Integrated Pest Management Plan for Freshwater Emergent Noxious and Quarantine Listed Weeds

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Washington State Departments of Agriculture and Ecology

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Section I.

INTRODUCTION

The development of this document was a collaborative effort between the Washington State Department of Agriculture (WSDA) and the Washington State Department of Ecology (Ecology). Authors and contributors include Kathy Hamel (Ecology), Chuck Perry (Rangelands Northwest), Bridget Simon (WSDA) and Greg Haubrich (WSDA). It is the intent of the authors that this adaptive document be viewed as a work in progress that will be updated from time to time as new information becomes available. Comments, new information or corrections should be directed to Greg Haubrich, WSDA at (509) 225-2604 or via email at ghaubrich@agr.wa.gov.

The Washington State Department of Agriculture holds a National Pollutant Discharge Elimination System (NPDES) permit issued by the Washington Department of Ecology under authority of the federal Clean Water Act for treating noxious and quarantine weeds growing in or near water with herbicides. This action was in response to a determination by the Ninth Circuit Court of Appeals that the application of an herbicide in compliance with the labeling requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) did not exempt an irrigation district from obtaining an NPDES Permit to control aquatic vegetation. WSDA provides coverage under this permit at no cost to agencies and individuals who wish to control noxious and quarantine listed weeds in or near water in compliance with terms of the permit. As required in the permit, WSDA and Ecology have developed monitoring plans and Integrated Pest Management (IPM) plans for these types of applications.

The purpose of this IPM plan is to offer advice to contractors/cooperators that seek to treat noxious emergent freshwater weeds under Agriculture's Noxious Weed NPDES permit. The permit calls for each cooperator/contactor to adopt this IPM plan when treating noxious emergent freshwater weeds. This plan offers clarifying information about the IPM approach and about specific practices appropriate to noxious weeds found in wetlands, lakeshores, riparian zones, ponds, and ditches. It is also intended that this plan will be periodically revised based on new research and implementation experience.

Section II.

NOXIOUS WEEDS

There are many definitions for when a plant crosses a certain line and becomes a "weed." One that is widely accepted in the weed world was penned by J.M. Torell; "A plant that interferes with management objectives for a given area of land at a given point in time." Noxious weeds are different, however, in that they have legal status. In Washington State a noxious weed is defined by law as a plant that when established is highly destructive, competitive, or difficult to control by cultural or chemical practices. (RCW 17.10, http://www.nwcb.wa.gov/weed_laws/17-10.pdf)

> Spotted knapweed arrived on the west coast in 1893 on the San Juan Islands in Washington. By 1920, this weed had established in over 24 counties in three northwestern states, with several large infestations near Missoula, Montana. Now, spotted knapweed has been reported from every county in the western United States and has invaded about five million acres in Montana alone.
> --Roger L. Sheley

These nonnative, invasive species threaten our agricultural base, rangelands, waterways, tidelands, parks, wildlife, property values, public health and safety, and the ecological health and diversity of our native ecosystems. While the economic effects of noxious weeds on agriculture are enormous, their effects on the natural resources and ecological diversity of the state compound these losses. Noxious weed infestations are the second leading cause of wildland habitat loss. These resources, once destroyed, are irreplaceable.

Non-native common reed (*Phragmites australis*) in Grays Harbor (WSDA).

Washington's noxious weeds are non-native, invasive plants that have been introduced to the state though human actions. Most of these species were brought in without any natural enemies, such as insects or diseases, to help keep their populations in check. As a result, these plants can often multiply rapidly. In the U.S., invasive weeds cover about 133 million acres in all ownerships nationwide and are expanding at the rate of about 1.7 million acres per year. (USDA Forest Service 2002). Weeds result in economic losses estimated at $35.5 billion a year in the U.S. in 1999 (Pimentel 1999). According to the Bureau of Land Management, roughly 4,600 acres of federal lands in the west are lost each day to weed infestations. Once infested, most lands cannot be reclaimed with our current technical and economic capabilities, resulting in significant or total loss of economic and environmental land values (Western Governors' Association 2000).

Aquatic and riparian weeds such as Eurasian watermilfoil (*Myriophyllum spicatum*) are often transported to uninfested waters by boaters (WSDA).

> On average, wildland weeds increase about 14 percent per year. That more than doubles the population every five years.
> --United States Department of the Interior

Introductions of nonnative species have been implicated in many of the natural resource and conservation problems the world faces today. In addition, nonnative species are now considered by some experts to be the second leading most important threat to biodiversity, after habitat destruction (FICMNEW 1998). According to University of California biologist Michael Soule', "Invasive alien plants pose a significant threat to the biodiversity of natural areas, to life on the planet." Of the 958 species federally listed as threatened or endangered, about 400 (42%) are threatened by non-native species (Pimentel 1999, TNC 1996, Wilcove et al 1998).

When knapweed replaces dense, native vegetation in riparian areas, it can cause a significant increase in soil erosion (Lacey, 1990). Erosion results in: (1) higher project costs, (2) damage to aquatic habitat, (3) reduced water quality, (4) elimination of trout and salmon fisheries, (5) lower shorefront property values, (6) higher property taxes, and (6) loss of business and jobs. (Maine Department of Environmental Protection, http://www.state.me.us/dep/blwq/doceducation/dirt.htm). Increasing water runoff and soil erosion, which induces higher sediment loads in streams, rivers and lakes negatively, impacts fisheries (Howery 2002)

In the South, kudzu vines have completely covered about 7 million acres, smothering other plants (University of Alabama, "The Amazing Story of Kudzu" http://www.cptr.ua.edu/kudzu/)

> Three million acres of American land is lost each year to invasive weeds -- an area equal to a strip of land nearly two miles wide stretching from coast to coast.
> --Audubon

The impacts of noxious weeds and other invasive species have been recognized at the highest levels of government. In 1999, Then-President Clinton issued an executive order that directed federal agencies to expand and coordinate efforts to combat the introduction and spread of non-native plants and animals. Several states are expanding or revamping their noxious weed programs. (WSNWCB 2003 report, http://www.nwcb.wa.gov/bireports/WeedBoardReport2003.pdf)

The Washington State Noxious Weed Control Board (WSNWCB) determines and adopts the Washington State Noxious Weed List. The complete weed list is published annually in Chapter 16-750 WAC (http://www.nwcb.wa.gov/weed_list/weed_listhome.html). The Board also systematically classifies noxious weeds as Class A, B or C based on the stage of invasion of each species. The classification system is designed to: 1) prevent small infestations from becoming large infestations; 2) contain already established infestations to regions of the state where they occur and prevent their movement to non-infested areas; and 3) allow flexibility at the local level to include widespread weeds for landowner management programs. The state is divided into ten regions for the purposes of classifying noxious weeds (http://www.nwcb.wa.gov/weed_list/designations.html).

Class A noxious weeds are non-native species with a limited distribution in the state. Eradication of all Class A noxious weeds is required by state law.

Class B noxious weeds are non-native species that are established in some regions of Washington but are of limited distribution or not present in other regions of the state. In regions where a Class B weed is unrecorded or of limited distribution, prevention of seed production is required. In these areas, the weed is a "Class B designate," meaning it is designated for control by state law. In regions where a Class B species is already abundant or widespread, control is a local option. In these areas, the weed is a "Class B non-designate," with containment, gradual reduction, and prevention of further spread being the chief goals.

Class C noxious weeds are already widely established in Washington or are of special interest to the state's agricultural industry. Placement on the state noxious weed list allows counties to enforce control if locally desired. Other counties may choose simply to provide education or technical consultation to county residents.

The language in Chapter 17.10 RCW makes it very clear that the duty to control noxious weeds is the responsibility of the landowner. This includes eradicating all Class A noxious weeds, controlling and preventing the spread of all Class B noxious weeds designated for control in that region within and from the owner's property, and controlling or preventing the spread of all Class B and Class C noxious weeds listed on the county weed list as locally mandated control priorities within and from the owner's property.

Saltcedar (*Tamarix ramosissima and T. parviflora*) is often found growing in urban areas. These plantings can serve as a seed source for spread into natural areas (WSDA).

Purple loosestrife (Lythrum salicaria) was introduced from Europe as an ornamental plant in the early 1800's. Loosestrife now invades wetlands in 48 states at an estimated cost of $45 million a year for control and loss of forage crops, crowding out 44 native plants and endangering the wildlife that depend on the native plants.
--David Pimental

WSDA determines the weed species that are regulated by quarantine under WAC 16-752. These include the Lythrum Quarantine (WAC 16-752-400), the Wetland and Aquatic Weed Quarantine (WAC 16-752-500) and the Noxious Weed Seed and Plant Quarantine (WAC 16-752-600) http://www.nwcb.wa.gov/weed_laws/quarantine.html. Under these quarantines it is prohibited, except under certain conditions, to transport, buy, sell, offer for sale or distribute plants or plant parts of the listed regulated species. It is also prohibited to intentionally transplant wild plants and/or plant parts of these species within the state of Washington. Many, but not all, of the

regulated plant species listed in the quarantines are also listed on the Washington State Noxious Weed List.

For the purposes of this document, the term "noxious weed" will include all species of noxious weeds on the Washington State Noxious Weed List and all species listed on WSDA's Quarantine Lists. These plants are all covered under WSDA's NPDES permit if growing in wetland or riparian habitat or when the application of herbicides for their control will result in any of the herbicide entering waters of the state.

