Assisting the Michigan Wildlife Action Plan: Relevant Information and Tools for Incorporating Plants

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Cover photographs clockwise from upper left: Four rare plant species endemic to Great Lakes shores: the federal and state threatened Houghton's goldenrod (*Solidago houghtonii*), the federal and state threatened dwarf lake iris (*Iris lacustris*), the federal and state threatened Pitcher's thistle (*Cirsium pitcheri*), and the federal and state endangered Michigan monkey-flower (*Mimulus michiganensis*). Michigan Natural Features Inventory photo library.

Abstract

Plants perform numerous critical ecosystem services and are essential to wildlife, yet despite their important role, they are poorly recognized in most state Wildlife Action Plans (WAPs). The creation and implementation of WAPs in 2005 signaled a new era in conservation, yet as developed and formally funded these plans can reference only free-ranging fauna and the definition of species of greatest conservation need (SGCN) specifically exclude plants. A recent study and analysis of state WAPs by NatureServe verified the currently limited role for plants, but recommended that plants could achieve a greater role by continuing to develop and add plant-specific components to existing wildlife plans. To that end, the purpose of this project was to take part in a multi-state effort through NatureServe to improve the incorporation of plant-specific components and plant conservation strategies into the Michigan WAP. The thrust of the Michigan project was to provide information on Michigan's rare flora that would promote the role of plants by focusing on climate change and additional tools to assist the state WAP. This project was designed to complement similar efforts taking place in North Dakota, New Jersey, Montana, and Colorado. The first component of this project was comprised of determining climate change vulnerabilities for a set of priority rare plant taxa and additional species important to wildlife as suggested by DNR biologists. The second component of the project consisted of augmenting the landscape features crosswalk created by the state WAP by expanding the crosswalk to include the state's 420 listed rare taxa. The third basic component of the project was a spatial analysis to aid in highlighting conservation gaps to assist in identifying potential future priority areas and to augment the information assembled in the expanded landscape features crosswalk. For the climate component, 76 species were assessed using the NatureServe Climate Change Vulnerability Assessment (CCVI) calculator. A majority of the species assessed was determined to be vulnerable to climate change, include more than half of the common species assessed. The landscape features crosswalk was incorporated into a database, and then joined to a rare plant species-natural community crosswalk embedded in the Michigan Natural Features Inventory (MNFI) Rare Species Explorer. This database was then augmented with information on each rare plant species, primarily with regard to describing habitat but also incorporated conservation and management considerations. Selected spatial analyses indicated that defined high quality areas contribute disproportionately to rare plant richness and diversity in Michigan and thus are worthy of strong consideration for contributing to WAP activities and goals. In concert with the currently proposed Biodiversity Stewardship Areas, these delineated landscapes can contribute significantly to the Michigan WAP.

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Introduction

Plants comprise much of the fabric and framework of our environment, perform numerous critical ecosystem services, and are unarguably essential to all animal life. Given their obvious importance, it is logical to assume that the role of plants should be carefully considered and incorporated into wildlife conservation efforts, particularly with the advent of wildlife action plans (WAPs) nationwide. Wildlife action plans, according to the review and analysis by Stein and Gravuer (2008), signaled a new era in conservation in 2005 through their collective effort to formulate a strategic blueprint to prevent wildlife from becoming endangered, as conceptualized by the Association of Fish and Wildlife Agencies (2006). As developed and funded, the definition of "wildlife" references only free-ranging fauna, and with regard to species of greatest conservation need (SGCN), the guidelines specifically exclude plants. Stein and Gravuer (2008) noted that states were allowed a high degree of flexibility in devising their wildlife action plans such that they could be adapted to local needs and conditions. Although according to federal guidelines states were not able to use federal funds to consider plant species in the plans, they were at the same time not specifically prevented from addressing plant species of concern in their plans.

Despite the ability to be more expansive and comprehensive in state wildlife action plans by addressing plant species of concern, relatively few states have thus far done so to more than a modest degree. Among the several recommendations provided in the thoughtful assessment by Stein and Gravuer was the suggestion to continue to develop and add "plant-specific components to existing wildlife plans". This is particularly important and timely as the first generation of wildlife action plans are updated, creating opportunities to subsequently incorporate plants, by directly including plant-specific components and/or by including and implementing actions and strategies that would benefit both wildlife and plant species of concern (Stein and Gravuer 2008). There are compelling reasons for incorporating plant species of concern into the Michigan WAP beyond the general imperative noted above. In terms of plant diversity as expressed by the number of native plant species, Michigan is relatively low in comparison to other states with a total of just over 1800 taxa. However, in terms of the proportion of plant species at risk, Michigan ranks among the highest in the Midwest (Stein and Gravuer 2008), which is perhaps a stronger basis for general comparison. More specifically, with 420 vascular plant taxa presently classified as rare (i.e. endangered, threatened, special concern, or extirpated), this means that more than 23% of the state's native flora is comprised of species of concern. The inherent rarity of such a high proportion of the native flora has many implications for wildlife, and in several cases there are direct linkages with SGCN, such as insects that have obligate relationships with rare plant species required for food, nectar sources, or breeding sites (e.g. the Northern blue butterfly and the state threatened dwarf bilberry).

The purpose of this project was to take part in a multi-state effort through NatureServe to improve the incorporation of plant-specific components and plant conservation strategies in state wildlife action plans. The thrust of the Michigan effort was to provide pertinent and detailed information on Michigan's rare flora to both promote and facilitate the integration of plant conservation, including climate change considerations, into the state WAP and related conservation activities. This project was designed to complement similar, concurrent projects in New Jersey, Montana, Colorado and North Dakota, and was focused on developing a suite of plant information products compatible for potential inclusion in the state WAP, working in collaboration with the Michigan WAP Coordinator. The first component of the project focused on calculating Climate Change Vulnerability Indices (CCVIs), according to the methodology developed by NatureServe, for a selected set of high priority rare plant species as well as an additional set of common taxa. The second component of the project was designed to provide pertinent information on plant species of concern to help further develop a landscape feature-natural community crosswalk as developed by the WAP. The third component of the project was to conduct a spatial analysis of the Michigan rare plant database to help highlight conservation gaps for assisting in the identification of potential priority areas and to augment the information provided in the landscape features crosswalk.

Methods

The project was initiated by consultation with the Michigan WAP Coordinator, who had assisted in proposal conceptualization and development and thus helped define the objectives and outcomes from the inception of this effort. For the first component of the project, the calculation of selected CCVI indices, the primary taxa were identified as all of Michigan's G3 and rarer taxa, including species with range-ranks and sub-specific taxa T3 and rarer, with the intention of adding additional rare taxa to this core list as time permitted and through related projects. The core list was expanded by running several series of queries on natural communities using the Michigan Natural Features Inventory (MNFI) Rare Species Explorer (see http://mnfi.anr.msu.edu/explorer/search.cfm), focusing on rare and other high priority natural communities, such as the diverse types of Great Lakes coastal areas, to identify additional plant species of interest. The core list was also expanded in consultation with the WAP Coordinator, who queried Wildlife Division biologists for suggested additional plant species, such as taxa considered important for game management, including species critical for food or cover and also competitive invasive species often dealt with in habitat management activities. The several suggestions from wildlife biologists were passed along and compiled into a list. CCVI training was initiated through Go-To meetings/presentations and cached training sessions on the NatureServe Web page. In addition, additional consultation and training was sought and completed with Kimberly Hall of the Michigan Chapter Office of The Nature Conservancy, a co-designer of the CCVI. Additional detailed training on the CCVI was acquired through a scheduled session with NatureServe staff at the initiation of a concurrent Michigan Department of Environmental Quality (MDEQ) Coastal Zone Management (CZM) funded project. CCVIs were methodically calculated following the protocols provided through training sessions and the written guidelines, beginning with version 2.0 and then converting to Release 2.1 (Young et al. 2011).

The second component of the project consisting of augmenting a landscape feature-natural community crosswalk completed for the WAP by incorporating rare plant species and including pertinent information where appropriate, with an emphasis on habitat and management comments. This was done by first linking plant species of concern to natural community types via the embedded species-community crosswalk in the MNFI Rare Species Explorer. The landscape feature-natural community crosswalk was essentially reformatted or expanded to first incorporate the linkage to associated rare plant species and then provide selected comments on rare plant species for the benefit of WAP users. The intent of augmenting this crosswalk was to illustrate to WAP users and others the strong relationship of rare plants to landscape features, natural communities, and by implication their relevancy to wildlife species of concern and how management activities can be potentially beneficial to both wildlife and plants.

The third component of the project was as a spatial analysis of the MNFI rare plant database, primarily to identify conservation gaps, such that it could be demonstrated how activities conducted through the Michigan WAP (e.g. such as the identification of priority areas) could be shown to be mesh with and contribute to plant conservation. To accomplish this, the MNFI rare plant database was screened against a set of spatially explicit criteria, which were developed during a previous project to study the value of using rare plant species as environmental indicators (Pearman et al. 2006, Penskar et al. 2003), with the goal of identifying and delineating areas in which plant species would likely be the most viable. The four spatial criteria collectively applied to delineate an ecological "footprint" of the high quality habitats of the state included a GIS layer of high ranking natural communities and state designated natural areas, contiguous forest patches no smaller than 100 ha within areas of unchanged vegetation (circa 1800-1978), contiguous wetland patches no smaller than 100 ha in areas of unchanged vegetation (circa 1800-1978), and unchanged vegetation circa 1800-1978 (Figures 1, 2a, 2b, 3a, 3b, 4, and 5). The plant database was also screened against an additional available layer, a set of potential biodiversity stewardship areas delineated in a statewide planning effort to identify intact, high priority landscapes (Cohen 2011).

