Identifying optimal restoration sites to connect prairie remnants in southwest Wisconsin

Amy Dubruiel, Barbara Heindl, Kerry Wilcox,

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Capstone statement

Wisconsin prairies are significantly reduced from their original pre-settlement range (WDNR, 2017). Remaining remnants are often small, fragmented and isolated making them vulnerable to environmental threats and prairie-dependent species more susceptible to edge effects and genetic bottlenecks (Winter, et al., 2000; Herkert, 1994). We will identify optimal sites for prairie restoration that will create natural corridors connecting existing prairie fragments in southwest Wisconsin. We will assess restoration potential and identify sites by intersecting historic prairie boundaries, current land cover, and the habitat needs of a prairie-dependent species.

Introduction and background

Prior to European settlement, tallgrass prairies covered 6% of the Wisconsin's land area; today they cover less than 1% and are of varying quality (WDNRa, 2017). Remaining remnants are often small (10-50 acres), fragmented and isolated making them vulnerable to environmental threats (Winter, et al., 2000; Herkert, 1994). The threats to grassland communities are numerous. They include conversion to agriculture, development, invasive plants, transportation projects, fire suppression, water quality issues and ecological simplification (WDNR, 2015b). Natural grassland communities are also moderately to highly vulnerable to climate change (WICCI, 2017).

One approach to limiting fragmentation effects is to connect isolated prairie habitats with restored grassy corridors. Restored habitat corridors not only add additional acreage, they also facilitate dispersal of plant and wildlife populations, further guarding against genetic isolation and extinction (Christie and Knowles, 2015; Beier, et al. 2008; Haddad, et al. 2003; Lubchenco et al., 1991; Wilcox and Murphy, 1985).

Restoration techniques vary with the community type, site factors, goals of the property owner, and cost. Techniques for prairie restoration include prescribed burns, seeding, mowing, herbicide treatment, woody brush removal, grazing, and tree clearing (WDNR, 2015b; Rowe, 2010). For wet and wet-mesic prairies, techniques can also involve hydrologic alteration (Rowe, 2010). For tallgrass prairie restoration, barriers to restoration include seed availability, drought, knowledge, access to more land to restore, neighbor constraints and economic feasibility; the latter being most common hindrance (Rowe, 2010).

There are eight natural grassland communities in Wisconsin, including dry prairie, dry-mesic prairie, mesic prairie, wet-mesic prairie, wet prairie, bracken grassland and surrogate grassland (WDNR, 2015b). This project focused on how to best connect existing fragments of dry-mesic, mesic, wet-mesic, wet and dry prairie. The first three were traditionally considered tallgrass prairie (WDNR, 2017).

The goal of this project was to model and evaluate corridors for their efficiency and continuity, their economic feasibility, and their ecological suitability for a focal species. We chose Henslow's Sparrow (*(Ammodramus henslowii)* as our focal species. Henslow's Sparrow is a migratory passerine that uses prairies and grasslands throughout eastern North America. It is listed as Near Threatened by IUCN Red List; listed as a Species of Concern by the US Fish & Wildlife Service; is a state threatened species; and listed as a Species of Greatest Conservation need by the Wisconsin Department of Natural Resources. It has been identified as the highest priority for grassland bird conservation in North America by Partners in Flight (PIF). PIF is advocating for establishing large grassland areas for this species.

Study area

Wisconsin is divided into 16 Ecological Landscapes (Figure 1) based on the ecological features and management opportunities (WDNR, 2015a). Our study area is the Southwest Savanna Ecological Landscape, which includes parts of Dane, Iowa, Lafayette, Grant, and Green counties. To include several more prairies into our analysis, we included the far west portion of the Southeast Glacial Plains Ecological Landscape. In total, the study area is 2,151 square miles (90% Southwest Savanna, 10% Southeast Glacial Plains) and contains some of the best remaining prairie remnants, which survived on the rocky hilltops and steep slopes during the conversion to agriculture (WDNR, 2015a). Prior to settlement, prairie covered approximately 18% and oak openings covered approximately 30% of this area (Finley, 1976).

The current land cover in our study area is primarily agricultural with some pasture, forest and residential areas including Dodgeville, Mineral Point and Mount Horeb (WDNR, 2015a). Active habitat management is conducted by multiple conservation organizations and private landowners. The Wisconsin Wildlife Action plan (WWAP) assigns management opportunity scores to natural communities and dry prairie, dry-mesic prairie, mesic prairie, surrogate grasslands all have the category of "Major Opportunity" in these Ecological Landscapes (WDNR, 2015b).

The WWAP also assigns association scores to rare or vulnerable animal species, known as Species of Greatest Conservation Need (SGCN). The Southwest Savanna Ecological Landscape has 82 SGCN that are highly or moderately associated with it as well as 69 SGCN with the "low" association score. Forty-two rare plant species have also been found in study area, including the state endangered prairie bush-clover (WDNR, 2015a).

Figure 1: Wisconsin's 16 Ecological Landscapes. (WDNR, 2015a)

Methods

Our Conceptual Diagram can be found in Appendix A and our Implementation Diagram can be found in Appendix B.

Creating corridor polygons

The Wisconsin DNR's Natural Heritage Conservation program provided a shapefile of all mapped sand, dry, dry-mesic, mesic, wet-mesic, and wet prairie sites in Dane, Iowa, Green, Lafayette, and Grant counties. Once we removed the prairies outside of our study area, there were 45 prairie remnants remaining. The prairie polygons were originally mapped in a variety of ways; some were mapped to a quarter section, some were mapped as a line and then buffered, and some were mapped to the prairie remnant borders. There were also several prairies that had not been observed or surveyed in more than 40 years.

Because of the condition of the mapped prairies, we verified the polygons by overlaying them to 2010 digital orthophotos (WROC, 2010) and eliminated areas with significant tree cover and agricultural fields. Of the 47 prairies in our study area, 8 polygons were removed completely, 16 were refined and 23 needed no revision. Table 1 shows the natural community types of prairie polygons remaining in the study area versus the original layer.

	Original	Removed	No Edits Needed	Refined	Finished Prairie Layer
Dry	26	4	13	9	22
Dry-mesic	9	1	6	2	8
Mesic	9	2	3	4	7
Wet	2	1	0	1	1
Wet mesic	1	0	0	1	1
Total	47	8	23	16	39

Table 1: Number of prairies in the original and refined polygon layers grouped by natural community type.

To create corridors between the remaining prairie areas, we used Linkage Mapper tools developed for the Washington Wildlife Habitat Connectivity Working Group's (WHCWG) statewide connectivity analysis (2010). The program considers resistance values and distances of pixels from the core areas being connected to determine Least Cost Paths (LCP) between the core area polygons. Our project used land cover at the WISCLAND 2-Level 4 data for the resistance layer and we grouped and reclassified land cover types based on their relative ease of restorability (Table 2, Figure 2).

Our reclassification was based on the idea that cleared, tilled land is easier to convert to prairie than areas with invasive grasses and forbs that would need extensive burning, brush removal and herbicide application (Kurtz, 2013; Rowe, 2010; Packard and Mutel, 1997). Some land managers have even reported a specific preference for creating prairies from tilled soybean fields (Rowe, 2010). We considered woody vegetation increasing in difficulty from shrub to forest, and that developed lands and water bodies would be ranked most difficult.

WISCLAND2 Landcover Type	Relative Ease of Restoration	Restoration Cost
Warm-season Grass	Very easy	1
Cash Grain	Very easy	2
Continuous Corn	Easy	3
Dairy Rotation/Potato/Vegetable	Easy	5
Hay/Cool-season Grass	Moderately easy	10
Pasture	Moderately easy	15
Buckthorn/Honeysuckle/Broad-leaved Deciduous Scrub/Shrub/Needle-leaved Scrub/Shrub/Shrubland	Moderately difficult	30
Barren	Moderately difficult	40
Jack Pine/Red Pine/White Pine/Aspen Forest/N. Pin Oak, Black Oak/Red Oak/White Oak, Burr Oak/Central Hardwoods/Sugar Maple/Other	Difficult	75
Developed, Low Intensity/Open Water/Floating Aquatic Herbaceous Vegetation/Cattails/Reed Canary Grass/Other Emergent/Wet Meadow	Very difficult	95
Developed, High Intensity	Extremely difficult	100

Table 2: Ranking relative ease of current land cover restorability to prairie as used in resistance layer.

