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Dustin A. Farnsworth
Iowa State University, dustinf6@gmail.com

Lisa A. Schulte
Iowa State University, lschulte@iastate.edu

Susanne Hickey
The Nature Conservatory

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Abstract
Half of Iowa's remnant prairie lies within the Loess Hills of western Iowa, yet development, woody encroachment, and agriculture continue to have an impact upon the size, shape, and quality of grasslands in the region. Given the limited resources available to manage grasslands, prioritizing restoration expenditures and targeting efforts to areas of greatest conservation potential are critical. To this end, we conducted an assessment of landscape patterns in the Loess Hills and developed a conservation priority index (CPI) to identify cropland with the greatest potential to promote connectivity of grasslands. Cropland parcels were given a CPI score between 1 and 100, with high values corresponding to areas having a low corn suitability rating and located close to prairie remnants, and with low values, the reverse. Over the entire Loess Hills landform, croplands dominate, comprising 47% of the land cover, while grasslands, forests, and developed areas comprise 23%, 20%, and 6%, respectively. Cropland patches tend to be contiguous and consist of large, relatively simple shapes, while the patches of remnant prairie are small, fragmented, and far apart. Our analysis also shows that grasslands are more abundant and more connected in the northern half of the Loess Hills. The CPI identified large portions of cropland with low overall agricultural production potential. If cropland areas scoring among the top 30% on the CPI were converted to native prairie, the total amount and connectivity of grasslands in the region would increase substantially, thereby buffering prairie remnants—regionally significant reservoirs of biodiversity—from conservation threats associated with development, woody encroachment, and row-crop agriculture.

Keywords
coarse-filter conservation, conservation priority index (CPI), Iowa, grassland, land use, remnant prairie, spatial pattern

Disciplines
Natural Resources Management and Policy

EVALUATION OF CURRENT AND ALTERNATIVE SPATIAL PATTERNS OF GRASSLAND IN THE LOESS HILLS

DUSTIN FARNSWORTH, Department of Natural Resource Ecology and Management, Iowa State University, Ames, IA 50011-3221, dustinf6@gmail.com

LISA A. SCHULTE, Department of Natural Resource Ecology and Management, Iowa State University, Ames, IA 50011-3221

SUSANNE HICKEY, The Nature Conservancy, Des Moines, IA 50309

Abstract: Half of Iowa's remnant prairie lies within the Loess Hills of western Iowa, yet development, woody encroachment, and agriculture continue to have an impact upon the size, shape, and quality of grasslands in the region. Given the limited resources available to manage grasslands, prioritizing restoration expenditures and targeting efforts to areas of greatest conservation potential are critical. To this end, we conducted an assessment of landscape patterns in the Loess Hills and developed a conservation priority index (CPI) to identify cropland with the greatest potential to promote connectivity of grasslands. Cropland parcels were given a CPI score between 1 and 100, with high values corresponding to areas having a low corn suitability rating and located close to prairie remnants, and with low values, the reverse. Over the entire Loess Hills landform, croplands dominate, comprising 47% of the land cover, while grasslands, forests, and developed areas comprise 23%, 20%, and 6%, respectively. Cropland patches tend to be contiguous and consist of large, relatively simple shapes, while the patches of remnant prairie are small, fragmented, and far apart. Our analysis also shows that grasslands are more abundant and more connected in the northern half of the Loess Hills. The CPI identified large portions of cropland with low overall agricultural production potential. If cropland areas scoring among the top 30% on the CPI were converted to native prairie, the total amount and connectivity of grasslands in the region would increase substantially, thereby buffering prairie remnants—regionally significant reservoirs of biodiversity—from conservation threats associated with development, woody encroachment, and row-crop agriculture.

Key Words / Search Terms: coarse-filter conservation, conservation priority index (CPI), Iowa, grassland, land use, remnant prairie, spatial pattern

INTRODUCTION

Over half of the remaining native prairie in the state of Iowa is found within the Loess Hills (Mutel 1989, NPS 2002), a region characterized by steep-sided bluffs and long, xeric ridge tops. Although prairie remnants are somewhat consolidated within the landform, conserving these remnants and their associated biodiversity remains difficult due to competitive land uses, such as row-crop agriculture, and the fragmentation that accompanies both rural and urban development (IDNR 2007). Given this situation, advocates of Loess Hills conservation are concerned about the current status of the remnant prairie and how best to carry out much-needed conservation efforts with limited resources. By evaluating the current land cover pattern in the landform, including the total area, shape, and connectivity of each land cover type, we can provide an important, broad-scale context for deciding how to apply limited resources toward on-the-ground conservation action.