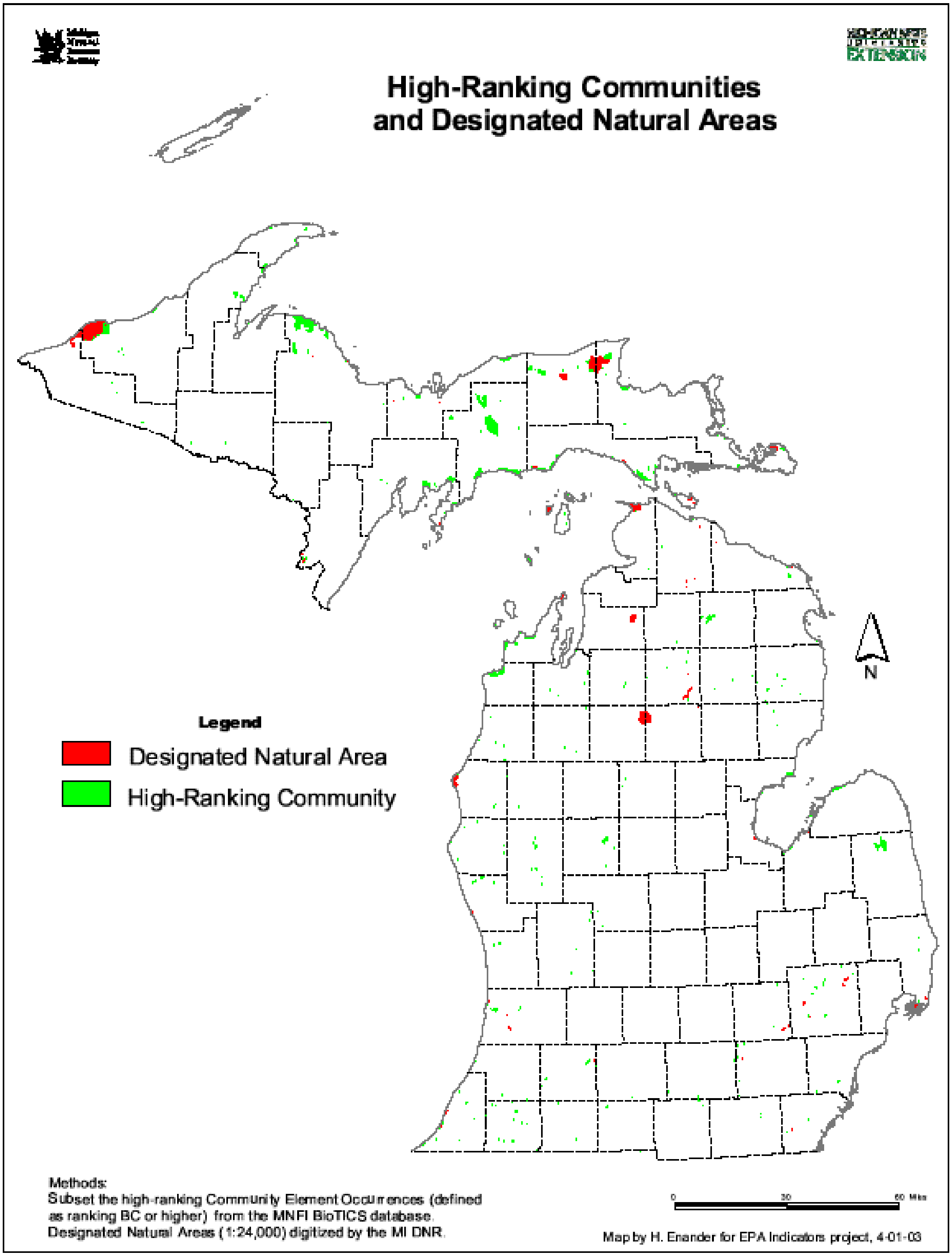

Figure 1. Identified high ranking natural communities and designated state natural areas.

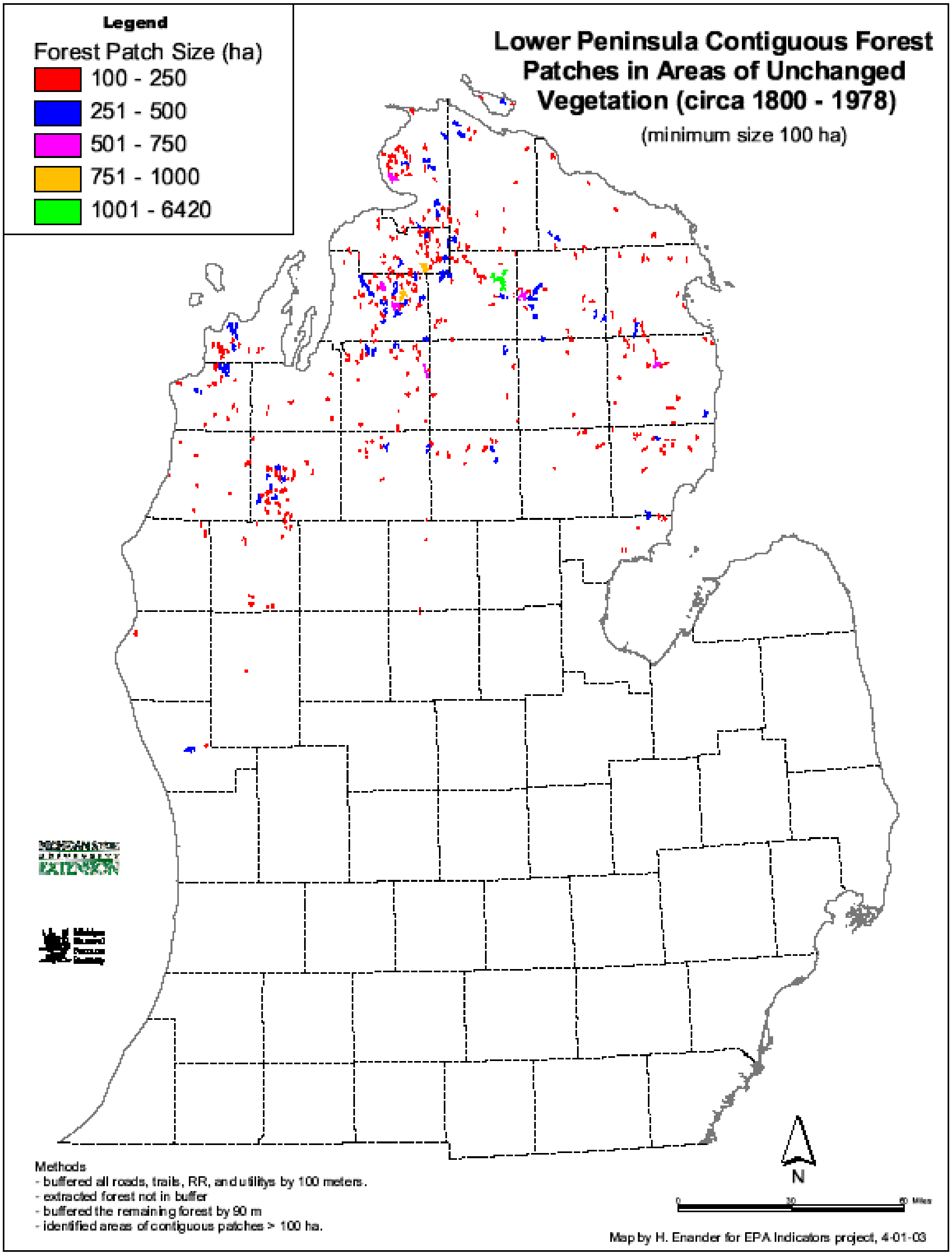

Figure 2a. Lower Peninsula contiguous forest patches in areas of unchanged vegetation (circa 1800-1978).

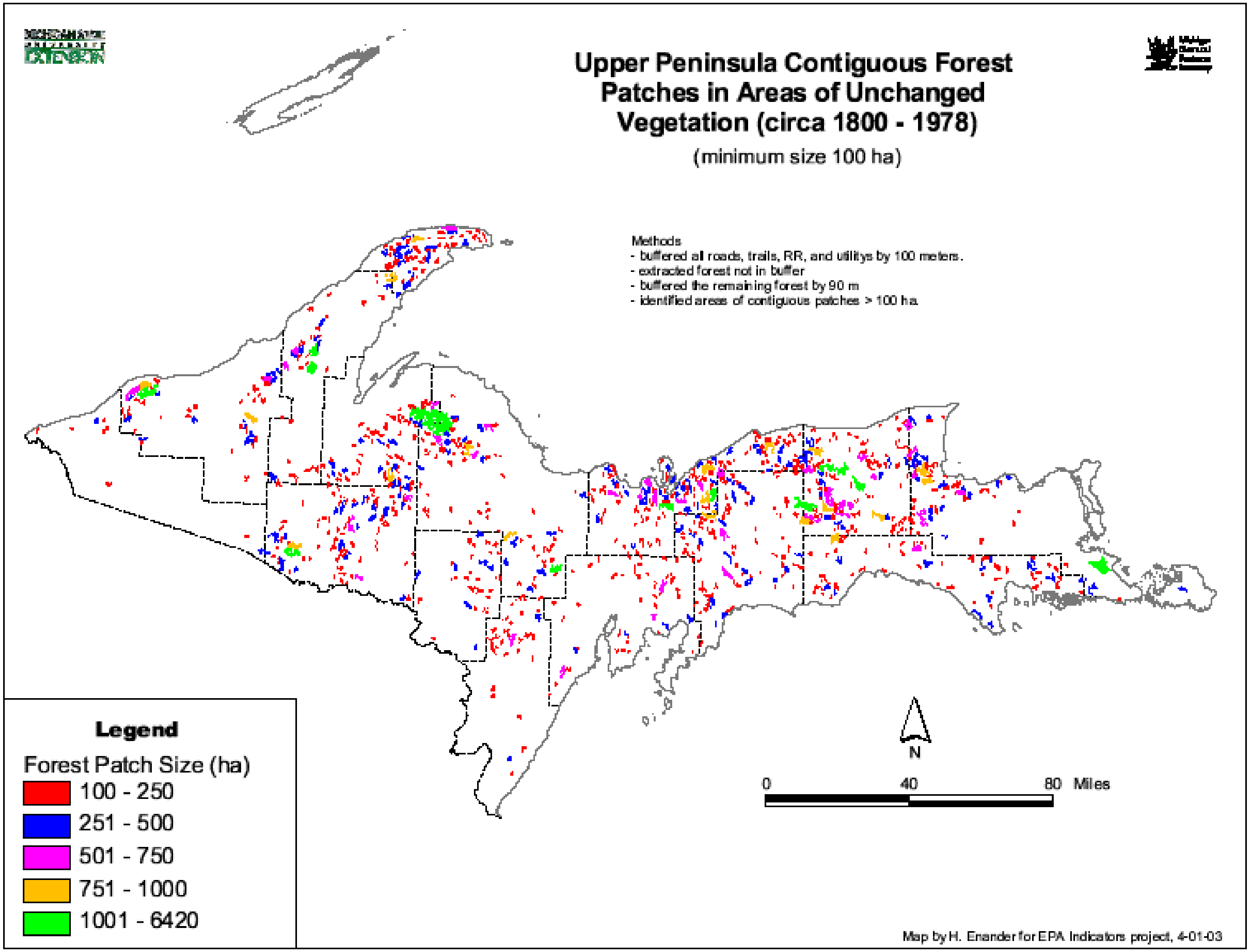

Figure 2b. Upper Peninsula contiguous forest patches in areas of unchanged vegetation (circa 1800-1978).

