4,851 m, a mean perimeter to area ratio of 237, a fractal dimension of 1.59, and a mean nearest neighbor distance of 620 m. However, only 480 ha can be considered interior forest. These results are compared with results of previous landscape level studies of Illinois, and the implications of these results for conservation and management of this landscape are discussed.

INTRODUCTION

Land cover in central Illinois has changed substantially from a landscape dominated by prairies with some forest to a landscape dominated by agriculture with a sparse forest distribution and almost no prairies (Iverson, 1988; Iverson et al., 1989). Forest cover of Champaign county has been mapped for several periods during the last 175 years. Using the General Land Office's original township vegetation maps, Anderson (1970) produced a map of the prairies and forests of Illinois. Similar earlier attempts by Gerhard (1857 in Barrows, 1910) and Vestal (1931) were less accurate than Anderson's. Attempts at mapping the forest cover during this century include those of Telford (1926) and Iverson et al. (1989; using 1980 data from the U.S. Geological Survey). In 1948, 1962 and 1985, the USDA Forest Service statistically sampled and inventoried the forests of the state but only county-level maps were possible from these data (US Forest Service, 1949; Essex and Gansner, 1965; Hahn, 1987). No more forest cover maps for Champaign county have been published with data obtained after 1980, and no forest inventories have been published after 1987.

This study describes the current forest distribution of Champaign county and compares it with the pre-settlement and the 1980 forest distribution.

STUDY AREA

Champaign county covers an area of nearly 259,000 hectares of essentially flat terrain resulting from the deposition of glacial material during the retreat of the Wisconsin glacier. The topography ranges in elevation between 192 to 262 meters above sea level. Five major rivers drain the county: Salt Fork, Sangamon, Kaskaskia, Vermilion, and Embarras Rivers. Most of the county belongs in the Grand Prairie Division of Illinois with some minor intrusions of the Ozark Division along two tributaries of the Vermilion River draining to the east (Schwegman, 1975).

The county was settled by European Americans beginning in the 1830's. Initially, forest areas were preferred for agriculture due to the lack of adequate machinery to plow the prairie soils. After the expansion of railroad lines in the mid 1800's the value of forests plummeted due to reduced transportation costs, and more forest lands were converted to agriculture (Iverson et al., 1989). Therefore, forest cover was reduced from about 6.3% of the county (~16,100 ha) in the 1830's to about 1% in the 1920's (Iverson et al., 1989). The most recent forest survey of the county estimated the forest cover at 1.4%, or about 3,600 ha (Hahn, 1987).

METHODS

GIS database

Forest cover was delineated from 1993 black and white aerial photos at a scale of 1:40,000. Boundaries of forest patches (i.e., patches with more than 50% tree cover and excluding forest present within urban areas) were traced on acetate transparencies with a 0.5 mm point felt pen. At least 9 reference points, also visible in the corresponding USGS topographic quadrangles, were also drawn on the transparencies. These transparencies were then scanned with a flatbed scanner at a resolution of 40 dots per centimeter and the resulting digitized images were converted to the format of a commercial raster-based GIS software. These files were then registered and placed into a mosaic at a pixel size of 10 x 10 meters and georeferenced to the Universal Transverse Mercator coordinate reference system. A second order polynomial transformation was used to rectify the images; in no case was the RMS error larger than 1 pixel (RMS is a measure of the difference between the true coordinates of a pixel and the resulting coordinates after transformation of geographical positions; equivalent to one standard deviation).

Analysis

Total forest area was determined from the digitized map by summing the areas of all forest patches (i.e., any aggregation of forest pixels larger than 1 ha). The number, area (in ha), and perimeter (in m) of the forest patches at least one hectare in size were also determined. The perimeter to area ratio (m/ha) and the fractal dimension (i.e., twice the slope of the regression of the log perimeter on the log area of the patches) were calculated to describe the shape of the forest patches. The fractal dimension is a measure of patch shape with values ranging from 1, for a circular or square patch, to 2 for a very complex shaped patch (McGarigal and Marks, 1995). Finally, the interior forest area of the county (i.e., forest

inside the first 100 meters from the patch edges) was calculated by adding the areas in forest after trimming the forest patches of their 100 meter borders. This digital map was subsequently resampled to a pixel size of 20 x 20 meters to determine the distance to edge of nearest neighbor forest patches.

A comparison of the 1993 forest cover map with a map of pre-settlement (1820) forest cover was also made. Due to different mapping criteria and procedures, these maps are presented only for visual comparisons and no statistical comparisons were attempted.

