Coarse-level monitoring protocol for assessing baseline condition and restoration progress in oak and pine barrens

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Introduction

Midwest oak and pine barrens are globally rare and have long been a focus of conservation efforts, with increased restoration focus beginning in the 1990s and expanding through the present. Most barrens have been degraded through past grazing, severely altered fire regimes, invasive species, and fragmentation. Oak and pine barrens support a disproportionate number of rare species relative to other natural communities, including federally endangered species such as the Karner blue butterfly (*Lycaeides melissa samuelis*) and the Kirtland's warbler (*Setophaga kirtlandii*). Significant resources have been invested in restoring and maintaining barrens by public agencies and private organizations and barrens restoration and management was identified as a high priority by the Wisconsin DNR in 2017.

As interest in managing barrens has increased, so has the need to identify sites with the highest restoration potential, as well as the need to assess restoration progress over time. Monitoring is often problematic for managers with limited time or those with limited botanical expertise, and is often limited to photo points or cursory, qualitative visual inspections that are inconsistent and non-repeatable. On a subset of sites, such as those managed for rare species like the Karner blue butterfly, species-specific monitoring is conducted. While population surveys and habitat suitability monitoring of indicator species is crucial, more comprehensive community-level monitoring of ecological integrity encompassing the full range of barrens sites is needed, especially for sites that are ecologically significant but are not known to support federally listed species. In addition, using consistent measures of community structure and composition in multiple barrens sites across multiple ownerships and ecological landscapes would provide a valuable index of their conservation status.

We designed a monitoring approach for oak barrens based on ecological integrity. Ecological integrity is a concept used extensively by NatureServe and is grounded in the best scientific understanding of high-functioning ecosystems, taking into account ecological processes, vegetation composition and structure, and anthropogenic disturbance (Parrish et al. 2003, Faber-Langendoen et al. 2016).

A key principle of ecological integrity assessments (EIA) is the ability to implement monitoring at multiple scales depending on level of detail desired, expertise, and available resources. Typically, these are designated as Level 1 (remote sensing), Level 2 (moderate detail), and Level 3 (most detailed). We designed barrens EIA protocols and forms for Level 2 (accommodates time-constrained practitioners and/or those with limited botanical expertise) and Level 3 (requires greater time investment and a high level of botanical expertise). While the Level 2

protocol is presented here; draft Level 3 forms and protocol are available upon request from the authors.

Coarse-level monitoring (also called coarse-level metrics) focuses on key ecological attributes, or metrics, that are biologically important for plant and animal species and that can be influenced by management. First developed and used by The Nature Conservancy (TNC) along with the Huron-Manistee National Forests (HMNF) in Michigan, coarse-level metrics have shown to provide a relatively quick and inexpensive means to track the progress of restoration and maintenance in oak and pine barrens (Keogh et al. 2011). Evaluation of these metrics requires basic understanding of barrens ecosystems but does not require extensive botanical expertise. The metrics are designed so that land managers and stewards can evaluate restoration success and determine the next restoration or management step(s) needed, without relying on external botanists or ecological consultants (Keogh 2011).

Ten metrics have been selected for coarse-level monitoring of oak barrens based on key ecological attributes. Each metric is evaluated independently, with observers recording their observation, a corresponding letter grade (A, B, C, D), and a numerical score. Metrics are grouped into four categories and include:

Barrens composition

1) Percent cover of native grasses and sedges not including Pennsylvania sedge
2) Number of native barrens indicator species (see checklist with photographs)
3) Percent cover of native disturbance indicators [e.g., Pennsylvania sedge (*Carex pensylvanica*), bracken fern (*Pteridium aquilinum*), blackberry/raspberry/bristleberry species (*Rubus* spp.), and other weedy natives]

General composition

4) Relative percent cover of all native plants (ratio of native to non-native species)
5) Percent cover of invasive species [e.g., knapweed (*Centaurea* spp.), orange hawkweed (*Hieracium aurantiacum*), bluegrass (*Poa pratensis*), sweet-clover (*Melilotus* spp.), etc.]
6) Tree composition appropriate for the region: relative percent cover of oaks (and regionally pines) in the tree layer (woody vegetation over 20 feet tall)

