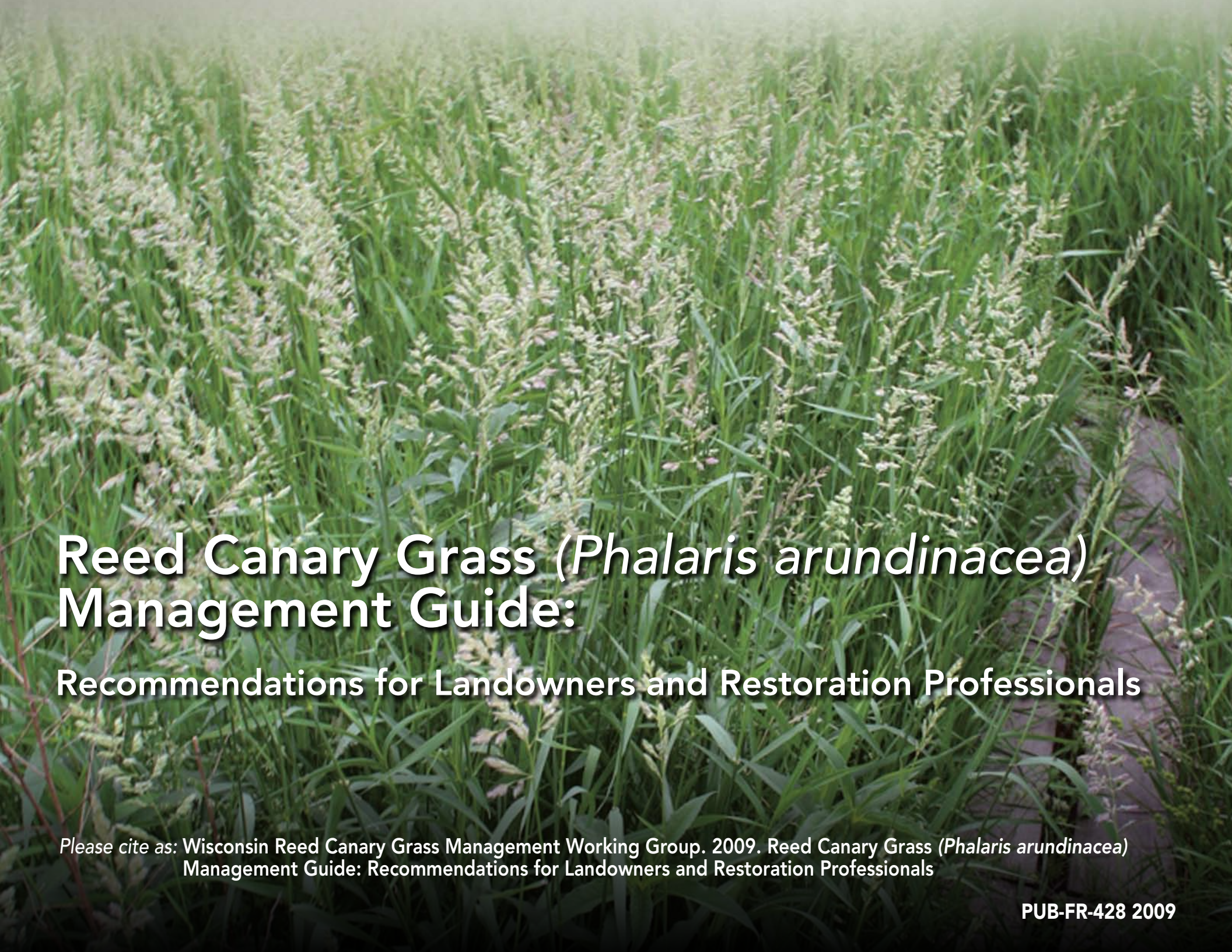

Reed Canary Grass *(Phalaris arundinacea)* Management Guide:

Recommendations for Landowners and Restoration Professionals

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RCG in Flower.

INTRODUCTION

How to use this manual

This guide walks you through the steps you can take to manage reed canary grass. Please start at the beginning and see TABLE 1 for a summary of treatment options that can be used. TABLE 2 will help you conduct a site assessment and decide which techniques are best suited to your budget and situation, and TABLE 3 lists native species that may provide competition for reed canary grass during restoration and management efforts

Reed canary grass (hereafter RCG) is a threat to the ecological integrity of countless wetlands across Wisconsin. Bernthal and Hatch (2008) found that 1 in 7 wetland acres in their southern and south-central Wisconsin study area were heavily dominated or co-dominated by RCG, and approximately 500,000 acres of wetlands in the entire state are infested. Reversing this pattern will require a large-scale, long-term, cooperative effort from scientists, policy makers, agency professionals, contractors, and non-profit organizations. It will also require cooperation from landowners. Consider taking an active role in the stewardship of our natural heritage through your actions to reduce RCG and promote native biodiversity in Wisconsin's wetlands!

This Reed Canary Grass Management Guide provides a template for local-scale RCG abatement, and it summarizes our current understanding of invasion biology and management tactics for RCG. It is our intention to periodically update this information as new results from ongoing research contributes to our understanding of this species.

What is the impact of RCG?

The impacts of reed canary grass on the habitats it invades are many. RCG greatly reduces botanical and biological diversity by homogenizing habitat structure and environmental variability (both of which correlate with species richness), alters hydrology by trapping silt and constricting waterways, and limits tree regeneration in riparian forests by shading and crowding out seedlings. RCG also decreases retention time of nutrients and carbon stored in wetlands, accelerating turnover cycles and reducing the carbon sequestration capabilities characteristic of diverse plant communities. Although its effects on wildlife are not yet entirely clear, preliminary data suggest that habitat specialist species (including several listed and protected species) are more adversely affected by reed canary grass dominance than habitat generalists.

Reed canary grass monotype(s).

LIFE CYCLE OF REED CANARY GRASS

Reed canary grass is an aggressive, cool-season perennial grass that invades and dominates a variety of wetland types. Invasion typically occurs after disturbance from erosion, sedimentation, nutrient enrichment, road salt inflows, hydrological instability or modification, and restoration efforts that expose bare ground and increase light availability. RCG responds positively to nutrient inputs, either as fertilizer or nonpoint agricultural runoff. Recently it was discovered that the presence of multiple disturbances, characteristic of many of Wisconsin's wetlands, can interact to accelerate the pace of invasion and native species displacement. Because of its vigorous growth in wet soils, RCG has been intentionally planted since the early 1900's by livestock producers for forage and seed production, and it has been used for erosion control and soil stabilization.