RESULTS & DISCUSSION

The forest area in the county totaled 3,380 ha, which corresponds to 1.3% of the county. This value is very close to the most recent USDA Forest Service estimate (1.4%; Hahn, 1987). However, only 14% of this forest area qualifies as interior forest (i.e., 480 ha). This low percentage of interior forest is a consequence of the many small patches, as well as the narrow shape of most of the larger patches present in this county (Fig. 1).

A total of 106 forest patches satisfied the size criteria (i.e., at least 1 ha; Figure 1). Their mean patch size was 32 ha (median = 8 ha, range 1 ha - 630 ha), their mean perimeter was 4,851 meters (median = 1,640 m, range 440 m to 75,500 m), and the mean perimeter to area ratio of 237 (median = 226, range 80 to 471). The size distribution of these patches was highly skewed to the small sizes (Figure 2). More than half of the patches were smaller than 8 hectares, accounting for only 7% of the county's forested area, while the 6 largest patches accounted for 60% of the total forest land. The fractal dimension of these 106 patches is 1.59, as compared to 1.33 for forests of the central Illinois quadrangle from U.S. Geological Survey data (Iverson, 1988). This value suggests a more complex patch shape than in Iverson's study. However, Anderson et al. (1971) mapped the U.S. Geological Survey data at a scale of 1:250,000 and a minimum resolution of 16 ha for forests, so their map would be more generalized than the results presented here and the differences in fractal dimension are not strictly comparable.

The mean nearest neighbor distance between forest patch edges is 620 meters (median = 240 m, range 20 - 6,807 m, N=104 at pixel size of 20 m). Although these are not large distances, they would certainly discourage the movement of species between forest patches. Several studies have indicated that forest species may become isolated from other forest patches by distances as short as 100 m or less (Bierregaard et al. 1992). In this case, forest patch isolation may especially affect the interior forest species movements considering that the mean nearest neighbor distance for the interior areas was 1,431 meters. On the other hand, the relatively low average patch distance may enhance the establishment of programs aimed at reducing fragmentation effects, because it indicates the feasibility of collapsing close patches to increase interior forest area.

The spatial distribution of patches in 1993 matches closely the distribution of the patches in pre-settlement times (Fig. 1). Almost all of the 1993 forest patches are clumped along the banks of the major streams of the county and are located within the extent of the pre-settlement forest patches (Fig. 1). This distribution matches well the distribution of 1980 forest patches, but contrasts to some extent with the distribution of 1820 forest patches illustrated by the statewide map of Iverson and Joselyn (1990). Their map, an overlay of

1820 forests from Anderson (1970) and 1980 forests from the U.S. Geological Survey data following Anderson et al. (1971), suggests that a relatively large portion of the 1980 forest cover in Champaign county occurs on sites that were not forested in 1820. This discrepancy in maps likely results from the coarse resolution and spatial inaccuracies of the 1820 data presented in Iverson and Joselyn (1990). The 1820 data were compiled by Anderson (1970), and reproduced by Iverson and Joselyn (1990) at scales which are informative at the statewide level but which make localized comparisons difficult.

The county's pre-European settlement vegetation was earlier digitized from original General Land Office plat maps at a scale of 1:42,200, and published in McKnight (1986). This map, reproduced in Figure 1, shows a much better correspondence between historic and current forests. However, these two mapped distributions differ considerably in the methodology for generating them (field mapping by the GLO surveyors vs photointerpretations in this study), as well as in their resolution. Therefore, Figure 1 should be considered only as a rough graphic comparison of the two distributions.

The forest cover of Champaign county was low at the time of European settlement in the early 1800's. In these times, most of the forest of this area grew along the major rivers, except for a few isolated groves on the uplands (Boggess 1963). This spatial distribution may be the result of protection of trees by rivers, especially on the leeward side of rivers and in the wedge surrounded by two forks, which prevented fires from invading as frequently (Gleason, 1913). In post-settlement times, other factors probably account for the present forest distribution due to the absence of fires for more than a century and the dominance of human activities on the landscape. For example, the cities of Champaign-Urbana can be thought of as a "forest island" in a "sea of agriculture", as it has been determined that within the city limits, there is 4% forest and another 22% of the land classed as residential with trees (Cook and Iverson 1991).