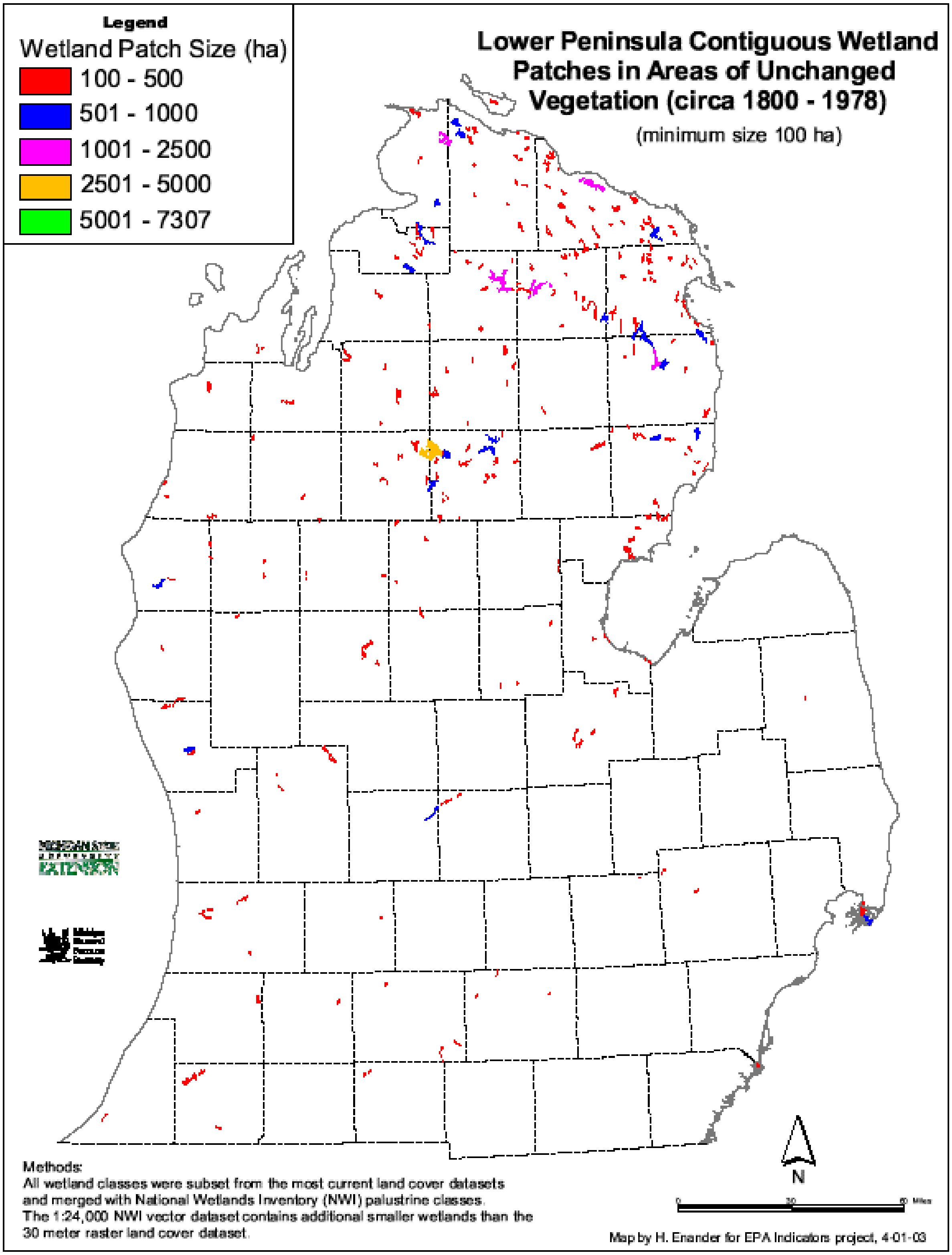

Figure 3a. Lower Peninsula contiguous wetland patches in areas of unchanged vegetation (circa 1800-1978).

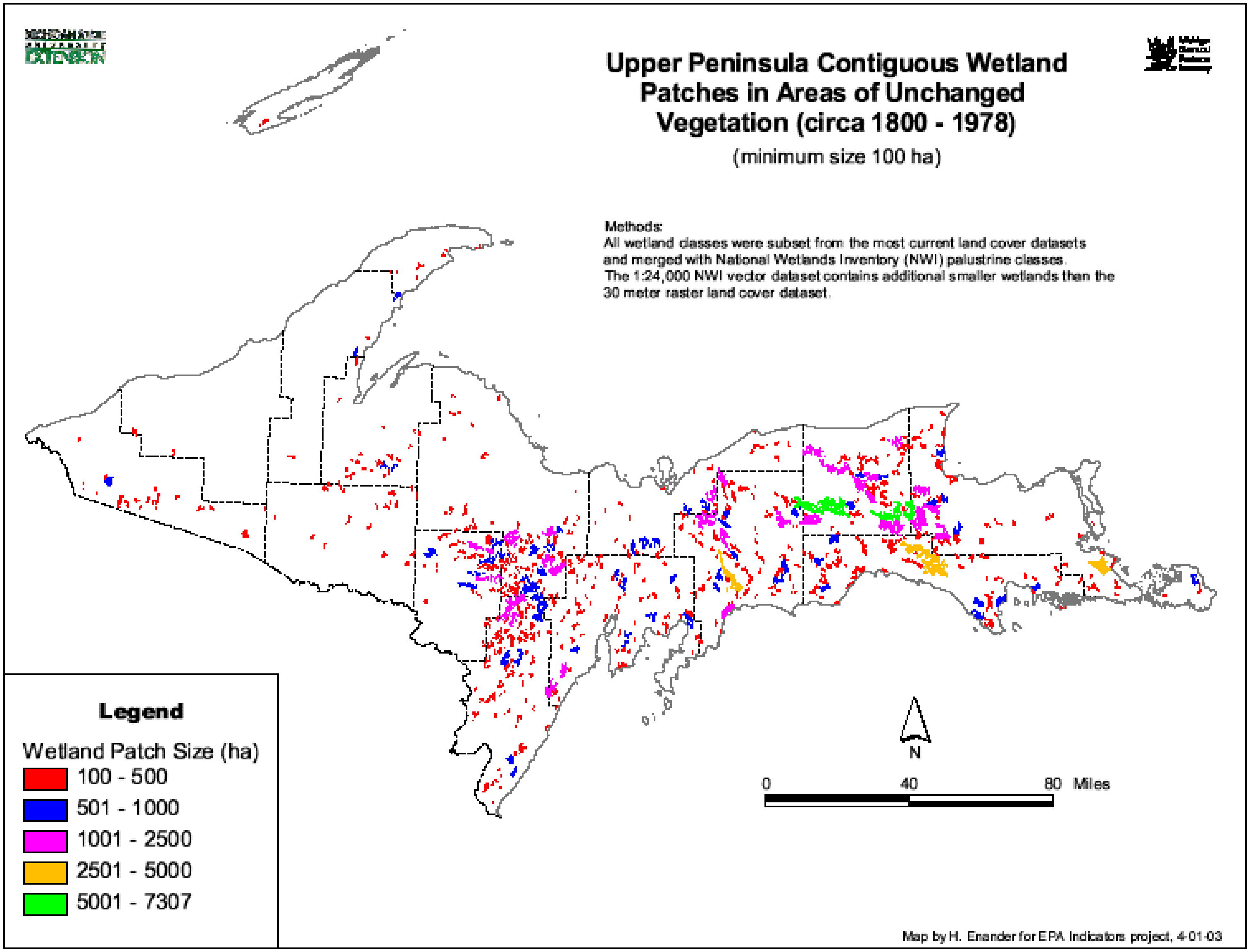

Figure 3b. Upper Peninsula contiguous wetland patches in areas of unchanged vegetation (circa 1800-1978).