RCG reproduces by seed, by stem fragments, and by underground horizontal stems (rhizomes). Field populations have a high degree of genetic variability, and it has been estimated that more than 115 artificially-selected reed canary grass genotypes have been developed. It is difficult to determine the genetic origin of a particular RCG stand, although the presence of both green and purple panicles (grass flowers) in mid-June point to the existence of different genotypes within the stand. This species is both drought and flood tolerant. Growth and productivity peak twice during the growing season, first in late spring and again in late summer. These growth peaks are under separate genetic control, with leaf and inflorescence growth dominating in the spring and stem and rhizome growth dominating during the late summer peak.

RCG is one of the first wetland plants to emerge in the spring, enabling it to shade out native species that emerge later in the growing season. RCG can stay

continued

RCG root mass.

RCG tillering from rhizome.

RCG can root from the stem nodes late in the growing season.

Reed Canary Grass Life Cycle *continued*

green and actively growing well past the first killing frost in autumn. Once established, RCG is capable of rapid clonal expansion, which is enhanced by high nutrient and light availability. Species with clonal growth mechanisms expand either by employing a phalanx strategy, where tillers mass into an impenetrable clone expanding over short distances, or a guerilla strategy, where the parent plant forms long rhizomes and new tillers emerge at a distance from the parent clone. RCG uses both the phalanx and guerilla strategies. It more typically spreads by vegetative shoots arising from shallow rhizomes which can extend over 10 feet per year and form a thick impenetrable mat below the soil surface. These rhizomes have numerous dormant buds that represent the primary mechanism for resurgence when above-ground growth is removed. Rapid expansion, early growth, and the mulching effect of a dense litter layer all interact to facilitate the decline of native species. Few native species can persist indefinitely within a dense clone of RCG. To make matters worse, seeds and vegetative fragments readily float, making streams and ditch networks effective dispersal corridors, especially during periods of flooding. RCG seed is also dispersed by humans and wildlife, as the seed adheres readily to moist skin or fur, and is transported in clothing, equipment, and vehicles.

Some members of the genus *Carex* begin active growth in early spring and will compete with RCG for light, nutirents and space.

For a RCG seed to germinate, or for a vegetative fragment to become rooted, a disturbance that creates a bare space is initially required. Seed germination is bimodal, peaking in March-May and again in June-July. Seedlings are vulnerable to management treatments and inter-specific competition until they become well-established. New seedlings allocate most of their growth to accumulating underground reserves and developing tillers during the first growing season, generally only needing a single growing season to become established. Once established, RCG emerges in the spring from rhizome reserves accumulated during the previous growing season. By using both new energy from photosynthesis and reserve energy from rhizomes for spring growth, RCG quickly towers over most other species, preempting all available space and light. Since most spring growth occurs aboveground, the rhizome becomes depleted of starch until flowering. After flowering, rhizomes elongate and tiller. Then, in late summer, the plants store energy in the rhizome for over-wintering.

RCG is biennial with respect to flowering. Like many cool-season perennial grasses, development of flowering stems requires vernalization (a combination of short day photoperiod and cold temperatures). The new stems that develop from seed or rhizome buds require two years to develop panicles. Flowering stems often comprise only about 15% of the total stem density per unit area. In spite of this, seed production in monotypic stands can exceed several hundred seeds per plant, and seed can remain viable in the soil for several years. Seed subject to prolonged inundation, however, can lose viability in as few as 2 years.

MANAGEMENT CONSIDERATIONS

Understanding your adversary is key for effective management. Following recommendations from this guide does not guarantee control and/or eradication of RCG. Site-specific conditions and timing variables are likely to influence results. Here are a few important points to remember when considering a management program for this species:

1. RCG is persistent and tenacious due to its prolific seed rain and dispersal, robust vegetative growth, and dense network of underground rhizomes with thousands of dormant buds. Therefore, techniques used to suppress above-ground vegetative growth need to be paired with techniques that address the underground rhizomes and seed bank. Neglecting any one component can lead to frustration. Annen (2008) provides a detailed overview of rhizome bud bank persistence and how to incorporate accessory treatments into your management program.

RCG can be identified by the rounded stem with prominent ligule or papery membrane at the base of its leaves.

RCG prooduces seeds that float and stick to skin, fur, clothing and footwear.

2. RCG often invades native plant communities that are under stress or have been disturbed by past farming practices. When designing a management strategy, be sure to consider the probable cause(s) of the RCG invasion. Underlying conditions such as high nutrient levels in the soil, excessive sedimentation, or off-site factors should be addressed, if feasible, in a site-specific treatment plan.
3. Timing is important, so try to time your treatment to achieve multiple benefits. Mowing, burning or herbiciding with grass-specific chemicals after reed canary grass has achieved some growth in the late spring will reduce or eliminate seed development, allow release of native vegetation to compete with subsequent re-growth, and drain rhizome carbohydrate reserves at a time when they are already being depleted. These same practices applied later in the growing season may be much less effective.
4. Be persistent. Once you start a management effort, do not allow RCG to recover by suspending your management efforts for a growing season. If you are forced to select alternative management measures due to weather conditions, machinery breakdown or other unforeseen obstacles, try to do something to interrupt its growth each year. Generally, you will need to treat the site for a minimum of 3 to 5 years.
5. Sites with diverse vegetation at the onset of management tend to respond more positively to treatments than monotypic stands. The primary goal is to replace RCG with a diversity of native species. If your resources are limited, it may be better to focus management in mixed stands of RCG and native species. Timing management practices to favor an existing native plant community, along with interseeding additional species, can reverse RCG dominance in as little as 2 to 3 years. Once re-established, the native plant community will compete for sunlight, suppressing the RCG seed bank and re-growth from its dormant bud bank. In contrast, formerly cropped sites with few residual native plants or seed often have other invasive species present, have higher management costs, and require more years of treatment to establish a desirable replacement plant community.
6. Finally, practice adaptive management. No single recipe works under all conditions. Keep in mind that the techniques, tools and materials presented here do not include all available management options. Chemical formulations, for instance, are constantly changing, with new products introduced every year. After applying a series of treatments, monitor the plant community response and be willing to change your techniques when conditions favor a different approach. Suppression of RCG may result in other invasive or undesirable species attempting to colonize the site. Learn from your experiences and share them with others.