Historically, the defining characteristic of grasslands, and specifically the mixed-grass prairies of the Loess Hills, was its continuously expansive, treeless character. Many grassland-obligate species in decline today once thrived in grass-dominated landscapes. Overall, 55 grassland species are threatened or endangered, and 728 species are candidates for listing (Samson and Knopf 1994). Forty-eight percent of grassland bird species within the United States are of conservation concern, and 55% have declining populations (NABCI 2009). In Iowa, 20% of the terrestrial species of greatest conservation need are dependent on warm-season grassland habitat (IDNR 2007). Grassland birds and other obligates are experiencing drastic population declines because of habitat loss and the related, indirect effect of habitat fragmentation (Knopf 1986, Herkert et al. 2003, IDNR 2007).

To accommodate obligate species that require expansive areas of grassland, landscapes must be managed to increase the size and decrease the fragmentation of the remnant prairie communities (Fletcher and Koford 2002, Shepherd and Debinski 2005, Walker 2005). In particular, the Iowa Wildlife Action Plan seeks to create grassland landscapes of 800 ha or more to benefit grassland-obligate species that require large areas (IDNR 2007). While individual pairs of grassland birds may successfully breed in smaller areas, large connected blocks of grassland habitat are required to maintain stable populations. For example, individual pairs of the grasshopper sparrow (*Ammodramus savannarum*) can be found in grassland patches of 30 ha; however, breeding sites measuring 800-1,400 ha in extent are likely required to support breeding populations (Vickery 1996). This example shows how species/habitat interactions are partially defined by the spatial characteristics of habitat over landscapes, such as the overall extent of a habitat type, but its connectivity, the shape of a habitat patch, or the amount of associated edge can also be important factors contributing to habitat quality (Strelke and Dickson 1980, Morgan and Gates 1982, Logan et al. 1985, McGarigal and Marks 1995, Turner et al. 2001). While species/habitat relationships are by their nature organism-specific and best studied on the level of the organism in question, insights can be gained by comparing influential metrics over landscapes and discussing the results in the context of specific organisms (Fischer et al. 2006, Lovell and Johnston 2009). Such a coarse-filter approach, in which the ecological status and value of broad-scale ecosystems and landscapes are assessed, is the only viable option where specific data on species' habitat requirements or response to changes in ecosystem processes are lacking, and in such cases constitute an efficient approach to conservation (Noss 1987, Hunter 1991).

This research focuses on Loess Hills prairie as an ecological community, with the assumption that a coarse-filter approach to conserving this community will benefit a large number of grassland-obligate species, even though the needs of some species are likely to be left unmet (Noss 1987, Groves 2003, Fischer et al. 2006). Grassland birds were selected as a primary example of grassland-obligate species and related species/habitat relationships because of their relatively well documented, rapidly declining populations (NABCI 2009) and for their value as indicators of habitat quality (Browder et al. 2002). Landscape characteristics that prominently and negatively affect many grassland bird species include decreased total area of habitat, decreased connectivity of habitat, and increased edge density (Fletcher and Koford 2002, Walker 2005).

For better or worse, the types of data available often determine the metric(s) used to quantify spatial pattern (Calabrese and Fagan 2004). In the Loess Hills, fine-grain biological data are lacking; however, newly acquired land cover data (Loess Hills Alliance 2008) provide spatially explicit information on vegetation types and arrangements, and are suitable for spatial pattern analysis. In using these land cover data, our objectives were to (1) define and quantify the landscape pattern of Loess Hills grasslands over multiple scales using multiple metrics, (2) develop a conservation priority index (CPI) to identify cropland parcels that would provide the greatest potential for promoting positive landscape characteristics if they were converted to grasslands (3) analyze potential increases in desirable spatial characteristics of grasslands within Special Landscape Areas using the newly developed CPI, and (4) interpret how landscape pattern might influence relationships between grasslands and grassland-dependent species, especially birds.

MATERIALS AND METHODS

STUDY AREA

The Loess Hills landform extends 321 kilometers from Holt County, Missouri, to Plymouth County, Iowa, along the eastern edge of the Missouri River, covering 279,776 ha (Figure 1). This distinctive geological landform is globally unique with respect to the deep deposits of loess, ranging from 18m to over 60m deep, and the highly dissected nature of the region (NPS 2002). The loess deposits are composed of sediment swept up from the nearby Missouri River floodplain and largely deposited over the last 30,000 years (Bettis 1990, NPS 2002).

