MANAGING INVASIVE PLANTS IN WETLANDS OF THE KENAI PENINSULA: *DEVELOPING A MANAGEMENT PROGRAM FOR REED CANARY GRASS INFESTATIONS*

FY2007 Progress Summary

A cooperative project by:
Homer and Kenai Soil and Water Conservation Districts
Through the Kenai Peninsula Cooperative Weed Management Area

Funded by: US Environmental Protection Agency

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Prepared by:
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For: Kenai Peninsula Cooperative Weed Management Area

In May of 2006, the Kenai Peninsula Cooperative Weed Management Area began efforts to survey primary and secondary roads to document the present extent of invasive reed canary grass (*Phalaris arundinacea*) on the Western Kenai Peninsula in Southcentral Alaska. Described as a "notorious global weed", reed canary grass (RCG) is known to **disrupt native wetland plant communities**, alter stream flow and degrade wildlife habitat (Lyons, 1998). The Kenai Lowlands are dominated by habitats, such as peat bogs and wetlands, which are reported to be particularly susceptible to infestation of RCG.

Infestation of invasive reed canary grass within the Kenai Keys area of the Kenai River, a world-famous salmon sport fishery (Photo courtesy: Marcus Mueller, Kenai Bourough)

From early June to early September, all primary and secondary Kenai Borough roads were surveyed and locations of RCG recorded and mapped. These records, along with estimates of infested area and percent cover, were compiled and submitted into a statewide, geospatial database for non-native flora (AKEPIC, 2006). As infestations were recorded opportunistically, the survey does not represent a census of the roads but is intended to build on the overall knowledge of the extent of RCG populations on the Peninsula.

Through a dedicated mapping effort, an additional **212 RCG infestations were documented** bringing the total number of record to 259 locations on the Peninsula (see attached map). The vast majority (92%) of infestations were estimated to be an acre or less in size with cover ranging from 1 to 100%. With assistance from the Kenai Watershed Forum, RCG records were appended with available wetland mapping and classification data layers for the Kenai Lowlands (Kenai Watershed Forum, 2006). Of land area suitable for analysis within the wetlands layer coverage (n=221), **51 were recorded within mapped wetlands**, with a 10m buffer of wetlands to account for GPS precision. Because of the potential threat to important anadromous stream habitat, sites within or adjacent to cataloged salmon streams were labeled as "high-priority". Of those that were either within or directly adjacent to mapped wetlands, 14 were in high-priority areas classified to serve habitat functions for Coho (*Oncorhynchus kisutch*) salmon (Kenai Watershed Forum, 2006).

Survey efforts have greatly contributed to the knowledge of RCG extent on the Peninsula and will assist land managers in assessing the threat posed by this aggressive, invasive weed. It will also provide valuable insight in prioritizing infestations for treatment and planning protection of the Kenai Peninsula's important natural resources.

Beginning in February 2007, planning began to invite and host visits to the Kenai Peninsula by two leading researchers with extensive experience in control and eradication of RCG. Concurrently, preparations were being made to plan and implement **plot-based test trials for RCG control** at several locations on the Peninsula to provide local insight about the efficacy of typically used control methods. In July, a literature review was conducted and a plan drafted for implementation of RCG control test plots. This draft plan was prepared to initiate discussion of potential control methods and plans for establishment and assessment of test plots.

Dr. Sue Galatowitsch from the University of Minnesota and Dr. Tim Miller, Washington State University, joined us for meetings and to tour **over 50 RCG infested sites** from August 16th-21st, 2007. The purpose of the site tours was to visit a representative selection of RCG infestations within a variety of sites including: wetland, riparian, agricultural, roadside and oil and gas pads. Site visits included high-priority riparian infestations on the Kenai River, Bishop, Beaver and Deep Creek, and the North Fork of the Anchor River. Visiting researchers provided the attached written recommendations for control and/or eradication of RCG and input on the methods and sites selected for test trials. In addition, the researchers prepared and delivered a brief **presentation to the Kenai Peninsula Borough Assembly** regarding the threat that RCG poses to Peninsula resources. Site visits were announced and a number of interested agencies and other groups facilitated or otherwise participated in one or more days of tours representing:

UAF Cooperative Extension Service, US Environmental Protection Agency, US Dept. of Agriculture – Natural Resource Conservation Service, Alaska's Plant Materials Center, Animal Plant Health Inspection Service, US Fish and Wildlife Service, Kenai Watershed Forum, Cook Inletkeeper and Kenai Peninsula Borough. Dr. Galatowitsch and Dr. Miller were also interviewed by local radio station AM 890 KBBI in Homer regarding their Borough Assembly presentation and site visits.

A concerned Kenai River landowner discusses control options for reed canary grass with Dr Galatowitsch. (Photo: Caleb Slemmons, Homer SWCD)

Potential test trial sites were also visited during the week of tours and discussed during a technical advisory committee meeting on August 21st. A number of recommendations included in the attached reports, as proposed by Dr. Galatowitsch and Dr. Miller, will improve the value and applicability of test plot results. Currently test plot work is scheduled to begin in June, 2008 and treatments and monitoring will be ongoing. Test plots will be then re-assessed and evaluated in June, 2009.

Overall, site visits were very successful and recommendations will be of tremendous value as additional work to develop management plans for RCG infestations move forward. Associated meetings also yielded important discussion about feasibility of control, strategic regional planning for RCG control, current gaps in knowledge and research and funding needs. In general, the researchers felt that there was more than **ample evidence to be concerned about the spread of RCG** and associated impacts to native plant communities, stream hydrology and wildlife habitat. They also expressed the general opinion that much can be done at this point to limit the spread of RCG and in working towards localized eradication of RCG on Peninsula watersheds.

Cited Resources

AKEPIC – Alaska Exotic Plant Information Clearinghouse hosted by the Alaska Natural Heritage Program (http://akweeds.uaa.alaska.edu/) accessed September 2007.

