# Noxious Weed Advisory Committee (NWAC) Invasive Plants Research Needs

## Date Approved: December 3, 2019

## Background:

The purpose of the Noxious Weed Advisory Committee (NWAC) is to advise the Commissioner of the Minnesota Department of Agriculture (MDA) regarding terrestrial invasive plants and regulated noxious weeds. Two main functions of the committee are (1) to review plant species and advise as the commissioner as to potential regulations and (2) to advise the commissioner on policies and procedures related to prevention and management of invasive plants and noxious weeds.

As NWAC works to accomplish these functions, it finds knowledge gaps related to invasive plant and noxious weed biology, ecology, risk assessment, prevention, management, policies, outreach, and related issues. To help NWAC better fulfil its functions, it developed this list of identified research needs. Results from these research questions would assist the committee in fulfilling its functions.

This is an informational list of research needs identified by the Noxious Weed Advisory Committee and its constituents and is not a policy document of the MDA. It is not an exhaustive list or a ranked list and is not associated with specific funds available for research. The intent of this list is to compile research needs for terrestrial invasive plants into a central place so that they can easily be shared with researchers, funding organizations, and other organizations in Minnesota. The list can help guide and encourage researchers to do research and fill these needs which can inform risk assessments and policy and procedure guidance.

The Noxious Weeds Advisory Committee welcomes your input on this list. If you know of research needs related to terrestrial invasive plants and noxious weeds please send them to the Noxious and Invasive Weed Program.

## Research Needs

### Objectives:

- To improve invasive species management and train the next generation of resource managers
- To guide and encourage researchers to do research and fill these needs, including research to inform risk assessments

1. *Biology and Ecology*
    a. The potential for species-specific hybridization among introduced plant species and native plants and the potential impacts of hybrid genetics on the native species and on native ecosystems (this information would also be useful for risk assessments)
        i. For example, maple species
    b. Species-specific invasion biology (pathways of introduction and spread, factors that affect establishment ability)
        i. For example: Palmer amaranth (*Amaranthus palmeri*), poison hemlock (*Conium maculatum*), winged burning bush (*Euonymus alatus*), wild parsnip (*Pastinaca sativa*) and common tansy (*Tanacetum vulgare*).
    c. Research into invasive potential of biofuel crops and development of non-invasive biofuel crops. Working with biofuel researchers to head off problem species before they are widely adopted.

d. Research into invasive potential of cover crops and development of non-invasive cover crops. Working with cover crop researchers to head off problem species before they are widely adopted.
e. Basic lifecycle information has not been documented for many of the less common species.
    i. Grecian foxglove (*Digitalis lanata*), it's very interesting that has only been recorded as invasive in MN and in Kansas. Are there similarities in soil type? Shade/sun levels? What other factors are similar? Pathways? Historically there was a nursery near Afton that was known to sell Grecian foxglove in the early 1900s, was it also sold in Kansas?
        1. Seed viability: very difficult to find information, would like a study to clarify how long seed is viable
        2. Herbicide efficacy: seems to have variability, would like a study that factors soil types, soil moisture, air temp at time of application, and what herbicide formulation works the best
        3. Toxicity: we have had difficulty finding research papers on how toxic this plant is; we've heard anecdotally that dried Grecian foxglove in hay has killed calves and horses but that has not been confirmed by veterinarians.
    ii. Do Japanese hops (*Humulus japonicus*) seeds germinate in the spring or throughout the growing season? What is the period of seed development? Are seedpods buoyant? How long do seeds remain viable in water, in mud and on dry ground?
f. A rust cycling between glossy buckthorn and reed canary grass was recently described by Yue Jin at the Cereal Disease Lab University of Minnesota (Jin 2018). It would be informative to learn about this rust and its potential impacts.
g. The invasion biology of winged burning bush (*Euonymus alatus*) is not clear. This species has been utilized for a long time but we are just beginning to see escapes. Why is winged burning bush (*Euonymus alatus*) starting to invade now? Is the invasive potential different between the cultivars planted previously and cultivars utilized now? Answers to these questions would inform regulation and best practices.
h. How well does garlic mustard survive annual flooding? Can we expect much out of a population in the future that has routinely been underwater for the majority of the past two growing seasons?
i.