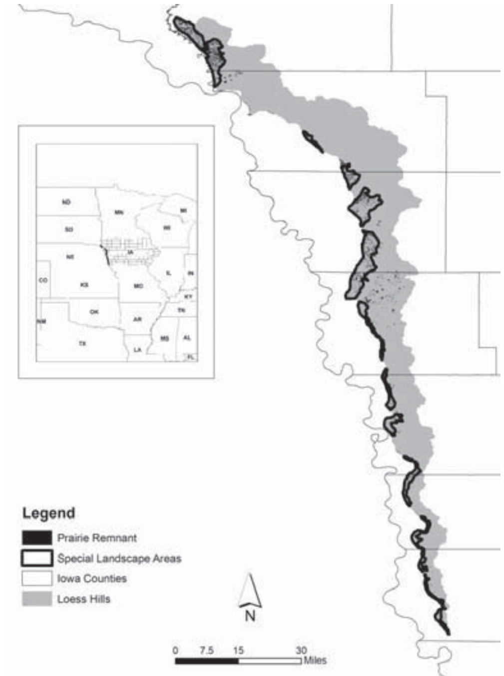

Figure 1. Map showing the location of Special Landscape Areas (SLAs) within the Loess Hills region of western Iowa, USA.

The average minimum and maximum temperatures for the Loess Hills region are -10.5° to 32.7°C (13°-91°F), respectively (US EPA 2009). Average annual precipitation ranges from 650.2 to 873.8 mm (25.6-34.3 in) (Bettis 1989), with higher precipitation levels in the southern hills. Well-drained aeolian soils in combination with steeply dissected topography create moisture-limited conditions on the upper portions of the slopes. Ridges, draws, and valleys also provide sheltered areas with moister microclimates, creating additional variability.

Historically, prairie vegetation was dominant throughout the Loess Hills, but areas with woody vegetation were patchily distributed within this matrix of open lands and were most often located in sheltered ravines and riparian areas (Mutel 1989, NPS 2002, Agren Inc. 2004, Stambaugh et al. 2006). Principle prairie species in the region include sideoats grama (Bouteloua curtipendula), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), heath aster (*Aster ericoides*), blue-eyed grass (*Sisyrinchium montanum*), Scribner's panic grass (*Dicanthelium oligosanthes*), whorled milkweed (*Asclepias verticillata*), Missouri goldenrod (*Solidago missouriensis*), leadplant (*Amorpha canascens*), and plains muhly (*Muhlenbergia cuspidata*) (Rosburg 1994). Bur oak (*Quercus macrocarpa*) dominated the majority of fire-tolerant savanna and woodland communities (Mutel 1989).

Loss of the historical fire regime (fire intervals of 2-7 years; Stambaugh et al. 2006), the temperate climate, and the topographic variability have led to an increase in woodland vegetation in the landform, where mesic deciduous forest and xeric prairie communities occur in relatively close proximity to one another. Today, 20% of the landform is in woodland or forest vegetation compared to presettlement estimates of 11%, and only 23% is in grassland vegetation, of which 3% is considered remnant prairie, compared to presettlement estimates of over 90% grassland (Farnsworth 2009).

In 2002, the National Park Service identified 12 Special Landscape Areas (SLAs) as "clusters of exemplary prairie and geological/topographic features based on past field surveys of prairie, forests and geological features" (NPS 2002) (Figure 1). These SLAs comprise 40,472 ha (100,000 ac) in 12 discrete areas spanning the Loess Hills, and contain greater than 80% of the region's biodiversity (NPS 2002). The SLAs are high-priority areas for a number of conservation organizations and thus are a focus of our research.

LOESS HILLS LAND COVER DATA

The primary source of data used in this study was a land cover classification performed by Saint Mary's Geospatial Services, Winona, Minnesota (Loess Hills Alliance 2008). Land cover units were classified and digitized as polygons using a 0.4 ha (1.0 ac) minimum mapping unit with one-meter-resolution National Agriculture Imagery Program aerial photographs (NAIP 2006) and one-meter-resolution 2002 false-color infrared imagery. Air photo interpretation was informed with field-based vegetation samples. A 1992 Gap Analysis Program (GAP) land cover dataset was used as ancillary data in conducting the classification.

Twenty-eight classes were identified in the classification following the National Vegetation Classification Standard for the Midwest, as modified by The Nature Conservancy (Iowa GAP Analysis Program 2001, Loess Hills Alliance 2008). For this analysis, we combined classes into broader land cover types and focused our analysis on those four classes that included the majority of the landform: croplands (i.e., corn, soybean), forests (e.g., deciduous woodland, red-cedar, grasslands (e.g., hay, brome, prairie), and development (e.g., residential, industrial). We calculated total area, mean patch size, edge density, nearest neighbor, and patch cohesion for these four major land cover classes to make more-specific vegetation comparisons and to provide an overall synopsis of Loess Hills land cover (McGarigal and Marks 1995, Turner et al. 2001).