Kenai Watershed Forum – Wetland Mapping and Classification of the Kenai Lowland, Alaska (http://www.kenaiwetlands.net/)

Lyons, K. 1998. Element Steward Abstract for *Phalaris arundinacia L*. The Nature Conservancy. Arlington, VA. (http://tncweeds.ucdavis.edu/esadocs/phalarun.html)

Attached Documents:

Reed Canary Grass Management on the Kenai Peninsula
Dr. Sue Galatowitsch, Professor
University of Minnesota
Department of Horticultural Science
St. Paul, Minnesota

Managing Reed Canary Grass on the Kenai Peninsula
Tim Miller, Extension Weed Scientist
Washington State University
Mount Vernon, Washington

High-priority Wetland Infestations of Reed Canary Grass Recorded on Western Kenai Peninsula, 2006

Homer Soil & Water Conservation District
4014 Lake St., Suite 201
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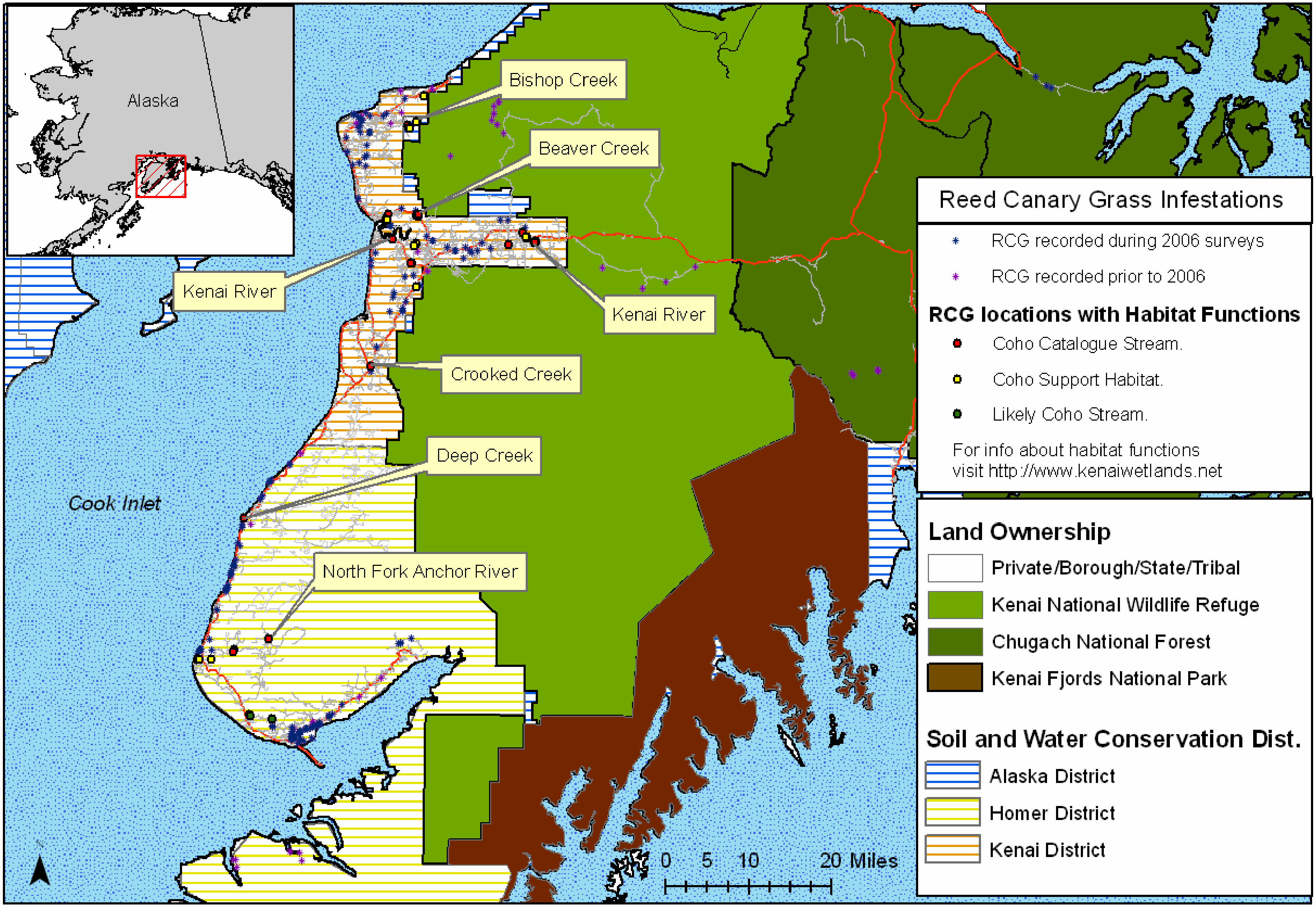

Reed Canary Grass Management on the Kenai Peninsula

Report to the Homer and Kenai Soil and Water Conservation Districts Through the Kenai Peninsula Cooperative Weed Management Area

September 2007

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Overview and Scope of Problem

Reed canary grass (*Phalaris arundinacea*, hereafter RCG) is a circumboreal plant that is reported to have dramatically increased in abundance in temperate North America approximately 40-60 years ago in response to increased soil nitrogen enrichment, impaired hydrology, and construction impacts to wetlands (Lavoie et al. 2005). RCG is, however, not believed to be native to Alaska; it was introduced to the SE and SC parts of the state as part of forage and stabilization projects (Wright, personal communication). RCG was recommended as a forage and stabilization species only for a brief period, primarily 20-30 years ago, although its use still continues to a limited extent. On the Kenai Peninsula, RCG has spread from a few deliberate introduction points to more than 260 populations (Slemmons, 2007). Most of these populations are associated with human disturbances, such as boat launches, roads, bridges, and pastures, RCG has, however, spread from these locations along river corridors. Although most Kenai RCG populations are currently small, if their growth and spread is unchecked, the likelihood that they will adversely affect aquatic systems of the Kenai Peninsula is high. In other parts of its range, RCG dominates the shorelines of lakes, rivers, and wetlands, hindering regeneration of woody and herbaceous native plant communities and reducing habitat suitability for some animal species. When RCG encroaches into active channels, as it has in the Pacific Northwest and Great Plains, it can accelerate siltation of rock and sand bars, reduce the active-channel area, and alter fluvial dynamics. These changes to stream geomorphology likely contribute to reduced suitability for species such as least terns, piping plovers, whooping cranes, and salmonids.

