

State of Minnesota

Tactical Invasive Species Management

Regional Prioritization Plan 2020



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Authors and Acknowledgements

Minnesota Department of Agriculture

Minnesota Department of Agriculture's (MDA) contributions focused on individual species resources and management and overall plan coordination.

Mari Hardel, B.S.	Mari.Hardel@state.mn.us	(218) 328-4397
Christina Basch, P.S.M.	Christina.Basch@state.mn.us	(507) 649-1949
Monika Chandler, M.S.	Monika.Chandler@state.mn.us	(612) 327-3857

University of Minnesota Extension

University of Minnesota's (U of M) contributions focused on developing distribution and multi-criteria decision analysis models including an economic component.

Jason Reinhardt, Ph.D.	reinh215@umn.edu	
William Lazarus, Ph.D.	wlazarus@umn.edu	(612) 625-8150
Angela Gupta, M.A.	agupta@umn.edu	(507) 280-2869
Matthew Russell, Ph.D.	russellm@umn.edu	(612) 626-4280

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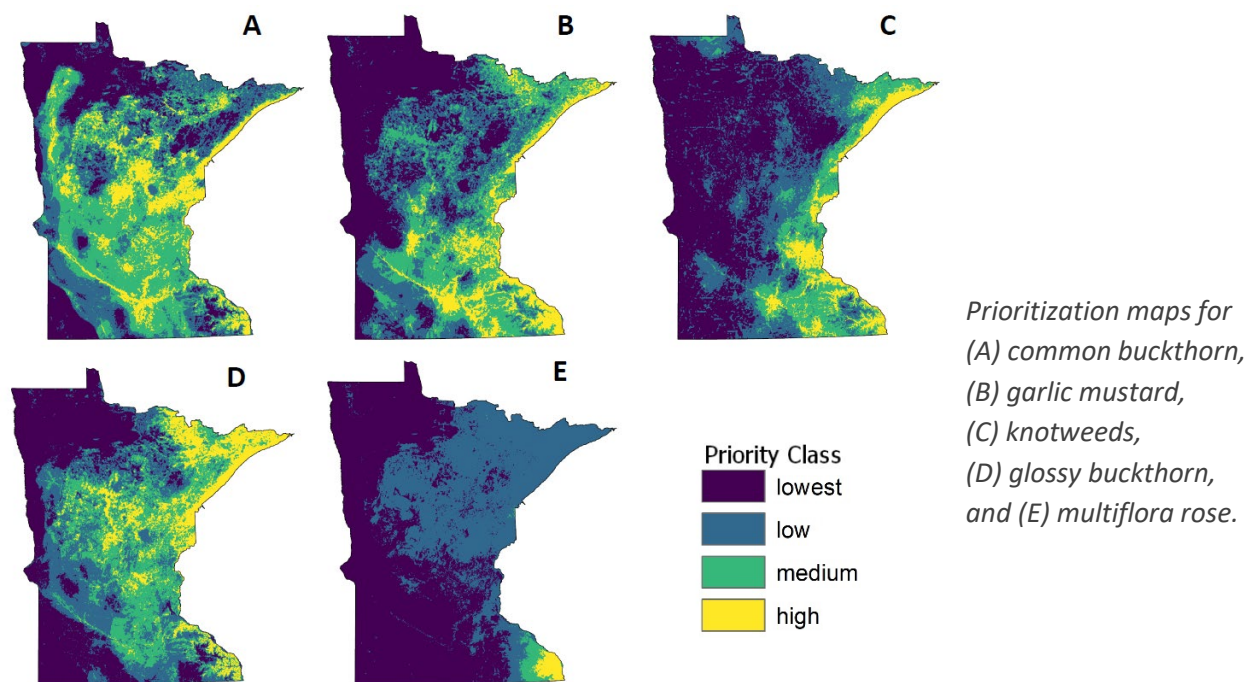
Plan Summary

This plan offers guidance to decision-makers for prioritizing invasive plant management activities. It is recognized that there are insufficient financial and personnel resources to control all invasive plant populations in Minnesota. The aim is to provide information in the form of invasive plant distribution modeling, prioritization maps based upon multiple criteria, identification and management timing guides, and tools for reporting invasive plants and tracking management activities. Decisions about which invasive plant infestations are controlled are made at all levels from federal to local, but the majority of decisions are made at the local level. The guidance in this plan was not available previously and hopefully will improve the efficiency and cohesion of invasive plant management at all levels.

Twelve individual species and two knotweed species were selected for assessment because they are:

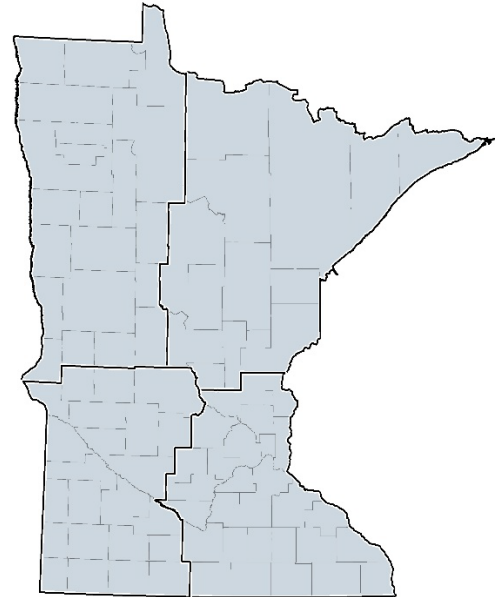
1. Designated noxious weeds in Minnesota; 2. Not considered early detection within the state but may be considered early detection at a regional or local level. The distribution and likelihood of spread or damage of a species varies from region to region. The following species were selected: Canada thistle (*Cirsium arvense*), common/European buckthorn (*Rhamnus cathartica*), common tansy (*Tanacetum vulgare*), garlic mustard (*Alliaria petiolata*), glossy buckthorn (*Frangula alnus*), knotweeds including Japanese (*Polygonum cuspidatum*) and Bohemian (*Polygonum × bohemicum*), leafy spurge (*Euphorbia esula*), multiflora rose (*Rosa multiflora*), narrowleaf bittercress (*Cardamine impatiens*), plumeless thistle (*Carduus acanthoides*), purple loosestrife (*Lythrum salicaria*), spotted knapweed (*Centaurea stoebe*), and wild parsnip (*Pastinaca sativa*). We did not have the capacity to assess all noxious weed species although an assessment for each species would be ideal. Species that are designated Prohibited Eradicate noxious weeds remain a top priority statewide.

The work on multi-criteria decision analysis (MCDA) identified priority areas for invasive plant management using a variety of sources. (More details can be found in the [Methodology section](#).)



To make the information from the project more digestible, the state was broken into four sections ([view map of regions](#)). MCDA maps were reviewed, and top regional priorities were determined for each region:

Regional Priorities	SW	NW	SE/ Metro	NE
Canada Thistle				
Common Buckthorn	•	•		•
Common Tansy	•	•	•	•
Garlic Mustard		•		•
Glossy Buckthorn		•	•	•
Knotweeds			•	•
Leafy Spurge	•	•	•	•
Multiflora Rose			•	
Narrowleaf Bittercress			•	
Plumeless Thistle		•		•
Purple Loosestrife	•	•	•	•
Spotted Knapweed	•	•	•	•
Wild Parsnip	•	•	•	•



Lifecycle graphics were developed for each species illustrating key life stages and highlighting when specific management activities are appropriate. This information is necessary for successful management. Applying the correct treatment at the correct stage increases efficacy and prevents wasteful or otherwise harmful treatments.

Data management is a necessary component of invasive plant management. This project relied on and recommends utilizing [EDDMapS tools](#) for reporting/mapping infestations and tracking management activities. Development continues for [ISM Track](#) (Invasive Species Management Tracking system), a tool within EDDMapS, making it increasingly useful. These tools enable effective data sharing across organizations and provide important datasets for research.

The University of Minnesota led modeling and economic analysis activities. The Minnesota Department of Agriculture (MDA) led plan development, lifecycle graphic creation, worked with University of Georgia on ISMTrack improvements and provided overall coordination. MDA's Noxious Weed Advisory Committee provided commentary through all plan development stages. Developing this plan was made possible with support from the Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizens Commission on Minnesota Resources.

Using This Plan

In this plan, the state of Minnesota has been divided into four regions: northwest, northeast, southeast/metro, and southwest. It is recognized that ecosystems and land use within a region are not homogenous. While focusing attention and efforts on a 'local' level, it is important to look beyond boundaries – such as boundaries in this plan, county boundaries, municipal boundaries, etc. – as species can move across these lines. While many management plans look at either state-wide or very local areas, this plan will identify shared goals for land managers within a region to facilitate a mutually beneficial, cohesive approach.

Goals for region-wide invasive plant management:

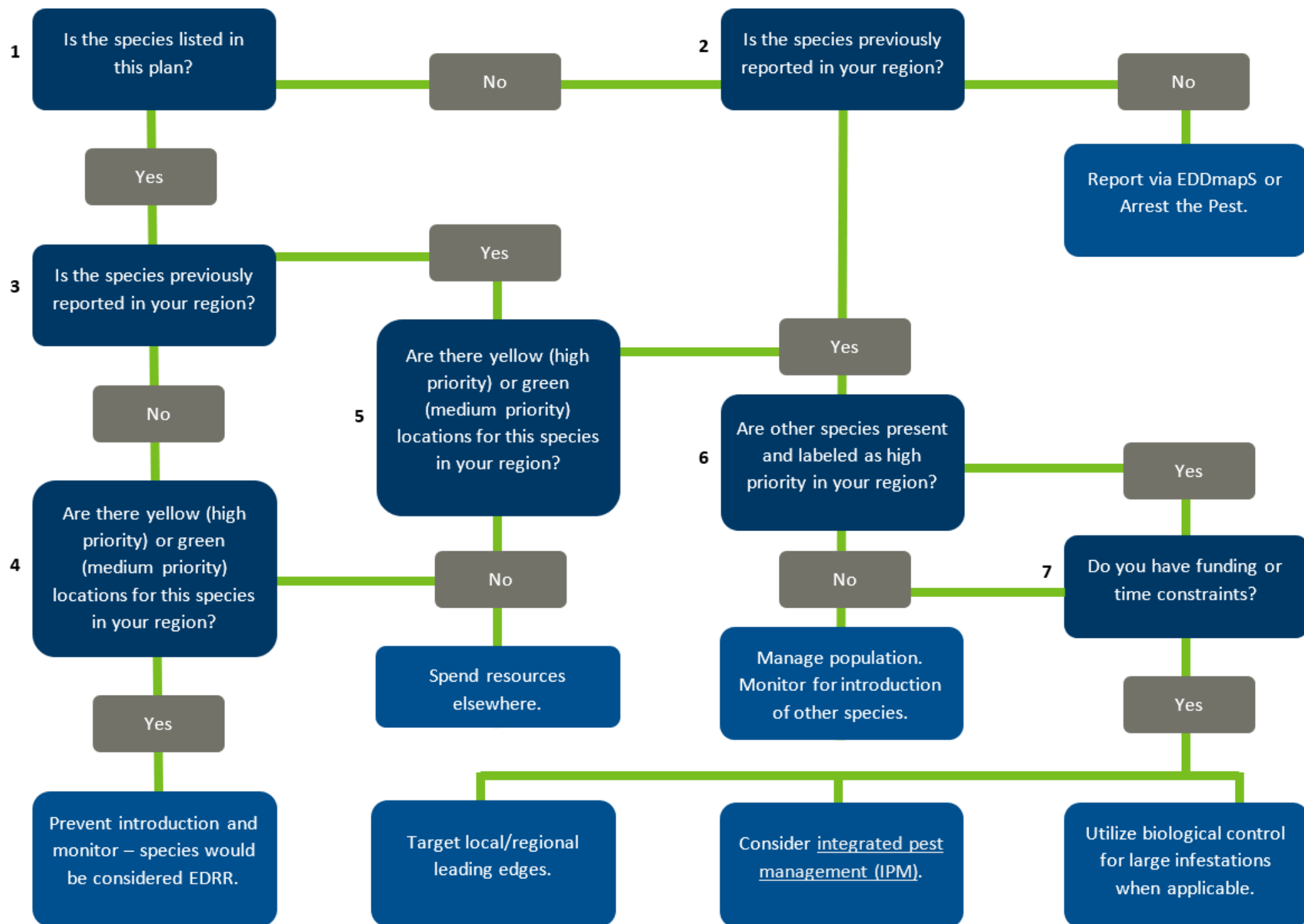
1. **Practice early detection and rapid response (EDRR) for emerging invasive plant threats.** EDRR at the state level ensures negative impacts of a species to any and/or all ecosystems and all Minnesotans is reduced or eliminated. These emerging species have been designated Prohibited Eradicate species on the [Minnesota Noxious Weed List](#).
2. **Target populations of invasive plant species which are regional priorities.** These species may be widespread in other parts of the state but were identified as regional priorities because they were not locally established, and/or an economic benefit would be gained from control, and/or to protect areas of high biodiversity significance.

This plan and the modeling outputs provide guidance for identifying regional priorities. Final determination of regional priorities should be made at the local level and consider existing management efforts, management resources and support for management efforts by local governments and impacted property owners.

While recognizing time and budget constraints, using this plan to identify regional priority plant species and priority locations for management will allow for targeted management of invasive plants across Minnesota and reduce the overall impact of invasive species across Minnesota.

Early Detection and Rapid Response is the idea that invasive species can be most easily controlled or eradicated when they are detected early in their timeline of introduction. Typically, a species requires some amount of time to become established and then abundant. Taking action within that window of lag time can maximize efforts. More information is available on the Midwest Invasive Plants Network (MIPN) website:

<https://www.mipn.org/edrr/>



Text explanation of flow chart:

Box 1: Is the species listed in this plan? If yes go to box 3, if no go to box 2.

Box 2: Is the species previously reported in your region? If yes go to box 6, if no report via EDDMapS or Arrest the Pest.

Box 3: Is the species previously reported in your region? If yes go to box 5, if no go to box 4.

Box 4: Are there yellow (high priority) or green (medium priority) locations for this species in your region? If yes prevent introduction and monitor – species would be considered EDRR. If no, spend resources elsewhere.

Box 5: Are there yellow (high priority) or green (medium priority) locations for this species in your region? If yes, go to box 6, if no spend resources elsewhere.

Box 6: Are other species present and labeled as high priority in your region? If yes go to box 7, if no manage population and monitor for introduction of other species.

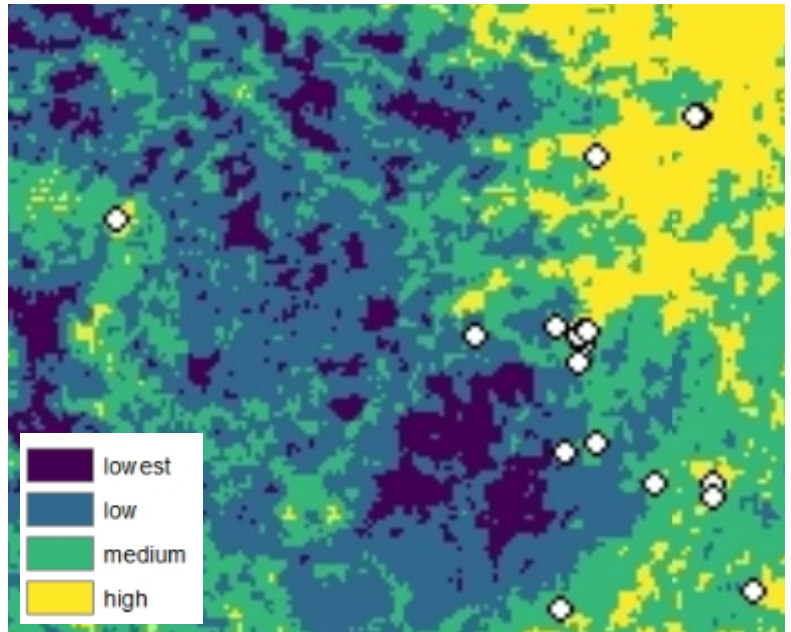
Box 7: Do you have funding or time constraints? If no manage population and monitor for introduction of other species. If yes target local/regional leading edges, consider integrated pest management (IPM), or utilize biological control for large infestations when applicable.

Interpreting Models

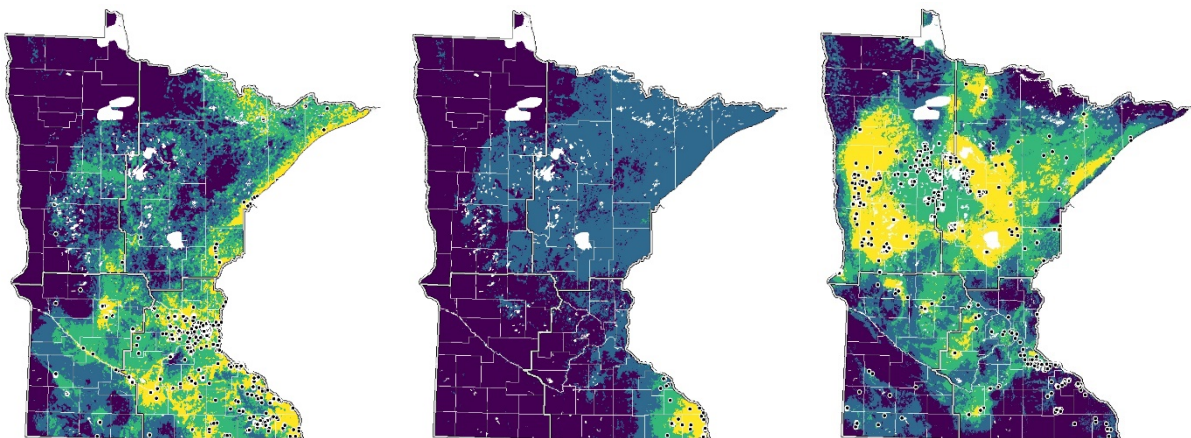
Maps presented in this plan are models created through a process of multi-criteria decision analysis ([more information on MCDA, pg.64](#)) to show prioritization for management. Color classes show four levels of prioritization for management: yellow as a high priority, green as a medium priority, light blue as a low priority and dark blue as the lowest priority for management. Models do take current distribution into account and also rely heavily on proximity to conservation features and recreational trails, economic benefits of treatment, and environmental factors.

These models show locations where management is most worthwhile taking into account environmental, human, and economic factors. Models also show the leading edges of infestations in the transition from yellow to green. It is assumed that a species will spread from this leading edge to proximate, uninfested areas with favorable environmental conditions. Targeting management within these leading edges can reduce spread to areas currently unimpacted by the species and are likely the ‘biggest bang for your buck’.

In addition to these modeled management suggestions, always consider isolated populations of a species and high value natural areas to be a high priority.



Glossy Buckthorn (*Frangula alnus*) Yellow coded areas show high priority locations for management of this species, dark blue show lowest priority for management.



Left to right: Garlic mustard (*Alliaria petiolata*), multiflora rose (*Rosa multiflora*) and plumeless thistle (*Carduus acanthoides*) models.

Regional Plans



Southwest Region

The southwest region is made up of 23 counties: Big Stone, Brown, Chippewa, Cottonwood, Jackson, Kandiyohi, Lac qui Parle, Meeker, Yellow Medicine, Lincoln, Lyon, Martin, Murray, Nobles, Pipestone, Pope, Redwood, Renville, Rock, Stevens, Stearns, Swift and Watonwan.

This region is almost completely made up of the Prairie Parkland biome, and land cover is mostly crop lands. ([See biomes map in Resources.](#))



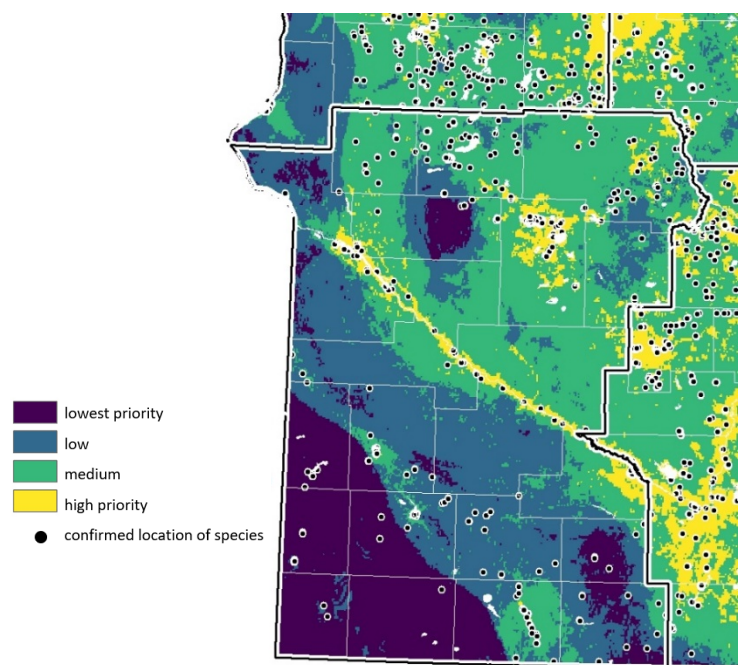
Regional Priority Species

(click on a species to view more information on that species)

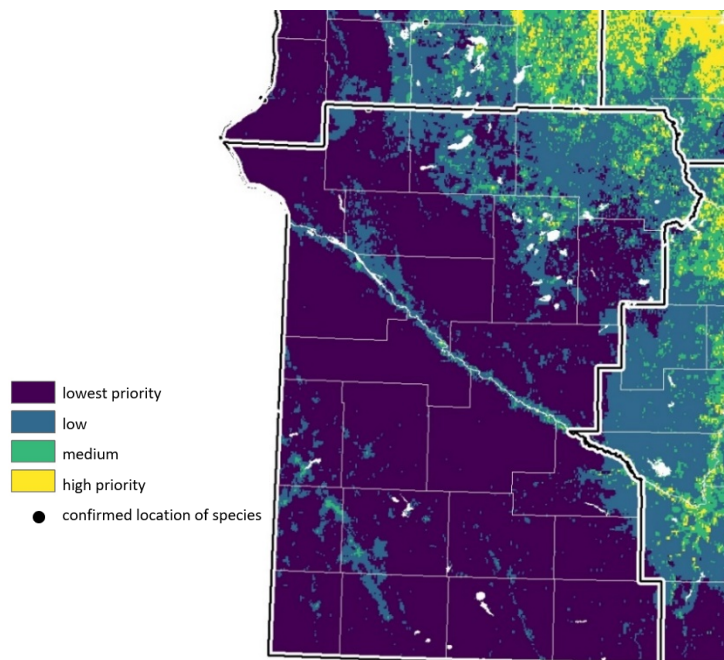
Common Buckthorn	<i>Rhamnus cathartica</i>
Common Tansy	<i>Tanacetum vulgare</i>
Leafy Spurge	<i>Euphorbia esula</i>
Purple Loosestrife	<i>Lythrum salicaria</i>
Spotted Knapweed	<i>Centaurea stoebe</i> ssp. <i>micranthos</i>
Wild Parsnip	<i>Pastinaca sativa</i>

View regional interactive Story Map for the Southwest:

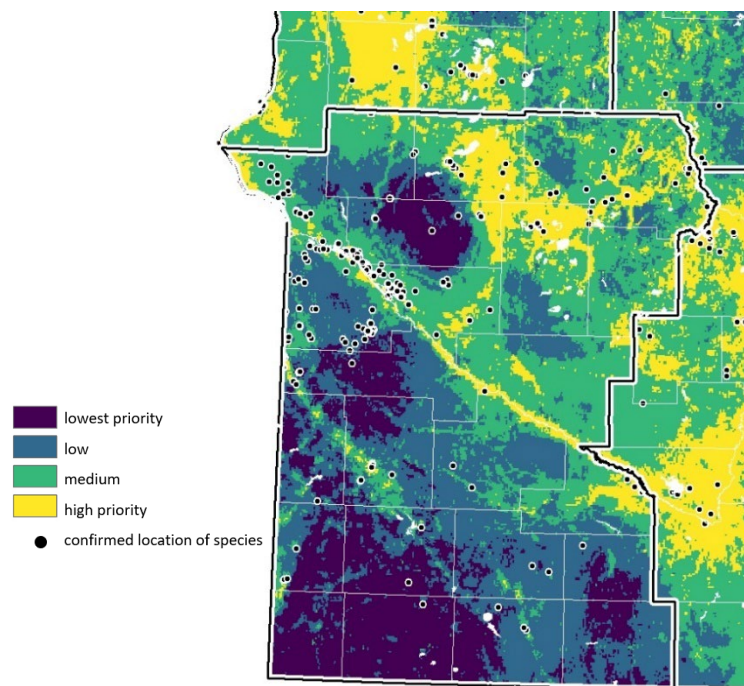
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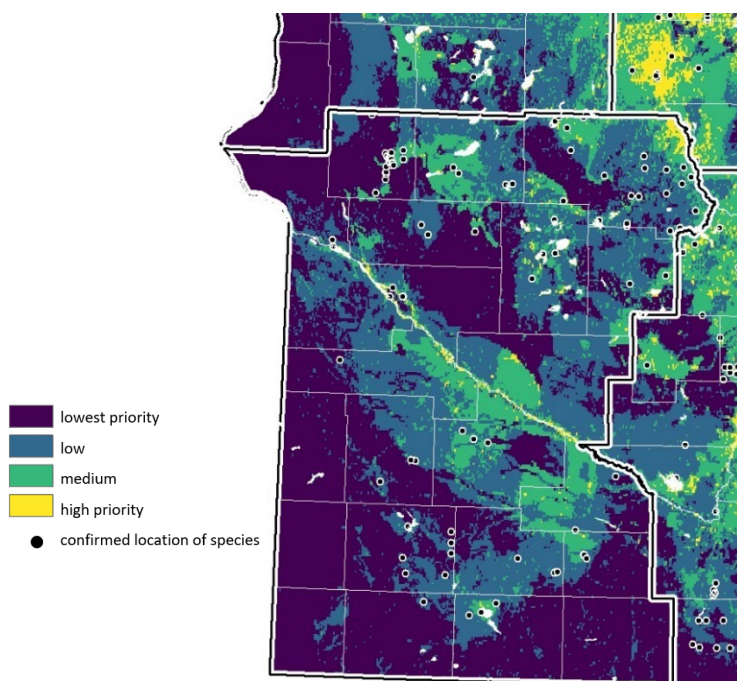
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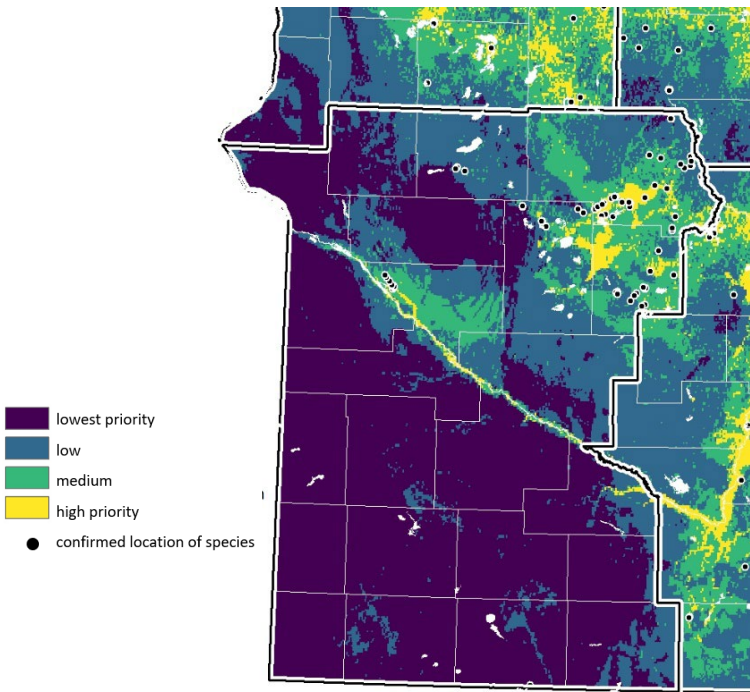
Common Tansy



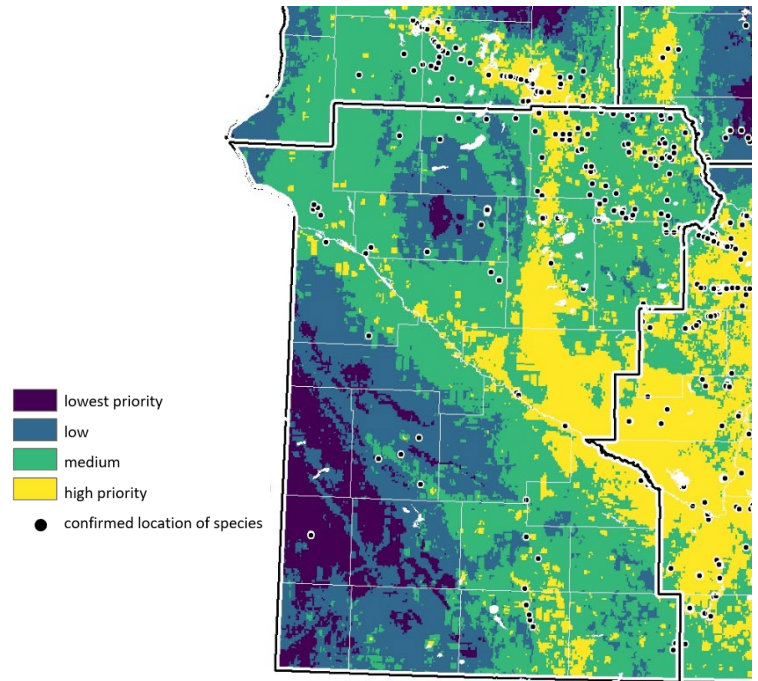
Leafy Spurge



Purple Loosestrife



Spotted Knapweed

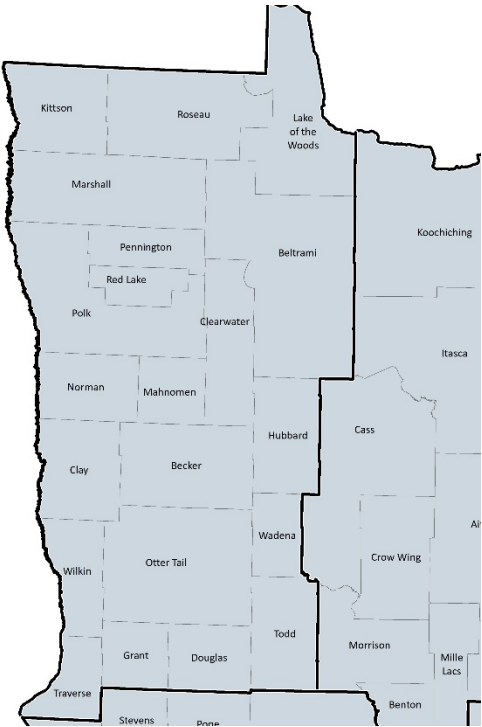


Wild Parsnip

Northwest Region

The northwest region is made up of 21 counties: Becker, Beltrami, Clay, Clearwater, Douglas, Grant, Hubbard, Kittson, Lake of the Woods, Marshall, Mahnommen, Norman, Otter Tail, Roseau, Pennington, Polk, Red Lake, Todd, Traverse, Wadena and Wilkin.

