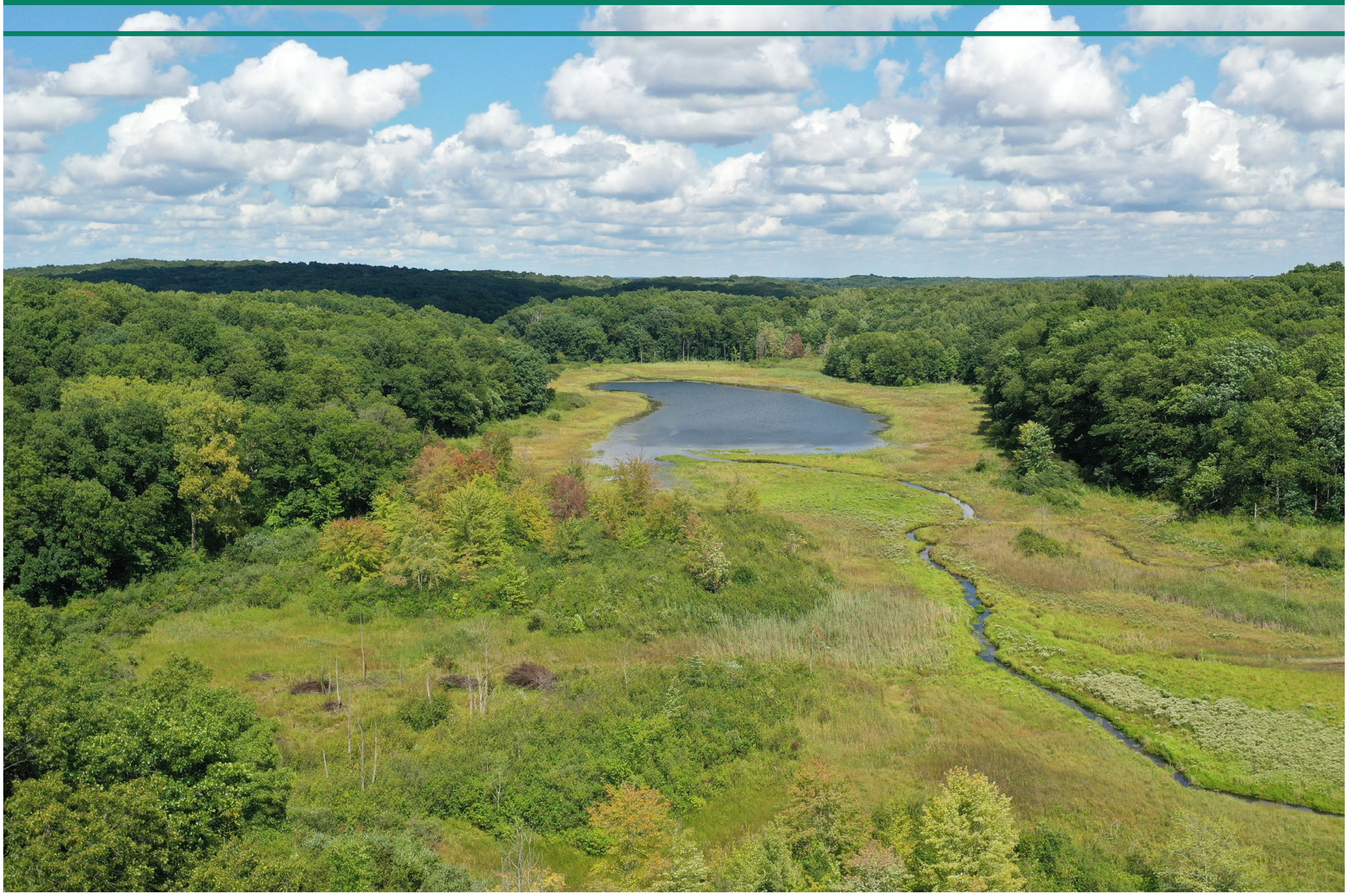
Prioritizing Invasive Species Treatment at Fort Custer Training Center Using GIS-Based Multicriteria Decision Analysis



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Prepared For:
Michigan Department of Military and Veterans Affairs
Fort Custer Training Center

March 31, 2023

MNFI Report Number 2023-04

Suggested Citation: Cohen, J.G., Cole-Wick, A.A., T.J. Bassett, H.D. Enander, C.M. Wilton, and C.N. Ross. 2023. Prioritizing Invasive Species Treatment at Fort Custer Training Center Using GIS-based Multicriteria Decision Analysis. Michigan Natural Features Inventory Report Number 2023-04, Lansing, MI. 34 pp.

Cover Photo: Aerial photo of Whitman Lake Fen and surrounding woodlands within stands ranked as highest priority by the Invasive Species Treatment Prioritization Model. Photo by Matthew J. Lewis, Michigan Aerospace Corporation.

Land Acknowledgement: We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan's twelve federally-recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous peoples.

Acknowledgements

This project was made possible with funds provided by the Fort Custer Training Center (FCTC). We thank everyone from FCTC, especially Michele Richards and Brian Huggett. We also thank the Michigan Department of Natural Resources (DNR) for our use of their Michigan Forest Inventory protocol and database and we are especially grateful to the DNR's Michael Donovan, Gregory Norwood, and Amy Derosier for supporting the initial development of the Invasive Species Treatment Prioritization Model. Numerous Michigan Natural Features Inventory (MNFI) staff contributed to this work including Michael Monfils, Brian Klatt, Ashley Adkins, Sarah Carter, Debra Richardson, Rebbeca Rogers, and Kraig Korroch. In addition, we thank Matthew Lewis and Michigan Aerospace Corporation for providing aerial photographs.

Prairie fen complex at Fort Custer Training Center with invasive glossy buckthorn (*Frangula alnus*) and narrow-leaved cattail (*Typha angustifolia*). Photo by Matthew J. Lewis, Michigan Aerospace Corporation.

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Introduction

Fort Custer Training Center (FCTC) is a federally owned, active National Guard Training Center operated by the Michigan Department of Military and Veteran Affairs. It is located on 7,570 contiguous acres in eastern Kalamazoo and western Calhoun Counties in southwestern Michigan between Kalamazoo and Battle Creek. Most military training is concentrated in the northern 10% of FCTC, and the remaining portion is managed for biodiversity conservation. As such, FCTC is regionally important as a contiguous block of habitat in the predominantly fragmented landscape of southern Michigan. Situated along a series of low morainal ridges in the Kalamazoo River watershed, the uplands and lowlands support both high-quality and degraded examples of the oak-hickory forest, mixed oak savanna, emergent marsh, shrub swamp, and mixed hardwood swamps that historically dominated the landscape. The headwaters of several streams are found within FCTC, including large portions of surrounding uplands that can be managed to protect them. Given this wealth of natural resources and a long history of prescribed fire and invasive species management, FCTC supports incredible biodiversity, including many rare plant and animal species and rare high-quality natural communities (Cohen et al. 2009, Bassett et al. 2022).

This rich biodiversity at FCTC faces a variety of threats, and foremost among these are the impacts of invasive plant species. Invasive plants affect natural communities by outcompeting native plants for light, soil, water, and nutrients. Through their patterns of resource acquisition and growth, invasive plants degrade native biodiversity by altering fundamental ecosystem structure and function (Ehrenfeld 2010). Invasive plants displace critical habitat for native species; interrupt food webs; alter soils, hydrology, and disturbance regimes; compromise pollinator services; change microclimates; despoil recreational resources; jeopardize human health; and degrade local economies (Zavaleta 2000, Pimental et al. 2005, Ehrenfeld 2010). Additionally, the economic impact of these species cannot be overstated, with recent work showing that invasive species costs across the United States totaled $4.52 trillion between 1960 and 2020 (Fantle-Lepczyk et al. 2022). Invasive infestations are projected to increase with continued fragmentation (Vila and Ibanez 2011) and climate change. Invasive plant infestations are distinguished from the spread of non-invasive exotic species by being rapid and extensive, occurring at regional scales as species disperse over long distances with the rate of spread often outpacing land managers' ability to effectively detect and control infestations (Lass et al. 2002, Lass et al. 2005, Mullerova et al. 2013, Mullerova et al. 2017).

The rapid spread of invasive plants demands dynamic tools that can help land managers match the pace and scale of invasive infestations and help prioritize control efforts in the most ecologically important areas. The resources (e.g., time, money, and labor) available to control invasive species are limited so it is imperative that proposed management efforts be informed by the best available ecological information. Where resources are directed, or not directed, may determine the fate of many species of conservation concern and the ecosystems on which they depend. We believe that ecosystems should be prioritized for invasive species treatment when they are characterized by high ecosystem integrity, support high biodiversity, are resilient to disturbance, provide ecosystem services, and are threatened by an invasive infestation that can alter species composition, structure, and processes. Using GIS-based multicriteria decision analysis, we developed a robust model for assessing where to focus invasive plant species management efforts at FCTC. This report details our methods, presents our results, and discusses model applications, model limitations, and next steps.

From 2018 to 2021, scientists from the Michigan Natural Features Inventory (MNFI) conducted surveys for high-quality natural communities, rare species, and wall-to-wall vegetation mapping at FCTC (Bassett et al. 2022). To aid natural resource managers at FCTC in deciding where to direct invasive species management efforts, we have used these inventory results to apply MNFI's Invasive Species Treatment Prioritization Model (hereafter referred to as "the model"; Cohen et al. 2019, Cole-Wick et al. 2021). The model facilitates identification of areas to prioritize monitoring, treatment, and containment of invasive plant species. The primary products generated from this model are geospatial stand-level data files attributed with general stand characteristics (e.g., natural community type), and invasive species treatment priority scores attributed to each stand.

Output from this modelling effort can be used to address important and frequently asked conservation planning questions like "Where should invasive species management be prioritized?" and "Which species should we prioritize?" In this report we describe the methods used to develop the model and provide recommendations on how to interpret model output in the context of on-the-ground conditions. In addition to this document, we also have provided FCTC with spatial results of the model via ArcGIS Online, which can be used for future planning endeavors and accessing all stand-level attributes.

Glossy buckthorn (*Frangula alnus*) (above) and invasive reed (*Phragmites australis* subspecies *australis*) (below) invading Whitman Lake prairie fen (stands 35 and 55) within the Fort Custer Training Center. These invasive plants degrade the ecological integrity of native ecosystems by altering floristic composition and vegetative structure. In addition, they displace critical wildlife habitat, interrupt food webs, alter soils and hydrology, and erode the ecosystem services provided by native ecosystems. Photos by Joshua G. Cohen.

Methods

We developed this model by adapting the methods of recent work developed by MNFI for the Michigan Department of Natural Resources (MDNR; Cohen et al. 2019) and applied to other partners' land (Cole-Wick et al. 2021). The foundational units of the model are stands within the Michigan Forest Inventory (MiFI) Database (MDNR 2022). Stands are polygons that represent relatively homogeneous areas of a similar cover type across the landscape. MNFI recently completed stand mapping of FCTC as part of the most recent ecological inventory (Bassett et al. 2022). Each stand is attributed with a MiFI cover type as well as an MNFI natural community type (Cohen et al. 2015, Cohen et al. 2020, Appendix 1). There are a total of 498 stands in 9 compartments at FCTC. Each stand was intersected with the following spatial datasets: invasive species data from three sources (KNC 2022, MISIN 2022, MDNR 2022); circa 1800 vegetation (Comer et al. 1995); TNC's climate resilience model (Anderson et al. 2018); and rare species and natural community element occurrences (MNFI 2023). An element occurrence (EO) is an area of land or water where an element of biodiversity (rare species or natural community) currently occurs or historically occurred (NatureServe 2012).