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.
--L.M. Cowardin

Section III.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is sometimes referred to as Integrated Vegetation Management (IVM) or Integrated Weed Management (IWM) when specifically implemented for managing noxious weeds. For the purposes of this document it will be referred to as IPM.

IPM is:

There are at least two definitions of IPM in Washington State law. Chapter 16-752 WAC defines IPM as a decision-making process which combines all feasible control techniques into a program for managing targeted noxious weeds including but not limited to prevention, monitoring, consideration of alternative methods, and evaluation

In 1997, The Washington State Legislature enacted Chapter 17.15 RCW that requires that all state agencies follow the principles of IPM.

Chapter 17.15 RCW defines IPM as "a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet agency programmatic pest management objectives." The chapter further defines the elements of IPM to include:

(a) Preventing pest problems;

(b) Monitoring for the presence of pests and pest damage;

(c) Establishing the density of the pest population, that may be set at zero, that can be tolerated or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic or aesthetic thresholds;

(d) Treating pest problems to reduce populations below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical, and chemical control methods and that must consider human health, ecological impact, feasibility, and cost-effectiveness; and

(e) Evaluating the effects and efficacy of pest treatments.

IPM is not:

- IPM is not new. Scientifically based programs specifically focused in this area, however, are only a few decades old.
- IPM is not implemented or successful overnight.
- IPM is not necessarily a formula to eliminate or reduce pesticide use. Well-developed, science-based IPM programs have consistently resulted in reduced pesticide use, as they employ a wider array of pest management techniques. IPM programs, by design, result in safer, more judicious use of pesticides.

- IPM is not a rigid program of management techniques. IPM is a balance of all suitable techniques, providing the landowner or manager with options to manage noxious weeds within a given set of circumstances.
- IPM programs are not all the same. Depending upon the species and its habitat, programs may differ dramatically for managing a given species. (Portions excerpted from CropLife America)

For more information on IPM and links to other sites see:

Washington State Department of Agriculture's IPM page
http://agr.wa.gov/PlantsInsects/IPM/default.htm

Washington State Department of Ecology's "What is IPM" page
http://www.ecy.wa.gov/programs/wq/pesticides/upest/what_ipm.html;

Compendium of IPM Definitions - A Collection of IPM Definitions and their Citations in Worldwide IPM Literature
http://www.ippc.orst.edu/IPMdefinitions/.

Section IV.

IMPLEMENTING IPM STRATEGIES THE IPM PROCESS

As stated above, IPM is defined as "…a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet agency programmatic pest management objectives."

When developing a weed control plan that incorporates the strategies of Integrated Pest Management, it is necessary to evaluate control options based on the biology of the plant, to consider the extent of the infestation, to know the control options available for that species, to be aware of the plants legal status and to know your management goals for the site.

- **Learn as much as you can about the biology of the species**.
  Is it an annual? Does it spread by seed, by rhizomes, or both?
- **Determine the legal status of the species.**
  Is it a Class A? B non-designate?
- **Survey the extent of the infestation.**
  Is it a pioneer site? An established 5 acres?
- **Research control options for the plant.**
  When is the best time to control? Fall?
- **Evaluate your site.**
  What type of access? What permits are required?
- **Determine your management goals for the site.**
  Eradication? Long-term control?
- **Coordinate with others.**
  What are the neighboring sites?
- **Implement the selected control options.**
  Follow control plan guideline and continue to evaluate the site.
- **Monitor the effectiveness of the control methods on controlling the plant.**
  Adjust your control plan as site conditions change.

1. Learn as much as you can about the biology of the species.

A. Is it a grass or broadleaf species? If using herbicides, some are selective for broadleaf weeds and some are broad spectrum and will affect grasses as well.

B. Is it a perennial, biennial or annual plant? Annuals and biennials lend themselves to manual control methods more easily than perennial species.

C. How does it reproduce and spread? Is it rhizomatous?

D. Is it a facultative wetland plant or is it a terrestrial plant growing in a wetland site?

E. How long has it been present at the site? Is there a seed bank? What is the length of viability of any seeds that may be in the soil?

2. What is the legal status of the species?

The species may require containment, control or eradication by state law.

A. Class A Weeds – limited distribution. Eradication required.

B. Class B designate weeds – somewhat limited distribution. Control required.

C. Class B non-designate – control requirements are determined locally by county noxious weed control boards. Contact the local weed board for information.

D. Class C – control requirements are determined locally by the county noxious weed control boards. Contact the local weed board for information.

E. Quarantine species - it is prohibited, except under certain conditions, to transport, buy, sell, offer for sale or distribute plants or plant parts of the listed regulated species. It is also prohibited to intentionally transplant wild plants and/or plant parts of these species within the state of Washington. Many, but not all, of the regulated plant species listed in the quarantines are also listed on the Washington State Noxious Weed List.

- **Containment** means to confine a noxious weed and its propagules to an identified area of infestation.
- **Control** means to prevent all seed production and to prevent the dispersal of propagules of aquatic noxious weeds.
- **Eradicate** means to eliminate a noxious weed within an area of infestation.

3. What is the extent and age of the infestation?

This will help determine your control options. In the case of new infestations it might be as simple as implementing manual or mechanical control methods and monitoring. However if the infestation is extensive and has been there a long time, other methods of control may need to be considered and the life of the seed bank taken into account.

4. What control options are available for this plant?

Review the literature and talk to weed specialists to determine what control options are available and are effective. Are biological controls available and appropriate? What mechanical or cultural methods work well for this species? What chemical choices are there? Are selective materials available and what material will result in the least amount of disturbance to the site?

5. Evaluate and assess the health of your site

Is there anything you can do to make your site less susceptible to invasion or to inhibit the expansion of your current infestation? Examples might be reduction of grazing, elimination or reduction of ground disturbing activities,

6. Evaluate what your management goals are for the site

Determine what you will do to prevent re-infestation. Is site re-vegetation a possibility?

Are there action thresholds that you can live with? In many cases with noxious weeds the threshold is zero plants either due to regulatory concerns or because the potential for domination of the site is too great.

7. Coordinate with others

An important aspect of emergent weed management involves other people and adjacent landowners. Even the best management plan cannot be entirely successful if applied on only one site or ownership in an area with wider weed infestations that are not being addressed. The probability of reinfestation from adjacent lands will be very high. Weed management should include communication and planning with neighbors and some agreement on goals, control priorities, and annual activities. Coordination at the local level will benefit all landowners, even if they do not currently have a weed problem. It will also protect individual weed management successes over the long run.

8. Implement your program

9. Monitor to determine efficacy of your efforts

Monitor the status of your control efforts to determine whether they are effective in achieving your goals. Monitoring can be tailored to suit resources and can be as simple as taking before and after photographs or as rigorous as setting out trials and evaluating biomass pre- and post-control method.

Summary

Manage desirable vegetation to maintain maximum plant vigor, providing most competition to potential weed invasion and thus prevent weed problems. Learn to identify noxious weeds and identify habitats where noxious weeds may occur.

Inventory and monitor often to find weeds when they first occur. Remove early weed infestations immediately or as soon as possible. If weeds are present, find out what they are, their density, all location and life history.

Develop a weed management goal, strategy and plan based on IPM principles. Take advantage of complimentary control technique impacts to improve effectiveness.

Re-vegetate all disturbed sites with desirable or native vegetation for long-term site control. Plan to monitor all potential weed growth areas, including successful control sites, at least annually, for appearance of new weed plants, so they can be removed immediately. In this, way weeds can be managed and the problems they cause minimized.

Section V.

PERMITS

Herbicide Application Permits

Aquatic herbicides are considered to be state restricted use pesticides in Washington State. These herbicides can only be used or applied by certified applicators or persons under the direct supervision of a certified applicator, and only for those uses covered by the certified applicator's license category (WAC 16-228-1231).

Two state agencies issue aquatic plant control permits, the Washington Department of Ecology and the Washington Department of Fish and Wildlife (WDFW). Sometimes local governments issue shoreline permits for aquatic plant control activities. The Army Corps of Engineers may also issue permits for some activities.

For more information on permits, or permit application, please follow the links listed in Appendix B at the end of this document.

National Pollution Discharge Elimination System (NPDES) Permits

These federal permits are issued by the Environmental Protection Agency (EPA) and they fall under the Clean Water Act. In Washington State, Ecology is the delegated authority to develop and administer these permits by EPA. Under the Clean Water Act, there are provisions for third party lawsuits and obtaining coverage under an NPDES permit helps protect parties from such lawsuits. The NPDES permits issued in Washington for aquatic herbicides are general permits. To be in compliance with the permit all permit provisions and procedures must be followed by all entities obtaining coverage. Not following these provisions will result in the entity being out of compliance and subject to penalties.

Ecology issues coverage under a general NPDES permit for Nuisance Aquatic Plants and Algae in lakes, rivers and wetlands; and for Weeds and Algae in irrigation ditches and canals. The Washington State Department of Agriculture (WSDA) issues coverage under its NPDES permit for Noxious Aquatic Weeds in lakes, rivers, wetlands, and marine.