Vegetation Structure

7) Percent cover of medium-statured shrubs (2 – 6 feet tall)
8) Percent cover of saplings and tall shrubs (6 – 20 feet tall)
9) Percent cover of overstory (trees over 20 feet tall)

Spatial Heterogeneity

10) Spatial heterogeneity of canopy and openings

General Methods

1. Divide the site into assessment areas (AAs) that are useful for both management and monitoring purposes (Figure 1). Assessment areas may be based on natural ecosystem boundaries, existing management units, or prescribed burn units. Disturbed areas, such as a ditched or plowed area, or dense clumps of invasive species, may be split into separate AAs. It is recommended that AAs be at least 2-3 acres in size and may be up to 40 acres in size or more, recognizing, however, that it may be challenging to accurately complete the coarse-level protocol in very large areas. In a

document or on a map, record the boundaries of your AAs and document the rationale for the layout to facilitate knowledge transfer.

It is recommended that a goal (or desired future condition) for the AAs be clearly articulated. Examples of desired future condition include dry sand prairie, oak barrens, jack pine barrens. The metrics described here may be applied differently, or not at all, in units having a goal other than oak or pine barrens.

2. To ensure AAs are adequately covered in surveys, meander through the AA being careful to equally cover all available habitat, including areas that are open, brushy, and canopied. To facilitate adequate coverage in the field and avoid observer bias, survey routes may be established *a priori* that zig-zag across the entire AA (Figure 1). For large AAs, surveyors have the option of recording interim observations (see Step 5 below).