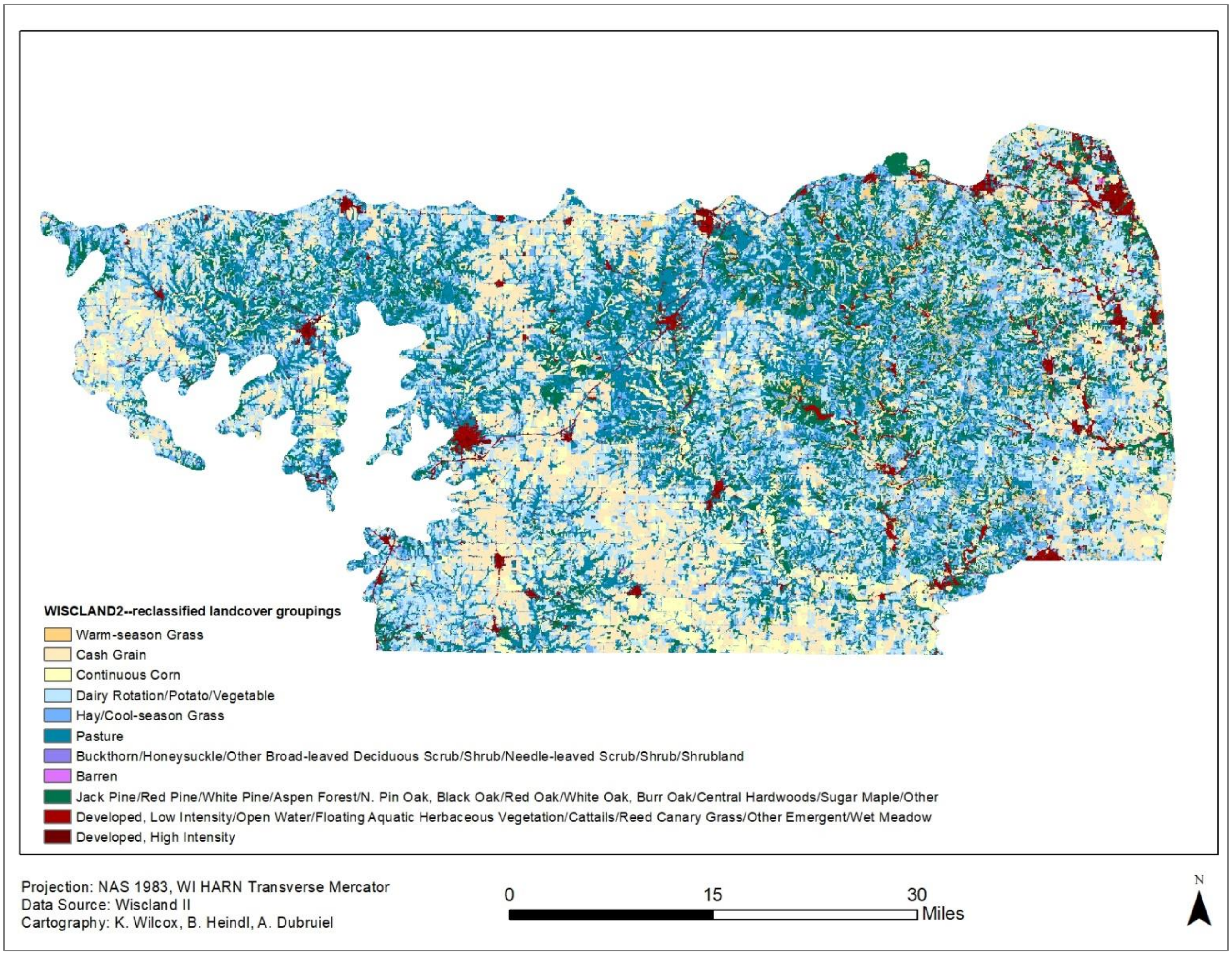

Figure 2: A close-up of the study area and the WISCLAND 2 reclassified landcover.

We set three parameters in Linkage Mapper when creating corridors: the maximum distance the program should look for prairies to connect, how many nearest neighbors to connect, and whether to pass through a prairie polygon on the way to another polygon. We ran the program using different maximum distances, and ultimately decided on 6500 meters, which captured 35 of the 39 prairie remnants and created 24 linkages (Figure 3). The remaining four prairies were isolated and separated by at least 10 km, which we felt would be beyond the scope of typical management goals. Changing the number of nearest neighbors did not change the results so we just used 1 nearest neighbor. We chose to have a corridor end whenever it hit a prairie polygon because we were not considering corridors that included more than two prairies as part of our ranking.

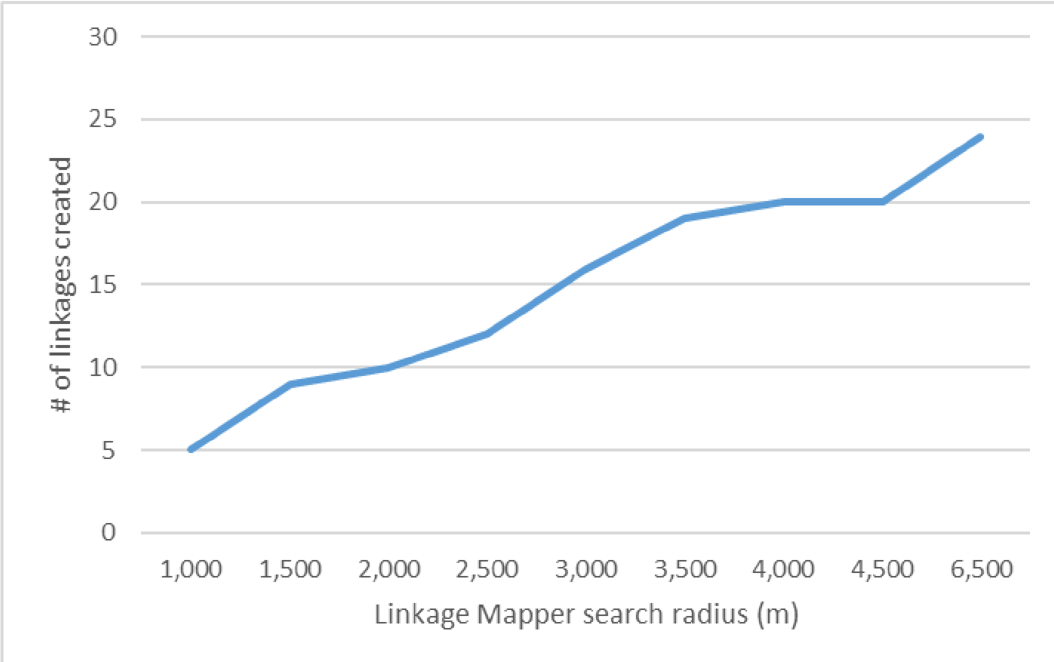

Figure 3: Number of linkages created by Linkage Mapper program as search distance increased.

We converted the generated linkages into least-cost corridors using the values of the cells assigned by Linkage Mapper at 0.125%, 0.25%, 0.5%, 0.75% and 1.0% of the highest value. These corridors represented the most 'restorable' habitat corridors between existing prairies. Sawyer et al. 2011, compared corridor studies and found there were several methods used to create the corridor. The method reflects the goal of the project and can include using a set buffer distance, using a cumulative kernel, or like us, selecting a percent of the lowest cost cells. Once we created the corridors to the different percent cut-offs, we converted them to polygons for further analysis.

Assessing efficient and continuous variables used for ranking corridors

Each polygon was assessed using area to perimeter, restorability cell values total, and road density. Area to perimeter assesses the "edginess" of the corridor. Restorability cell values totals are the values of the cells inside the corridor assigned by our WISCLAND 2 resistance layer. Road density was assessed by overlaying the roads and summarizing the raster values using Arcmap Zonal Statistics within the corridor (see Figure 4).