Ecology now issues coverage under a general NPDES permit for:

- Nuisance Aquatic Plants and Algae in lakes, rivers, and wetlands
- Weeds and Algae in irrigation ditches and canals
- Noxious Emergent and Aquatic Weeds in lakes, rivers and wetlands

All of the weed permits require:

- Integrated Pest Management (IPM) plans
- Monitoring of the herbicide used
- Annual reporting of monitoring results, and
- Spray reports to Ecology.

Nuisance weeds are generally native plants growing where they aren't wanted. Coverage is issued out of Ecology's regional offices and each permittee pays an annual permit fee of at least $300 dollars

Applies to Irrigation Districts treating the water for weeds and/or algae. This permit is issued out of Ecology headquarters in Lacey. Each permittee pays a minimum annual permit fee of $300 dollars.Noxious Freshwater Emergent Weed Control in Wetlands and Along the Shorelines of Rivers, Lakes, and Reservoirs; submersed, freely-floating, and floating leaved Noxious Weed Control in Lakes and Rivers and noxious marine emergent control for Spartina.

Aquatic Noxious Weed Control NPDES Permit

The noxious weed permit is unique because WSDA provides umbrella coverage to other entities who wish to treat noxious weeds under its permit. The permit covers all of the plant species on the Washington State Noxious Weed List and also all plant species on the WSDA quarantine lists. Any noxious weed found growing in an aquatic situation is covered under this permit. The Noxious Weed five-year permit was issued to WSDA in 2002. WSDA pays an annual $300+ fee to Ecology for the permit. WSDA, in turn, provides free coverage to their cooperators for noxious weed control in aquatic situations.The permit covers all noxious weed control activities that discharge herbicides directly into surface waters of the state of Washington, including:

- Into waterbodies that are contiguous with rivers, creeks, and lakes, or
- Into navigable waters, or
- In other situations as determined by Ecology.

You do not need this permit for terrestrial applications of herbicides.

You do not need a permit if you do not get any herbicide into the water.

Generally, there are no buffer or setback requirements for river banks or ditches – just ensure that you don't get any herbicide in the water. However you are subject to court ordered buffers stemming from a lawsuit (Washington Toxics Coalition, et al., v. EPA, et al.) that was signed in January, 2004. See the following link for more information.
http://agr.wa.gov/PestFert/EnvResources/Lawsuit.htm

If you think that you may get herbicide into the water (dripping from treated plants), you should obtain permit coverage. You can treat in dry wetlands without an NPDES permit …"Weed control activities with herbicides conducted on seasonally dry land surfaces where the bio-available active ingredient does not persist at time of water return are not required to be covered under this permit"

The noxious weed permit is divided into 3 categories:

1. Submersed and floating leaved plants (Eurasian milfoil, water lilies, etc.) found in lakes;
2. Marine emergents (*Spartina*), and
3. Freshwater emergents (purple loosestrife, knotweeds, etc.).

Each category has special provisions that must be followed. The notification and posting requirements are different when treating milfoil in a lake versus treating the shoreline of the lake

for purple loosestrife. The applicator must ensure that he/she follows the special provisions for each plant category.**Hydraulic Project Approval (HPA) Permits**

HPA permits are issued by the WDFW for a variety of aquatic plant management activities. The agency issues a permit by pamphlet called "Aquatic Plants and Fish" that is available free of charge. It allows noxious weed removal without an individual HPA. It allows some de minimus native weed removal without an individual HPA. Pamphlet provisions must be followed to be in compliance.

Some projects that require HPA permits include hand pulling, raking, cutting, use of bottom barriers, diver dredging, weed rolling, mechanical cutting, mechanical harvesting and rotovation.

Grass carp stocking permits

These permits are issued by WDFW and are required for stocking for aquatic plant control. There is a $25.00 charge for the permit.

Purple loosestrife and Quarantine Listed plants transport permit

Plants that are quarantined in the state of Washington cannot be bought, sold, offered for sale or transported. See this link for a list of the affected plant species and more information: http://www.nwcb.wa.gov/weed_list/prohibited.html This sometimes becomes an issue when plants, or plant parts, need to be transported to disposal sites.

Section 404 permit

The Army Corps of Engineers may require a Section 404 permit for diver dredging depending on the extent of the project and the site. For example, diver dredging on the Columbia River would probably trigger this permit. Diver dredging in lakes is dependent on the Corps permit writer.

Shoreline Management Permit

Sometimes aquatic weed control activities require a local Shoreline Management Permit. This is dependent on the local jurisdiction (city or county). Sometimes these permits can be quite expensive. Please check before starting an aquatic plant removal project.

See Appendix B for links to permitting information.

Section VI.

FRESHWATER EMERGENT NOXIOUS WEEDS

Freshwater emergent noxious weeds are non-native species listed on the state noxious weed list or on the WSDA list of quarantine plant species (refer to Appendix C for these plants lists). Emergent noxious weeds, in general, grow out into shallow water from 1" – 24" deep and up onto shore slopes to a point where their roots can easily reach the water table. These extremes will vary by species.

Freshwater emergent noxious weeds can survive in many soil types that are normally associated with wetlands. This varies somewhat by area of the state and the site involved. For instance along river edges soils are often gravelly or sandy, while around lake edges and emergent wetlands the soils are much finer.

--WSDA SEPA checklist for Freshwater Emergent Noxious Weeds

Many freshwater emergent noxious weeds have been intentionally introduced to Washington as ornamental plants (purple loosestrife, garden loosestrife, saltcedar, Japanese knotweed), or for stream bank stabilization (reed canarygrass) or by accidental introduction (*Phragmites*).

These introduced species "escaped" into our waterbodies naturally, through floods or by wildlife, by people discarding plants and plant parts, and by being deliberately planted. Once introduced to their new habitat, these invasive plants rapidly out compete our native plants, forming single-species stands, and reducing habitat for fish, waterfowl, and aquatic mammals and invertebrates. (Ecology) Some noxious weeds can even harm humans and animals. The sap of giant hogweed, a plant that grows in wet areas, can cause severe burns. Poison hemlock, which can also grow in wet areas, can be lethal if ingested.

One of the primary reasons non-native noxious weeds are so competitive in North America is that they left behind natural predators that evolved with them in their native countries such as insects, disease, and the native animals that use them as a food source. Without these normal checks and balances associated with their natural environment, plants that may pose few problems in their native countries can become aggressive noxious weeds in North America. When invasive plants are able to establish dense populations and impact areas on a large scale, biological control agents are introduced in an effort to reduce this advantage.

In addition to having few natural predators, many noxious weeds have characteristics that permit them to rapidly invade new areas and out-compete native plants for resources such as light, water and nutrients. Once noxious weeds become established, they can crowd out native vegetation, and in severe cases, form monocultures and become the only plants growing in the area.

Some invasive characteristics of noxious weeds include:

- Early germination and maturation providing an advantage over native plants or agricultural plants that germinate later in the season.
- Profuse reproduction by seeds and/or vegetative structures.
- Long seed life in the soil.

- Seed dormancy that ensures periodic germination and prevents seedlings from sprouting during unfavorable conditions.
- Adaptations for spread with crop seeds, by natural agents (wind, water) and by humans.
- Production of biological toxins that suppress the growth of other plants.
- Prickles, spines, or thorns that can cause physical injury and repel animals.
- The ability to parasitize other plants.
- Seeds that are the same size and shape as crop seeds, which makes cleaning difficult.
- Roots or rhizomes with large food reserves.
- Survival and seed production under adverse environmental conditions.
- High photosynthetic rates.

Section VII.

NEGATIVE IMPACTS OF FRESHWATER EMERGENT NOXIOUS WEEDS

Freshwater wetlands support a variety of fish and wildlife species and contribute to the aesthetic and environmental quality in every state. Millions of Americans use freshwater wetlands for hunting, fishing, bird watching and other outdoor activities. An estimated 100.2 million acres of freshwater wetlands of various types remain in the conterminous United States.

> Riparian is a word used to describe anything connected with or next to the banks of a stream, pond or lake. A "riparian area" is a body of water and the land adjacent to it. Riparian areas typically have a unique combination of flora, fauna and soil characteristics compared to nearby deserts, grasslands or forests. Although riparian areas occupy less than one percent of the landscape, they support some of the greatest diversity of plant and animal species and are essential habitat for much of the native flora and fauna
> --United States Department of Agriculture

Washington State has wetlands, waterways and riparian areas that are already impacted by freshwater emergent noxious weeds and we have areas that are still weed-free but potentially susceptible to these impacts. The type of weed management program required will depend on each site. Waters that are still weed-free require preventative measures, including early plant identification and diligence in removing the pioneer plants before they establish in an area. Areas already impacted by invasive weeds will require long term and costly control programs utilizing many weed control strategies and techniques. These strategies will change as site conditions change.

Purple loosestrife (*Lythrum salicaria*) and fragrant water lily (*Nymphaea odorata*) choke the shoreline in this area of Long Lake in Kitsap County (WSDA).

> The long-term trends in freshwater wetlands since the 1950's, show that freshwater emergent wetlands have declined by the greatest percentage of all wetland types with nearly 24 percent lost (8 million acres).
> --U.S. Fish and Wildlife Service

Plants like purple loosestrife, reed canarygrass, saltcedar, non-native *Phragmites*, knotweeds, yellow flag iris and other freshwater noxious weeds invade wetlands, shallow waters and aquatic margins. They destroy the commercial or aesthetic standards, fish and wildlife habitat, and the recreational value of these areas. Dense, established stands of weeds displace native vegetation and harm wildlife habitat (Chapter 16-750 WAC). Freshwater emergent noxious weeds can also impact agriculture when costly control measures are required to keep irrigation ways clear and open.