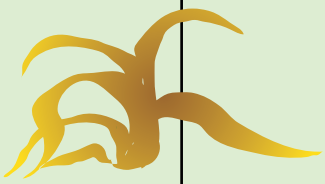
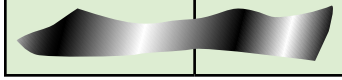
Remember:

- If using a chemical management technique, be sure to read and follow all labeling instructions. It is a violation of federal law to use an herbicide in a manner inconsistent with its labeling.
- Federal, state and local permits may be required when performing restoration work in wetlands or along waterways. Contact your local DNR office or county zoning administrator before initiating reed canary grass management work
- It is easy to spread reed canary grass seeds, rhizomes or other plant parts to new locations. Be sure to clean equipment, clothes and footwear before leaving a site.

For more information on reed canary grass, there is a list of resources and readings in the back.

TABLE #1 – Management Practices

Treatment	Effect	Should use	Could use	Should not use	Comments
Burning 	• Removes biomass and litter; may kill seeds on soil • Reduces available nitrogen over multiple burns • Releases seed bank of desirable/undesirable species • Stimulates dormant buds of RCG, rhizomes re-sprout • Can jumpstart growing season by warming soil	• To reduce RCG in late spring after RCG is active but before natives break dormancy • To force RCG to re-sprout and use reserves from rhizomes • Use in combination with other practices	• To remove thatch prior to a planting/seeding of desirable natives • To remove thatch and prompt early spring sprouting of RCG, which can then be treated with glyphosate or sethoxydim	• In fall to control RCG in short term; RCG benefits from high light conditions after fire • In early spring in mixed vegetation sites; RCG growth is encouraged by increased light, unless you plan to combine with another treatment • On organic sites if very dry	• Jumpstart occurs if burn done in fall or spring • No research on critical density of RCG that can be controlled by burning alone • Early burns will stimulate RCG; timing and frequency critical
Excavation 	• Removes rhizomes and seed bank • Removes sediment and nutrients • Alters hydrology	• Where material can be pushed to fill drainage ditches or where it can be moved off site; where deeper water is desired • During winter, to reduce soil compaction • During summer when wet sites are dry	• To remove alluvium over native wetland soils	• If there is no soil disposal site. • If compaction is an issue • If you don't want a deep-water marsh. • If there is a high-quality remnant plant community in area	• May cause soil compaction • RCG will rapidly re-colonize disposed soil; use caution when selecting a disposal site • Additional treatments will be necessary on drier sites • Seed with natives afterwards, except in the deepest water, or if a rich native seed bank exisits • May require special permits
Tree/shrub planting 	• When woody species overtop RCG, shade slows its growth • May change plant community • Adds structure to habitat	• Where herbaceous vegetation cannot gain a competitive advantage	• Where landscape is receiving RCG seed inputs • Where inflows can't be diverted • To connect existing woody patches	• Where management goal is to maintain grassland habitat	• Apply herbicide/mulch around newly planted trees/shrubs • Conifers may be the most effective at shading RCG • Need to control RCG for 3-5 years to allow trees to establish
Grazing 	• Reduces biomass in spring • Causes disturbance • Allows seedling establishment (good/bad) • Adds nutrients to system	• In highly disturbed sites to reduce RCG biomass • In fall, after a prescribed burn (RCG regrowth more palatable)	• To reduce biomass and height before herbicide treatment • To reduce seed production • Lightly, to sustain diversity	• During wet conditions in spring where trampling and compaction can damage a site • If there is a high-quality remnant plant community in area	• Effective at suppression only • Use proper stocking rates to prevent overgrazing of desirable species
Mowing & harvesting (haying) 	• Removes biomass and nutrients • Reduces RCG height • Similar to fire (promotes seed establishment, stimulates plant growth by increasing light)	• To reduce biomass before herbicide treatment • To remove P from site • Before RCG seed heads appear • To prepare for herbicide application	• As a substitute for fire (though not quite the same) • To change fire behavior by reducing fuel height	• Where tussocks and microtopography will be damaged • When grassland bird nesting habitat will be impacted. • If site is too wet for equipment	• On high quality sites, avoid use during growing season • Mow before RCG seed heads appear (boot to late boot stage)* to prevent seed production
Mowing without harvesting	• Reduces RCG height • Increases light—promotes competition • Depletes rhizome reserves • Creates dry biomass for fire	• To prepare for herbicide application • To stress RCG • When harvesting equipment is unavailable	• To change fire behavior by reducing fuel height	• Where tussocks and microtopography will be damaged • When grassland bird nesting habitat will be impacted. • If site is too wet for mower	• Mow before RCG seed heads appear (boot to late boot stage)* to prevent seed production • May impede establishment of natives, due to remaining mat of vegetation

Herbicide: broad spectrum (i.e. glyphosate, imazapyr) 	• Reduces plant height • Increases light—promotes competition • Depletes rhizome reserves • Creates dry biomass for fire	• On sites without native plants prior to reseeding. • To dry out RCG in order to burn • In late summer for maximum translocation to roots	• For treating clones within areas of natives • As an initial herbicide treatment on monotypic stands of RCG • If RCG height precludes use of other herbicides • In early spring or late fall, when RCG is live, but other plants dormant • On wet sites, with a surfactant approved for aquatic use	• On sites with desirable native plants actively growing • Soon after mowing/burning • When amphibians are on site (unless using Rodeo + a surfactant approved for aquatic use, as Roundup formulation can have negative effects on amphibians)	• Should be part of a continued control strategy, where natives are later introduced • Multiple treatments may be necessary • May need a permit for application on wetlands • Rhizome translocation less effective if temperature >70°F • Other treatments may influence herbicide effectiveness • Add ammonium sulfate to tank mix if water is hard
Herbicide: grass-specific (i.e. sethoxydim or fluazifop)	• Suppresses growth of most grasses • Releases native plant community (except for grasses)	• On sites with desirable, native, non-grass species • When active growth resumes after burning/ mowing, when RCG is 6-12" tall	• Following other herbicide treatments to control residual or re-emerging RCG	• For immediate eradication • If standing water is present • On sites with desirable grasses • When RCG is >12" tall	• Apply with surfactant/crop oil • > one treatment required • Effectiveness of sethoxydim is reduced by UV light • Add a water conditioner or acidifier if water is hard
Tillage 	• Exposes rhizomes to light; might activate dormant buds • Fragments rhizomes and may increase RCG density • Can contribute to erosion	• In combination with herbicide treatment (makes dormant rhizome buds respond to chemical control) • On monotypic, damaged sites to prepare for crop production	• To prepare a seedbed • To reduce RCG seed bank	• Where microtopography must be maintained. • Where RCG is mixed with desirable natives • On wet sites, where soil could become compacted, or equipment can get stuck • If offsite impacts are possible (sedimentation/erosion)	• For most effective control, combine with another treatment • Depth should be 4-6" to target RCG rhizomes • Till in spring or early summer • Repeated tillage can be effective if conducted every four weeks.
Altering hydrology 	• Prolongs/increases water levels • Prevents RCG seed germination • Kills RCG rhizomes	• If new water depth is > 12" • If high water can be maintained through the growing season.	• To promote the growth of emergent plants such as native cattail, burr-reed and bulrush species	• If new water depth is < 12" or site seasonally dries out • If other invasives are nearby (*Typha* x glauca, *Phragmites*)	• High water can promote growth of other invasives (*Typha* x glauca, *Phragmites*) if present in the area • May require special permits
Mulching / solarization with plastic or fabric 	• Non-selective treatment; shades out all plants • Kills adult plants • Kills RCG rhizomes	• For small, isolated RCG clones • For 1-3 consecutive years • On patches with high edge:area ratio, to facilitate recolonization by soil fauna	• To facilitate seeding or planting of natives	• Where desirable natives are mixed with RCG • For abatement on large sites • If native species are present • In areas with microtopography	• Resurgence from seedbank may occur when tarping removed • May have adverse effects on soil microorganisms • May alter soil chemistry • Not always an effective treatment