## 2. *Ecological Impacts*

a. Research focused on quantifying and documenting harm relative to invasive species in native ecosystems for regulated and potential threatening emerging species.
    i. Regulated species examples: Amur maple (*Acer ginnala*), Japanese barberry (*Berberis thunbergii*), poison hemlock (*Conium* maculatum) and wild parsnip (*Pastinaca sativa*).
    ii. Potential threat examples forest/woodland ecotype: wild chervil (*Anthriscus sylvestris*), yellow bedstraw (*Galium vernum*), yellow archangel (*Lamium galeobdolon*), honeyberry (*Lonicera caerulea*), big leaf lupine (*Lupinus polyphyllus*), Amur corktree (*Phellodendron amurense*), Siberian squill (*Scilla siberica*), goldencreeper (*Thladiantha dubia*), garden valerian (*Valeriana officinalis*).
b. Research the cumulative impacts of multiple invasive species in a given environment.
c. Research on terrestrial invasive plant species that significantly exacerbate other stressors. For example, the Phillips-Mao 2016 paper demonstrated how various terrestrial invasive plant scenarios impacted survival of C*ypripedium candidum* populations under a changing climate (Phillips-Mao et al 2015).

## 3. *Distribution, Biogeography and Range Modeling*

a. Improve use of drones and remote imaging for tracking presence and absence of specific invasive species.
b. Documentation of the current and projected distribution and prevalence (density) of individual invasive species and the combined coverage of all invasive species
    i. For example: winged burning bush (*Euonymus alatus*), Norway maple (*Acer platanoides*).
c. There are species that are likely to be assessed in the future that could use additional research on their distribution.
    i. Examples include: wild chervil (*Anthriscus sylvestris*), yellow bedstraw (*Galium vernum*), yellow archangel (*Lamium galeobdolon*), honeyberry (*Lonicera caerulea*), big leaf lupine (*Lupinus polyphyllus*), Amur corktree (*Phellodendron amurense*), Siberian squill (*Scilla siberica*), goldencreeper (*Thladiantha dubia*), garden valerian (*Valeriana officinalis*).
d. Continue to refine and automate existing distribution models and identify at risk habitats.
e. Oriental bittersweet risk map
    i. Create an Oriental bittersweet (*Celastrus orbiculatus*) risk map based on the four factors outlined below. The map will be used to inform where survey efforts should be focused and where management efforts should be concentrated to limit spread.
        1. Cold tolerance of Oriental bittersweet
            a. The cold tolerance needs to be determined to understand northern range limits.
            b. Bittersweet vines can replace vascular tissue damaged by freeze induced embolism. The range of the native congener American bittersweet (*C. scandens*) extends from the southern US into Canada. This is a wide climatic range. American bittersweet thrives in all areas of Minnesota and is not cold limited. Oriental bittersweet may have a similar climatic range.
            c. U of M researchers have conducted some cold tolerance pilot studies on seed, seedlings and mature vines.
        2. Proximity to documented infestation/s
        3. Flight patterns of frugivorous birds in relation to seed vectoring
        4. Suitable habitat for Oriental bittersweet

## 4. *Risk Assessment*

a. Assess the potential risk of gene flow within and between populations of brown knapweed (*Centaurea jacea*) and meadow knapweed complex (*Centaurea* x *moncktonii*) and adjacent spotted knapweed (*C. stoebe* ssp. *micranthos*). This information will be used to determine an appropriate response to both meadow knapweed and spotted knapweed populations. Knapweeds hybridize readily and novel forms have been documented. Novel forms may have competitive advantages or expanded ranges. Introgression of meadow knapweed complex genes into spotted knapweed may be occurring now but could remain unnoticed until well established within spotted knapweed (hybrids). Some knapweed samples collected in Minnesota can't be clearly identified to species based on morphology.
    i. Describe existing populations in terms of species and ploidy levels
    ii. UMD botanists described species in at least one infestation based upon morphological characteristics.
    iii. Assess hybridization potential

b. What is the risk of naturalizing barberry populations? Can populations host stripe and/or black stem rust that impact small grain production? Are barberry populations creating habitat resulting in increased deer tick abundance and pathogen presence.
c. Assess the viability of noxious weed seed and knotweed parts in compost made using common compost methods.
d. Evaluate the costs and benefits of common management options, including the option of doing nothing.
    i. For example: grazing, herbicides, mowing

5. *Climate Change and Other Human-Caused Factors Aiding Invasion*
    a. Can we predict invasive species movement and/or change of range?
        i. For example: kudzu research predictions