This region contains all four of Minnesota’s biomes: Eastern Broadleaf Forest, Laurentian Mixed Forest, Prairie Parkland, and the entirety of the Tallgrass Aspen Parklands. Land cover is about half cropland and about half forest and woody wetlands. ([See biomes map in Resources.](#))



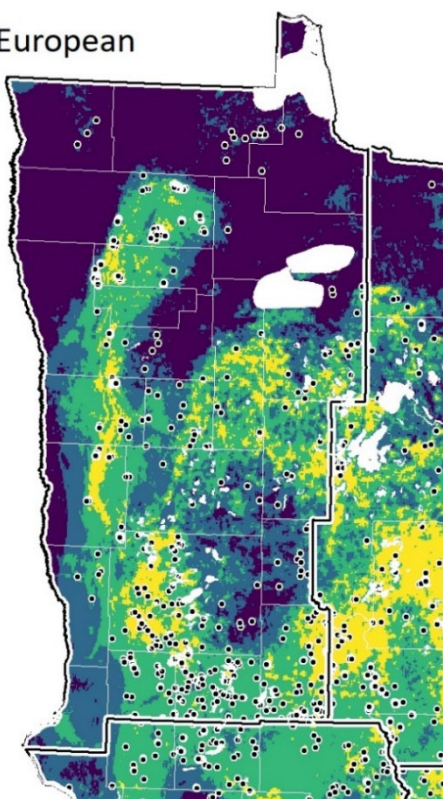
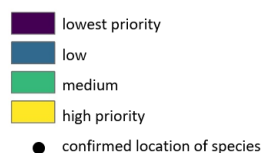
Regional Priority Species

(click on a species to view more information on that species)

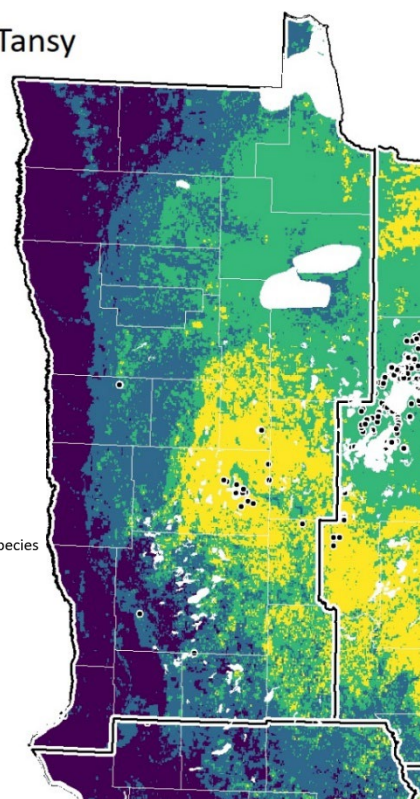
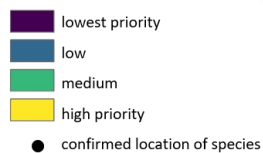
Common Buckthorn	<i>Rhamnus cathartica</i>
Common Tansy	<i>Tanacetum vulgare</i>
Garlic Mustard	<i>Alliaria petiolata</i>
Glossy buckthorn	<i>Frangula alnus</i>
Leafy Spurge	<i>Euphorbia esula</i>
Plumeless Thistle	<i>Carduus acanthoides</i>
Purple Loosestrife	<i>Lythrum salicaria</i>
Spotted Knapweed	<i>Centaurea stoebe</i> ssp. <i>micranthos</i>
Wild Parsnip	<i>Pastinaca sativa</i>

View regional interactive Story Map for the Northwest:
<https://arcg.is/19Ounj>

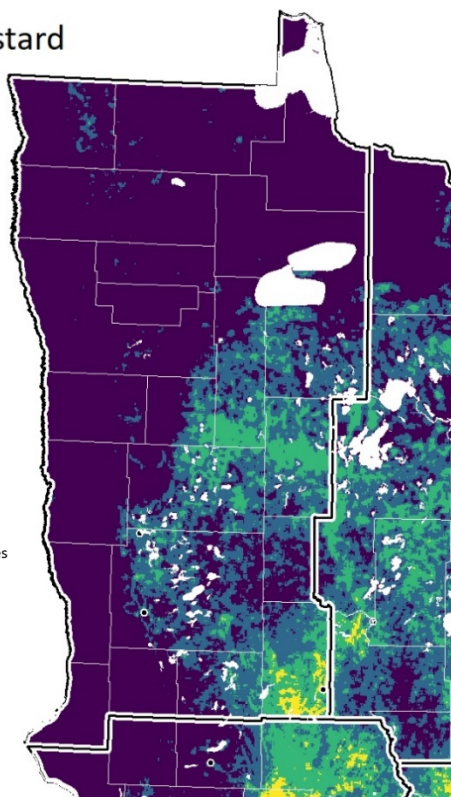
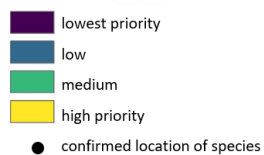
Common/European
Buckthorn



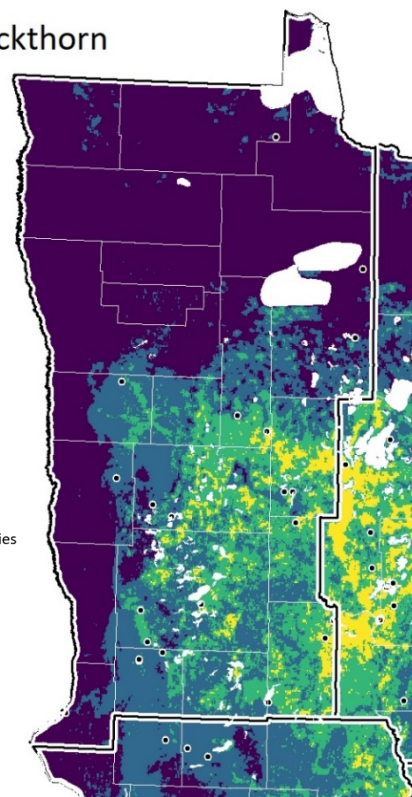
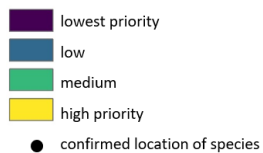
Common Tansy



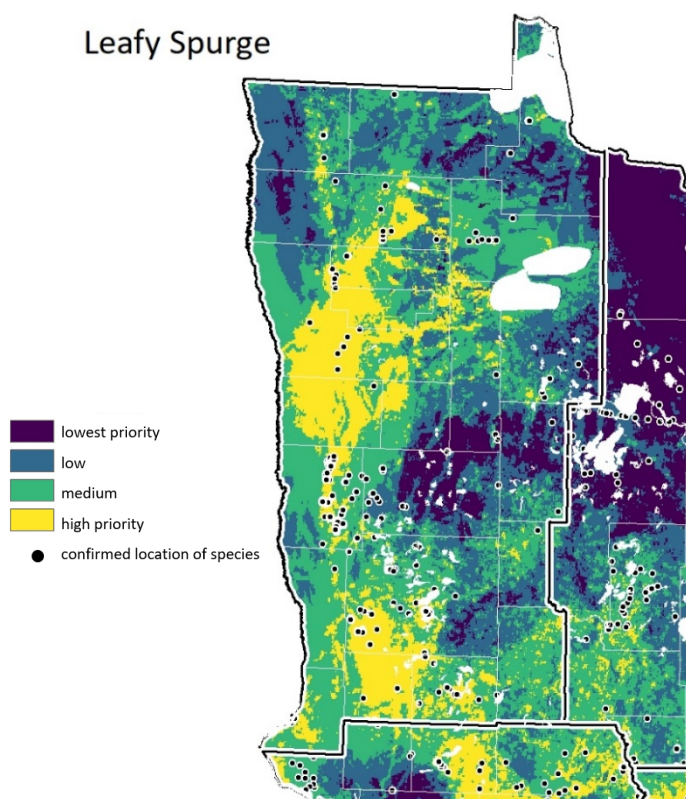
Garlic Mustard



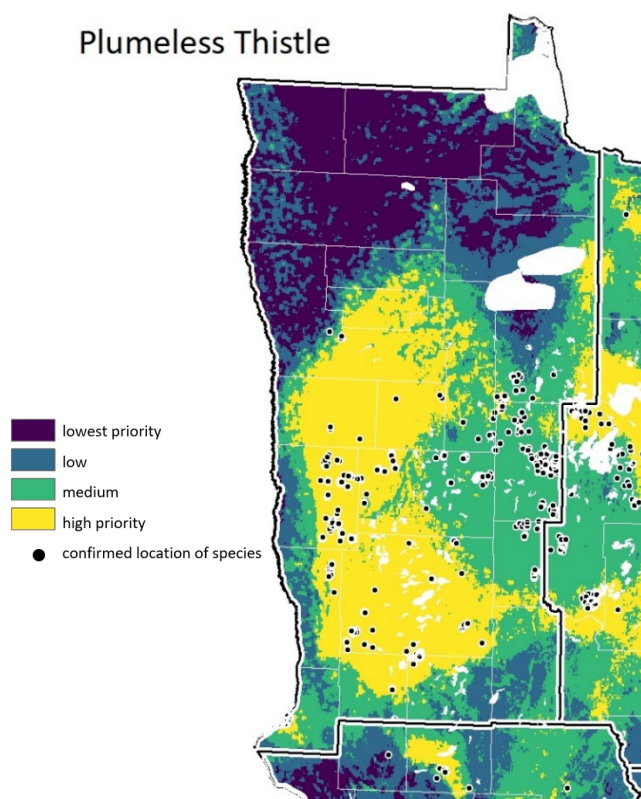
Glossy Buckthorn



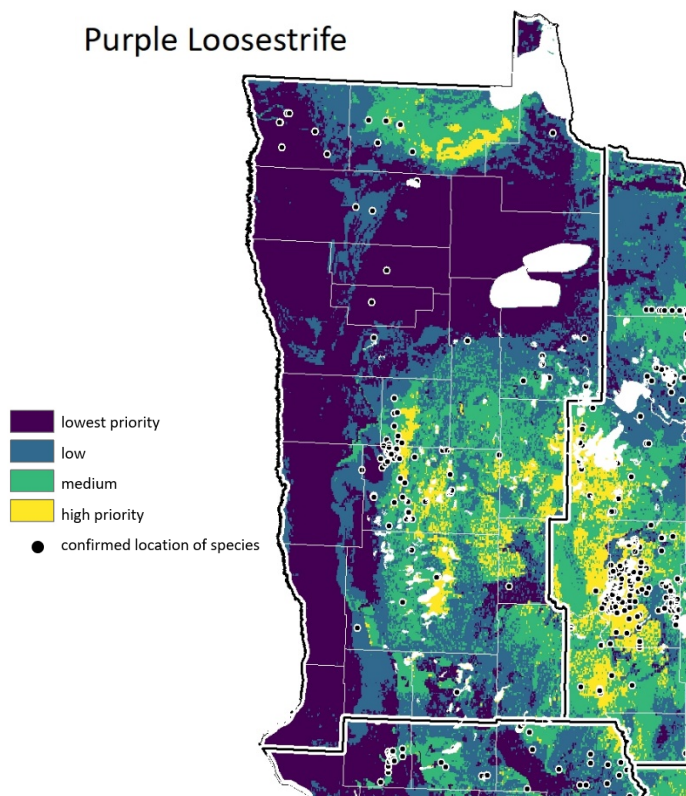
Leafy Spurge



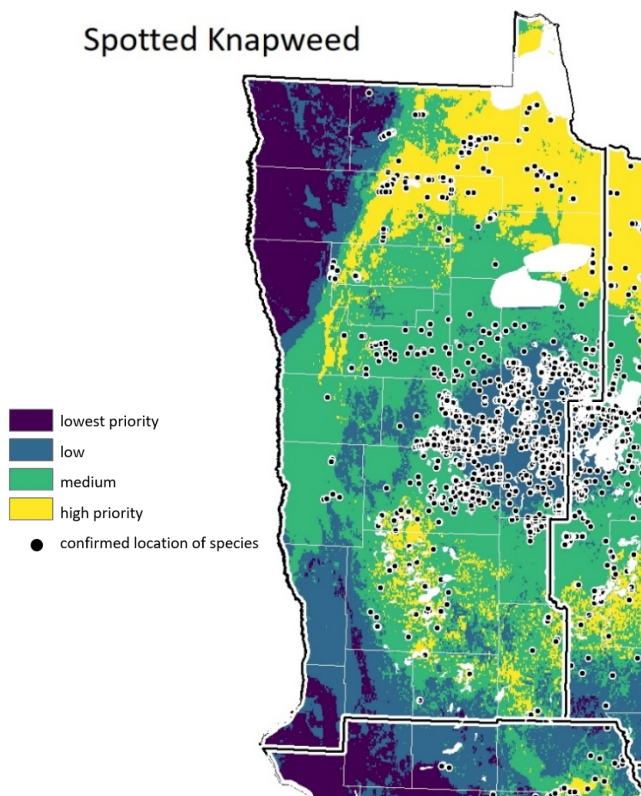
Plumeless Thistle



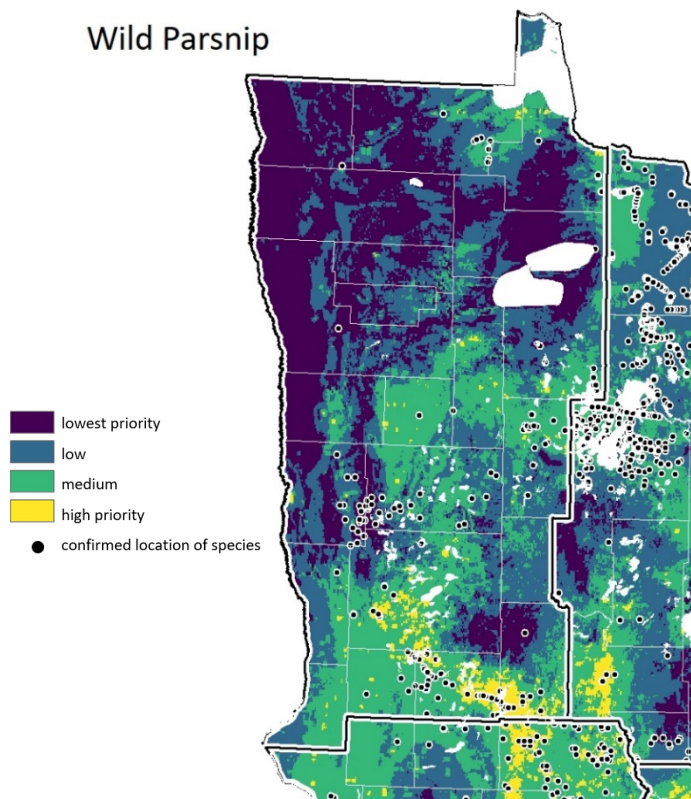
Purple Loosestrife



Spotted Knapweed



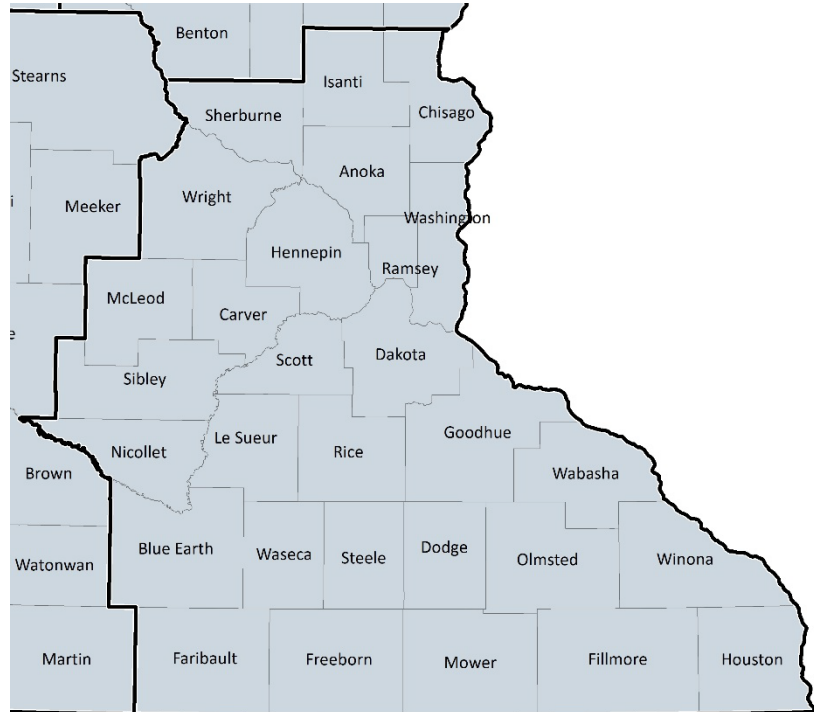
Wild Parsnip



Southeast/Metro Region

The southeast and metro region is made up of 29 counties: Anoka, Blue Earth, Carver, Chisago, Dakota, Dodge, Faribault, Fillmore, Freeborn, Goodhue, Hennepin, Houston, Isanti, Le Sueur, McLeod, Mower, Nicollet, Olmsted, Scott, Ramsey, Rice, Sherburne, Sibley, Steele, Wabasha, Waseca, Washington, Winona and Wright.

This region is almost completely made up of the Eastern Broadleaf Forest biome, and land cover is majorly made up of crop lands. The far southeast corner contains forested land cover, and the metro area is mostly considered 'developed' land cover. (See [biomes map in Resources](#).)



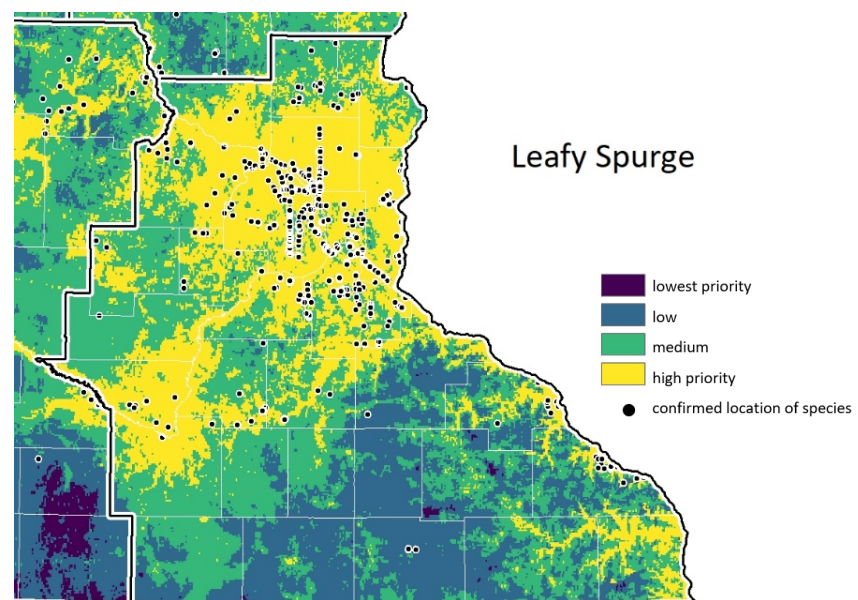
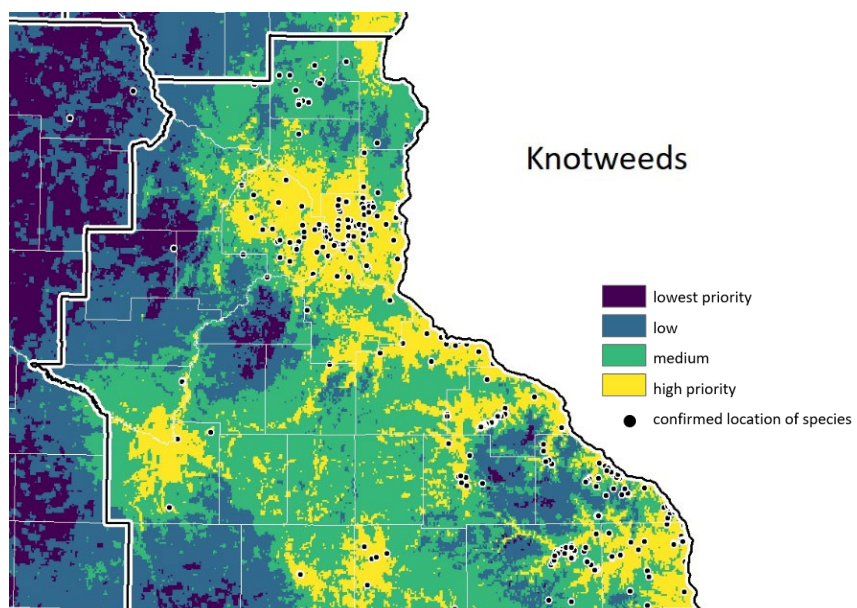
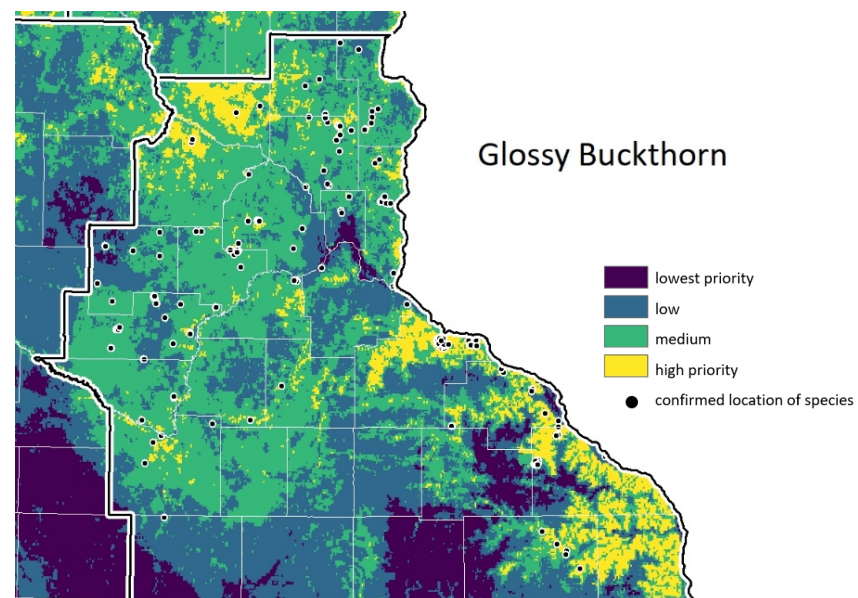
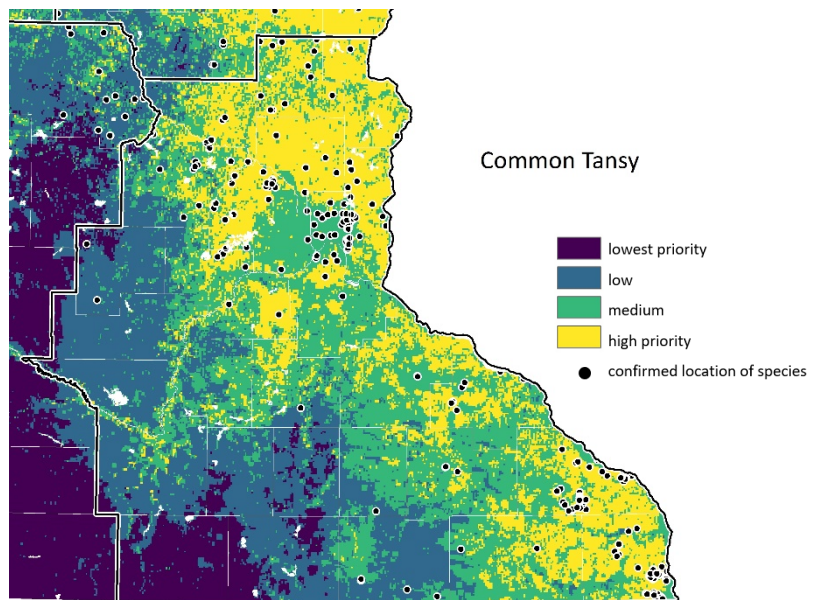
Regional Priority Species

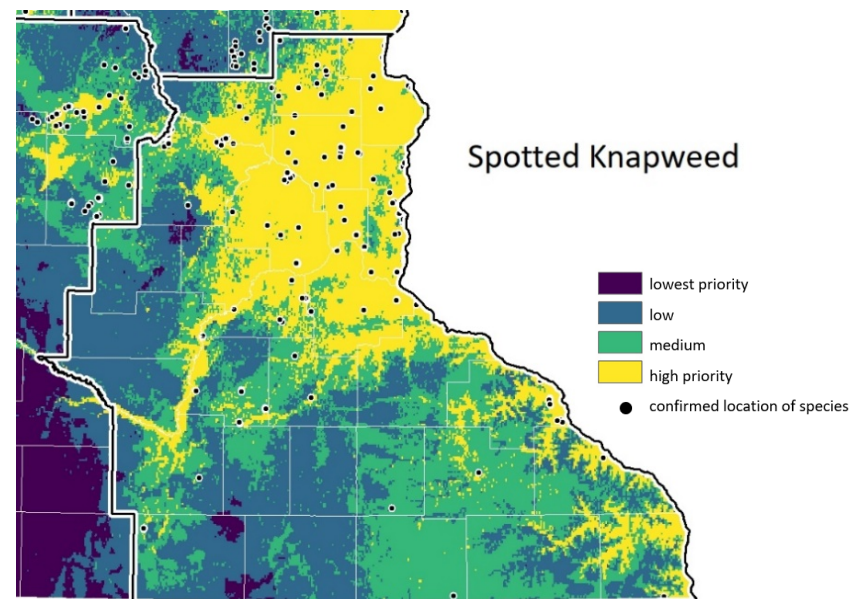
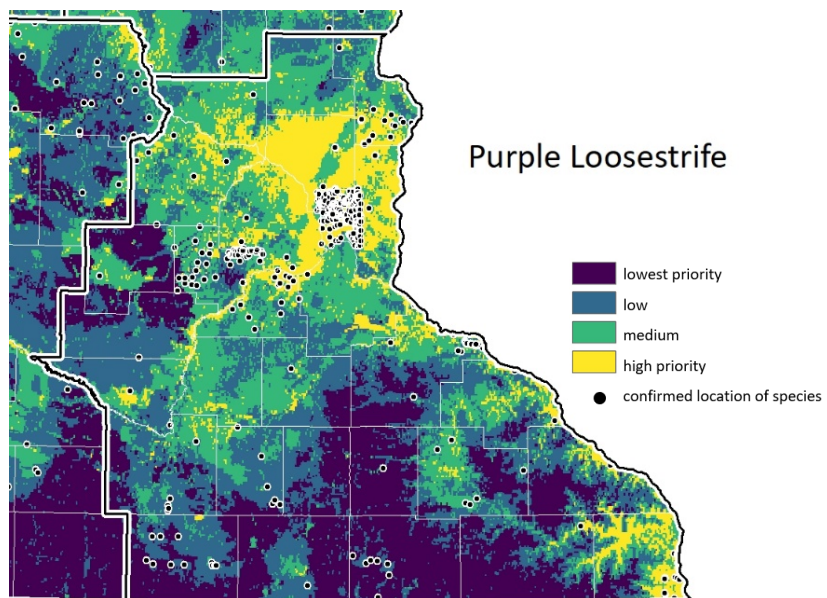
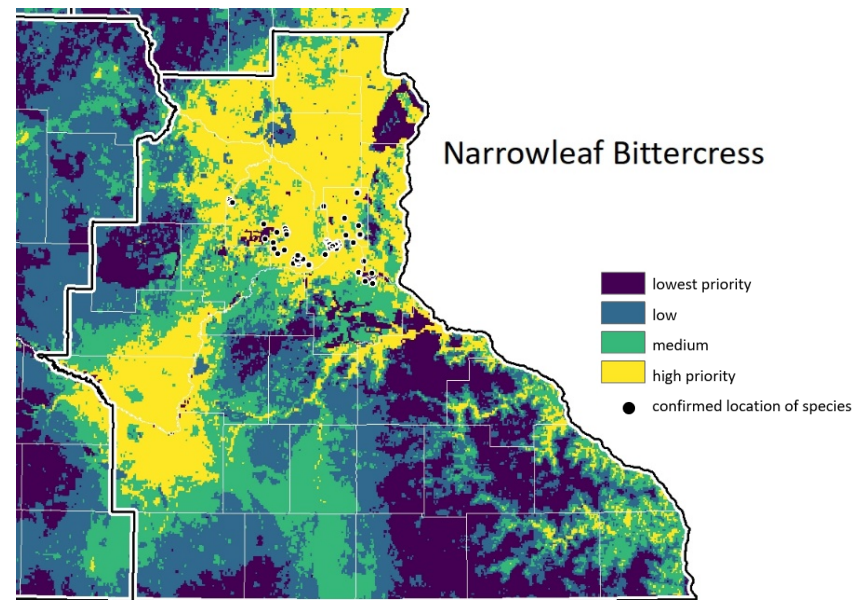
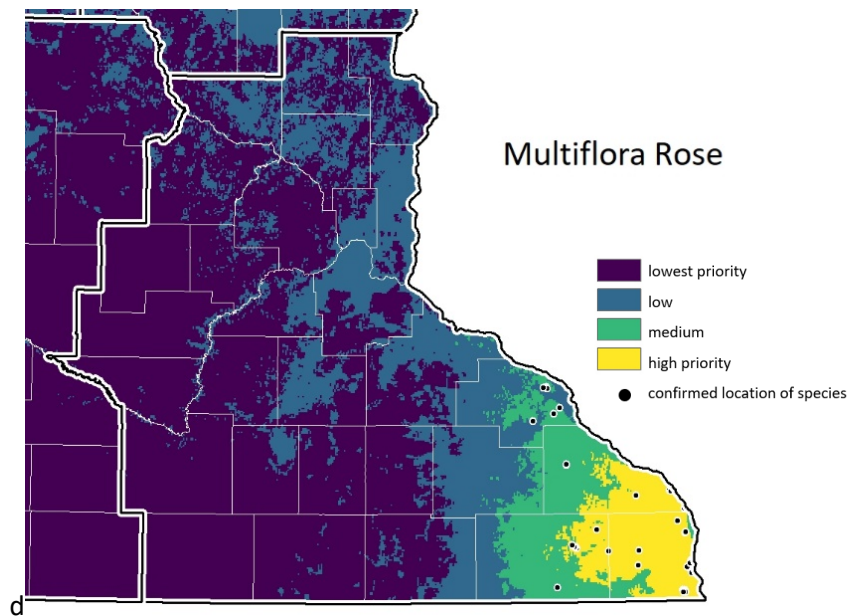
(click on a species to view more information on that species)

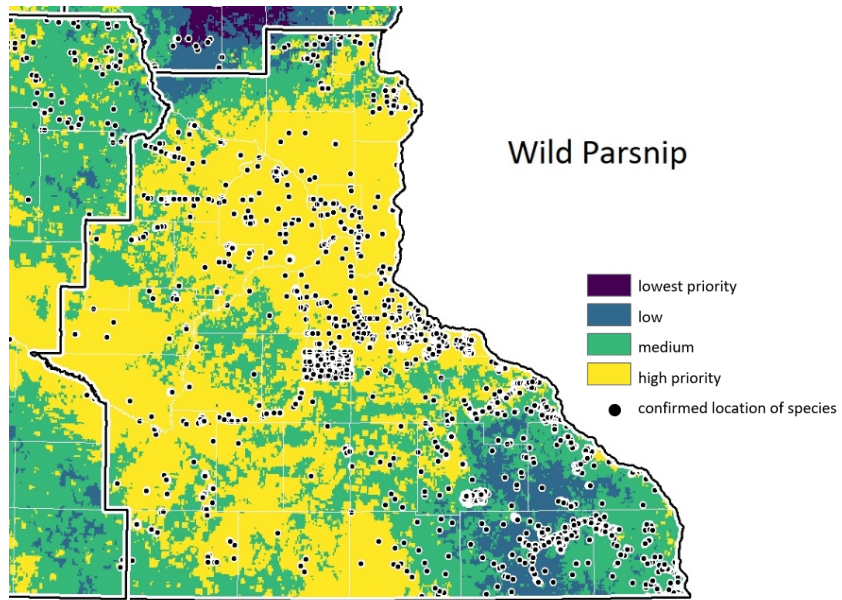
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Wild Parsnip	<i>Pastinaca sativa</i>

View regional interactive Story Map for the Southeast/Metro:

<https://arcg.is/quz14>



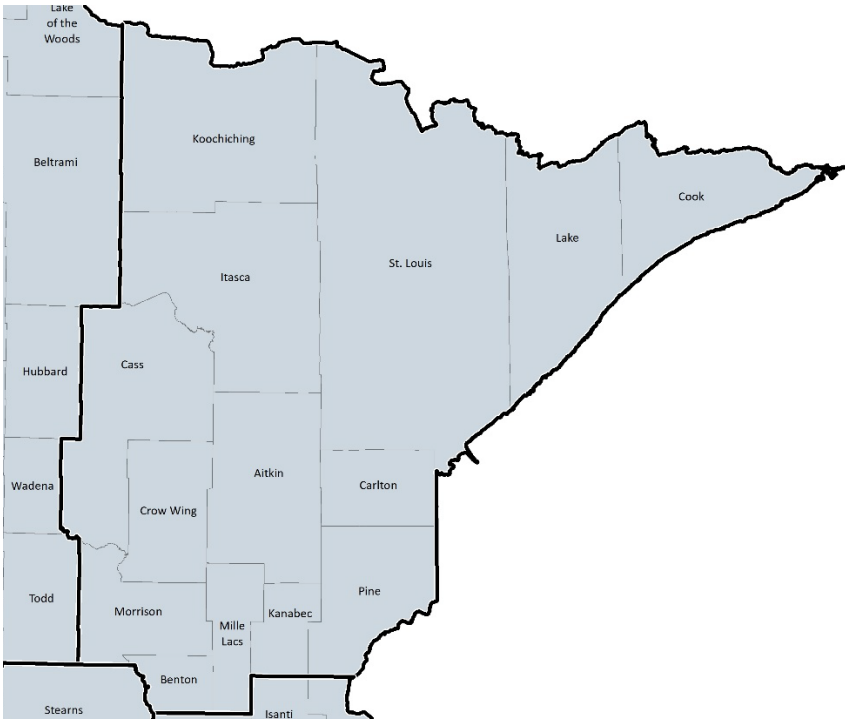




Northeast Region

The northeast region is made up of 14 counties: Aitkin, Benton, Carlton, Cass, Cook, Crow Wing, Itasca, Kanabec, Koochiching, Lake, St. Louis, Morrison, Mille Lacs and Pine.