> Purple loosestrife now invades wetlands in 48 states at an estimated cost of $45 million a year for control and loss of forage crops, crowding out 44 native plants and endangering the wildlife that depends on the native plants.
> --ATTRA 1997

The following negative impacts of emergent noxious weeds are discussed individually, but in reality almost never happen alone. The severity and order of occurrence depend on the species, site conditions, existing plant communities and current land management practices. Usually all or some combination of impacts will occur as a freshwater emergent noxious weed invades.

Impacts are often dependent on each other, as are all factors in an ecosystem. For example as *Phragmites* invades a site it shades out and occupies space normally used by native plants; it then forms a monoculture growing from shallow water on up the shore slope, which can limit invertebrate and some fish production that can in turn affect shorebirds and larger fish. The site now accumulates silt, which narrows the channel, reduces water flow and increases weed growth potential, shorebirds and furbearers can not use the site now, and tall vegetation eliminates dabbling ducks and goose use, and so on into a connected web of interactions.

Reversing these impacts through a committed weed management strategy takes time, effort and considerable expense with no certainty of a successful outcome. Implementing an IPM management program that includes inventory, prevention, early detection, immediate control action and monitoring is generally the most effective.

NEGATIVE IMPACTS

1. Economic Impacts

The economic impacts of terrestrial weeds have been well documented. For example the cost of leafy spurge in Montana, North Dakota, South Dakota, and Wyoming totals $129.5 million each year and may result in the loss of 1,433 jobs (Sheley 2001). In Oregon, 21 species of noxious weeds reduce Oregon's total personal income by about $83 million. This is equivalent to 3,329 annual jobs lost to Oregon's economy from the production foregone by the presence of these noxious weeds (Oregon Department of Agriculture 2000).

The economic impacts of emergent weeds are not as well documented. It has been estimated that the cost of purple loosestrife in the United States is $45 million dollars a year for control and loss of forage crops.

2. Displacement and Suppression of Native Plant Species

While invasive species cause damage in many ways, one of the most devastating effects is habitat modification. Once a habitat is physically altered, even if the invader is removed, it becomes difficult or impossible to reverse the effects. In *Life Out of Bounds*, author Chris Bright describes the cycle of degradation (1998). As local organisms disappear, the loss weakens the strength of their ecosystem. Invasive species alter habitats in a number of ways. Changes in the physical structure of the land are the most visually obvious. Examples include the narrowing of stream channels.

> Up to 46% of plants and animals federally listed as endangered species have been negatively impacted by invasive species.
> --Wilcove *et al.* 1998

Often weeds will become established when some site disturbance occurs, which opens desirable plant community for invasion. Once established, many weed species have some competitive advantage over native plants. As an example purple loosestrife has tall dense growth, produces deep organic litter, shades out shorter plants and has exceptionally large seed production. The weed uses this advantage to maintain itself and often spread into undisturbed sites.

When planning a control strategy, these factors must be taken into consideration for inventory, initial control work, and particularly in follow up and continued monitoring. However, successful weed management that results in establishment of a desirable plant community will not lessen the need to look for new weed invasion in that area.

> Extinction by habitat destruction is like death in an automobile accident: easy to see and assess. Extinction by the invasion of exotic species is like death by disease: gradual, insidious, requiring scientific methods to diagnose.
> --E.O. Wilson, Harvard University

Here are a few examples of sites that have undergone negative habitat modification in Washington State:

- Tall, dense growth of reed canarygrass (*Phalaris arundinacea*) has occupied all adapted shallow water and high water table habitat on the Washington Department of Fish and Wildlife (WDFW) Snoqualmie Wildlife Area, Cherry Valley unit in the Snoqualmie River Valley near Duval.
- There are extensive, dense purple loosestrife (*Lythrum salicaria*) stands on the WDFW, Desert Wildlife Area, southwest of Moses Lake in Central Grant County.
- Saltcedar (*Tamarix ramosissima*) is growing in areas adjacent to the Columbia River, north of the Tri-Cities in Franklin County.

Each of these emergent noxious weeds occupies shoreline or shallow water habitat, thus preventing desirable or native plant communities from growing there. Once established, and particularly after developing extensive stands, these weeds are very difficult to manage. They have accumulated seed banks with soil seed reserves, and sites are often modified through silt collection or with saltcedar, the sites are too saline for native species. In addition many large weed sites are able to produce many outlaying infestations that often go un-noticed with most attention focused on the larger stands.

3. Increased Silt Accumulations

In situations where silt moves through a surface water system, such as streams, ditches or sites with tidal influence and others, emergent noxious weeds can accumulate silt at a much higher rate than native vegetation sites. This often happens as weed density increases and fills the shallow water with stems and plant litter. Silt accumulation can change bank, channel, and shallow water habitat character; in some cases even changing site potential to support native or desirable plants. As silt builds up, particularly during high water events, what were low sloping banks or shallow water may become uplands with steep banks with less water transport capacity. Even though plant roots may easily reach the water table, desirable vegetation may not be able to re-establish with the wet/dry soil conditions that now prevail.

In Washington, rapid silt accumulation caused by dense weed growth occurs in stands of purple loosestrife along waterways in central Grant County and in the Yakima River back waters south of Yakima City. Reed canarygrass growing in central Grant County and in the Snoqualmie Valley near Duval in King County tends to creep out into the water, resulting in accelerated silt accumulation in these channels. *Spartina*, in Willapa Bay in Pacific County, collects much silt transported by rivers flowing into the bay and carried by tidal action. In each case, as silt accumulated, it provided increased substrate for weed expansion. With purple loosestrife and reed canarygrass this process also narrowed channels, reducing water carrying capacity, interfering with anadramous fish passage, and displacing native species. Spartina silt accumulation actually raises the tide flat elevation, changing its potential to accommodate more upland plants. Silt accumulation by plants along natural streams can be a very positive process. However, when it contributes to increased weed production and site changes that reduce native plant competitive ability, the process stops being positive.

Yellow flag iris (*Iris pseudocorus*) has changed the flow levels and the course of this small creek in Yakima County. The creek once flowed next to the Russian olive trees on the left (WSDA).

4. Degradation of Recreational Opportunities

Emergent noxious weeds typically occupy the shallow water-shoreline interface (e.g. stream, river, pond, lake, estuary or etc.). This is the same area supporting much water-associated recreation. Generally emergent noxious plants produce a dense growth form and site coverage, which interferes with or precludes use by people or boats. Large, tall emergent weed stands can prevent activities that depend on open shorelines. This unwanted vegetation may make physical access very difficult or even make being there unpleasant. Tall noxious weeds may block the view. Many species provide for increased insect populations that could spoil recreational use of infested areas. Purple loosestrife occurs in similar habitats as cattail and hardstem bulrush. The native cattail and bulrush grow in open stands, allowing fishermen to move their boat through to launch or fish with little interference.

Purple loosestrife will occupy sites with shallow 12"-16" deep water on up a shore slope to about 12 inches plus above the water table. Its very dense growth and tall stature prevents people movement and completely eliminates boat transport from shore into open water.

Emergent weed problems probably happen regularly on private shorelands, where home owners may be unaware of the growth and dominance potential of these plants. Extensive, dense growth of both purple loosestrife and saltcedar has also caused major problems with boat launch facilities on public lands. Purple loosestrife has grown so dense along parts of the Winchester Wasteway in central Grant County, that boat launching was reduced to a single, narrow slot boats could just fit through on a previously open shoreline. Saltcedar caused the same problems in northern Franklin County on the Columbia River launch site.

Intense control efforts were needed to open both of these areas enough for full public use. Strong weed management programs in both areas have now minimized this problem. For a home owner or private property owners this could challenge their use of waterfront property. With well established weed infestations it could be both difficult and expensive to manage this problem.

5. Degradation of Wildlife Habitat

A dense forest of stems essentially eliminates habitat elements provided by normally open shallow water and shorelines. Stem density, stiffness, and litter accumulations may even preclude animal passage and changes vegetative structure, both in and above the water. Wildlife affected by these conditions includes fish, waterfowl, shorebirds, and some furbearers.

A. Impacts on Fish - including yellow perch, bluegill, crappie, bass, salmonids and others.

- Interference in salmonid use of habitat and passage has been observed in the Snoqualmie Wildlife Area that is managed by WDFW. Reed canarygrass clogged small ditches to the extent that they no longer provided rearing habitat for young fish (Perry 2003).
- Reduced space for movement.
- Reduced access to normal bottom cover features.
- Reduced production of and/or reduced access to insect and invertebrate food sources.
- Litter decomposition may serve to reduce dissolved oxygen in the water.

