



Restoring Your Invasive Perennial-Dominated Grassland to Conservation Meadow

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Cover photo taken at Twin Valley Prairie by Justin Meissen.



Restoring Your Invasive Perennial-Dominated Grassland to “Conservation Meadow”

In this guide, you will learn the basic steps to restore a grassland dominated by invasive perennial weeds to a conservation meadow. The precise restoration actions will depend on the particular features of your site as well as your budget, preferences and project goals.

When planning your restoration, we recommend you consult with restoration professionals to evaluate your site’s unique characteristics. Please visit [nature.org/MNPrarieRestorationGuides](https://www.nature.org/MNPrarieRestorationGuides) for more information on who to contact or other publications that cover site assessment protocols.

What is conservation meadow?

Conservation meadow is a wet grassland designed to closely mimic native wet prairie and sedge meadow using seed mixes that have many native species adapted to the restoration site. It occurs on poorly-drained, wet to moderately wet soils that are saturated up to 8 weeks following snowmelt and are prone to temporary ponding after large rainfall events. Conservation meadow often occurs in a transition zone between emergent marsh and upland prairie and may be either sedge-dominated (“sedge meadow”) or grass-dominated (“wet prairie”) depending on the duration of soil saturation.

The diversity of plants in conservation meadow provides habitat and food for native wildlife and insects, including pollinators. A wide variety of flowering plants and grasses is also visually

interesting to people. Conservation meadow is not suitable for forage production, commercial uses or high-impact recreational activities such as driving ATVs.

Compatible land uses include:

- Carefully managed grazing for habitat goals¹
- Haying for habitat goals
- Occasional seed harvest
- Low-impact recreational activities, such as hiking, photography, or hunting

Conservation benefits include improved water quality, flood control, and habitat for birds, animals and insects. Conservation prairie can also buffer high-quality native meadows and prairies and support threatened and endangered plants and animals that depend on large contiguous areas of grassland.

Why restore invasive perennial-dominated grasslands?

Restoring invasive perennial-dominated grasslands to utility meadow increases the diversity of species on the site and provides valuable habitat for prairie wildlife and pollinators. Invasive perennial-dominated grasslands have substantial coverage (>75%) of exotic invasive perennials, such as reed canary grass, smooth brome and birdsfoot trefoil. Often used as pasture or hay fields, these sites are dominated by aggressive species that persist for many years and can quickly outcompete and suppress planted natives. Reed canary grass is particularly common on wet sites and may require multiple years of repeated treatments to control. Invasive woody

¹ Very wet sites are vulnerable to damage by trampling and are dominated by sedges, which are not preferred forage for cattle. Moderately wet sites, which are dominated by grasses and have a shorter duration of seasonal ponding, will generally be more suitable for grazing.

species may also be present and require additional removal strategies².

Invasive perennial-dominated grasslands are one of the most challenging starting conditions for restoration, because they require substantial investment of time before and after seeding prairie species. Restoring these sites often requires multiple seasons of vegetation control prior to seeding, and attentive management through the seedling establishment phase and beyond. When possible, cropping these fields is an increasingly popular and more affordable option for achieving the level of weed control required for successful restoration. Additionally, if the site has been drained with drainage tiles or ditches, restoring hydrology by breaking tiles, plugging ditches, and—in some cases—installing water control devices, will be required.

This guide assumes that your site is wet to moderately wet and has been drained via tiles or ditches³. Sites that have not been drained will not require the additional steps to restore the hydrology.



Restoring hydrology at Glacial Ridge
© TNC\Jason Eckstein

What will it involve?

Meadow restoration typically includes these basic steps:

- **Site Assessment**— Identify the site characteristics and define goals for the restoration.
- **Vegetation Removal** – Remove existing weeds and undesired vegetation from the site to prevent aggressive weedy species from out-competing native meadow plants.
- **Seedbed Preparation** – Prepare a seedbed to ensure good seed-soil contact and promote germination of planted seeds.
- **Seeding/Planting** – Select seed mixes and seeding methods that are well suited to the site and project goals. Or, in the case of small sites of less than half an acre, consider hand-planting plugs for quicker results⁴.
- **Hydrologic Restoration** – Remove drainage features by breaking tile or plugging ditches to restore the site’s original soil moisture and seasonal flooding patterns.
- **Establishment & Aftercare** – Control weeds and promote the establishment and growth of meadow plants through the first few years after seeding.
- **Long-term Management** – Maintain the health and diversity of native meadow into the future.