Conceptualization and development of the model were informed by literature review and interactions with natural resource managers and invasive species experts. The goal of developing this model is to focus invasive species control efforts in the most ecologically important landscapes and ecosystems and thereby increase the integrity of native ecosystems and improve habitat for native biodiversity.

We identified four factors that are critical for determining a site's priority for invasive species treatment: integrity, biodiversity, resiliency, and ecosystem services. For each of these critical factors we developed variables to score on a scale of 0 to 5 (with 0 being no priority and 5 being the highest priority). Scores for all variables were scaled equally within 6 integers and typically ranged between 0 and 5, in order of increasing priority for invasive treatment (i.e., 0 = No Priority, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High, and 5 = Highest).

For each stand a suite of thirteen variables were scored, weighted, and summed using GIS-based multicriteria decision analysis, which combines spatially referenced data and multi-attribute criteria in a problem-solving environment (Malczewski 2006, Malczewski et al. 2020). We selected this methodology because it provides the ability to weight and combine multiple inputs to create an integrated analysis.

Model Development

Each variable used in the model is binned into one of four categories: integrity, biodiversity, resiliency, and ecosystem services, described individually below (Figure 1, Table 1). A subset of the variables (Natural Community Rarity, Natural Community Richness, Natural Community Resilience, and Ecosystem Services) are defined by natural community type and the classification of each stand to a natural community type facilitates the scoring.

Integrity

To evaluate a stand's integrity, we developed seven variables, two that gauge how invasive species impact the integrity of the stand (**Invasive Species Impact** and **Invasive Species Density**), three that characterize the landscape surrounding a stand (**Land Use Index**, **Invasion Risk**, and **Buffer**), and two that assess the ecological integrity of the stand (**EcoScore** [Appendix 2] and **Stand Age**).

A stand's invasive species integrity score is based on both Invasive Species Impact and Invasive Species Density. Geospatial invasive species presence and density data were compiled from three sources: MiFI surveys conducted by MNFI from 2020 to 2021 (Bassett et al. 2022), observations in the Midwest Invasive Species Information Network (MISIN) data repository, and long-term mapping and data collection efforts by FCTC contractors (KNC 2022). Eighty invasive plant species were systematically evaluated and scored based on their establishment, spread, and impact potentials. We utilized a Weed Risk Assessment (WRA) tool developed by the United States Department of Agriculture (USDA) to inform this process (USDA 2019). Each invasive species assessed using the WRA procedure received a probability of becoming a major-invader, relative to their probability of becoming a minor- or non-invader. Based on this probability assessment, we generated bins based on the minimum, median, and maximum of each invasiveness probability category and assigned each species a treatment priority ranking ranging from 0 to 5, with 0 as "no priority" and 5 as "highest priority" or critical (Appendix 3). When a stand contained an invasive species, either within the MiFI data or when it intersected with MISIN or KNC data, the stand received both an Invasive Species Impact score based on that species' assigned treatment priority ranking and an Invasive Species Density score based on the recorded density of that invasive species.

To evaluate a stand's landscape integrity, we developed a Land Use Index based on the land use adjacent to the stand, estimated Invasion Risk based on the proximity of

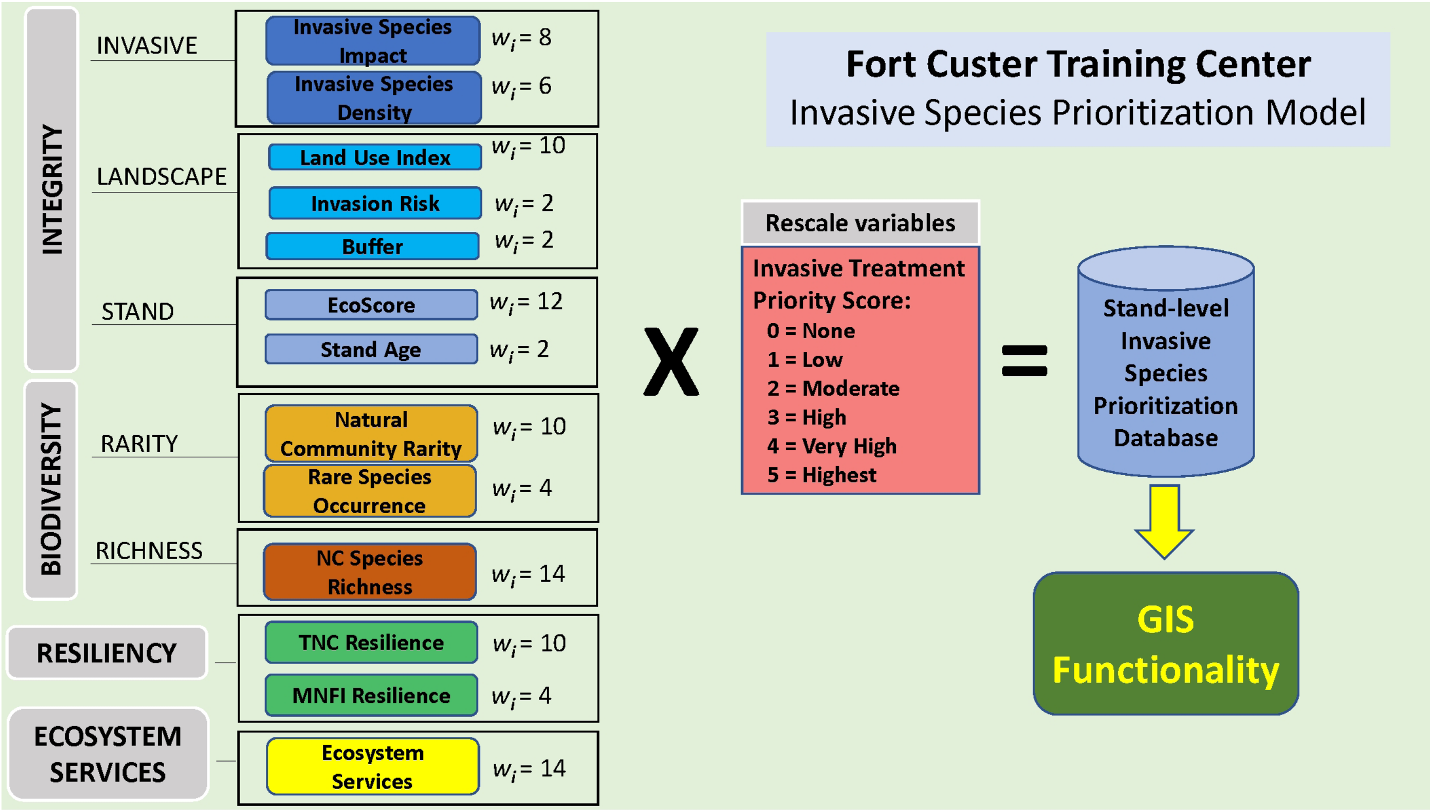


Figure 1. The Invasive Species Treatment Prioritization Model gauges each stand's priority for invasive species treatment based on an array of spatial variables. For each stand, multiple input variables were evaluated, scored, and weighted to generate an overall priority score. Each variable was binned into one of four factors or categories: integrity, biodiversity, resiliency, and ecosystem services.

Glossy buckthorn (*Frangula alnus*) (left) and purple loosestrife (*Lythrum salicaria*) (right) invading the Mott Road prairie fen (stands 50 and 65) within the Fort Custer Training Center. The unprecedented rate of spread of pernicious invaders across landscapes demands efficient tools like the Invasive Species Treatment Prioritization Model that help prioritize control efforts in the most ecologically important areas. Photos by Joshua G. Cohen.

Table 1. Variables used in the Invasive Species Treatment Prioritization Model with weighting, description, and source data. Each variable is categorized (Cat.) as a proxy for one of the following: integrity, resiliency, biodiversity, or ecosystem services. Those variables highlighted with an asterisk (Natural Community Rarity, Natural Community Richness, Natural Community Resilience, and Ecosystem Services) are defined by natural community type and the classification of each stand to a natural community type facilitates their scoring.

Cat.	Variable (variable # = weight)	Description	Source Data	% Weighted Total
Integrity Invasive	Invasive Species Impact (w_{2a}=8)	Sum of invasive species scores present in a stand	MISIN 2022, KNC 2022, MDNR 2022	8%
	Invasive Species Density (w_2b=6)	Mean density score for each unique invasive species in a stand	MISIN 2022, KNC 2022, MDNR 2022	6%
Integrity Landscape	Buffer (w_{11}=2)	Percentage of perimeter with undeveloped/natural land cover	Roberts and Cooper 1989	2%
	Invasion Risk (w_1=2)	A proxy for invasion risk, this variable is the distance to nearest physical invasive species vector (e.g., road, powerlines)	Center for Shared Solutions and Technology Partnerships 2017	1%
	Land Use Index (w_{10}=10)	Proportion of intensive land cover to natural land cover in buffer surrounding stand based on NatureServe's landscape scale ecological integrity variable	Faber-Langendoen et al. 2016, Cohen et al. 2019	10%
Integrity Stand	Stand Age (w_{13}=2)	Recent tree core(s) of dominate tree species in forested stands	Bassett et al. 2022	2%
	EcoScore (w_7=12)	Score, ranging from 1 to 5, to develop a relative ranking system of stand quality, assigned during MiFI	Bassett et al. 2022	12%
Biodiversity	Rare Species Occurrence (w_9=4)	Rank based on presence and year of last observation of intersecting rare species EO with historic records excluded	MNFI 2023	4%
	Natural Community Rarity* (w_5=10)	Rank based on rarity of natural community type both within Michigan and globally	Cohen et al. 2019	10%
	Natural Community Species Richness* (w_{14}=14)	Rank based on species richness and diversity of ecosystem processes of the natural community type assigned to the stand	Cohen et al. 2019	15%
Resiliency	TNC Resilience (w_4=10)	Rank determined by The Nature Conservancy's (TNC) climate resilience model	Anderson et al. 2016	10%
	MNFI Resilience* (w_6=4)	Rank by MNFI experts based on resilience to disturbance and invasive encroachment	Cohen et al. 2019	3%
Ecosystem Services	Ecosystem Services* (w_{15}=14)	Rank by expert based on contribution to provisioning, regulating, supporting, and cultural services (e.g., pollinator habitat, recreation, water filtration) of the natural community type assigned to a stand	Cohen et al. 2019	15%

the stand to invasive species vectors, and characterized the Buffer of natural cover surrounding a stand. The Land Use Index is based on NatureServe's landscape scale ecological integrity metric (Faber-Langendoen et al. 2016). This metric score is based on the proportion of land use in a surrounding buffer. Stands surrounded by intensive land use (e.g., urban centers and parking lots) receive lower scores, and stands surrounded by natural cover (e.g., a prairie fen surrounded by an oak-hickory forest) receive higher scores. We evaluated Invasion Risk to each stand by developing an index of exposure to invasives based on a stand's distance to potential vectors (e.g., roads, powerlines, trails, and parking areas). Greater distances to potential vectors resulted in higher priority scores. For the Buffer variable we measured the proportion of the stand perimeter (or edge) that is adjacent to a natural landcover type and assigned higher scores for stands with higher proportions of buffer.