This region is almost completely made up of the Laurentian Mixed Forest biome, and land cover is majorly made up of forest and woody wetlands. ([See biomes map in Resources.](#))



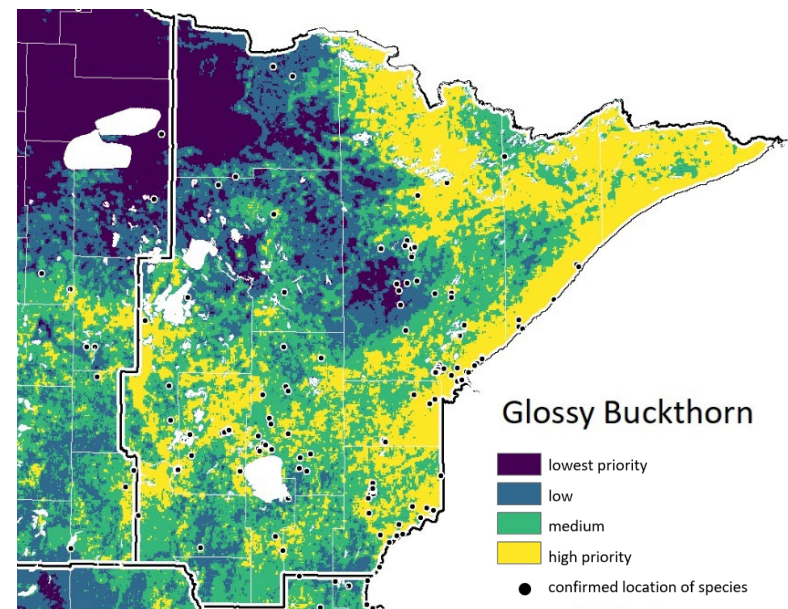
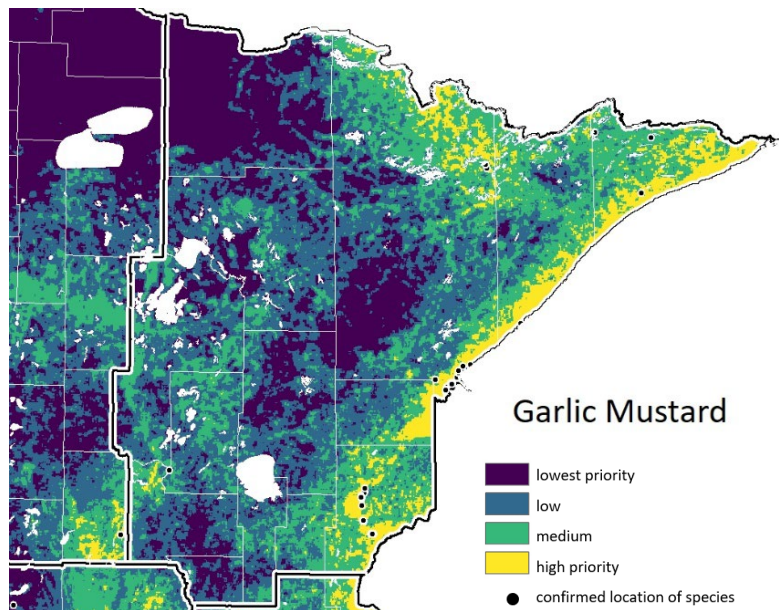
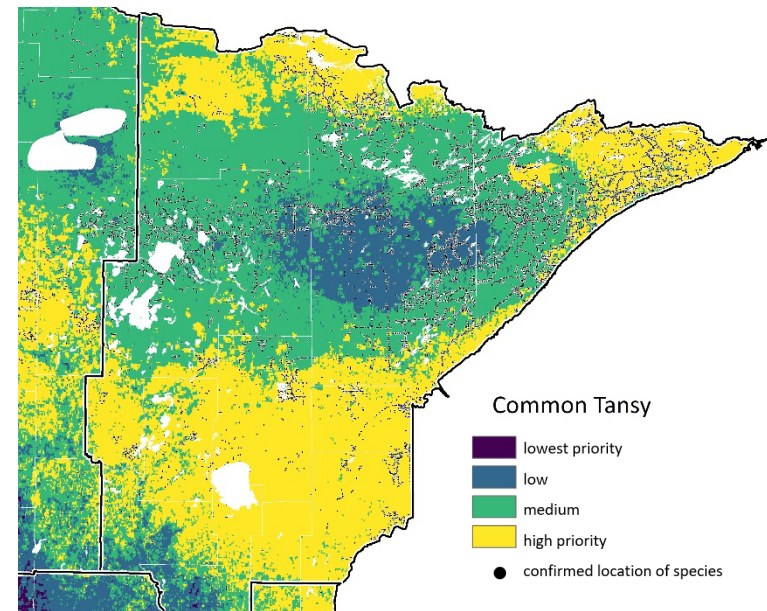
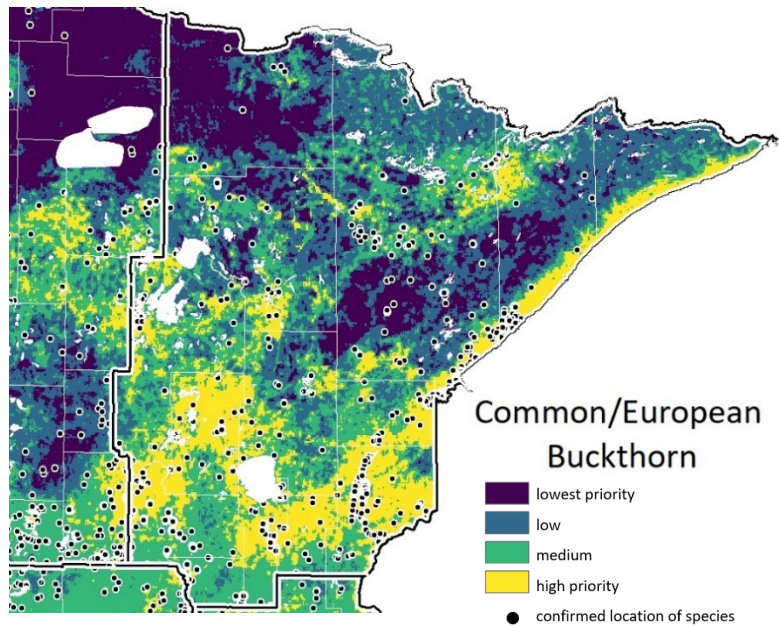
Regional Priority Species

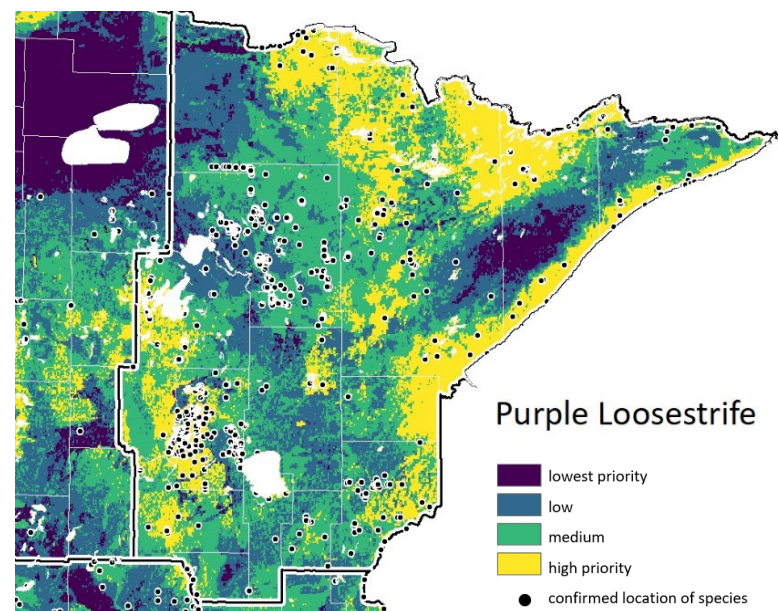
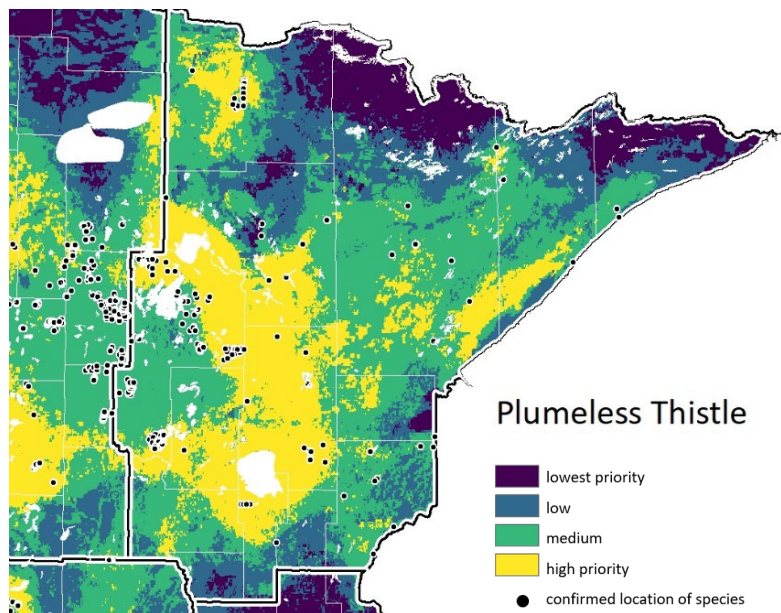
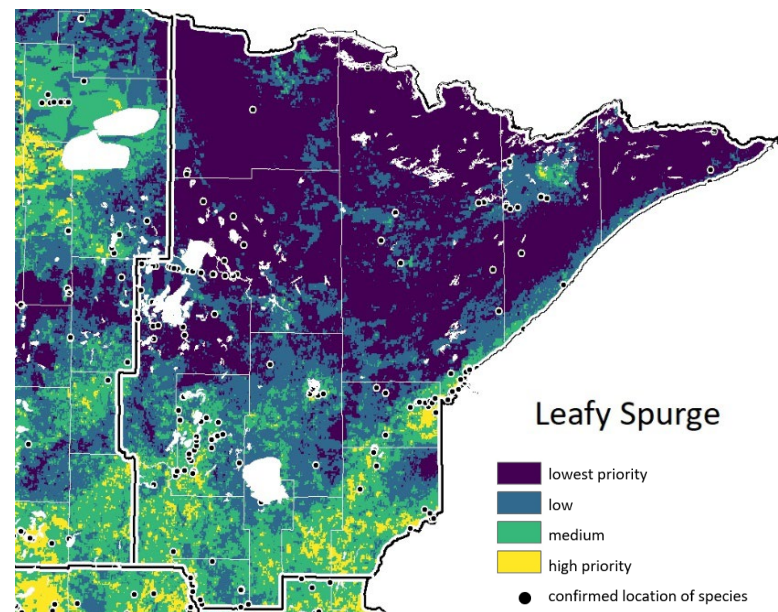
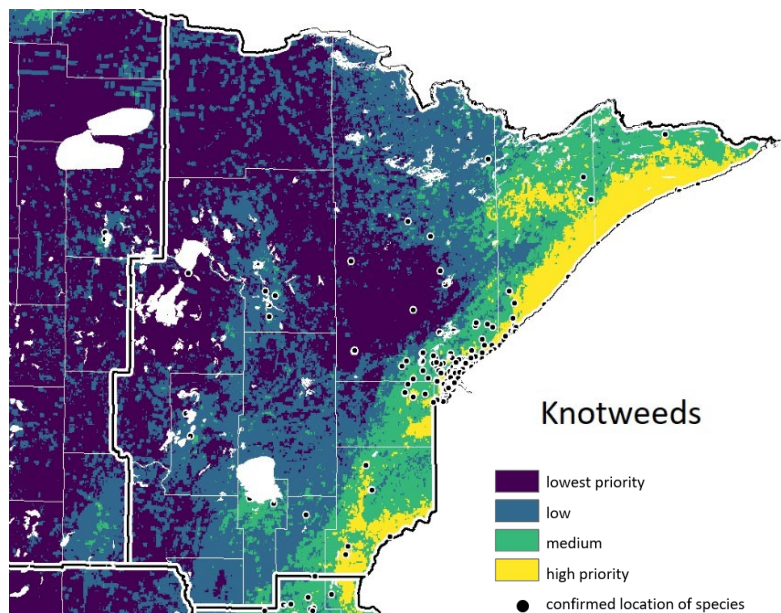
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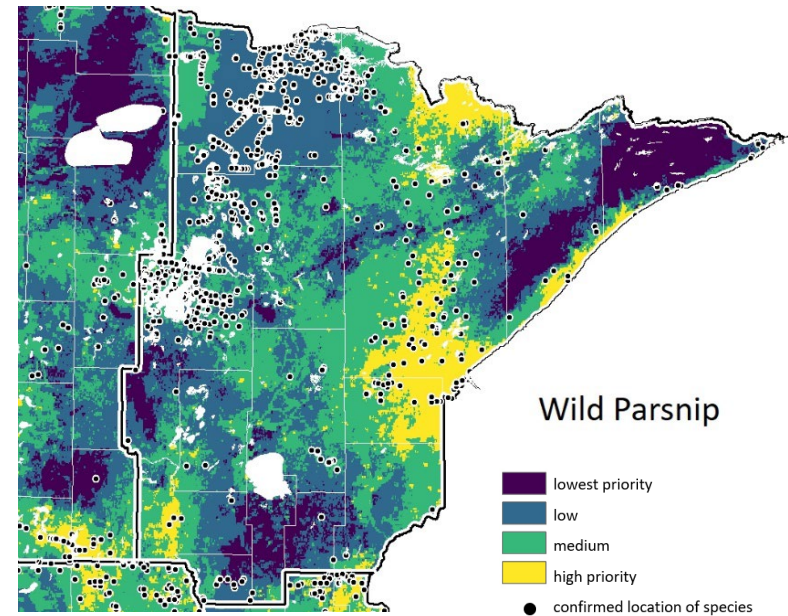
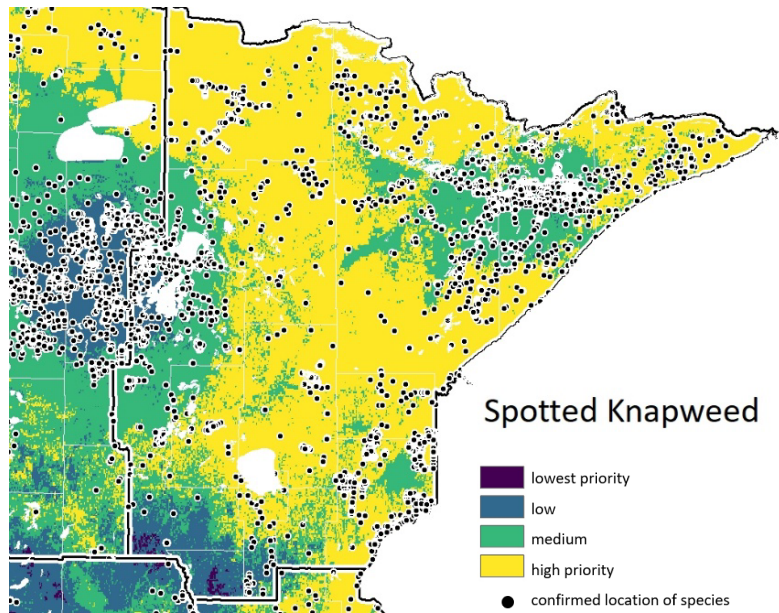
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Glossy Buckthorn	<i>Frangula alnus</i>
Knotweeds	<i>Polygonum</i> spp.
Leafy Spurge	<i>Euphorbia esula</i>
Plumeless Thistle	<i>Carduus acanthoides</i>
Purple Loosestrife	<i>Lythrum salicaria</i>
Spotted Knapweed	<i>Centaurea stoebe</i> ssp. <i>micranthos</i>
Wild Parsnip	<i>Pastinaca sativa</i>

View regional interactive Story Map for the Northeast:

<https://arcg.is/1iXnv1>







Species Resources & Management



Species Included

<u>Canada Thistle</u>	<i>Cirsium arvense</i> (L.) Scop.
<u>Common or European Buckthorn</u>	<i>Rhamnus cathartica</i> L.
<u>Common Tansy</u>	<i>Tanacetum vulgare</i> L.
<u>Garlic Mustard</u>	<i>Alliaria petiolata</i> Bieb.
<u>Glossy Buckthorn</u>	<i>Frangula alnus</i> Mill.
<u>Knotweeds</u>	<i>Polygonum</i> spp.
<u>Leafy Spurge</u>	<i>Euphorbia esula</i> L.
<u>Multiflora Rose</u>	<i>Rosa multiflora</i> Thunb.
<u>Narrowleaf Bittercress</u>	<i>Cardamine impatiens</i> L.
<u>Plumeless Thistle</u>	<i>Carduus acanthoides</i> L.
<u>Purple Loosestrife</u>	<i>Lythrum salicaria</i> L.
<u>Spotted Knapweed</u>	<i>Centaurea stoebe</i> L. ssp. <i>micranthos</i> (Gugler) Hayek
<u>Wild Parsnip</u>	<i>Pastinaca sativa</i> L.

All species included in this plan are on the Minnesota Noxious Weed List and have been evaluated through a thorough risk assessment process. To view risk assessments of these or additional species, visit the [Minnesota Invasive Species Advisory Council webpage](https://mninvasives.org/risk-assessments) (mninvasives.org/risk-assessments).

Canada Thistle • *Cirsium arvense*

Identification: herbaceous perennial plant up to five feet tall; leaves alternate, lance shaped, with irregular spine-tipped lobes; flowers purple to white in clusters at end of stems bloom July to August; vigorous, rhizomatous root system.



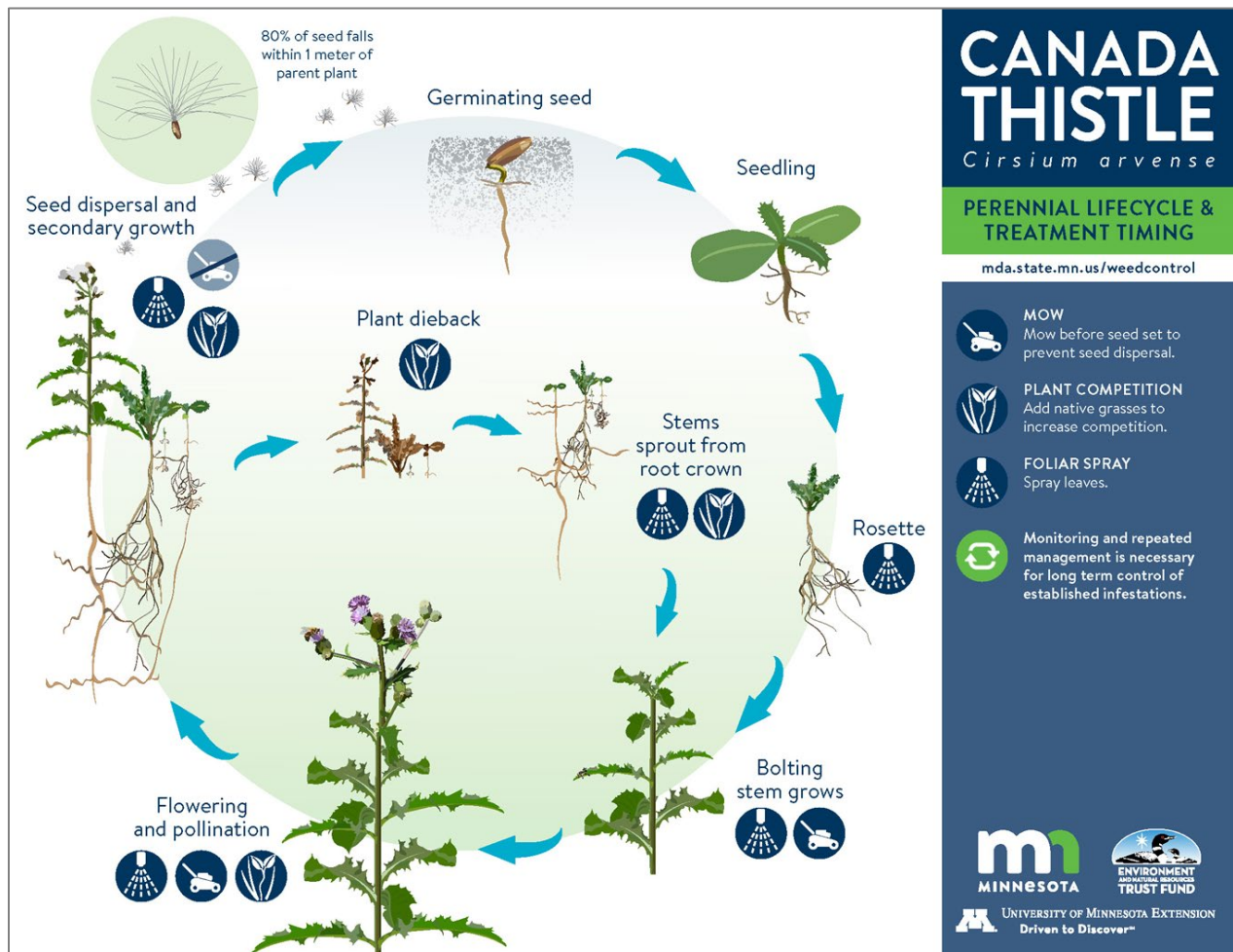
Infestation



Leaves with spines

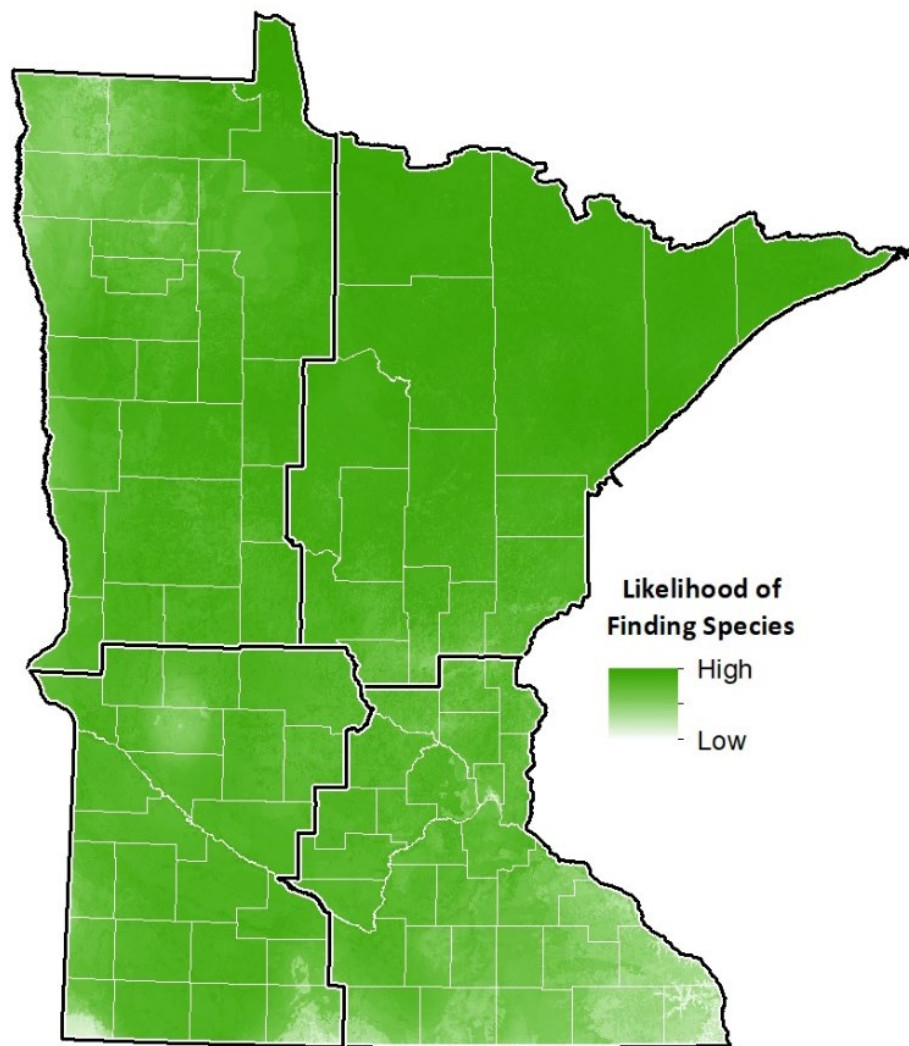


Flower and buds

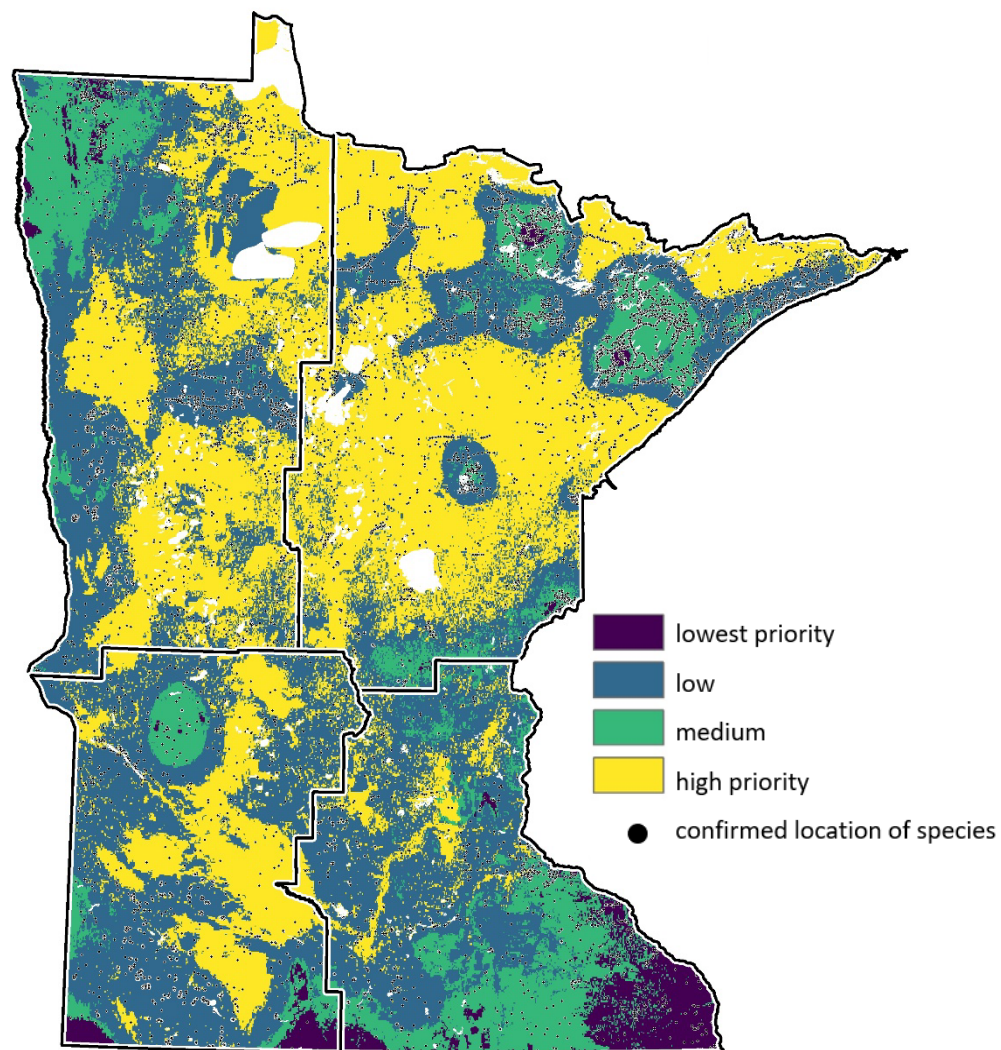


Note: Canada thistle was not a priority in any region because it was ubiquitous. Being abundant in all regions of the state, control of Canada thistle will not prevent regional introduction or reduce statewide presence. Controlling Canada thistle at an individual site level to protect pasture, crops or high value habitat is sensible.