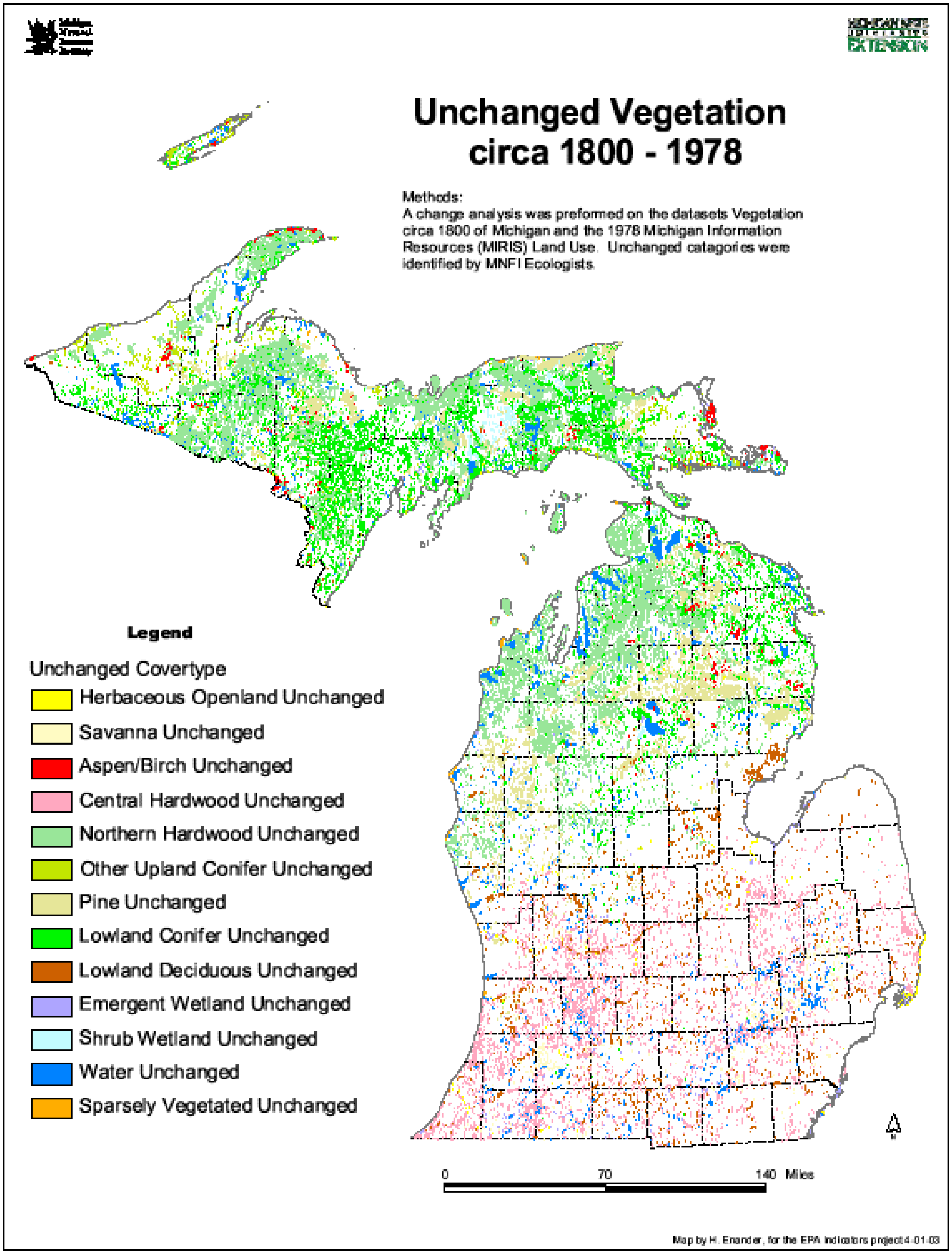

Figure 4. Unchanged vegetation circa 1800-1978, against which forest and wetland blocks were filtered.

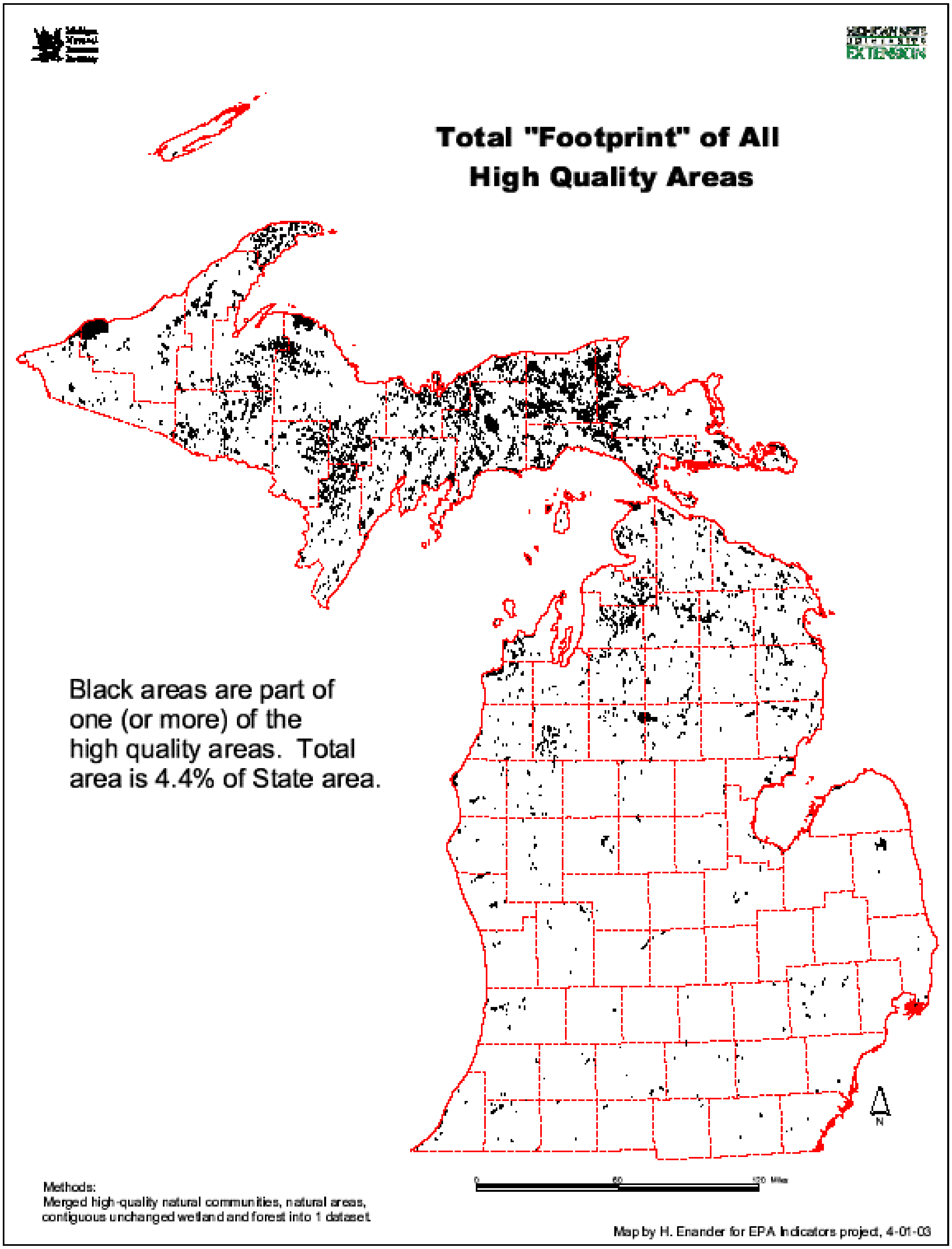

Figure 5. Total spatial state footprint of all high quality sites.

Results and Discussion

Climate Change Vulnerability Assessment

CCVI calculations were conducted for a total of 76 species, including all but two of Michigan's globally rare and rarer taxa (35 taxa)[1] and a selected group of common (unlisted) species as well two well-known, noxious invasive taxa, the latter two sets of species drawn from a list of plant taxa suggested by wildlife biologists via the state WAP Coordinator (Table 1). Overall, the plant species selected for the vulnerability assessment were both taxonomically diverse (including ferns and fern allies, conifers, orchids, sedges, grasses, and numerous dicots) and highly varied in terms of state distribution, ecology, morphology, and life history. This group of species is collectively associated with several natural community types occurring in Michigan and throughout the Great Lakes region, and included one mycoheterotrophic (i.e. "saprophytic") taxon (*Orobanche fasciculata*) and two insectivorous species, butterwort (*Pinguicula vulgaris*) and English sundew (*Drosera anglica*).

The majority of the vascular plant species assessed were determined to be extremely, highly, or moderately vulnerable to climate change, as summarized in Tables 1 and 2. Of the 76 species scored, 57 species (75%) were predicted to be vulnerable to climate change, of which 14 (18%) were found to be "Extremely Vulnerable," 24 (32%) were found to be "Highly Vulnerable," and 19 (25%) were found to be "Moderately Vulnerable". Of the 19 species (25 %%) not found to be vulnerable to climate change, 16 species (21%) were scored as "Presumed Stable" and 3 (4%) were scored as "Not Vulnerable/Increase Likely" (Tables 1 and 2). Specific factor scoring for all plant species that were assessed are provided in Attachment 1.

Conservation status and vulnerability to climate change appear to be strongly related for the plant species assessed. Table 2 presents a summary of the vulnerability assessments ordered hierarchically by both global and state rank within each vulnerability category, and also provides both state and federal listing status. For the 65 state listed plant taxa assessed, 52 species (80%) were found to be vulnerable. Of the subset of 33 globally rare listed species assessed, 27 species (82%) scored as vulnerable, and this was also similar for the globally secure (G4-G5) listed species assessed, with 25 of the 32 species (78%) found to be vulnerable. However, despite a similarity in the overall percentage of vulnerable taxa between the globally rare and the globally secure species assessed, there was a marked difference in the distribution of the species among the vulnerability categories. For the globally rare listed species, 22 of the 27 species assessed were scored as extremely vulnerable and highly vulnerable, whereas for globally secure species, 23 of the 25 species assessed were scored in the highly vulnerable to moderately vulnerable categories. A single listed species, the Midwest endemic and globally rare *Cirsium hillii* (Hill's thistle), was assessed as "increase likely", which is highly tenable for this oak barrens species of fire-prone habitats in future climate warming scenarios.

For the 9 unlisted native species assessed, 5 (56%) were assessed as vulnerable to climate change, whereas 4 were assessed as remaining stable. *Thuja occidentalis* (Northern white cedar), a species extremely important for wildlife as food and thermal cover, was scored as extremely vulnerable, and *Fagus grandifolia* (American beech) and *Tsuga canadensis* (Eastern hemlock), both also important to a variety of wildlife for food, thermal cover, and/or as breeding (e.g. nesting) sites , were scored as highly vulnerable. The remaining vulnerable species consisted of *Populus grandidentata* (Bigtooth aspen) and *P. tremuloides* (Trembling aspen), both of which are critical species for wildlife (e.g. upland game birds). Unlisted species assessed to be stable included *Lupinus perennis* (Wild lupine), an obligate plant for the Karner blue butterfly, *Lemna minor* (Duckweed), and important waterfowl food, *Pinus banksiana* (Jack

[1] Data were not available for two of these taxa, one consisting of a state extirpated species and the other a newly listed taxon.

pine), which comprises the obligate nesting habitat for the endemic Kirtland's warbler, and *Vallisneria americana* (Wild-celery), whose tubers are a critically important waterfowl food source. *Phragmites australis* (common reed) and *Lythrum salicaria* (purple loosestrife) comprised the two exotic, invasive species assessed to likely increase, which is not unexpected given their current status as aggressive competitors.

Table 1. Climate change vulnerability index and confidence scores for plant species assessed using the NatureServe Climate Change Vulnerability Index (CCVI). Species highlighted in bold comprise those taxa selected from a list of species suggested by MDNR wildlife biologists, including important food and cover plants and two noxious, invasive species as noted by their respective state ranks of "SNR" and "SE".