Stand level integrity was evaluated by assessing two variables, EcoScore (Appendix 2) and Stand Age. An EcoScore was assigned to each stand during MiFI inventory. The EcoScore is a field-based classification system for defining the ecological integrity or quality of a stand based on its assigned natural community type, where 0 represents a severely degraded condition and 5 represents a minimally degraded, high-quality condition (Appendix 2). An EcoScore of 3.0 represents a moderately degraded stand condition but retains many of the core components of its assigned natural community (e.g., species assemblage, natural processes). Stands with higher EcoScores received higher treatment priority scores. Additionally, for a stand with an EcoScore less than 3.0, the total stand score was adjusted down to reflect its degraded condition and exclude it from management consideration, while no restrictions were placed on the total stand score for stands with an EcoScore of 3.0 and above. For forested stands, we also used Stand Age (based on tree ring dating) to evaluate stand integrity, with older forested stands receiving higher priority scores.

Biodiversity

To evaluate a stand's biodiversity, we focused on two variables that assess a stand's rarity (**Natural Community Rarity** and **Rare Species Occurrence**) and one variable that measures species richness of natural community types (**Natural Community Species Richness**). Stands that intersect with natural community element occurrences were scored based on the natural community type's state and global rarity ranks (Appendix 4) to determine the Natural Community Rarity score, with rarer ecosystems receiving higher priority scores. Rare plant or animal species element occurrences within stands further increased the biodiversity score. We used MNFI's Natural Heritage Database (MNFI 2023) of element occurrence (EO) records for rare plant and animal species to determine which stands contain rare species. The Rare Species Occurrence variable was generated by intersecting rare species EOs with all FCTC stands. We scored each stand using equal interval bins derived from the summed proportion of a stand's geographic area covered by all rare species polygons to assign scores from 1 to 5 (if no rare species polygons intersected a stand, we assigned a score of 0). For all stands with rare species polygons, these summed proportions ranged from 0.95 to 6.5, so the bins were as follows: 0.95 – 2.06 = 1, 2.07 – 3.17 = 2, 3.18 – 4.28 = 3, 4.28 – 5.39 = 4, and 5.39 – 6.5 = 5. For example, a stand with a 0.50 overlap by species A, 0.75 overlap with species B, and 0.25 overlap with species C would receive a score of 1 (0.50+0.75+0.25=2.00). Element occurrences with low representational accuracy were omitted from analysis, including 85 plant and animal EOs (e.g., EOs known only from historic museum specimens with vague locality information).

We developed a Natural Community Species Richness variable to account for a stand's contribution to native species diversity and diversity of ecosystem processes. For each natural community type, we assigned a score based on that natural community type's average species richness and diversity of ecosystem processes (e.g., gap-phase dynamics, fire, and seasonal flooding). For example, prairie fens receive the highest biodiversity score because they are characterized by high species richness driven by diverse processes including groundwater seepage, fire, and the small-scale formation of sphagnum hummocks and hollows that generates fine-scale gradients in soil moisture and chemistry. Those stands that were crosswalked to a natural community type were assigned that natural community type's species richness score, with higher scores for ecosystems characterized by higher diversity (See Appendix 1).

Resilience

To evaluate a stand's resilience, we employed two variables, climate resilience (**TNC Resilience**) and natural community resilience (**MNFI Resilience**). A stand's resilience to climate change, or TNC Resilience, was evaluated using The Nature Conservancy's climate resilience model (Anderson et al. 2018). Stands that occur within areas identified by the resilience analysis as being resistant to climate change were given higher priority scores. The natural community resilience variable, or MNFI Resilience, was derived by evaluating each natural community type's resilience to disturbance and invasive species encroachment. For each natural community type, we assigned a score based on that natural community type's ability to respond to disturbance and resist invasive encroachment (See Appendix 1). Those stands that were crosswalked to a natural community type were assigned its natural community resilience score, with higher scores for ecosystems characterized by greater resilience to disturbance and invasive infestation. Stands not crosswalked to a natural community type typically indicated that the stand was unrecognizable as a natural community during MiFI inventory (e.g., old field, parking lot) and were given a score of 0.

Ecosystem Services

The final variable developed for this model was an **Ecosystem Services** variable. For each natural community type, we assigned an Ecosystem Services score based on ten factors that gauge contribution to provisioning, regulating, supporting, and cultural services (Appendix 1). These ten ecosystem service factors are water filtration, carbon sequestration, pollinator habitat, recreation, subsistence foraging, coastal shoreline buffer, cultural value, flood protection, nutrient cycling, and regulation of climate and air quality. Those stands that were crosswalked to a natural community type were assigned that natural community type's ecosystem services score, with higher scores for ecosystems characterized by greater contribution to these ten servicing factors.

Scoring

For each variable we developed detailed rules for scoring. For example, for stands with invasive species "IF Invasive Species Impact = 5 (Major Invader), THEN Score = + 5". Additional examples of rules include: "IF TNC Climate Resiliency = Far Above Average, THEN Score = + 5"; "IF percent of natural cover within buffer > 80% THEN Score = + 5"; "If natural community rarity rank = S1 or G1, THEN score = +5"; "IF Natural Community Ecosystem Services = Floodplain Forest, THEN Score = + 5"; and "IF Land Use Index = 0-10, THEN Score = + (0-10)/2, respectively".

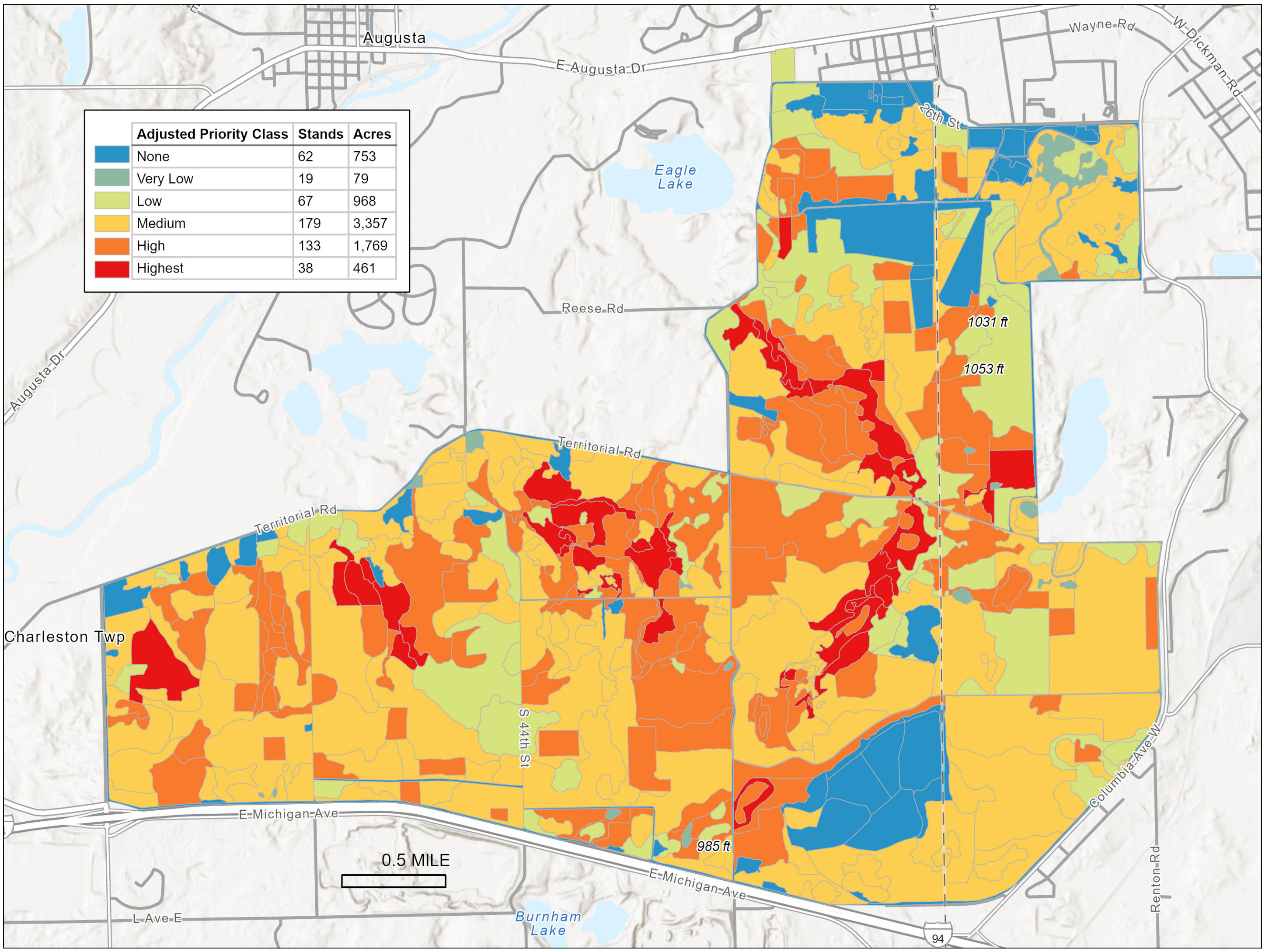
The total "invasive treatment priority score" was developed using GIS-Based Multicriteria Decision Analysis. Each of the variables in the model had a possible score ranging from 0 to 5, with 0 representing lowest priority and 5 representing the highest priority (Table 1). Each variable score is multiplied by an assigned proportional weighting factor based on expert opinion of MNFI scientists. Assigned variable weights are as follows: x8 Invasive Species Impact, x6 Invasive Species Density, x10 Land Use Index, x2 Invasion Risk, x2 Buffer, x12 EcoScore, x2 Stand Age, x10 Natural Community Rarity, x4 Rare Species Occurrence, x14 Natural Community Species Richness, x10 TNC Resilience, x4 MNFI Resilience, and x14 Ecosystem Services (Figure1, Table 1). For each stand, the "invasive treatment priority score" was calculated by summing the weighted scores for each variable and then rescaling/converting the final score to a 0 to 5 range for interpretation on original scale. Higher scores convey a higher priority for invasive species treatment. To visualize the scoring, the scores were assigned colors on a blue to red color gradient with higher scores corresponding to reds and displayed within a GIS. For the final score, we adjusted some scores to emphasize stands with invasive species present. Stands that did not have any invasive species present were de-emphasized by reducing their priority scores by 2 if the final score remained greater than zero (Cohen et al. 2019).

Glossy buckthorn (*Frangula alnus*) management in Whitman Lake Fen (stands 35 and 55). These stands were indentified as highest priority by the Invasive Species Treatment Prioritization Model. Photo by Tyler J. Bassett.