GRASSLAND ANALYSIS

Land cover data for the Loess Hills (Loess Hills Alliance 2008) and a modified version of a Loess Hills remnant prairie data layer from The Nature Conservancy (TNC) were used as inputs for spatial pattern analysis of the four grassland categories: remnant prairie, warm-season grassland, cool-season grassland, and combined warm- and cool-season grassland. It should be noted, however, that the prairie remnant and warm-season grassland classes are not independent of one another. The prairie remnant class was extracted from the grassland land cover class using a version of the remnant prairie data layer obtained from TNC, modified from the original to improve its accuracy (Farnsworth 2009). There is roughly a 35% overlap between prairie remnant and warm-season grassland polygons. While this relationship compromises any statistical comparison among these classes, we found the information nonetheless useful to the overall understanding of landscape patterns in the Loess Hills.

For all data, we converted GIS vector-based data layers to raster format and overlaid the boundaries of the Loess Hills SLAs to extract land cover data per individual SLA. Grassland pattern analysis was conducted on the entire Loess Hills landform and within SLAs using ArcMap (ESRI 2009) and FRAGSTATS (McGarigal and Marks 1995), a computer software program designed to quantify the spatial characteristics of landscapes. Landscape metrics included total area, mean patch size, nearest-neighbor mean, nearest-neighbor coefficient of variation, patch cohesion, and edge density. These metrics were specifically chosen for their ability to describe the structural pattern of communities over landscapes while also inferring potential connectivity. Structural descriptors are best used when organism-specific information is lacking (McGarigal and Marks 1995). Total area, mean patch size, and edge density all relate to core area, which is an important spatial quality of habitat that affects population dynamics, specifically for grassland birds (Coppedge et al. 2001, Johnson and Igl 2001). While an important factor, core area is an organism-specific metric that could not be calculated here because of a lack of organism-specific information for the Loess Hills. Thus, this research evaluates landscape patterns relative to grassland-obligate species in general, and does not consider the specific spatial requirements of individual organisms. Nearest-neighbor and patch cohesion values are class metrics that can be used to evaluate the relative connectivity of a community type (McGarigal and Marks 1995). Connectivity is a major factor considered in preserve design and species conservation (Diamond 1975, Groves 2003). These metrics are also landscape structural attributes that can be defined without knowledge of organism-specific requirements following a coarse-filter approach.

CONSERVATION PRIORITY INDEX (CPI)

We developed a conservation priority index (CPI) to evaluate current areas of row-crop agriculture for their potential to contribute to grassland conservation. The CPI values a particular map pixel according to the distance to the nearest prairie remnant and its corn suitability rating (CSR). The additive value is weighted by the maximum score of the nearest remnant and CSR value, subtracted from one, and then multiplied by 100 to create a relative index (Equation 1).

Equation 1.

$$CPI = [1- ((CSR+distance) / maximum(CSR+distance))]*100$$

We hypothesize that restoration of cropland close to prairie remnants will disproportionately affect connectivity, patch size, and edge density in a positive direction from a grassland conservation perspective. Prairie remnants are often relegated to the most rugged terrain and consequently are less suitable for cultivation due to extreme slope and less-productive soils. Cropland closest to prairie remnants is hypothesized to have a higher chance of connecting to other nearby remnants or contributing to the patch size of an individual remnant patch if it were converted back to grassland.

Including CSR in the CPI provides additional benefit. The calculation of CSR takes weather, soils, slope, and other soil profile properties into consideration (ISU Extension 2005). A low CSR rating suggests that these areas are not well suited for the production of row crops. CSR thus can infer the potential for restoration from an economic perspective. If a parcel of land is less suitable for row-crop production (i.e., low CSR), it is likely to have lower market value in comparison to land with high CSR. Lower crop productivity can equate to a higher probability for restoring or conserving native vegetation.

Spatial data on CSR was obtained from an Iowa Soil Properties and Interpretations Database (ISPAID) and converted to raster format. ISPAID data were then extracted for cropland identified in the 2008 vegetation classification for the whole landform and then again by SLAs. CPI was calculated using this CSR raster layer and a raster layer showing distance to remnant constructed using the Euclidean distance tool in the ArcGIS (ESRI 2009) toolbox.