Canada Thistle • *Cirsium arvense*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Common/European Buckthorn • *Rhamnus cathartica*

Identification: large shrub up to 30 feet tall; branches terminate in small thorns; leaves sub-opposite, egg shaped with finely serrated margins and veins curving toward apex; flowers small, green with four petals produce black berries in fall; outer bark silvery, heartwood is orange, sapwood is yellow.



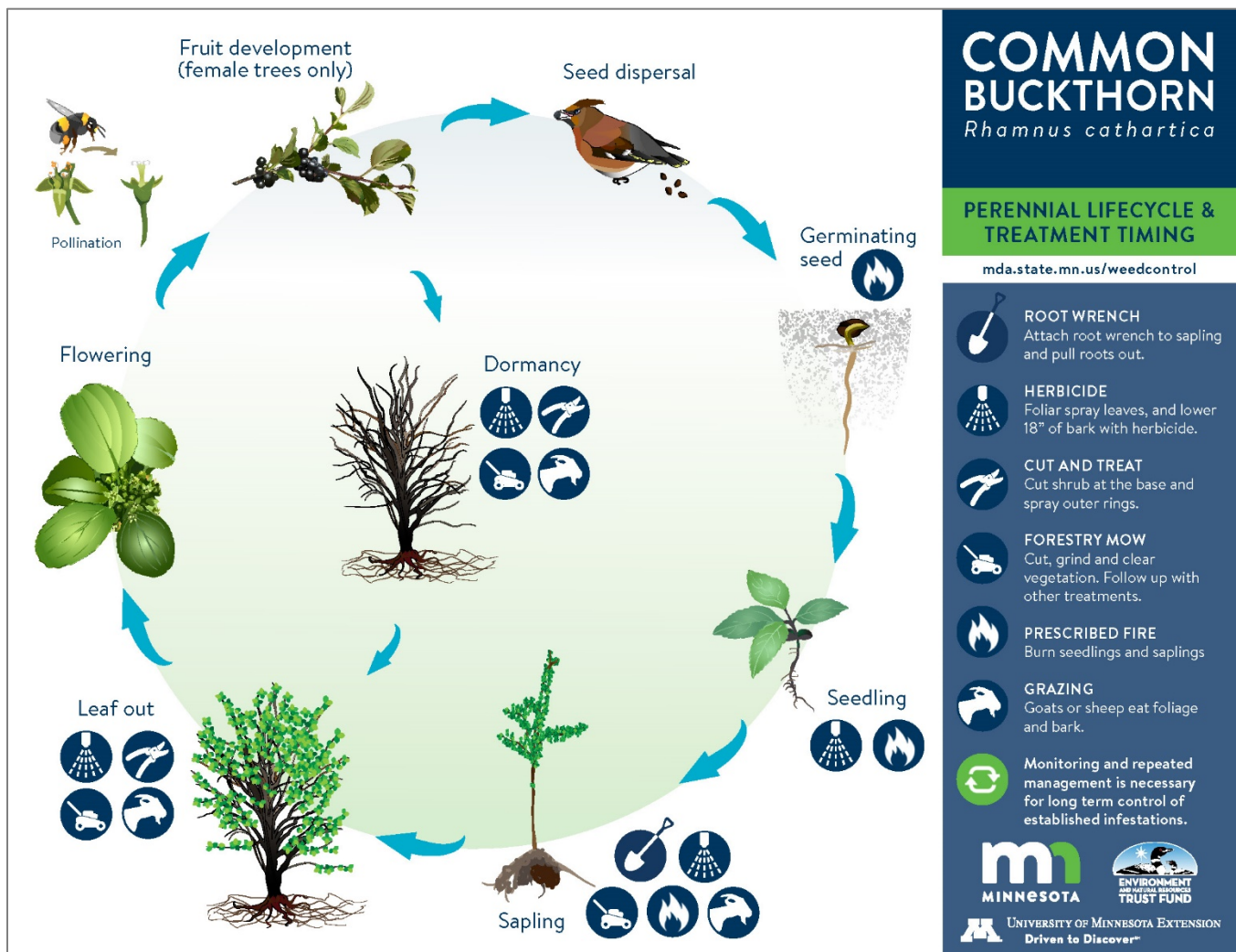
Infestation



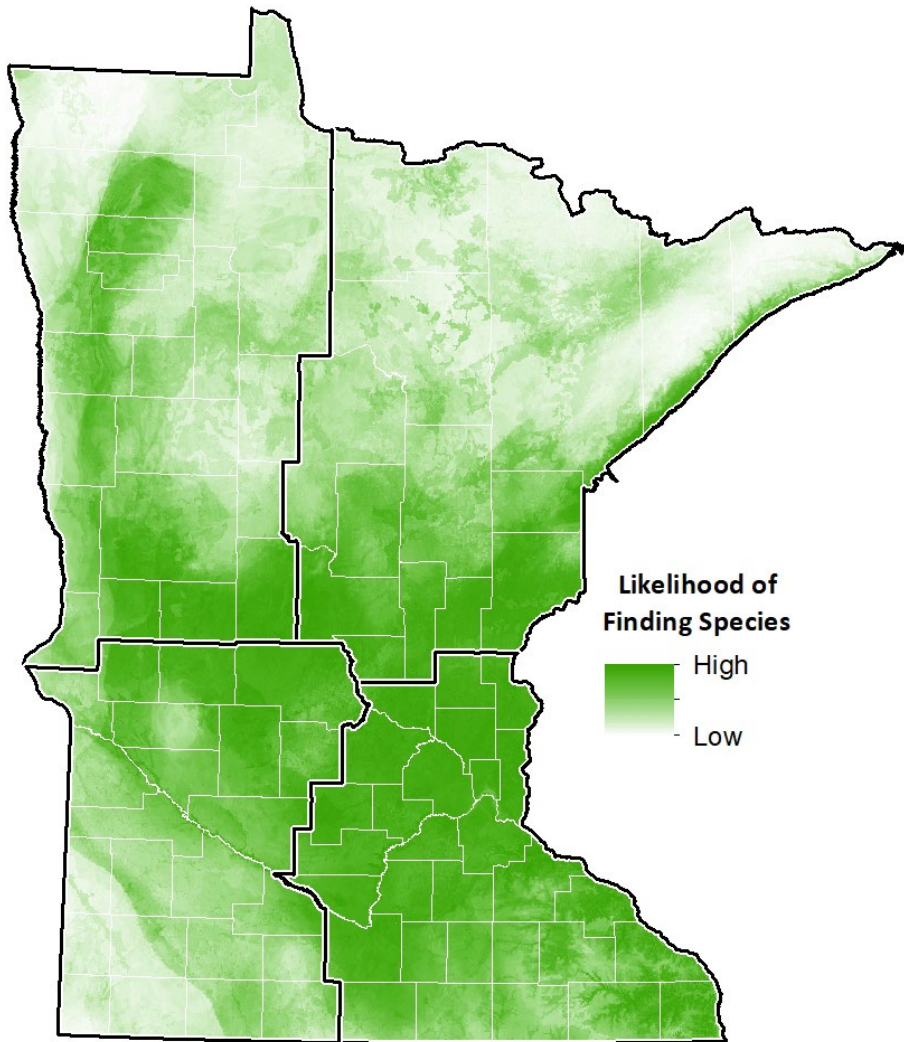
Leaves and thorn



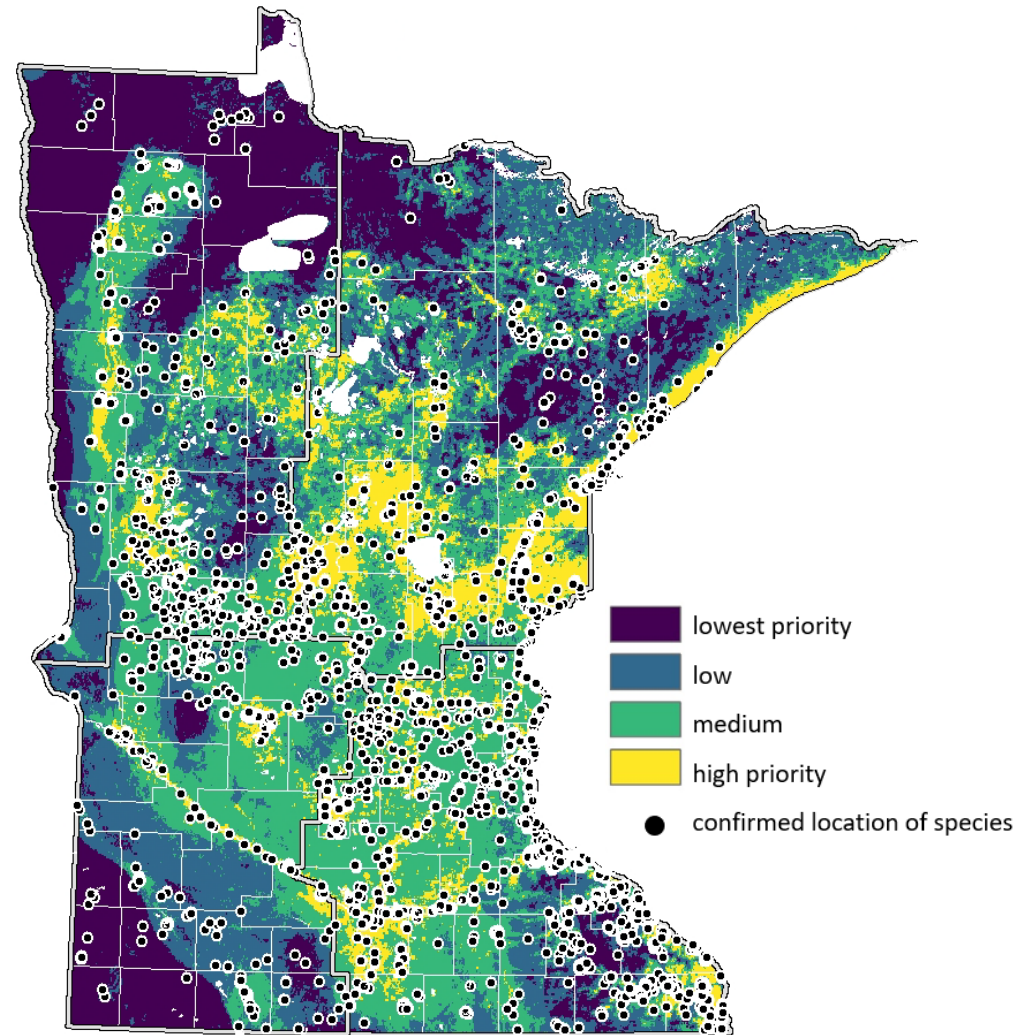
Orange heartwood



Common/European Buckthorn • *Rhamnus cathartica*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Common Tansy • *Tanacetum vulgare*

Identification: herbaceous perennial plant up to 6 feet tall, often growing in clumps; leaves alternate, finely divided with fern-like appearance; flowers yellow, button-like, arranged in umbels at stem tips; vigorous, rhizomatous root system; crushed plants emit strong odor.



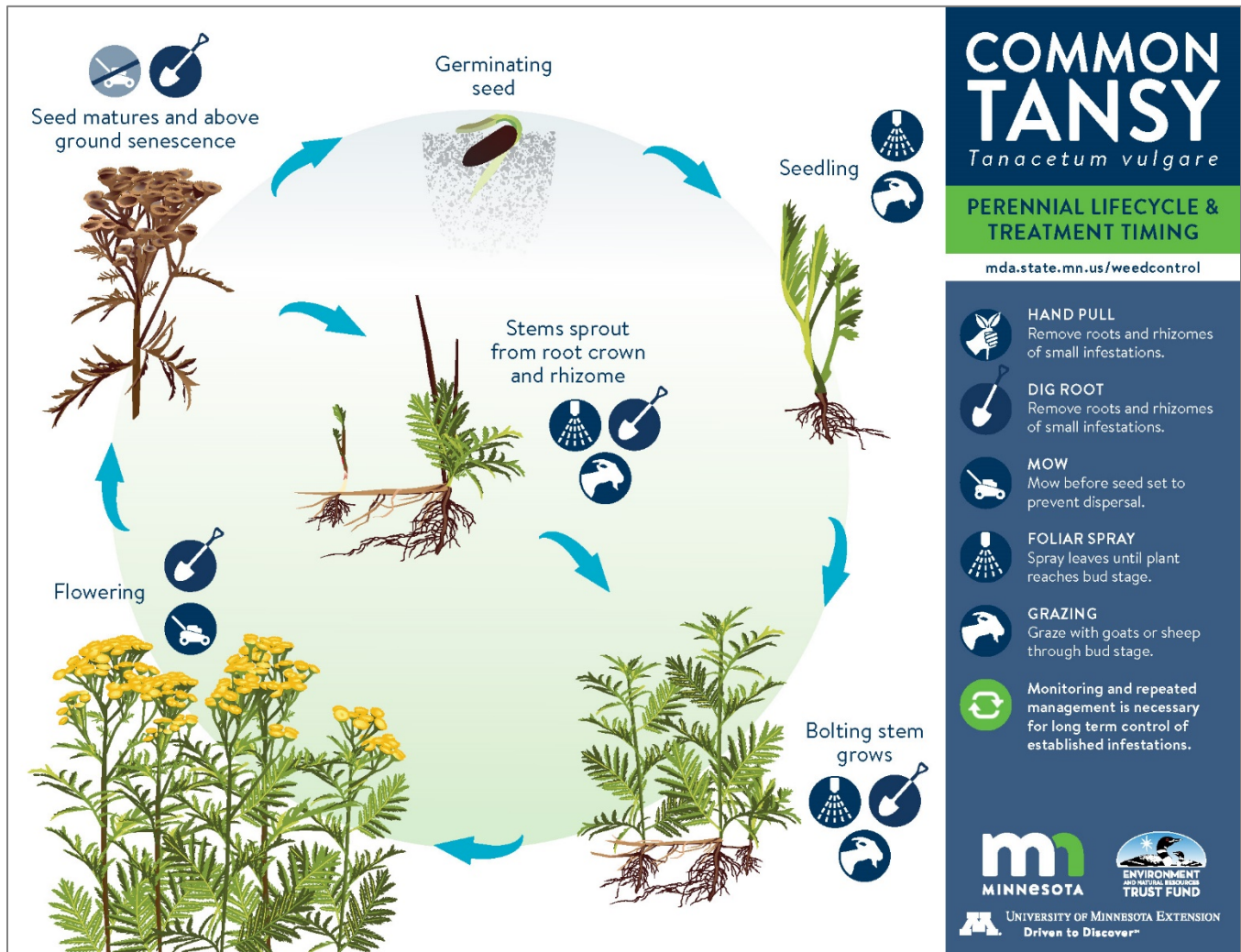
Infestation



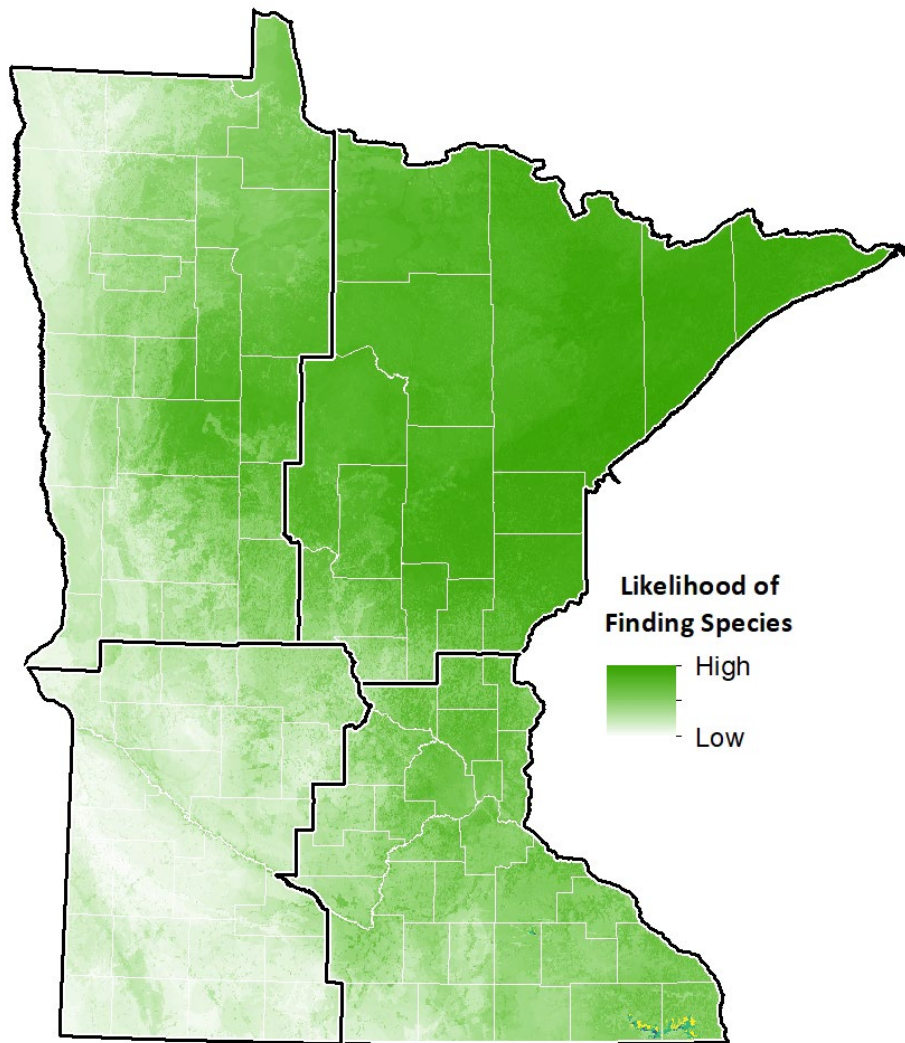
Fern-like leaves



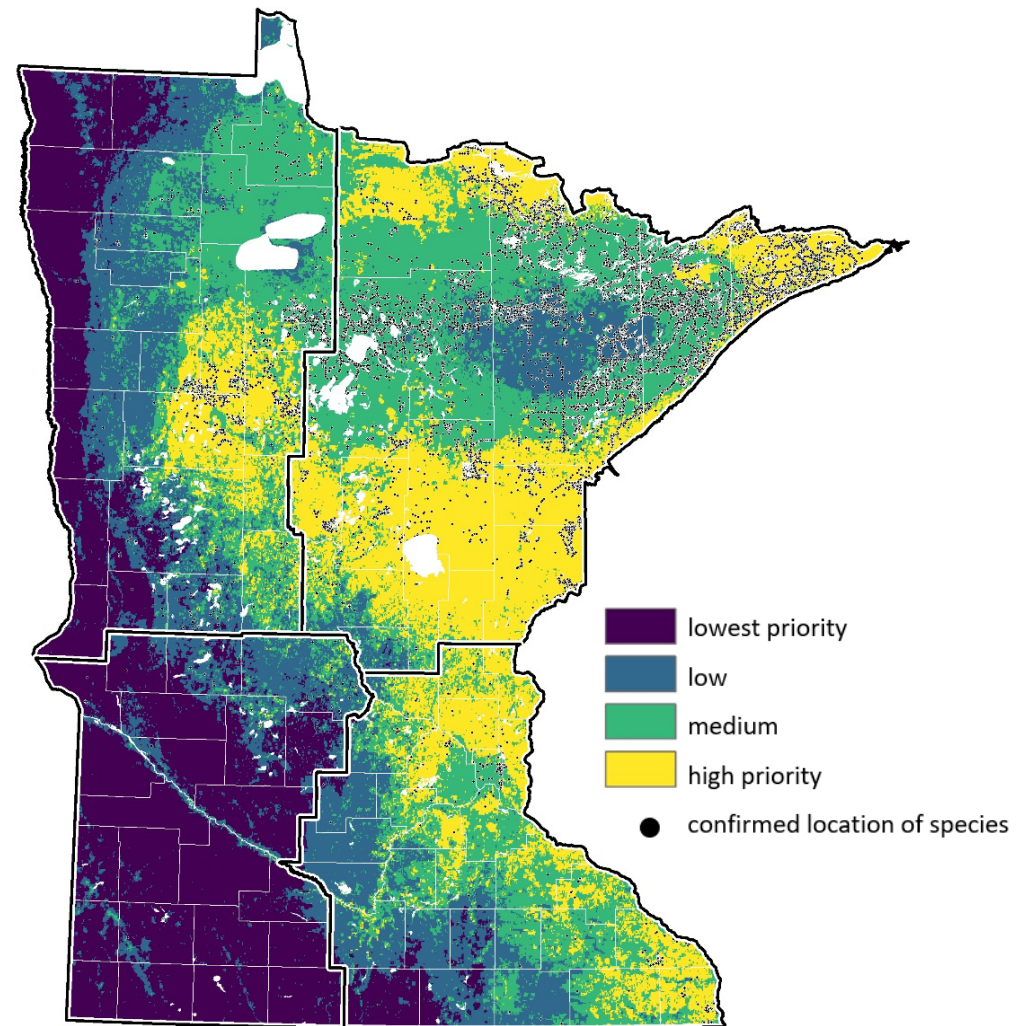
Flower umbel



Common Tansy • *Tanacetum vulgare*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Garlic Mustard • *Alliaria petiolata*

Identification: herbaceous biennial plant up to 4 feet tall; leaves alternate with scalloped margins, lower leaves heart shaped, upper leaves triangular; flowers small, white with four petals produce slender seed capsules; short tap root; crushed plants emit garlic odor.



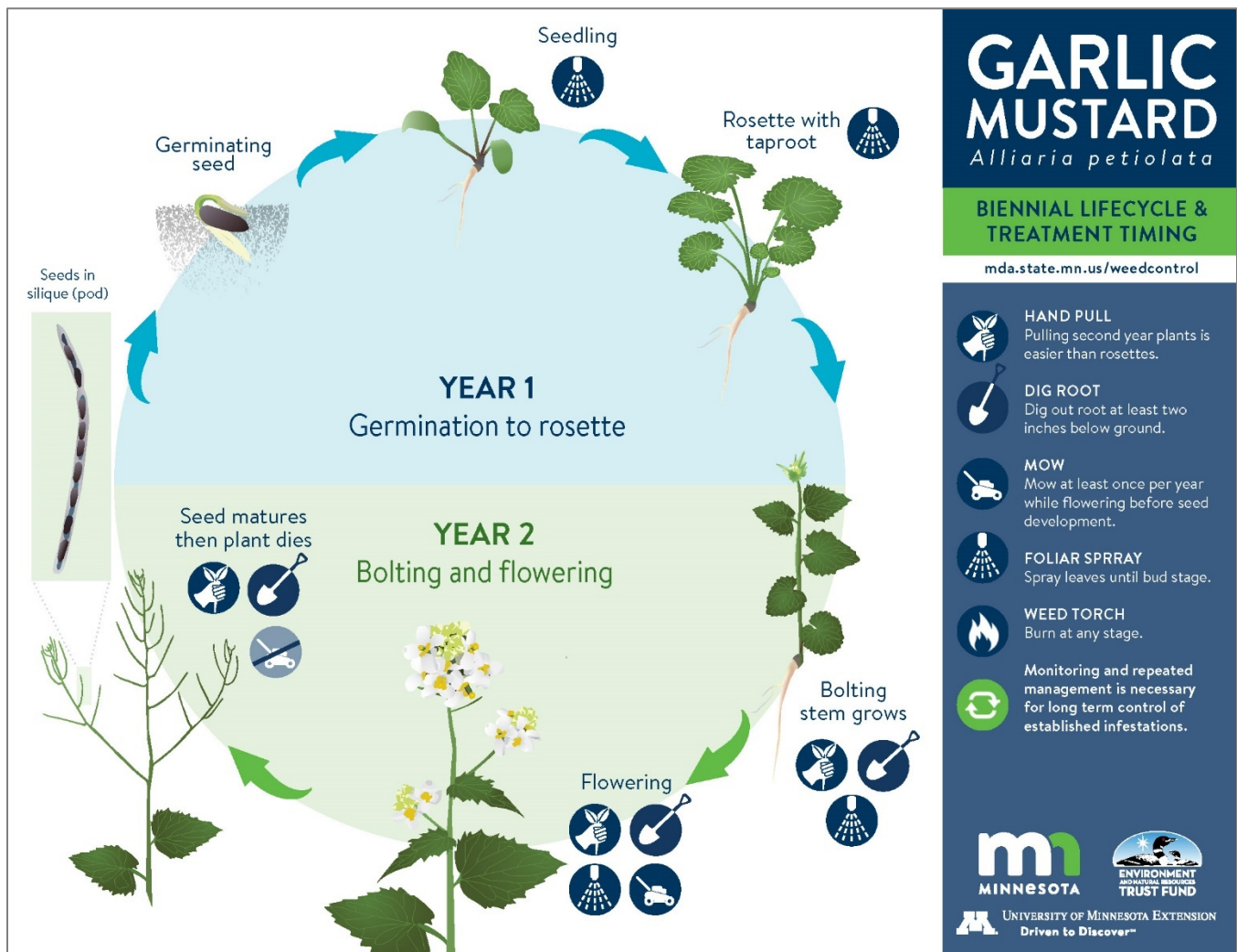
Infestation



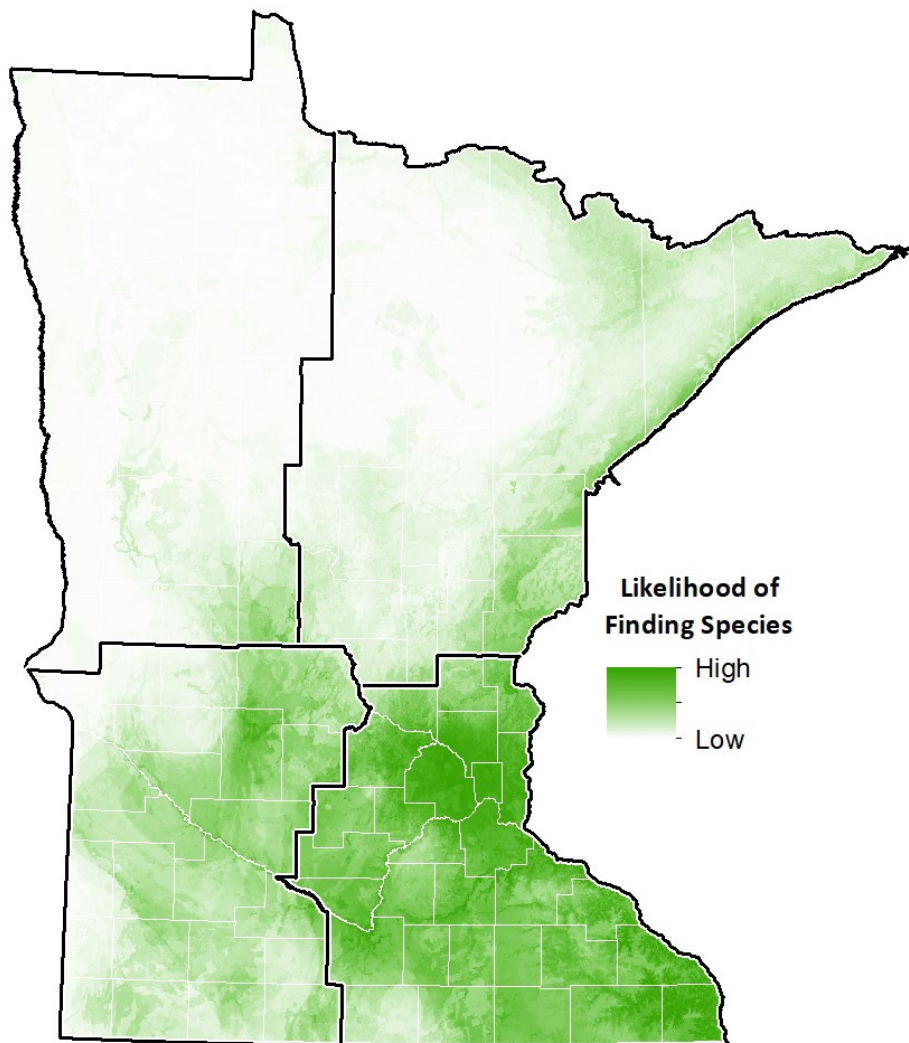
Leaves



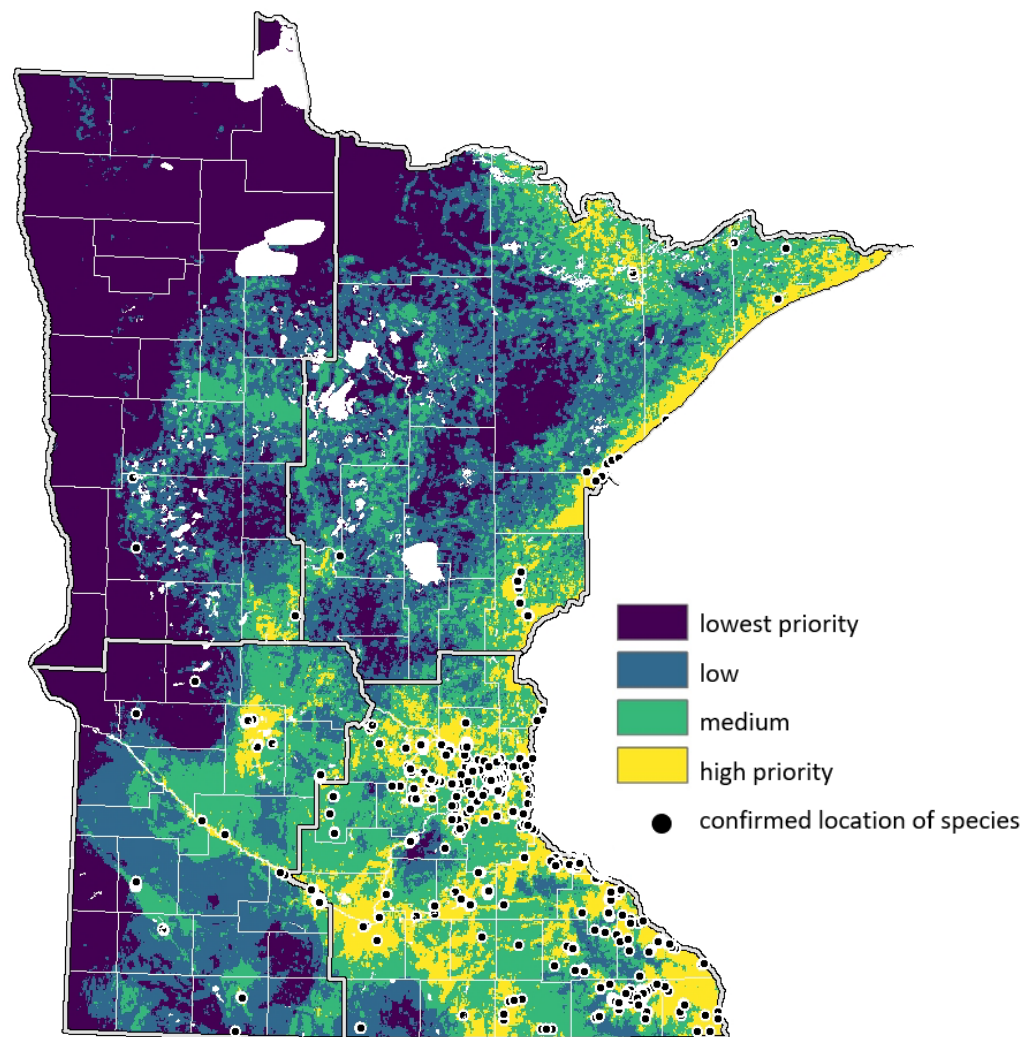
Flower cluster



Garlic Mustard • *Alliaria petiolata*



Current Distribution Model



**Multi-Criteria Decision Analysis
Prioritization Model**

Glossy Buckthorn • *Frangula alnus*

Identification: large shrub up to 20 feet tall; leaves alternate, oval with smooth margins and parallel veins; flowers small, greenish-white with five petals produce black berries in fall; outer bark brown with lenticels, heartwood is orange, sapwood is yellow.