Results

We assigned invasive species treatment priority scores for variables that address a stand's invasive species impact and risk, ecological integrity at multiple scales (e.g., landscape and stand), biodiversity in terms of rarity and richness, resiliency to disturbance and climate change, and contribution to ecosystem services. The primary products that we have generated from this model are stand-level data files attributed with the described data and priority scores, as well as the spatial representation of those stands at multiple scales (Figure 2). In addition, MNFI has made this model accessible to FCTC land managers via ArcGIS Online through the FCTC Web App.

Invasive species treatment priority scores were assigned to 498 stands. The model ranked 38 stands, totaling 461 acres, as the "highest" priority for invasive species management; 133 stands, totaling 1,769 acres as "high priority"; 179 stands, totaling 3,357 acres as "medium priority"; 67 stands, totaling 968 acres as "low priority"; 19 stands, totaling 79 acres as "very low priority"; and 62 stands, totaling 753 acres as "none" (Figure 3). For the highest priority stands for treatment identified by the model, we provide the total priority score as well as each individual variables score in Appendix 5.



Adjusted Priority Class	Stands	Acres
None	62	753
Very Low	19	79
Low	67	968
Medium	179	3,357
High	133	1,769
Highest	38	461

Figure 2. Map of the Invasive Species Treatment Prioritization Model for the Fort Custer Training Center showing stands adjusted priority class ranked from none to highest.

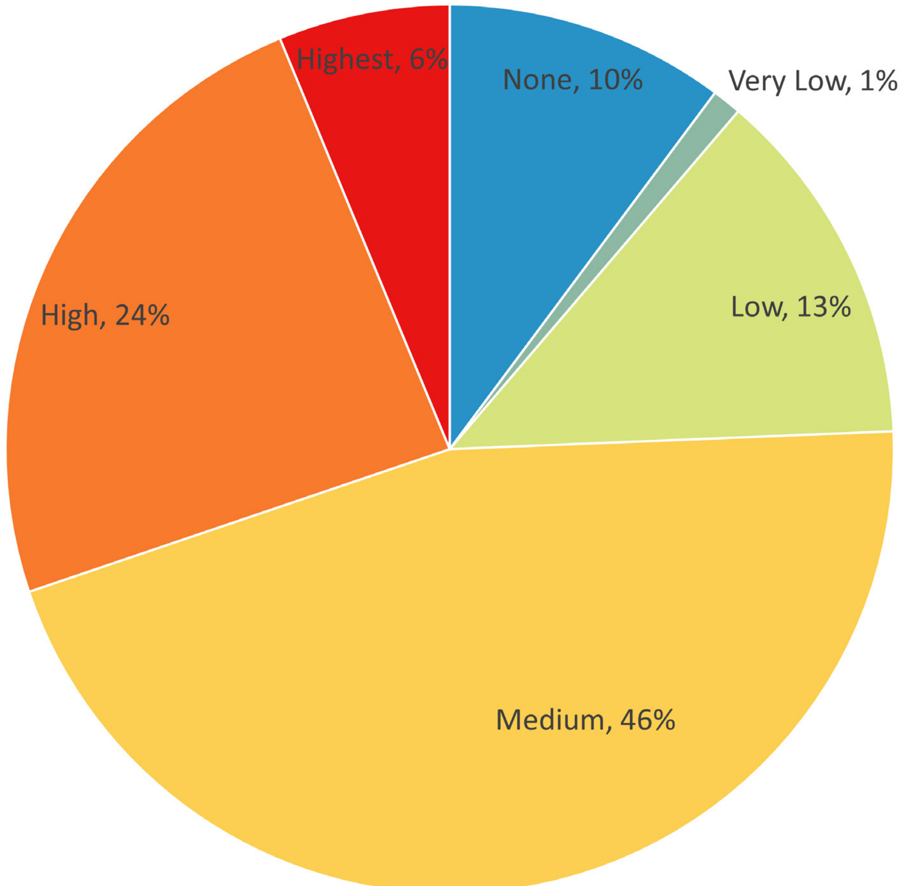


Figure 3. Summary of Invasive Species Treatment Prioritization Model priority ranking for Fort Custer Training Center.

A restorable oak barrens site with a moderate density of autumn olive (*Elaeagnus umbellata*). These stands were identified as medium to high priority by the Invasive Species Treatment Prioritization Model. Photo by Tyler J. Bassett.

Discussion

The Invasive Species Treatment Prioritization Model can be used to aid in decision-making for invasive plant species management at FCTC. The use of stands as the building blocks of the model allows resource managers to evaluate invasive species treatment priorities at multiple scales across FCTC. Managers can evaluate invasive species scores by stands, among groups of stands, and within distinct management units across the base (e.g., training areas, burn units). This model can provide resource managers with an effective tool for both site-based management decisions as well as landscape-level planning. The model was developed to foster informed discussion and facilitate difficult decisions about allocation of finite resources.

Interpreting the model output and deciding how to implement the prioritization of invasive species control based on these results requires several considerations. First, this model is a tool and should be used in conjunction with on-the-ground knowledge as a part of the decision-making process. Interpretation of the model may rely on stand or landscape characteristics not quantified across the model. Examples of such characteristics are nearby or bordering rare species occurrences (e.g., stands adjacent to documented rare species occurrences that may nonetheless provide habitat or act as a buffer), hydrological interactions, field-knowledge that may not be captured in stand-level attributes, and attributes of the stand that have changed since the surveys for this model were conducted. Second, this model is static in that it represents a temporal snapshot. We recommend updating the model when input data is updated, especially invasive species presence and density data. The model is only as good as the data supporting it, and there may be instances where invasive species abundances have changed or are greater or lesser than the model recommendations suggest. Third, it is important to remember that the model places the abundance of invasive species in a conservation priority context and ranks stands based on multiple considerations. For example, stands with very low numbers of invasive species may rank as higher priority in the model because eradication is feasible. The ranking may increase further in cases where the conservation benefits of eradication or control are particularly high, such as where invasive species threaten the viability of rare species populations or high-quality natural communities. In contrast, stands with many invasive species may not rank as highly if they do not support rare species or high-quality natural communities. In other cases, the converse is true, for example, the high-quality Longman Road Bogs (TA 5, Stands 17-20; TA 6, Stand 1) do not rank as 'highest' in the model despite supporting several rare species and high-quality natural communities, because invasive species abundance is low.

A woodland dominated by black locust (*Robinia pseudoacacia*) and Japanese barberry (*Berberis thunbergii*) from a stand identified as a low priority by the Invasive Species Treatment Prioritization Model. Photo by Tyler J. Bassett.

The model ranked 38 stands (totaling 461 acres) as the "highest" priority for invasive species management (Figure 3, Table 2, Appendix 5). We strongly support decisive and prompt implementation of invasive species management efforts in these highlighted stands but also recognize that resources are finite and may prohibit immediate action in many of these stands. Therefore, we provide a further prioritization of the "highest" priority stands that can be staged over multiple years of implementation (Table 2). We suggest a finer-scale prioritization of these 38 stands based on threats (invasive species and their densities) and conservation targets (rare species and high-quality natural communities) and informed by MNFI's knowledge of these stands (Bassett et al. 2022).

We identified seven core areas centered around one or more high-quality natural community EO that can serve as management areas where multiple invasive species are managed at the scale of multiple stands (Table 2). Within each complex we assign two or three levels of priority. Stands that substantially intersect with natural community polygons are assigned the highest priority level (Priority 1 in Table 2). Stands that partially intersect or are directly adjacent to natural community EOs were assigned medium priority (Priority 2), while stands not associated with natural community EOs were assigned the lowest level (Priority 3). Finally, we suggest additional stands to consider when managing invasive species in these core areas. These stands did not rank 'highest' in the model, however, controlling invasive species in these stands will limit reinvasion of the highest priority stands. This additional prioritization is intended as a flexible tool for land managers at FCTC, as is the Invasive Species Treatment Prioritization Model as a whole. In Table 2 we summarize the primary criteria we used to guide prioritization to facilitate adaptive management decisions by FCTC managers.

Fort Custer Training Center is at the forefront of landscape-scale restoration management in southern Michigan and within the Great Lakes region, where it supports a uniquely high concentration of rare species and high-quality natural communities for which sustained stewardship is vital. Invasive species management, in conjunction with large-scale prescribed fires, is essential for the ecological integrity of those communities and the persistence of those species. To facilitate continued effective invasive species management we provide a reference guide in Appendix 6 for treatment and timing of treatment for the known invasive species present on FCTC lands. We encourage the continued use of fire and emphasis on invasive species treatment and stress that applying this prioritization model can help focus sustained biodiversity stewardship efforts within the most ecologically important sites. Achieving the best possible outcomes for the high concentration of rare natural features at FCTC is an essential contribution to the conservation of biodiversity in Michigan.

Continued use of prescribed fire, mechanical treatment, and herbiciding is recommended for invasive species management in high-quality areas like the stands corresponding to the Whitman Lake Fen that are being impacted by infestations of glossy buckthorn (*Frangula alnus*) and invasive reed (*Phragmites australis* subspecies *australis*). These stands were indentified as highest priority by the Invasive Species Treatment Prioritization Model. Photo by Matthey J. Lewis, Michigan Aerospace Corporation.

Table 2. All stands ranked as 'highest' in the model are presented as priorities for invasive species treatment, organized by core areas centered around one or more natural community EO. We provide further details on the acreage of each stand, the natural communities present, the score (0-5) each stand received in the model, rare species present, and invasive species (with abundance on a scale of 0-5) observed in each stand. Within core areas, stands are ranked in decreasing priority as intersecting with natural community EO (1), adjacent to EO and supporting similar habitat (2), and neither intersecting nor adjacent to EO (3). Invasive species in bold are highest priority based on location and natural community type. For each core area, we suggest additional priority stands not ranked 'highest'.