RCG= Reed canarygrass * For a description of growth stages see the bulletin, *Growth and Staging of Wheat, Barley and Wild Oat* at http://plantsci.missouri.edu/cropsys/growth.html

TABLE #2 – Site Assessment

Amount of RCG present[1]	Site characteristics/vegetation (recent <25 years)	Hydrology[2]	Inputs[3]	Tree Planting	Burn*	Excavate[4]*	Graze	Mow[5]	Broad-Spectrum Herbicide[6]	Grass-specific Herbicide[7]*	Tillage/ Farming	Raise water levels[8]	Seeding[9]
RCG Monotypes	< 25 years since tillage/farming, uniform topography[a]	Normally wet	High/low	E	2	2			2	2		1	1
		Seasonally dry		1	1	1	1	1	1	2	1		1
	> 25 years since tillage/farming or no ag history, uneven topography[b]	Normally wet	High/low	E	2					2		1	2
		Seasonally dry	Low		1			2		2			2
			High	2	1		2	2		2			2
	Shrub or forest edge[c]	Normally wet	High/low	E	2			1	2	2			2
		Seasonally dry		1	2			1	2	2			1
RCG Mixtures	Mixed with non-native grasses and/or weedy forbs	Normally wet	High/low	E	2	2			2	2		1	1
		Seasonally dry		1	1	1	1	1	1	2	1		1
	Mixed with native grasses	Normally wet	High/low		2				spot-spray	spot-spray			2
		Seasonally dry			1			2	spot-spray	spot-spray			2
	Mixed with native sedges, rushes and forbs	Normally wet	High		2					2			2
			Low		2					2			2
		Seasonally dry	High/low		1			1		1			2
	Mixed with shrub or forest matrix[d]	Normally wet	High/low	E						2			2
		Seasonally dry		1						1			2
	Discreet linear strips or clumps of RCG within a desirable native plant community				1			1	spot-spray	spot-spray			1

KEY TO TABLE
1 = Suitable treatment
2 = May be a suitable treatment, site conditions need to dictate treatment(s) methods
E = Experimental treatment

Superscripts
1- Monotypic stands contain >75% RCG with few other (often ruderal) species.
2- Hydrology- *Normally wet* refers to saturation and inundation for all or most of the growing season. *Seasonally dry* allows for access and treatment for a significant portion of the growing season.
3- Input refers to sediment, flooding, nutrient and stormwater inputs.
4- Excavated RCG sod and rhizomes should be placed on existing monotypic RCG stands, used in ditch filling or spread on cropland where it can be controlled. Check for any required state and local permits before starting and follow with a native seed mix tailored to the sites hydrology.
5- Mowing includes either harvesting and bailing or leaving clippings in place. To avoid negative impacts of mowing on nesting birds, be sure to consult a grassland bird specialist before selecting a mowing date.
6- Broad spectrum herbicides that have been experimentally tested or are currently being tested for RCG control include glyphosate, imazapyr, and amitrole.
7- Grass specific herbicide should not be applied to open water or areas where standing water is present. Consult herbicide label for application instructions.
8- To be effective, water levels should be raised > than 1 foot above RCG crown buds for more than 3 months of the growing season for more than one growing season.
9- Seeding- Reference the seed list and seeding should typically be used with other treatments.
a- Sites with uniform topography lack microtopographic features.
b- Sites with uneven topography possess microtopographic features (springs, seeps, boulders, tussocks, internal drainage channels, snags, downed logs, etc.) and may harbor suppressed native plant communities or remnant native seed banks.
c- Shrub or forest edge refers to the RCG population existing on the edge of the shrub or forest wetland
d- Shrub or forest matrix refers to the RCG population existing within the shrub or wetland wetland with a patchy distribution
** refers to the potential need for local, state and/or federal permitting*

NOTE: *Optimal results will be obtained by using two or more treatments in combination over a period of years, combined with active reseeding of native species. Site conditions should dictate the treatment(s) methods. Always read the herbicide label before application.*

SPECIES RECOMMENDED FOR REED CANARY GRASS REPLACEMENT

Introduction

Bare ground created by management activities (e.g. removing trees, constructing scrapes, re-contouring wetlands, using nonselective herbicides) should be reseeded quickly, as RCG can rapidly colonize these sites after the disturbance. When reseeding for RCG abatement, your goal should be to create a closed canopy of herbaceous species as quickly as possible, before RCG can re-establish. Research has shown that a closed herbaceous canopy will filter sunlight, increasing the amount of far-red (FR) light reaching the soil surface. As transmission of far-red light increases (relative to blue light), the percentage of RCG seeds that germinate decreases. Furthermore, RCG displays very low establishment rates and low seedling aggressiveness under light-limited conditions. The ideal endpoint planting, therefore, is one that exhibits a complex, multi-species herbaceous canopy that is vertically and phenologically layered. The best way to ensure this is to plant a diverse species mixture of different shapes and forms (e.g., sedges, rushes, cool- and warm-season grasses, and forbs).