Extremely dense purple loosestrife growth out into a lake, wetland or stream to a depth of about 16 inches seems to interfere with fish use of these shallow water sites. During an informal WDFW sampling of sites in central Grant County, with and without dense purple loosestrife growth, many fish seemed to occur along the non-infested areas and few to none were evident in water just outside weed growth depth limits. Several factors may be involved, e.g. weed stems take up most water space and additional plant litter accumulation from past year's growth and its decomposition may reduce dissolved oxygen, thus limiting invertebrate organism food source production. Also, shallow water fish, pushed out to deeper water may be more vulnerable to predators (Perry 2003)

B. **Impacts on shorebirds** - including avocet, blacknecked stilt, greater yellowlegs, Wilson's phalarope, dowitcher and others.

- Shallow water and shorelines are not open for their use.
- Reduced production and access to insect and invertebrate food sources.
- Open nesting and rearing areas densely vegetated and covered with plant litter.

Invasive species are the leading cause of bird extinctions. Invasive species have entirely or partially caused the majority of all bird extinctions since 1800.
--Audubon

Shorebirds seem to prefer shallow water and nearly bare shore areas or those covered with low growing vegetation. This allows them to readily see predators, look for invertebrate food in water and on the shore, and may provide needed habitat features for nesting and rearing young. When purple loosestrife, reed canarygrass, *Phragmites*, or other emergent noxious weeds get established, open shorelines become covered with tall dense vegetation, eliminating open habitat for this class of birds.

In Willapa Bay, conversion of intertidal mudflats and native saltmarsh habitats to stands of *Spartina* threatens to devastate imperiled shorebird populations that rely on the increasingly rare coastal mudflats as their last remaining habitat. The *Spartina* infestation represents a particularly acute threat to already-declining populations of the Short-billed Dowitcher, and Audubon Watch List species. Other Watch List species harmed by the *Spartina* infestations in Willapa Bay include Pacific Island-Plover, American Golden-Plover, Whimbrel, Marbled Godwit, and Red Knot (Audubon).

C. **Impact on Furbearers -** including muskrat, mink, beaver and others

- Shallow water and shorelines not open for their use.
- Difficult passage from water to upland areas.
- Shallow water fish and other food now at much lower densities.
- Reduced cattail, hardstem bulrush and other plants limit food or house/den building material.

Furbearers prefer areas where they have good access to the water and material to use for den construction. For example muskrats build houses from cattail and hardstem bulrush and use roots and lower stems of bulrush for food. When *Phragmites*, purple loosestrife and other emergent weeds become established, they produce dense stands that displace most other shallow water plants species. This removes an important muskrat food source, prevents easy access from upper shore areas to open water, and limits house building material.

D. **Impacts on Waterfowl - i**ncluding dabbling ducks such as mallards, widgeons, shovelers, teal and other waterfowl including geese.

- Shallow water and shorelines not open for their use.
- Water surface and aerial food plants not available.
- Tall dense weeds prevent them from seeing danger and easily escaping.

Dabbling ducks feed by floating in shallow water and tipping over to reach submerged plants and invertebrates. They do not dive. They also use open shorelines or areas with low growing vegetation for resting. Being able to see out for some distance probably provides some security from predators. If emergent weeds have filled up the shallow water space and shore areas, these ducks will not use the area. Diving ducks, e.g. redheads, buffelheads, ringneck ducks, and others use much deeper water and dive to considerable depths to feed. This class of waterfowl does not seem to be bothered by dense emergent weed growth in shallow water.

Canada geese also tend to prefer shore areas with low growing vegetation and easy access to the water. Tall dense emergent weed growth largely eliminates goose use of many close-by desirable feeding areas.

6. Degradation of Water Quality

If emergent noxious weed infestations remain for more than two years, dense plant litter can accumulate and ultimately decompose. This litter decomposition will decrease dissolved oxygen and can release additional nutrients into the water. These factors can serve to increase algal growth resulting in further decreases in dissolved oxygen levels. Dense weed stem growth may also reduce water exchange within the stand. Under these conditions water becomes cloudy and often develops a scum on the surface and can produce a strong unpleasant odor.

When this happens it reduces or eliminates most wildlife uses and many fish species cannot survive under these conditions. It may also reduce some aquatic insect and invertebrate production. Both of these groups of organisms and small fish species are major food sources for larger fish and shore birds.

Water degradation may be one reason that when WDFW conducted informal fish abundance sampling in the central Grant County area, few fish were noted near dense emergent weed infestations (Perry 2003)

7. Interference with Water Transport

Waterways developed for water transport have a high potential for emergent noxious weed infestation. Seeding desirable species, compatible with waterway objectives, on banks and along the waters edge will help resist weed invasion and erosion. If emergent weeds do appear, they may often move out into shallow water and collect silt. Their dense stem growth also can slow water flow. Silt accumulates changing channel shape and reducing water flow volume. As silt builds up, it allows weeds to move farther out into the channel thus compounding both effects. If a new infestation remains unchecked, it will result in additional costs to maintain water carrying capacity. In some cases, dredging could be necessary to restore channel shape and volume, which then may require re-vegetation to maintain site control and prevent weed re-establishment.

Weeds established along dirt lined water transport channels produce seed and broken off plant parts that are easily carried by water to new locations along the channel or into water use areas. This readily expands weed problems and greatly increases control costs both along waterways and for land owners and managers where water may be delivered. Prevention coordinated with close inventory and monitoring and immediate control action if weeds are detected are necessary to prevent problems caused by emergent weeds. Even if weeds are not present or successfully managed monitoring must continue for early detection and to maintain weed free conditions.

WDFW's Snoqualmie Wildlife Area, Cherry Valley Unit has many ditches used for water transport in a large, very high water table area. Reed canarygrass dominates most sites, right up to the water and below the surface in ditches. Each year this plant grows out from banks and into the channel. This dense vegetation and its litter collect silt

transported in the water. The silt builds up narrowing the channel, reducing water volume and flow velocity. The captured silt provides more rooting zone for reed canarygrass and it moves farther out into the channel. After a year or two, water flow can become very restricted. In this case dredging these ditches every three to five years has been necessary. A management plan directed at replacing this very dominant weed has been instituted, but it will take many years to make substantial plant community changes.

8. Promotion of Mosquito Production

With the current status of West Nile Virus and other mosquito borne diseases on the rise in the U.S., reducing mosquito populations has become even more important.

Mosquitoes generally require still or slowly moving water for some parts of their life cycle, particularly from egg deposition through final larval development. Water that is rapidly flowing or open to wind and wave action does not provide suitable habitat for these insects. Once emergent weeds move into open shallow water areas, they offer protection from both wind and wave action and slow water movement. Their presence may now allow or increase mosquito production in these sites.

Previous years weed growth often accumulates on the bottom of shallow water areas. As it decomposes additional nutrients are released into the water. These nutrients may serve to stimulate the growth of algae, bacteria and other organisms that mosquito larvae feed upon. Emergent weed growth may also discourage fish predation on mosquito larvae as high stem densities can limit access to shallow water.

9. Reduced Property Values

A 1995 Washington Attorney General's opinion stated that noxious weed infestations adversely affect property values and should be disclosed by owners at time of sale (Washington Association of Realtors)

Emergent noxious weeds should play a major role in property value assessment. The state noxious weed law requires that property owners or managers control noxious weed problems on all but federal and tribal owned and managed lands, at their expense.

> In 1988, a 1,300 acre ranch in Klamath County, Oregon, was abandoned due to the invasion of leafy spurge. The ranch was then purchased at an auction for about 10 percent of what it would have sold for otherwise (Humphrey 1988). In 1991, a 3,200 acre ranch in Ward County, North Dakota, sold for about 40 percent of the market value due to the same weed.
> (Weiser 1995).

The presence of noxious weeds can adversely affect the potential uses of a property depending on the goals of the owner. For instance if a land owner want to keep horses in a pasture that is infested with tansy ragwort, these plants that are toxic to horses would need to be removed first. Similarly the acquisition of a waterfront lot that is infested with purple loosestrife or other noxious emergent species may require a substantial investment

in control before the property could be used or enjoyed to its full benefit. The expense of controlling the infestation is also a negative that should be considered when purchasing property. This applies to agencies as well as private individuals. If insufficient resources are available for controlling invasive species and restoring the property to a useful condition, then the acquisition of the property in question should be reconsidered.

Unfortunately the presence of noxious weeds is rarely considered in real estate transactions. Property obtains value solely based on location, physical features and improvements. Vegetative features or costs associated with their management are usually not considered, unless they add property value, e.g. standing trees that could be harvested. The vast majority of real estate people and buyers are totally unaware, or choose to ignore, ownership costs and responsibility for noxious weed management.

10. Loss of Bio-diversity

High bio-diversity assumes existence of most potential native and/or desirable adapted life forms. In Washington, areas with certain physical characteristics will support emergent noxious weeds, such as open shallow water and/or a high water table. Native plants and animals adapted to such areas include: song birds, shore birds, waterfowl, fur bearers, fish, other wildlife, aquatic and semi-aquatic insects and invertebrates, grasses, sedges, rushes, broad leaved forbs, and woody plants. With enough area and site diversity, representatives of all these species might be present. These groups interact, forming a dynamic ecosystem with varying entity abundance and succession that might support them all or some diverse combination. Noxious weeds can change these ecosystems greatly by reducing plant diversity, bank shape and water features, and this in turn may affect everything else. Usually a weed dominated area will have less plant and animal species diversity.