² If invasive trees and shrubs are present on site, refer to the restoration guide “Restoring your Woody-Invaded Meadow to Conservation Meadow” for information on controlling woody species.

³ For sites with moderate to dry soil moisture, refer to the restoration guide “Restoring your Invasive Perennial-Dominated Field to Conservation Prairie”.

⁴ Plugs are young plants sold in 4- or 6-packs. Plugs cost substantially more than seed, but they establish rapidly and can produce a resilient and visually appealing meadow more quickly than seeding, so it is often a preferred option for smaller sites.

How long will it take?

On an invasive perennial-dominated grassland, the initial site preparation typically requires at least one full calendar year prior to seeding. When possible, spending two growing seasons on thorough invasive species control prior to seeding will yield more optimal results. The more you invest in weed control up front, the less time and effort you will need to spend controlling weeds in the long term. After the year it's seeded, expect to spend at least three to five years on aftercare to ensure good establishment of the conservation meadow. This period is referred to as the establishment phase of restoration.

After establishment, often after year five for conservation meadow, the long-term management phase begins. Management actions are typically less frequent and intensive than during the establishment phase, but are critical for maintaining the health and diversity of the meadow into the future.

What will it cost?

The cost of the restoration will be influenced by:

- Management level required to control weeds
- Species and number of species selected for the seed mix
- Cost of seed, which fluctuates from year to year
- Hydrologic factors, such as drainage type, size and depth; soil type and sediment deposits; and whether management of wetland discharge is required
- Labor and equipment available for the project

The cost estimate in this document will give you a baseline for what you can expect to spend through the initial establishment phase of your restoration (i.e. through three years after seeding). It may be tempting to cut costs by reducing the number of species planted or the frequency of weed control activities. Be aware that these investments on the front end can actually save costs in the long run. A healthy and diverse meadow will be more resilient to disturbance, invasion by exotic species, and extreme weather events such as drought.



Reed canary grass infested meadow near Bluestem Prairie
©TNC\Steve Chaplin

Invasive Perennial-Dominated Grassland to Conservation Meadow Restoration Guidelines

Site assessment

A successful meadow restoration is highly dependent on specific characteristics of a site. Important considerations when planning a restoration include:

- Has the site had herbicide treatments that would prohibit seed from germinating?
- Is there a risk of herbicide drift from neighboring cropfields?
- Are the soils dry, moderate or wet?
- How long are the soils saturated in the spring?
- Has the site been drained with drainage tiles or ditches?
- Is there a substantial build up of sediments on site that may require excavation?
- Are there steep slopes that may be vulnerable to erosion?
- What types of vegetation are currently present on the site?

If you are new to meadow restoration, we strongly encourage enlisting someone who has restoration experience to help you assess the characteristics of the site and develop a restoration plan suited to your site's specific features and your project goals.

Vegetation removal

Invasive perennials, such as reed canary grass, can out-compete native wet meadow species. Reed canary grass can continue germinating from the seed bank for 10 years or more, at densities that can rapidly overwhelm planted

native vegetation. Restoration of wet prairie and sedge meadow communities almost always involves control and prevention of reed canary grass invasion. Thorough site preparation is critical prior to planting, because control options after seeding and hydrologic restoration are limited by the presence of standing water and saturated soils. Post-seeding control also risks harming planted meadow species. This is especially important for conservation meadows, which often include more costly and sensitive species.

A carefully timed "spray-burn-spray" approach using glyphosate (Roundup if the site is dry; or aquatic-approved Rodeo if standing water is present) is an effective strategy for controlling reed canary grass and other invasive perennials. Timing is critical—herbicide should be applied in the fall (September) when reed canary grass is still physiologically active in order to affect mature plants and regrowth from rhizomes. Burning and mowing increase light availability and stimulate reed canary grass germination, so they should be followed with a late spring/summer herbicide application to kill emerging seedlings.

Two complete sequences of the spray-burn-spray approach (i.e. two full calendar years of invasion control) are recommended prior to seeding conservation meadow. Wet meadow restoration requires a certain amount of flexibility, as wet site conditions may preclude necessary management actions in any given year. When possible, it is preferable to delay seeding to allow for the full sequence of reed canary grass control rather than seed with incomplete management.