***Helenium autumnale* is an effective competitor.**

Purpose of this Species List

We recommend species that have potential to coexist with RCG in situations where the latter is under stress from management treatment. Proactive re-vegetation with a diversity of native species should be a component of any RCG abatement project. Research has demonstrated that competition from established native species augments and accelerates RCG management efforts. Restoring hydrology, fire regime, etc., is important, but the idea that these will facilitate passive immigration and reestablishment of native vegetation generally lacks empirical support because the present landscape is often too fragmented for adequate gene flow between existing natural areas.

Guidelines for Planting

Seeding rates – Seed bare ground at high rates, 7 to 10 pounds/acre (60 – 100 seeds/ft^2) and augment seeding with plugs of live plants where feasible after RCG propagules have been eliminated. RCG monocultures should also be seeded at this rate after management efforts have significantly weakened RCG resurgence capacity. **Note:** do not rely on a one-time treatment to adequately manage a RCG monotype. Mixed stands can be inter-seeded at a lower rate, 4 to 7 pounds/acre (40 – 60 seeds/ft^2), depending on your budget and the density and composition of native species already present. Consider augmenting seedings with live plants (plugs), rhizome fragments (sedges), rooted tubers (emergent plants), or even entire tussocks or sod transplants if a suitable (non-protected) donor site is available. Plugs should also be used in areas prone to erosion where seeds can easily be washed away. When plugging, keep in mind that animal browsing, dry weather, and transplant shock can reduce establishment. You may have to install browsing exclosures around plugs and water them regularly during the first growing season. Dip plugs in rooting hormone immediately prior to planting to improve establishment.

Timing and Site Preparation – Generally, sowing seed in late fall/winter (frost seeding) favors establishment of most forbs, sedges, and cool-season grasses, while spring seeding favors establishment of warm-season grasses. Plugs of most species should be planted in spring to take advantage of wet spring weather and to ensure they have one complete growing season to prepare for overwintering (consult with your local seed distributor if you are unsure of when to plug certain species). To frost seed, one proven method is to burn the site after the first hard frost and broadcast seed onto bare ground. If possible, use a cultipacker to mend the sown seed to the soil surface. Subsequent freezing and thawing of the soil will work the seed to proper depth over the winter. An advantage of frost seeding is that seed does not have to be stratified prior to planting. A disadvantage is that weather conducive to stratification cannot be ensured. For sites that have been re-contoured, ask the contractor or agency representative to include microtopographic features. Increasing microtopography will add diversity to the microhabitats available to species and promote canopy complexity. If feasible, consider installing a passive water control gate to stabilize water levels during plant establishment and to increase long-term management capability.

Adaptive Seeding – Species vary in their germination requirements, and site conditions can vary considerably by year. Consider boosting initial high-density plantings with multiple-year seedings at reduced planting densities. This is a way to hedge your bets against adverse conditions during any single growing season, and it will help to recharge the native species seed bank. You may also need to adopt a mosaic planting strategy for sites that are still being actively managed during seedling establishment or if bare ground persists.

continued

Recommended Native Species *continued*

RCG spreads easily by vehicles and water, and is one of the first wetland plants to green up in the spring.

Financial Considerations – Compare prices! Costs can vary substantially among local nurseries. Plugs, rootstock, rooted tubers, and rhizome fragments are considerably more expensive than seeds. To achieve a high-diversity planting on a budget, design your seed mix to include one dominant (matrix) species, a few subdominant species and a few species of intermediate abundance, with most species present in rare or uncommon abundance. Try to imitate this natural pattern in your seed mix. This approach reduces costs because the matrix and sub-dominant species are relatively inexpensive while the less common species are often the most expensive. Keep in mind that differing germination requirements of individual species and rapid establishment of aggressive native species (e.g. *Panicum virgatum*) can make this goal difficult to achieve in a practical setting. If you are on a tight annual budget, one strategy is to spread out costs with consecutive-year reseedings. However, doing this may lead to increased costs for weed control because less space will be occupied by desirable native species. Frank Egler's "Initial Floristic Composition Model" predicts that the most diverse endpoint community will be the one with the most native propagules present at the outset (bare ground stage). Thus, an ounce of prevention (initial seeding at a high rate) is worth a pound of cure (consecutive years of chemical and mowing costs required to suppress secondary weed outbreaks).

Cool-Season Cover Crops/Companion Crops – Realistically, it will take several years for a native planting to mature to the point of canopy closure. RCG and/or other weeds can quickly (re)establish during the interim, particularly if there is off-site impact and propagule influx from adjacent non-treated areas. One way to forestall subsequent infestations (and associated abatement costs) is by planting a rapidly establishing cover crop or companion crop along with your native species mixture. Cover crops are typically annual species (e.g., annual ryegrass (*Lolium multiflorum*), or beggarticks (*Bidens* sp.)), whereas companion crops are short-lived perennials (e.g., Virginia wild rye (*Elymus virginicus*) or Canada wild rye (*Elymus canadensis*)). In theory, cover crops and companion crops reduce competition from weeds while native perennials are establishing. Cover crop seed is available from most native seed nurseries and also from local farm seed suppliers. When purchasing cover crops from local farm seed dealers, be sure to request certified weed-free seed. NOTE: do not include cover crop seeding densities when tabulating seeding rates for a planting.

Other Considerations – Sedges of the genera *Carex* and *Scirpus* (now called *Schoenoplectus, Bolboschoenus, Isolepis*, or *Trichophorum*) can be difficult to establish, particularly at sites with flashy or variable hydrology. Consider using a mix of seeds and plugs of these taxa. Alternatively, some sedge species can be propagated from rhizome fragments. Also, recent research has shown that *Carex* seeds have limited storage life. Sow *Carex* seeds in the same growing season you collect them, or, if ordering seeds from a nursery, inquire about the collection date for the seed lot you are ordering. For sites with variable hydrology, consider planting species that are adapted to grow in more than one hydrologic regime or species with plastic morphological responses to water level variations (e.g. *Polygonum amphibium*) so that RCG cannot take advantage of fluctuating water level disturbances to recolonize a site. When collecting seed, remember to increase your seeding rate (by at least 50%) because site-collected seed typically has a lower germination rate (lower titer or PLS-pure live seed) than nursery seed. Use of PLS seed in plantings has been shown to make a big difference in germination of desired endpoint species. If not used immediately, store any seed in a cool, dry location that is not exposed to direct sunlight or extreme temperature fluctuations. Plugs, sprigs, or live plants should be set out as soon as possible. If this is not possible, store in damp peat moss or sand in a cool location away from direct sunlight or follow instructions and recommendations from the supplier. Try to collect or purchase seeds from source populations that are located as close to the planting site as possible. Most seed nurseries keep records of seed genotype and label their seed lots with this information. If your goal is not ecological restoration of a native plant community, contact your local USDA-Natural Resources Conservation Service for alternative seeding options.