EO	EOID	TA	Stand	Acres	Community Type	Score	Rare species	Invasive Species	Priority
Cemetery Complex - include stands 22, 55, 65									
Yes	3093	4	23	16.2	Mesic Southern Forest*	4.273	Ginseng, Goldenseal, Cut-leaved water parsnip, Wahoo, Red mulberry; Watercress snail	*Berberis thunbergii* (1-2), *Elaeagnus umbellata* (1-2), *Phragmites australis* (1-2), *Rhamnus frangula* (1-5), ***Rosa multiflora*** **(1-5)**	1
Yes	8692	4	24	14	Mesic Southern Forest	4.308	Showy orchis, Ginseng	*Alliaria petiolata* (1), ***Berberis thunbergii*** **(1)**, *Ligustrum vulgare* (1), *Rhamnus frangula* (1), ***Rosa multiflora*** **(1)**	1
Yes	8692	4	71	3.4	Mesic Southern Forest	4.131	Showy orchis; Eastern box turtle, Watercress snail	***Elaeagnus umbellata*** **(5)**	1
No	3093	4	21	7.2	Prairie Fen*	4.708	Cut-leaved water parsnip; Watercress snail	*Berberis thunbergii* (1), *Celastrus orbiculatus* (5), *Elaeagnus umbellata* (1-2), *Lythrum salicaria* (2-5), ***Phalaris arundinacea*** **(2-5), *Phragmites australis*** **(1-5)**, ***Rhamnus frangula*** **(2-5)**, *Rosa multiflora* (1), *Typha angustifolia* (2-5)	2
No	3093	4	46	7	Mesic Southern Forest*	4.097	Eastern box turtle, Watercress snail	***Berberis thunbergii*** **(5), *Celastrus orbiculatus*** **(2), *Elaeagnus umbellata*** **(5)**, *Phalaris arundinacea* (5), ***Rosa multiflora*** **(1-5)**, *Typha angustifolia* (2)	2
No	8692	4	45	13.1	Mesic Southern Forest	4.135	Cerulean warbler	*Alliaria petiolata* (3), ***Rosa multiflora*** **(3)**	2
Mott Road Fen Complex - include stands 50, 65									
Yes	5258	5	46	9.7	Prairie Fen	4.721	Cut-leaved water parsnip; Eastern box turtle	***Alnus glutinosa*** **(1)**, *Berberis thunbergii* (1), *Elaeagnus umbellata* (1), *Lonicera* spp. (1), ***Lythrum salicaria*** **(1-5), *Phalaris arundinacea*** **(5), *Phragmites australis*** **(1-5), *Rhamnus frangula*** **(1-5)**, *Rosa multiflora* (5), *Typha angustifolia* (2-5)	2
Yes	5258	7	40	21.5	Prairie Fen	4.905	Black and gold bumble bee, Golden borer, Watercress snail, Eastern box turtle, Blanding's turtle	***Lythrum salicaria*** **(2-5), *Phalaris arundinacea*** **(2), *Phragmites australis*** **(1-5), *Rhamnus frangula*** **(2-5)**, *Typha angustifolia* (2-5)	1
No	5258	7	48	3	Southern Shrub-carr	4.013	Eastern box turtle, Blanding's turtle?	***Lythrum salicaria*** **(5), *Phalaris arundinacea*** **(5), *Rhamnus frangula*** **(3)**	2
No	NA	7	49	6.8	Southern Hardwood Swamp	4.099	Eastern box turtle, Blanding's turtle?	*Berberis thunbergii* (5), *Elaeagnus umbellata* (5), ***Rhamnus frangula*** **(5), *Rosa multiflora*** **(5)**	3

*Cemetery Complex Seeps (EOID 3093) is a southern hardwood swamp included within several MiFI stands classified as mesic southern forest and one classified as prairie fen. Natural community and MiFI delineation methods differ

Table 2. All stands ranked as 'highest' in the model are presented as priorities for invasive species treatment, organized by core areas centered around one or more natural community EO (continued).

EO	EOID	TA	Stand	Acres	Community Type	Score	Rare species	Invasive Species	Priority
Mott Road Prairie Complex - include stands 31, 32									
Yes	10017	7	21	3.8	Mesic Sand Prairie	4.069	Stiff gentian	***Elaeagnus umbellata* (2-5)**, *Lonicera maackii* (1), *Lythrum salicaria* (1-5), ***Rhamnus frangula* (1-5),** *Rosa multiflora* (1-5)	1
No	NA	7	18	1	Southern Wet Meadow	4.030	Cut-leaved water parsnip	*Elaeagnus umbellata* (1), *Lythrum salicaria* (2), ***Rhamnus frangula* (5),** *Rosa multiflora* (1), *Typha angustifolia* (2)	3
No	NA	7	24	8.1	Mesic Southern Forest	4.143	None	***Rosa multiflora* (5)**	3
High-quality Woodlands Throughout									
Yes	3628	6	11	10.3	Dry-mesic Southern Forest	4.119	Beaked agrimony; Cerulean warbler, Hooded warbler, Eastern box turtle, Blanding's turtle	***Berberis thunbergii* (5), *Celastrus orbiculatus* (3-5)**, *Elaeagnus umbellata* (1-5), *Euonymus alata* (4), *Prunus avium* (4), *Rhamnus cathartica* (4), ***Rosa multiflora* (5)**	1
No	NA	3	14	47.1	Dry-mesic Southern Forest	4.032	Hooded warbler	***Berberis thunbergii* (5)**, *Celastrus orbiculatus* (3), *Rhamnus cathartica* (5), *Robinia pseudoacacia* (5), *Rosa multiflora* (3)	3
No	NA	9	39	30.8	Dry-mesic Southern Forest	4.145	Beaked agrimony	***Berberis thunbergii* (5)**, *Celastrus orbiculatus* (3), *Elaeagnus umbellata* (5), *Rhamnus frangula* (5), *Rosa multiflora* (2)	3
No	NA	9	86	7.4	Dry-mesic Southern Forest	4.017	Eastern box turtle	*Berberis thunbergii* (3), *Celastrus orbiculatus* (5), *Euonymus alatus* (4), *Lonicera morrowii* (5), ***Rosa multiflora* (5)**	3
Saddleback Woodland Complex - include stands 11, 35									
Yes	23953	7	33	21.4	Dry-mesic Southern Forest	4.401	Virginia flax; Eastern box turtle	***Elaeagnus umbellata* (5)**, *Ligustrum vulgare* (4), *Lonicera morrowii* (5), *Rhamnus frangula* (5), ***Rosa multiflora* (2-5)**	1
No	NA	7	9	10.6	Southern Wet Meadow	4.198	Cut-leaved water parsnip; Blanding's turtle, Eastern box turtle	*Lythrum salicaria* (2), ***Phragmites australis* (2-5), *Rhamnus frangula* (5)**, *Typha angustifolia* (5)	3
No	NA	7	10	6.6	Southern Hardwood Swamp	4.461	Watercress snail	***Berberis thunbergii* (5)**, *Rosa multiflora* (2)	3
No	NA	7	12	3.4	Southern Shrub-carr	4.043	Cut-leaved water parsnip; Eastern box turtle	***Rhamnus frangula* (5)**, *Rosa multiflora* (5)	3
No	NA	7	46	20	Oak Barrens	4.066	Eastern box turtle	*Celastrus orbiculatus* (5), *Elaeagnus umbellata* (5), *Robinia pseudoacacia* (3-5)	3

Table 2. All stands ranked as 'highest' in the model are presented as priorities for invasive species treatment, organized by core areas centered around one or more natural community EO (continued).

EO	EOID	TA	Stand	Acres	Community Type	Score	Rare species	Invasive Species	Priority
Territorial Road Fen Complex - include stands 52, 72									
Yes	16989	9	7	31.9	Prairie Fen	5.000	Cut-leaved water parsnip, Prairie dropseed; Blanding's turtle, Eastern box turtle	*Elaeagnus umbellata* (1), *Lythrum salicaria* (1-5), ***Phalaris arundinacea* (2-3), *Phragmites australis* (1-5), *Rhamnus frangula* (1-5)**, *Typha angustifolia* (2-5)	1
No	16989	9	8	19.1	Southern Shrub-carr	4.020	Cut-leaved water parsnip; Blanding's turtle, Eastern box turtle	*Berberis thunbergii* (1-2), *Elaeagnus umbellata* (5), *Ligustrum vulgare* (2), *Lythrum salicaria* (5), ***Rhamnus frangula* (2-5)**, *Rosa multiflora* (2), *Typha angustifolia* (2-5)	2
No	NA	9	14	11	Prairie Fen	4.822	Eastern box turtle	*Lythrum salicaria* (5), ***Rhamnus frangula* (5)**	3
No	NA	9	62	13.3	Dry-mesic Southern Forest	4.215	None***	*Berberis thunbergii* (3), *Elaeagnus umbellata* (5), ***Rosa multiflora* (5)**	3
No	NA	9	78	13.6	Southern Hardwood Swamp	4.399	Cut-leaved water parsnip	*Berberis thunbergii* (3), *Lonicera morrowii* (5), ***Rosa multiflora* (3)**	3
No	NA	9	91	5.2	Dry-mesic Southern Forest	4.048	Yellow fumewort; Cerulean warbler	*Alliaria petiolata* (5), ***Berberis thunbergii* (5), *Celastrus orbiculatus* (5)**, *Elaeagnus umbellata* (5), *Lonicera morrowii* (3), *Rosa multiflora* (3)	3
Whitman Lake Fen Complex - include stands 35, 55									
Yes	3628	8	36	6.1	Dry-mesic Southern Forest	4.470	Cerulean warbler	***Berberis thunbergii* (5)**, *Celastrus orbiculatus* (5), *Elaeagnus umbellata* (1-3), *Lonicera* spp. (1), *Rhamnus cathartica* (4), ***Rosa multiflora* (2-3)**, *Typha angustifolia* (2)	1
Yes	3628	8	38	17.8	Dry-mesic Southern Forest	4.173	None***	***Berberis thunbergii* (5)**, *Celastrus orbiculatus* (2-5), *Elaeagnus umbellata* (1-5), *Euonymus alata* (4), *Lonicera morrowii* (5), *Phragmites australis* (1-2), ***Rosa multiflora* (1-5)**	1
Yes	3628	8	49	11.5	Dry-mesic Southern Forest	4.035	Beaked agrimony, Upland boneset; Eastern box turtle	***Berberis thunbergii* (3)**, *Celastrus orbiculatus* (3), *Elaeagnus umbellata* (3), *Euonymus alata* (5), ***Rosa multiflora* (3)**	1
Yes	7503	8	13	17.8	Prairie Fen	4.915	Cut-leaved water parsnip, Prairie dropseed; Eastern box turtle, Watercress snail	*Lythrum salicaria* (5), *Phalaris arundinacea* (2-5), ***Phragmites australis* (1-5), *Rhamnus frangula* (2)**, *Typha angustifolia* (2-3)	1
Yes	7503	8	15	3	Prairie Fen	4.631	Queen-of-the-prairie; Eastern box turtle	*Berberis thunbergii* (1), *Elaeagnus umbellata* (2), *Lythrum salicaria* (2-5), *Phalaris arundinacea* (2), ***Rhamnus frangula* (1-2)**, *Rosa multiflora* (1-3)	1
Yes	7503	8	43	1.7	Rich Tamarack Swamp	4.074	Watercress snail	*Elaeagnus umbellata* (5), *Lonicera morrowii* (5), ***Rhamnus frangula* (2-3), *Rosa multiflora* (5)**, *Typha angustifolia* (2)	1

Table 2. All stands ranked as 'highest' in the model are presented as priorities for invasive species treatment, organized by core areas centered around one or more natural community EO (continued).