With funding from the U.S. Environmental Protection Agency, the Kenai Peninsula Weed Management Area Partnership (KP-CWMA) is developing a management program for RCG infestations. To date, the KP-CWMA has developed a GIS-database of known infestations, reviewed the literature to identify control approaches likely to be effective for the Kenai Peninsula, and a technical advisory panel. In August 2007, The KP-CWMA led a one-week working tour of RCG locales to catalyze management planning efforts. Participants in this tour included local natural resource and environmental professionals, citizen-scientists with long-term management experience in the region, representatives from several state and federal organizations, and consultants from Washington State University (Dr. Timothy Miller) and University of Minnesota (author of report). This report summarizes the findings from this tour and provides recommendations for the KP-CWMA planning effort.

Invasion Biology of Reed Canary Grass

RCGs invasive potential stems from its high capacity for viable seed set and rhizomatous spread, rapid establishment following disturbances, and plastic response to changing hydrologic conditions. At the time of initial introductions to Alaska in the 1970's, RCG was reported to lack viable seed production, presumably because of the short growing season (Wright, personal communication). Because mature RCG seed was observed at several populations during the KP-CWMA tour; the importance of seeds to spread and establishment needs to be evaluated for the Kenai Peninsula.

Up to 872 seeds m^2 have been reported for RCG in wetland seed banks in Minnesota (Adams & Galatowitsch 2006). A dense canopy of perennial vegetation can preclude these seeds from germinating since the seeds of RCG require light to germinate

(Lindig-Cisneros & Zedler 2002). Because gap-forming disturbances are common in floodplain and palustrine wetlands (i.e., from flooding/drawdown and herbivory), invasion windows for RCG are common even in relatively unimpacted systems. An effective invasion event, i.e., one with the potential to create a persistent stand, does not require a high influx of seeds. Green and Galatowitsch (2002) observed that at only 136 seeds m^2, RCG growth resulted in 1426 g m^2 of biomass (dry) after a single growing season, one-half of that of the total community. RCG can begin to tiller (e.g., spread vegetatively) shortly after seedling establishment, when plants are less than 3 cm tall (Galatowitsch personal observation). A dense network of rhizomes capable of excluding the growth of other species can form within a single growing season. Although seedling establishment of RCG is restricted to high-light canopy gaps, rhizomes often extend into low-light areas (Maurer & Zedler 2002).

RCG establishment from seed is typically much greater in saturated than flooded soils. It can, however, invade under a wide range of hydrologic conditions by shifting its growth strategy (Conchou & Pautou 1987). Tussock-forming plants allocate more resources to shoots than roots, an advantage under flooded conditions. As water-levels recede, these plants shift allocation to favor lateral spread. This “plastic response” to hydrology allows RCG to be better suited to water-level fluctuations occurring at a magnitude and frequency greater than many other perennial wetland species. High nutrient additions also favor RCG over other species. Perry et al. (2004) observed that RCG is relatively inefficient at acquiring and using nitrogen. Consequently, the growth of RCG is stimulated more with nitrogen addition than is the growth of its potential competitors within wet meadows. The competitive response of RCG in wet meadow as a function of hydrologic alterations and nutrient additions is relatively well-understood; these relationships have not been adequately investigated in many other wetland and riparian systems, including those of the Kenai Peninsula.

Inventory Status and Needs

In 2006, KP-CWMA conducted a roadside survey of RCG populations. This comprehensive survey of primary and secondary roads increased the total number of known populations to 259. As importantly, it established a GIS system that can be used to track new infestations and those that have been eradicated. Because RCG readily spreads along waterways (which is clearly evident in the Kenai River downstream of Kenai Keys), there is a critical need to expand this survey to include areas not accessible by road. The highest priority for survey should be in drainages where RCG has already been identified. Aerial surveys may be the most efficient way to survey the Kenai Peninsula; this is likely to be most reliable in autumn when *Calamagrostis canadensis*, a native species of similar stature and appearance, has already begun to senesce but RCG remains green. Air photo or satellite image interpretation is unlikely to be reliable because of the difficulty of distinguishing RCG at typical resolutions of images. All populations observed from air should be ground-truthed. Useful information to include as data fields includes (note: a plant is defined as an individual “clump”):

1. Date of first observation
2. Population estimate: 1-5 plants, 6-20 plants, > 20 plants but less than 100 sq m, 100-1000 sq m, >1000 sq m.
3. Dispersion: Infested area is (A) a dense monotype, (B) patches of RCG

interspersed with patches of natives, (C) RCG and natives in a mixture.

4. Common species in infested area
5. Habitat: Riparian/wetland, upland
6. Origin of population, if known
7. Control and restoration history

The population estimate, dispersion, common species, and habitat should facilitate management planning. Control and restoration history fields can be used to track the success of eradication efforts across the Kenai Peninsula.

Eradication and Control Strategies

Eradicating the smallest RCG populations (e.g., 1-5 plants) should be feasible by digging them out by their roots with a spade. The RCG root and rhizome network is dense but shallow (< 30 cm). Removal of shoots without roots/rhizomes (by pulling or mowing) will not kill RCG. Somewhat larger patches (e.g., generally less than 100 sq m) may be treatable by covering with opague tarps for several growing seasons. By eliminating light, the rhizome and root system will eventually be starved of needed carbohydrates from the leaves. This treatment will likely be most effective if the population is mowed first to aid in installation of the tarp. Maintaining tarps over populations that are too large or on sites that are too unstable (e.g., river channels) may not be feasible over multiple growing seasons.

Larger populations of RCG are reduced most efficiently with herbicides such as glyphosate or fluazifop. Glyphosate is widely used for treating invasive species in natural areas because of its low persistence and toxicity. Glyphosate is a non-selective herbicide that causes the greatest mortality in perennials when it is translocated with carbon (produced in the leaves) to the roots and rhizomes. For RCG, the net direction of carbon flow is towards the roots at the end of the growing season, as plants store carbohydrates in rhizomes for overwintering. In cold climates, most effective control occurs around the first killing frost. While some mortality can be achieved earlier in the growing season, it is unlikely to be as effective. Herbicide treatments immediately following cutting are least likely to be effective because the plants are cued to send up new shoots which is net upward flow of carbon. The extensive and tough rhizome system must be treated over multiple growing seasons (>2 years) to achieve low enough RCG levels to proceed with community revegetation (Adams & Galatowitsch 2006). After vegetative stands have been eradicated, spring applications of herbicides can be used to kill emerging seedlings. Depleting the seedbank may take several years, since seeds can persist for 5-7 years in wetland sediments (Galatowitsch and Bohnen, unpublished data).

