Reed Canary Grass Management Workshop
MIPN 2008

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Overview of RCG Methods of Spread
+ Summary of Recent Control Based Research

- Craig A. Annen, Integrated Restorations, LLC
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- Chris Reyes, University of Wisconsin-Madison
- Joy Zedler and many students
  University of Wisconsin-Madison
Invasion Mechanisms

Two components to RCG invasion:

1. Site disturbances
2. Invasive/competitive characteristics of RCG

New RCG invasion requires disturbances that create bareground areas

Multiple disturbances interact synergistically to accelerate the rate of invasion

Lindig-Cisneros & Zedler (2001 et seq.)
Conditions that predispose sites to RCG invasion:

- Nutrient enrichment
- Hydrological alteration or modification:
  - Flashy hydroperiod (stormwater systems)
  - Prolonged drawdown (ditching/drainage)
- Sedimentation
Characteristics of highly competitive species
(Grime 1973; Prach & Pysek 1999)

1. Tall perennial
2. Wind-pollinated
3. Responds positively to nutrient enrichment
4. Responds to soil moisture
5. Capable of intense lateral spread
6. Plastic response to environmental variability
7. Long growing period
8. Tendency to deposit a dense litter layer
9. High potential growth rate
RCG expands on two fronts

- Rhizomes are short and closely spaced = Leading Edge
- Rhizomes are long and wide spaced = Spotty Expansion
• RCG displays a consolidation strategy (Maurer & Zedler 2002)

• Spot expansion tillers do not require bareground disturbance
What makes RCG control so difficult?
Challenges of RCG Control

- Expensive
- Often too costly or impractical to ameliorate underlying causes of invasions
- Difficulty reestablishing native species under some treatment regimes
- Secondary outbreaks of other invasives
- RCG is ubiquitous in the landscape
- Requires multiple-year effort
- Nonselective herbicides can eliminate non-target species
Resurgence Mechanisms in RCG

- The ability to recover from treatments

1. **Active seed bank**
   - 31 – 437 viable seeds/m²
   - Estimated viability: 2 years (Comes et al. 1978)

2. **3000 – 6500 buds/m²** (Reyes, 2004)

3. **Rhizome apical dominance**
   - 47 – 76% of rhizome buds in a RCG population are metabolically dormant (Reyes 2004)
     - Herbicides translocate only to apex due to apical dominance; most lateral buds are unaffected and can resprout.
During Application

- $^{14}\text{C}$ glyphosate
- $^{14}\text{C}$ sethoxydim

CH$_2$O/herbicide

Post-Application

- Apex and distal buds killed
- RCG resprouts from lateral buds
Short-Circuiting Apical Dominance (Annen, 2008)

1. Tillage (followed by herbicide app.)
   - Decapitate rhizomes to encourage lateral growth
Tillage + Sethoxydim

(Annen 2008)

- Pretreatment rotovation enhanced RCG suppression with sethoxydim:
  - 35% greater suppression after one year
  - 443% after two consecutive years
- Tillage also enhanced native species abundance (up to 127%) and diversity (up to 87%)
Tillage + Glyphosate

(Kilbride & Paveglio 1999; Paveglio & Kilbride 2000)

- Disking enhanced RCG suppression with glyphosate
  
  36 – 90% greater suppression than herbicide only after one year of treatments

- Tillage also enhanced native species richness (up to 379%) and diversity (up to 302%)
RCG Resurgence Capacity
(1-year post treatment)

- Tillage + sethoxydim reduced RCG resurgence capacity 228% greater than herbicide application alone

*In general, coupling tillage to herbicide application results in longer carryover effects than solitary herbicide use*
Tillage has drawbacks…

- Destroys microtopographic heterogeneity and homogenizes soil variability
- Repeated tillage can compact and clod soil
- Disrupts VAM colonization
- Limited by site accessibility and/or site conditions
- Can surface weed seeds, especially in restored landscapes
Are there any no-till methods for short-circuiting apical dominance?
Short-Circuiting Apical Dominance

Plant Growth Regulator (PGR) Pretreatments

- Plant hormone analog sends false molecular signal for rhizome to initiate lateral growth
- Distributes herbicide more uniformly within rhizome