Species Scientific Name	Species Common Name	Global Rank	State Rank	Vulnerability Index Score	Confidence Score
Agalinis skinneriana	Skinner's agalinis	G3G4	S1	Extremely Vulnerable	Very High
Amerorchis rotundifolia	Small round-leaved orchis	G5	S1	Extremely Vulnerable	Very High
Besseya bullii	Kitten-tails*	G3	S1	Extremely Vulnerable	Very High
Betula murrayana	Murray birch	G1Q	S1	Extremely Vulnerable	Very High
Bromus nottowayanus	Satin brome	G3G5	S3	Extremely Vulnerable	Moderate
Isotria medeoloides	Smaller whorled pogonia	G2	SX	Extremely Vulnerable	Very High
Listera auriculata	Auricled twayblade	G3	S2S3	Extremely Vulnerable	Very High
Mimulus michiganensis	Michigan monkey-flower	G5T1	S1	Extremely Vulnerable	Very High
Panax quinquefolius	Ginseng	G3G4	S2S3	Extremely Vulnerable	Moderate
Poa paludigena	Bog bluegrass	G3	S2	Extremely Vulnerable	Very High
Prosartes maculata	Nodding mandarin	G3G4	SX	Extremely Vulnerable	Very High
Saxifraga paniculata	Encrusted saxifrage	G5	S1	Extremely Vulnerable	Moderate
Schoenoplectus hallii	Hall's bulrush	G2G3	S2	Extremely Vulnerable	Low
Thuja occidentalis	**Northern white cedar**	**G5**	**SNR**	**Extremely Vulnerable**	**Very High**
Asclepias hirtella	Tall green milkweed	G5	S2	Highly Vulnerable	Low
Asclepias sullivantii	Sullivant's milkweed	G5	S2	Highly Vulnerable	Low
Asplenium scolopendrium	American hart's tongue fern	G4T3	S1	Highly Vulnerable	Very High
Aster furcatus	Forked aster	G3	S1	Highly Vulnerable	Very High
Cacalia plantaginea	Prairie Indian-plantain	G4G5	S3	Highly Vulnerable	Low
Calypso bulbosa	Calypso orchid	G5	S2	Highly Vulnerable	Low
Carex richardsonii	Richardson's sedge	G4	S3S4	Highly Vulnerable	Very High
Cypripedium arietinum	Ram's head lady's-slipper	G3	S3	Highly Vulnerable	Very High
Drosera anglica	English sundew	G5	S3	Highly Vulnerable	High
Fagus grandifolia	**American beech**	**G5**	**SNR**	**Highly Vulnerable**	**Very High**
Gymnocarpium robertianum	Limestone oak fern	G5	S2	Highly Vulnerable	Moderate
Hymenoxys herbacea	Lakeside daisy	G3	S1	Highly Vulnerable	Very High
Iris lacustris	Dwarf lake iris	G3	S3	Highly Vulnerable	Very High
Lycopodiella margueritae	Northern prostrate clubmoss	G2	S2	Highly Vulnerable	Very High
Lycopodiella subappressa	Northern appressed clubmoss	G2	S2	Highly Vulnerable	Very High
Orobanche fasciculata	Fascicled broom-rape	G4	S2	Highly Vulnerable	Very High
Pinguicula vulgaris	Butterwort	G5	S3	Highly Vulnerable	Very High
Platanthera leucophaea	Eastern prairie fringed-orchid	G3	S1	Highly Vulnerable	Moderate
Potamogeton hillii	Hill's pondweed	G3	S2	Highly Vulnerable	Moderate

Saxifraga tricuspidata	Prickly saxifrage	G4G5	S2	Highly Vulnerable	Low
Solidago houghtonii	Houghton's goldenrod	G3	S3	Highly Vulnerable	Very High
Triphora trianthophora	Three birds orchid	G3G4	S1	Highly Vulnerable	Low
Tsuga canadensis	**Eastern hemlock**	**G5**	**SNR**	**Highly Vulnerable**	**Very High**
Valerianella umbilicata	Corn salad	G3G5	S2	Highly Vulnerable	Moderate
Arnica cordifolia	Heart-leaved arnica	G5	S1	Moderately Vulnerable	Moderate
Botrychium campestre	Prairie moonwort, dunewort	G3G4	S2	Moderately Vulnerable	Very High
Bromus pumpellianus	Pumpelly's bromegrass	G5T4	S2	Moderately Vulnerable	Very High
Carex scirpoidea	Bulrush sedge	G5	S2	Moderately Vulnerable	Very High
Cirsium pitcheri	Pitcher's thistle	G3	S3	Moderately Vulnerable	Very High
Crataegus douglasii	Douglas's hawthorn	G5	S3S4	Moderately Vulnerable	Moderate
Elymus glaucus	Blue wild-rye	G5	S3	Moderately Vulnerable	Very High
Empetrum nigrum	Black crowberry	G5	S2	Moderately Vulnerable	Low
Hypericum adpressum	Creeping St. John's-wort	G3	S1	Moderately Vulnerable	Very High
Populus grandidentata	**Bigtooth aspen**	**G5**	**SNR**	**Moderately Vulnerable**	**Very High**
Populus tremuloides	**Trembling aspen**	**G5**	**SNR**	**Moderately Vulnerable**	**Very High**
Pterospora andromedea	Pine-drops	G5	S2	Moderately Vulnerable	Moderate
Rubus acaulis	Dwarf raspberry	G5T5	S1	Moderately Vulnerable	Moderate
Sisyrinchium strictum	Blue-eyed-grass	G2Q	S2	Moderately Vulnerable	Very High
Stellaria longipes	Stitchwort	G5	S2	Moderately Vulnerable	Very High
Tanacetum huronense	Lake Huron tansy	G5T4T5	S3	Moderately Vulnerable	Very High
Tomanthera auriculata	Eared foxglove	G3	SX	Moderately Vulnerable	Moderate
Utricularia subulata	Bladderwort	G5	S1	Moderately Vulnerable	Very High
Zizania aquatica var. *aquatica*	Wild rice	G5T5	S2S3	Moderately Vulnerable	Very High
Adlumia fungosa	Climbing fumitory	G4	S3	Presumed Stable	Moderate
Amorpha canescens	Leadplant	G5	S2S3	Presumed Stable	Very High
Botrychium acuminatum	Moonwort	G1	S1	Presumed Stable	Very High
Botrychium hesperium	Western moonwort	G4	S2	Presumed Stable	Low
Botrychium mormo	Goblin fern	G3	S2	Presumed Stable	Moderate
Botrychium spathulatum	Spatulate moonwort	G3	S2	Presumed Stable	Low
Calamagrostis lacustris	Northern reedgrass	G3Q	S1	Presumed Stable	Low
Cystopteris laurentiana	Laurentian fragile fern	G3	S1S2	Presumed Stable	Very High
Lemna minor	**Duckweed**	**G5**	**SNR**	**Presumed Stable**	**Very High**
Leymus mollis	American dune wild-rye	G5	S3	Presumed Stable	Very High
Lupinus perennis	**Wild lupine**	**G5**	**SNR**	**Presumed Stable**	**Moderate**
Nelumbo lutea	American lotus	G4	S2	Presumed Stable	Low
Pinus banksiana	**Jack pine**	**G5**	**SNR**	**Presumed Stable**	**Very High**
Ribes oxyacanthoides	Northern gooseberry	G5	S3	Presumed Stable	Very High
Sagittaria montevidensis	Arrowhead	G4G5	S1S2	Presumed Stable	Very High
Vallisneria americana	**Wild-celery**	**G5**	**SNR**	**Presumed Stable**	**Very High**
Cirsium hillii	Hill's thistle	G3	S3	Increase Likely	Very High
Lythrum salicaria	**Purple loosestrife**	**G5**	**SE**	**Increase Likely**	**Very High**
Phragmites australis	**Common reed**	**G5T5**	**SE**	**Increase Likely**	**Very High**

Table 2. Summary of CCVI calculations by assessed vulnerability category and stratified by global and state status. Taxa shaded in green comprise globally rare to rarer taxa, whereas taxa shaded in yellow represent globally secure species. SNR = state non-ranked, SE = state exotic

Scientific Name	Common Name	Global Rank	State Rank	State Status	US Status
Extremely Vulnerable					
Isotria medeoloides	Smaller whorled pogonia	G2	SX	X	LT
Mimulus michiganensis	Michigan monkey-flower	G5T1	S1	E	LE
Betula murrayana	Murray birch	G1Q	S1	SC	
Schoenoplectus hallii	Hall's bulrush	G2G3	S2	T	
Poa paludigena	Bog bluegrass	G3	S2	T	
Besseya bullii	Kitten-tails	G3	S1	E	
Listera auriculata	Auricled twayblade	G3	S2S3	SC	
Prosartes maculata	Nodding mandarin	G3G4	SX	X	
Agalinis skinneriana	Skinner's agalinis	G3G4	S1	E	
Panax quinquefolius	Ginseng	G3G4	S2S3	T	
Bromus nottowayanus	Satin brome	G3G5	S3	SC	
Amerorchis rotundifolia	Small round-leaved orchis	G5	S1	E	
Saxifraga paniculata	Encrusted saxifrage	G5	S1	T	
Thuja occidentalis	Northern white cedar	G5	SNR	-	
Highly Vulnerable					
Lycopodiella margueritae	Northern prostrate clubmoss	G2	S2	T	
Lycopodiella subappressa	Northern appressed clubmoss	G2	S2	SC	
Aster furcatus	Forked aster	G3	S1	T	
Hymenoxys herbacea	Lakeside daisy	G3	S1	E	LT
Platanthera leucophaea	Eastern prairie fringed-orchid	G3	S1	E	LT
Potamogeton hillii	Hill's pondweed	G3	S2	T	
Cypripedium arietinum	Ram's head lady's-slipper	G3	S3	SC	
Iris lacustris	Dwarf lake iris	G3	S3	T	LT
Solidago houghtonii	Houghton's goldenrod	G3	S3	T	LT
Triphora trianthophora	Three birds orchid	G3G4	S1	T	
Valerianella umbilicata	Corn salad	G3G5	S2	T	
Asplenium scolopendrium	American hart's tongue fern	G4T3	S1	E	LT
Orobanche fasciculata	fascicled broom-rape	G4	S2	T	
Carex richardsonii	Richardson's sedge	G4	S3S4	SC	
Saxifraga tricuspidata	Prickly saxifrage	G4G5	S2	T	
Cacalia plantaginea	Prairie Indian-plantain	G4G5	S3	SC	
Asclepias hirtella	Tall green milkweed	G5	S2	T	
Asclepias sullivantii	Sullivant's milkweed	G5	S2	T	
Calypso bulbosa	Calypso orchid	G5	S2	T	
Gymnocarpium robertianum	Limestone oak fern	G5	S2	T	
Drosera anglica	English sundew	G5	S3	SC	
Pinguicula vulgaris	Butterwort	G5	S3	SC	
Fagus grandifolia	American beech	G5	SNR	-	
Tsuga canadensis	Eastern hemlock	G5	SNR	-	