Although glyphosate has low toxicity, RCG populations should be treated to maximize effects and minimize overall usage. Since glyphosate’s mode of action is based on a single-gene trait, populations should be thoroughly treated to avoid selection for herbicide resistance. For RCG, a 3% solution is recommended because of the extent of above and belowground biomass. In riparian and wetland settings, an aquatic form of glyphosate should be used. Glyphosate formulations labeled for aquatic use should have surfactants that are less toxic than those for general use. For this reason, products relying on X-77 (i.e., “Spreader”) should not be used if aquatic toxicity is an issue (Tu et al. 2001).

Infestations where RCG is mixed with other native species can be especially challenging to control with glyphosate, since it is non-selective. Patchy populations can often be successfully spot-treated (e.g., hand-wicking, squirt bottle, or backpack sprayer). Since most of the Kenai populations are small, this should be a feasible approach. Some grass-specific herbicides, such as fluazifop and sethoxydim, have been somewhat useful for RCG when sedges are the dominant native species. The Kenai RCG populations are generally intermingled with *Calamagrostis* (blue joint grass), so grass-specific herbicides are unlikely to be an improvement over glyphosate. Moreover, these herbicides are not approved for aquatic use and are more costly (Tu et al. 2001).

Spring burning can be a useful strategy for reducing seedbanks but is not an effective method for killing rhizome networks. Likewise, mowing and disking may temporarily reduce aboveground RCG, but typically does not reduce rhizome density to low enough levels to proceed with revegetation. Combining herbicide treatments with burning or disking are typically part of effective prescriptions for RCG reductions that have been developed at the stand-scale.

Restoration after Control

Restoring invaded sites such as streambanks, floodplains, and wetland edges requires reducing the effects of the stressors that induced the invasion (i.e., hydrologic changes, soil enrichment), eradicating RCG, and promoting revegetation of the desired community. On the Kenai Peninsula, hydrologic changes and nutrient enrichment, are generally not as great as elsewhere in the range of RCG. Nonetheless, some populations adjacent to fertilized hayfields or near roads likely are stressed in ways that favor RCG over non-invasive species. Actions that will likely increase abnormal flood pulsing or increase nutrient runoff into riparian areas will likely increase the abundance of RCG and should be avoided. Areas with persistent nutrient inputs or abnormal hydrology should be considered poor candidates for restoration. Sites with nearby RCG propagule sources (especially upstream) will be prone to reinvasion and therefore also poor candidates for full restoration.

To minimize the likelihood of RCG reinvasion, treated areas need to be revegetated (unless the removal was of several plants). Closing the canopy rapidly should be an initial aim. Infested riparian areas on the Kenai Peninsula could be planted with woody species such as alders or willow from adjacent stands. On potentially unstable streambanks, willows could be installed as brush mattresses and allowed to adventitiously root. Many sites, including streambanks, could be seeded with local *Calamagrostis canadensis*. Seeds could be collected from adjacent areas or native hay could be spread. Direct seeding allows for control on seeding rates; seeds should be broadcast (without nurse crops) at a high rate (e.g., 20-30 lbs/ac). Seeding rates should be calculated based on pure live seed (not bulk), so should be adjusted for viability and non-seed matter in the mix. If harvested seed is stored overwinter prior to planting, it should be prestratified (60-90 days, cold-moist) prior to seeding. While native hay does not permit careful control of seeding rate, it does have the advantage of providing some initial ground cover after eradication. This cover will also restrict the germination of *Calamagrostis* (i.e., also has light-triggered germination), so the hay layer should not be too thick. Directly seeding *Calamgrostis* coupled with a light hay layer would be ideal. For the first 3-5 years, revegetated areas should be scouted for RCG. Emerging plants are often best controlled by handpulling.

Recommendations for control trials

The Kenai Peninsula CWMA plans to conduct RCG experimental trials to determine how various strategies for control used elsewhere perform locally. The KP-CWMA proposes to treat 2-3 dense infestations, comparing five techniques: herbicide and rototill, cardboard and bark mulch, shade cloth, mow 2X with herbicide, mow 3X with herbicide. Each treatment will be replicated four times. The treatments and control will be randomly assigned to one of 25 4' x 4' blocks (4 reps each). The effectiveness of the treatments will be evaluated by comparing pre- and post-treatment stem counts and cover.

Developing locally reliable approaches for RCG control should be a priority and formulating these from experimental evidence (vs. trial and error) is crucial. Also important for this region is to compare chemical and mechanical approaches, given public concerns about herbicide use and the importance of the aquatic resource. The ways that KP-CWMA proposes to evaluate these treatments is also sound. The KP-CWMA may be able to get more useful information from their experiment with some refinements that address the following issues:

- *What treatment strategies are optimal for smaller or lighter infestations?* There are very few known dense RCG infestations on the KP. Some strategies may work on smaller or lighter infestations but fail on dense ones. It may be useful to consider doing the trials on 3 sites that form a gradient from light to dense infestation. Lighter infestations include more "salvageable" non-invasive species; at least one treatment could be configured that is less likely to impact non-target species (e.g., wick herbicide treatments) than those proposed.

- *What are the relative efficiencies of the various techniques?* The current design should identify the treatments that are better or worse at killing plants during the initial control phase (i.e., first few years). What will be less clear (but is equally crucial) is what level of effort is needed to produce a certain level of mortality. When control programs are implemented across landscapes, a technique that is highly effective but requires much more labor (say, 5x), will mean less area is treated (up to 5x less) than could be if another effective technique is chosen. The team should consider keeping research-quality records of all time and materials expenses for each block and evaluating this alone or as a response variable that incorporates both changes in plant abundance and costs. In addition, although the grant period is short, to adequately evaluate the effectiveness of treatments, the experiment should be tracked for several years following control. Even continuing the least labor-intensive sampling, cover estimates, will be worthwhile.