Increments of 10%, ranging from 0% to 100% of the total CPI raster score, were selected and made into separate data layers, merged with the modified remnant data layer, and analyzed in FRAGSTATS. These incremental layers were analyzed for potential connectivity using the patch cohesion metric in FRAGSTATS (McGarigal and Marks 1995). We calculated edge density by using Xtools extension in ArcMap (ESRI 2009) to determine the perimeter and area of polygons using the same incremental framework as patch cohesion calculation. At each increment, edge was calculated by taking the log transformed result of the perimeter divided by area (Equation 2).

Equation 2.
Edge density = ln(perimeter/area)*

*Results were log transformed and plotted against incremental CPI scores.

RESULTS

OVERALL LAND COVER ANALYSIS

Within the entire Loess Hills landform, croplands are dominant, comprising 47% of the land cover; grasslands, deciduous woodlands and forests (hereafter, forests), and developed areas comprise 23%, 20%, and 6% of the land cover, respectively (Table 1). The cropland class has the largest mean patch size, lowest edge density values, and largest cohesion. In other words, cropland patches tend to be contiguous, and consist of large, relatively simple shapes. By comparison, grassland and forest patches are much smaller (roughly one-sixth the size), tend to have a greater amount of edge, and be less well connected (Table 1). Forests tend to be further apart and have higher edge densities than all grasslands combined (Table 1). The land cover pattern in individual SLAs largely mimicked the patterns of the region as a whole (Farnsworth 2009); however, the six northern SLAs contained a comparatively larger proportion of grassland land cover (86%), while the six southern SLAs were occupied by much less grassland cover (14%).

GRASSLAND LAND COVER COMPARISON

The total area in prairie remnants was smaller than all other grassland vegetation types (Table 2). Total area and mean patch size increased between remnant, cool-season, and warm- and cool-season grassland combined. This trend of increasing values from prairie remnant to combined grassland land cover was consistent for metrics describing individual patches (i.e., total area, mean patch size), but metrics describing spatial arrangement (i.e., patch density, mean nearest-neighbor distance, and edge density) showed different results (Table 2). Using patch density and Euclidean distance nearest-neighbor values, remnant prairies were shown to be closer to each other than warm-season, cool-season, or combined warm- and cool-season grassland land cover types (Table 2). The combination of mean nearest-neighbor distance and coefficient of variation in this measure, which considers the standard deviation in nearest-neighbor distance relative to the mean, revealed that prairie remnants are closer to each other on average than other grassland cover types, but that this pattern is highly variable (Table 2). The edge density metric supported the dissected pattern among prairie remnants, with prairie remnants having high edge density in comparison to the other grassland cover types. The other grassland cover types were blocky in shape compared to the prairie remnants (Table 2). Overall, prairie remnants tend to be

Table 1. Quantitative comparison of spatial patterns among dominant land cover classes in the Loess Hills region of western Iowa, USA, based on 2006 imagery.

METRICS	CROPLAND	GRASSLAND	FOREST	DEVELOPED
Total area (ha)	132,585.6	65,473.7	55,205.2	16,843.0
Percent area (%)	47.4	23.4	19.7	6.0
Mean patch size (ha)	74.0	12.6	11.6	8.4
Edge density (m/ha)	366.6	477.5	531.2	360.2
Mean nearest neighbor (m)	115.7	114.4	127.3	382.7
Patch cohesion (index score)	99.7	97.7	97.8	97.8

small, fragmented, and have high amounts of edge compared to other grassland types (Table 2) as well as to croplands, forests, and developed areas (Table 1).

Among the 12 SLAs, those in the northern half of the Loess Hills consistently show higher amounts of grassland vegetation and greater connectivity. The second most northern SLA had the highest value of total grassland area (2,747 ha), second highest cohesion (99.6), and nearest-neighbor distance (86.7m) between grassland cover types. The southernmost SLA showed the opposite scores (grassland area = 250 ha; cohesion = 88.8; nearest-neighbor distance = 119.9 m).

CONSERVATION PRIORITY INDEX (CPI)

The overall distribution of CPI scores was skewed toward 100; in other words, toward values with high conservation potential (Figures 2 and 3). Eighty-three percent of all cropland within SLAs (33,591 ha) scored over 70 on the CPI (Figure 2), showing that much of the cropland within SLAs has a low CSR and is located proximal to prairie remnants (Figure 3). Cropland areas with a CPI score greater than 70 would account for 93% of the increase in the connectivity of prairie remnants if these areas were converted to grassland (Figure 4). We found similar results for edge density: croplands with a CPI score of >70 captured 92% of the potential improvement (low edge density) (Figure 5). Converting just 30% of the highest-scoring croplands to grassland, however, would result in substantial increases in patch cohesion and decreases in edge density (Figures 4 and 5).