6. *Control and Management Methods*
    a. Quantification of the real-world efficacy of invasive species management strategies including biological controls and their environmental impacts
    b. Biological control
        i. Completion of garlic mustard biological control host specificity testing for the insects *Ceutorhynchus scrobicollis* and *C. constrictus*. Research on effectiveness if they are approved and released.
        ii. Improve implementation of spotted knapweed biological control. The biological control agents are approved for field release.
            1. Develop a system for collecting and moving the root-boring moth, *Agapeta zoegana*. This moth is approved for field release and documented to effective for spotted knapweed management. Unfortunately, the adult moth is very difficult to collect so the species is seriously underutilized.
            2. A detailed understanding of the spotted knapweed root weevil, *Cyphocleonus achates*, lifecycle and a degree day model would allow us to better time collection activities
        iii. Tansy biocontrol development
            1. Work with APHIS, CABI and consortium partners to complete host-specificity testing.
        iv. Buckthorn biocontrol development
            1. Consider asking/funding APHIS to complete buckthorn seed feeder host-specificity testing.
        v. Document the efficacy of leafy spurge, spotted knapweed and/or purple loosestrife biological control in Minnesota.
    c. Grazing
        i. The goat grazing for buckthorn control research sponsored by Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC) is a great start. Its results will likely include additional topics for follow-up research and longer term research.
        ii. Grazing animals as invasive plant seed vectors. With increased conservation grazing practices, cattle are being moved. How effective are methods to prevent the spread of invasive plant seeds both on the cattle and in their waste.
        iii. Long-term effectiveness of cattle or goat grazing on reducing invasive species and increasing native species in a variety of habitat types. Quantify potential for damage to native species.
    d. New techniques
        i. Genetic control techniques for widespread species, for example, the [gene silencing work on non-native Phragmites by the USGS](gene silencing work on non-native Phragmites by the USGS) (Kowalski 2018).

        ii. Develop new management methods that are more effective, cost less, give better control, fewer non-target impacts, etc.
        iii. Use of drones or other aerial equipment for invasive weed treatment in situations where typical equipment cannot enter wet sites
            1. For example: non-native reed canary grass, non-native phragmites, etc
    e. Impacts of management
        i. The impacts of terrestrial invasive plant treatments on native remnant plant communities. Guidance for managers to determine when the benefits outweigh the costs.
        ii. Impacts of brush mowing on native species. Costs and benefits to native species.
        iii. Response of rare species to invasive species removal.
            1. For example: tubercled rein orchid (*Platanthera flava* var *herbiola*), kitten tails (*Besseya bullii*), etc. during woody invasive species removal
    f. Clarification and refinement of existing management practices
        i. Timing existing practices to maximize treatment effectiveness of the target species.
            1. For example: burning, mowing, spraying, grazing, biocontrol
        ii. Herbicide choice and application rate/timing comparisons of Pathfinder II RTU, Garlon 4 Ultra, Round Up Pro, and Krenite in cut stump treatments, in fall versus late winter/early spring applications. The same products in basal bark treatments in fall versus late winter/early spring applications. The same products when preceeded by a spring brush cut/mow/chop. For all comparisons look at control effectiveness and non-target impacts.
        iii. How effective are mowing and spot spraying treatments currently applied in maintaining or reducing the spread of invasive plants from year to year.
        iv. Effectiveness of late summer/early fall forestry mowers and brush hogs for the control of woody invasive species without herbicides (some projects have shown potential for effective control during this time)
        v. Effectiveness of Krenite on controlling woody invasive species sprouts and seedlings.
    g. Management practices specific to woody species
        i. Best treatment options for Japanese barberry (*Berberis thunbergii*) given small stem size and difficulty finding them all for basal bark or cut stump treatments.
        ii. Targeted control of thick buckthorn and non-native honeysuckle seedlings and regrowth.
        iii. Most effective methods for eradicating Siberian elm (*Ulmus* pumila) from grasslands.
        iv. Improved, targeted control and management strategies for common and glossy buckthorn in urban and rural woodland/wetland ecosystems
    h. Management practices specific to herbaceous species
        i. Wild parsnip (*Pastinaca sativa*) management
            1. Increased selectivity and efficacy of wild parsnip treatment options in multiple habitat types.
            2. Management by mowing
                a. Determine whether mowing when the secondary inflorescences begin to flower is effective for wild parsnip management in Minnesota regions. Consider also researching this question for wild carrot, a related species.
                b. Is viable seed produced post mowing at this stage?
            3. Model wild parsnip development stages
                a. Build a degree day model for wild parsnip
                    i. Determine the lower developmental threshold

ii. Determine the degree days needed for each developmental stage.
iii. Write an algorithm to calculate current developmental stage based upon degree days accumulated.

b. Display degree day model as a map of wild parsnip development in Minnesota.
    i. Enable users to receive email notifications about developmental stages.