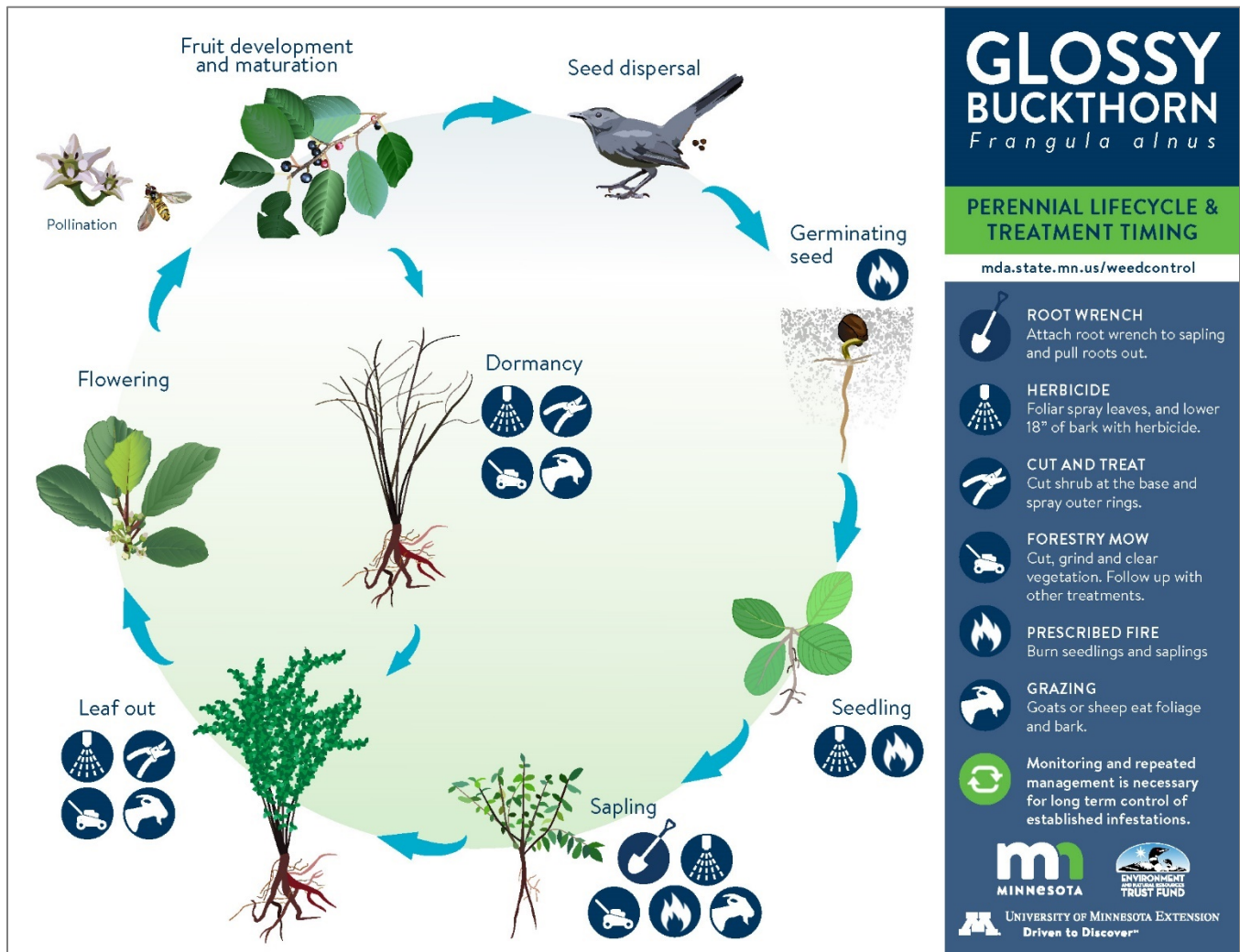
Infestation



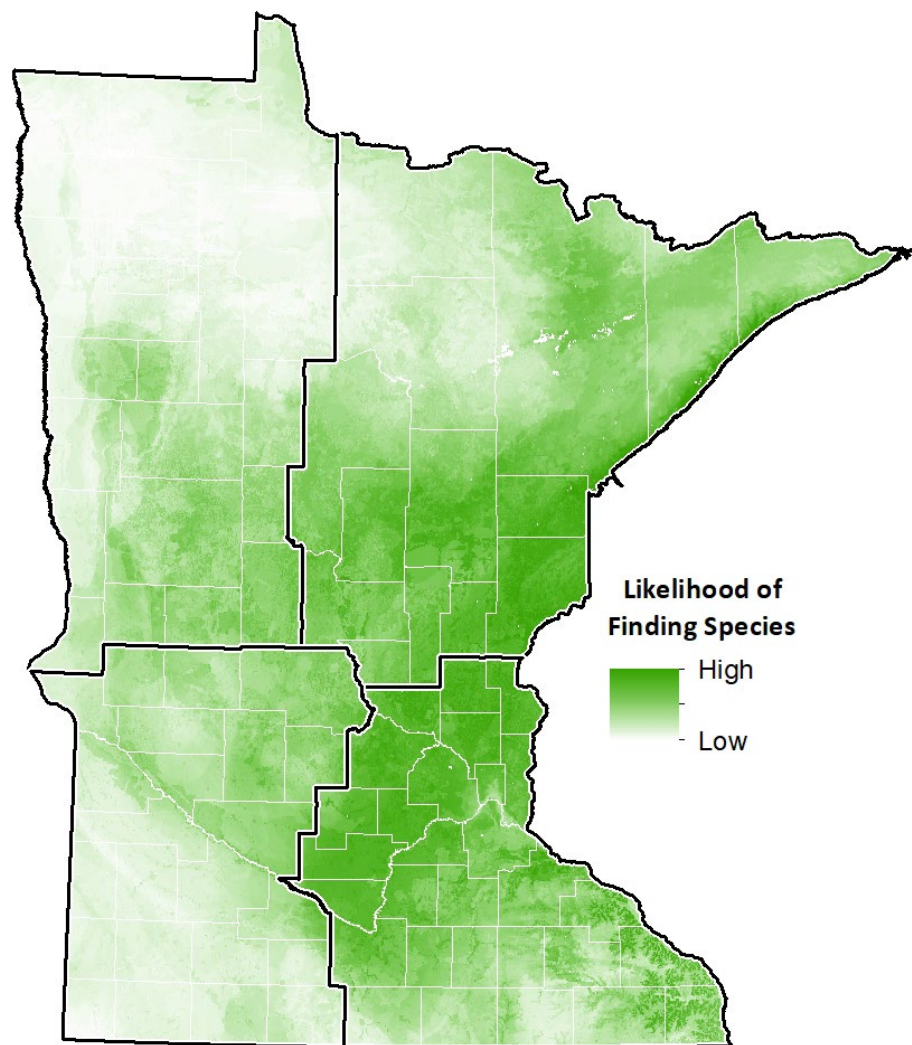
Leaves and berries



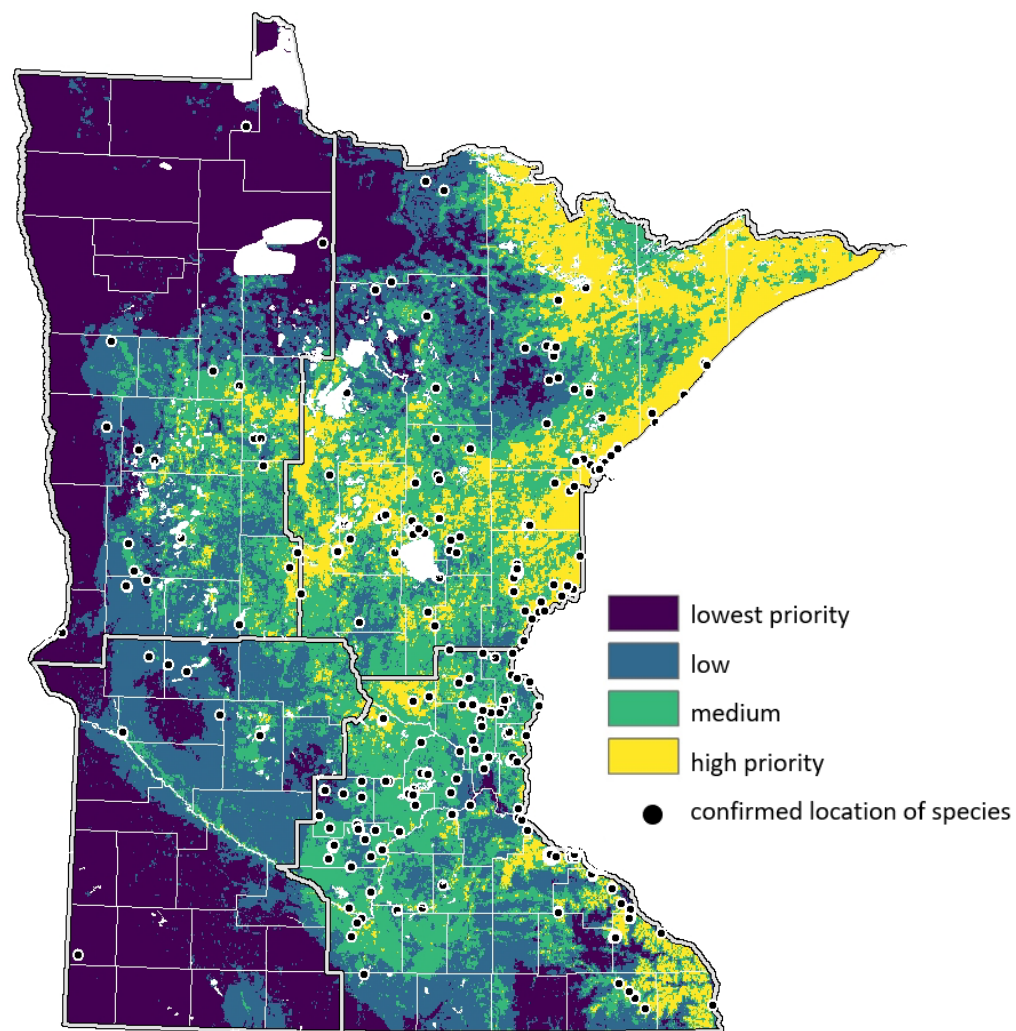
Bark



Glossy Buckthorn • *Frangula alnus*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Knotweeds • *Polygonum* spp.

Identification: herbaceous perennial plant up to 15 feet tall; leaves alternate with smooth margins and pointed apex, spade to heart-shaped, can be 12 inches long; flowers white in lacy clusters at stem tips, bloom in late summer; extensive rhizomatous root system; stems segmented, hollow, green in summer and red in winter.



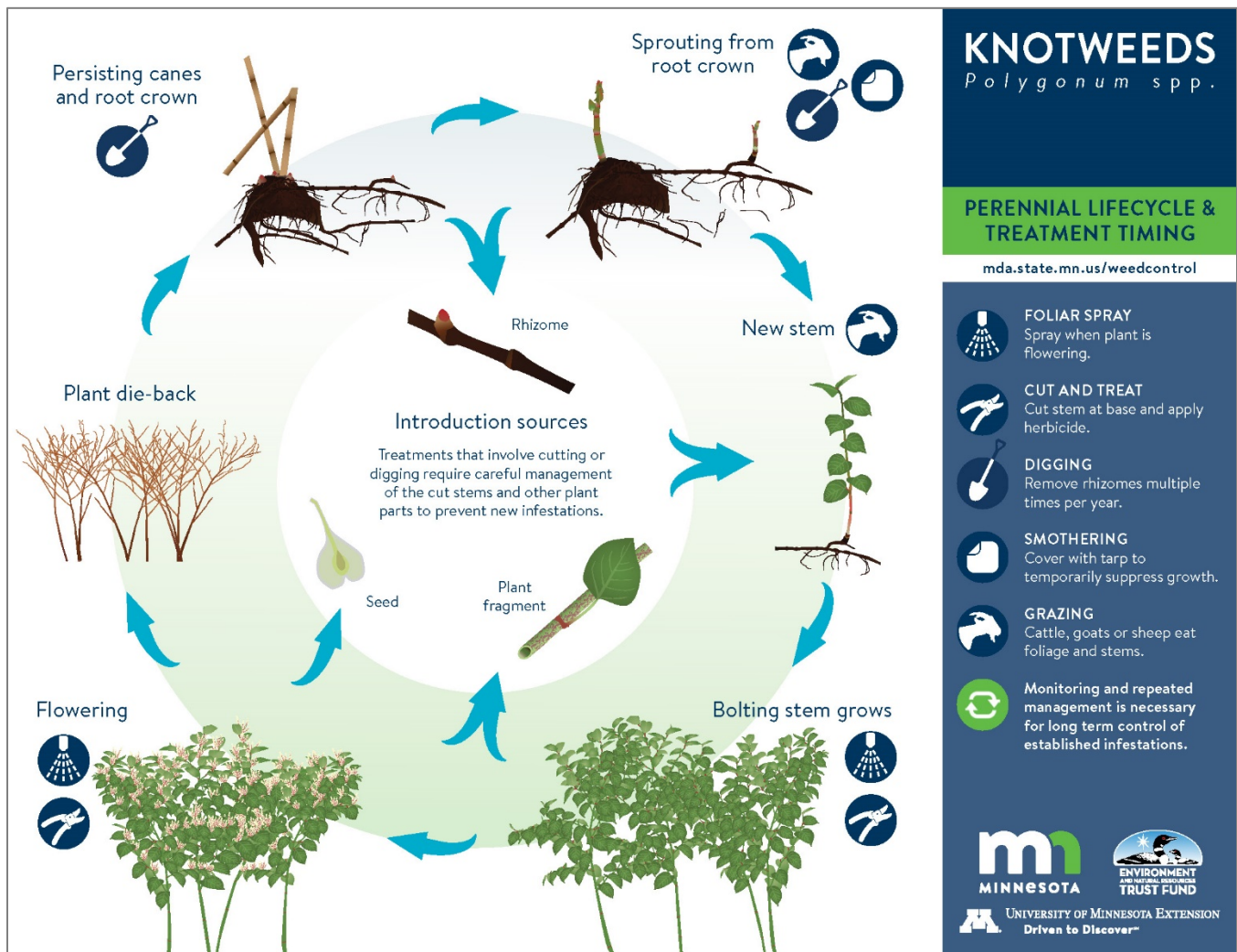
Infestation



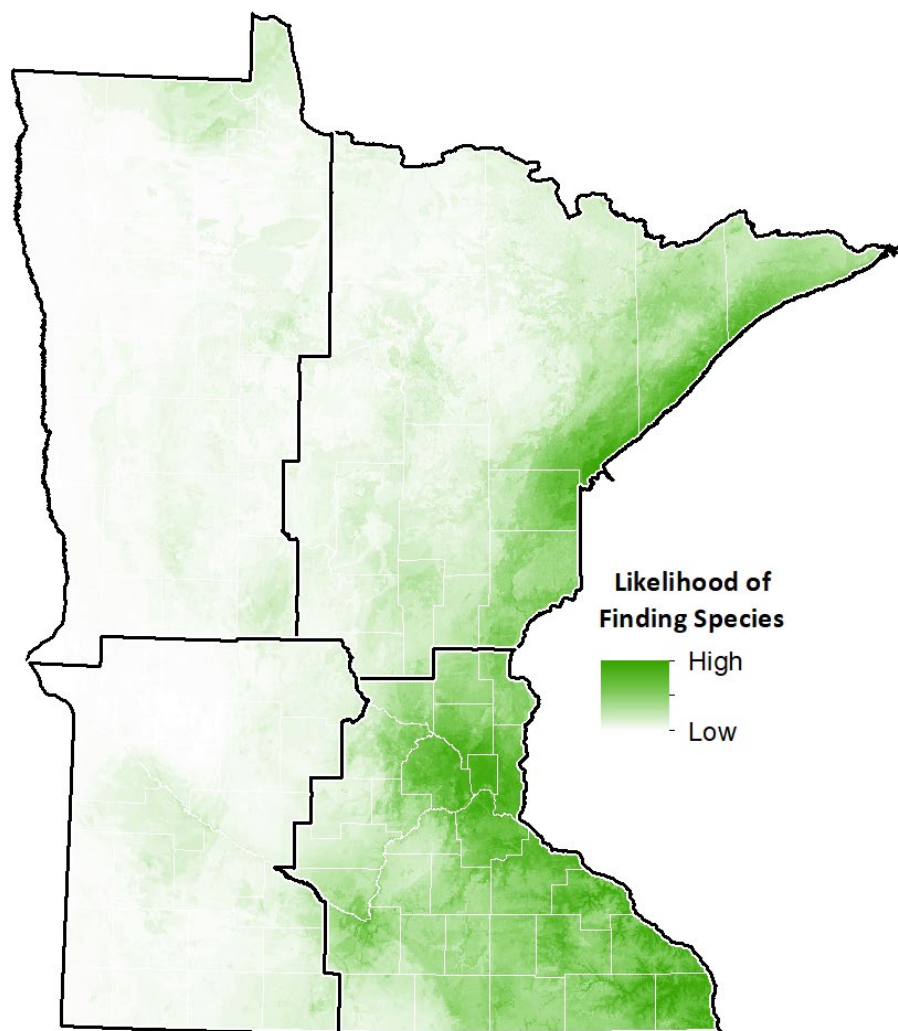
Leaves



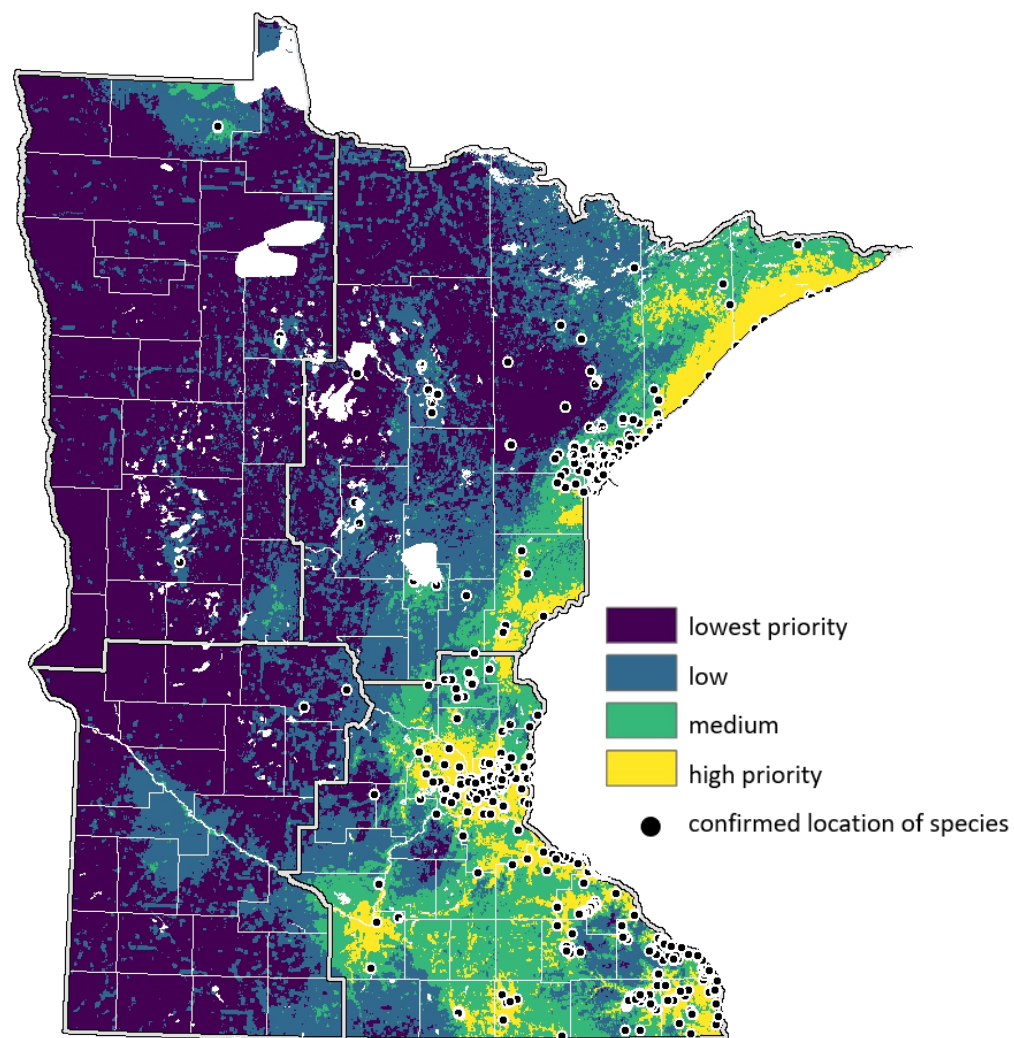
Live (green) and old (red) stems



Knotweeds • *Polygonum* spp.



Current Distribution Model



**Multi-Criteria Decision Analysis
Prioritization Model**

Leafy Spurge • *Euphorbia esula*

Identification: herbaceous perennial plant up to 4 feet tall; leaves opposite, linear with smooth margins and blue-grey; flowers greenish-yellow bloom in early summer; rhizomatous root system; broken stems exude white milky sap.



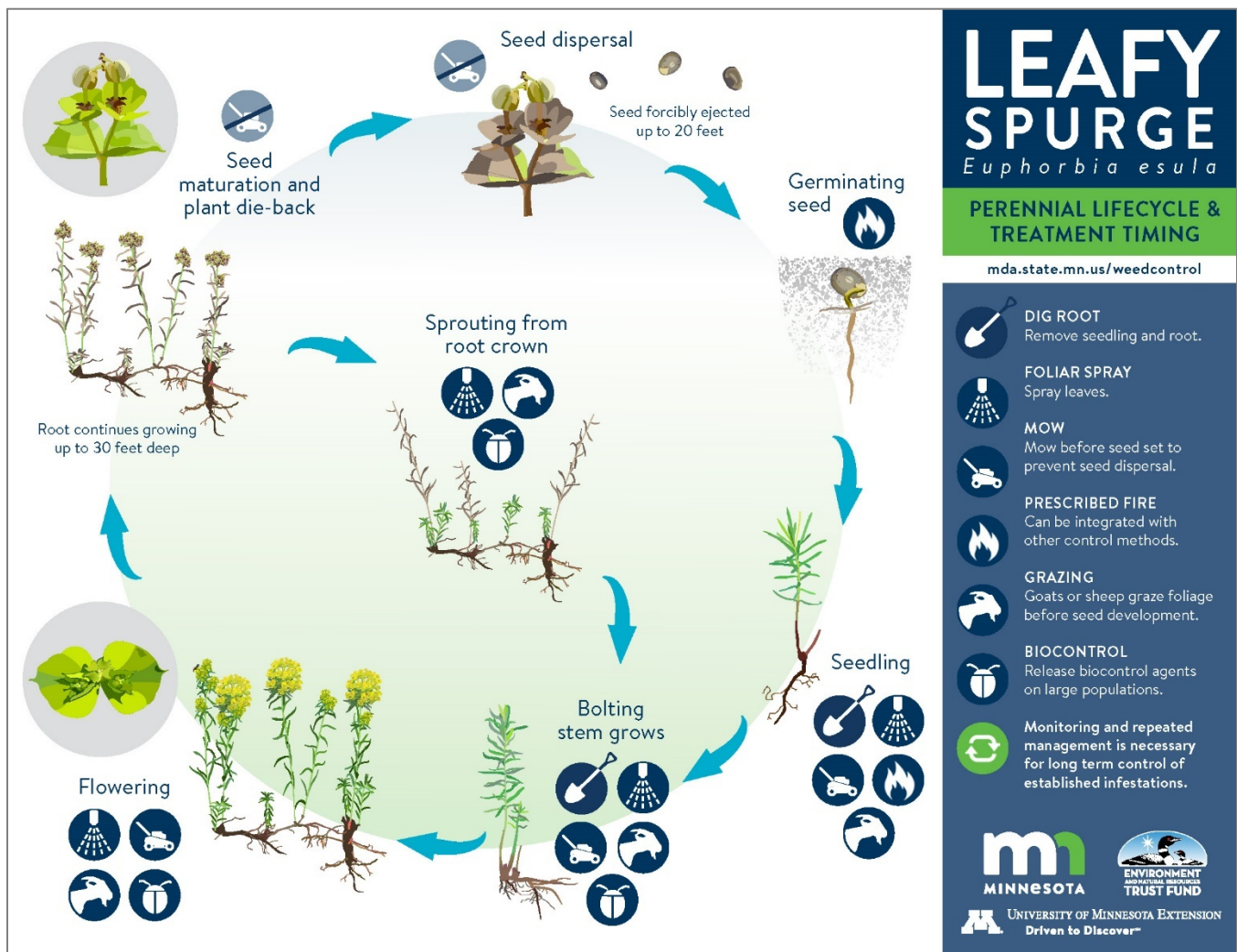
Infestation



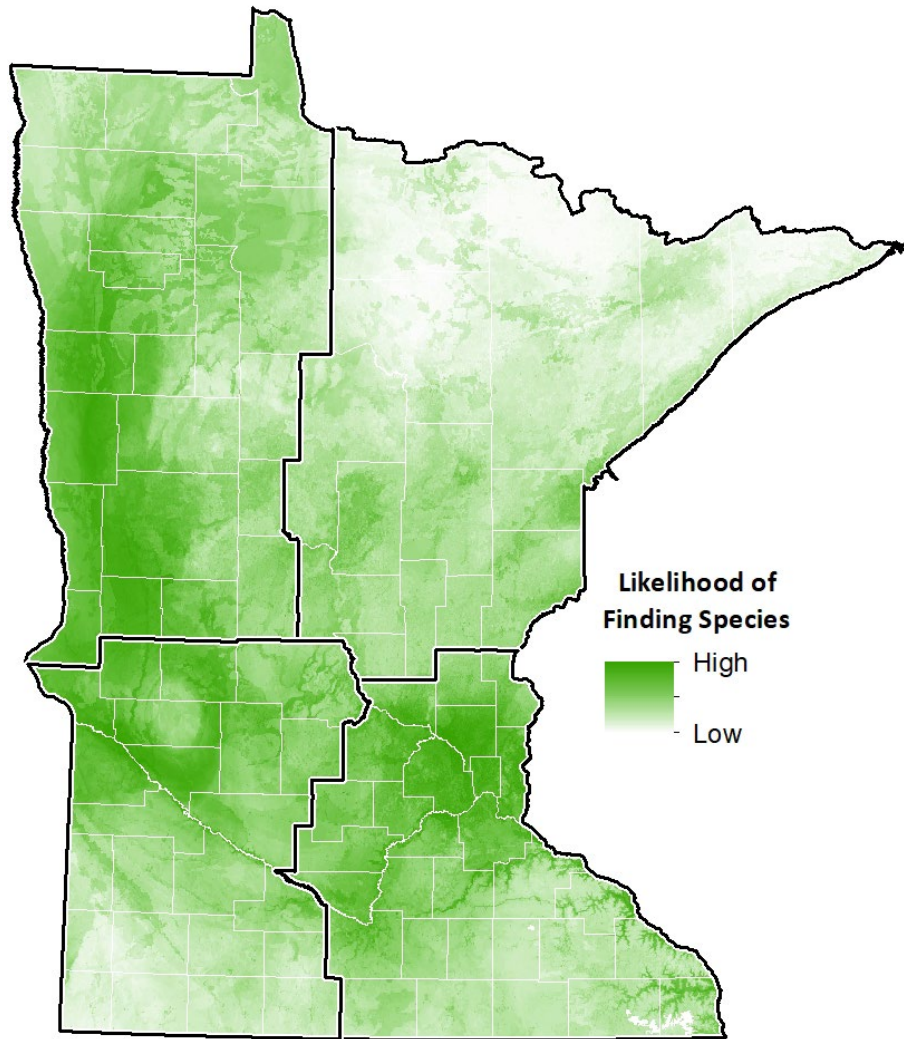
Leaves and rhizome



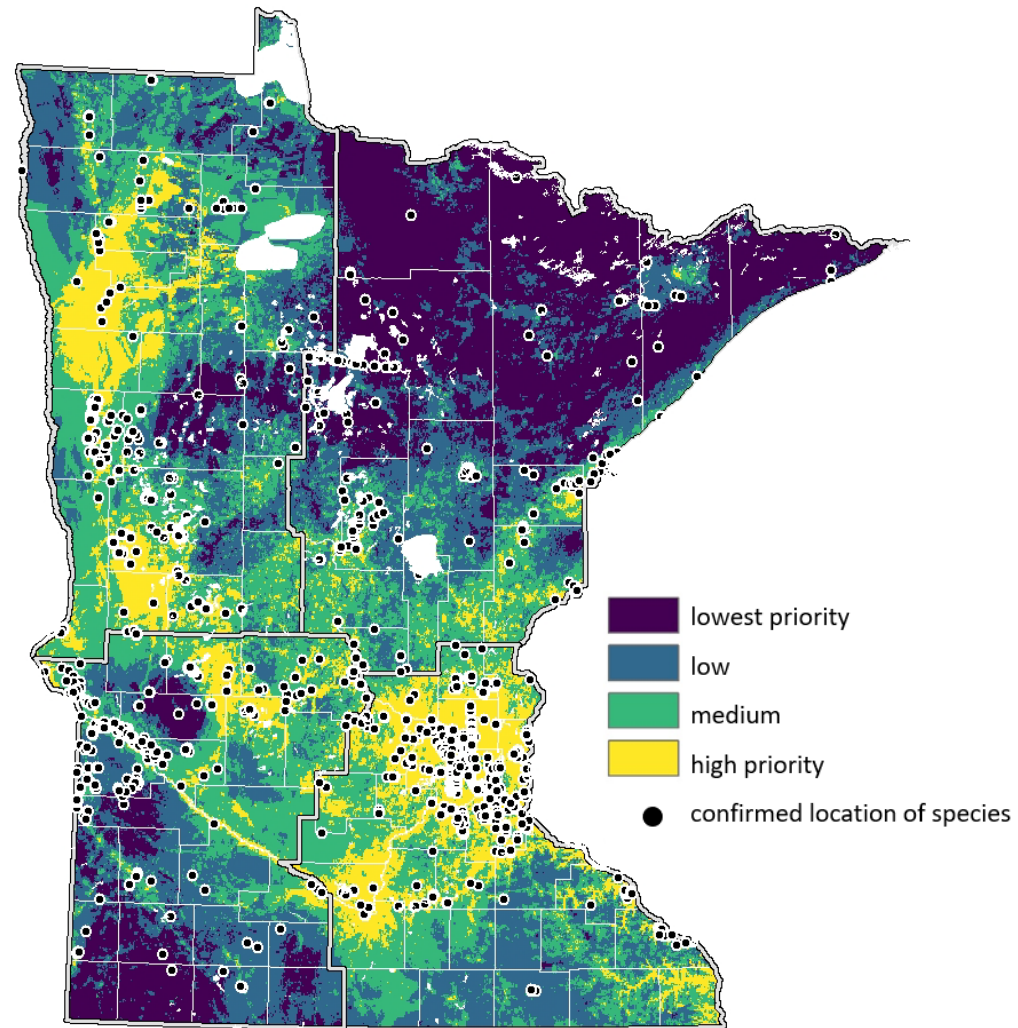
Flowers



Leafy Spurge • *Euphorbia esula*



Current Distribution Model



**Multi-Criteria Decision Analysis
Prioritization Model**

Multiflora Rose • *Rosa multiflora*

Identification: multi-stemmed shrub up to 6 feet; leaves alternate, pinnately compound with 5-11 finely toothed leaflets; flowers white in clusters, bloom in early summer, abundant stamens with yellow anthers; stems contain stiff backward-curved thorns, can tip-root when in contact with soil.