DISCUSSION

The lack of in-depth knowledge on the status and trends of species and ecosystems, the extreme degree to which many natural systems have been altered, and the limited availability of resources for restoration often necessitates a coarse-filter conservation approach (Noss 1987, Groves 2003, Fischer et al. 2006, Seastedt et al. 2008). The evaluation and restoration of key landscape characteristics, with an eye toward a handful of desirable species for which the habitat requirements are better known, is a coarse-filter approach intended to preserve a significant portion of biodiversity, while acknowledging that some species will not be accommodated (Groves 2003, Fischer et al. 2006).

The Loess Hills of western Iowa is one such region where a coarse-filter conservation approach is needed, due to the high level of ecosystem alteration and lack of information on the needs of individual species. Although the region contains one-half of the remnant prairie in the state of Iowa, cropland still comprises the majority of land cover, followed by grasslands, forests, and developed areas (Table 1). While prairie remnants harbor much native biodiversity, they are small, fragmented, and largely relegated to the more rugged and agriculturally unfit portions of the landscape (Table 2).

Substantial opportunity exists to improve the structural characteristics of these prairie remnants, as well as surrounding grasslands, for the purposes of biodiversity conservation.

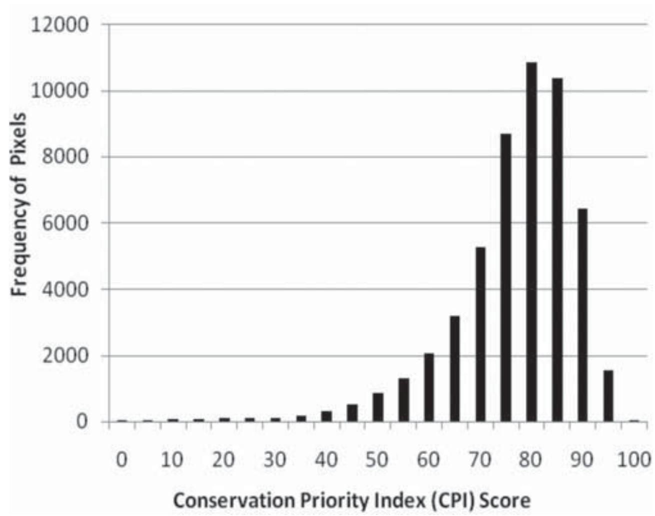

Figure 2. Frequency of cropland pixels by Conservation Priority Index (CPI) scores.

Such improvement could be achieved in two ways: first, by improving the structural characteristics and management of existing nonnative grassland patches. At the patch level, many grassland obligates, especially birds, show a lower response to the species composition of grasslands than to their structural characteristics (Chapman et al. 2004). For example, dickcissels (Spiza americana) will occupy fallow fields and unmown hayfields in addition to native prairie, but the proximity to

Table 2. Quantitative comparison of spatial patterns among grassland land cover classes within the Loess Hills of western Iowa, USA. Note that prairie remnants are not completely independent of the warm-season grassland class (see methods for details).

METRICS	PRAIRIE REMNANTS	WARM-SEASON GRASSLAND	COOL-SEASON GRASSLAND	WARM & COOL-SEASON GRASSLANDS COMBINED
Total area (ha)	8,574.8	14,144.3	49,391.9	63,536.2
Patch density (ha/patch)	26.3	13.4	8.4	7.2
Mean patch size (ha)	3.8	7.4	11.9	13.9
Mean nearest neighbor distance (m)	121.5	222.9	140.4	123.0
Nearest neighbor coefficient of variation (index score)	133.8	144.2	91.4	84.0
Patch cohesion (index score)	95.1	93.9	96.8	97.7
Edge density (m/ha)	285.8	221.2	177.6	167.8