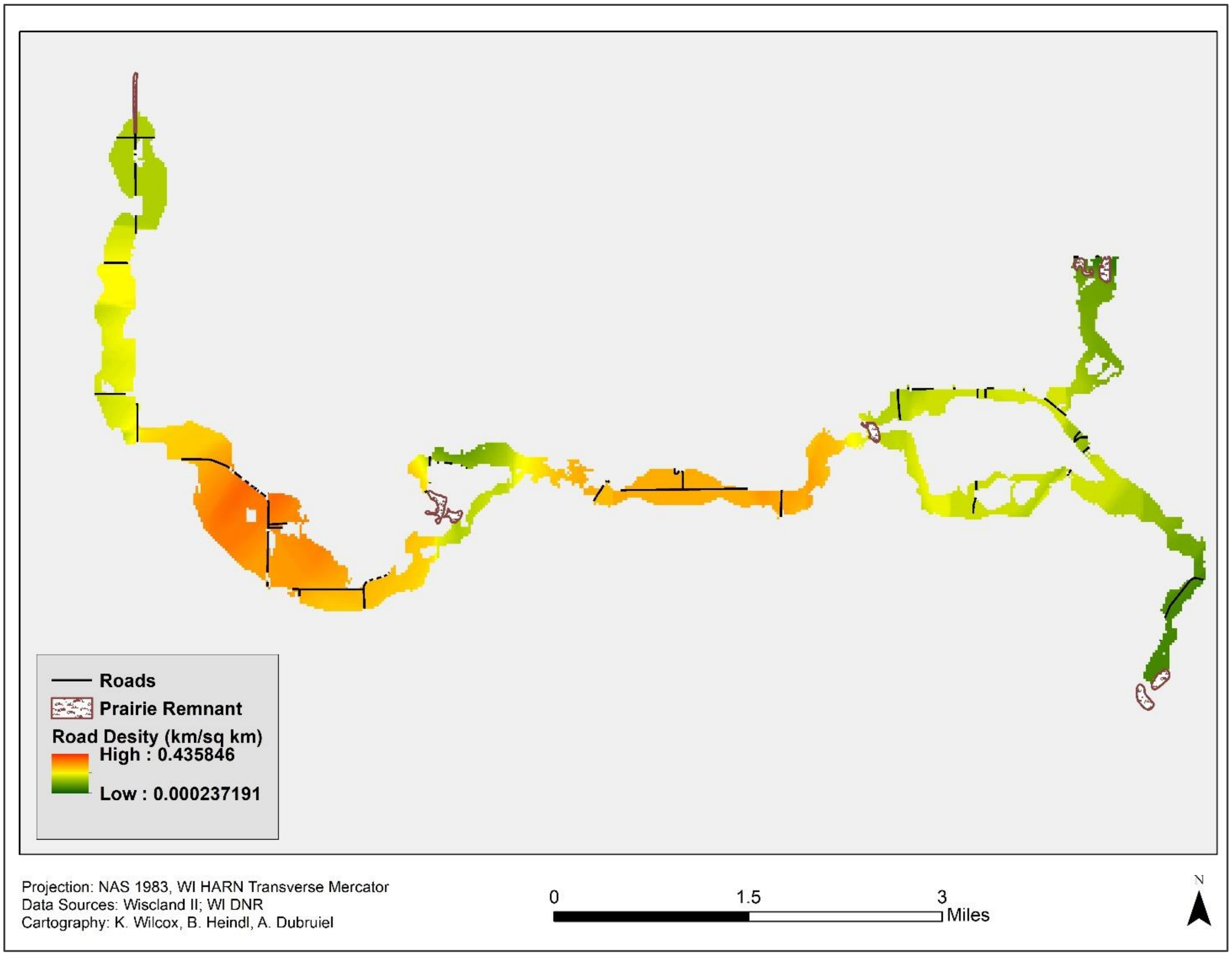

Figure 4: Visualization of road density and roads within a corridor.

Assessing economic variables used for ranking corridors

Each polygon was assessed based on its ease of restoration by criteria related to parcel ownership. Ranking criteria included number of land owners across the polygon (land ownership) and percent of corridor under current easement/stewardship activity (LIP) or owned by a conservation minded organization such as The Prairie Enthusiasts (TPE), The Nature Conservancy (TNC) or the DNR.

Assessing suitability for a focal species for ranking corridors

Although individual territories of Henslow's Sparrow are often less than 1 hectare, the overall size of the grassland habitat usually needs to be a minimum of 55 hectares for the species to utilize the patch consistently; larger areas are likely necessary in isolated patches (Reinking, 2002; Herkert, 1998). To assess whether a corridor met this minimal requirement, we considered all corridors 55 ha or greater as suitable, and all corridors under 55 ha were considered not suitable.

Distance to current Henslow's Sparrow populations may also be a critical factor for dispersal. Hayden (1995, cited in Herkert (1998)) suggests that especially for small fragments, the distance be less than 1.6 km. To assess whether a corridor was suitable, we measured the distance from the closest known Henslow's Sparrow location (WDNR unpublished data) to the Least Cost Path (LCP) of the corridors. If the corridor was 1.6 km or less from the Henslow's Sparrow's location, it was deemed suitable; if the distance was greater than 1.6 km, the corridor was deemed not suitable.

Finally, studies indicate that individuals are less likely to occupy and nest within 50m of shrub or woodland boundaries (O'Leary and Nyborg, 2000; Winter et al., 2000; Winter, 1998). We assessed the corridor for how often it became restricted or "pinched" to less than 100m in width. To accomplish this, we measured the length of the Least Cost Path (LCP) when the corridor was less than 100m (Figure 5).

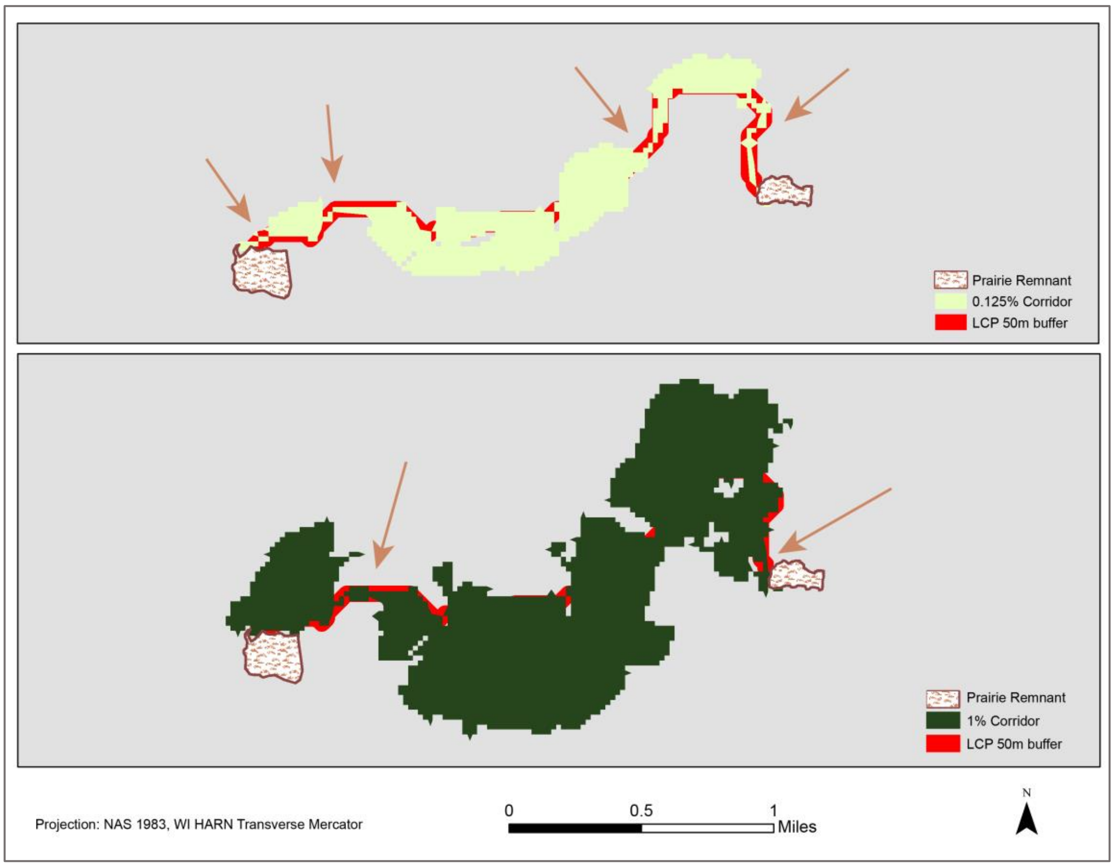

Figure 5: "Pinchpoints", or corridor lengths less than 100 m wide.