RCG re-growth following one glyphosate herbicide application. It will take multiple growing seasons of management actions to reduce RCG.

RCG mowed and prepared for herbicide application.

GUIDELINES FOR USING TABLE 3 TO CUSTOMIZE SEED MIXTURES

- ✔ Phenology mix should be a minimum of 5 early species, 5 mid, and 5 late season (time of peak productivity).
- ✔ Use a low Graminoid/Forb ratio (1:4 or lower) to maximize canopy closure.
- ✔ Use a minimum of three late successional species.
- ✔ Use a minimum of 15 species (50% early successional, 25% mid successional, and 25% late successional).
- ✔ A complex canopy with mixed height and variable leaf morphology should be implicit in seed designs.
- ✔ Consider cool season and early emerging annual species to accelerate canopy closure and provide competition for seedling RCG.
- ✔ For woody species, employ protective shelters and tall, mature stock. Consider a tree-planting mix that includes evergreens to provide early and late-season shade.

Key

Species ranking: 1 = highly recommended/high importance; 2 = moderate importance; 3 = low importance or importance unknown

Phenology: Early (April – May peak productivity), Mid (June – mid July peak productivity), Late (mid July – September peak productivity).

Trees: Trees should be taller than RCG, 1" minimum dbh is recommended. Use of a weed barrier and deer/rodent protection is also recommended.

Successional Stage: Early (25-50% bare ground, many weedy or short-lived species present), Mid (10-25% bare ground, self seeders common, a few species often dominate), Late (0-10% bare ground, many conservative species are present, plant community is stable with few canopy gaps).

Hydrology

Mesic plant community type:

Deep, well-drained to moderately well-drained soils with moderate permeability and high available water capacity. These are typically mineral soils with no equipment limitations throughout the growing season.

Wet-mesic plant community type:

Deep, somewhat poorly-drained soils with moderately slow permeability and a seasonal high water table to within 1 ft of the surface for part of the growing season. Soils are mineral or shallow organic with moderate equipment limitations during the growing season.

Wet plant community type:

Deep poorly-drained to somewhat poorly-drained soils with slow permeability and a seasonal high water table at or near the surface for much of the growing season. Soils can be mineral or deep organic with severe equipment limitations for most of the growing season.

TABLE #3a – Species recommended for reed canary grass replacement

Latin name	Common name	Species Preferred Ranking	Successional Stage			Phenology	Hydrology	Geographic Area	Comments
			Early	Mid	Late				
Grasses									
Calamagrostis canadensis	Canada blue-joint	1			x	mid	wet/wet mesic	statewide	rhizomatous
Cinna arundinacea	Wood reed	3		x	x	mid	mesic	more common south	semi shade-- may be good in tree planting areas, prefers loam soils
Cinna latifolia	Drooping wood reed	3		x	x	mid	mesic	more common north	semi shade-- may be good in tree planting areas, prefers loam soils
Echinochloa muricata	Coastal barnyardgrass	1	x			mid	wet mesic	statewide	annual; use as cover crop
Echinochloa walteri	American barn-yardgrass	1	x			mid	wet mesic	statewide	annual; use as cover crop
Elymus canadensis	Canada wild rye	1	x			early-mid	mesic	more common south	semi shade-- may be good in tree planting areas
Elymus riparius	Riparian wild rye	1	x			early-mid	wet mesic	more common south	semi shade-- may be good in tree planting areas
Elymus virginicus	Virginia wild rye	1	x			early-mid	wet mesic	more common south	semi shade-- may be good in tree planting areas
Glyceria canadensis	Rattlesnake grass	2	x	x		mid	wet/wet mesic	more common north	can be difficult to establish
Glyceria grandis	Reed manna grass	2	x	x		mid	wet/wet mesic	statewide	shorelines, shallow water
Glyceria striata	Fowl manna grass	2	x	x		mid	wet/wet mesic	more common south	shorelines, shallow water
Leersia oryzoides	Rice cut-grass	1	x	x		late	wet	statewide	does well in organic soils
Muhlenbergia racemosa	Wild timothy	1	x	x		early-mid	wet mesic	statewide, less common south-west	may be resistant to grass-specific herbicide, prefers loamy soils
Panicum virgatum	Switch grass	3		x		late	wet mesic/mesic	statewide	bimodal, prefers sandy soils
Poa palustris	Fowl meadow-grass	2	x	x		early	wet mesic	more common south	statewide
Spartina pectinata	Prairie cord grass	1			x	mid	wet mesic/mesic	statewide	Try to use plugs, rhizomatous, prefers mineral soils

Latin name	Common name	Species Preferred Ranking	Successional Stage			Phenology	Hydrology	Geographic Area	Comments
			Early	Mid	Late				
Other Graminoids									
Bolboschoenus fluviatilis	River bulrush	1		x	x	mid	wet/wet mesic	statewide	Rhizomatous, tolerates standing water
Carex annectens	Yellow head fox sedge	1	x	x		early	wet/wet mesic	statewide	
Carex atherodes	Hairy-leaved lake sedge	2			x	early	wet	statewide	use on wetter sites
Carex bebbii	Bebb's oval sedge	2		x	x	early	wet mesic/mesic	statewide	use on drier sites
Carex comosa	Porcupine sedge	2			x	early	wet/wet mesic	statewide	
Carex crinita	Fringed sedge	2		x	x	early	wet mesic	more common north	common generalist
Carex emoryi	Emory's sedge	3			x	early	wet mesic	statewide	
Carex hystericina	Bottlebrush sedge	2		x	x	early	wet/wet mesic	statewide	common generalist
Carex lacustris	Lake sedge	1		x	x	early	wet/wet mesic	statewide	wettest sites, rhizomatous
Carex pellita	Broad-leaved wooly sedge	2		x		early	wet/wet mesic	statewide	rhizomatous, use vegetative plugs
Carex rostrata	Beaked sedge	2			x	early	wet mesic	northern	
Carex scoparia	Broom sedge	2	x	x		early	wet/wet mesic	statewide	common generalist
Carex stipata	Common fox sedge	1	x	x		early	wet/wet mesic	statewide	common generalist
Carex stricta	Tussock sedge	1			x	early	wet/groundwater	statewide	use plugs or very fresh seed; rhizomatous
Carex trichocarpa	Hairy-fruit lake sedge	1			x	early	mesic/wet mesic, wet	southern and north-western WI	rhizomatous, use vegetative plugs
Carex tuckermanii	Tuckerman's sedge	2		x		early	forest	statewide	shade tolerant
Carex utriculata	Common yellow lake sedge	2			x	early	wet/wet mesic	southern	wettest sites, rhizomatous
Carex vulpinoidea	Brown fox sedge	1	x	x		early	wet mesic	statewide	common generalist
Juncus effusus	Soft rush	1		x		early	wet	statewide	
Scirpus atrovirens	Dark green bulrush	1	x	x		mid	wet/wet mesic	statewide	establishes well from seed
Scirpus cyperinus	Woolgrass	1		x	x	mid	wet/wet mesic	statewide	slow growing, tolerates standing water
Schoenoplectus tabernae-montani	Softstem bulrush	2		x	x	mid	wet	statewide	tolerates standing water, prefers silty/clay soils