> "On a global basis…the two great destroyers of biodiversity are, first habitat destruction and, second, invasion by exotic species"
> --E.O. Wilson, Harvard University

In Washington State, *Spartina* grows in estuarine areas on saltwater mud flats, usually not covered with other vegetation. The best example occurs on Willapa Bay, in Pacific County. *Spartina's* dense growth tends to collect silt from rivers flowing into these areas and from tidal movement of soil. As silt accumulates around *Spartina* patches, the soil elevation increases. If left unchecked some areas that were formerly tidal mud flats become non-tidal uplands. Plant diversity may actually increase in these sites. However, the high production of invertebrates, shellfish, micro-flora, and the fish and shorebirds that eat them are eliminated, so overall bio-diversity decreases. The entire site affected now has a different potential for even native species. Non-native *Phragmites* is beginning to spread in Grays Harbor and will have similarly detrimental affects if allowed to expand unchecked.

11. Expensive Control Costs

Control costs can only be kept in check by identifying weed establishment early, when the infestation contains only one to a few plants over a very small area. Once weeds establish over more than a few hundred square feet, control cost go up dramatically.

Each site visit to apply a control method adds more cost to the management strategy. Even using bio-controls requires a combination of techniques to insure full control coverage of outlying infestations. Inventory, prevention, early detection, immediate action and monitoring remains the most effective, lowest cost weed management. A potential weed problem can easily be ignored until it becomes plainly visible. If scattered over several acres, any control strategy can be costly and less effective than if management starts earlier.

Combining complimentary techniques will not reduce the cost of each, but may make the overall weed management program more effective, thus reducing long term re-treatment expenses.

Emergent noxious weeds grow on stream, pond, lake or other waterway banks, in saturated soils, wetlands, tide lands, and other places where water is a major site element. All sites have at least one common feature; they are generally difficult to access on foot, with machines, or by any other means. Difficult field conditions slow all weed management actions from initial inventory to re-establishing desirable vegetation. This may dramatically increase costs of implementing any management strategy. Even if a site does provide reasonable access, often conditions will limit control technique alternatives and/or their effectiveness. Each factor can add its own level of difficulty, often compounding management effort and costs.

A. Mechanical Control

In Washington, emergent weed management costs can be very high, but vary greatly, usually based on how a weed species occurs, such as infestation size, age, density, distribution, associated plant communities, and difficulty of site access or on-site movement. Mechanical control of large or dense stands can cost several hundred dollars per acre or much more depending on the need for special equipment or techniques. Hand removal of scattered plants in a small area may be less, but time and wages can push the price up sharply, if an infestation covers more than a few hundred square feet.

B. Chemical Control

Herbicides application costs are extremely variable based on the weed species being controlled, infestation size, density, distribution, material used, application method, site access, and permit costs. Chemical control may vary from a minimum of $50 - $60 per acre, per year using aerial application to $200 - $300 or more per acre, each year for ground based hand application.

C. Grazing

Grazing can be used in very specific circumstances, on weed species palatable to the animal being grazed. For example cows will eat reed canarygrass, particularly in early spring, to limit seed production, weaken plant growth or even reduce stand density. Grazing as a control technique, and the costs associated with it, will vary greatly relative to the convenience or availability of animals that will eat target weeds, fencing costs and animal management.

One grazing treatment, for most emergent weeds, will not often be enough to significantly affect weed occurrence or seed production. Usually some combination of multiple grazing events and/or complementary control methods developed into an IPM plan is most effective. An herbicide application on weakened weed growth following a grazing treatment may improve the herbicide's effectiveness. Seeding desirable or native plants following herbicide treatment would provide for their establishment in an open plant community and provide strong competition to weed re-establishment.

D. Biological Control

Bio-control, when effective, is often the lowest cost weed treatment, even if introduced organisms are quite costly to begin with. This method usually works best on established weed infestations of one half acre or more. Once introduced, it may take several years for an organism to impact a weed stand. The *Galerucella* beetles, introduced in central Grant County to control purple loosestrife in 1991, had little impact on this weed until 1995. It took that long for increasing beetle populations to have a measurable impact. Over the next several years these insects devastated the purple loosestrife population in the area.

Some bio-controls are not as effective and may only reduce seed production or affect weed abundance a small amount or over a long time. Bio-controls can be effective on large weed infestations, but should not be used as the sole control method. Even if a bio-control eventually proves effective for controlling a weed species, other containment strategies may be needed until the bio-control builds its population. Also, outlying infestations usually need to be managed with other techniques to keep them from spreading in the short term. If a bio-control agent does not develop into an effective weed control, and no other control strategies are being applied, the target weed may have several years head start in establishing itself. This could greatly increase management costs of other methods applied later to a now larger weed infestation.

The use of bio-control may not be acceptable in areas where control of a certain weed species is mandatory. Bio-control agents will not eliminate a species nor prevent seed production in most cases.

Using an IPM approach usually works best for most weed species, at least until the bio-control has a chance to show if it will be a viable control technique.

Section VIII.

WEED MANAGEMENT TECHNIQUES

How to control noxious weeds depends on what weed species you are controlling, the location or habitat where it is found, and the size of the infestation. The IPM process takes all these facts into consideration when developing a control plan. It also takes into consideration the combination of control options with the least impact to the environment and the greatest impact to the weed species.

Before deciding on a prioritized control plan, consider your management goals for the site, and the requirements that determine those goals.

Once the weed species and the site have been considered, it is time to choose one or several weed management techniques.

- **Prevention and Early Detection**.
- **Mechanical Removal.** Hand pulling, mowing, covering, water management, environmental conditions, dredging/cookie cutter, etc.
- **Cultural Removal.** Re-vegetation, grazing, burning, coordination with others.
- **Chemical Control.** Herbicides, adjuvants, fertilizers,
- **Biological Control.** Natural enemies – insects, diseases.
- **Monitoring.**

1. Prevention and Early Detection

Prevention and early detection is always the recommended management technique and these methods must be considered as part of a successful weed management plan. Prevention and early detection is the most cost effective in terms of time and money. Site surveys and early plant identification lead to rapid response to newly invading species. If weed problems are ignored until they are plainly evident, management difficulties and control costs are compounded.

As weeds increase in area and density the effectiveness of any control strategy or methodology will correspondingly decrease, costs will steeply increase, and success will be much harder to attain and maintain.

If noxious weeds are present, care should be taken to prevent seeds or other plant parts from moving to and infesting other sites. If seed production can be stopped or minimized, transport will be less likely. If mature plants and seed production does occur consider the following precautions:

- Prevent boats and land vehicles from transporting either seeds or propagative plant parts. Make sure boats and vehicles do not enter weed infested areas, if possible. If they do, for example a tractor mowing weeds, they should be thoroughly cleaned after removal from the site.
- If weeds are hand pulled, dug up, or mechanically removed, make sure any soil, plant material and seeds are deposited into permanently dry sites, well above the water

table. Even mud deposits on people, animals, or vehicles can contain seed and/or plant parts capable of developing new plants if they land in suitable habitat.

- Do not graze livestock in these areas, unless part of a weed management plan. If animals are used as a weed control strategy, ensure that they don't spread the noxious weed to their next site. Move them into an upland pasture with no suitable habitat for emergent noxious weeds.
- Wildlife may transport both seed and plant parts to other areas, but little can be done to minimize this possibility.
- Manage land to maintain healthy, vigorous, productive desirable plant communities. This will help prevent existing weed infestations from rapidly expanding and discourage new weeds from getting started on new sites.
- Inventory and monitor all suitable emergent plant habitats for new noxious weed appearance at least annually. It is not possible to control weed seed and plant part transport from all sources. Therefore early identification of any new weed establishment, even one plant, will provide for a rapid control response.
- Encourage state and local governments to enforce plant quarantines and plant transport laws.

2. Mechanical Removal

A. Hand Pulling/Grubbing

To be most effective hand pulling or grubbing should remove the entire above-ground portion of the plant and as much of the root as practical. Removing the entire root is optimal.

This method can be very effective with most annual species and perennials that have minimal root structure and no rhizomes. Pulling can be effective when plants have enough strong top growth to remain attached to their roots during pulling events. Pulling has little effect on strong-rooted perennial plants with well-developed rhizomes or that have weak top growth that does not stay connected to the root during hand removal.

Many emergent weed species will re-sprout from roots left in the ground. Care should be taken to remove all roots when manually removing a perennial plant. Pulling may force new shoot growth from the plants root system with the result that several shoots may occupy a space where one shoot was removed. Digging up the roots of such perennial species can increase hand removal effectiveness, however this is practical on only very small infestations.

B. Mowing/Cutting

For emergent weeds, mowing is generally only practical on ground solid enough to support mowing equipment. Emergent plants often grow in saturated soils that are not easily accessible. If the soil supports equipment, mowing is most effective when flowers and the resultant seed production is eliminated or minimized. For many species, the most vulnerable period for mowing occurs just before to just after flower bud formation. At this time major plant energy resources are used for

top growth and bud formation. Mowing at this time will remove most photosynthetic material and greatly weaken the plants ability to re-grow and produce seeds. On some species this may have to be done several times during a growing season to be effective for minimizing seed production. Repeated mowing may reduce target weed density.

Mowing is non-selective and will affect desirable species in the plant community as well as the targeted weeds. It is most effective when applied to nearly monoculture stands. Fragments of some plants that are cut during mowing operations may find their way to new sites and form new plants. Cutting weeds can be made more selective on small or scattered infestations by using hand-operated equipment such as weed eaters.