We suggest that the qualitative similarity in spatial location between the forest patches of today and those of pre-settlement times is the result of a complex of natural and socioeconomic factors. Primarily the forests remaining today are a result of them being generally less suitable for agriculture; they may be excessively wet or excessively erosive in the sloping lands next to streams. It is also likely that forest regenerated close to their former locations due to persistence of a soil seed bank and/or relict trees in these locations. However, some of these areas may remain in a forested condition primarily because of government set-aside programs. With the current uncertainty about national support for these set-aside programs, some of the forest cover of this county is vulnerable to clearing in the coming years. This would be an unfortunate scenario considering the already inadequate landscape configuration of the present forest patches. Further fragmentation would be most evident in terms of a further reduction of interior forest and the potential negative impact this would have on already declining abundances of neotropical avian migrants (Iverson and Schwartz 1994, Robinson et al. 1995). On the other hand, as mentioned previously, there is opportunity to form reasonably sized corridors and larger patches by enlarging smaller patches that are in close proximity, thus reducing the negative impacts of forest fragmentation on the biota (e.g., neotropical migrant songbirds; Robinson et al. 1993, Brawn and Robinson 1996). We suggest that government agencies and other landowners take the present and potential future landscape

distribution of the forests of this county into account when developing programs to maintain an ecologically adequate forest patch configuration.

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REFERENCES

Anderson, R.C., 1970: Prairies in the Prairie State. Illinois State Academy of Science Transactions 63:214-221.

Anderson, J.R., E.E. Hardy, and J.T. Roach. 1971. A land-use classification for use with remote-sensor data. United States Geological Survey Circular 671. Washington, D.C.

Barrows, H.H., 1910. Geography of the Middle Illinois Valley. Illinois State Geological Survey Bulletin 15. 128 pp.

Bierregaard, R.O., T.E. Lovejoy, V. Kapos, A.A. Dos Santos, and R.W. Hotchings 1992. The biological dynamics of tropical rainforest fragments. Bioscience 42:859-866.

Boggess, W.R., 1963. Prairie forests - then and now. Illinois Research 5:10-11.

Brawn, J.D. and S.K. Robinson 1996. Source-sink population dynamics may complicate the interpretation of long-term census data. Ecology 77:3-12.

Cook, E.A. and L.R. Iverson. 1991. Inventory and change detection of urban land cover in Illinois using Landsat Thematic Mapper Data. Pages 83-92 *in* Proceedings of the 1991 ASPRS/ACSM Annual Convention, Volume 3, Remote Sensing. American Congress on Surveying and Mapping and American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland.

Essex, B.L., and D.A. Gansner, 1965. Illinois' timber resources. U.S. Department of Agriculture, Forest Service Resources Bulletin LS-3. Washington, D.C. 56 pp.

Gleason, H.A., 1913. The relation of forest distribution and prairie fires in the Middle West. Torreya 13:173-181.

Hahn, J.T., 1987. Illinois forest statistics, 1985. USDA, Forest Service, Resource Bulletin NC-103. St. Paul, Minnesota.

Iverson, L.R., 1988. Land-use changes in Illinois, USA: the influence of landscape attributes on current and historic land use. Landscape Ecology 2:45-61.

Iverson, L.R., R.L. Oliver, D.P. Tucker, P.G. Risser, C.D. Burnett, and R.G. Rayburn, 1989. The forest resources of Illinois: an atlas of spatial and temporal trends. Illinois Natural History Survey Special Publication 11.

Iverson, L.R., and M.J. Joselyn. 1990. Forest cover in Illinois, 1820-1980, with accompanying maps on forest composition, volume, diversity, and cover. Illinois Natural History Survey, Champaign (1:500,000 map).

Iverson L R, and M. W. Schwartz. 1994. Forests. Pages 33-66 in Illinois Department of Energy and Natural Resources. The Changing Illinois Environment: Critical Resources. Volume 3. Technical Report. ILENR/RE-EA-94/05. Illinois Department of Energy and Natural Resources. Springfield, IL.

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

McKnight, B.N. 1986. The bryophytes of Champaign county, Illinois. Transactions of the Illinois State Academy of Sciences 79:35-52.

Robinson, S.K., J.A. Grzybowski, S.I. Rothstein, M.C. Brittingham, L.J. Petit, and F.R. Thompson 1993. Management implications of cowbird parasitism on neotropical migrant songbirds. In: Finch, D.M. and P.W. Stangel (eds.) Status and management of neotropical migratory birds; 1992 September 21-25; Estes Park, CO. Gen. Tech. Rep. RM-229. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Mountain Forest and Range Experiment Station. 422 p.