4. How long does it take for wild parsnip furanocoumarins to break down to safe levels for humans to touch? For example, shovels that were used for parsnip removal still had enough furanocoumarins on them to cause burns on a person handling the shovels months later. There was no visible sign of furanocoumarin presence to signal caution.
    a. Are there methods to speed the break down of furanocoumarins?

ii. Identify best management practices for controlling non-native invasive legumes in Minnesota prairies.

iii. Most effective and targeted controls in diverse native plant communities
    1. For example: garlic mustard (*Allaria petiolata*), smooth brome (*Bromus inermis*), Canada thistle (*Cirsium arvense*), Queen Anne's lace (*Daucus carota*), dame's rocket (*Hesperis matronalis*), birdsfoot trefoil (*Lotus corniculatus*), wild parsnip (*Pastinaca sativa*), reed canarygrass (*Phalaris arundinacea*), bouncing bet (*Saponaria officinalis*), crown vetch (*Securigera varia*).

i. Establish thresholds for appropriate responses to invasive plant populations.
    i. When should strategies of eradication, containment and control be used?
        1. Strategies to employ at different scales such as a site, a county and the state of Minnesota

## 7. *Restoration*

a. Documentation of the impacts of high populations of white-tailed deer on restoration efforts and on the success of invasive species
b. Effectiveness of native species reestablishment after invasive species control and guidance on when active restoration work is needed after control.
c. Review areas that have had consistent buckthorn (*Rhamnus cathartica* and *Frangula* alnus) control. Evaluate if it has produced the intended reduction over time and restoration of the site.
d. In newer, very diverse prairie restorations, managers may not do spot spraying for Canada thistle (*Cirsium arvense*) during the establishment phase in order to increase the establishment of the planted species. They may mow if they get Canada thistle complaints. Evaluate if mowing is detrimental to the native forbs during establishment. These diverse pollinator restorations can be expensive plantings made up of 50% forbs. Spraying and mowing can prevent the establishment of these species. Research to provide guidance on balancing Canada thistle control with establishing high quality, diverse prairie restorations.
e. Determine whether native plant communities can resist or outcompete wild parsnip on roadsides. Many roadside systems invaded by wild parsnip were previously smooth brome. Competition against taller and more robust native grasses such as big bluestem and Indian grass may reduce wild parsnip invasion by shading the parsnip.

## 8. *Economic Impacts*

a. For all listed and potential invasive species, estimate the economic impacts of infestations of individual species and the cumulative impacts of multiple species in a given environment

        i. Establish a framework for evaluating abstract values such as the value of a rare species or recreational lands.
        ii. Establish a framework for consistently evaluating management costs.
        iii. Document and quantify current and potential economic impacts of all noxious weeds.

9. *Social Issues*
    a. Social science research on invasive plant management and prevention outreach. Measuring what works and guiding best methods of outreach. How to design and implement community-based social marketing to reduce the spread of invasive plants.
    b. Social science research on public perceptions on invasive plant management and prevention outreach.
    c. What are the environmental impacts of public use trails? Do they tend to spread new invasive species into the surrounding landscape? What species are spread? Under what circumstances may this occur?
        i. For example: horse trails, ATV trails, hiking trails, snowmobile trails
    d. Do invasive species issues increase with added public use? Are there specific types of public use that appear to cause more invasive species impacts than others?
    e. How do we engage landowners and communities about invasive plant topics?
        i. What are the most effective methods of communication?
        ii. What factors are important for landowner and community decision-making about whether to take action on an invasive species topic?

10. *Policy and Laws*
    a. The feasibility and impact of regulation that requires all new plant introductions to be evaluated (to the extent feasible) for potential invasiveness (including the potential for hybridization with native species) before being introduced.
    b. What policies would encourage private landowners to control abundant species such as common buckthorn (*Rhamnus cathartica*)? For example, would a tax incentive be effective and acceptable? Are the other/better ideas?

11. *Agronomic, Horticultural, & Silvicultural Species Impacts* (including agricultural cover crops and biomass crops, sterile or low fecund cultivars, alternative plants)
    a. Viable alternatives to valued landscape species, conduct marketing research about how to best promote native and/or non-invasive plants that are already in production systems.
    b. Development and documentation of sterile or low fecund cultivars of ornamental plants such as Amur maple (*Acer ginnala*), Japanese barberry (*Berberis thunbergii*), Siberian peashrub (*Caragana arborescens*) and winged winged burning bush (Euonymus alatus) (*Euonymus alatus*).

12. *Prevention and pathways*
    a. Research into the effectiveness of equipment cleaning to prevent spread of invasive species.
    b. Are weed seeds surviving at compost sites, brush pile and yard waste sites?

13. *Education*
    a. Evaluation of effectiveness of current weed program trainings as well as “on the job” annual trainings
    b. Is existing education effective? What educational programs exist locally and nationwide?

## References

Jin, Y. 2018. Biology of a rust fungus infecting Rhamnus frangula and Phalaris arundinacea. Presented at Upper Midwest Invasive Species Conference. Rochester MN, 15-18 October, viewed 16 July 2019.

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Kowalski, K. 2018. Controlling invasive Phragmites in the Great Lakes through science, collaboration and the GLRI. USGS. Last accessed 16 July 2019. https://www.usgs.gov/center-news/controlling-invasive-phragmites-great-lakes-through-science-collaboration-and-glri

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