- *Can the results be applied to larger areas?* The treatment blocks (4' x 4') are likely too small for large, clumped perennial grasses like RCG. Edge effects will be very strong and plot-to-plot differences in initial stem densities are likely to be very high. In addition, implementing treatments at this scale will bear little resemblance to typical control. The team should consider treating larger areas and trying fewer techniques. Some treatments that seem less important are 1) mowing 3x with herbicide (unlikely to be much different than 2 mowings or even 1 mowing), and 2) cardboard and bark mulch. Mulch blocks light and so will prevent regeneration of RCG and non-native grasses. Using a technique that only has the potential to be a short-term control approach will likely be of limited long-term interest, given the logistics of acquiring and installing mulch. Some additional refinement of other treatments may also be useful to reduce costs and non-target effects. For example, since herbicides are known to be very effective when appropriately timed and applied, rototilling may offer fewer benefits than costs/risks. Multiple mowings also are likely to increase costs with marginal control benefit since herbicide translocation can be disrupted and the two techniques are unlikely to be synergistic, given glyphosate's mode of action. An herbicide-only treatment could be applied to all plants, from dense to light, varying the application approach as needed.

In summary, a refinement to the current approach is to compare a control to 3 treatments, herbicide, mow and herbicide, shade, over large blocks (i.e., 10' x 10'), with sites ranging from densely to lightly infested. Keep track of both control costs and plant response.

RCG Management Scheme for the Kenai Peninsula

Even at the current level of RCG inventory it is possible to develop a landscape-scale plan to reduce RCG distribution and abundance on the Kenai Peninsula. The recommendation here is to categorize RCG by effort and expertise needed for eradication and implement by category. The recommended categories are:

1. *Small populations* (less than 20 plants). These sites can be hand dug by volunteers with minimal oversight by trained staff (typical "Pulling for Natives" events). Volunteers need to be trained to identify the species, to know the importance of digging up the root system, and to properly dispose of the RCG. While these sites are not the highest priority for control if resources were ample, eliminating them sooner, rather than waiting for more complex sites to receive treatment, will significantly contribute to reducing the total number of site. Also, these events can help build public support for more costly projects. Follow-up scouting and control commitment needed should be minimal.

2. *RCG Patches* (less than 100 square meters). These sites were commonly observed along streambanks and in floodplains. These sites will likely require two years of control with a year or two of scouting and follow-up control. They are likely to be more amendable to mechanical control, although chemical control could be quickest (unless ample labor is available for digging). Simple restoration approaches (a few people hand harvesting seed, dividing nearby *Calamagrostis* clumps, or planting willow cuttings) will likely be adequate. These stands will likely require more involvement from trained staff and dedicated funds for supplies and some labor. To limit the likelihood of reinvasion, controlling upstream to downstream is advisable (especially if populations are not producing viable seed). Because costs to control an individual site may be modest, grouping these by watershed when seeking grant funds may be an efficient use of staff time.

3. *Large Monotypic stands* (over 100 square meters). On the Kenai Peninsula, these stands are most frequently associated with agricultural areas. Generally they are dense infestations with little salvageable non-invasive populations. The size and density of these stands, as well as their locations on uplands, makes them more logical candidates for chemical than mechanical control. Revegetation will likely be more complex and could require acquiring plants off-site. These sites will likely take at least two years to control RCG, followed by 5 years of replanting and scouting with follow-up treatment. Recovering these sites are significant time and money commitments and should be considered a priority if seeds threaten downstream aquatic systems, if sites are not being fertilized, and if available resources are available to follow through after initial eradication. If recovery isn't feasible, preventing seed production by mowing may be a logical alternative to minimize their potential to be a propagule supply for other areas.

4. *Active Channel populations*: Within-channel sites on the Kenai River may require novel approaches for control. The need to develop mechanical control approaches and avoid herbicide use is especially important here. Because water levels rise throughout the growing season, it may be possible to kill plants by cutting at lower water levels early in the growing season. Plants may suffocate with prolonged inundation later in the summer since air should not be available to the rhizomes. Because this technique has not be used elsewhere (glacier-fed rivers are not typical across the range of RCG), there is a need to conduct some local trials.

Research Needs

RCG seed production: Typically RCG control must cause rhizome mortality and exhaust the seedbank to be effective. Reducing the risk of reinvasion requires different control tactics for eliminating rhizomes and seedbanks of RCG. Seedbanks, for example, require attention in the spring, at emergence, for many years following rhizome control (i.e., 5-7 years). Whether RCG populations on the Kenai Peninsula are producing viable seed is uncertain. According to the Alaska USDA Plant Materials Center (Wright, personal communication), RCG did not produce viable seed when it was released. Ripe seed was observed on several sites, however, during the 2007 tour. Observations during the tour suggest that there is considerable variability in time of anthesis among plants within populations. Determining whether Kenai RCG populations are producing viable seed should be a research priority. If seed is being produced, additional research on factors affecting seed production could be important for devising locally relevant control strategies. For example, knowing whether mowing (even one pass in early spring) could be enough to thwart seed production requires more local knowledge of RCG seed ecology. Improved knowledge of seed ecology will also be valuable for prioritizing control at the landscape scale. If seed production is significant, controlling RCG upstream to downstream will be especially important.

Optimizing control strategies: The planned experiment (with some refinement) will begin to address the need to develop RCG control approaches for the Kenai Peninsula. Control approaches are needed for: 1) active channels (e.g., islands within the Kenai River), 2) streambanks and floodplains, 3) upland sites, including road verges and agricultural edge sites. For these different situations, the optimal approach will likely vary according to the size and extent of the population and whether there are salvageable non-target species.

Developing restoration approaches: The recommendations in this report should be considered a starting point for developing restoration approaches. Eradication of RCG stands alone seldom triggers recolonization of non-invasive species. Revegetation can be the most costly and failure-prone part of reversing an RCG problem. Because non-invasive vegetation often remains on or adjacent to RCG stands on the Kenai, revegetation approaches may be more affordable and likely to success than elsewhere. However, there still needs to be experimentation on the best timing for seeding, how native hay performs, and ways to create shrub carr/meadow mosaics in stream floodplains.