Robinson, S.K., F.R. Thompson, T.M. Donovan, D.R. Whitehead and J. Faaborg 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987-1990.

Schwegman, J.E., 1975. The natural divisions of Illinois. Pages 1-47 in R.H. Mohlenbrock, ed., Guide to the vascular flora of Illinois. Southern Illinois University Press, Carbondale.

Telford, C.J., 1926. Third report on a forest survey of Illinois. Illinois Natural History Survey Bulletin 16:1-102.

US Forest Service, 1949. Forest resources of Illinois, U.S. Department of Agriculture, Forest Service, Central States Forest Experiment Station Forest Survey Release 7. Columbus, Ohio. 53 pp.

Vestal, A.G., 1931. A preliminary vegetation map of Illinois. Illinois State Academy of Science Transactions 23:204-217.

Figure 1. Forest cover of Champaign County. Black patches illustrate the 1993 forest cover. Thick lines indicate the pre-settlement forest distribution (redrawn from McKnight, 1986). The thin lines represent streams.

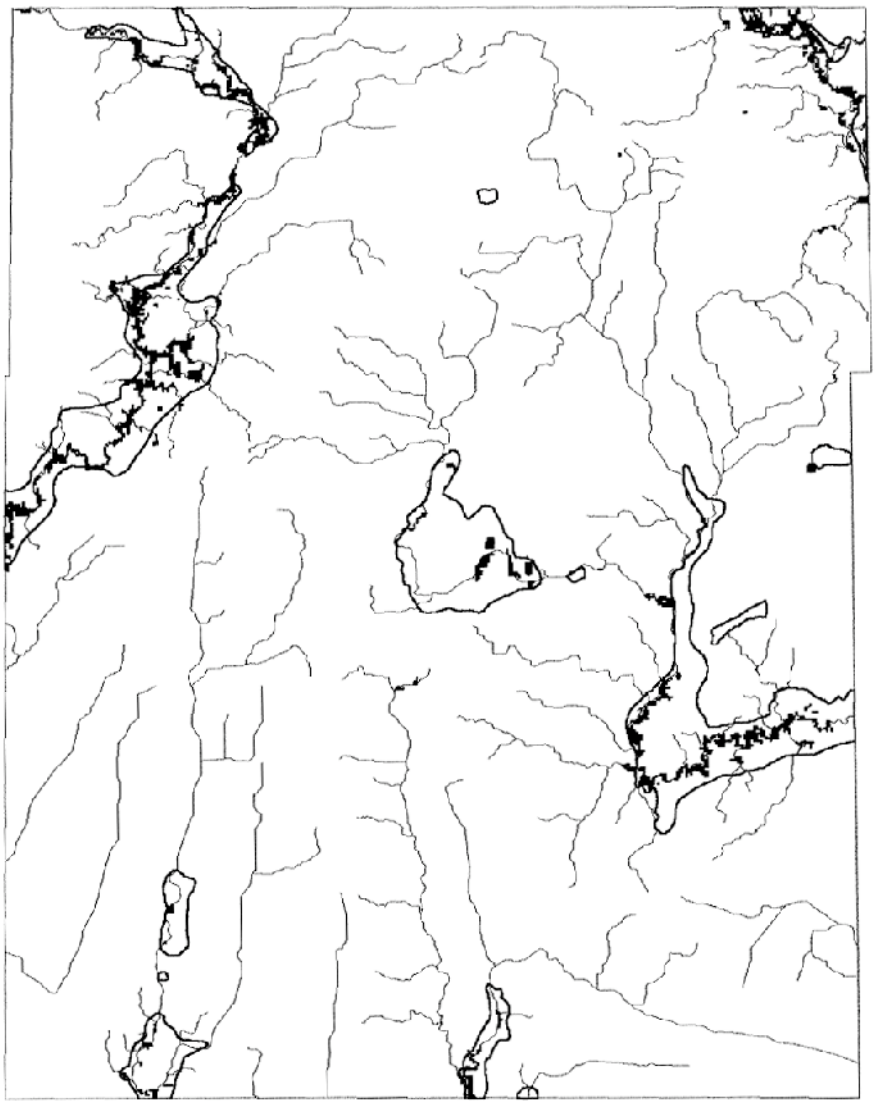

Figure 2. Size distribution of the 1993 forest patches of Champaign County; (a) all patches, (b) expanded view of the first two size classes in (a).