The significant control effort and costs required to produce a successful restoration outcome may be unfeasible for some heavily invaded sites. Consider cropping these fields for 2-3 years prior to initiating restoration to exhaust the seed/rhizome bank.

Recommended protocol:

Year 1:

- Apply glyphosate to reed canary grass in the fall. September is optimal.
 - Use broadcast application, such as with a tractor-mounted boom sprayer.
 - If standing water is present, use an aquatic-approved formula, such as Rodeo.

Year 2:

- Spring burn to stimulate reed canary grass seed germination.
 - Note: if site is likely to be too wet for a spring burn, burn in fall of year 1 instead.
- Apply second glyphosate application to kill emerging weed seedlings in late spring/early summer.
- Fall: assess re-emergence of reed canary grass from rhizomes:
 - If site is fairly clean (< 5% cover), spot-spray remaining vegetation in September, mow or burn to remove thatch, and prepare to seed.
 - If > 5% cover, repeat herbicide applications in September, either broadcast or spot-spray as needed, and continue spray-burn-spray sequence through year 3. Consider planting a cover crop to prevent erosion and re-invasion in the meantime.

Year 3:

- Spring burn to stimulate reed canary grass seed germination.
- Apply second glyphosate application to kill emerging seedlings in late spring/early summer.
- In Fall assess re-emergence of reed canary grass from rhizomes:

- If site is clean, spot-spray remaining vegetation in September and prepare to seed.
- If > 5% cover, decide whether to proceed with planting or continue invasion control for another year.
- Wait at least 2 weeks following last herbicide application to seed.

Additional notes:

- If invasive woody species are present, saplings less than ½ inch in diameter can be herbicide-treated along with invasive perennials, but larger trees will require mechanical removal⁵.
- Alternate option 1 is to crop field for 1-4 years to deplete invasive perennial seed and rhizome bank, ending on a rotation of Roundup Ready soybeans (if site conditions allow)⁶.
- Alternate option 2 is to apply grass-specific herbicides, such as sethoxydim (Poast, Vantage), in late spring/early summer to control reed canary grass that is mixed with native sedges and forbs (flowering plants). These herbicides can only be used in dry sites (no standing water), and should be used cautiously if native grasses are present.
- Alternate option 3 is to start with spring mowing/burn and herbicide application. Then disk the site repeatedly, every 3-4 weeks, throughout the growing season to maximize control of invasive perennial rhizomes. Follow with additional herbicide applications as needed.
 - This risks bringing additional invasive seeds and rhizomes to the soil surface and should be done in conjunction with multiple herbicide treatments to control regrowth.

⁵ Refer to the restoration guide "Restoring your Woody-invaded Meadow to Conservation Meadow" for more information on controlling invasive trees and shrubs.

⁶ Refer to the restoration guide "Restoring your Crop to Conservation Meadow" for more information on restoration from a crop field.



Native seed mixes should be planted with equipment designed to handle different-sized seeds ©Justin Meissen

- Not recommended for highly erodible sites.
- This method requires dry, firm soils throughout the summer.

Seedbed preparations

The best method of seedbed preparation in an invasive perennial-dominated site is influenced by the site conditions, the amount of resources available for continued vegetation management, and the intended seeding method.

If the soil surface is uneven or severely compacted, harrowing or disking may be required to prepare the site. This often results in a flush of new invasive perennial growth, as seeds and rhizomes are brought to the soil surface. If soil cultivation is required, invasive perennial regrowth should be treated with repeated herbicide applications prior to seeding.

Alternatively, several rounds of deep tillage may be used intentionally to break up rhizomes and bring them to the surface for winter kill. However, most practitioners prefer to avoid soil disturbance to prevent bringing seeds and rhizomes to the soil surface and minimize both reinvasion and the need for continued intensive management.

For this conservation meadow restoration plan, broadcast seeding is the recommended seeding method. Late summer or fall is the best time

for seedbed preparations in wet sites, as the soils are more likely to be firm and dry.