Latin name	Common name	Species Preferred Ranking	Successional Stage			Phenology	Hydrology	Geographic Area	Comments
			Early	Mid	Late				
Forbs									
Angelica atropurpurea	Angelica	3		x	x	early	wet/groundwater	statewide	monocarpic perennial
Apocynum sibiricum	Clasping dogbane	1	x	x		mid	mesic/wet mesic	statewide	clonal, grows in patches
Asclepias incarnata	Swamp milkweed	1		x		mid	wet mesic	statewide	likes occasional disturbance
Aster firmus	Shiny-leaved aster	1	x	x	x	late	mesic/wet mesic	south and east WI	rhizomatous
Aster lanceolatus	Marsh aster	1		x		late	mesic/wet mesic	statewide	rhizomatous
Aster novae-angliae	New England aster	1		x		late	mesic/wet mesic	south and east WI	establishes well from seed
Aster puniceus	Swamp aster	1	x	x	x	late	wet/wet mesic	statewide	rhizomatous
Bidens cernuus	Nodding bur marigold	1	x			mid	wet mesic	statewide	annual
Bidens frondosa	Common beggars-ticks	1	x			mid	wet mesic	statewide	annual
Hasteola suaveolens	Sweet Indian plantain	2		x	x	mid	mesic/wet mesic	southern WI	spreads from seed
Cicuta maculata	Water hemlock	2		x		mid	wet/wet mesic	statewide	perennial
Eupatorium maculatum	Spotted Joe pye weed	1		x	x	mid	wet/wet mesic	statewide	establishes well from seed
Eupatorium perfoliatum	Common boneset	1		x	x	mid	wet/wet mesic	statewide	establishes well from seed
Euthamia graminifolia	Grass-leaved gold-enrod	1		x	x	mid-late	wet mesic/mesic	statewide	rhizomatous
Helenium autumnale	Sneezeweed	1		x	x	mid	wet/wet mesic	statewide	establishes well from seed
Helianthus giganteus	Tall sunflower	1		x	x	late	wet mesic	more common north	important for wildlife, rhizomatous
Helianthus grosseserratus	Sawtooth sunflower	1		x	x	late	wet/wet mesic	more common southern	may dominate your planting, rhizomatous
Heracleum maximum	Cow parsnip	3		x	x	early	wet mesic/mesic	statewide	semi shade-- may be good in tree planting areas
Hypericum pyramidatum	Giant St.John's wort	2		x	x	mid	wet mesic/mesic	statewide	semi shade or full sun
Impatiens capensis	Jewelweed/touch-me-not	1	x			early	wet/wet mesic	statewide	annual, semi shade or sun
Lycopus americanus	American water hore-hound	3	x			mid	wet/wet mesic	statewide	does not persist without disturbance
Lycopus uniflorus	Northern bugleweed	2				mid	wet/wet mesic	statewide	can persist without disturbance
Mentha arvensis	Wild mint	2	x	x		mid	wet/wet mesic	statewide	establishes well from seed
Mimulus ringens	Monkey flower	3	x			mid	wet mesic/mesic	statewide	establishes well from seed
Monarda fistulosa	Bergamot	1	x	x	x	mid	wet mesic/mesic	statewide	establishes well from seed
Penthorum sedoides	Ditch stonecrop	3	x			mid	wet mesic/mesic	statewide	establishes well from seed
Polygonum amphibium	Water smartweed	2	x	x		mid-late	wet/wet mesic	statewide	comes in on its own, not usually planted
Polygonum pensylvanicum	Pennsylvania knotweed	2	x			mid-late	wet/wet mesic	statewide	annual
Pycnanthemum virginianum	Common mountain mint	2		x	x	mid	wet/wet mesic/ mesic	more common south	long-lasting, rhizomatous

Latin name	Common name	Species Preferred Ranking	Successional Stage			Phenology	Hydrology	Geographic Area	Comments
			Early	Mid	Late				
Forbs *continued*									
Ratibida pinnata	Yellow coneflower	1	x	x		mid	wet mesic/mesic	statewide, not as common north	good self seeder, colorful
Rudbeckia hirta	Black-eyed Susan	1	x			mid	wet mesic/mesic	statewide	establishes well from seed
Rudbeckia laciniata	Wild golden glow	1	x	x		mid	wet mesic	statewide	may have advantage in light shade
Rudbeckia triloba	Brown-eyed Susan	1	x			mid	wet mesic	east and southeast	establishes well from seed
Rumex orbiculatus	Water dock	2			x	mid	wet/wet mesic	statewide	grows in very wet sites, prefers organic or loamy soils
Silphium perfoliatum	Cup plant	1		x	x	mid-late	wet mesic/mesic	south and west	establishes well from seed, may dominate a planting
Solidago gigantea	Giant goldenrod	1	x	x		late	wet mesic/mesic	statewide	may dominate; rhizomatous
Solidago riddellii	Riddell's goldenrod	3		x		late	wet/wet mesic	more common south	Requires alkaline soils
Stachys palustris	Hedge nettle	2		x	x	mid-late	wet/wet mesic	statewide	
Verbena hastata	Blue vervain	1	x			mid	wet/wet mesic/ mesic	statewide	establishes well from seed
Vernonia fasciculata	Ironweed	2		x	x	mid-late	wet mesic/mesic	statewide	slow to establish

Restored wet prairie on Madison Audubon Society land in Jefferson County, Wisconsin.