EO	EOID	TA	Stand	Acres	Community Type	Score	Rare species	Invasive Species	Priority
No	7503	8	16	1.8	Southern Shrub-carr	4.031	Eastern box turtle	*Phalaris arundinacea* (5), ***Rhamnus frangula* (5)**, *Rosa multiflora* (5)	2
No	7503	8	19	1.2	Prairie Fen	4.372	Cut-leaved water parsnip; Eastern box turtle	*Phalaris arundinacea* (2), ***Rhamnus frangula* (5)**, *Typha angustifolia* (2-5)	2
No	7503	8	8	12	Southern Shrub-carr	4.065	Eastern box turtle, Bald eagle	*Berberis thunbergii* (5), *Elaeagnus umbellata* (4), *Ligustrum vulgare* (5), *Lonicera morrowii* (3), *Lythrum salicaria* (2-5), *Phalaris arundinacea* (5), ***Phragmites australis* (2-5)**, *Rhamnus cathartica* (5), ***Rhamnus frangula* (2)**, *Rosa multiflora* (5), *Typha angustifolia* (2)	3
No	NA	8	4	22	Prairie Fen	4.671	Blanchard's cricket frog	*Lythrum salicaria* (3), ***Phalaris arundinacea* (2), *Phragmites australis* (5), *Rhamnus frangula* (2-3)**, *Typha angustifolia* (2-5)	3

The southern wet meadow in the Mott Road Prairie Complex in Training Area 7 was identified by the Invasive Species Treatment Prioritization Model as highest priority. The meadow is being impacted by invasive reed (*Phragmites australis* subspecies *australis*). Photo by Tyler J. Bassett.

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Appendix 1 - Scoring for Natural Community Variables

This appendix provides the scoring for the natural community variables developed by Cohen et al. (2019). All Michigan natural community types are listed with their associated global and state ranks (G-rank and S-rank) assigned by NatureServe and MNFI as well as each natural community type's Rarity, Resilience, Richness, and Ecosystem Services variable scores. Natural community types found within the Fort Custer Training Center are highlighted in bold. See Table 1 for descriptions of the Natural Community Rarity, Resilience, Richness, and Ecosystem Services variables and See Appendix 4 for the definitions of the global and state ranks.

Natural Community Type	G-RANK	S-RANK	Natural Community Rarity	Natural Community Resilience	Natural Community Richness	Natural Community Ecosystem Services
Alvar	G2?	S1	5	2	4	2
Bog	G3G5	S4	2	4	2	3.5
Boreal Forest	GU	S3	3	4	2	3.5
Bur Oak Plains	G1	SX	5	0	0	0
Cave	G4?	S1	4	5	1	1
Clay Bluff	GNR	S2	4	1	1	1
Coastal Fen	G1G2	S2	4	2.5	3	3
Coastal Plain Marsh	G2	S2	4	1	5	3
Dry Northern Forest	G3?	S3	3	3	2	3
Dry Sand Prairie	G3	S2	4	2	3	2.5
Dry Southern Forest	G4	S3	3	2	3	3
Dry-mesic Northern Forest	G4	S3	3	3	3	3
Dry-mesic Prairie	G3	S1	4	1	4	2
Dry-mesic Southern Forest	G4	S3	3	2	3	3.5
Emergent Marsh	GU	S4	2	2	1	2.5
Floodplain Forest	G3?	S3	3	2	5	5

Appendix 1. Scoring for Natural Community Variables (continued)

Natural Community Type	G-RANK	S-RANK	Natural Community Rarity	Natural Community Resilience	Natural Community Richness	Natural Community Ecosystem Services
Granite Bedrock Glade	G3G5	S2	4	2.5	2	2
Granite Bedrock Lakeshore	G4G5	S2	4	3	1	1
Granite Cliff	G4G5	S2	4	5	1	0.5
Granite Lakeshore Cliff	GU	S1	5	5	1	0.5
Great Lakes Barrens	G3	S2	4	2	2	2.5
Great Lakes Marsh	G2	S3	3	1.5	4	5
Hardwood-Conifer Swamp	G4	S3	3	3	4	3
Hillside Prairie	G3	S1	4	1	3	2.5
Inland Salt Marsh	G1	S1	5	2	1	1
Interdunal Wetland	G2?	S2	4	3	2	1.5
Intermittent Wetland	G2	S3	3	3	2	2
Inundated Shrub Swamp	G4	S3	3	4	1	1.5
Lakeplain Oak Openings	G2?	S1	5	1	3	3
Lakeplain Wet Prairie	G2	S1	5	1	4	4
Lakeplain Wet-mesic Prairie	G1?	S1	5	1	5	4

Appendix 1. Scoring for Natural Community Variables (continued)

Natural Community Type	G-RANK	S-RANK	Natural Community Rarity	Natural Community Resilience	Natural Community Richness	Natural Community Ecosystem Services
Limestone Bedrock Glade	G2G4	S2	4	2	2	2
Limestone Bedrock Lakeshore	G3	S2	4	2.5	1	1
Limestone Cliff	G4G5	S2	4	5	1	1
Limestone Cobble Shore	G2G3	S3	3	2.5	1	1
Limestone Lakeshore Cliff	G4G5	S1	4	5	1	1
Mesic Northern Forest	G4	S3	3	3	4	3
Mesic Prairie	G2	S1	5	1	5	2
Mesic Sand Prairie	G2	S1	5	1	4	2
Mesic Southern Forest	G2G3	S3	3	2	4	3
Muskeg	G4G5	S3	3	4	2	4
Northern Bald	GU	S1	5	2.5	2	1
Northern Fen	G3	S3	3	3	4	3.5
Northern Hardwood Swamp	G4	S3	3	3	2	3
Northern Shrub Thicket	G4	S5	1	3	1	2.5
Northern Wet Meadow	G4	S4	2	2	2	2.5
Oak Barrens	G2?	S1	5	2	3	3

Appendix 1. Scoring for Natural Community Variables (continued)

Natural Community Type	G-RANK	S-RANK	Natural Community Rarity	Natural Community Resilience	Natural Community Richness	Natural Community Ecosystem Services
Oak Openings	G1	S1	5	1	4	3
Oak-Pine Barrens	G3	S2	4	2	4	3
Open Dunes	G3	S3	3	2	4	4
Patterned Fen	GU	S2	4	3	4	4
Pine Barrens	G3	S2	4	2	4	3
Poor Conifer Swamp	G4	S4	2	4	2	3.5
Poor Fen	G3	S3	3	4	3	4
Prairie Fen	G3	S3	3	2	5	4.5
Rich Conifer Swamp	G4	S3	3	3	5	3.5
Rich Tamarack Swamp	G4	S3	3	2	4	3.5
Sand and Gravel Beach	G3?	S3	3	3	1	1
Sandstone Bedrock Lakeshore	G4G5	S2	4	3	1	1
Sandstone Cliff	G4G5	S2	4	5	1	0.5
Sandstone Cobble Shore	G2G3	S2	4	3	1	1.5
Sandstone Lakeshore Cliff	G3	S2	4	5	1	1.5
Sinkhole	G3G5	S2	4	5	1	1

Appendix 1. Scoring for Natural Community Variables (continued)

Natural Community Type	G-RANK	S-RANK	Natural Community Rarity	Natural Community Resilience	Natural Community Richness	Natural Community Ecosystem Services
Southern Hardwood Swamp	G3	S3	3	3	3	3
Southern Shrub-carr	GU	S4	2	2	3	3
Southern Wet Meadow	G4?	S3	3	1.5	3	3
Submergent Marsh	GU	S4	2	2	1	1.5
Volcanic Bedrock Glade	GU	S2	4	2.5	2	1.5
Volcanic Bedrock Lakeshore	G4G5	S2	4	3	1	1
Volcanic Cliff	G4G5	S2	4	5	1	0.5
Volcanic Cobble Shore	G4G5	S3	3	3	1	1
Volcanic Lakeshore Cliff	GU	S1	5	5	1	1
Wet Prairie	G3	S1	4	1	4	2.5
Wet-mesic Flatwoods	G2G3	S2	4	2	3	3
Wet-mesic Prairie	G2	S1	5	1	4	2.5
Wet-mesic Sand Prairie	G2G3	S2	4	1	4	2.5
Wooded Dune and Swale Complex	G3	S3	3	3	5	5

Appendix 2 - Descriptions of EcoScores

Descriptions of EcoScores assigned to natural communities during stand mapping.

1 = Very heavily modified by past human activity. Essentially destroyed from a natural plant community perspective. Most native vegetation or community assemblage is gone. Invasive species likely dominant. Examples: Weedy tree groves on spoil areas, former farm fields now containing non-native cover, and marshes with rampant non-native Phragmites.

2 = Heavily modified by past human activity. Native vegetation or community assemblage is reduced to an altered state but still recognizable as having once been some type of a natural community (the original type of community may not be obvious). Examples: early seral scrub areas grown after clearcutting, “ponds” formed after meadows are impounded, marshes with growing populations of cattail, or old upland fields with a mix of native and non-native grassland species.

3 = Moderately to heavily altered by past human activity. Native vegetation or community assemblage is altered but somewhat recognizable as a type of a natural community (the original type of community may still be present, but it is not a very high-quality example). Examples: early to mid-seral forest areas grown after logging 10 to 60 years prior, wet meadows with some hydrologic impact, prior ditching, or some invasive species, marshes with low species diversity and scattered purple loosestrife, or old upland fields with several prairie species mixed with non-native grassland species.

4 = Lightly to moderately altered by past human activity. Native vegetation or community assemblage is apparently altered but quickly recognizable as a type of a natural community (the original nature of the natural community type is not entirely certain due to a history of factors like fire suppression or past tree removal, but the site has a fairly natural level of plant diversity and is more or less sustainable). Examples: maturing native forest areas grown after logging 60 years-or-more prior, or native forest recovering from selective tree removal, or wet meadows with increasing brush but covered almost entirely by native species.

5 = Unaltered to lightly altered by past human activity. Native vegetation or community assemblage may be a bit altered but is clearly a natural community (the original nature of the natural community type could be debated due to a history of factors like fire suppression or past selective tree removal, but the site has a natural level of plant diversity, many conservative species, and if correctly managed is sustainable). Examples: Mature native forest with no indications of human modification, mature native forest which may have been selectively logged 50 or more years prior, mature native forest which may have been heavily logged in the 1800s, wet meadows with little brush and covered by native species, or marshes with diverse native species composition.

Appendix 3 - Invasive Plant Species Weed Risk Assessment Scores

This appendix provides a list of invasive plant species included in the Invasive Species Treatment Prioritization Model and their scores calculated using the United States Department of Agriculture's Weed Risk Assessment scoring schema (USDA 2019). Most scores were developed for Cohen et al. (2019) and used to calculate the Invasive Species variable for this model.