C. Covering

Small infestations of emergent noxious weeds can be killed or weakened by covering them with opaque materials such as heavy black plastic sheeting to block all sunlight. Covers should be installed before or when plants first germinate in the spring. The targeted plants must be completely covered making sure the cover edges are sealed with rocks, soil, or heavy objects. The covering should be left in place for at least one year. Some tenacious species may require two full years for control. This treatment will kill some individual plants and cause stunted growth in others. The remaining plants will generally exhibit much reduced vigor when uncovered.

Covering is non-selective and will have equal effects on desirable vegetation. This may not be a problem if used on small homogenous weed infestations. It may work well when in combination with other treatments such as hand removal/digging or herbicide application. Due to the difficulty of keeping a cover intact and in place for long periods in an emergent plant habitat, this method is generally only effective on small infestations. Also the edges of the cover should be checked periodically to ensure that plants remain completely covered.

D. Water Management

This method involves raising or lowering the level of water in a water body for a period of time long enough to either drown the plants or dry them out. Emergent plants need saturated soils or a very high water table to grow. If the water level can be manipulated when the plant is actively growing it may serve to limit the growth or kill the plant. Water level control might be most appropriate for large monoculture weed populations or those covering most of a shoreline.

Evaluate this option carefully as desirable associated and adjacent vegetation may be damaged by high water or as the soil dries with lower water levels. Water level fluctuation will also affect shoreline residents, and public access. A water draw down may only be effective if the low water can be maintained long enough for the soil to dry out where emergent noxious weeds were growing. Careful monitoring is required following this treatment as seeds present in the soil can germinate as the water levels rise. A more open plant community may allow some weeds to become established at even higher densities from the seed bank.

Lowering water levels also has significant impact on animal communities and can strand fish. Only consider this option after talking to your local jurisdiction, WDFW, and others.

Raising water levels may also be a control option for some emergent species under specific conditions. Emergent weeds only grow in limited water depths and must have their top growth above the water's surface. If the water level is raised in spring when plants start growing, this may kill or severely minimize growth for that season. Water levels need to be raised for long enough periods that new growth is eliminated for that year and perhaps into the following year. However, this method is not selective for the target weed species so all shoreline vegetation will be impacted.

For both raising and lowering water elevation, maintaining these levels for several years would likely be required to eliminate perennial weed species.

E. Manipulating Site Environmental Conditions

Some emergent plants, like purple loosestrife, grow in shallow water to a depth of about 16 inches and upland to about 18 inches above the water table. They do best along shorelines that slope gradually out into the water. If banks can be reshaped to have a steep gradient to the water and below its surface, site conditions suitable for emergent plants can be minimized. This should be a strong consideration when planning a new pond or other water developments, but is not a suitable control technique for managing noxious weeds in naturally occurring wetlands or lake shores. This method also eliminates habitat for desirable native emergent species and the animals that depend on them. Bank reshaping during pond construction using heavy equipment, dredges, or cookie cutters narrows the habitat for emergent vegetation and emergent weed species. If emergent weeds invade, they can then only grow within a narrow band along the shoreline. This results in less control efforts that are focused on target plants.

F. Removal, e.g. dredging or cookie cutter

In extensive areas of shallow water that support large monoculture stands of emergent weeds, dredging or cookie cutter type equipment can be used. Either method increases water depth, reshapes banks, and/or removes plants, root mass, and soil from the site. These techniques are expensive, non-selective, cause major site changes and much disturbance, and leave areas that must be re-vegetated. However with large weed infestations, these techniques can result in more open and deeper water, resulting in less potential emergent weed habitat. A much narrower area remains to establish competing vegetation and for weeds to re-invade. Over all, both monitoring requirements and possible control efforts for new invaders are minimized.

3. Cultural Control

A. Re-vegetation

Re-vegetation with suitable desirable species may be required as part of an overall weed management plan or used on its own as a primary control technique. Re-vegetation is often needed after other management methods have reduced or

eliminated a population of noxious weeds. Establishing desirable vegetation helps prevent the re-establishment of the noxious species from seeds and helps ensure that another noxious species doesn't replace the species that was removed. Generally re-establishment of native plants from associated or adjacent native plant communities happens rapidly in emergent habitats, but sometimes the removal of a weed species opens up habitat for other noxious species to invade. Where the potential for this to occur exists or where bare areas remain, it is desirable to plant suitable native species.

Re-vegetation should always be considered as the next management step once emergent weeds have been controlled when existing desirable plants do not provide complete site cover and where another noxious weed species seems poised to invade. Re-vegetation is particularly important if a control technique has resulted in bare ground. Re-vegetation can be done with mechanical equipment if site conditions allow or by hand on small scattered sites. Establishing desirable competing vegetation as quickly as possible minimizes potential weed re-invasion. Re-vegetation might be combined with water draw down that could make the site easier to access with heavy equipment. Or, follow with a light herbicide application to remove re-sprouting weeds to give desirable planted species a competitive advantage.

After site modification or construction of stormwater ponds or wetlands, vegetate all bare soil areas with suitable desirable species to establish a good mix of native species to prevent weed invasion. Desirable plants can be introduced as seed or nursery stock. When established, these plant communities will help resist weed invasion.

B. Grazing

Livestock grazing using sheep, goats, cattle, or other grazing animals can be effective in reducing weed top growth and plant vigor. If weeds are grazed during a plant growth stage when they are palatable to the animals, much of the weeds top growth will be eaten. For example, cattle will leave about a one-inch stubble height on herbaceous species; sheep and goats may graze the same species more closely to the ground. Goats will also eat woody plants. However, grazing by itself may not kill plants and not all emergent species are palatable to grazing animals. Also grazing in wetland or shoreline areas may contribute to water quality and habitat degradation from site disturbance and manure production. Be selective in choosing suitable sites.

Using temporary fences, grazing animals can be confined to targeted weed areas to minimize their impact to desirable plant communities. If grazing can be repeated within each year and for several years in a row, it will greatly reduce weed density and vigor and may kill some plants. Grazing might be combined with other treatments or re-vegetation to increase actual weed control effectiveness. Animal grazing is not completely selective to target weeds but because emergent noxious weeds often develop monoculture stands; this may not be a problem.

Grazing results in ground disturbance, particularly in emergent plant habitat. This disturbance can be used as a tool to prepare a site for planting and/or to plant seed of desirable vegetation. Consider seeding the area with desirable species when animals are present so they can trample the seed into the soil. This technique can often be used effectively when desirable plant communities occupy the site but scattered bare patches or weed infestations need re-vegetation. Moderate grazing used for weed control will generally not change associated plant communities.

C. Burning

Burning by itself usually does not result in control of emergent weeds, but burning can be an effective tool to remove dead, dried vegetation to allow better access to the site for other control measures. No matter what season they are burned, because the roots of emergent plants are in cool moist soil, they never get hot enough to completely eliminate their ability to re-sprout in the spring.

In eastern Washington, emergent vegetative growth from the previous year often dries enough in late winter to burn. At this time fire can be easily controlled and has little effect on weed plants or other vegetation the following spring. It does remove accumulations of standing and down litter from weed infestations. With the litter overstory removed, new weed growth can be easily accessed for covering, herbicide application, mowing, grazing, or re-vegetation.

D. Coordination with Others

Once an emergent noxious weed has become established, any management strategy and/or IPM control plan will be most effective if all landowners or managers are informed and become involved with management. Inventory and monitoring should occur on all properties that have potential habitat since weeds do not respect property lines. Sharing information on weed locations from monitoring and control activities should result in a higher chance of weed eradication or confinement in that area. Through a coordinated effort of education, inventory, planning, both prevention and control implementation, monitoring both infested and non-infested sites and continued communication, a weed can be prevented from spreading rapidly over wide areas. With emergent weeds, communication should include the local and/or state and federal governments since permits are often needed for control methods in aquatic sites.

When an infestation first appears, initiating immediate weed management results in the most effective control at the lowest cost. Identification of a new weed on one site should be a concern for that landowner and for the owners of all surrounding properties with potential habitat. By using a coordinated local community approach, including prior planning and rapid implementation, weed impacts and costs can be minimized on extensive areas and both agricultural and wildlands may be protected. Without all involved from the start, a weed has a much better chance to spread widely throughout an area increasing management costs for everyone

4. Chemical Control

In Washington State, aquatic herbicides are all restricted use. Any person purchasing or applying aquatic herbicides in Washington State is required to have a valid Washington State Applicators License with all applicable endorsements. In addition, if herbicides are applied in areas where they may enter the water, coverage under the Noxious Weed National Pollutant Discharge Elimination System (NPDES) permit is required. See the permit section for other legal requirements necessary to apply aquatic herbicides in Washington State.

A. Herbicides

Herbicides are chemicals that interfere with vital plant functions and result in weakened growth or death of the plant. To be used effectively label rates must be followed and important factors to consider when using a herbicide include timing, application method, concentration, weather conditions, plant growth stage, plant coverage and environmental conditions. Herbicides can be very effective in some situations, although depending on the product used, they may not be selective for the target species. If used improperly herbicides also have the potential to contaminate water, to degrade water quality, and impact human health. There also may be irrigation, livestock watering, or potable water restrictions after application to water. For emergent weed control, herbicides can only be used in dry weather and require special spray equipment and training.