Literature

Maurer, D.A. and J.B. Zedler. 2002. Differential invasion of a wetland grass explained by tests of nutrients and light availability on establishment and clonal growth. Oecologia 131: 279-288.

Conchou, O. and Pautou, G. 1987. Modes of colonisation of an heterogenous alluvial area on the edge of the Garonne river by *Phalaris arundinacea* L. Regulated Rivers 1: 37–48.

Adams-Reinhardt, C. & S. Galatowitsch. 2006. Increasing the effectiveness of *Phalaris arundinacea* L. (reed canary grass) control in wet meadow restorations. *Restoration Ecology* 14: 440-450

Green, E. & S.Galatowitsch. 2002 Effects of *Phalaris arundinacea* and nitrate-N addition on wetland plant community establishment. *J. Applied Ecology* 39: 134-144.

Lavoie, C., F. Dufresne, & F. Delisle. 2005. The spread of reed canary grass in Quebec (*Phalaris arundinacea*): a spatiotemporal perspective. *Ecoscience* 12: 366-375.

Lindig-Cisneros, R. & J.B. Zedler 2002. *Phalaris arundinacea* seedling establishment: effects of canopy complexity in fen, mesocosm, and restoration experiments. *Canadian Journal of Botany* 80: 617-624.

Perry, L., S. Galatowitsch, & C.Rosen. 2004. Competitive control of invasive vegetation: a native wetland sedge suppresses *Phalaris arundinacea* in carbon-enriched soil. *J. Applied Ecology* 41: 151-162.

Poiani, K.A. & W.C. Johnson. 1993. A spatial simulation model of hydrology and vegetation dynamics in semi-permanent prairie wetlands. *Ecological Applications* 3: 279-293.

Slemmons, C. 2007. Managing invasive plants in wetlands of the Kenai Peninsula: developing a management program for reed canary grass infestations. Annual summary to the U.S. Environmental Protection Agency.

Tu, M., C. Hurd, J. Randall. 2001. Weed control methods handbook: tools & techniques for use in natural areas. The Nature Conservancy. 219 p. (Ch. 5-8)

Managing Reed Canarygrass on the Kenai Peninsula

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1. Background and Scope

Reed canarygrass (*Phalaris arundinacea*) has been a major weed in the Pacific Northwest for decades. Reed canarygrass (RCG) infests thousands of acres of riparian habitat, affecting hydrology of streams, increasing potential for flooding, and detrimentally affecting wildlife species, including threatened or endangered salmonids, through degradation of habitat.

While we know what RCG is capable of in the lower 48 states, the potential impact of the weed in Alaska is not so clear. Differences in temperature extremes, streamflow periodicity, and presence of competitive native perennial grasses in much of Alaska may degrade the ability of this species to infest and dominate sites to the extent we see in the contiguous states. There are, however, widespread infestations in southeastern Alaska each with the potential to cause detrimental ecological impacts in that region. Given that the Kenai Peninsula has similar climate and vegetation as is found in other locations in Alaska and the Pacific Northwest, the expectation is that RCG will be problematic here as well.

2. Survey/Inventory Suggestions

Our touring of RCG infestations on the Kenai Peninsula included riparian sites, roadside infestations, upland sites, and hay/pasture areas. The current survey of the Kenai Peninsula has been relatively thorough and well-mapped. Roadsides comprise the most thorough component of that survey to date, although many infestations on streambanks have also been identified. What remains now is to identify the RCG sites located furthest upstream of currently identified sites, to determine the suitability of eradication efforts in specific drainages. For example, several RCG sites have been identified on the lower and middle reaches of Bishop Creek, but it is not known whether headwater areas contain additional RCG populations. Since conventional wisdom for weed eradication efforts are to begin at the sites farthest upriver moving in a down stream direction, a thorough survey of upper Bishop Creek should be a high priority for inventory and mapping. Once a reasonably thorough survey has been accomplished, decisions can be made of which streams represent the highest priorities for eradication efforts.

3. Research Needs

A. Timing of herbicide application studies.

(1) Given that RCG has a tremendous rhizome system, it is important to obtain maximal levels of herbicide translocation from foliage to rhizomes. Timing of application for maximal perennial weed control is generally understood to be during two timings: early-bolting to pre-bud stages and in the fall. Testing herbicide application timing under Alaskan weather conditions is therefore important prior to initiation of RCG control programs.

(2) Given that RCG is often found in mixed stands with native *Calamagrostis canadensis* (?), it would be of interest to determine if selective control of RCG in these mixed stands is possible. Several people involved in our tours of the Kenai Peninsula sites mentioned that the *Calamagrostis* plants often die back in late summer two to three weeks earlier than does RCG, potentially giving a window for more selective use of glyphosate. Applications of glyphosate should be made at several rates to determine relative injury to RCG and *Calamagrostis*. Should spring emergence of the two species also display a similar pattern (RCG emerging earlier than *Calamagrostis*), spring applications of glyphosate may also injure RCG more than *Calamagrastis*.

B. Non-chemical control studies. In certain situations, herbicides may not be the preferred treatment for RCG infestations. For those sites, it is important to know which treatments to proceed with (e.g., tarping, mowing, physical removal of rhizomes, combination treatments, etc.), the general cost of these treatments in materials and labor, and the likelihood of successful RCG control. To that end, studies should be undertaken to test non-chemical treatment efficacy under Alaskan conditions.

C. Seed germination studies. There is apparently some question as to whether RCG is capable of producing viable seed in Alaska. Stoney Wright (Alaska Division of Agriculture Plant Materials Center) has volunteered to conduct germinability tests of RCG seed from populations sampled on the Kenai Peninsula, and I suggest that seed samples be collected from various sites to ascertain that information. If seed is found to be of low viability, eradication efforts can concentrate on control of existing stands and prevention of rhizome spread. Should seed be highly germinable, eradication efforts must include strategies to prevent seed production and dispersal.