Scientific name	**Common name**	**Score**
Acer platanoides	Norway maple	2
Achyranthes japonica	Japanese chaff flower	4
Aegopodium podagraria	Bishop's goutweed	3
Ailanthus altissima	Tree of heaven	5
Alliaria petiolate	Garlic mustard	5
Alnus glutinosa	Black/European alder	3
Amorpha fruticose	False indigo	4
Ampelopsis brevipedunculata	Turquoise berry	2
Arctium minus	Common burdock	3
Barbarea vulgaris	Garden yellowrocket	3
Berberis spp.	Barberry	4
Berberis thunbergia	Japanese barberry	4
Berberis vulgaris	Common barberry	3
Berteroa incana	Hoary alyssum	3
Buddleja davidii	Butterfly Bush	3
Butomus umbellatus	Flowering Rush	3
Campsis radicans	Trumpet vine	1
Cardamine impatiens	Narrow-leaved bitter cress	4
Carex kobomugi	Asiatic sand sedge	3
Celastrus orbiculatus	Oriental bittersweet	5
Centaurea jacea	Brown knapweed	4
Centaurea stoebe	Spotted knapweed	5
Cirsium arvense	Canada thistle	5
Cirsium palustre	European swamp thistle	4
Cirsium vulgare	Bull thistle	4
Conium maculatum	Poison hemlock	4
Convolvulus arvensis	Field bindweed	5
Cynanchum louiseae	Louise's swallow-wort	4
Cynanchum rossicum	European swallow-wort	4
Cynoglossum officinale	Hound's-tongue	4
Daucus carota	Wild carrot, Queen-Anne's-lace	3
Dioscorea oppositifolia	Chinese yam	3
Dipsacus laciniatus	Cut-leaf teasel	4
Elaeagnus umbellate	Autumn olive	4
Euonymus alatus	Wahoo/burning bush (Invasive)	2
Euonymus europaeus	Spindle tree	2
Euonymus fortune	Wintercreeper	3

Appendix 3. Invasive Plant Species Weed Risk Assessment Scores (continued)

Scientific name	Common name	Score
Euphorbia esula	Leafy spurge	5
Fallopia japonica	Japanese knotweed	4
Fallopia sachalinensis	Giant knotweed	4
Frangula alnus	Glossy buckthorn	5
Galeopsis tetrahit	Hemp-nettle	2
Galium odoratum	Sweet woodruff	1
Glechoma hederacea	Ground-ivy, creeping Charlie	2
Glyceria maxima	Reed manna grass	4
Gypsophila paniculata	Baby's breath	3
Heracleum mantegazzianum	Giant hogweed	3
Hesperis matronalis	Dame's rocket	4
Hydrocharis morsus-ranae	European frog-bit	3
Hypericum perforatum	Common St. John’s-wort	5
Impatiens glandulifera	Himalayan balsam	3
Iris pseudacorus	Pale yellow iris	3
Lespedeza bicolor	Shrubby lespedeza	3
Lespedeza thunbergia	Japanese bush clover	3
Leucanthemum vulgare	Ox-eye daisy	3
Leymus arenarius	Lymegrass	2
Ligustrum obtusifolium	Border privet	2
Ligustrum spp.	Privet (spp.)	2
Ligustrum vulgare	Common privet	2
Lonicera maackii	Amur honeysuckle	3
Lonicera morrowii	Morrow honeysuckle	3
Lonicera spp.	Lonicera species	3
Lonicera tatarica	Smooth Tartarian honeysuckle	3
Lonicera x bella	Hybrid honeysuckle	3
Lonicera xylosteum	European fly honeysuckle	3
Lotus corniculatus	Bird's-foot trefoil	4
Lupinus polyphyllus	Bigleaf lupine	3
Lysimachia nummularia	Moneywort	3
Lythrum salicaria	Purple loosestrife	5
Melilotus alba	White sweet clover	5
Melilotus albus	White sweet clover	5
Melilotus officinalis	Yellow sweet clover	5
Microstegium vimineum	Japanese stiltgrass	5
*Myriophyllum spicatum**	Eurasian water-milfoil	3
*Nitellopsis obtusa**	Starry stonewort	4
Pastinaca sativa	Wild parsnip	2
Persicaria perfoliate	Mile-a-minute weed	4
Petasites hybridus	Butterbur	2

Appendix 3. Invasive Plant Species Weed Risk Assessment Scores (continued)

Scientific name	Common name	Score
Phalaris arundinacea	Reed canary grass	5
Phleum pratense	Timothy	5
Phragmites australis subsp. Australis	Phragmites (exotic)	4
Pinus sylvestris	Scotch pine	2
Poa compressa	Canada bluegrass	4
Poa pratensis	Kentucky bluegrass	3
Poa spp.	Poa species	4
Populus alba	White poplar	2
Populus nigra	Lombardy poplar	2
Potentilla recta	Sulphur cinquefoil	3
Prunella vulgaris	Self-heal, heal-all	2
Prunus avium	Sweet cherry	2
Pueraria lobata	Kudzu	3
Pueraria montana	Kudzu	3
Ranunculus repens	creeping buttercup	4
Rhamnus cathartica	Common buckthorn	4
Rhamnus frangula	Glossy buckthorn	5
Rhamnus utilis	Chinese buckthorn	3
Rhodotypos scandens	Jetbead	2
Robinia hispida	Bristly locust	2
Robinia pseudoacacia	Black locust	3
Rosa multiflora	Multiflora rose	4
Rumex acetosella	Sheep sorrel	5
Salix fragilis	Crack willow	2
Salix x rubens	Hybrid crack willow	2
Saponaria officinalis	Bouncing bet, soapwort	1
*Securigera varia**	Crown vetch	4
Senecio jacobaea	stinking willie	4
Solanum dulcamara	Bittersweet nightshade	2
Tamarix parviflora	Smallflower tamarisk	3
Taraxacum officinale	Common dandelion	3
Torilis japonica	Hedge-parsley	2
Trifolium pratense	Red clover	3
Trifolium repens	White clover	3
Typha angustifolia	Narrow-leaved cattail	5
Typha x glauca	Cattail	5
Ulmus pumila	Siberian Elm	2
Verbascum thapsus	Common mullein	2
Vincetoxicum nigrum	Black swallow-wort	4
Vincetoxicum rossicum	Pale swallow-wort	4

Appendix 4 - Global and State Element Ranking Criteria

GLOBAL RANKS

G1 = critically imperiled: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.

G2 = imperiled: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.

G3 = vulnerable: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.

G4 = apparently secure: uncommon but not rare; some cause for long-term concern due to declines or other factors.

G5 = secure: common; widespread.

GNR = Global rank not yet assessed. Unranked.

GU = currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

GX = eliminated: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

G? = incomplete data.

STATE RANKS

S1 = critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2 = imperiled in the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3 = vulnerable in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 = uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5 = common and widespread in the state.

SNR = State rank not yet assessed. Unranked.

SX = community is presumed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

S? = incomplete data.

Appendix 5 - Scores for the Highest Priority Stands for Treatment

Training Area	Stand	Score	Invasive Species Impact	Invasive Species Density	Land Use Index	Invasion Risk	Buffer	EcoScore	Stand Age	Natural Community Rarity	Rare Species	Natural Community Species Richness	TNC Reslience	MNFI Resilience	Ecosystem Services
3	14	4.032	0.5	4	3.5	1	5	4.5	5	3	1	3	5	2	3.5
4	21	4.708	4.1	2	3.6	3	5	5	0	3	2	5	3	2	4.5
4	23	4.273	2.1	1	3.5	3	5	5	0	3	3	4	5	2	3
4	24	4.308	2	1	3.5	2	5	5	5	3	2	4	5	2	3
4	45	4.135	0.5	3	3.6	1	5	4	5	3	2	4	5	2	3
4	46	4.097	2.7	4	3.5	3	5	4	0	3	2	4	3	2	3
4	71	4.131	0.4	5	3.6	2	3	4	0	3	2	4	5	2	3
5	46	4.721	4.7	2	3.7	0	5	4.5	0	3	4	5	3	2	4.5
6	11	4.119	2	4	3.5	2	5	4	5	3	2	3	3	2	3.5
7	9	4.198	0.4	3	3.6	2	5	3	0	3	3	5	5	2	5
7	10	4.461	0.9	5	3.7	2	5	4	0	2	4	3	5	2	3
7	12	4.043	0.5	4	3.4	2	5	3	0	5	3	3	5	2	3
7	18	4.030	2.3	2	4.1	1	5	4	0	3	3	3	5	1.5	3
7	21	4.069	2.6	3	3.6	0	5	4	0	5	4	4	3	1	2
7	24	4.143	2.5	4	3.5	0	5	4.5	5	3	2	3	3	2	3.5
7	33	4.401	0	0	3.6	2	5	3	0	3	3	5	5	2	4.5
7	40	4.905	2.9	2	3.7	1	5	5	0	3	4	5	5	2	4.5
7	46	4.066	0.4	5	3.5	2	5	3.5	0	3	3	4	5	2	3
7	48	4.013	1.5	4	3.6	2	5	4	0	2	4	3	5	2	3
7	49	4.099	0.5	5	3.7	2	5	3.5	0	3	4	3	5	3	3
8	4	4.671	2.9	3	3.9	1	5	3.5	0	3	2	5	5	2	4.5
8	8	4.065	5	3	3.8	2	5	3	0	2	2	3	5	2	3
8	13	4.915	2.4	2	4.2	3	5	5	0	3	3	5	5	2	4.5
8	15	4.631	2.7	2	4.2	3	5	3	0	3	3	5	5	2	4.5
8	16	4.031	1.4	5	3.4	3	5	4	0	2	3	3	5	2	3
8	19	4.372	1.5	3	3.5	2	5	4	0	3	3	5	3	2	4.5
8	36	4.470	2.9	2	3.5	3	5	5	5	3	3	3	5	2	3.5
8	38	4.173	2.6	3	3.5	2	5	5	5	3	2	3	3	2	3.5
8	43	4.074	2.1	3	3.5	2	5	4	0	3	3	4	3	2	3.5
8	49	4.035	1.9	3	3.6	3	5	4	5	3	3	3	3	2	3.5
9	7	5.000	4.3	2	3.7	1	5	5	0	3	3	5	5	2	4.5
9	8	4.020	4	2	3.7	0	5	4	0	2	3	3	5	2	3
9	14	4.822	1	5	4.0	0	5	4.5	0	3	3	5	5	2	4.5
9	39	4.145	1.8	4	3.5	1	5	4.5	5	3	1	3	3	2	3.5
9	62	4.215	1.2	4	3.5	2	5	4	5	3	2	3	5	2	3.5
9	78	4.399	0.4	3	3.5	2	5	3	0	3	2	5	5	2	5
9	86	4.017	1.8	4	3.5	2	5	4.5	5	3	3	3	5	2	3.5
9	91	4.048	3.1	2	3.5	1	5	4.5	5	3	2	3	3	2	3.5

Appendix 6 - Treatment & Timing Information for Invasive Plant Species

In this appendix we have compiled treatment and timing information for invasive species. This table is meant as a quick guide to facilitate site-specific species management plans by providing possible treatments of invasive species. Direction on the pesticide label should always be followed and the State Department of Environment, Great Lakes, and Energy and Department of Natural Resources should be consulted for up-to-date regulations, restrictions, permitting, and application information. Adopted from Cole-Wick et al. 2021.