Moderately Vulnerable					
Sisyrinchium strictum	Blue-eyed-grass	G2Q	S1	SC	
Cirsium pitcheri	Pitcher's thistle	G3	S3	T	LT
Hypericum adpressum	Creeping St. John's-wort	G3	S1	T	
Tomanthera auriculata	Eared foxglove	G3	SX	X	
Botrychium campestre	Prairie moonwort, dunewort	G3G4	S2	T	
Arnica cordifolia	Heart-leaved arnica	G5	S1	E	
Rubus acaulis	Dwarf raspberry	G5T5	S1	E	
Utricularia subulata	Bladderwort	G5	S1	T	
Bromus pumpellianus	Pumpelly's bromegrass	G5T4	S2	T	
Carex scirpoidea	Bulrush sedge	G5	S2	T	
Empetrum nigrum	Black crowberry	G5	S2	T	
Pterospora andromedea	Pine-drops	G5	S2	T	
Stellaria longipes	Stitchwort	G5	S2	SC	
Zizania aquatica var. *aquatica*	Wild rice	G5T5	S2S3	T	
Elymus glaucus	Blue wild-rye	G5	S3	SC	
Tanacetum huronense	Lake Huron tansy	G5T4T5	S3	T	
Crataegus douglasii	Douglas's hawthorn	G5	S3S4	SC	
Populus grandidentata	Bigtooth aspen	G5	SNR	-	
Populus tremuloides	Trembling aspen	G5	SNR	-	
Presumed Stable					
Botrychium acuminatum	Moonwort	G1	S1	E	
Cystopteris laurentiana	Laurentian fragile fern	G3	S1S2	SC	
Botrychium mormo	Goblin fern	G3	S2	T	
Botrychium spathulatum	Spatulate moonwort	G3	S2	T	
Calamagrostis lacustris	Northern reedgrass	G3Q	S1	T	
Botrychium hesperium	Western moonwort	G4	S2	T	
Nelumbo lutea	American lotus	G4	S2	T	
Adlumia fungosa	Climbing fumitory	G4	S3	SC	
Sagittaria montevidensis	Arrowhead	G4G5	S1S2	T	
Amorpha canescens	Lead plant	G4	S3	SC	
Leymus mollis	American dune wild-rye	G5	S3	SC	
Ribes oxyacanthoides	Northern gooseberry	G5	S3	SC	
Lemna minor	Duckweed	G5	SNR	-	
Lupinus perennis	Wild lupine	G5	SNR	-	
Pinus banksiana	Jack pine	G5	SNR	-	
Vallisneria americana	Wild-celery	G5	SNR	-	
Increase Likely					
Cirsium hillii	Hill's thistle	G3	S3	SC	
Lythrum salicaria	Purple loosestrife	G5	SE	-	
Phragmites australis	Common reed	G5T5	SE	-	

One of the principal risk factors contributing to the determination of climate change vulnerability for plants was historical hydrological regime, which was scored as “greatly increase” for more than 50% of the species assessed. For all but one of the remaining species (which was scored as “somewhat increase”), this factor was scored as “increase”, and in no case did historical hydrological regime score as low as “neutral.” Thus, it was clearly a significant factor. One of the other prominent risk factors for plants was the allied category of physiological hydrological niche, which indicates that several of the taxa included have a strong wetland affinity, particularly those species that inhabit ecotones and/or depend on seasonal flooding and drawdown cycles, although in general most wetland-related species would be expected to experience more adverse and disrupted conditions owing to the projected drier, warmer conditions for 2050. Approximately 50% of the species assessed for this factor were scored from “slightly increase” or higher, with more than half of those scored as “greatly increase”.

Other prominent risk factors included the category of natural barriers and dispersal/movement, as in both of these categories well over 50% of the species assessed were scored above neutral (i.e. as “increase” or higher). For natural barriers, many of the shoreline species will be impeded by the inability to migrate northward over the portions of the Great Lakes, particularly, for example, for species along the southern shore of Lake Superior. Although it is expected that several species would migrate lakeward, following the water’s edge as basins presumably retract, and thus ostensibly continue to occupy available habitat, long-distance dispersal will still be problematical. In addition, plant species in southern Michigan may have formidable barriers with regard to dispersing north over the largely agricultural interior in the southern Lower Peninsula, where there is extensive and often contiguous unsuitable habitat. For the category of dispersal/movement, the scores largely indicate the relatively limited short-dispersal distances that many plants have, especially those species that have few or no animal vectors (particularly for graminoids) and thus can only scatter seeds very locally (i.e. less than about 100 meters), although this is necessarily qualified. Many small seeds, such as the tiny, dust-like propagules produced by orchids, may be carried considerable distances via wind, whereas other species may have the ability to be dispersed fairly long distances via stream and river transport.

Additional notable risk factors included physical habitat (restriction to uncommon geological features or derivatives) and reliance on interspecific interactions. For the former category, about 50% of the species assessed were scored as “increase” or higher, indicating the dependence several of the assessed species have on such habitats as dunes, certain wetland types, and specialized substrates such as those that are found on bedrock shorelines (e.g. limestone/alvar, volcanic, etc.). With regard to interspecific interactions, more than 10 species were scored as “increase” or “slightly increase,” including several orchids and one saprophyte which have obligate relationships with fungi, and thus, due to this dependence, such species have a greater vulnerability to climate change.

<u>Landscape Features Crosswalk</u>

As described above, an existing landscape features-natural community crosswalk developed for the Michigan WAP was used to provide a linkage to all of Michigan’s rare plant taxa. A spreadsheet of this crosswalk, provided by the Michigan WAP Coordinator, was first converted into a database, and then this table was joined to the natural community-rare species crosswalk embedded within the MNFI Rare Species Explorer. Following the joining of these tables, which then linked all the natural community types of each landscape feature to every associated rare plant species, a comments field was created. This field was then methodically populated within Microsoft Access. The original intention was to include information only for selected, highlighted species regarding management needs and related comments on rarity and vulnerability, etc. As the species were reviewed and considered, it became apparent that a primary need for the table was to provide a brief habitat description for each species, which is a logical extension of the linkage from landscape feature to natural community to each particular taxon. To accomplish this, the species were subsequently reviewed in concert with the MNFI Rare Species Explorer (http://mnfi.anr.msu.edu/explorer/search.cfm) through which summarized habitat descriptions were drawn and modified accordingly as needed for each species, thus this was necessarily a methodical, manual procedure. As the comments field was populated, selected management and conservation notes were included where appropriate. Habitat and management information could not be included for every species, such as for species listed as extirpated and/or known only via vague historical records; in these cases, information on the paucity of the species was given as well as knowledge of the known habitat elsewhere. The completed crosswalk as a WAP related resource can thus be queried as needed and possibly further developed with additional information, as well as updated as needed following periodic technical list reviews. Tables 3, 4, and 5 were prepared to provide selected examples of the landscape features-natural community-rare species crosswalk. It is anticipated that this crosswalk will be added to the Wildlife Action Plan database such that users will be able to create summaries on SGCN, their habitats, and key plant species. By including plant species in the updated WAP, it will be possible to show how priority actions help the full breadth of biodiversity in the state – animals (SGCN and game species), plants, and natural communities.

Spatial Analysis

The spatial analysis conducted is only one of many possible ways to explore the pattern of rare plant occurrences in Michigan, the purpose of which was to provide a potential means of identifying priority areas likely to support the most viable rare plant populations. This analysis took advantage of several existing GIS layers (Figures 1-4) developed for an indicator species project (see Pearman et al. 2006, Penskar et al. 2003) such that a high quality ecological footprint (Figure 5) of the state could be constructed based on rigorous, spatially explicit criteria. The Michigan rare plant database was screened against this ecological footprint to determine what was captured in terms of both representation and quality and serve as a basis for suggesting potential priority areas where WAP activities would convey a high value for plant species of concern. Unlike the species indicator project, this effort also included screening the rare plant database against the MDNR draft biodiversity stewardship areas (BSA) layer (Figure 6) for potential additional linkages.

Screening the rare plant database against the ecological footprint and the BSA layer resulted in several spreadsheets that were examined and summarized. The MNFI rare plant database at the time of the ecological footprint and BSA screening consisted of 5,938 element occurrences. Screening the database against the ecological footprint intersected a total of 1,535 rare plant occurrences, representing nearly 26% of the state rare plant database, as shown in Figure 7. Given that the ecological footprint, as shown in Figure 5, delineates only 4.4% of Michigan's land area based on the strict requirements to identify high quality sites, the intersection with 26% of the state's rare plant occurrences is highly disproportionate. In terms of representation with respect to species, 252 of Michigan's 420 rare vascular plant taxa occurred in the high quality footprint, including 20 of the state's 35 G1-G3 (globally rare) taxa (57%) and 232 of the state's 385 G4-G5 (globally secure) taxa (60%).

The occurrences captured by this screening were reviewed and then summarized with regard to ownership and global rank, which after examination of the intersection data appeared to be the most meaningful way to organize and depict the results, as shown in Tables 3 and 4. In Table 3, the ecological footprint screening data are summarized by ownership and number of occurrences by the respective global rank classes. In terms of rank class, of the 1,535 occurrences within the high quality state footprint, 300 (20%) were comprised of globally rare taxa whereas 1,235 (80%) were comprised of globally secure species occurrences. With regard to ownership, nearly 50% of the globally rare EOs was found to occur on state land, with 17% on federal lands, and 23% occurring on private land. For globally secure taxa, the ownership breakdown is somewhat similar, with the majority of EOs occurring on state land, but nearly as many found on private, and relatively similar proportions are shown in the total column.

Table 3. Examples of output from landscape feature-natural community-rare species crosswalk.