4. Eradication/Control Suggestions

A. Agricultural sites. RCG is capable of producing substantial growth, resulting in relatively high tonnage of hay or grazable forage for livestock. As such, several fields on the Kenai Peninsula have been planted to RCG over the years. Some of these fields are still planted exclusively to RCG, although mixed stands of timothy and RCG are currently more prevalent. We observed RCG persisting on some of these sites along drainage ditches in varying degrees of density, from scattered plants to near monotypic stands. At the time of our visit, many plants were fully flowered, some heads still bearing stamens and some nearing seed maturity.

Quality of RCG hay is enhanced by early cutting (late boot stage of growth) when productivity and total digestible nutrient is higher. As seedheads emerge, quality of forage declines and potential for seed production, and spread, increases (provided that seed is shown to be viable, see Section 3C). Therefore, it is advisable to time haying operations as much as feasible to pre-flowering RCG, both for forage quality and to prevent new infestations of RCG. Ensiling RCG may also aid in achieving this outcome. (See the following website for more information on baled silage: http://ces.ca.uky.edu/owen/anr/Forages/Forage-baledsilageFAQ.htm).

(1) Herbicide treatments. If harvested and handled correctly, risk of RCG spread from hay fields is minimal. Vegetative growth from managed fields into field margins via rhizome expansion is a constant threat, however, necessitating vigilance on the part of the hay producer, and quick action if RCG is found to be growing on adjacent sites. Where RCG is growing on the banks of drainage ditches, use of glyphosate can be helpful to control those infestations. Spring applications may be helpful to minimize seed production (see Sections 3A and 3C), and perhaps also give a good amount of RCG control on those sites. If water is present in the ditch, a formulation approved for aquatic use (Aquamaster, Rodeo) must be used. Make applications after RCG has initiated flower heads (see Section 3A), usually when stems are at least two feet tall, at a rate of 2 to 3 lbs ae/acre (1.5 to 2.3 quarts Aquamaster per acre or a 0.75% solution for spot treatments; see page 7 of Aquamaster label).

(2) Non-chemical treatments. Tarping of these field edges might also provide some control of RCG (see Section 3B). A thick layer of plastic mulch must be used (consistent with experimental results from the above section). Tarp-laying equipment is available from many vendors which allow long rolls of plastic to be laid with minimal effort (see this website for one example of this type of equipment: http://www.robertmarvel.com/MulchLayers.html). Plastic mulch rolls come in a variety of sizes and thicknesses (http://www.robertmarvel.com/Plastic_Mulch.html). RCG should be scalped to the ground level, then plastic tarping applied. I anticipate that mulch will probably have to be left in place for two years to achieve control of this species. It is not clear how well RCG rhizomes will be able to penetrate plastic film. The thicker the plastic or tarp, the more likely it will be to prevent rhizome penetration.

(3) Re-vegetation suggestions. Given the ability of RCG to persist and spread from intentionally planted areas, continued use of this species for forage crops is problematic. Fields currently seeded to RCG should be replaced with other grass species that have been evaluated for forage use in Alaska and are less invasive (such as timothy or perhaps smooth brome). One way to replace the grass species of these fields is to treat with glyphosate at 2 to 3 lbs ae/acre and, after one week to allow for herbicide translocation to rhizomes, fields should be disked. It is often advisable to wait for two or three weeks to allow this treated RCG to re-grow and treat again, if necessary. Re-seeding then can be done, as most RCG will have been killed.

B. Riparian/wetland. The strategy employed for RCG control on these sites will depend largely on the peculiarities of these sites. The overall size and density of the RCG population will probably be the primary consideration, but the amount of and species comprising the streamside vegetation will also play a role, as will the stage of growth of aquatic species that may be present. If limited to only a few scattered plants in a 10-m^2 area, mechanical control (digging by hand for rhizome and foliage removal) may be the least damaging to the site. If the infestation covers a half acre and is a dense stand in scattered alder and spruce, however, mechanical control operations will likely cause more damage to the site (injury to desirable vegetation, increased siltation in the stream) and result in poorer overall weed control than a well-timed herbicide application. Each site should be evaluated on its own merits first, but also as part of a weed management plan for the entire infested drainage.

(1) Herbicide treatments. Because of the high potential for overspraying water during these applications, only aquatic formulations of glyphosate should be considered for this use. Glyphosate (Rodeo formulation) has a remarkably high 96-hr LC_{50} of >1000 mg/L for rainbow trout and 930 mg/L for *Daphnia*, so the product is considered practically non-toxic to those species. Still, applications should be timed to coincide with those months when juvenile salmonids are not present in the streams to avoid potential sub-chronic effects. When using these formulations, be sure to select an aquatic-approved surfactant for addition to the spray mix, and apply that mix at the proper rate and timing (see Section 3A).

(2) Non-chemical treatments. Tarping of some sites may offer some potential for control of smaller, but dense infestations (see Section 3B). Black plastic mulch (as discussed above) or typical blue- or brown-plastic tarps can provide good control of many perennial weed species. Keep in mind, however, that RCG rhizomes are sharp-tipped and may penetrate thinner materials (< 1 mil, for example). Testing of tarping materials should be conducted to provide local information about the potential for success using this strategy (see Section 3C). While these plastic materials are relatively durable, they can become dislodged due to flowing water or wind, by animal or humans, or over time, from the UV radiation in sunlight. There should also be a plan for remove tarps after the scheduled time of placement has elapsed.

(3) Re-vegetation suggestions. Land managers should not be too quick to re-vegetate infested riparian sites, as full control of RCG may take several months or years to accomplish, and both chemical or non-chemical control of this grass is more difficult when other plants are present. Once RCG has been controlled, however, it is generally advisable to aid re-vegetation with desirable species as quickly as possible to prevent other weed species from colonizing (or re-colonizing) the site. If appropriate, woody vegetation such as cottonwood, alder, aspen, or willow saplings can be re-introduced, as can various grass species. If seed/plants are available from the immediate area, they can be selectively dug and used to re-vegetate the site. Or seed can be collected from the site, seedlings grown in a greenhouse, and resultant plants can be transplanted at an appropriate time. Transplants generally establish more quickly on these "empty" sites, so their use is usually preferred over scattering seed of desirable species at the site. Use of

nets or straw mulches or hydroseeding may also be helpful, depending on the species being used, and the "cleanliness" of those materials in regard to seeds or vegetative propagules of invasive species.