(Annen, 2008)
4,000 ppm 2:1 CCC/etephon (May)

Control

“Activated” lateral rhizome buds
RCG Resurgence Capacity (1-year post treatment)

The ability to recover from treatments

- CCC/ethephon pretreatment reduced RCG resurgence capacity 26% (Annen 2008)
- Kinetin pretreatment reduced resurgence capacity 169% (Annen, in progress)
Cost Analysis

- Sethoxydim application only $100/acre
  (3.75 pints/acre)
- Tillage & sethoxydim application $140/acre
  (3.75 pints/acre)
- CCC/ethephon & sethoxydim $530/acre
  (1.25 pints/acre and 3.75 pints/acre)
- Kinetin & sethoxydim application $115/acre
  (Paired apps @ 1 pint/acre and 3.75 pints/acre)
Treatment responses often depend upon initial site conditions
PGR + Sethoxydim plot
(Complex, multi-layered canopy)
*Most positive response to treatments*
PGR + Sethoxydim plot (Mixture of sedges and RCG)

*Intermediate response to treatments*
PGR + Sethoxydim plot (RCG-dominated)

Least positive response to treatments
Which sites are worth the effort and cost?

- Mixed stands – <50% RCG with ESTABLISHED native species or intact native species seed bank
- Isolated sites with low off-site impact
- When chronic disturbances can be ameliorated
- Younger RCG stands
Synergizing Treatments with Integrated Control Programs

- **Rx fire only**: Negligible effects (Reyes 2004)
- **Mow only**: Increase in stem density (Tu, 2006)
- **Till only**: 61% increase in stem density (Kilbride & Paveglio 1999)
- **Herbicide only**: 50% suppression (Annen et al. 2005)
- **Rx fire + herbicide**: 40% increase in suppression over herbicide only (Healy & Zedler, in progress)
- **Till + herbicide**: 443% increase in suppression c.f. herbicide only (Annen 2008)
- **Rx fire + till + herbicide**: 2,100% increase in suppression c.f. herbicide only (Annen, in progress)
Reed Canary Grass
Phalaris arundinacea L.

A workgroup of Wisconsin natural resource professionals with experience in reed canary grass control have been meeting since the fall of 2005 to develop materials to aid landowners and land managers with guidelines for the control of this invasive grass in Wisconsin wetlands. Information generated by the group include a table of available control techniques along with a companion prescription guide that provides information on how to set up a management control plan using a combination of practices and timing of treatments that's tailored to specific site conditions.

**Step 1**

Reed Canary Grass Management Table - DRAFT
[Formatted for quicker download-PDF, 513 KB](#)
[Formatted for printing on 11" x 17" paper-PDF, 3 MB](#)

**Step 2**

[Reed Canarygrass Control Prescription Table (PDF, 47 KB)](#)

This table should be used in conjunction with the Reed Canary Grass Management Table above.

A third table (Step 3) is being developed that will include plant species and recommended seed mixes that will compete with Reed Canary Grass (RCG).

[Herbicide Selection (PDF, 23 KB)](#)