Ranking methodology

To rank the corridors, we took the values generated in previous steps and normalized the data to area of the proposed corridor. We then divided the values into 5 Natural Jenks categories for perimeter to area, restorability cell value total, road density, the number of landowners, percent owned or managed by conservation-minded groups or individuals and Henslow Sparrow "pinch" data. Henslow's Sparrow distance to corridor and Henslow's Sparrow hectare requirement were simple Boolean evaluations.

Once the appropriate ranks were assigned, we combined the numbers. If a corridor was of the highest rank for 2 of the 3 variables in the efficient and continuous category, it proceeded to the next step. The economic variables were restrictive, so if a corridor was the highest rank for 1 of the 2 variables, it proceeded to next step. For the ecological (Henslow's Sparrow) variables, if a corridor was the highest rank for 2 out of the 3 variables, it proceeded to the next step. The corridors that proceeded to the next step in all 3 categories, it was considered the "best" corridors. Table 3 shows top ranking corridors and how they ranked. Appendix C has all corridors and how they ranked.

Results

Running Linkage Mapper using a 6500m search radius produced 24 Least Cost Paths (LCP) (Figure 6). From those 24 we were able to create 120 corridors by applying the five cost weighted cut-off values at 0.125%, 0.25%, 0.5%, 0.75% and 1.0% for each of the 24 corridors.

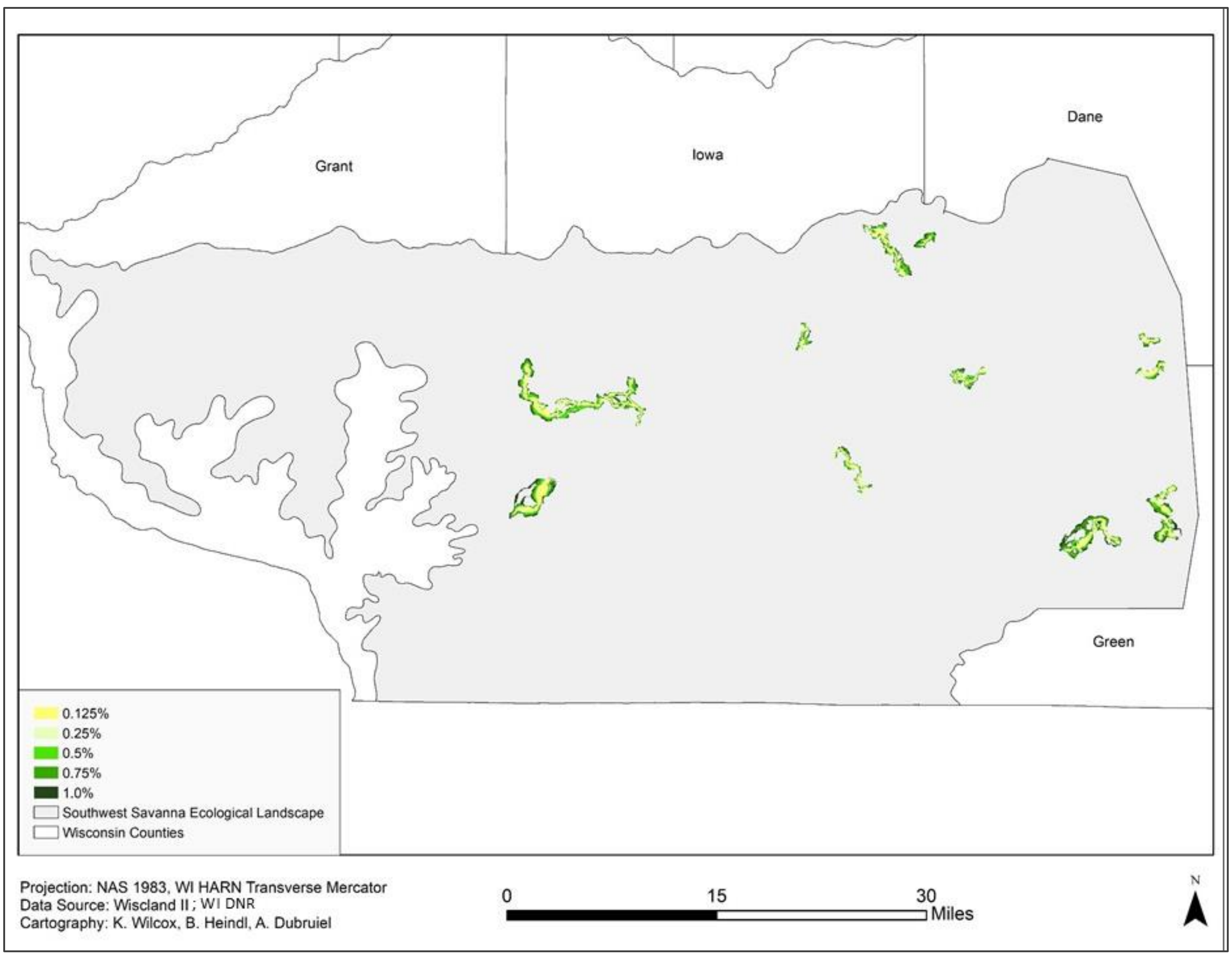

Figure 6: Location of the twenty-four corridors at five cost-weighted value cutoffs.

The initial Linkage Mapper output raster covered the entire study area with each LCP needing refining (Figure 7), which was not practical as a management tool. As discussed in the methods section, we trimmed the raster output to five value cutoff widths (0.125%, 0.25%, 0.5%, 0.75%, 1.0%), and converted the results to polygons (Figures 6, 8). The area covered by all twenty-four of the largest corridor polygons (at the 1.0% value cutoff) is 19344 acres; the area covered by the twenty-four smallest polygons (0.125% cutoff) is 4688 acres.