System	Ecoregion	Feature	Natural Community	Species Name	Comment
Terrestrial	SLP	Mesic hardwood	Mesic Northern Forest	Panax quinquefolius	Found in rich shaded forests with loamy soils and heavy canopies. This species is highly threatened from collection of the root, commonly used in herbal remedies. Large colonies have completely vanished due to illegal poaching. Highly vulnerable to unsustainable harvesting and poaching.
Terrestrial	SLP	Mesic hardwood	Mesic Southern Forest	Polymnia uvedalia	Known from rich woods and moist borders of swamps
Terrestrial	SLP	Mesic hardwood	Mesic Northern Forest	Prosartes hookeri	Found in rich mesic northern forests in the western Upper Peninsula dominated by hemlock and sugar maple; found rarely in association with aspen in early successional forest.
Terrestrial	SLP	Mesic hardwood	Dry-mesic Southern Forest	Quercus shumardii	Often found in wet, low woods on clay soils in glacial lakeplain landscapes
Terrestrial	SLP	Mesic hardwood	Mesic Southern Forest	Ruellia strepens	Known only from two collections in rich lowland woods in Lenawee County. In the Chicago region, this species is known from shaded floodplains long the Kankakee River valley
Terrestrial	SLP	Mesic hardwood	Mesic Southern Forest	Scutellaria elliptica	Occurs in deciduous forests

Table 3 continued. Examples of output from landscape feature-natural community-rare species crosswalk.

System	Ecoregion	Feature	Natural Community	Species Name	Comment
Terrestrial	SLP	Prairie	Dry Sand Prairie	Agoseris glauca	Occurs in pine barrens, jack pine savanna, jack pine-red oak savanna, and open shrub-grassland in central northern Lower Michigan
Terrestrial	SLP	Prairie	Dry-mesic Prairie	Amorpha canescens	Found in dry to mesic prairies and savannas, dry bluffs and hills, sandy roadsides and clearings. Most records consist of small colonies in degraded, marginal habitat
Terrestrial	SLP	Prairie	Dry Sand Prairie	Amorpha canescens	Found in dry to mesic prairies and savannas, dry bluffs and hills, sandy roadsides and clearings. Most records consist of small colonies in degraded, marginal habitat
Terrestrial	SLP	Prairie	Mesic Prairie	Amorpha canescens	Found in dry to mesic prairies and savannas, dry bluffs and hills, sandy roadsides and clearings. Most records consist of small colonies in degraded, marginal habitat
Terrestrial	SLP	Prairie	Dry Sand Prairie	Androsace occidentalis	Known only from a single collection near Niles in southwestern Lower Michigan, where it was likely collected within an oak barrens or dry prairie
Terrestrial	SLP	Prairie	Lakeplain Wet Prairie	Arabis missouriensis var. deamii	Occurs in sandy, open woodlands and savannas, occasionally in association with coastal plain marshes, borrow pits in lakeplain prairies, and oak-pine woodlands

Table 3 continued. Examples of output from landscape feature-natural community-rare species crosswalk.

System	Ecoregion	Feature	Natural Community	Species Name	Comment
Terrestrial	SLP	River/stream/riparian/floodplain corridor	Prairie Fen	Berula erecta	Occurs in cold headwater streams and seeps within a variety of non-forested and forested wetlands, including prairie fens, southern wet meadow, southern shrub-carr, rich tamarack swamp, hardwood-conifer swamp, and rich conifer swamp
Terrestrial	SLP	River/stream/riparian/floodplain corridor	Rich Tamarack Swamp	Berula erecta	Occurs in cold headwater streams and seeps within a variety of non-forested and forested wetlands, including prairie fens, southern wet meadow, southern shrub-carr, rich tamarack swamp, hardwood-conifer swamp, and rich conifer swamp
Terrestrial	SLP	River/stream/riparian/floodplain corridor	Prairie Fen	Cacalia plantaginea	Occurs in a variety of moist, calcareous open habitat including fens, prairies, sedge meadows, and calcareous lakeshores.
Terrestrial	SLP	River/stream/riparian/floodplain corridor	Rich Tamarack Swamp	Cacalia plantaginea	Occurs in a variety of moist, calcareous open habitat including fens, prairies, sedge meadows, and calcareous lakeshores.
Terrestrial	SLP	River/stream/riparian/floodplain corridor	Rich Tamarack Swamp	Calamagrostis stricta	Northern Michigan collections have come from the rocky shoreline of Lake Superior (on conglomerate bedrock). In southern Michigan it is known from streams and marshes, prairie fens, and a stream mudflat
Terrestrial	SLP	River/stream/riparian/floodplain corridor	Prairie Fen	Calamagrostis stricta	Northern Michigan collections have come from the rocky shoreline of Lake Superior (on conglomerate bedrock). In southern Michigan it is known from streams and marshes, prairie fens, and a stream mudflat

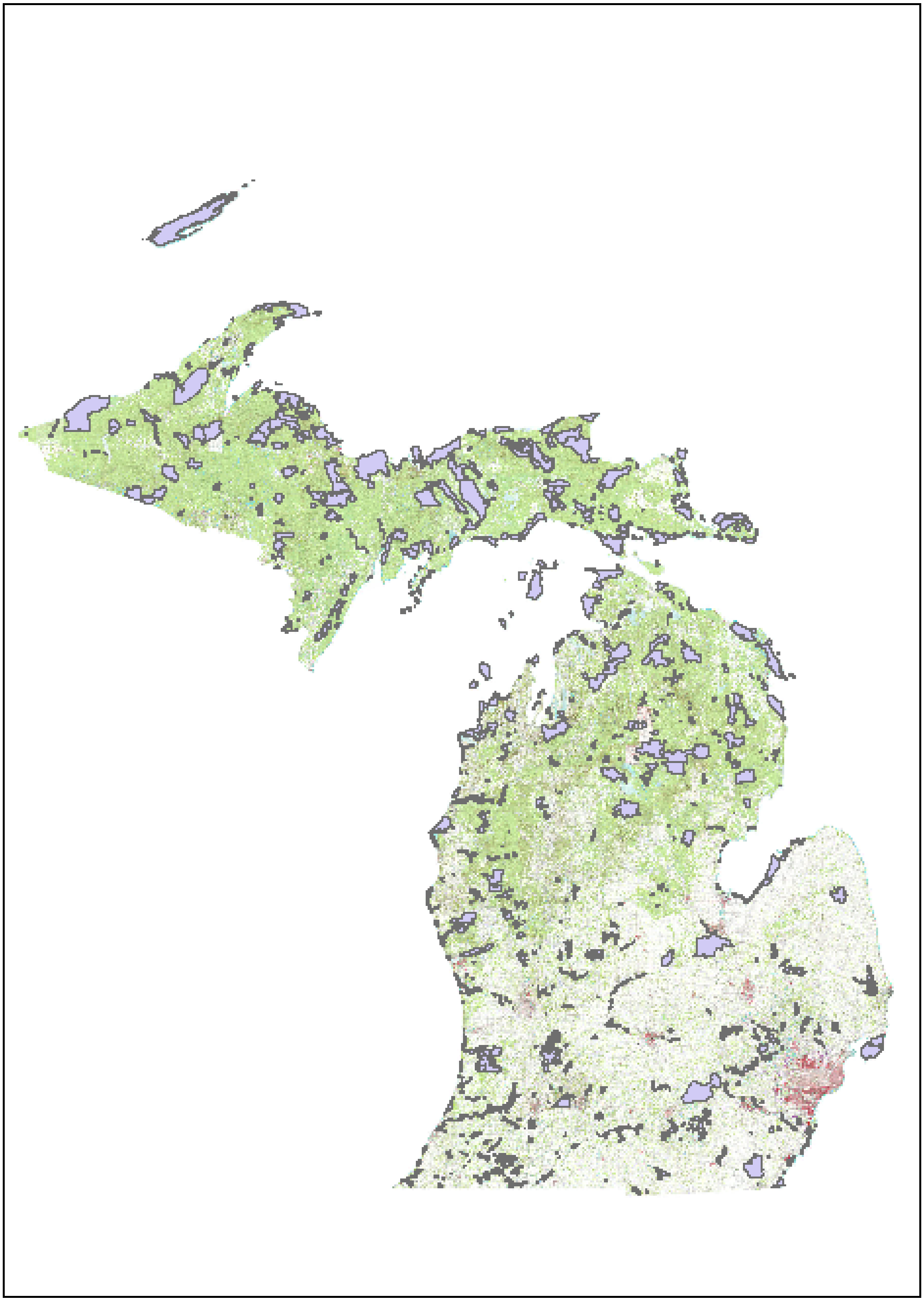

Figure 6. Biodiversity stewardship areas map (MDNR 2012).