Recommended protocol:

- Forgo site preparation to minimize soil disturbance and subsequent reinvasion. Frost-seeding, snow seeding or ash seeding may help incorporate seeds into soil.
- Exceptions:
 - If soil surface is very uneven with numerous soil clods, lightly harrow to create a smoother surface. Treat invasive regrowth with repeated herbicide applications prior to native seedling establishment.
 - If soils are severely compacted, multiple rounds of tilling and disking (4-inch depth) may be used to loosen soil and break up invasive rhizomes. Finish soils by harrowing to break up soil clods. Treat invasive regrowth with repeated herbicide applications prior to native seedling establishment.

Seeding

The key to establishing a successful meadow is to maximize seed-to-soil contact during planting.

Broadcast seeding with a spreader mounted to a tractor or ATV is recommended for meadows, because wet soils often cannot support heavy machinery such as seed drills, and many wet meadow species have very small, light-sensitive seeds that can be buried too deeply by a seed drill. However, if the seedbed is dry and firm, grasses may be seeded with a no-till drill, followed by broadcasting forbs and sedges. In some cases, the wettest areas may need to be hand-seeded or planted with plugs.

If broadcasting seed, native-seed broadcasters such as a Vicon seeder should be used. They are designed to spread mixes with different sized seeds. If planting with a drill, use a seed drill designed specifically to plant prairie grasses and flowers. Persistent drill rows can be minimized by drilling the site in two passes at right angles to each other, producing a grid.

Recommended protocol:

- How to seed:
 - Broadcast seeds into prepared seedbed using an agitating spreader such as a Vicon seeder mounted to a tractor or ATV.
 - Incorporate the seeds into the soil with a light drag, such as a piece of chain link fence or packer pulled behind the tractor/ATV while broadcasting.
 - Note: If dormant seeding (late fall through early spring) or ash seeding (sowing into ash immediately following a burn), mechanical incorporation may not be needed. Freeze-thaw, snowmelt and rainfall action may naturally incorporate seeds into the soil.
 - Alternative seeding method: If seedbed is dry and firm, drill grass seeds directly

into crop residue, or prepared seedbed, using a no-till drill such as a Truax. Additional mechanical incorporation or packing is not required when using a no-till drill. Broadcast forb and sedge seed.



- For areas that are too wet for a tractor or ATV, a second alternative seeding method is to broadcast seed by hand.
- When to seed:
 - Planting dates will vary depending on the weather and location within the state. Consult with native seed suppliers or restoration specialists to determine the best planting dates for the year.
 - Dormant seeding is recommended for meadows, because the ground is more likely to be dry and firm in the late fall and early winter⁷. Dormant seeding should occur Dec. 1 to April 1 OR after soil temperatures fall below 50 degrees F for a consistent period of time. Dormant seeding before the ground is frozen, sometimes called “frost seeding”, can be done with a seed drill or by broadcasting. When possible, timing the seeding before a snowfall may help prevent seed loss to birds and wildlife. After the ground is frozen in winter/early spring, seed can also be broadcast over snow, although results of snow seeding are more variable and dependent on weather conditions. Dormant seeding promotes cool season grasses, sedges and flowering plants.

⁷ Early fall seeding is not recommended for meadows, because seed may germinate too early and not survive over winter.

- Spring and growing season plantings (April 1 – July 1) are not typically recommended for wet meadows because the soils are often too saturated to support equipment, spring flooding may wash seeds away, and overwintering is necessary to trigger germination in many wetland sedges and flowering plants. However, when conditions allow, growing season seeding can yield satisfactory results, particularly for wetland grasses⁸.
- Seed mixes will vary but should take into account:
 - Consider soil moisture conditions of the site.
 - Include species that provide habitat value for wildlife and insects, including mixed-height grasses and sedges and a diversity of flowering plants.
 - Select a mix of both warm- and cool-season species and species that bloom in spring, summer, and early fall to encourage resilience to disturbances and ensure year-round habitat resources and visual interest⁹.
 - Cover/nurse crops such as oats are optional, but should be included with the seed mix when seeding steep slopes.
- Design:
 - Apply seed mixes to “seeding zones” on site based on soil moisture conditions and hydrology; for example: seed a wet prairie mix into areas that are saturated 3-4 weeks annually, and a sedge meadow mix into areas that are saturated 6-8 weeks annually.
 - Wet prairie and sedge meadow mixes can be combined and seeded across the entire site if seed zones are closely intermixed and seeding individual zones is not feasible.
- If there are dry to moderately moist soils on the site, select a separate conservation prairie seed mix for these seeding zones¹⁰.
- Seed rate:
 - Plant at a minimum of 160 seeds/sq. foot to reduce risk of weed invasion.
 - Seeding rates may need to be increased by 25% for dormant seedings to account for lower germination rates and loss of seed to wildlife.