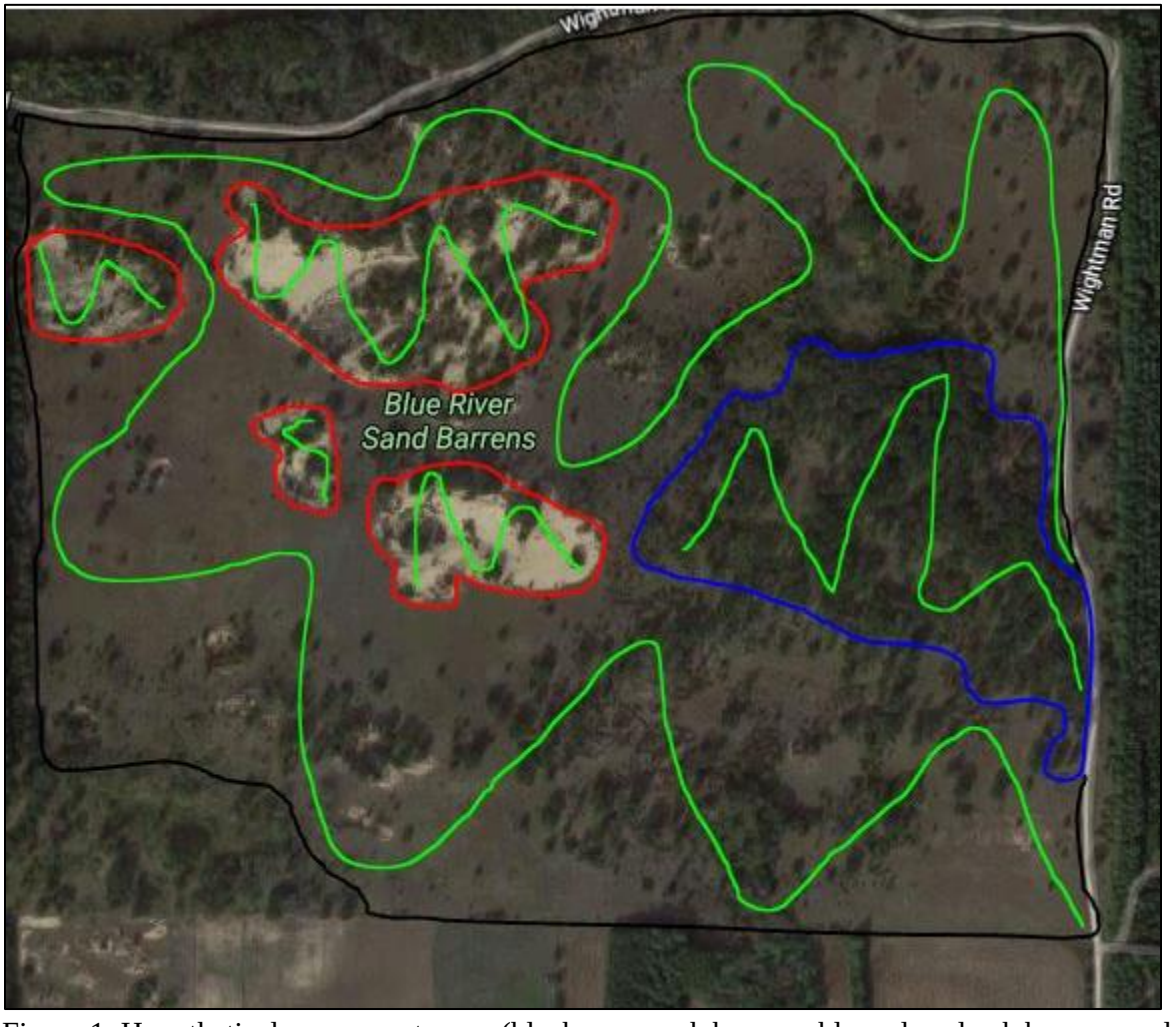


Figure 1. Hypothetical assessment areas (black: open oak barrens, blue: closed oak barrens, red: sand barrens) and survey routes (green zig-zag) at Blue River Sand Barrens SNA.

3. It is recommended that the assessments be performed by at least two people familiar with barrens ecology. This is particularly helpful for metrics that require estimates of percent cover, which are subjective and may thus vary among surveyors. While illustrations of various degrees of percent cover are provided on the field form as a guide, the effect of individual bias may be reduced by having surveyors make independent assessments of percent cover and average the values at the end of the survey. Cell phone apps such as CanopyApp may be helpful, particularly for estimating tree canopy cover in AAs with a partially closed canopy.

4. For each metric in the AA, write the corresponding estimate to the nearest whole percent in the column "Your Obs", then assign a letter rank (A, B, C, D) for that metric using guidelines provided on the form (Attachment A - Oak Barrens Monitoring Form). Note that there are unique descriptions of A- through D-ranks for each individual metric. Convert the letter rank into a numerical score using a grade-point style conversion (i.e., A=4, B=3, C=2, D=1).

5. Optional: For larger AAs, it may be helpful to record interim observations at various points within the AA. Similarly, if a survey route has been pre-established, it may be beneficial to evaluate metrics at multiple points along the survey route. In these instances, record interim estimates for metrics of percent cover on page 2 of the form. Do not record interim observations for indicator species or spatial heterogeneity, which should be integrated across the entire AA. At each interim stop, note the approximate proportional area of the AA covered by the stop. This is especially important if some stops offer longer sight lines, while others are limited (e.g., five interim stops with one stop covering 60% of an AA, and four stops each covering 10% of the AA). If each interim observation covers approximately the same proportion of the AA, divide by the number of stops (e.g., five interim stops each covering an equal area for a proportional area for each stop of 20%). Upon completion of the survey, calculate the weighted average for each percent cover metric in the AA, based on the proportional area of each stop. Write the weighted average in the "Your Obs" column on the front of the form, and follow Step 4 to translate the observation to an A-D rank and numerical score for each metric.

6. For the metric for number of indicator species, use the indicator species checklist form and check off each species observed during the survey. The species were selected among those that are readily identifiable in July and August in Wisconsin with minimal botanical expertise. When looking for indicator species, move slowly and check habitat microsites thoroughly, such as sand blows, dry depressions, ridges, slopes, shady areas, and large and small openings. Keep a running tally of species for the entire AA; do not track zig-zag segments separately. Upon completion of the survey, count the total number of indicator species observed in the AA and enter it on the main form, and follow the procedure in Step 4 to translate that into a letter grade and numerical score.