The following is an abridged version of Dr. Mandy Tu's study on reed canary grass. References to the paper follow.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Effect</th>
<th>Should use</th>
<th>Could use</th>
<th>Should not use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burning</td>
<td>• Removes biomass and litter; might kill seeds on soil</td>
<td>• To reduce RCG in late spring after RCG is active but before natives break dormancy</td>
<td>• To remove thatch prior to a planting/seeding of desirable natives</td>
<td>• In fall to control RCG in short term, because RCG benefits from high light conditions that follow fire</td>
<td>• Jumpstart occurs if burn done in fall or spring</td>
</tr>
<tr>
<td></td>
<td>• Reduces available N over multiple burns (N volatilized)</td>
<td>• To force RCG to re-sprout and use reserves from rhizomes</td>
<td>• Prompt early spring sprouting of RCG, which can then be treated with glyphosate or sethoxydim</td>
<td>• In early spring in mixed vegetation sites, because RCG growth will be encouraged by increased light, unless you plan to combine with another treatment</td>
<td>• No research on critical density of RCG that can be controlled by burning alone</td>
</tr>
<tr>
<td></td>
<td>• Seed bank released, both desirable/undesirable species</td>
<td>• Use in combination with other practices</td>
<td></td>
<td>• On organic sites when very dry</td>
<td>• Early burns will simulate RCG; timing and frequency critical</td>
</tr>
<tr>
<td></td>
<td>• Stimulates dormant buds of RCG, rhizomes re-sprout</td>
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<tr>
<td></td>
<td>• Can jumpstart growing season by warming soil</td>
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<tr>
<td>Excavation</td>
<td>• Removes rhizomes and seed bank</td>
<td>• Where material can be pushed to fill drainage ditches or where it can be moved off site; where deeper water is desired</td>
<td>• To remove alluvium over native wetland soils</td>
<td>• If there is no soil disposal site.</td>
<td>• May cause soil compaction</td>
</tr>
<tr>
<td></td>
<td>• Removes sediment and nutrients</td>
<td>• During winter, to reduce soil compaction</td>
<td></td>
<td>• If compaction is an issue</td>
<td>• RCG will rapidly re-colonize disposed soil; use caution when selecting a disposal site</td>
</tr>
<tr>
<td></td>
<td>• Alters hydrology</td>
<td>• During summer when wet sites are dry</td>
<td></td>
<td>• If you don’t want a deep-water marsh</td>
<td>• Additional treatments will be necessary on drier sites</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>• If there is a high-quality remnant plant community in area</td>
<td>• Seed with natives afterwards, except in the driest water, or if a rich native seed bank exists</td>
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<td>• May require special permits</td>
</tr>
<tr>
<td>Tree/shrub</td>
<td>• When woody species overtop RCG, shade slows its growth</td>
<td>• Where herbaceous vegetation cannot gain a competitive advantage</td>
<td>• In an area where landscape is receiving RCG seed inputs</td>
<td>• Where management goal is to maintain grassland habitat</td>
<td>• Need to apply herbicide/mulch around newly planted trees/shrubs</td>
</tr>
<tr>
<td>planting</td>
<td>• May change plant community</td>
<td></td>
<td>• Where inflows can’t be diverted</td>
<td></td>
<td>• Conifers may be the most effective at shading RCG</td>
</tr>
<tr>
<td></td>
<td>• Adds structure to habitat</td>
<td>• To connect existing woody patches</td>
<td></td>
<td></td>
<td>• Need to control RCG for 3-5 years to allow trees to establish</td>
</tr>
<tr>
<td>Grazing</td>
<td>• Reduces biomass in spring</td>
<td>• In highly disturbed sites to reduce RCG biomass</td>
<td>• To reduce biomass and height before herbicide treatment</td>
<td>• During wet conditions in spring where trampling and compaction can damage a site</td>
<td>• Shelter tubes may be cost-effective</td>
</tr>
<tr>
<td></td>
<td>• Causes disturbance</td>
<td>• In fall, after a prescribed burn (RCG regrowth more palatable)</td>
<td>• To reduce seed production</td>
<td>• On high quality sites</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Allows seedling establishment (good/bad)</td>
<td>• Lightly, to sustain diversity</td>
<td></td>
<td></td>
<td>• Once started, cannot stop, unless you switch to another treatment</td>
</tr>
<tr>
<td>Mowing &amp;</td>
<td>• Removes biomass and nutrients that are accumulated</td>
<td>• To reduce biomass before herbicide treatment</td>
<td>• As a substitute for fire (though not quite the)</td>
<td>• On high quality sites, avoid use during growing season</td>
<td>• Not an effective practice alone</td>
</tr>
<tr>
<td>harvesting</td>
<td></td>
<td></td>
<td>• Where tussocks and microtopography will be damaged</td>
<td></td>
<td>• Use proper stocking rates to prevent overgrazing of desirable species</td>
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</table>
## Reed Canarygrass Control Prescription Table