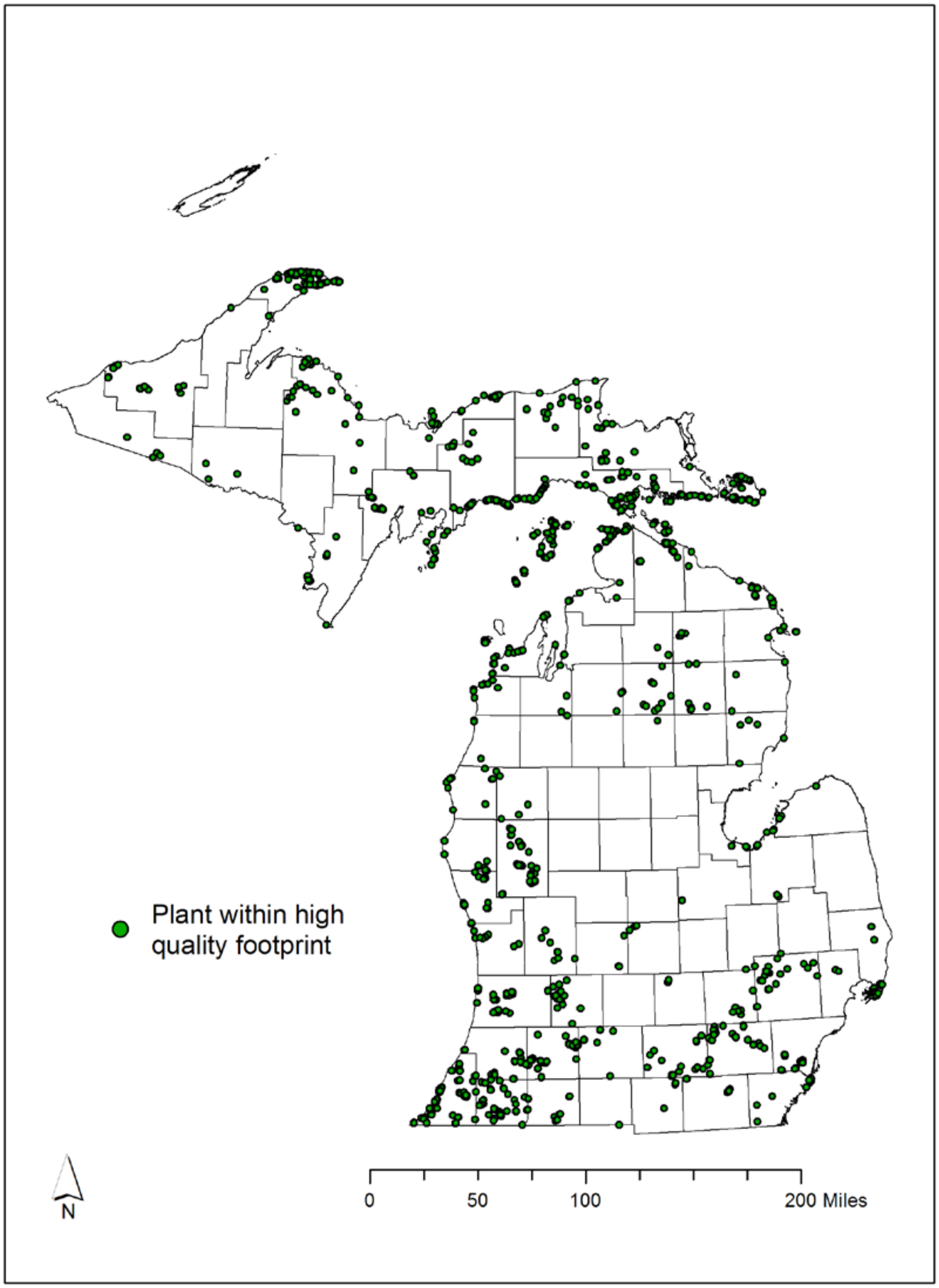

Figure 7. Rare plant occurrences intersecting the high quality ecological footprint.

Table 4. Results of screening the Michigan rare plant database against the high quality state footprint, summarized by land ownership and global rank classes.

Ownership	G1-G3 Plant Occurrences	G4-G5 Plant Occurrences	Totals
Federal	53 (17%)	123 (10%)	176 (11%)
State	139 (46%)	461 (38%)	600 (39%)
County	3 (1%)	15 (1%)	18 (1%)
Local	11 (4%)	43 (3%)	54 (4%)
NGO	25 (8%)	138 (11%)	163 (11%)
Private/Likely Private	69 (23%)	455 (37%)	524 34%)
Totals	300 occurrences	1235 occurrences	1535 occurrences

Table 5. Results of screening the Michigan rare plant database against the high quality state footprint, summarized by land ownership and Element Occurrence Rank classes.

Ownership	A-B Rank Plant Occurrences	C-E Rank Plant Occurrences	Totals
Federal	104 (13%)	72 (10%)	105 (13%)
State	312 (40%)	284 (38%)	313 (40%)
County	10 (1%)	8 (1%)	10 (1%)
Local	26 (3%)	27 (4%)	28 (4%)
NGO	100 (13%)	68 (9%)	100 (13%)
Private/Likely Private	236 (30%)	288 (38%)	232 (29%)
Totals	788 occurrences	747 occurrences	1535 occurrences

Table 4 provides the same ownership summary but in this case via a breakdown by rank class with respect to the quality of occurrences when classed according their assigned EO ranks. Here the A to B ranked occurrences constitute the largest and most viable EOs in contrast to the C to E ranked EOs. Interestingly, there were roughly equal numbers of occurrences within the higher and lower quality occurrence rank classes. Of the 788 high quality occurrences, the majority (40%) were found to occur on state land, with 30% occurring on private land. For the 747 C-E ranked occurrences, the majority (76%) was virtually split evenly between state and private land. Overall, the majority of occurrences (40%) were on state land, followed by private land (29%) and then federal land (13%) and NGO lands (13%). Overall, the high number of occurrences with respect to the footprint reflects the high proportion of state land ownership in northern Lower Michigan and the Upper Peninsula, which contain most of the state's intact and most extensive ecosystems and landscapes.

The last portion of the spatial analysis consisted of briefly screening the rare plant database against the draft map of the state's biodiversity stewardship area system (Figure 6), a project in progress to identify a set of exemplary, ecological reference areas within Michigan. Using a version of the currently drafted boundaries, 357 rare plant occurrences were found to intersect it, consisting of 102 globally rare occurrences and 255 globally secure occurrences. The different approach and criteria employed for the BSA system may be very useful to the Michigan WAP, as indicated in a comparison with the high quality footprint, as the BSA map depicts considerably more areas delineated in southern Lower Michigan.

Linking Plant Information to the Wildlife Action Plan

Michigan is beginning to start revising the Wildlife Action Plan. The work in this project provides key linkages to allow plants to become part of the updated plan. Climate change vulnerability assessments for Michigan demonstrated that there is a strong correlation between global rarity and vulnerability, although most of the other taxa assessed, including selected common species, were also assessed as being vulnerable to climate change. This may have been due to the fact that many of the listed, globally secure species assessed consisted of those selected from relatively rare Great Lakes natural communities, including several wetland habitats likely to be impacted in future climate change scenarios. There are significant migration barriers for many plant species, though it was presumed that many coastal species would be able to follow successional pathways along the Great Lakes assuming that lake basins would steadily retract and provide colonization habitat. Although Michigan supports a comparatively small proportion of globally rare species, there is strong merit in continuing assessments on the remainder of the state's tracked taxa. Several common plant species known to be significant to wildlife were also found to be vulnerable, and although the number of species assessed was not large, the results indicated that further assessments on additional species important to wildlife should be conducted and considered, especially plant species important to SGCN. Work is currently underway on a climate adaptation plan for Michigan's natural resources. The results of the CCVII for plants in this project will help the Wildlife Division to include plants into the adaptation plan. Many of Michigan's animals, both rare and common, have also been run through the CCVII. And so Michigan will have a wide variety of taxa groups to analyze and compare to explore how climate change could affect Michigan's biological diversity. This adaptation plan will be used as a guide aid the Wildlife Action Plan update.

The landscape features-natural community-rare plant species crosswalk, originally conceived for providing comments on selected species, was developed into larger and more comprehensive tool by adding general to specific habitat information for all species where known. The expanded crosswalk will be added to the Wildlife Action Plan database such that enhanced summaries can be created for SGCN, their habitats, and key plant species. Moreover, the crosswalk can continue to be developed around this framework as necessary to add further relevant information on plants, such as management activities that promote both SGCN and rare and common plant taxa. In the Wildlife Action Plan revision, we plan to highlight key plants to better highlight the full biological diversity of Michigan, and to show where conservation actions for animals also benefit key rare plants. The linkages may also allow us to flag where particular priority conservation actions developed in the revision may negatively impact rare plants. This tool enhances the information available to make decisions and revise the Wildlife Action Plan.

Selected spatial analyses indicated that defined high quality areas contribute disproportionately to rare plant richness and diversity in Michigan and thus are worthy of strong consideration for contributing to WAP activities and goals. In concert with the currently proposed Biodiversity Stewardship Areas, these delineated landscapes can contribute significantly to the Michigan WAP.

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This project would not have been possible with funding from NatureServe via the Doris Duke foundation, and Michigan Natural Features Inventory is indebted for the opportunity to take part in this interesting, multi-state effort to begin to better incorporate plants into state Wildlife Action Plans. Much appreciation is extended to past and present NatureServe staff members, including Kelly Gravuer, Judy Soule, and Leah Oliver. Kelly worked on the design the Climate Change Vulnerability Index, co-authored versions of its manuals, and trained many of us in its reliable use. Her assistance in the initial portion of this project was extremely helpful, both in administration and in technical issues. Judy Soule provided guidance in preparing our proposal and setting up a contract with her former program in Michigan. Leah Oliver served as the NatureServe project officer for the majority of this effort, and kindly, knowledgeably, and patiently managed all that needed to be done, arranging and overseeing our conference calls, answering financial and other administrative matters, and advising and coaching all the way through. I would also like to thank Kimberly Hall of The Nature Conservancy for taking the time to review the CCVI and provide further training, tips, and encouragement. Several colleagues in MNFI provided important help as well, including Helen Enander, for supplying her abundant GIS analyst skills, Kraig Korroch, for his daily technical wizardry that always gets us through, and Becca Rogers, for assistance with everything from Biotics and the database to the inevitable problems with report preparation and layout.

Literature Cited

Cohen, J.G. 2011. Natural community surveys of potential biodiversity stewardship areas. Submitted to Michigan Dept. of Natural Resources, Wildlife Division and Forest Management Division. MNFI Report Number 2011-08. Lansing, MI. 21 pp.

Cuthrell, D.L. and M.R. Penskar. 2005. Animal, plant, and natural community relationship table. Unpublished crosswalk. Michigan Natural Features Inventory, Lansing, MI. 9 pp.

Lee, Y.M., M.R. Penskar, P.J. Badra, B.J. Klatt, and E.H. Schools. Climate Change Vulnerability Assessment of Natural Features in Michigan's Coastal Zone – Phase I: Assessing Rare Plants and Animals. Submitted to Michigan Coastal Management Program, Office of the Great Lakes, Michigan Dept. of Environmental Quality. MNFI Report Number 2011-18. Lansing, MI. 80 pp.

Pearman, P.B., M.R. Penskar, E.H. Schools, and H.D. Enander. 2006. Identifying potential indicators of conservation value using natural heritage occurrence data. Ecological Applications 16: 186-201.

Penskar, M.R., E.H. Schools, H.D. Enander, M.A. Kost, D.L. Cuthrell, P.B. Pearman. 2003. The Potential for Using Rare Species as Environmental Indicators: A Methodology Using Natural Heritage Program Data. Submitted to Great Lakes National Program Office, U.S. Environmental Protection Agency. MNFI Report Number 2003-20. Lansing, MI. 42 pp. + appendices.

Stein, B.A. and K. Gravuer. 2008. Hidden in Plain Sight: The Role of Plants in State Wildlife Action Plans. Arlington, VA: NatureServe. 27 pp.

Voss, E.G. and A.A. Reznicek. 2012. Field Manual of the Michigan Flora. University of Michigan Press, Ann Arbor, MI. 990 pp.

Add citation for Michigan Flora Web page

Young, B., E. Byers, K. Gravuer, K. Hall, G. Hammerson, and A. Redder. 2011. Guidelines for Using the NatureServe Climate Change Vulnerability Index. Release 2.1, 7 April 2011. Arlington, VA. 58 pp.

Appendices

Attachment 1: CCVI calculator with results

Attachment 2: Landscape Feature Crosswalk