7. Calculate subtotal scores for Barrens composition, General composition, Structure, and Spatial heterogeneity.

    a. For Barrens composition subtotal, calculate the average the three numerical scores for the barrens composition metrics. If two of the three barrens metrics are D (1), write D (1) for the overall barrens subtotal. This helps separate the lowest quality sites from sites that have better restoration potential. To facilitate calculation of the overall composite score for the site, multiply the Barrens composition subtotal score by 0.60 and enter it in the weighted average field in the far right column.

b. For General composition subtotal, calculate the average the three numerical scores for the general composition metrics. If two of the three metrics are D (1), write D (1) for the overall barrens subtotal. This helps separate the lowest quality sites from sites that have better restoration potential. To facilitate calculation of the overall composite score for the site, multiply the General composition subtotal score by 0.15 and enter it in the weighted average field in the far right column.
c. For Structure subtotal, calculate the average the three numerical scores for the general composition metrics. If the Tree canopy metric is D (1), write D (1) for the overall structure subtotal. Because sites with a very closed canopy have a lower restoration potential, or in some cases may not be barrens at all, this helps separate the lowest quality sites from better sites. To facilitate calculation of the overall composite score for the site, multiply the Structure subtotal score by 0.2 and enter it in the weighted average field in the far right column.
d. For the subtotal score for spatial heterogeneity, multiply the numerical value of the score by 0.05 and enter the value in the weighted average field in the far right column.

8. Calculate a composite rank for the entire management unit by adding all of the weighted subtotal scores in the far right column and translate the total to a letter rank using the Composite Rank Guide (provided below and on the form).

A	3.8-4.0
A-	3.5-3.79
B	3.0-3.49
B-	2.5-2.99
C	2.0-2.49
C-	1.5-1.99
D	<1.49

9. In some cases, a site may be composed of more than one assessment area, or an assessment area may not be uniform and may be subdivided for estimates (e.g., multiple sand barrens AAs in Figure 1). To determine values for each metric for the entire community, or for multiple communities across the entire site, calculate a weighted estimate for each assessment area:
    a. First, calculate the area of each assessment area and determine the proportional area of each assessment area over the whole site.
    b. Second, calculate the weighted value for each metric in each assessment area by multiplying the estimated values by the proportional area.
    c. Lastly, determine the sum of all weighted values for each metric across all assessment areas.

10. Illustrate locations of specific management concerns on a map. Reference concerns in the notes section of the form and include recommendations for those areas of management concern.

Guidelines for Field Estimates

1. Conduct field monitoring during July and August when herbaceous species are easiest to identify, especially native grasses, indicator species and invasive species.
2. Ensure all areas within an AA are visible and accessible to observers on the ground. Exclude features that may be inaccessible or separate inaccessible features into different AAs (e.g., blufftops surrounded by cliffs, areas split by rivers or streams that cannot easily be crossed, etc.).
3. Conduct field monitoring when high priority invasive species are most visible (e.g., July is best for spotted knapweed during its flowering season).
4. The vegetation patterns of savannas are intrinsically uneven due to variable degrees of shade and woody cover, and patchy distribution of various species, thus it is important to evaluate each metric thoroughly across the entire assessment area. For example, percent cover of herbaceous species in open areas should be averaged with those that occur underneath shrubs or trees.