<table>
<thead>
<tr>
<th>Amount of RCS present</th>
<th>Site characteristics/vegetation (recent &lt;25 years)</th>
<th>Hydrology</th>
<th>Inputs</th>
<th>Tree Planting</th>
<th>Bum</th>
<th>Excavate</th>
<th>Grazing</th>
<th>Mow</th>
<th>Broad-Spectrum Herbicide</th>
<th>Grass-specific Herbicide</th>
<th>Tillage</th>
<th>Fallow</th>
<th>Raised water levels</th>
<th>Seeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25 years since tillage/tilting, uniform topography*</td>
<td>Normally wet</td>
<td>High flow</td>
<td>E</td>
<td>2</td>
<td>1</td>
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<tr>
<td>&gt; 25 years since tillage/tilting or no ag history, uneven topography*</td>
<td>Normally wet</td>
<td>High flow</td>
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<tr>
<td>Mixed with native sedge, rushes and forbs</td>
<td>Normally wet</td>
<td>High flow</td>
<td>E</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Mixed with shrub or forest matrix*</td>
<td>Normally wet</td>
<td>High flow</td>
<td>E</td>
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<td>1</td>
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</tbody>
</table>

**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 >50% RCS with few other (often natural) species.
2 = Hydrology- normally wet refers to saturation and inundation for all or most of the growing season.
3 = Inputs refers to sediment, flooding, nutrient and stormwater inputs.
4 = Excavated RCS sedge and mesocosms should be planted on existing monotypic RCS stands, used in slitch filling or spread on cropland where it can be controlled.
5 = Check for any required state and local permits before starting, and follow with a native seed mix tailored to the site’s hydrology
6 = Mosquito includes other harvesting and silting or leaving dippings in place.
To avoid negative impacts of mowing on nesting birds, be sure to consult a grassland bird specialist before selecting a mowing date.
8 = Grass-specific herbicide should not be applied to open water or areas where standing water is present. Consult herbicide label for application instructions.
9 = To be effective, water levels should be raised > 1 foot above RCS for 2 to 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.
* = Sites with uniform topography lack microtopographic features.
5 = Sites with uneven topography possess microtopographic features (slopes, seeps, bedrock, tussocks, internal drainage channels, snags, raised ridges, ridges, etc.) and may harbor salmon native plant communities or remain native seed banks.
6 = SHrub or forest edge refers to the RCS population existing on the edge of the shrub or forest wetland.
7 = Forest or matrix refers to the RCS population existing within the shrub or wetland wetland with a patchy distribution.
8 = 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.
Best Management Practices for the Invasive
*Phalaris arundinacea* L. (Reed canary grass) in
Wetland Restorations

Final Report

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Guidelines for Selecting Herbicide Additives for Reed Canarygrass Control

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Herbicide performance depends on how an herbicide is used. Field conditions and selection of herbicide additives can affect the outcome of reed canarygrass (Phalaris arundinacea L.) control strategies. Grass-specific herbicides (e.g., Vantage®, Point Plus®, Select 2E®, Atrac® and Roundup® 2X®) require additives to work effectively. There are several types of additives, including crop oils, surfactants, stabilizers, and conditioning agents, to name a few. Although they are not phytoxic themselves, herbicide additives enhance herbicide phytotoxicity by increasing solubility of the herbicide in water, promoting herbicide uptake and translocation, or altering tank mixture pH. When more herbicide is taken up and translocated, more control is achieved. Choosing an additive (or combination of additives) can be difficult. The additive industry is not regulated and there are no set standards for composition, quality, or even terminology among additives. Furthermore, the availability, price, and active ingredients of additives can change year-to-year. The purpose of this article is to briefly define the conditions under which grass-specific herbicides should be applied, and which additives to use for optimum reed canarygrass control.

Crop oils and nonionic surfactants are additives that enhance uptake and translocation of herbicides. Crop oils are designed to dissolve the waxy cuticle that covers plant leaves. The cuticle acts as a barrier to the passage of substances into and out of the leaf, and removal of the cuticle enhances absorption of foliar-applied herbicides. As a result, more of the herbicide ends up in plant tissues where it can have phytotoxic effects. Crop oils may be petroleum or vegetable (e.g., soybean) based. Nalewaja and Szyrpiczak (1986) tested the effects of crop oils on grass control with sethoxydim. In the absence of additives, treated leaves absorbed only 1% and translocated only 10% of the total applied herbicide. In contrast, total uptake and translocation of sethoxydim more than doubled when tank mixtures were supplemented with additives. Absorption increased to 42% and translocation to 34% when soybean-based crop oil was added to tank mixtures.