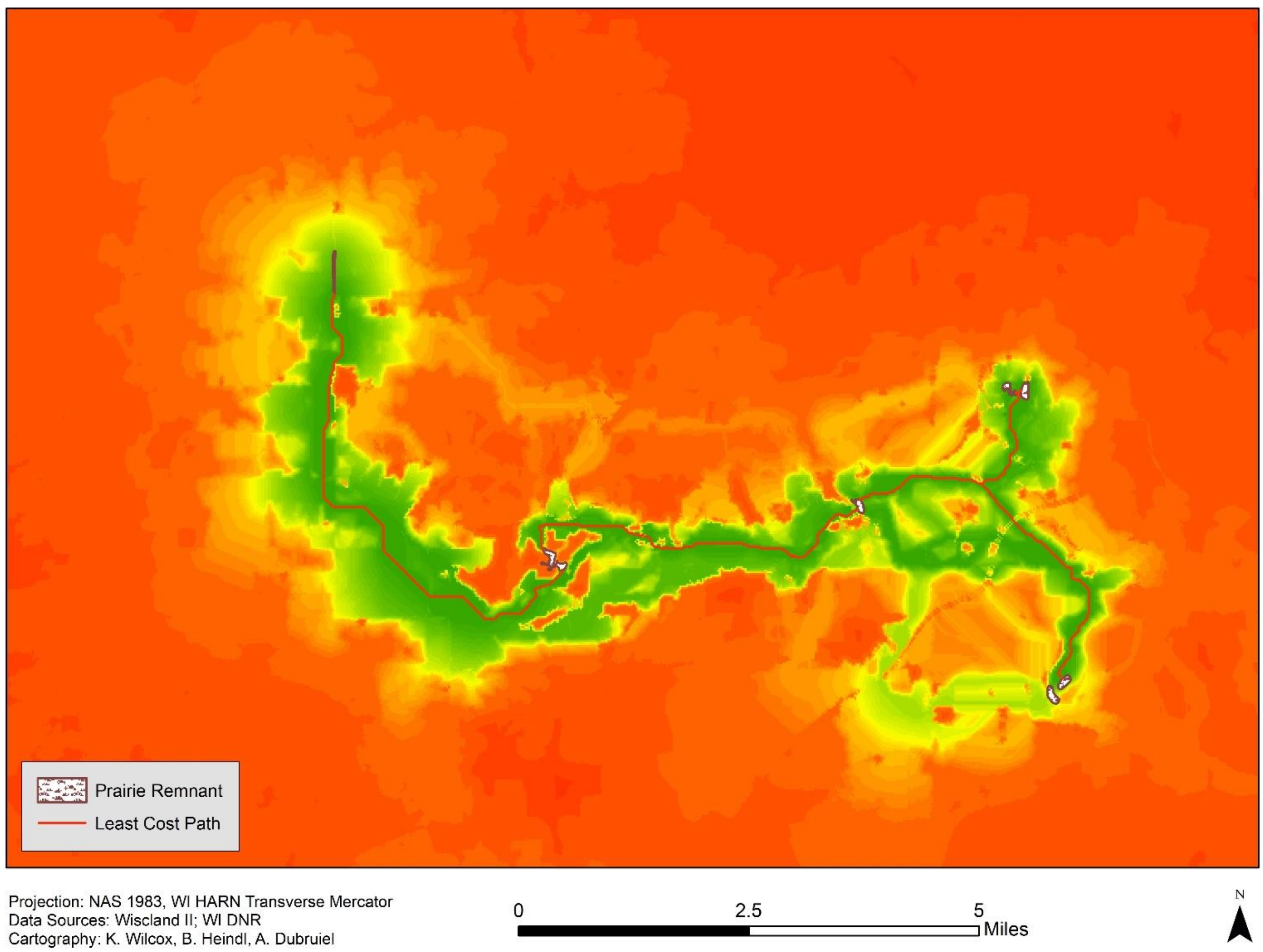

Figure 7: Linkage Mapper output showing pixel values increasing from green to red, with green being the most efficient route between prairies regarding landcover restorability.

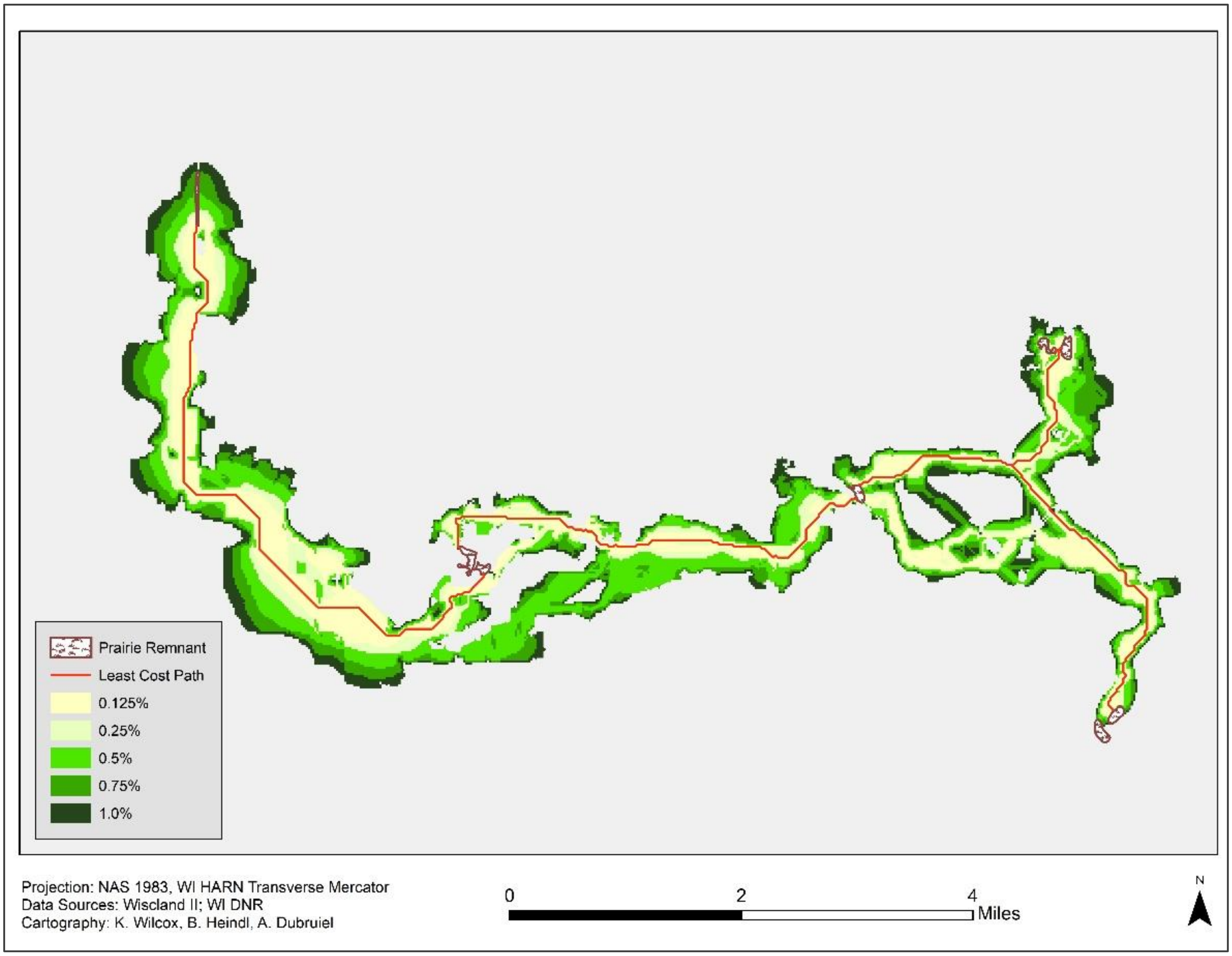

Figure 8: Close up of corridor cluster with least cost path, percent cut-off boundaries and core prairie locations.

No corridors were the highest rank for all the variables. Only 3 corridors (bolded in Table 3) showed up in all 3 categories (efficient and continuous, economic and focal species suitability) with looking at 2 out of 3 or 1 out of 2 variables (Table 3). Table 3 also highlights the corridors that ranked highest for individual categories.

	Efficient and Continuous Variables			Economic Variables		Focal Species Suitability		
LINK AT % CUT-OFF	RANK_ AreatoPerimeter	RANK_ COST	RANK_ Road	RANK_ Landowner	RANK_ Con-Minded	RANK_ HESPDist	RANK_ HESPArea	RANK _ HESPPinch
28 at 0.125	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**
28 at 0.25	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**
85 at 0.125	**1**	**1**	**2**	**1**	**4**	**1**	**1**	**4**
52 at 0.125	2	1	1	4	1	2	1	3
67 at 0.125	2	1	1	4	1	2	2	2
7 at 0.25	5	1	1	5	5	2	1	1
52 at 0.25	3	2	2	5	1	2	1	1
67 at 0.25	3	2	1	5	1	2	1	1
85 at 0.25	1	2	3	1	4	1	1	1
27 at 0.5	3	2	1	4	1	2	1	1
85 at 0.25	1	2	3	1	4	1	1	1
17 at 0.5	2	3	1	5	5	1	1	1
59 at 0.5	2	3	3	5	4	1	1	1
85 at 0.5	3	3	1	2	5	1	1	1
17 at 2000	3	4	2	5	5	1	1	1
58 at 2000	3	3	5	4	4	1	1	1
59 at 2000	3	4	4	5	4	1	1	1
78 at 2000	3	5	5	4	5	1	1	1
85 at 2000	3	4	2	3	5	1	1	1
89 at 0.125	1	1	1	4	5	2	2	1

Table 3: Top ranking corridors with the ranking scheme. The bolded corridors ranked highest overall.

Discussion

Most literature we reviewed prior to this project focused on a species-first approach (WHCWG, 2010; Beier and Noss, 1998). While a species-centric approach is logical, especially when dealing with species of concern, we focused first on the restoration potential of the current landcover. We feel this strategy is more realistic and easier to adapt depending on the specific needs or available resources of the manager, whether they be a focal species' site needs, group finances, grant considerations and goals, etc. It also acknowledges that we live in a heavily modified environment and focuses on land potential not on what is left, we also feel that this is a more optimistic look at the future instead of trying to piece together corridors from the bare bones remains of prairie fragments left on the landscape.