TABLE #3b – Tree and shrub species recommended for reed canary grass replacement

Latin name	Common name	Species Preferred Ranking	Phenology	Hydrology	Geographic Area	Comments
Trees/shrubs (rootstock) (Trees should be taller than RCG, 1" minimum dbh is recommended. Use of a weed barrier and deer/rodent protection is also recommended.)						
Abies balsamea	Balsam fir	1	early-mid	wet/wet mesic	northern	not preferred deer food
Acer rubrum	Red maple	2	early-mid	wet mesic/mesic	statewide	Slow-growing, mineral soils
Acer saccharinum	Silver maple	1	early-late	flood tolerant	more common south	Fast-growing, weak limbs, mineral soils
Alnus incana subsp.rugosa	Speckled alder	1	early-mid	wet/wet mesic	statewide but more common north	invasive to uplands
Cephalanthus occidentalis	Buttonbush	2	early	wet/wet mesic	more common south	Can grow in shallow water
Cornus amomum	Silky dogwood	1	early-mid	wet/wet mesic	statewide	browsed heavily by deer
Cornus racemosa	Grey dogwood	2	early-mid	wet mesic/mesic	more common south	mineral soils, can be invasive
Cornus stolonifera	Red-osier dogwood	1	early-mid	wet/wet mesic	statewide	browsed heavily by deer
Fraxinus nigra	Black ash	3	early-late	wet/wet mesic	more common north	emerald ash borer concern keep <10% of trees planted. Better for wet sites.
Fraxinus pennsylvanica	Green ash	2	early-late	wet mesic/mesic	statewide	emerald ash borer concern keep <10% of trees planted
Ilex verticillata	Winterberry	1	shade tolerant	wetmesic/ mesic	more common north	Good for songbirds, prefers sandy/loamy soils
Larix laricina	Tamarack	1	early-late	wet/wet mesic	more common north	sensitive to flooding, does well in organic soils
Physocarpus opulifolius	Common ninebark	1	mid-late	wet mesic/mesic	more common south	somewhat drier sites, mineral soils
Picea glauca	White spruce	1	late	wet mesic/mesic	northern	not preferred deer food
Picea mariana	Black spruce	1	late	wet/wet mesic	northern	not preferred deer food, prefers acidic soils
Pinus strobus	White pine	3	late	wet mesic-mesic	statewide, more common north	Protect from deer browse, somewhat drier sites
Populus balsamifera	Balsam poplar	1	early-mid	wet/wet mesic	northern	
Populus deltoides	Cottonwood	1	early-mid	flood tolerant	statewide	invasive to uplands
Populus grandidentata	Bigtooth aspen	1	early-mid	wet mesic/mesic	statewide	somewhat drier sites, invasive to uplands
Populus tremuloides	Quaking aspen	2	early-mid	wet mesic/mesic	statewide	invasive to uplands
Quercus bicolor	Swamp white oak	1	late	wet mesic/mesic	southern	somewhat flood tolerant (short duration flooding)
Rhamnus alnifolia	Native buckthorn	2	mid	wet/wet mesic	Door County, north	Prefers mineral soils with high ph
Ribes americanum	Black currant	2	early-mid	wet/wet mesic	statewide	shade tolerant shrub
Salix nigra	Black willow tree	1	early-mid	wet/wet mesic	statewide	
Salix sp. (Bebb's, discolor, exigua)	Willows (Bebb's, pussy, sandbar)	1	early-mid	wet/wet mesic	statewide	some species can be invasive, especially s.exigua
Sambucus canadensis	Elderberry	1	mid	wet/wet mesic	statewide	good wildlife shrub, good in organic soils
Spiraea alba/tomentosa	Meadowsweet/ stee-plebush	2	mid	wet/wet mesic	statewide but more common north	common in fens/groundwater wetlands, bogs
Viburnum lentago	Nannyberry	1	mid	wet mesic/mesic	more common south	clonal
Viburnum opulus subsp. trilobum	High bush cranberry	2	mid	wet mesic/mesic	statewide	shade tolerant shrub, mineral soils

Following are examples of 15-species seed mixes. You may want to add or substitute additional species to your mix to compensate for changes in hydrology, climate and other site conditions affecting seed germination.

Wet Meadow 1	Wet Meadow 2	Sedge Meadow	Low Forest
Asclepias incarnata	*Asclepias incarnata*	*Asclepias incarnata*	*Acer saccharinum*
Aster puniceus	*Bidens cernuus*	*Aster firmus*	*Calamagrostis canadensis*
Bidens frondosa	*Calamagrostis canadensis*	*Bolboschoenus fluviatilis*	*Carex comosa*
Calamagrostis canadensis	*Carex stricta*	*Calamagrostis canadensis*	*Carex lacustris*
Carex scoparia	*Carex vulpinoidea*	*Carex comosa*	*Cinna arundinacea*
Carex stipata	*Cicuta maculata*	*Carex lacustris*	*Cinna latifolia*
Cicuta maculata	*Echinochloa muricata*	*Carex stricta*	*Cornus stolonifera*
Elymus canadensis	*Elymus virginicus*	*Carex vulpinoidea*	*Elymus virginicus*
Eupatorium maculatum	*Eupatorium perfoliatum*	*Elymus virginicus*	*Eupatorium maculatum*
Helianthus giganteus	*Glyceria grandis*	*Eupatorium maculatum*	*Fraxinus nigra*
Leerzia oryzoides	*Helenium autumnale*	*Impatiens capensis*	*Muhlenbergia mexicana*
Rudbeckia hirta	*Monarda fistulosa*	*Juncus effusus*	*Populus tremuloides*
Scirpus cyperinus	*Ratibida pinnata*	*Pycnanthemum virginianum*	*Rudbeckia laciniata*
Solidago gigantea	*Scirpus atrovirens*	*Rudbeckia laciniata*	*Scirpus cyperinus*
Spartina pectinata	*Verbena hastata*	*Scirpus cyperinus*	*Viburnum lentago*

Former RCG monotype restored to native wet meadow on private land in Dodge County, Wisconsin (See also photo above Table 3a).

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Restored wet meadow on private land in Sauk County, Wisconsin.

For more information on reed canary grass, please visit:

Delaware River Invasive Plant Partnership, http://www.paflora.org/DRIPP.html

Illinois Nature Preserves Commission, Vegetation Management Guidelines, http://www.inhs.uiuc.edu/chf/outreach/VMG/rcanarygr.html

Invasive Plants Association of Wisconsin, http://ipaw.org/invaders/reed_canary_grass/index.htm

Invasive Plant Atlas of New England, http://invasives.eeb.uconn.edu/ipane/

Mid-Atlantic Exotic Pest Plant Council, Inc., http://www.ma-eppc.org

National Invasive Species Information Center, http://www.invasivespeciesinfo.gov

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