Petroleum-based crop oils were somewhat more effective at enhancing herbicide uptake and movement than vegetable-based oils. Absorption increased to 48% and translocation to 34% when petroleum-based crop oil was added to tank mixtures.

Surfactants reduce surface tension of spray water, allowing spray mixtures to cover leaf surfaces evenly and be absorbed over a large surface area. Surfactants usually do not dissolve cuticular waxes, but some surfactant blends contain a chemical penetrant for this purpose. Surfactant-oleic blends are also available. These mixtures take advantage of both the surface tension-reducing properties of a surfactant and the cuticle-penetrating properties of crop oils. Although research shows that crop oils are more effective at promoting herbicide uptake and translocation than nonionic surfactants (Becket al. 1992), a number of crop oil blends can cause "sparking" (localized areas of tissue
Field conditions can affect herbicide performance

- **Temperature**
  - Affects translocation patterns of sethoxydim and glyphosate

- **UV Radiation**
  - Degrades sethoxydim, clethodim, and imazapic
  - Do not apply during mid-day or on bright, sunny days
  - Methylated vegetable oils offer some protection

- **Inclement Weather**
  - Precipitation deficits, precipitation surpluses, stress, inactive growth, etc.
Additives Enhance Herbicide Performance

Hard water cations
Inactivate herbicides and accelerate physical and chemical decomposition

*Water conditioning agents, acidifiers, or AMS*

✓ Add to tank mixtures **BEFORE** herbicide
Additives Enhance Herbicide Performance

**Surfactants**
- Enhance uptake and translocation of herbicides by reducing surface tension of spray mixtures
- Herbicide spray comes in contact with a larger surface area of the leaf

**Crop Oils**
- Dissolve the leaf cuticle to promote greater absorption

✓ *Tip:* *Spend the extra money on refined crop oil blends; these are less apt to clog spray nozzles*
Additives Enhance Herbicide Performance

Surfactant-Crop Oil Blends

***The best option for RCG control***

• Combine the surface tension-reducing properties of surfactants with the cuticular-penetrating properties of crop oils
• Methylated surfactant-oil blends also offer some protection from UV degradation
• Generally inexpensive: ca. 10 cents per mixed gal.
Additives Enhance Herbicide Performance

WARNING!!!

> Herbicide-additive tank mixtures have LIMITED shelf life. *Mix only as much as you intend to use each day.*
Spring or Autumn Applications? (Annen, in preparation)

1. Increase in effects size of autumn treatments is only 15%
2. Resurgence occurs regardless of season of application
3. Fall applications enable anthesis and seed set
4. RCG leaf growth predominates in spring; stem growth in autumn
5. Senescence and inactive leaf growth in autumn
Spring or Autumn Applications? (Annen, in preparation)

6. Leaf cuticles are thicker in late summer and autumn *(less herbicide penetration)*

7. Greater volume of plant material in autumn *(herbicide is diluted within plant)*

8. Rhizome carbohydrate reserves are minimum in spring/early summer *(etiolated regrowth is only 0.04 g in June)*

9. RCG max productivity is in mid-June
Spring or Autumn Applications?
(Annen, in preparation)

10. Rhizome apical dominance is most pronounced during tillering
11. Late season applications do not allow for native species release (*competition augments treatment effects*)
12. RCG can enter quasi-dormancy during hot summer/autumn months
13. Lodging and blowdown reduce herbicide performance
Spring or Autumn Applications?
(Annen, in preparation)

14. Greater volume of herbicide required for late season treatments \textit{(adds to cost)}

15. Herbicide treatments at flowering may stress RCG and hinder resurgence more that at other stages \textit{(energy investment has been channeled into flowering and seed development)}

16. Seedlings are eliminated by spring applications; seedlings are allowed to tiller by autumn applications
Spring or Autumn Applications?
(Annen, in preparation)

17. Seeds shatter over equipment and clothing, increasing the chance of contaminating other sites

18. Site accessibility and ease of application are lower in late summer and autumn *(dense, lodged)*
   *RCG hides obstacles that can damage equipment*

19. Safety – Late season applications increase the risk of chemical exposure

20. Nesting birds can be disturbed by late season applications