Though initially we wanted to include a suite of different species, we focused ultimately on Henslow's Sparrow primarily because significant habitat research had already been done on them, especially regarding spatial needs and aversion to edge habitat. While we wanted to include species which had a variety of needs including different dispersal strategies which might be more affected by road or water crossings (the slither effect) or different substrate needs such as fossorial species (Franklin's Ground squirrel or Badgers) we were unable to find sufficient literature in a timely fashion for this project. That being said, we believe that we have set up a framework that could easily be adapted for a number of different scenarios, including different species.

A number of what seemed like excellent corridors, in regard to economic considerations and restorability, ultimately were ranked low when we added Henslow's Sparrow occupancy data, meaning they were simply too far from current populations. Depending on the needs/resources of a manager these could still be considered, especially if the manager were willing to look at a potential translocation.

Ranking was accomplished by evaluating each corridor separately, and without considering the prairies it connected. This may have led to the exclusion of potentially beneficial corridors for reason that may have been resolved as part of a larger network or cluster. Further iterations of this project might include a weighting or higher ranking for corridors that are a part of a larger network to give slightly deficient corridors the boost of being part of a greater complex of corridors and furthering the goal of increasing prairie remnant networking across the area.

In the process of creating Least Cost Paths (LCPs) we limited our model to creating LCPs for prairies that were within 6.5 km of each other. While we could have expanded that distance and potentially created potential corridors that reached our 4 isolated prairies, these prairies were at least 10 km away from the others. We decided to restrict generated lengths because the likelihood of a having the economic resources to restore 10 km+ corridors felt unrealistic. That being said, with enough money anything is possible, and potential corridor paths could be generated if other resources were plentiful.

Various other studies used different methods to create corridor widths for generated LCP's including fixed length buffers and kernel density estimates (Sawyer et al, 2011). Again, these are fine techniques if the aims of the project are specific and resources are never ending and may be preferable to use areas with lower variation in landcover types. Buffering, for example, would allow areas that would be very costly and inefficient to restore since they weigh surrounding landcover types with less scrutiny.

Given that our study area has a large variety of landcover types that are frequently matrixed alongside relatively decent restorable areas, we decided to go with defined percentage cutoffs for our corridor width determination, which focused on our reclassified landcover and the restorability of a corridor. This allowed the economic advantage on focusing on relatively cost efficient, restorable corridors which we thought was more realistic and then assessing from there as to whether corridors met overall goals for the project, in our case suitability for Henslow's Sparrow. While using a buffer would have easily given us corridors of appropriate widths for Henslow's Sparrow, we felt that the cost value based on restorability of many corridors would have increased drastically given the highly diverse mix of landcover types in our study area.

While we did not generate fixed length buffer corridors to compare due to time constraints, we did compare the restorability values along the LCP versus the Euclidean distance between the same prairie fragments, and found Euclidean restoration costs, albeit shorter, were more costly to restore in every case (Figure 9).

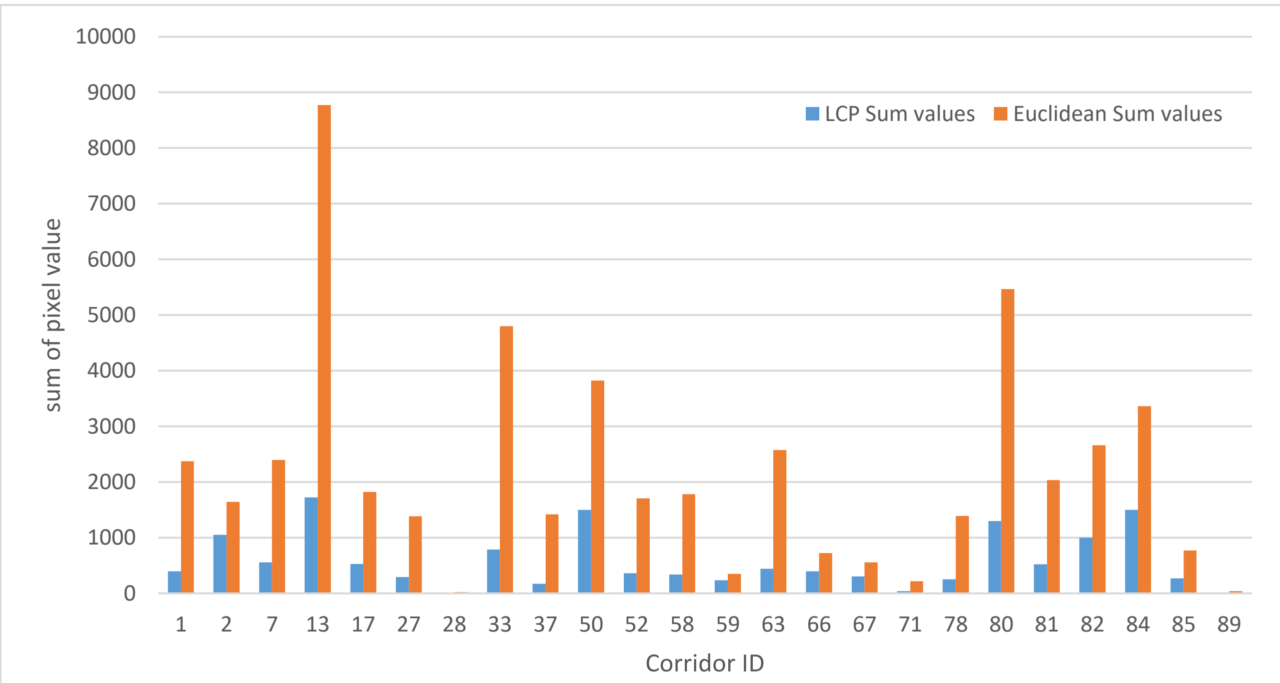

Figure 9: Summed Least Cost Path (LCP) pixel values compared to summed Euclidean distance values, confirming that the LCP was 'cheaper' to pass through than a straight line between prairie remnants, with respect to restoration ease for the associated land.

While our project focuses on the restoration potential of a corridor, all species ranking is done based on the assumption that a corridor is actually restored to natural prairie. This does not take into account that many non-native/non-restored landcover types can still be useful corridors for several species. We based rankings and focused on the ideal situation and aim of restoring all proposed corridors. If we took a more species-focused front-end approach, it might have been more advantageous to rank areas like cool-season grasslands or pasture land higher as they can provide proxy habitat for species like Henslow's Sparrows even though it is potentially more difficult to restore due to compacted soils and established non-native plant species.

Like all modeling projects, site visits and ground truthing should be done before any actual restoration is done. We visited several of our proposed corridors and were relatively pleased with what we saw. While our prairie layer omitted several properties owned by known conservation organizations such as The Nature Conservancy and The Prairie Enthusiasts, we found that a number of those properties were present in our proposed corridors. Working these sites earlier into the corridor creation process, and potentially into the landcover reclassification, might create different proposed corridors which have the added benefit of already being under active restoration management.

If the largest corridors (1.0% cutoff) were to be restored based on our output, an additional 19,344 acres of prairie habitat would be created; restoring the smallest corridors (0.125% cutoff) would yield 4688 acres. Either scenario significantly increases the amount of prairie habitat in Wisconsin, which currently stands at less than 10,000 acres. The value of these restored acres would likely be multiplied due to their connectivity with current habitat fragments, allowing for safe passage and genetic exchange (Christie and Knowles, 2015; Beier and Noss, 1998).

It is clear that while our prairie fragments were much smaller than typical core habitat patches in restoration literature (WHCWG, 2010), the corridors that our analysis produced would significantly increase prairie habitat, buffer the remnants and provide better mobility opportunity for wildlife. This is a testament to the need for restoration and importance of corridors to decrease species isolation and genetic bottlenecks within the remnants we worked with and attempt to slow the decline of many of our native unique prairie species.

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Project shapefiles

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Landowner Incentive Program grants--Wisconsin Department of Natural Resources.

Land trust easements--Driftless Area Land Conservancy.

Wiscland 2--Wisconsin Department of Natural Resources.

Wisconsin NHI data (Henslow’s Sparrow)--Wisconsin Department of Natural Resources.