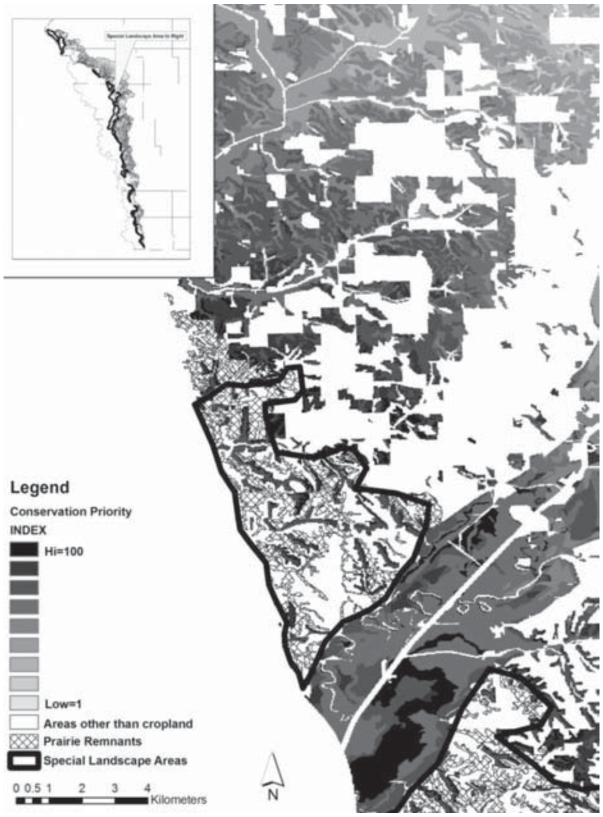

Figure 3. Spatial distribution of remnant prairies and Conservation Priority Index (CPI) scores for a portion of the Loess Hills in western Iowa. White areas within the boundary of the Loess Hills landform include non-prairie remnant and non-cropland cover types (i.e., other grasslands, forests, and developed areas).

wooded areas decreases the quality of these habitats (Temple 2002). The fact that grasslands comprise a substantial proportion (26%) of the land cover in the Loess Hills represents a substantial opportunity; yet, most of this vegetation type consists of cool-season nonnative species, and includes pastures that are often grazed or hayed and grass plantings associated with the United States Department of Agriculture's Conservation Reserve Program (CRP). The habitat value of these cover types for grassland birds and other obligate-grassland species is highly variable (McCoy et al. 1999, Johnson 2000). Appropriately applied livestock grazing (Chapman et al. 2004), conservation strategies such as delayed haying (Horn and Koford 2000, Perlut et al. 2006), and other forage-reserve strategies can enhance the contribution of cool-season grasslands to conservation by increasing the available cover for breeding birds and other obligates (Patterson and Best 1996). Cool-season grasslands can also contribute to the overall extent of open, grass-covered habitat, decreasing the amount of edge and fragmentation associated with remaining remnant prairies. While cool-season grasslands might not meet the plant compositional needs of some grassland-obligate species (e.g., specific nectar- or fruit-bearing plants), they can meet some of the structural criteria (e.g., permanent cover, lack of perches for predators). Additionally, many critical ecosystem processes, such as the movement of organisms, the redistribu-

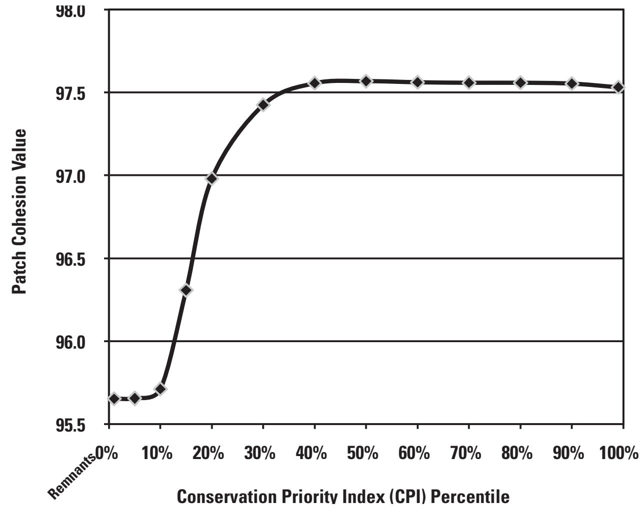

Figure 5. Potential decrease in edge density of prairie remnants if cropped areas within Loess Hills Special Landscape Areas (SLAs) displaying high values of a conservation priority index (CPI) were restored to native vegetation.

tion of nutrients, and the spread of natural disturbance, are linked to the size and spatial arrangement of patches (Johnson and Igl 2001, Turner et al. 2001, Shepherd and Debinski 2005, Fischer et al. 2006). Increasing the total area of grassland has the potential to improve the spread of fire by increasing the spatial extent of more flashy fuels (i.e., grass) and therefore improving the effectiveness of prescribed fire management in reducing woody encroachment.