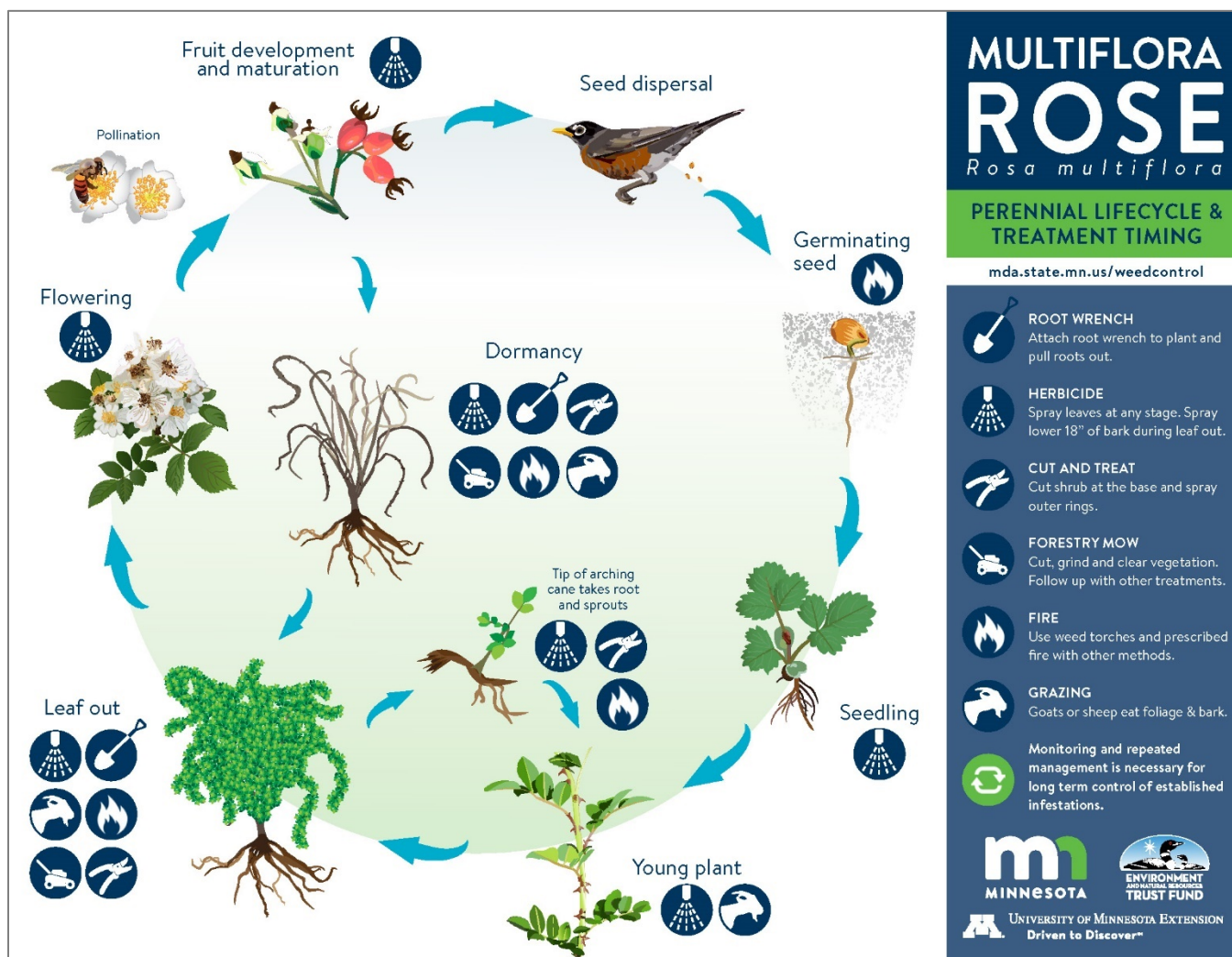
Fringed stipule and thorns



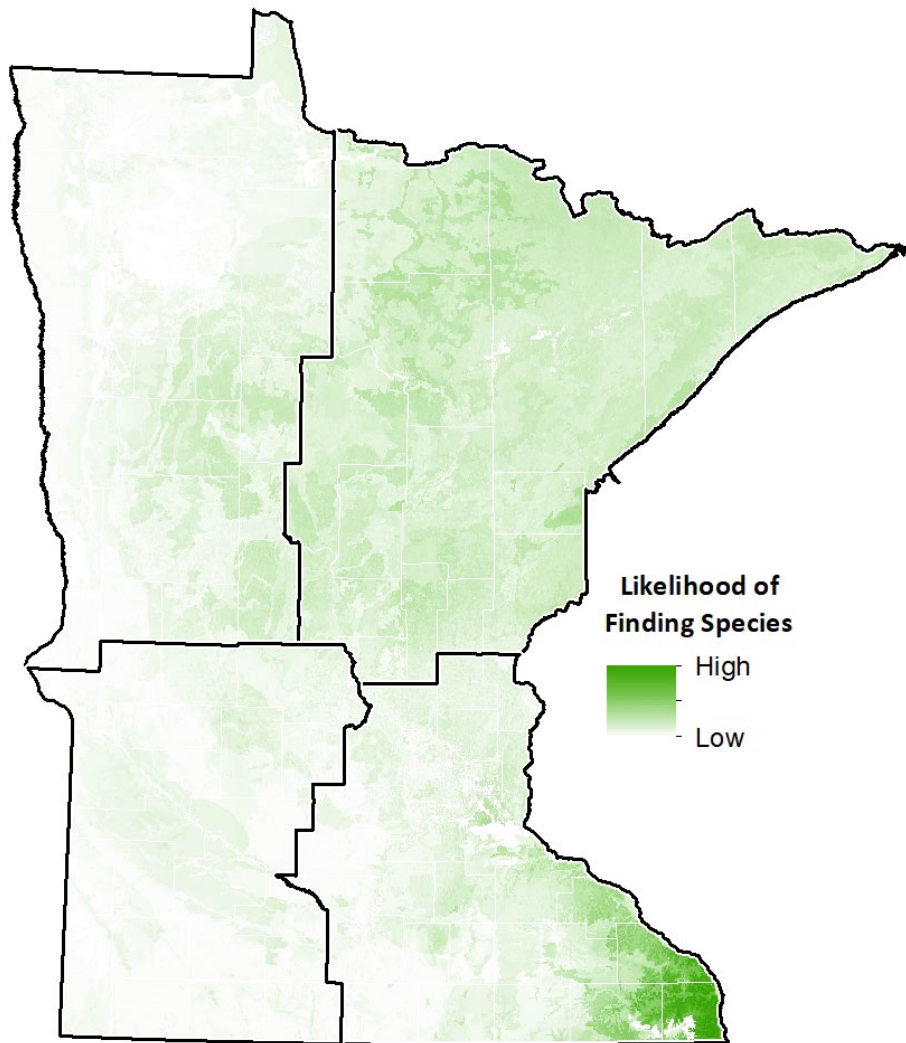
Compound leaves



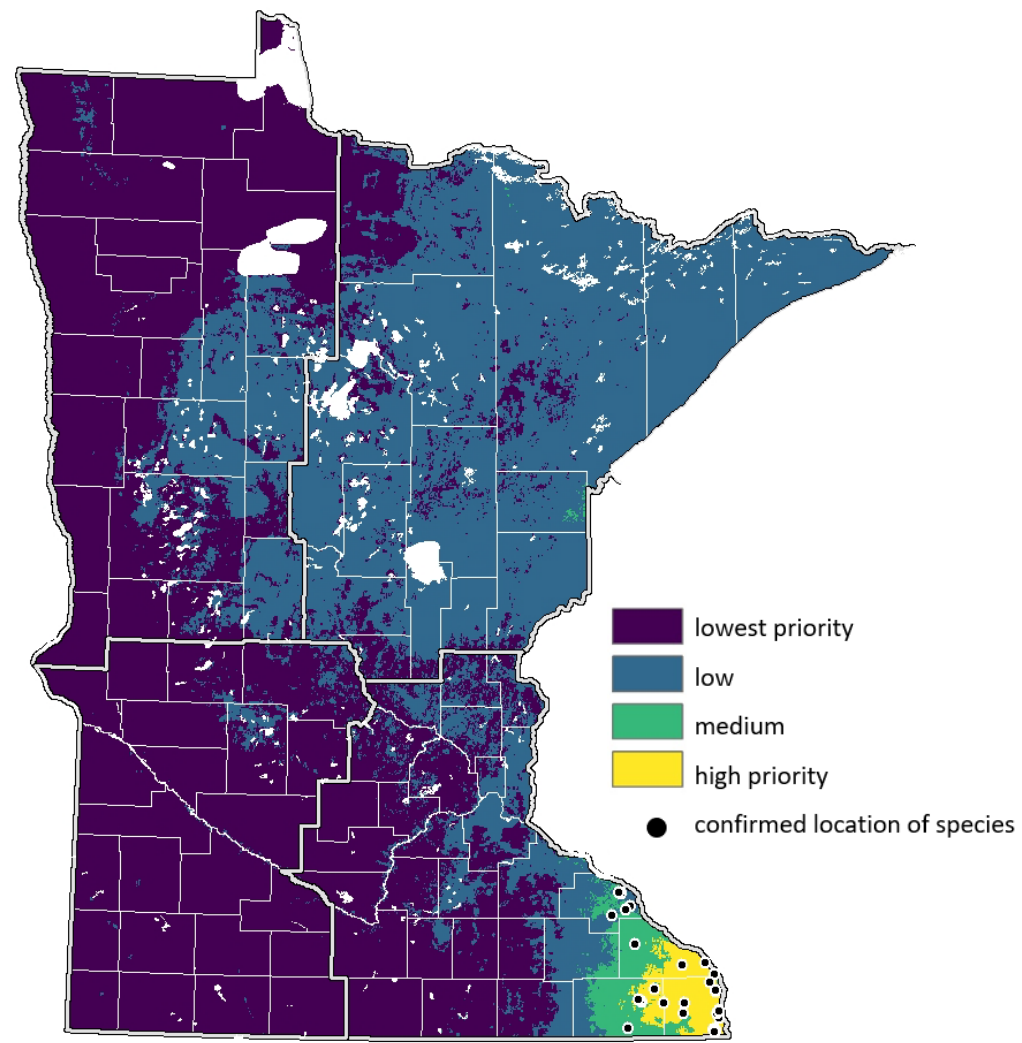
Flowers



Multiflora Rose • *Rosa multiflora*



Current Distribution Model



**Multi-Criteria Decision Analysis
Prioritization Model**

Narrowleaf Bittercress • *Cardamine impatiens*

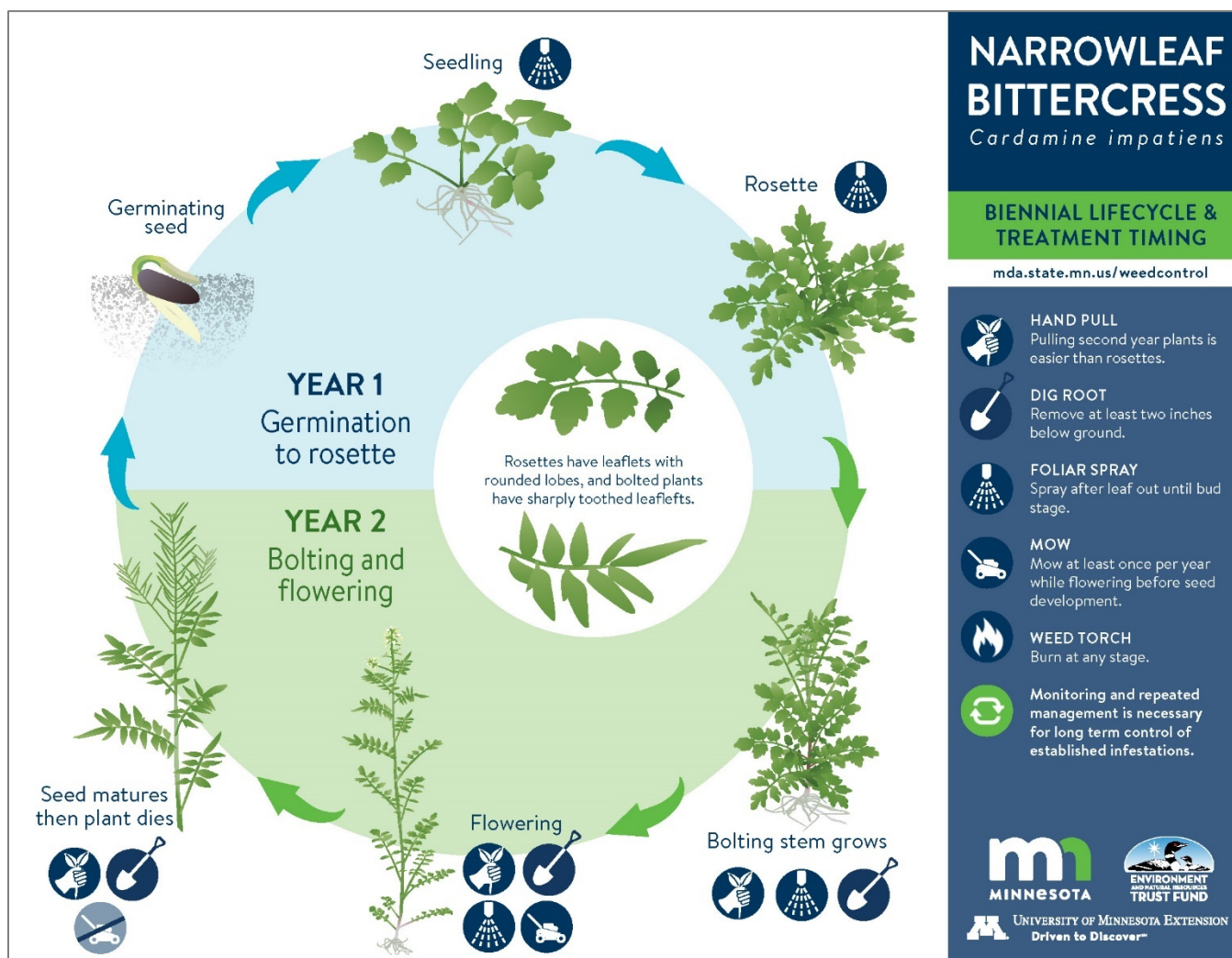
Identification: herbaceous biennial or annual plant up to 31 inches tall; leaves of rosettes compound with 3-11 rounded leaflets, leaves of bolted plants compound with 6-12 sharply toothed leaflets; flowers small, white with four petals, produce slender seed pods in summer.



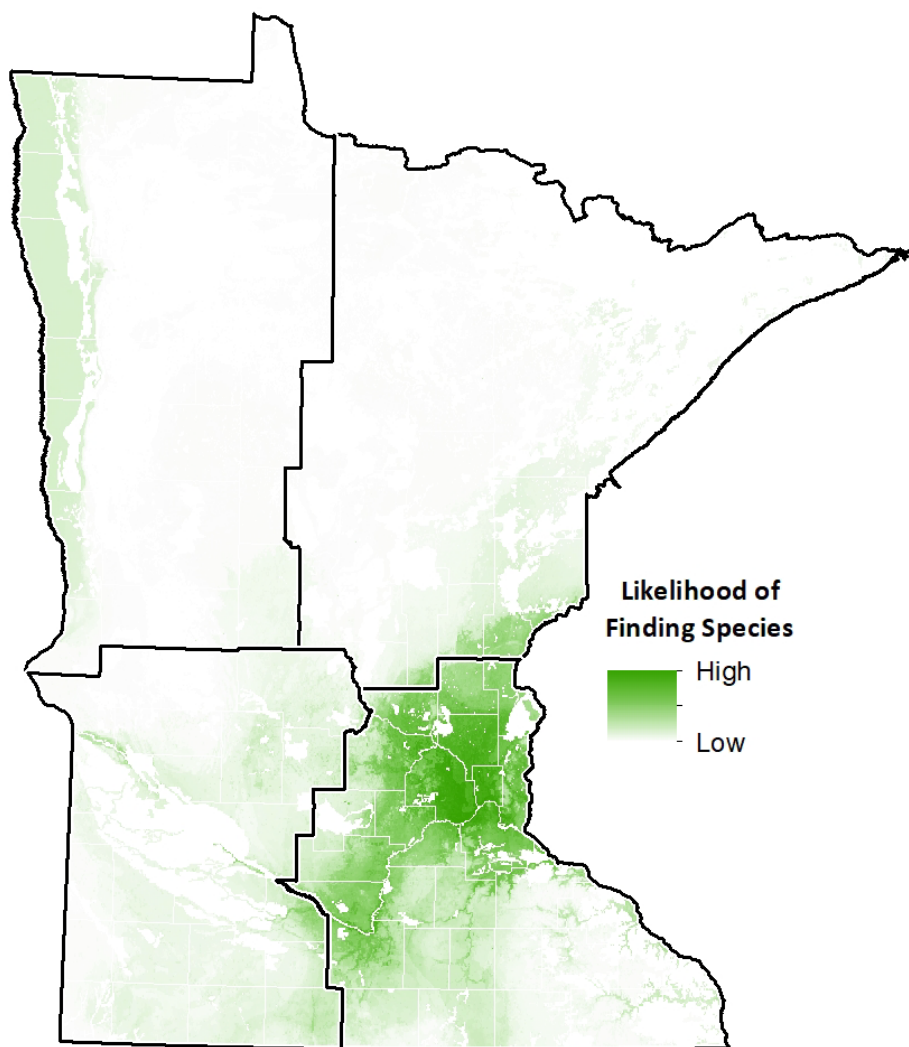
Infestation



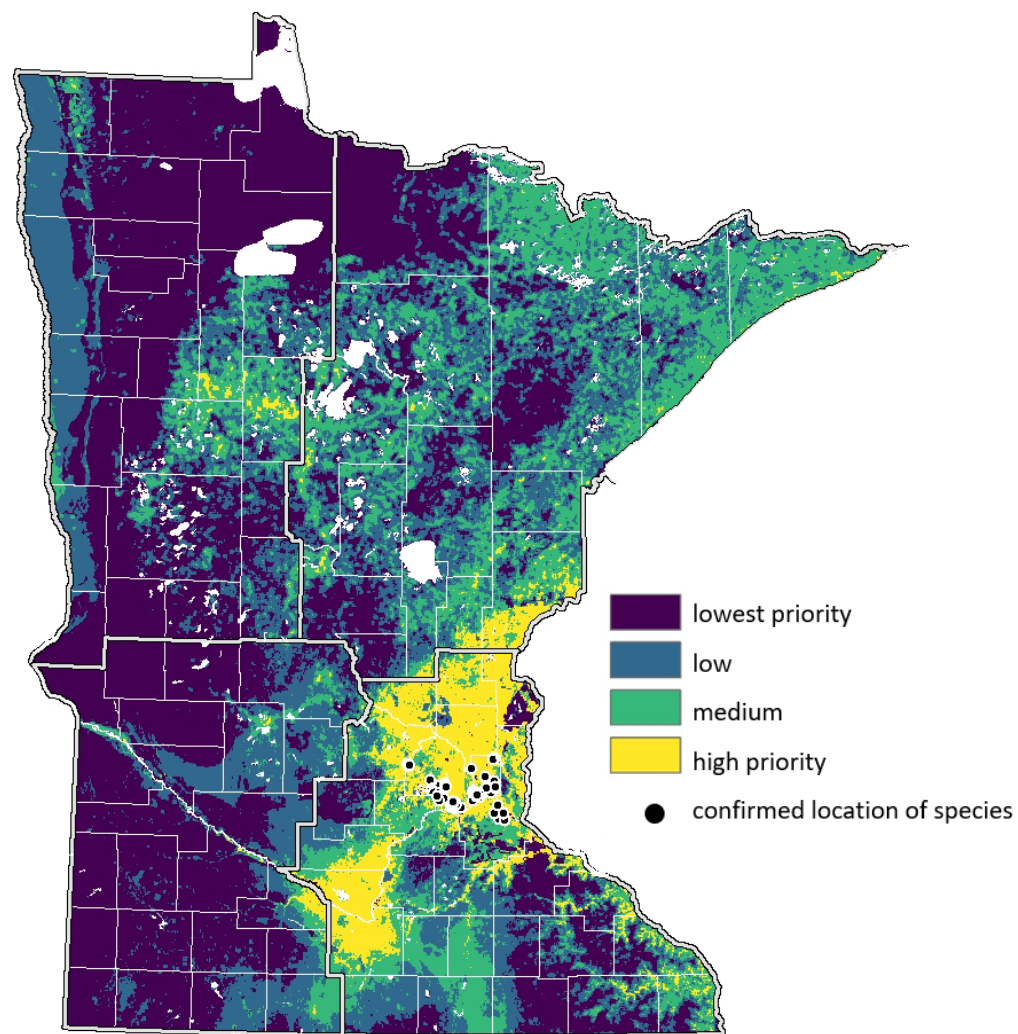
Compound leaves: rosette leaf on left, bolted plant leaf on right



Narrowleaf Bittercress • *Cardamine impatiens*



Current Distribution Model



**Multi-Criteria Decision Analysis
Prioritization Model**

Plumeless Thistle • *Carduus acanthoides*

Identification: herbaceous biennial up to 5 feet tall; leaves alternate, wavy spine-tipped lobes, extend onto stem; flowers purple to pink single or in clusters at end of stems, bloom mid-summer, can be bulbous in shape; stems branched and very spiny.



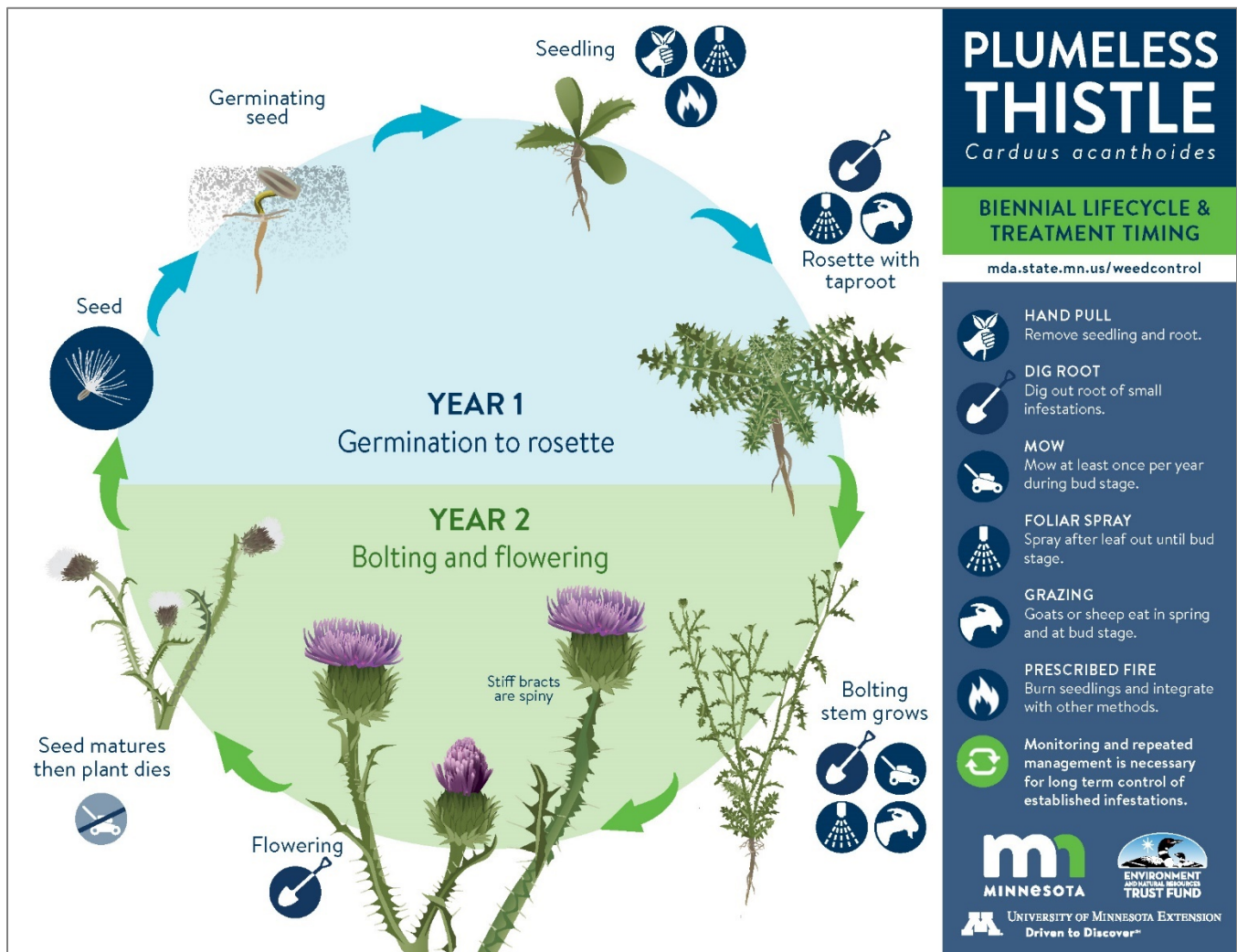
Plant



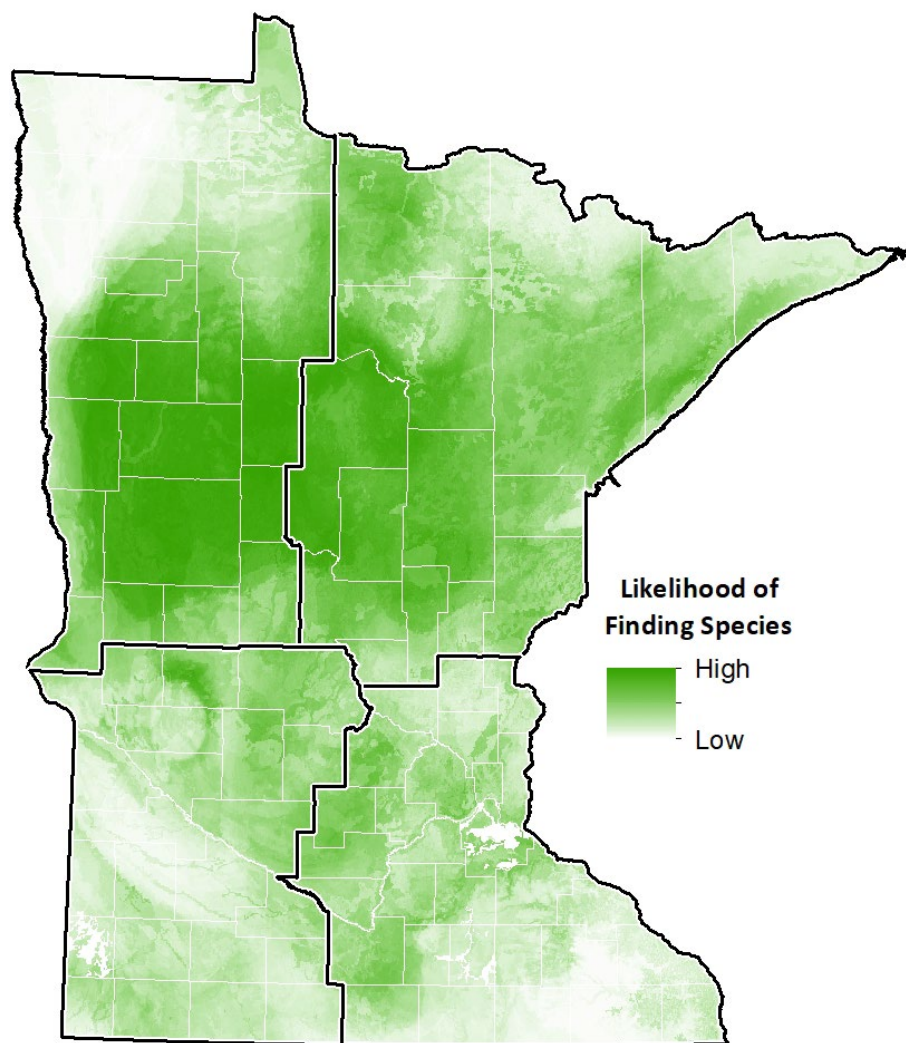
Spiny stems



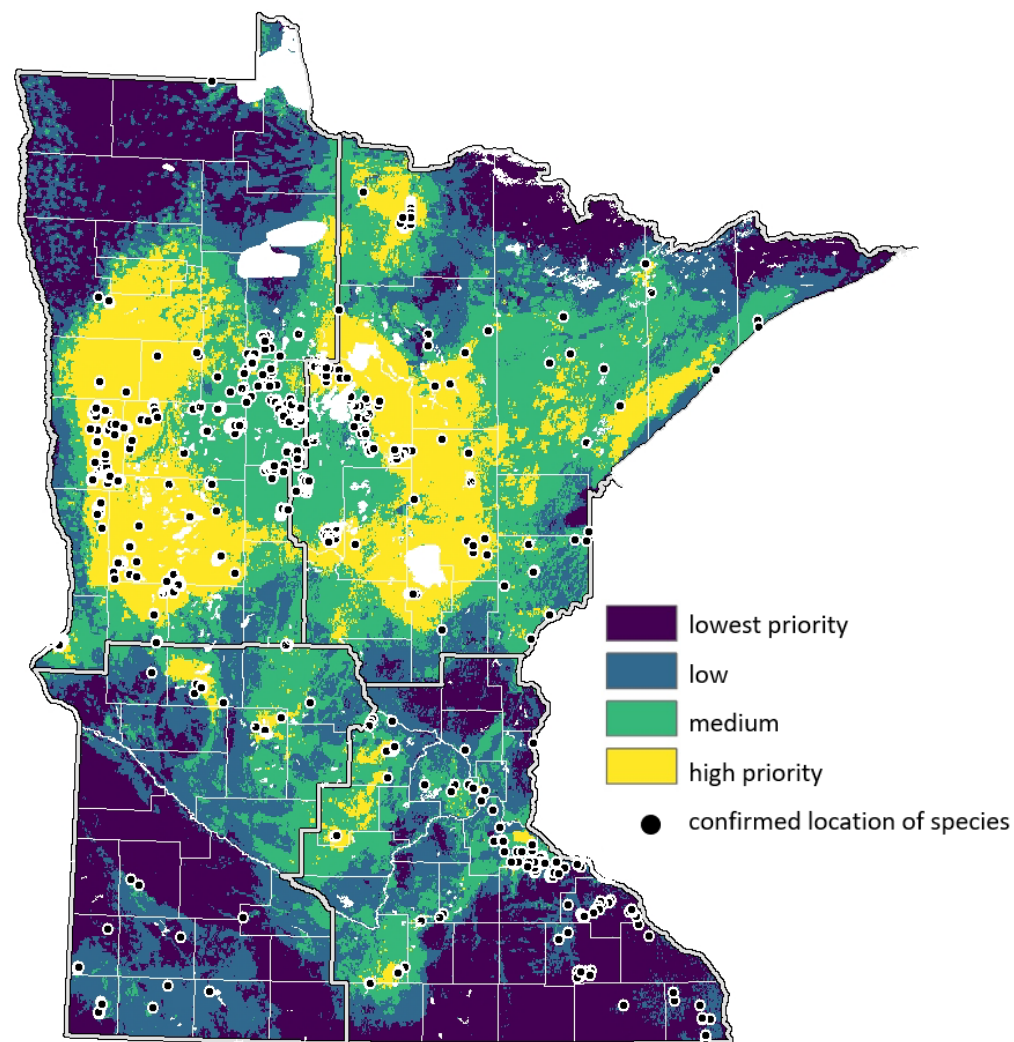
Flower and buds



Plumeless Thistle • *Carduus acanthoides*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Purple Loosestrife • *Lythrum salicaria*