Hydrologic restoration

Nearly all wet meadow sites in western Minnesota have been impacted by altered hydrology. Restoring hydrology by removing drainage features is a critical component of wet meadow restoration. When planning a meadow restoration, take note of the following recommendations and refer to the [Minnesota Wetland Restoration Guide](#) (BWSR) or [Restoring Prairie Wetlands: an ecological approach](#) (Galatowitsch and van der Valk 1994) for additional information. For further guidance on evaluating and implementing the engineering aspects of hydrologic restoration, consult with experienced restoration professionals or local Soil and Water Conservation District representatives (www.maswcd.org).

Recommended protocol:

- Use a backhoe to break drainage tiles and/or plug drainage ditches.
- Break tile in strategic locations, for example: at the wetland’s outlet (it is usually not necessary to remove the entire length of tile).

⁸ Summer seeding after July 1 leads to poor seedling survival and is not recommended for wet meadows.

⁹ See nature.org/MNPrairieRestorationGuides for more information on seed mix design and examples of conservation meadow seed mixes for different regions and soil moisture.

¹⁰ See nature.org/MNPrairieRestorationGuides for examples of conservation prairie seed mixes appropriate for dry to moderately moist soils.

- Hydrologic restoration should be implemented after vegetation removal. After the site is flooded, access will be limited and herbicide options are restricted to aquatic-approved formulas such as Rodeo.
- Time hydrologic restoration to occur in the fall or early winter in close conjunction with seeding, preferably 1-2 weeks following seeding (after flooding, site access will be limited).
- Reserve a small amount of seed to hand-broadcast over areas disturbed by backhoe operations.
- If transplanting live plant material or plugs, this can be done in the late spring following hydrologic restoration.



Breaking tile with a backhoe © MN BWSR

Post-seeding aftercare and long-term management

Conservation meadow establishment generally takes 5 to 7 years, but will vary depending on soil moisture and climate conditions. Early management (aftercare) is critical for preventing perennial weeds, particularly reed canary grass, and woody species from invading and displacing establishing meadow species. However, saturated conditions may limit management options, preventing access by heavy equipment.

In wet prairie zones, annual weeds can also be problematic in the early stages of restoration. They can quickly overtop and shade meadow seedlings, resulting in decreased growth and survival. Frequent mowing can prevent annuals from forming a dense canopy and building up thatch that can further suppress native seedlings.

Post-seeding aftercare goals include discouraging weeds and encouraging rapid and robust establishment of native species that can sustain grazing, haying and other uses. The restoration site should be divided into management units for burning on a rotational basis to maintain diversity and wildlife refuges. Management strategies during the establishment phase include:

- Mowing annual weeds
- Selective use of appropriately-timed aquatic-approved herbicide to control reed canary grass and other invasive perennials
- Prescribed fire to promote native meadow species and discourage further invasion, particularly in the wet prairie zone
- Monitoring vegetation to evaluate establishment of meadow seedlings and detect invasive species problems. This is particularly important in wet sites, because site conditions may prevent management in some years.

Throughout the establishment phase and beyond, adjust management plans as necessary, including the option to reseed, to achieve the desired species composition and diversity.

Recommended management protocol:

Year 1:

- When the site is dry and firm enough (early to mid-summer), spot-mow annual weeds and cover crops in wet prairie zone to a height of 4-6 inches when canopy reaches a height of 12-18 inches. Most meadow plants will not reach this height in the first year and will not be damaged by a mower.



Prescribed fire is an important tool in maintaining conservation meadow ©Chris Helzer/TNC

- Avoid mowing reed canary grass except to prevent going to seed. Mowing may reduce effectiveness of herbicide and stimulate seed germination.
- Spot-spray re-invading reed canary grass in September using aquatic-approved glyphosate, such as Rodeo, using methods that will minimize damage to native seedlings. For example, use a backpack sprayer or wick applicator and avoid windy days to minimize drift.