Supplies and Equipment

- Compass
- GPS unit or digital map depicting assessment area boundaries
- Aerial photographs depicting assessment area boundaries
- Data sheets (Pro Tip: if not using the optional "interim observations" on page 2 of the form, simply print pages 1 and 3 for a single page form, front and back)
- Clipboard
- Pencils with erasers
- Field guide to Wisconsin wildflowers (can be a simple, introductory guide if all indicator species are included)

Literature Cited

Faber-Langendoen, D., W. Nichols, J. Rocchio, K. Walz, J. Lemly, R. Smyth and K. Snow. 2016. Rating the condition of reference wetlands across states: NatureServe's Ecological Integrity Assessment method. National Wetlands Newsletter 38 (3):12-16

Keough, H.; M. Kleitch; and J. McGowan-Stinski. 2011. Coarse-Level Metrics Methods and Guidelines for Assessing Restoration Progress in Oak Barrens, Pine Barrens, Dry Sand Prairie and Dry Prairie. USDA Forest Service Huron-Manistee National Forest and The Nature Conservancy. Lansing, Michigan.

Parrish, J.D., D. P. Braun, and R.S. Unnasch. 2003. Are we conserving what we say we are? Measuring ecological integrity within protected areas. BioScience 53: 851-860.

Appendix A: Field Form

Page 1

Wisconsin DNR Barrens Monitoring Form — Version 2.2

Site Name:_____ Management Unit Name/# _____ AA Name/#_____ Date_____

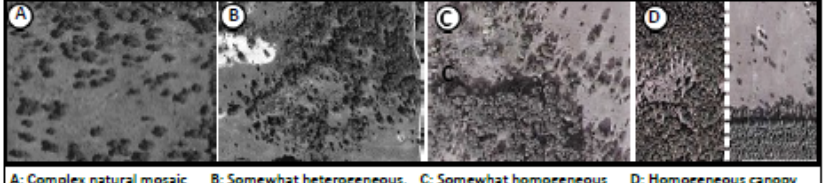
AA Description_____ AA acres_____

GPS coords start_____ GPS coords end _____ Surveyors_____

Instructions: For each metric, write the corresponding measurement for your assessment area in "Your Obs" column, then enter a letter rank for that metric in the "Letter Rank" column following the ranking guidance. Convert the letter rank into a numerical score using a grade -point-average style conversion (A=4, A-=3.5, B=3, C=2, C-=1.5, D=1), and enter this number in the "Score" column.

		Ranking Guidance for each metric							
	METRIC	A (Excellent)	B (Good)	C (Fair)	D (Poor)	YOUR OBS	LETTER RANK	SCORE (1-4)	Weighted Avg for final score
Barrens Composition	Total % cover of native grasses and sedges, not including Pennsylvania sedge	30%+	15-29%	5-14%	0-4%				Multiply subtotal of Barrens comp by 0.6 ↓
	Number of native indicator species *(see checklist with photographs)*	15+	11-14	8-10	0-7				
	Total % cover of native disturbance indicators *(e.g., Pennsylvania sedge, bracken fern, blackberry/dewberry, etc.)*	0-20%	21-40%	41-60%	61%+				
	Subtotal of Barrens comp: *Avg of scores above; if 2 of the 3 metrics are D, overall Barrens comp = D*					NA			
General composition	Total % cover of invasive species *(as defined under Wisconsin NR 40)*	<1%	1-3%	C: 4-10% C-:11-30%	31%+				Multiply subtotal of General comp by 0.15 ↓
	Relative % cover of all native plants *(ratio of all natives to non-natives, including trees and shrubs)*	A: >99% A- 95-99%	85-94%	60-84%	0-59%				
	Relative % cover of appropriate oak barrens trees *(ratio of oak & regionally jack/red pine to other tree species)*	96-100%	90-95%	80-89%	0-79%				
	Subtotal of General Comp: *Avg of scores above; if 2 of the 3 metrics are D, overall General comp = D*					NA			
Structure	Total % cover of all medium-statured woody plants *(2-6' tall; includes natives and non-natives)*	0-15%	16-30%	31-50%	51%+				Multiply subtotal of Structure by 0.2 ↓
	Total % cover of saplings and tall shrubs *(6-20' tall)*	5-15%	<5 or 16-30%	31-50%	51%+				
	Total % cover of trees *(>20' tall)*	5-40%	<5 or 41-60%	61-75%	76%+				
	Subtotal of structure: *Avg of scores above; if tree comp = D, overall Structure = D*					NA			
						Spatial hetero:			Multiply Het by 0.05 ↓
						Sum of weighted scores:			
						Composite letter rank:			