Wisconsin parcel data-- Statewide Parcel Map Database Project (V3). Created by: The Wisconsin State Cartographer's Office

Wisconsin roads—Wisconsin Department of Natural Resources.

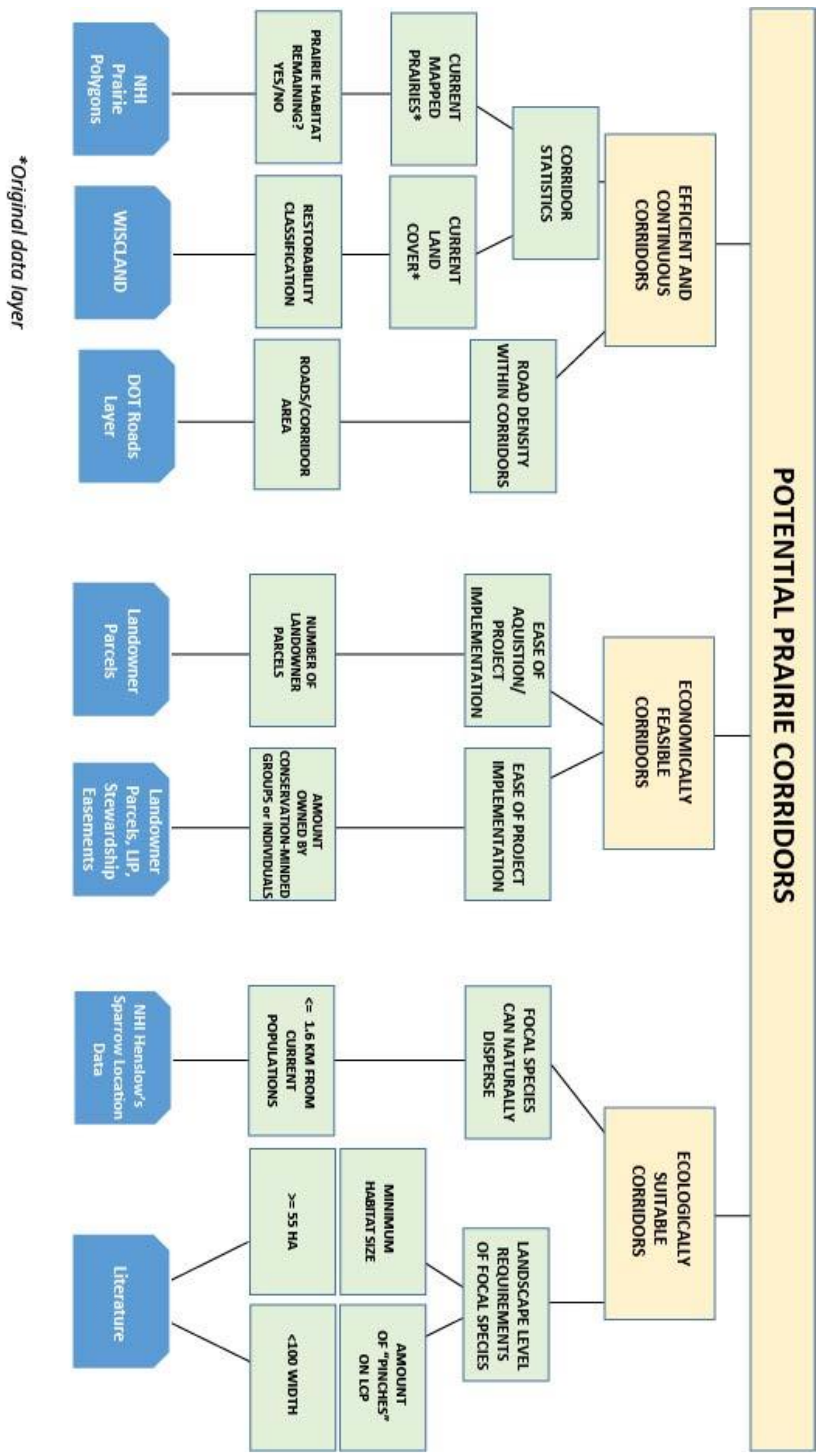
Digital Orthophoto (DOP) Coverage for Dane County- WI Regional Orthophoto Consortium (WROC) 2010.