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Trees														
Black locust (*Robina pseudoacacia*)	Chemical & Mechanical: cut-stump 0F0F[1,]1F1F[2,]2F2F[3,]3F3F[4]	Monitor for resprout	X	X	X			X	X	X	X	X	X	X
	Chemical: foliar spray [1,]4F4F[5]	Used for resprouts after cut-stump treatment						X	X			X	X	
	Chemical: basal bark [1,]5F5F[6]	Stems less than 6" diameter Do not use when snow or water are on ground or stems Monitor for resprout						X	X	X	X	X	X	X
	Chemical: girdle/frill [1,4]	For larger trees	X	X	X			X	X	X	X	X	X	X
	Chemical: injection [4]	For larger trees	X	X	X			X	X	X	X	X	X	X
	Biological: grazing	Can be toxic to cattle, sheep, horses Saplings only Multi-year						X	X	X	X	X		
Shrubs														
Autumn olive (*Elaeagnus umbellata*)	Chemical & Mechanical: cut-stump [1,2,3,4]	Monitor for resprout	X	X	X			X	X	X	X	X	X	X
	Chemical: foliar [1,4]	Used for resprouts after cut-stump treatment						X	X			X	X	X
	Chemical: basal bark [1]	Stems less than 6" diameter Do not use when snow or water are on ground or stems Monitor for resprout						X	X	X	X	X	X	X
	Chemical: Injection [4]	For larger trees	X	X	X			X	X	X	X	X	X	X
	Mechanical: pulling/digging	Young plants only					X	X	X					
	Biological: grazing	Multi-year						X	X	X	X	X		

[1] Triclopyr ester with penetrating oil (not approved for wetland use)

[2] Triclopyr ester + 3% Imazapyr and penetrating oil (not approved for wetland use)

[3] Triclopyr amine

[4] Triclopyr amine with aminopyralid

[5] Triclopyr amine with non-ionic surfactant

[6] Triclopyr ester with aminopyralid and penetrating oil

Appendix 6. Treatment and Timing Information for Invasive Plants Species (continued)

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Buckthorns:	Chemical & Mechanical: cut-stump [1,2,3]	Treat cuts immediately	X	X	X			X	X	X	X	X	X	X
Common buckthorn (*Rhamnus cathartica*) Glossy buckthorn (*Frangula alnus*)	Chemical: basal bark [2]	Do not use when snow or water are on ground or stems; stems > 0.25 inch and < 6 inches in diameter							X	X	X	X	X	X
	Chemical: foliar [5,]6F6F[7]							X	X	X	X	X	X	X
	Chemical: injection [3]		X	X	X			X	X	X	X	X	X	X
	Mechanical: pulling	Less than 0.5 in in diameter					X	X	X					
	Mechanical: girdling	Reduces resprouting by 40-50%					X	X	X					
	Biological: *Chondrostereum purpureum* (fungal plant pathogen)	Ongoing research No products registered for use in Michigan Applied to girdled cut						X	X					
Honeysuckles:	Chemical & Mechanical: cut stump [1,3,]7F7F[8]		X	X	X			X	X	X	X	X	X	X
(*Lonicera spp, L. maackii, Lonicera x bella*)	Chemical: foliar [1,3,]8F8F[9]											X	X	X
	Chemical: basal bark [1,2,7]	Do not use when snow or water on ground or stems stems > 0.25 in and < 6 in in diameter							X	X	X	X	X	X
	Mechanical: hand pulling	Stem less than 0.5 in. Monitor for resprout										X	X	X
	Mechanical: Girdling	Combine with herbicide					X	X	X					
	Fire: prescribed burn	Not effective for large shrubs Repeated every 1-2 years				X	X	X						
	Biological: grazing						X	X	X	X	X	X		
Japanese barberry (*Berberis thunbergii*)	Mechanical: hand pulling		X	X	X	X	X	X	X	X	X	X	X	X
	Mechanical & Chemical: cut stump		X	X	X			X	X	X	X	X	X	X
	Chemical: foliar [3,9]	Better when paired with early season mechanical or fire control				X	X	X					X	
	Fire: Propane torch	Pre- and multiple post-leaf out treatment					X	X		X				

[1] Triclopyr ester with penetrating oil (not approved for wetland use)

[2] Triclopyr ester + 3% Imazapyr and penetrating oil (not approved for wetland use)

[3] Triclopyr amine

[5] Triclopyr amine with non-ionic surfactant

[7] Triclopyr ester with vegetable oil-based multi-purpose adjuvant (not approved for wetland use)

[8] Glyphosate

[9] Bentazon

Appendix 6. Treatment and Timing Information for Invasive Plants Species (continued)

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Multiflora rose (*Rosa multiflora*)	Mechanical & Chemical: cut stem [1,3,8]	Thorny brambles make this treatment more difficult than usual	X	X	X			X	X	X	X	X	X	X
	Mechanical: pulling	Small plants/populations only					X	X	X					
	Mechanical: mowing	Restricts spread Multiple times per year (3-6x) Susceptible to flat tires						X	X	X	X	X	X	
	Chemical: foliar [9]	Most effective after flowering							X	X	X	X	X	
	Biological: grafting of rose rosette disease (virus via mites)	Ongoing research Possible non-target effects on cultivated *Rosa* sp. less than 100 m away										X	X	X
	Biological: grazing	Sheep and goats					X	X	X	X	X	X		
Herbaceous – terrestrial														
Canada thistle (*Cirsium arvense*)	Prevention: competition and shading	Susceptible to shading and crowding					X	X	X	X	X	X		
	Chemical: foliar [8]	Must susceptible during bud stage, before flowering							X	X	X			
	Mechanical & Chemical: pull/cut and foliar	Cut or pull several times during growing season Chemical spot treatment in fall						X	X	X	X	X	X	
Garlic mustard (*Alliaria peiolata*)	Mechanical: hand pull/clip	Pull prior to seed set					X	X	X					
	Chemical: foliar [8,9]					X	X	X					X	X
	Fire: mid-intensity burn							X	X					

[1] Triclopyr ester with penetrating oil (not approved for wetland use)

[3] Triclopyr amine

[8] Glyphosate

[9] Bentazon

Appendix 6. Treatment and Timing Information for Invasive Plants Species (continued)

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Spotted knapweed (*Centaurea stoebe*)	Mechanical: Shading						X	X	X	X	X	X		
	Mechanical: hand pull							X	X					
	Mechanical: mowing							X	X	X	X			
	Chemical: foliar 9F9F[10],10F10F[11],11F11F[12],12F12F[13]	Some effective herbicides persist in environment Herbicides can be used individually or combined						X	X	X				
	Chemical: fertilizer	Must have native grasses present to compete Integrate with other treatments						X	X	X				
	Fire: propane torch	Small infestations only Best on young seedlings and rosettes						X	X					
	Biological: Grazing	Sheep and goats will eat if grazing area is restricted (fenced). Viable seeds in manure can spread 7-14 days after ingestion						X	X	X				
	Biological: weevils (*Larinus minutus, L. obusus, Cyphocleonus achates*)	No measurable impacts on spotted knapweed populations in Michigan three years after release												
	Biological: moth (*Agapeta zoegana*)	Best for areas abundance in knapweed, but not yet monoculture. More successful in combination with plantings No Michigan specific studies in establishment found												

[1] Triclopyr ester with penetrating oil (not approved for wetland use)

[10] Clopyralid

[11] Dicamba

[12] Picloram

Appendix 6. Treatment and Timing Information for Invasive Plants Species (continued)

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Sweet clover (*Melilotus spp., M. albus, M. officinalis*)	Mechanical: hand pulling	Prior to seed set Multi-year treatment Integrations with chemical treatment method improve effectiveness					X	X	X			X	X	
	Mechanical: mowing	Prior to seed set Results mixed Multi-year treatment Integrations with chemical treatment method improve effectiveness					X	X	X					
	Chemical: foliar [13,]13F13F[14,]14F14F[15,]15F15F[16,]16F 16F[17]	Integrations with mechanical treatment method improve effectiveness					X	X						
	Fire: prescribed burn	2nd-year plants survive better than 1st-year plants Best when actively growing						X	X	X	X	X		
	Fire: propane torch							X	X					
Herbaceous – Aquatic/Wetland														
Cattail (*Typha angustifolia*)	Mechanical: mowing	Twice per growing season: before flowers reach maturity and 1 month later Cutting below waterline is more effective Remove litter if possible							X	X	X	X		
	Chemical: foliar [8,12,13,]17F17F[18,] 18F18F[19]							X	X	X	X	X	X	

[8] Glyphosate

[13] 2,4-D

[14] Chlorsulfuron

[15] 2,4-DB

[16] Clopyralid

[17] Triclopyr

[18] Impazapyr

[19] Imazamox

Appendix 6. Treatment and Timing Information for Invasive Plants Species (continued)

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Eurasian water-milfoil (*Myriophyllum spicatum*)	Chemical: submerged-use [17,]19F19F[20,]20F20F[21,]21F21F[22,]22F 22F[23,]						X	X	X					
	Mechanical: harvesting, weed roller	Repeat visit in single season required Can exacerbate invasion if fragments are not collected properly						X	X		X			
	Mechanical: driver assisted suction	Works best in small areas near docks and piers					X	X	X	X	X	X		
	Physical: benthic barriers	Works best in small areas near docks and piers where non-target effects are minimized					X	X	X	X	X	X	X	
	Biological: predator insect introduction	Research ongoing												
European frog-bit (*Hydrocharis morsus-ranae*)	Mechanical: hand removal	Time prior to mid-summer turion development Annual spring removal efforts						X	X	X				
	Chemical & Mechanical: treatment and hand pulling 23F23F[24,]24F24F[25,]25F25F[26]	Time hand removal prior to mid-summer turion development Efficacy research on chemical treatments is ongoing						X	X	X	X	X		
	Physical: shading							X	X	X	X	X		
Non-native Phragmites (*Phragmites australis* subsp. *australis*)	Chemical & Mechanical: foliar [8,18] and mowing	Spray, then mow 2 weeks or more after treatment Cutting below waterline is more effective Remove litter if possible Herbicides can be used individually or combined Mow and remove when ground is frozen to avoid soil disruption	X	X	X	X					X	X	X	X
	Chemical & Fire: foliar [8,18] and prescribed burn	Spray, then burn the following year Herbicides can be used individually or combined		X	X	X	X			X	X	X	X	
	Mechanical: tarping	For small sites only					X	X	X	X	X	X	X	

[8] Glyphosate

[17] Triclopyr

[18] Impazapyr

[19] Imazamox

[20] Chelated copper

[21] Diquat

[22] Flumioxazin

[23] Granular 2,4-D

[24] Diquat

[25] Flumioxazin

[26] Endothall

Appendix 6. Treatment and Timing Information for Invasive Plants Species (continued)

Species Name	Treatment Method	Notes	Winter			Spring			Summer			Fall		
			D	J	F	M	A	M	J	J	A	S	O	N
Purple loosestrife (*Lythrum salicaria*)	Chemical: foliar [8,17]										X	X		
	Biological: *Galerucella* beetles; *Hylobius transversovittatus* weevil, *Nanophyes marmoratus* weevil	Successful suppression, not eradication												
Reed canary grass (*Phalaris arundinacea*)	Chemical: foliar [8]	Fall more effective than spring										X	X	X
	Mechanical: mowing	Alone not successful long-term treatment Prior to flowering							X				X	
Starry stonewort (*Nitellopsis obtusa*)	Chemical: submerged-use 26F26F[27]	Efficacy of copper-based algaecides is in question				X	X	X	X	X	X			
	Mechanical: driver assisted suction	Repeated visits necessary				X	X	X	X	X	X			

[8] Glyphosate

[17] Triclopyr

[27] Copper-based algaecide – sometimes combined with Flumioxazin or Endothall