Herbicides can sometimes be used selectively in plantings of woody transplants. products such as imazapyr (Arsenal, Habitat, and others), sulfometuron (Oust), and even glyphosate are registered for RCG control and have been used as directed applications to control sprayed vegetation but not injuring vegetation provided it is shielded from spray mist. My trials have shown good response of willow, alder, and cottonwood to these products, although the focus of these trials is not eradication of RCG, but woody species establishment to suppress RCG growth with shade and make the sites more self-sustaining. I would suggest that these products should probably only be used when weedy, undesirable vegetation accounts for the majority of species growing around the transplants, or as spot-treatments to scattered RCG plants that may have survived initial control efforts. Some desirable species, including transplanted species, can be severely injured by these herbicides, however, so maintenance sprays should be used with care on plants that will tolerate them.

C. Roadside/upland. The majority of the roadside/upland RCG sites we saw on the tour were mixed stands of various plant species, both native and non-native. If no control efforts are undertaken, these stands will likely coalesce as the infestation matures, resulting in monotypic RCG populations on these sites.

(1) Herbicide treatments. Glyphosate, imazapyr, and sulfometuron are all registered for right-of-way and non-cropland applications, and all are labeled for postemergence control of RCG. Herbicide sprays need to be coordinated with mowing operations, as RCG is easiest to control when plants are about two feet tall or greater, or in late summer before plants have lost appreciable chlorophyll (see Section 3A). Treatments, therefore, should not too quickly follow mowing operations, but only after RCG has had a chance to re-grow to a treatable stage of growth. In a similar way, treated RCG should not be mown for about seven days after foliar application in order to allow maximal translocation of herbicide to RCG rhizomes. All these products need to be evaluated for their potential to injure non-target vegetation, but all could play a role in RCG management on these sites, as well as offering good control of other non-native weedy species. Glyphosate should be applied at 2 to 3 quarts/acre (3 lbs ae/gallon Roundup Pro label). Imazapyr should be applied at 3 to 4 pints/acre (for 2 lbs/gal Arsenal), plus adjuvant (nonionic surfactant, crop oil concentrate, etc.) as stipulated on the label. Sulfometuron should be applied at 3 to 5 ounces/acre (for 75% Oust), plus 0.25% nonionic surfactant, v/v.

Use of brush control mowers that allow for herbicide to be streamed onto the blade or injected within the cutting chamber (wet-blade mowers, Brown Brush Monitor, among others) have shown fair to excellent control of many perennial weeds on roadsides and other sites. I do not know how effective these systems would be for RCG (they are more often used to control woody species along roadsides), but they might be worth investigating, as the herbicide application is applied directly to vegetation as it is mowed, rather than as a foliar application where drift can be an issue.

(2) Non-chemical treatments. Most roadside RCG stands do not lend themselves to use of tarping for control. Mowing, if done frequently enough, can prevent seed production. This could be an important factor in limiting spread of this plant, if seed is shown to be germinable (see Section 3C). It is unlikely that mowing alone will eliminate RCG from these sites or prevent rhizome spread from existing stands, however.

(3) Re-vegetation suggestions. Rights-of-way sites generally are best kept vegetation free along the side of the roadway (Zone A) to prevent roadbed damage and the tendency to move drivers from the edge of the road toward the centerline. Noninvasive, shorter grass species (primarily fescues) are preferable to RCG on sites further off the road, but still along the rights-of-way (Zone B). On other upland sites, native vegetation can be transplanted or seeded as discussed in the riparian section (Section 4B(3)).

D. Oil and gas pads. Sites visited on the Kenai National Wildlife Refuge were sparsely infested with RCG and a large number of other weed species that could potentially be devastating to Alaska's largely pristine ecosystems. Management of these sites is aimed at maintaining them free of all vegetation, but the level of maintenance on most of the pads we visited is currently inadequate to achieve this goal. Clearly these sites need more frequent, or different, management strategies to prevent them from becoming infested with invasive, non-native species.

(1) Herbicide treatments. Since these oil and gas pads are generally packed gravel and sand, application of moderately- or easily-leached residual herbicides is not a good choice for total vegetation management in these relatively high rainfall regions and shallow water tables. Low- or no-residual herbicides, such as glyphosate (Roundup and others) or sulfometuron (Oust), can be used with good results on such sites. Unfortunately, they must be applied repeatedly, as re-growth from uncontrolled rhizomes or new seed germination may result in continued infestation or re-colonization of these sites by RCG or other weed species. While contact herbicides (such as paraquat (Gramoxone) or pelargonic acid (Scythe) and organic herbicides such as clove oil (Matran) or vinegar (several brands)) can also aid in control of annual and seedling perennial and biennial species, it is unlikely that even repeated applications will adequately control of established perennial or biennial weeds.

(2) Non-chemical treatments. Scraping of the top several inches of the pad using a grader or other blade two to three times per year will help prevent RCG and other weed species from becoming established on oil and gas pads. Tarping along edges of the pads may effectively control RCG and prevent encroachment back onto the pad surface itself (see Section 3B). Repeated flaming has provided good control of annuals and seedling biennials and perennials on similar sites in Washington (power substations, gravel parking lots, etc.) but open flaming near oil and gas wells, even if capped, is probably not

a good idea. Finally, paving with asphalt or concrete will certainly reduce maintenance on those sites, but cost may be prohibitive and other factors may preclude this option.

(3) Re-vegetation suggestions. Since oil and gas pads need to be maintained vegetation-free, no re-vegetation is necessary as long as these sites are to remain operational. On sites where the wells have been or are to be removed, re-vegetation can proceed as outlined for riparian areas (see Section 4B(3)).

5. Appendix.

Pesticides Currently Allowed for Use in Washington State Waters (from http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/registered_pesticides.html).

Noxious weed control

- Diquat dibromide
- Endothall
- Glyphosate
- 2, 4-D
- Fluridone
- Imazapyr
- Triclopyr

Adjuvants/Surfactants

- Agri-Dex™
- LI-700™
- Class Act Next Generation™
- Kinetic™
- Competitor™
- Dyne-Amic™
- Bond™
- Cygnet Plus™
- Exciter™
- Intensify™
- Interlock™
- Liberate™
- Magnify™
- Sinker™
- Tactic™