Photo credit

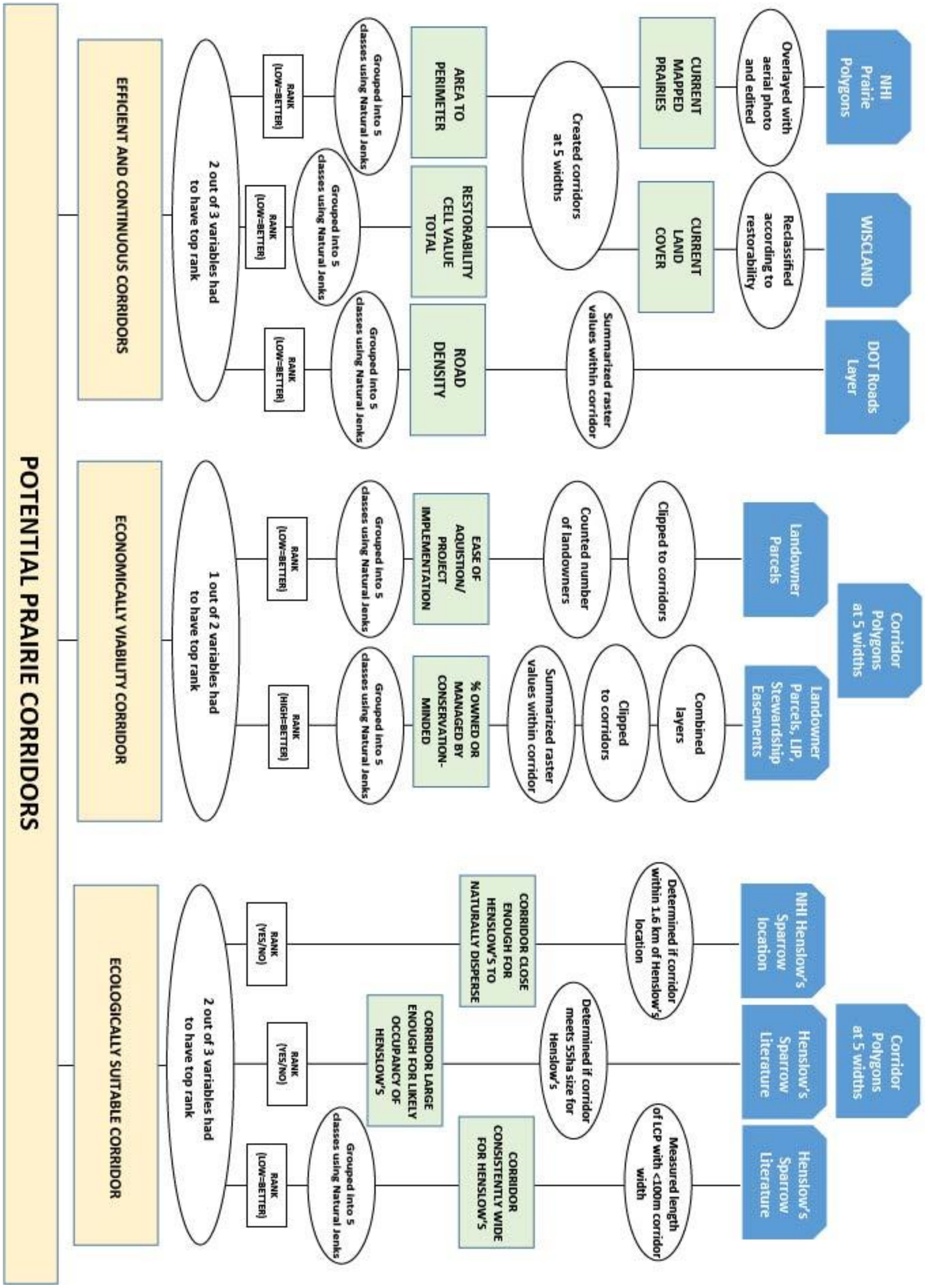
Amy Dubruiel

Appendices

Appendix A-Conceptual diagram



Appendix B-Implementation diagram



Appendix C-All corridors and their ranks

Width_ Percentage	Link_ Width	Link_ Num	CorridorID	Rank_ AreatoPeri	RANK_ COST	RANK_ Road	RANK_ #Landowner	RANK_ Con-Minded	RANK_ HESPDist	RANK_ HESPArea	RANK _ HESPPinch
0.125	250	1	251	2	1	3	2	5	2	1	4
0.125	250	2	252	2	2	2	3	5	2	1	3
0.125	250	7	257	4	1	1	5	5	2	1	2
0.125	250	13	263	1	3	1	4	3	2	1	5
0.125	250	17	267	1	2	1	4	2	1	2	3
0.125	250	27	277	2	2	1	3	5	2	2	2
0.125	250	28	278	1	1	1	1	1	1	2	1
0.125	250	33	283	3	1	2	4	5	2	1	2
0.125	250	37	287	2	1	2	2	5	2	2	1
0.125	250	50	300	2	2	1	2	5	2	1	3
0.125	250	52	302	2	1	1	4	1	2	1	3
0.125	250	58	308	2	2	2	3	4	1	2	2
0.125	250	59	309	2	2	2	3	4	1	2	1
0.125	250	63	313	2	1	2	2	4	2	1	3
0.125	250	66	316	3	2	2	4	5	2	1	2
0.125	250	67	317	2	1	1	4	1	2	2	2
0.125	250	71	321	1	1	2	3	2	2	2	2
0.125	250	78	328	1	4	1	3	2	1	2	3
0.125	250	80	330	1	3	2	3	5	2	1	4
0.125	250	81	331	1	2	1	2	5	2	2	4
0.125	250	82	332	1	4	1	3	5	2	1	4
0.125	250	84	334	1	4	1	4	5	2	1	5
0.125	250	85	335	1	1	2	1	4	1	1	4
0.125	250	89	339	1	1	1	4	5	2	2	1
0.25	500	1	501	3	2	4	2	5	2	1	1
0.25	500	2	502	2	2	3	4	5	2	1	2
0.25	500	7	507	5	1	1	5	5	2	1	1
0.25	500	13	513	2	3	2	5	3	2	1	4
0.25	500	17	517	2	2	2	4	2	1	1	2
0.25	500	27	527	3	2	1	3	5	2	1	1
0.25	500	28	528	1	1	1	1	1	1	2	1
0.25	500	33	533	4	1	3	4	5	2	1	1
0.25	500	37	537	3	1	3	2	5	2	2	1
0.25	500	50	550	3	2	1	2	5	2	1	3
0.25	500	52	552	3	2	2	5	1	2	1	1
0.25	500	58	558	2	2	3	3	3	1	2	1
0.25	500	59	559	1	2	3	4	4	1	2	1
0.25	500	63	563	2	2	3	2	4	2	1	2

0.25	500	66	566	4	2	3	4	5	2	1	1
0.25	500	67	567	3	2	1	5	1	2	1	1
0.25	500	71	571	2	2	3	4	2	2	2	1
0.25	500	78	578	2	5	2	2	3	1	2	2
0.25	500	80	580	2	3	3	4	5	2	1	3
0.25	500	81	581	1	3	1	3	5	2	1	3
0.25	500	82	582	2	4	2	3	5	2	1	3
0.25	500	84	584	2	5	2	5	5	2	1	2
0.25	500	85	585	1	2	3	1	4	1	1	1
0.25	500	89	589	1	2	4	1	5	2	2	1
0.5	1000	1	1001	4	2	3	3	5	2	1	1
0.5	1000	2	1002	3	3	1	4	5	2	1	2
0.5	1000	7	1007	5	2	2	5	3	2	1	1
0.5	1000	13	1013	3	4	1	5	2	2	1	2
0.5	1000	17	1017	2	3	1	5	5	1	1	1
0.5	1000	27	1027	3	2	1	4	1	2	1	1
0.5	1000	28	1028	1	3	3	5	5	1	2	1
0.5	1000	33	1033	4	2	3	5	5	2	1	1
0.5	1000	37	1037	3	2	1	3	5	2	1	1
0.5	1000	50	1050	3	3	2	2	1	2	1	3
0.5	1000	52	1052	4	2	3	5	4	2	1	1
0.5	1000	58	1058	3	2	3	4	4	1	2	1
0.5	1000	59	1059	2	3	3	5	4	1	1	1
0.5	1000	63	1063	3	2	3	2	5	2	1	1
0.5	1000	66	1066	5	2	1	5	2	2	1	1
0.5	1000	67	1067	3	3	3	5	2	2	1	2
0.5	1000	71	1071	2	2	2	5	3	2	1	1
0.5	1000	78	1078	2	5	3	3	5	1	2	1
0.5	1000	80	1080	3	4	1	5	5	2	1	2
0.5	1000	81	1081	2	4	2	4	5	2	1	1
0.5	1000	82	1082	3	5	2	5	5	2	1	1
0.5	1000	84	1084	3	5	3	5	4	2	1	1
0.5	1000	85	1085	3	3	1	2	5	1	1	1
0.5	1000	89	1089	1	5	5	1	5	2	2	1
0.75	1500	1	1501	3	2	4	4	5	2	1	1
0.75	1500	2	1502	3	3	3	4	5	2	1	1
0.75	1500	7	1507	5	2	3	5	3	2	1	1
0.75	1500	13	1513	3	4	3	5	2	2	1	2
0.75	1500	17	1517	3	3	2	5	5	1	1	1
0.75	1500	27	1527	3	3	1	4	1	2	1	1
0.75	1500	28	1528	1	4	4	3	5	1	2	1
0.75	1500	33	1533	5	2	4	5	5	2	1	1

0.75	1500	37	1537	4	2	2	4	5	2	1	1
0.75	1500	50	1550	4	3	3	2	2	2	1	3
0.75	1500	52	1552	4	3	4	5	4	2	1	1
0.75	1500	58	1558	3	3	5	4	4	1	1	1
0.75	1500	59	1559	3	4	4	5	4	1	1	1
0.75	1500	63	1563	3	2	4	3	5	2	1	1
0.75	1500	66	1566	4	2	2	5	2	2	1	1
0.75	1500	67	1567	3	4	4	5	2	2	1	2
0.75	1500	71	1571	3	2	2	5	3	2	1	1
0.75	1500	78	1578	3	5	4	5	5	1	1	1
0.75	1500	80	1580	4	4	2	5	5	2	1	2
0.75	1500	81	1581	3	4	4	4	5	2	1	1
0.75	1500	82	1582	4	5	4	5	5	2	1	1
0.75	1500	84	1584	3	5	4	5	4	2	1	1
0.75	1500	85	1585	3	4	3	3	5	1	1	1
0.75	1500	89	1589	1	4	5	3	5	2	2	1
1	2000	1	2001	4	3	4	4	5	2	1	1
1	2000	2	2002	3	3	3	5	5	2	1	2
1	2000	7	2007	5	2	3	5	3	2	1	1
1	2000	13	2013	3	4	3	5	2	2	1	2
1	2000	17	2017	3	4	2	5	5	1	1	1
1	2000	27	2027	3	3	1	4	1	2	1	1
1	2000	28	2028	1	4	5	3	5	1	2	1
1	2000	33	2033	5	2	5	5	5	2	1	1
1	2000	37	2037	4	2	2	5	5	2	1	1
1	2000	50	2050	4	3	4	2	2	2	1	2
1	2000	52	2052	4	3	5	5	4	2	1	1
1	2000	58	2058	3	3	5	4	4	1	1	1
1	2000	59	2059	3	4	4	5	4	1	1	1
1	2000	63	2063	3	3	5	3	5	2	1	1
1	2000	66	2066	5	2	2	5	2	2	1	1
1	2000	67	2067	4	4	4	5	2	2	1	1
1	2000	71	2071	4	3	2	5	3	2	1	1
1	2000	78	2078	3	5	5	4	5	1	1	1
1	2000	80	2080	4	4	2	5	5	2	1	1
1	2000	81	2081	3	4	4	4	5	2	1	1
1	2000	82	2082	4	5	4	5	5	2	1	1
1	2000	84	2084	4	5	4	5	4	2	1	1
1	2000	85	2085	3	4	2	3	5	1	1	1
1	2000	89	2089	2	4	5	5	5	2	2	1