Identification: herbaceous, semi-aquatic perennial plant up to 7 feet tall; leaves slender with smooth margins, in pairs rotated 90 degrees from pair below; flowers purple with 5-7 petals, arranged in spikes, bloom mid-summer through September; robust root systems; stems ridged.



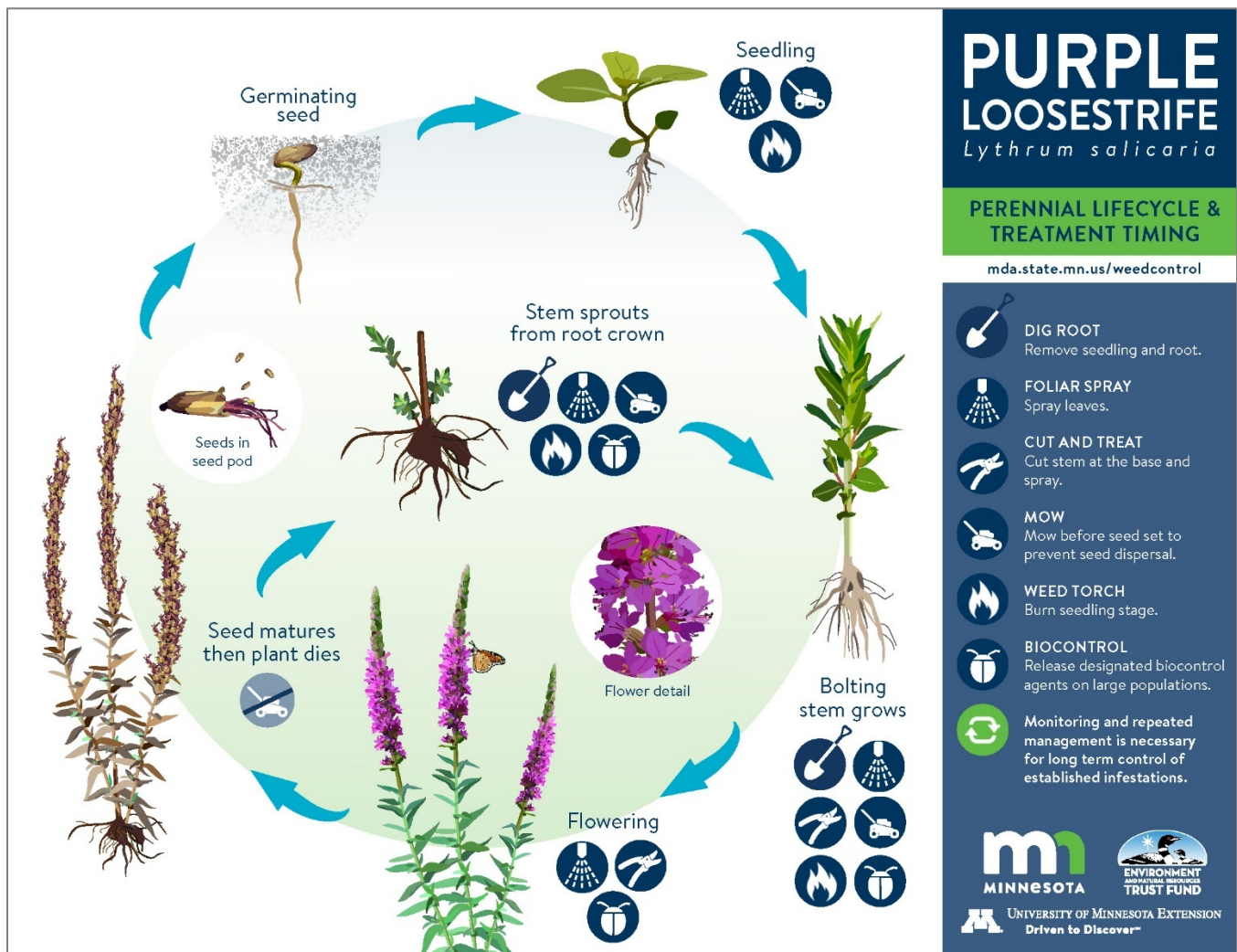
Infestation



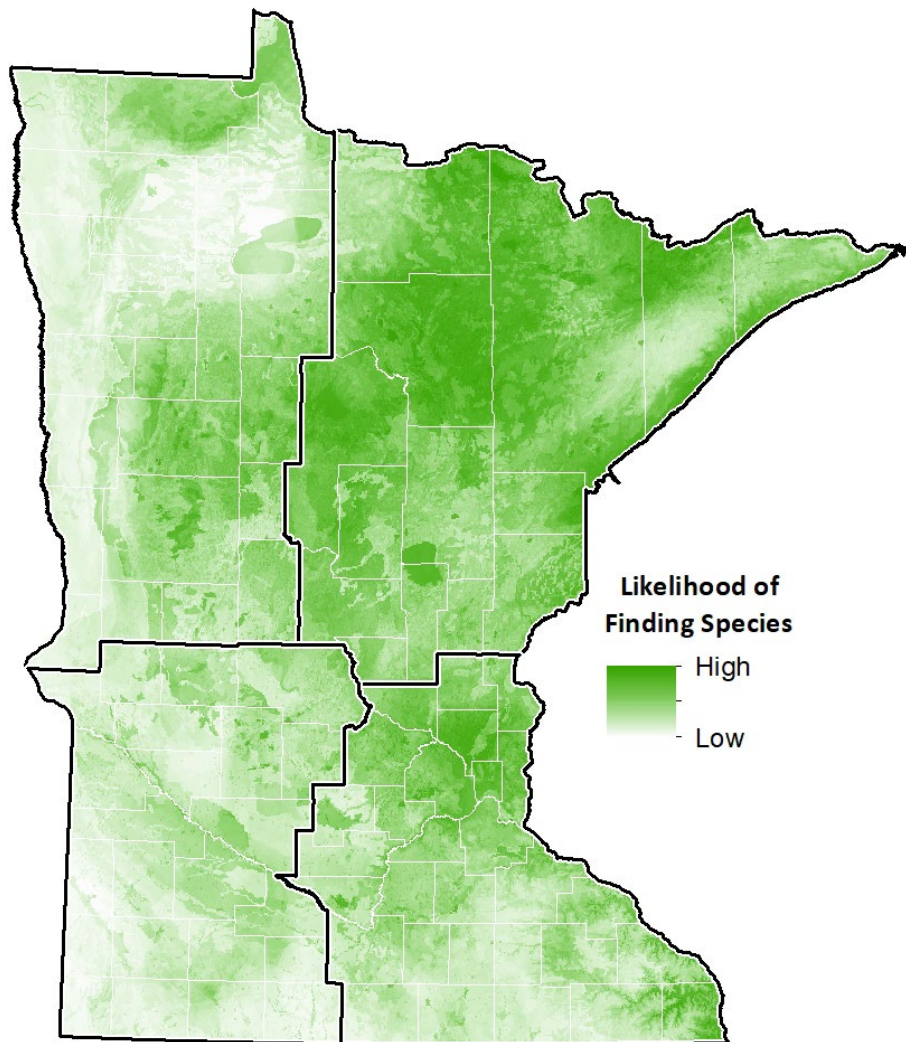
Leaves



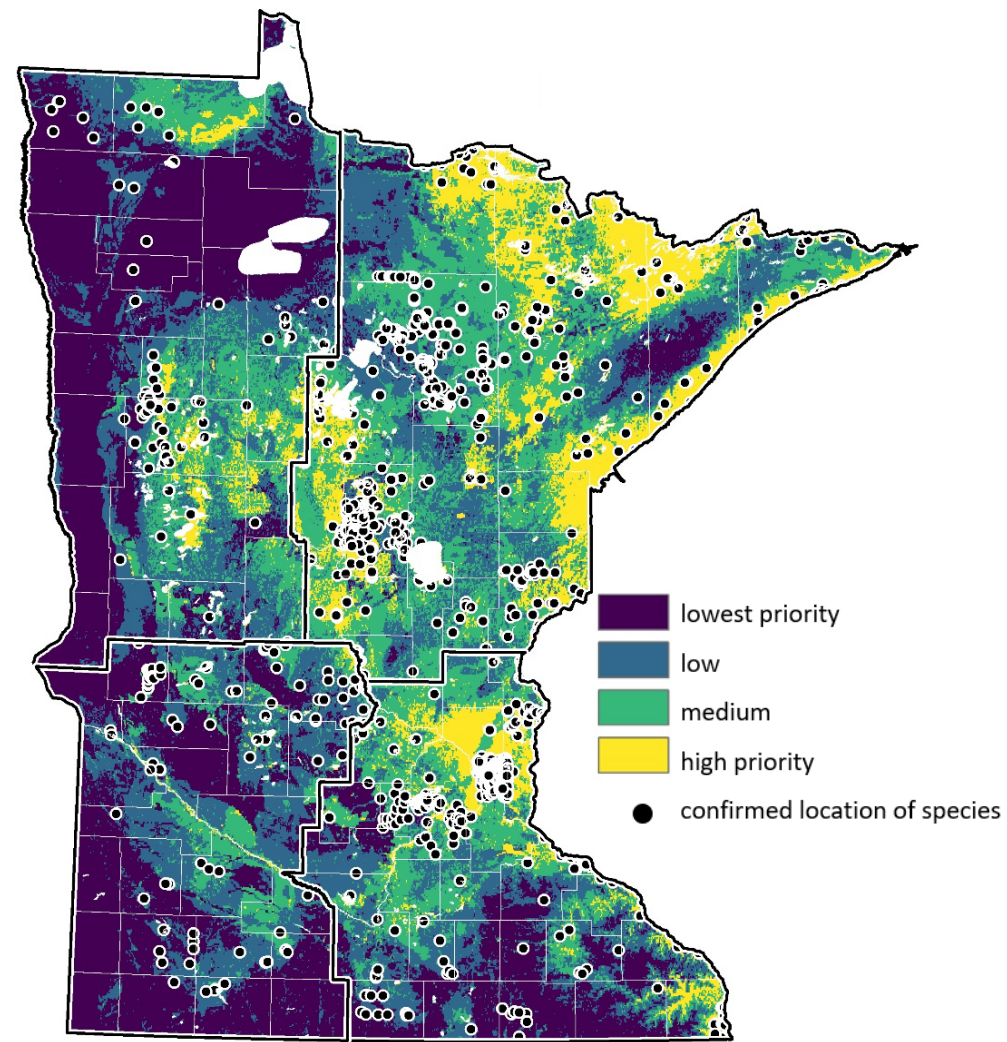
Flower racemes



Purple Loosestrife • *Lythrum salicaria*



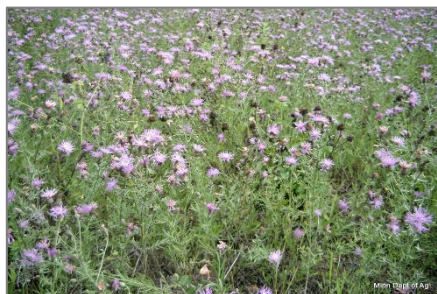
Current Distribution Model



**Multi-Criteria Decision Analysis
Prioritization Model**

Spotted Knapweed • *Centaurea stoebe* ssp. *micranthos*

Identification: herbaceous perennial plant up to 4 feet tall, often growing in clumps; leaves alternate, gray-green, lower leaves deeply lobed upper leaves small and linear; flowers purple to pink in clusters at end of stems, bloom mid-summer, have black-tipped ('spotted') bracts; long tap root.



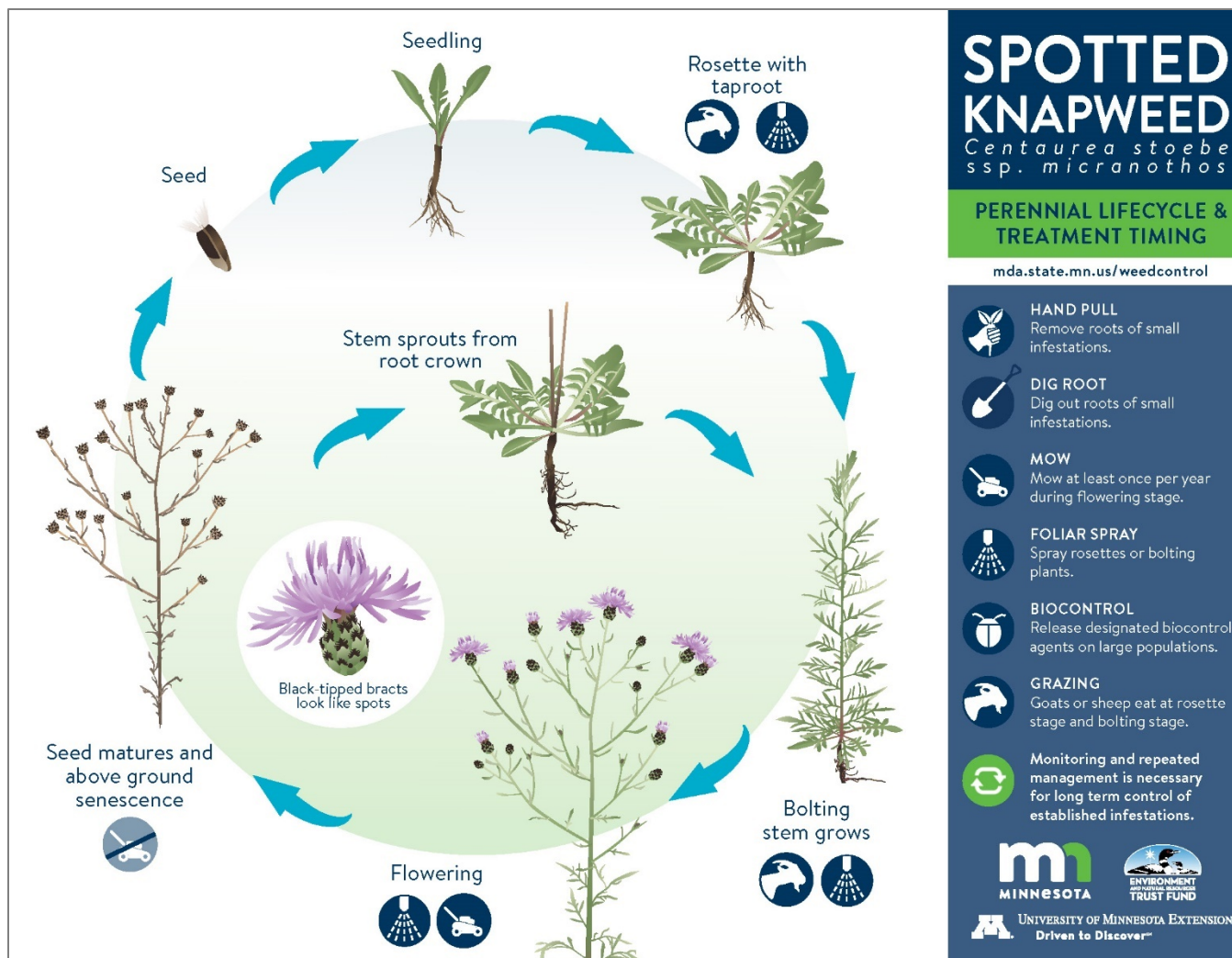
Infestation



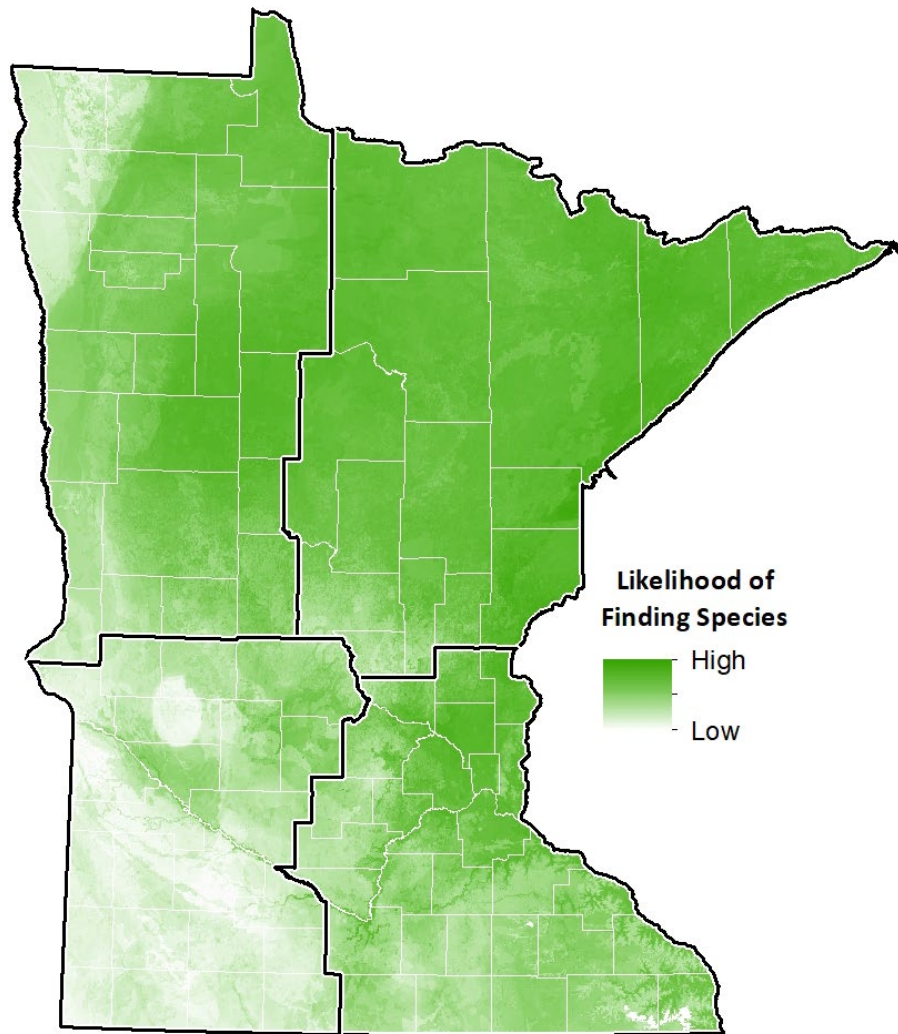
Rosette leaves



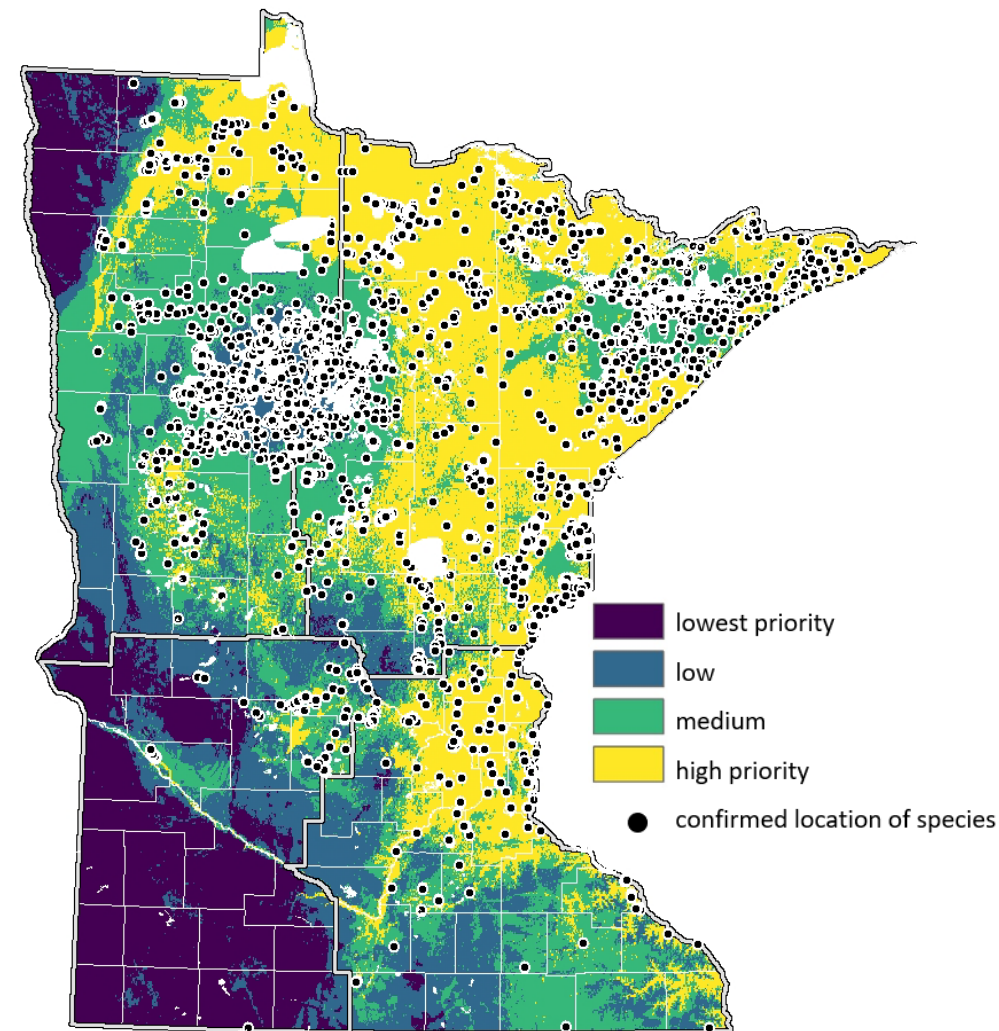
Flower with spotted bracts



Spotted Knapweed • *Centaurea stoebe* ssp. *micranthos*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Wild Parsnip • *Pastinaca sativa*

Identification: herbaceous biennial plant up to 6 feet tall; leaves alternate, compound with saw-toothed leaflets in pairs; flowers yellow, arranged in flat-topped umbels at stem tips, bloom mid-summer; thick taproot; stems ridged, exude sap which may cause phytophotodermatitis on contact with skin.