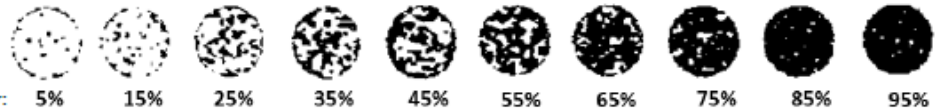
Spatial heterogeneity



A: Complex natural mosaic that includes canopy and openings of varying shapes and sizes	B: Somewhat heterogeneous, but canopy and/or openings clustered in portions of the unit	C: Somewhat homogeneous with mostly small canopy gaps, as well as occasional larger openings	D: Homogeneous canopy with only small canopy gaps or few large openings with hard edges

Composite Letter Rank Guide	
A	3.8 - 4.0
A-	3.5 - 3.79
B	3.0 - 3.49
B-	2.5 - 2.99
C	2.0 - 2.49
C-	1.5 - 1.99
D	<1.49

Notes and management comments (for specific metrics or for entire unit):



Guide to Percent Cover: 5% 15% 25% 35% 45% 55% 65% 75% 85% 95%

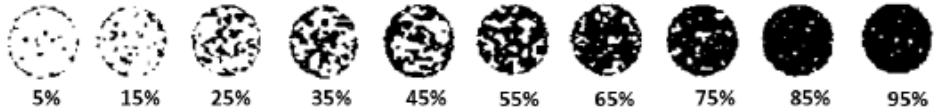
Page 2

Wisconsin DNR Barrens Monitoring Form — **Version 2.2**

Optional Worksheet for Interim Observations: For each metric below, write the corresponding measurement for each interim stop. Estimate the approximate proportion of the AA covered by each interim observation. Calculate a weighted average based on the proportional area of the AA each interim stop covers (or, if equal proportions, a straight average) . Write the weighted average for the entire Assessment Area in the "Your Obs" column on the other side of the form. See the "Coarse-level monitoring protocol for assessing baseline condition and restoration progress in oak and pine barrens" for further guidance.

		INTERIM STOP										Weighted Avg
		1	2	3	4	5	6	7	8	9	10	
	Approximate proportion of AA											
	METRIC											
Barrens Composition	Total % cover of native grasses and sedges, not including Pennsylvania sedge											
	Number of native indicator species *(see checklist with photographs)*	*No interim observations needed; enter single value for entire AA on other side of form.*										
	Total % cover of native disturbance indicators *(e.g., Pennsylvania sedge, bracken fern, blackberry/dewberry, etc.)*											
General composition	Total % cover of invasive species *(as defined under Wisconsin NR 40)*											
	Relative % cover of all native plants *(ratio of all natives to non-natives, including trees and shrubs)*											
	Relative % cover of appropriate oak barrens trees *(ratio of oak & regionally jack/red pine to other tree species)*											
Structure	Total % cover of all medium-statured woody plants *(2-6' tall; includes natives and non-natives)*											
	Total % cover of saplings and tall shrubs *(6-20' tall)*											
	Total % cover of trees *(>20' tall)*											
	Spatial heterogeneity	*No interim observations needed; enter single value for entire AA on other side of form.*										

Guide to Percent Cover:



5% 15% 25% 35% 45% 55% 65% 75% 85% 95%

Wisconsin Oak Barrens Native Indicator Species — Check all that are present on your site