Year 2:

- Mow annual weeds in wet prairie zone to a height of 12 inches as needed to reduce cover and seed set.
 - If annual weeds are limited to individual patches, may spot-mow, perhaps even with a string trimmer, instead of mowing whole field.
- Spot-spray reed canary grass in September using methods that will minimize damage to native meadow species.

Years 3-5:

- Begin prescribed burns after three growing seasons, or as soon as biomass accumulation is sufficient to carry a burn.
- Rotate burns in management units, burning no more than one third of site (one half for small sites) at a time to maintain diversity and a local refuge for wildlife. Burn at an interval of every 4-7 years.

- Spot-treat reed canary grass (in September) and other weeds as necessary with aquatic-approved herbicide.
- Conduct a stand evaluation to assess seedling establishment outcomes. If native plant density is less than 1 plant per square foot, interseed to increase cover and diversity.

Year 4 & beyond (long-term management phase):

- Burn every 4-7 years to stimulate productivity of native meadow plants (particularly in the wet prairie zone) and prevent invasion of perennial weeds and woody trees and shrubs.
 - Note: burning more frequently may negatively impact sedges.
- Continue to burn in rotations, disturbing no more than one third of a field at a given time, to maintain diversity and a local refuge for wildlife.
- Adjust seasonality of burning to maximize diversity. For example, alternate between spring and fall burns on individual management units, as site conditions allow.
- If conservation grazing is used, graze in rotations at low to moderate intensities, or at stocking rates prescribed by a grazing management plan written to meet the objectives of the conservation prairie. Avoid grazing in saturated conditions.
- Every 1 to 3 years, monitor vegetation composition and diversity.

- Interseed as needed to increase native cover and diversity if native species are declining.
- Adjust management plan, such as frequency and intensity of burning or grazing, if:
 - cover of native species is declining
 - desired composition is not being maintained
 - cover of invasive species is increasing
- Spot-treat reed canary grass and other weeds as needed by hand-pulling, backpack sprayer, wick-applicator or dormant-season application. Note that reed canary grass may continue to emerge from the seed bank for 10 years!
- Temporarily increase burn frequency if woody invasions increase in cover. Note that sustained burn intervals of less than 3 years will negatively impact cool-season natives and wildlife.



Cost estimate

The estimated cost to restore an invasive perennial-dominated grassland to utility meadow in Minnesota is \$2,638 per acre plus a \$700 flat rate, for a minimum total of \$3,338, based on 2013 prices. Costs associated with site assessment and project planning are excluded from this estimate.

This cost estimate assumes vegetation removal includes:

- four broadcast herbicide applications
- one follow-up spot-spray herbicide application to invasive regrowth
- two controlled burns (whole site)

This cost estimate also assumes the site is broadcast seeded and cultipacked. The \$700 flat rate is a low-end estimate of hydrologic restoration (e.g. tile removal) that assumes a modest mobilization fee and includes the costs to excavate, remove tile, seal the ends, and backfill and compact the trench.

Post-seeding management costs include aftercare activities through year 3, specifically: mowing the wet prairie portions of the site six times, spot-spraying re-invading perennial weeds three times, and conducting three prescribed burns (burning no more than one third of the site per season). Actual project costs will be lower if a less-frequent mowing schedule is required. Long-term management costs are not included in this cost estimate but can be quite variable depending on site needs. Costs assume services and seed are purchased from restoration contractors and native seed nurseries.

Useful references

Going Native: A prairie restoration handbook for MN Landowners – MN Dept. of Natural Resources
<http://files.dnr.state.mn.us/assistance/backyard/prairierestoration/goingnative.pdf>

Invasive Plant Species Management & Identification – MN Dept. of Natural Resources
www.dnr.state.mn.us/invasives/terrestrialplants

Minnesota Noxious Weeds – MN Dept. of Transportation
www.dot.state.mn.us/roadsides/vegetation/pdf/noxiousweeds.pdf

Native Vegetation / Seed Mixes – MN Board of Water & Soil Resources
www.bwsr.state.mn.us/native_vegetation

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The Tallgrass Restoration Handbook for Prairies, Savannas, and Woodlands. S. Packard and C. F. Mutel, editors. 2007. Island Press, Washington, D.C.

What's Working: Invasive Species Control – MN Board of Water & Soil Resources
www.bwsr.state.mn.us/practices/whats_working-invasivespecies