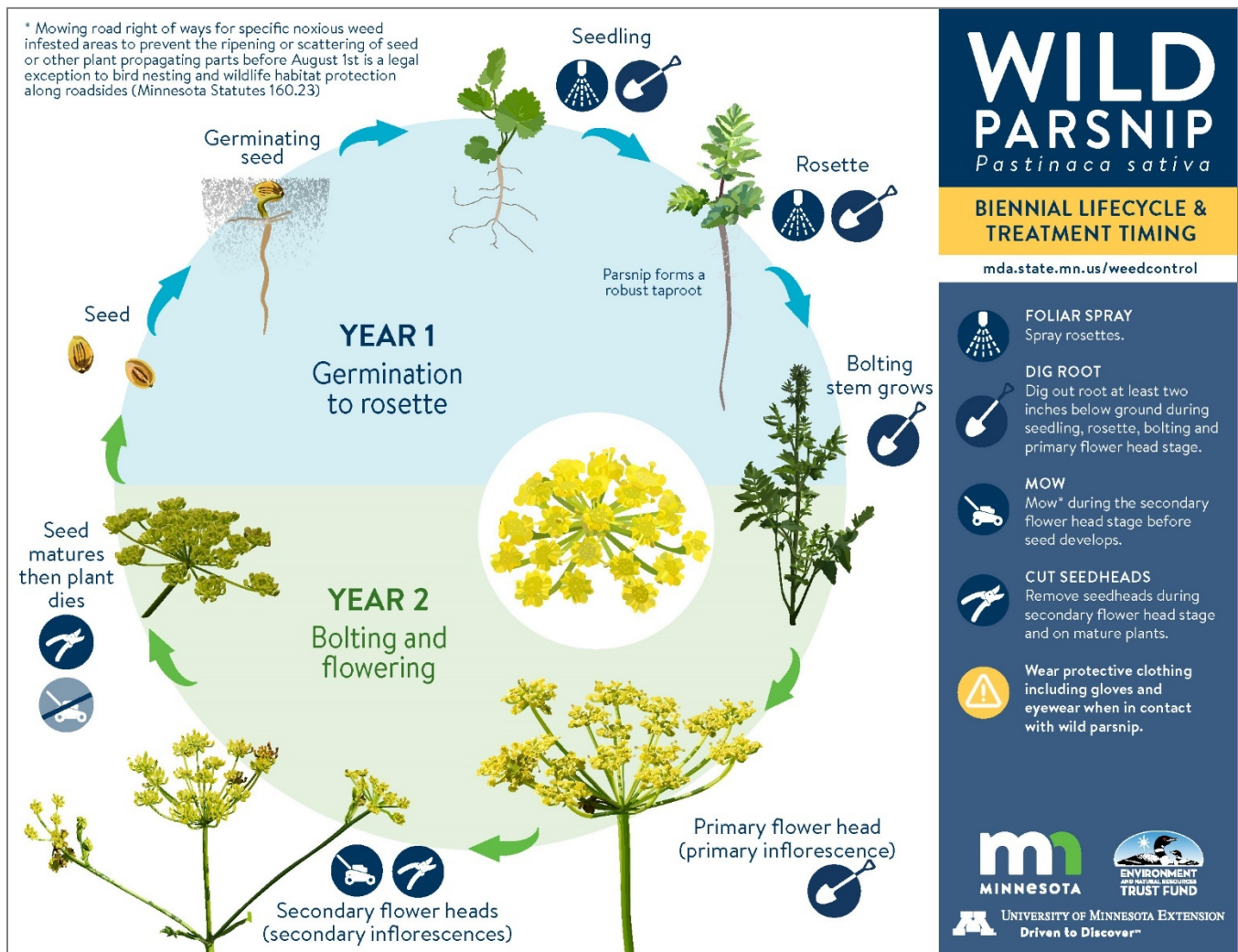
Infestation



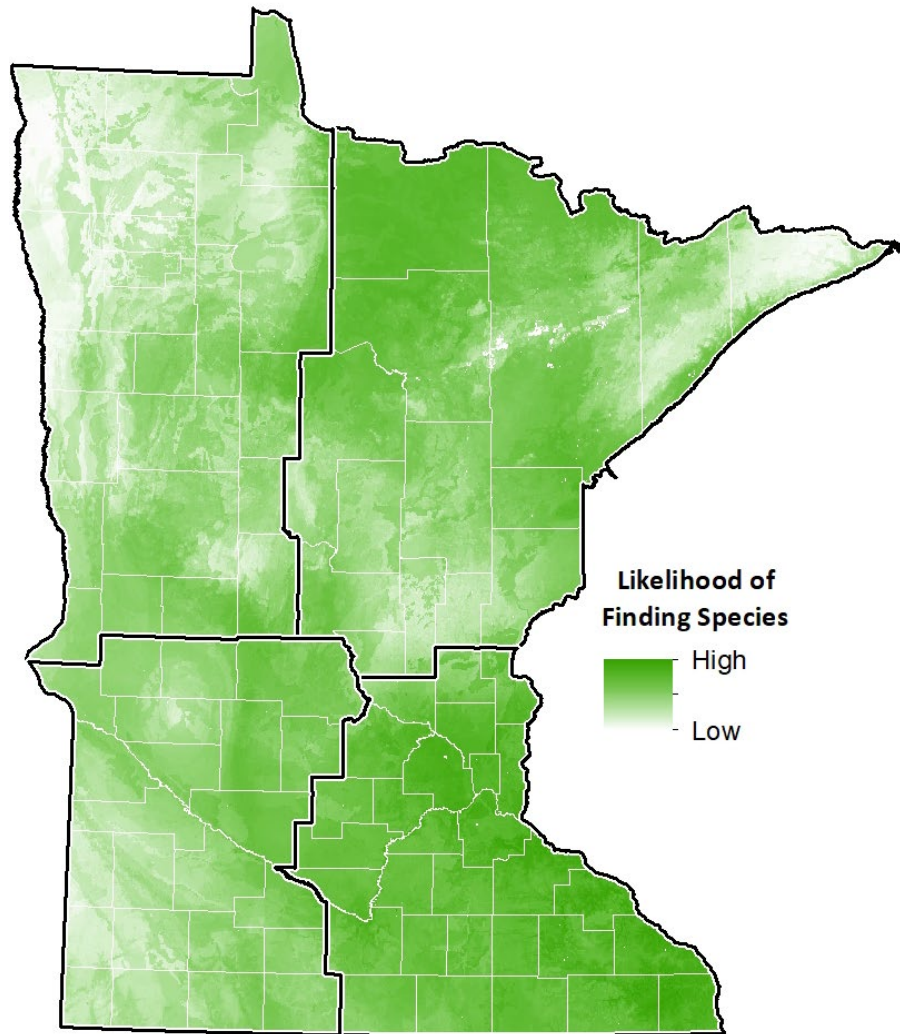
Compound leaves



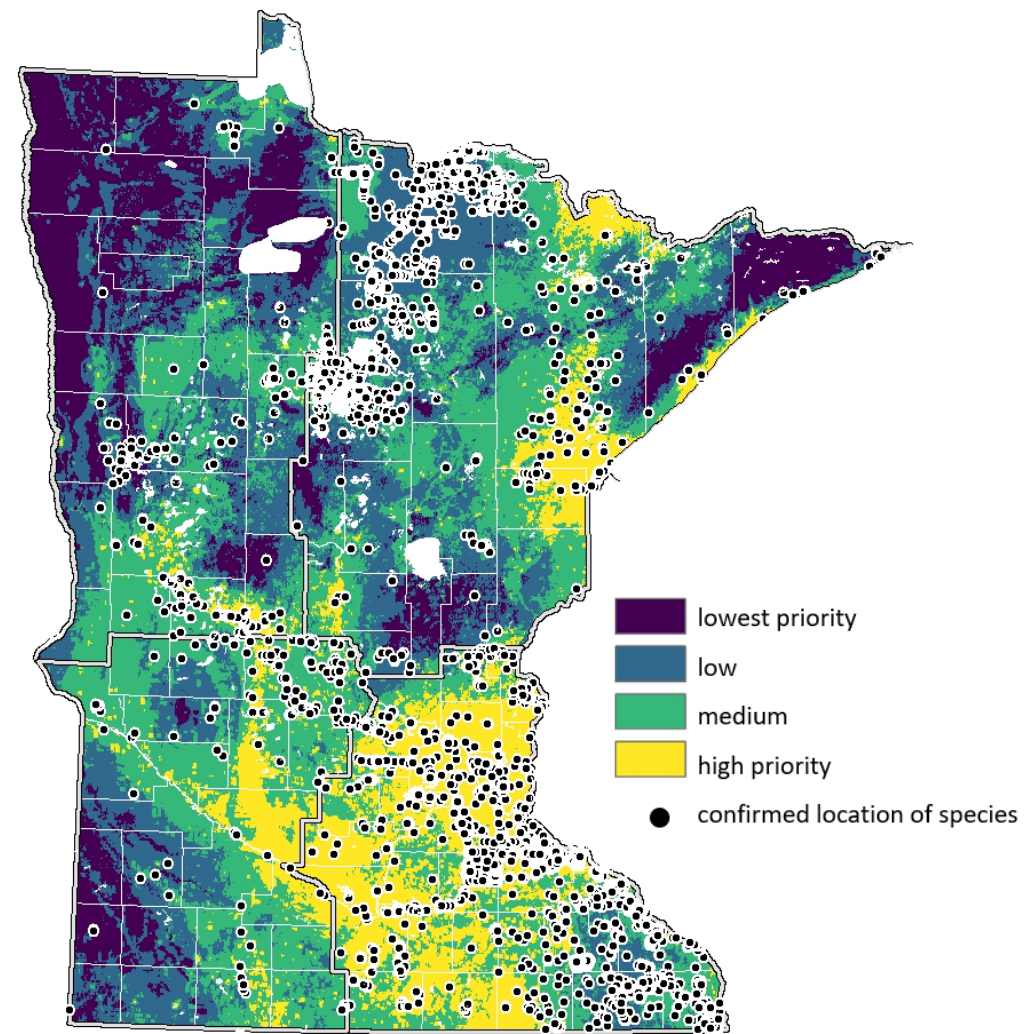
Flower umbel



Wild Parsnip • *Pastinaca sativa*



Current Distribution Model



Multi-Criteria Decision Analysis
Prioritization Model

Identification Resources



Minnesota Department of Agriculture

MDA's website has pages for each of Minnesota's noxious weeds.

Found at: mda.state.mn.us/plants-insects/minnesota-noxious-weed-list

Minnesota Noxious Weeds

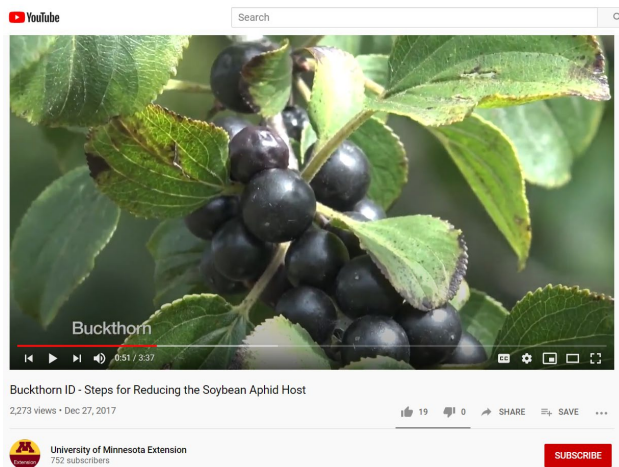
Includes Native and Nonnative Look-alike Species for Comparison



Minnesota Department of Transportation

MnDOT's Noxious Weed book includes identification information and photographs, and information on management strategies and timing.

Found at: dot.state.mn.us/roadsides/vegetation/pdf/noxiousweeds.pdf



University of Minnesota Extension

Extension has produced a variety of videos covering identification, management, and impact.

Found at: youtube.com/user/UofMNEExt/videos



Minnesota Department of Natural Resources

The DNR provides information for noxious weeds and additional invasive plants including native substitute species.

Found at: mndnr.gov/invasive-plants



Minnesota Wildflowers

This website and accompanying mobile app provide identification information on most plant species in Minnesota, native and invasive.

Found at: minnesotawildflowers.info

Data Collection and Tracking

EDDMapS

EDDMapS (Early Detection and Distribution Mapping System) is a “web-based mapping system for documenting invasive species” and includes a mobile app for field reporting.

Using a unified mapping system across agencies allows for better collaboration and efficiency of communication.

For more information: eddmaps.org



ISM Track

ISM Track (Invasive Species Management Tracking System) connects to distribution data from EDDMapS and allows land managers to report management activities, tracking infestation size, abundance, and information over time.

For more information: ismtrack.org



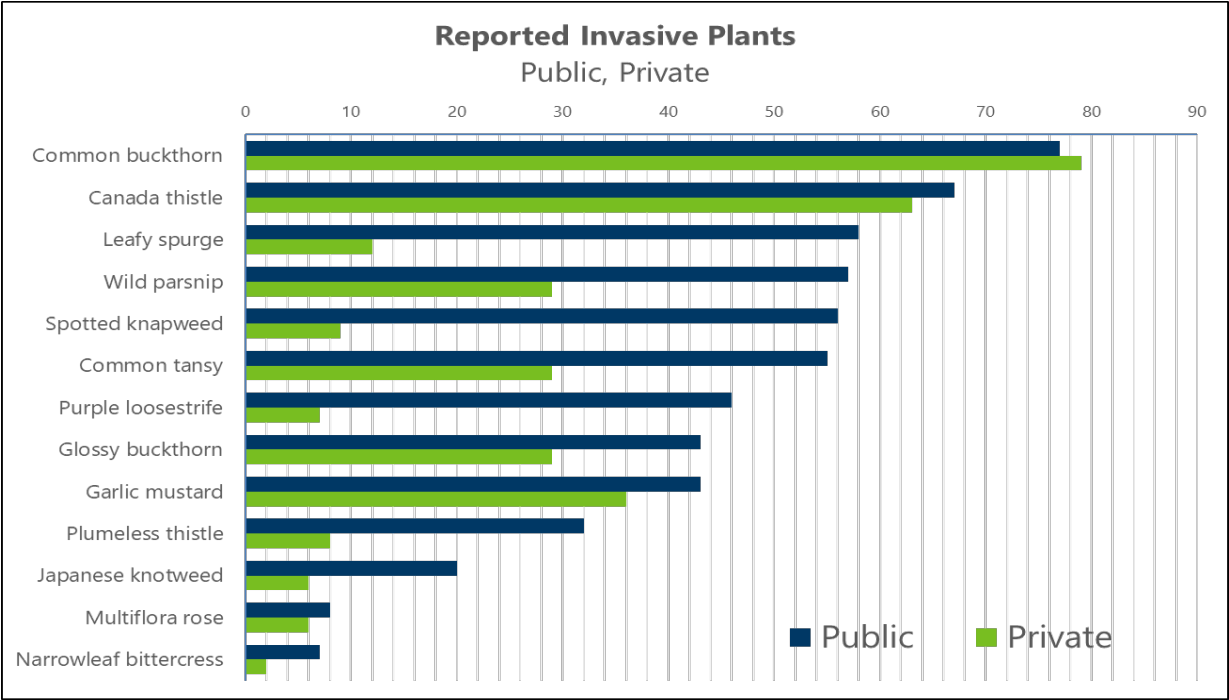
Methodology



Survey of Land Managers

Prior to this project there were relatively few datasets regarding species-specific concerns, costs, and management efforts addressing invasive plant-related problems in Minnesota. As a part of this project, a questionnaire was developed and delivered it to private landowners, stakeholders, and land managers. The questionnaire, which received responses from 249 individuals, asked a series of questions regarding this project’s thirteen invasive plants. Respondents shared their concerns, cost information, and information regarding recent and planned management efforts for these invasive plants.

Frequently cited concerns varied considerably by species and type of respondent, but broadly included the potential impacts of invasive plants on conservation and ecology, forest regeneration, and recreation. Reported costs and management approaches varied depending on respondent type (private landowner or public lands professional), with public land professionals generally more willing and able to implement more expensive management approaches than private landowners. The broad results and data from this survey may be of interest to a number of researchers and natural resource professionals, as it provides some foundational context for further analyses.



Survey respondents indicated which invasive plants species are on property they manage.

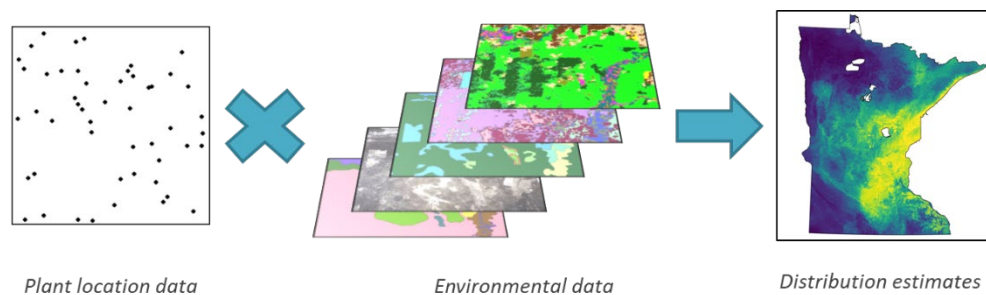
View the full report containing more detailed information on the survey results:

<https://conservancy.umn.edu/handle/11299/216295>

Distribution Mapping

One of the most useful tools in region-wide management planning are continuous distribution maps for a wide area. Predicted current distribution model maps were created using current distribution data from EDDMapS and the USDA Forest Service Forest Inventory and Analysis, alongside a variety of environmental data sets including soil, topography, climate data.

These maps allow us to identify ‘hot spots’ where a species has been documented to exist and isolated pockets of potential presence based on suitable habitat for that species. They also provide a foundation for which statewide ecologic and economic analysis can be built.



Hear the expert explain the modeling and process:

<https://youtu.be/iVL-6kPHy5k>

Spatial bias was mitigated by allowing one-occurrence per cell using a 900 m² grid. Distribution models were computed using a random forests approach which is a machine learning analytical tool based on decision tree analysis, frequently used in predictive modeling efforts. Background points were generated proportionally to occurrence points for each species. Prior to the final analyses, model selection was conducted for each species using an iterative parsimony-based approach allowing for the selection of the most parsimonious models, while not sacrificing model performance. This process allowed for simplification of the models. Final model performance was assessed using the internal random forest performance estimates produced from out-of-bag samples, as well as a separate 70:30, training:testing, data split. Performance was assessed using Cohen’s kappa (κ), positive predictive values, correlation coefficients, and the area under the receiver operating characteristic curve (AUC). All processing and analyses were completed in R (v 3.6.1).

Using these models, continuous distribution estimate maps were produced for Minnesota for each invasive plant species. These maps illustrate the relative likelihood of occurrence for a species at any given location within the state.

Download Distribution Map Models for all 13 invasive plants:

<https://doi.org/10.13020/bgg5-kk86>

Economic analysis

Cost estimates for management of noxious weeds were compiled and literature was reviewed for data on economic impacts of the presence of the noxious weeds. From there, an economic optimization model was developed to select the treatment (management strategy) that maximizes the net benefit/acre of any particular location passed on land use, the presence and density of each weed, and the costs of alternative treatments. The model allows for the user to indicate a limited budget and suggests a breakdown of land-use types and species to manage for maximum economic benefit.

Hear the expert explain the economic analysis process and results:

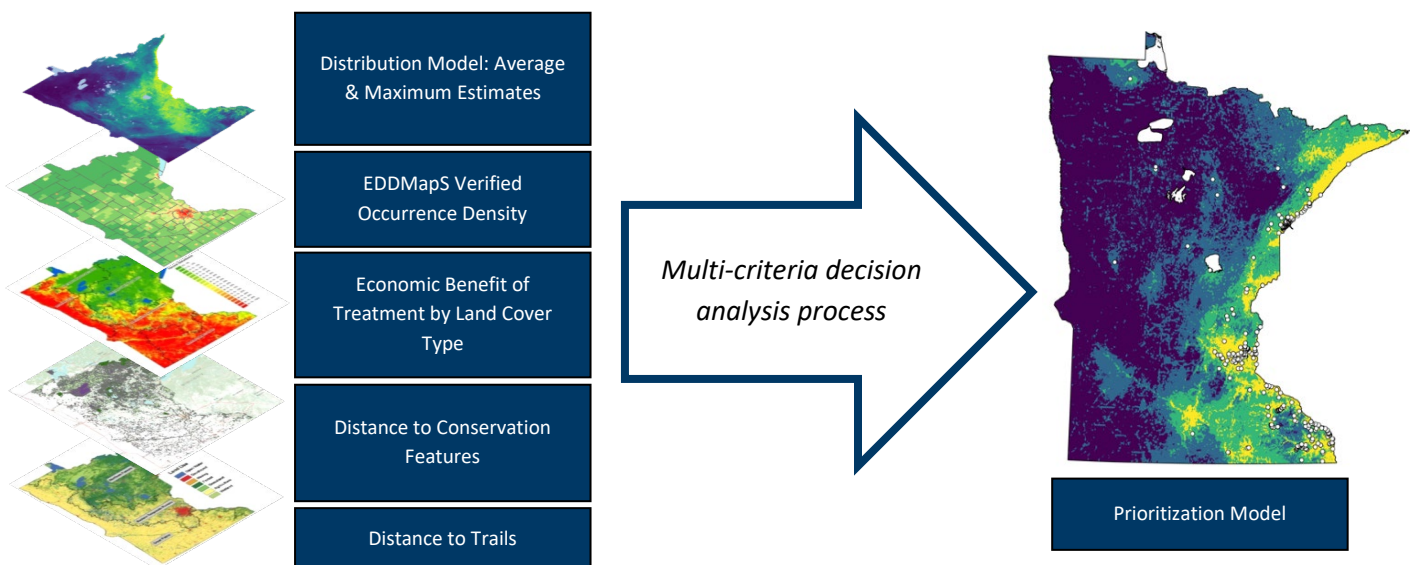
<https://youtu.be/0cAo1CjoQxM>

Multi-criteria decision analysis

An analytical tool and mapping product tying multiple components of the Tactical Plan Project together was desired. Multi-criteria decision analysis (MCDA) aggregates information from multiple different factors, concerns, or criteria in order to make a single decision support tool and is capable of handling spatial data. Combining input from economic analyses, distribution estimates, known occurrences, proximity to conservation features, and proximity to recreational trails into a single prioritization would provide useful context to planning efforts.

The distribution modeling and economic analysis are useful in and of themselves, but it's also possible to consider them together. Multi-criteria decision analysis, or MCDA, allows us to consider multiple relevant factors at once linking them together and creating a single output. In this project, MCDA links the economic analysis and ecological distribution models with other data producing a state-wide management prioritization output for each species.

The data and factors considered included five main categories: distribution model estimates, verified occurrence density, economic benefit of treatment or management, proximity to conservation features and proximity to recreational trails. All of these inputs were considered for each species and a single state-wide output was created for each of the 13 species in the project, and therefore priorities vary for each species.



Hear the expert explain the process:

<https://youtu.be/Wddwpj7ZEFk>

The analytical hierarchy process (AHP) was used to weight each factor included in the MCDA. This process involves creating relative priority rankings for every possible pairwise combination of factors, which results in a final priority matrix. Computing the right-eigenvectors of this matrix provides a weighting factor for each criteria, where all factors combined add up to 1. The AHP was completed based on input from a group of Tactical Plan development team members and outside agency professionals. Matrices and eigenvector weights were computed using R (v 3.6.1).

Criteria	Weight (AHP right-eigenvector)
Distribution model (average)	0.336
Proximity to conservation features	0.237
Economic benefit of treatment by land use	0.196
Occurrence density (inverted)	0.086
Proximity to recreational and other trails	0.081
Distribution model (maximum estimate)	0.065

Using the results from the AHP, a statewide continuous-scale prioritization map product was completed for each species in the Tactical Plan. The continuous-scale prioritization was converted into a 4-class (“lowest”, “low”, “medium”, “high”) scale using Jenks’ optimization method. Final maps were produced using ArcGIS Pro.

While these MCDA maps are a useful addition to the planning toolbox allowing us to assess priority and help make decisions, they do not replace decision making.

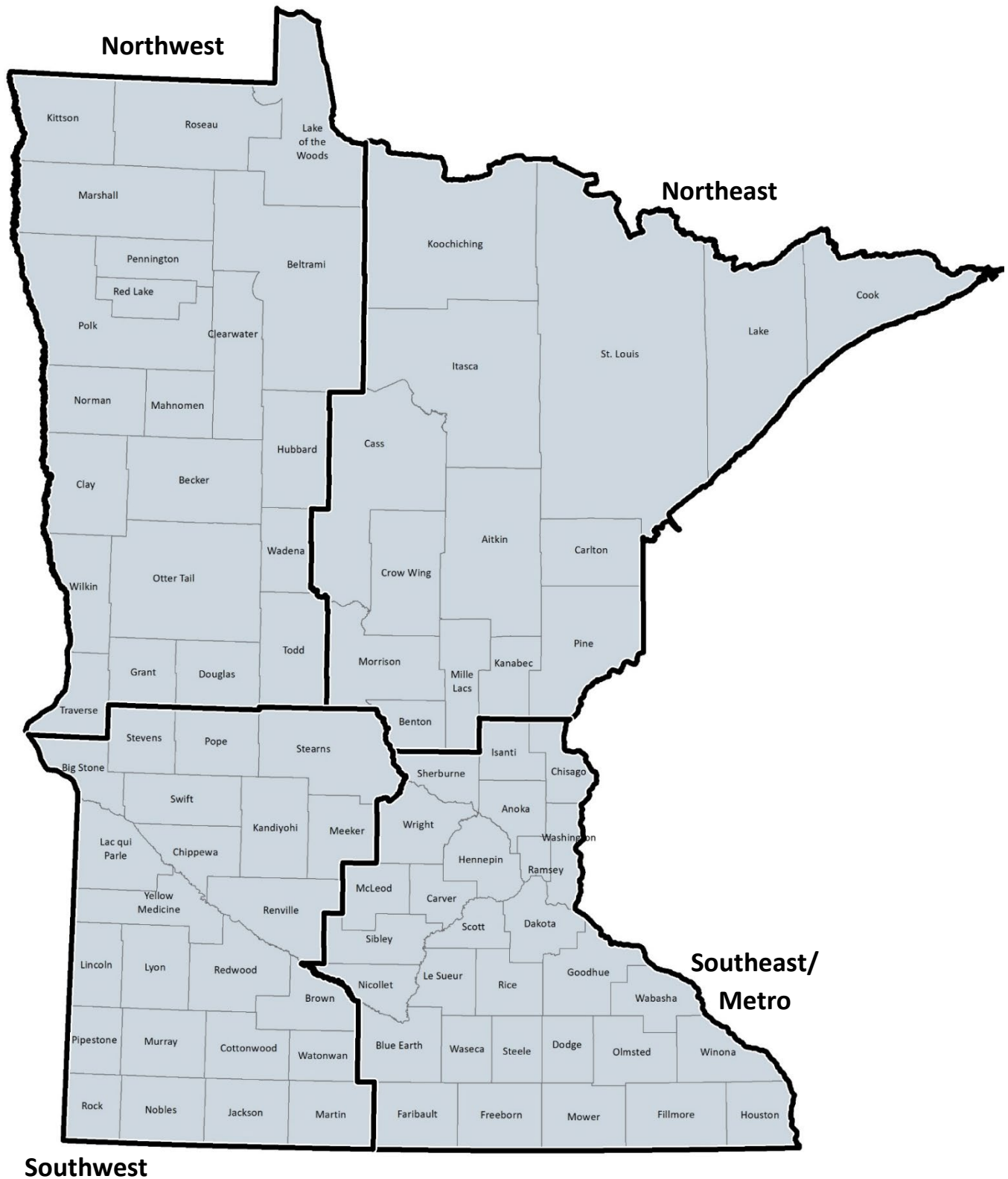
View the MCDA maps note layers for each species can be turned on/off:

<https://mnag.maps.arcgis.com/apps/webappviewer/index.html?id=0c9cd91b55f54af2ae39e9d9f61ebee7>

Resources



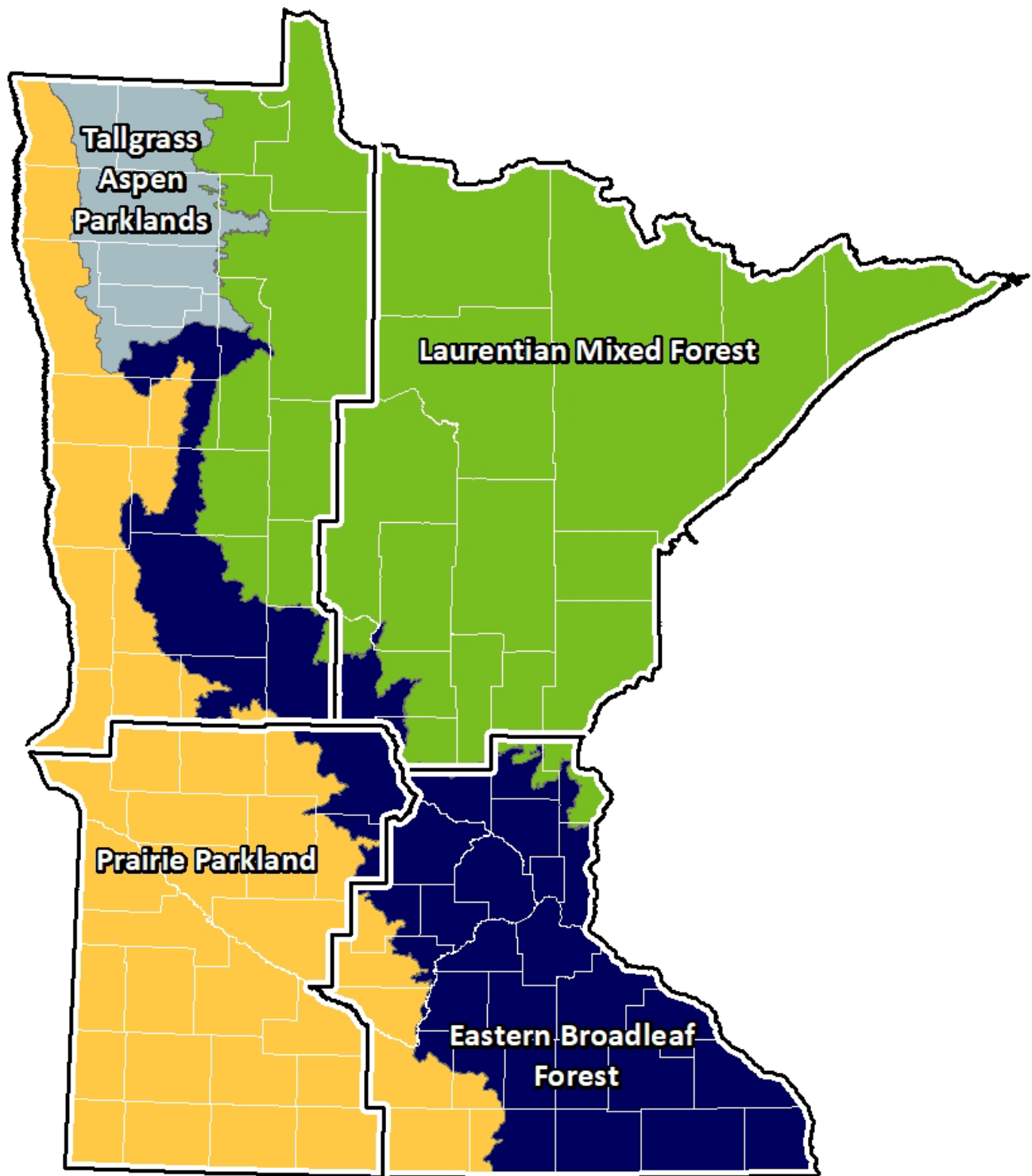
Regions in this Project



<p>Northwest:</p> <p>Lake of the Woods, Kittson, Roseau, Marshall, Beltrami, Polk, Pennington, Clearwater, Red Lake, Norman, Mahnomen, Hubbard, Clay, Becker, Wadena, Otter Tail, Wilkin, Todd, Grant, Douglas, Traverse</p>	<p>Northeast:</p> <p>Koochiching, St. Louis, Cook, Lake, Itasca, Cass, Aitkin, Crow Wing, Carlton, Pine, Morrison, Mille Lacs, Kanabec, Benton</p>
<p>Southwest:</p> <p>Stevens, Stearns, Pope, Big Stone, Swift, Kandiyohi, Meeker, Lac qui Parle, Chippewa, Yellow Medicine, Renville, Redwood, Lincoln, Lyon, Brown, Pipestone, Murray, Cottonwood, Watonwan, Rock, Nobles, Jackson, Martin</p>	<p>Southeast/Metro:</p> <p>Isanti, Chisago, Sherburne, Wright, Anoka, Washington, Hennepin, Ramsey, McLeod, Carver, Dakota, Scott, Sibley, Goodhue, Le Sueur, Rice, Nicollet, Wabasha, Blue Earth, Winona, Waseca, Steele, Dodge, Olmsted, Houston, Faribault, Fillmore, Freeborn, Mower</p>



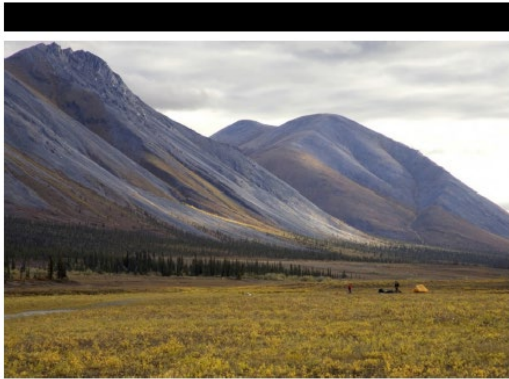
Biomes of Minnesota



MnDNR on biomes:

dnr.state.mn.us/biomes/index.html

Planning Tools

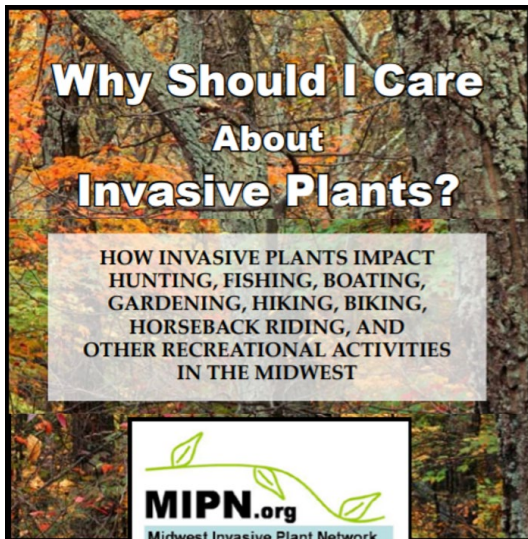


Land Manager's Guide to Developing an Invasive Plant Management Plan



Found at:

[cal-ipc.org/resources/library/publications/
developingplan/](http://cal-ipc.org/resources/library/publications/developingplan/)



Found at:

[bugwoodcloud.org/mura/mipn/assets/File/
InvasivesBrochure.pdf](http://bugwoodcloud.org/mura/mipn/assets/File/InvasivesBrochure.pdf)

Regional Research

Minnesota Invasive Terrestrial Plants and Pests Center

Science-based solutions to protect Minnesota's prairies, forests, wetlands, and agricultural resources

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