☐ bird's-foot violet (*Viola pedata*)
☐ black-eyed Susan (*Rudbeckia hirta*)
☐ butterfly milkweed (*Asclepias tuberosa*)
☐ dotted horsemint (*Mondarda punctata*)
☐ false toadflax (*Comandra umbeliata*)
☐ field sage-wort (*Artemisia campestris*)
☐ white sage (*Artemisia ludoviciana*)
☐ foxglove spp. (*Aureolaria spp.*)
☐ goat's-rue (*Tephrosia virginiana*)
☐ hairy hawkweed (*Hieracium longipilum*)
☐ New Jersey tea (*Ceanothus herbaceus*)
☐ Kalm's brome (*Bromus kalmii*)
☐ lead-plant (*Amorpha cancescens*)
☐ slender beard-tongue (*Penstemon gracilis*)
☐ plains prickly-pear (*Opuntia macrorhiza*)
☐ prairie tickseed (*Coreopsis palmata*)
☐ Puccoon spp. (*Lithospermum spp.*)
☐ rock spike-moss (*Selaginella rupestris*)
☐ rough blazing-star (*Liatris aspera*)
☐ round-headed bush-clover (*Lespedeza capitata*)
☐ sand violet (*Viola sagittata*)
☐ short green milkweed (*Asclepias viridiflora*)
☐ showy goldenrod (*Solidago speciosa*)
☐ sky-blue aster (*Aster oolentangiensis*)
☐ Spiderwort spp. (*Tradescantia spp.*)
☐ stiff sunflower (*Helianthus pauciflorus*)
☐ western sunflower (*Helianthus occidentalis*)
☐ thimbleweed (*Anemone cylindrica*)
☐ flax-leaved aster (*Ionactis linariifolia*)
☐ wild lupine (*Lupinus perennis*)

Photography Credits for Wisconsin Oak Barrens Native Indicator Species

Latin Name	Common Name	Photographer	Other Copyright Notes
Viola pedata	bird's-foot violet	Merel R. Black*	
Rudbeckia hirta	black-eyed Susan	Merel R. Black*	
Asclepias tuberosa	butterfly milkweed	Matthew L. Wagner*	
Monarda punctata	dotted horsemint	Janice Stiefel*	
Comandra umbellata	false toadflax	James R. Sime*	
Artemisia campestris	field sage-wort	Diane Cadrain: Stitching It All Together Blog	Blog: http://stitching-it-all-together.blogspot.com/2012/09/?_sm_au_=iTV5MrW51tjGDk1N. No photo usage restrictions indicated.
Ionactis linariifolia	flax-leaved aster	merel r. black*	
Aureolaria spp.	foxglove spp.	Merel R. Black*	
Tephrosia virginiana	goat's-rue	Emily J. Lain*	
Hieracium longipilum	hairy hawkweed	Derek Anderson*	
Ceanothus herbaceus	inland New Jersey tea	Stephen L. Solheim*	
Bromus kalmii	Kalm's brome	Christopher Noll*	
Amorpha canescens	lead-plant	Derek Anderson*	
Penstemon gracilis	slender beard-tongue	Robert W. Freckmann	
Opuntia macrorhiza	plains prickly-pear	Paul Drobot*	
Coreopsis palmata	prairie tickseed	Robert Bierman*	
Lithospermum spp.	puccoon spp.	Corey Raimond (leaves)*; Merel R. Black (flowers)*	
Selaginella rupestris	rock spike-moss	Christopher Noll*	
Liatris aspera	rough blazing-star	Aaron Carlson*	
Lespedeza capitata	round-headed bush-clover	Emmet J. Judziewicz*	
Viola sagittata	sand violet	Merel R. Black*	
Asclepias viridiflora	short green milkweed	Aaron Carlson*	
Solidago speciosa	showy goldenrod	Paul Drobot*	
Symphyotrichum oolentangiense	sky-blue aster	Merel R. Black*	
Tradescantia spp.	spiderwort spp.	Christopher Noll*	
Helianthus pauciflorus	stiff sunflower	Merel R. Black*	
Anemone cylindrica	thimbleweed	Aaron Carlson*	
Helianthus occidentalis	western sunflower	Aaron Carlson*	
Artemisia ludoviciana	white sage	Emmet J. Judziewicz*	
Lupinus perennis	wild lupine	Merel R. Black*	

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Pruka, B. 1995. Lists indicate recoverable oak savannas and open oak woodlands in southern Wisconsin. Restoration and Management Notes 13(1): 124-126.

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