Second, croplands of low economic value and located close to remnant prairie could be targeted for conversion to reconstructed prairie, thereby increasing the overall extent and connectivity of grasslands in the Loess Hills. This approach may be more cost-effective compared to focusing on restoration of overgrown areas commonly found within and around prairie remnants, because intensive woody vegetation removal can be quite costly, ranging from $620 to $2,500

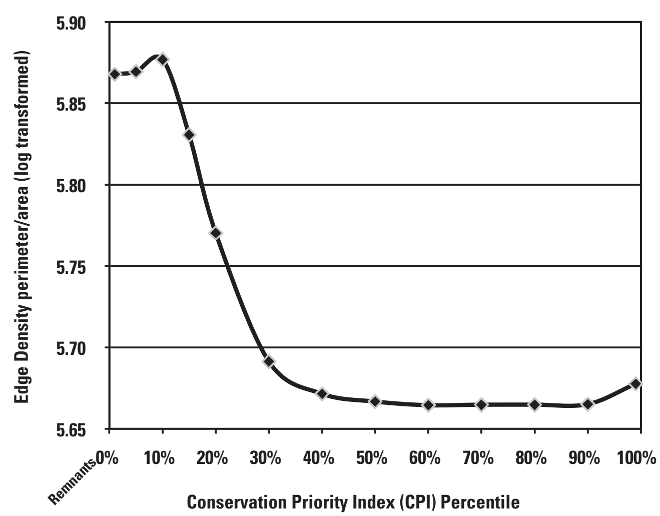

Figure 4. Potential increase in patch cohesion of prairie remnants if cropped areas within Loess Hills Special Landscape Areas (SLAs) displaying high values of a conservation priority index (CPI) were restored to native vegetation.

per hectare ($250-$1,000/ac). In many cases, we expect that the reconstruction of native grassland on former croplands will be more efficient at increasing core area for some area-sensitive species while lessening the impact of edge effect, than removing forest on lands once occupied by remnant prairie. We developed the conservation priority index (CPI) with this in mind.

We analyzed the CPI within SLAs, and our focus on them represents a further targeting mechanism—SLAs were previously selected by the Loess Hills Alliance, a multi-stakeholder conservation coalition—as focal conservation areas, thanks to the density of prairie remnants and the overall level of biodiversity contained within. The CPI further assists in the spatial prioritization of cropped areas that, when restored to prairie, might disproportionately affect the connectivity of remnants relative to their total extent. We found that the CPI revealed that a large proportion of land within SLAs was both near prairie remnants and had low suitability for growing corn. If croplands with high CPI values are converted to reconstructed prairie, dramatic increases in the total area and connectivity of grassland, along with a reduction in edge density, will result (Figures 4 and 5).

Challenges to both of these approaches remain, however. For example, sizable pockets of mature forest occur even within grassland-dominated areas of the Loess Hills today, compromising their potential to contribute to the effective conservation of grassland-obligate species in the region (Samson and Knopf 1994, Temple 2002, Walker 2005). Also, while grassland-dominated landscapes are larger and prairie remnants are relatively more connected in the Loess Hills compared to other regions of Iowa, they still may not be suitable for some species that are sensitive to edge effects and require large areas of core habitat, such as bobolinks (*Dolichonyx oryzivorus*) and northern harrier (*Circus cyaneus*) (Johnson and Igl 2001). Lastly, while the density of prairie remnants is higher within SLAs, the SLAs are 5.5 km apart on average and remain isolated from one another at the scale of the entire Loess Hills region (Figure 1). Thus, while efforts to alter the spatial characteristics within SLAs may prove successful to enhance the extent and connectivity of grasslands for grassland-obligate species, the conservation of these species could be still be thwarted by the lack of connectivity among SLAs.

CONCLUSION

While prairie remnants represent the richest pool of native biodiversity among land cover types in the Loess Hills, the landscape character of the region at present compromises their contribution to biodiversity preservation. Species dependent on grasslands require landscapes with large open spaces covered with perennial vegetation (Samson and Knopf 1994, Herkert et al. 2003). The Iowa Wildlife Action Plan is therefore seeking to create grassland landscapes of 800 ha or more to benefit grassland-obligate species that require large areas (IDNR 2007). Fulfilling the habitat requirements of these species necessitates the expansion of grassland habitat and an increase in its connectivity, if preservation goals are to be met. Effective methods of habitat expansion require a targeted approach to make the most of limited conservation funding. The future reconstruction of native prairie and the modification of nonnative grassland management should focus on portions of the landscape that provide the greatest potential conservation gains per expenditure of resources. We conducted our assessment with the goal of informing such a targeted approach and thereby revealed key landscape-level limitations associated with the current configuration of remnant prairie and other grassland types. In developing a Conservation Priority Index, we offered a mechanism to further prioritize the expenditure of restoration resources to improve the structural qualities of the Loess Hills landscape now and for the future.

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