Even with all these considerations, a carefully planned weed management program or IPM plan can include herbicides, although the number of herbicides labeled for aquatic use is limited. The selection of the herbicide or herbicide formulation may depend on variables such as water exchange, presence of endangered species, areal coverage and density of the targeted plant, susceptibility of the targeted plant to that particular herbicide, water chemistry, etc. The herbicide that has the least toxic impacts to non-target organisms, but is still highly effective in controlling the targeted species should be used. Herbicides are a valuable management tool for emergent noxious weeds and can often work well within an integrated program.

B. Adjuvants

Adjuvants, in general, are anything added to or applied with an herbicide to increase its efficacy. In the U.S., there are several hundred name brand adjuvants that have various effects on aquatic herbicides. In general, adjuvants can be classified into three categories:

1) **Activator adjuvants** increase the effectiveness of the herbicide by altering the spray droplet size, distribution of the spray on the plant, viscosity of the spray, evaporation rate, rate of uptake (absorption) by the plant, and solubility of the herbicide in the spray solution. These include:

a) Surfactants (surface-active agent) promote the penetration of the chemical into the leaves of the plant.

b) Wetting agents increase the ability of water to displace air or liquid from the plant's surface so the herbicide will spread more evenly over the plant.

c) Oils increase the retention time of the sprayed material on the plant and enhance uptake though the leaf surface.

2) **Spray-modifier adjuvants** affect the delivery and placement of the spray solution. They make the herbicide spray easier to aim, reduce herbicide drift in the air, and cause the spray to more readily adhere to the plant. These include:

a) Stickers and spreaders are made of gels, oils, and waxes that help spread and adhere herbicide spray droplets to foliage.

b) Foams make it easier to control drift--so the herbicide is less likely to be misapplied.

c) Polymers are also used for drift control and to help break surface tension on the water, thus enabling the herbicide to sink onto submersed aquatic weeds.

d) Inverting oils form a viscous blend that reduces drift during application, increases contact time on the plant, and sinks the herbicide onto submersed plants.

3) **Utility-modifier adjuvants** make the herbicide more useful in certain environmental conditions. These include:

a) Buffering agents help to disperse the herbicide in alkaline or acidic water.

b) Anti-foam agents enable the herbicides to mix with soft water.

The above information was taken from the Aquatic Herbicidal Control, Adjuvants website at the University of Florida (http://aquat1.ifas.ufl.edu/guide/adjuva.html).

Currently the adjuvants that may be used on aquatic sites under WSDA's NPDES permit include:

- R-11
- LI-700
- Agri-Dex™
- Class Act Next Generation™
- Competitor™
- Dyne-Amic™
- Kinetic™

This list is subject to change as other registered surfactants are approved through the SEPA process.

For more information on adjuvants approved for use for 2004, see Summary of Aquatic Acute Toxicity Five Spray Adjuvants.

Food grade colored dyes may be used as an aid to ensure accurate and even application of chemicals on vegetation to be controlled.

See the glossary of adjuvant terms for additional information.

Also, see the online version of the *Compendium of Herbicide Adjuvants, 6th Edition* by Bryan Young, Southern Illinois University, Carbondale.

C. Fertilizers

These products improve the growth and vigor of plants. They can be used to increase the productivity of the desirable competing vegetation making it more effective in occupying space both above and below the ground. This reduces the chance a weed species will be able to gain a foothold on that site. However, it is generally not a good idea to use fertilizers around natural lakes, rivers, and streams since this can lead to problems with algae and nuisance aquatic weeds.

5. Biological Control

Bio-control involves introducing an organism (often an insect or disease) that attacks a plant in its native area, to limit its growth or occurrence where it has become a weed problem outside of its native range. Potential bio-control organisms collected from weed species growing in their native range are intensely screened for their specific plant impacts and preferences. If the potential bio-control organisms affect only the target weed species, these organisms may be permitted for release on the target weed in areas where the plant has become a weed. A good example of a successful bio-control program involves insects that attack purple loosestrife.

Biological controls should only be considered as a control option for noxious weeds that are well established in an area. Biological controls are not an option for Class A weeds, or for Class B-designate weeds with a limited distribution on site. Biological controls function best on large monoculture stands or many smaller, scattered stands that are close enough together that control organisms can easily travel between them. It does not work well on stands of widely scattered individual plants.

In most cases, when a biological control has been introduced, it takes time, possibly several years or more, to get established, produce a large population, and start having noticeable impacts on target species. In some cases biological control insects, like the *Galerucella* beetles used on purple loosestrife, have killed much of the existing weed population with no direct effect on associated plant communities. In other cases, control organisms may fail to establish on site or may have limited-to-no impact on the target species.

Bio-control organisms do not generally eradicate their host species. As population levels increase, the target plants are weakened, seed production is reduced, and ultimately plants may be killed or out competed by native (or other non-native) species. Eventually the remaining weed population will not be large enough to support a large predator population. The predators then die back until their population balances with the available weeds. With the pressure from predators reduced, the weed population expands. As their food source increases the predator population also increases. Assuming no other influences this mutual cycling of predator and host will continue, keeping the weed population in check, but not completely eliminating its occurrence.

APPENDIX A

Profiles of Selected Freshwater Emergent Noxious and Quarantine Weeds and Specific Control Alternatives for Each

Other species to be added, check back

8. Giant hogweed (*Heracleum mantegazzianum*) - under development
9. Hairy willow herb (*Epilobium hirsutum*) – under development
10. Indigobush (*Amorpha fruticosa*) – under development
11. Poison hemlock (*Conicum maculatum*) - under development

Common Reed or *Phragmites*

(*Phragmites australis*)
Non-native genotypes

Phragmites invasion replacing native wetland plants in Washington State (Dr. Bernd Blossey)

Plant Characteristics:

Phragmites or common reed (non-native genotype) is a very large, perennial grass growing to 15 feet tall under favorable conditions. It has large hollow stems, (with bases as big as a finger), which produce leaves up to 16 inches long and ½ -1½ inches wide along most of their length. Ligules, (short papery bracts growing from the leaf where it bends out from the stem) look yellow or green on weedy forms. Weedy genotype stems are ribbed, rougher, and larger than native plants. They produce dense feathery flower heads 8-16 inches long from July through October.

The seeds are generally dispersed from November to January, distributed by wind, water, birds, and attached to animals. Seedlings may be produced on nearly any site that has some surface water (even somewhat brackish or alkaline water); however the plant generally spreads by rhizomes. Many seeds are sterile.

Non-native *Phragmites* in King County (WSDA).

Phragmites prefers sites near stagnant water or where wave action is minimal. New plants often get started on disturbed sites, areas with considerable water fluctuation, or with new sediment accumulations. Mature plants produce stout rhizomes five to fifteen feet or longer. The rhizomes may live three to six years, but new rhizomes are also produced every year. New plants develop at each node, allowing spread into adjacent plant communities. In some cases, plants also produce stolons (horizontal above ground stems) that also produce additional plants.

Distribution and Impacts:

Phragmites australis occurs throughout the world except in Antarctica and this species may be more widely distributed than any other flowering plant. It has many genotypes adapted to the environmental conditions where they are native. The Pacific Northwest genotype grows in wetlands, on stream and ditch banks, and on lake, pond or some estuary shores. It occurs as part of the natural plant community and does not spread aggressively.

Phragmites seedlings may germinate and develop some top growth and remain as relatively small plants for several years. They blend in with existing grasses and are very difficult to spot during a weed inventory or when doing follow-up monitoring. Once well established, they produce massive top growth in a very dense stand, which eliminates most other competing plants.

Mature stands can reach densities of 200 culms per m^2 in wet areas to 300 culms per m^2 in dry areas. These stands are poorly utilized by mammals or birds and species diversity is low in dense stands.

Another genotype, probably of European or Asian origin, has become established in Washington and elsewhere in the US. Although physically similar to the native variety,

this non-native genotype has some distinctive features, including an aggressive, dominant, growth habit. This aggressive genotype has recently been recognized as a non-native weed and currently appears on Washington's noxious weed list as a Class C weed.

For further information and additional photographs, please refer to the following websites:

Ecology and Management of Invasive Plants Program, Dr. Bernd Blossey, Cornell University: http://www.invasiveplants.net/invasiveplants/default.asp

Note: The morphological characteristics to distinguish native from non-native genotypes of *Phragmites* are being updated as field data from around the U.S. is being reported to Cornell researchers. Please refer to this website for the most up-to-date identification information: http://www.invasiveplants.net/*Phragmites*/phrag/morph.htm

For an overview of the genetics of *Phragmites*, see Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of *Phragmites australis* into North America. Proceedings of the National Academy of Sciences, USA. 99(4): 2445-2449.

MANAGEMENT PLANS

Integrated Pest Management, as defined by RCW 17.15, is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet programmatic pest control objectives.

When following this IPM plan, be sure that site-appropriate control methods are used.

Before starting a control program, distinguish between the native and introduced genotypes of *Phragmites*. The Washington State Department of Agriculture is conducting a survey and inventory of *Phragmites* populations in Washington in 2003 and 2004. Check with Agriculture before conducting any control work. Only the aggressive introduced genotype should be controlled. The native genotype has been found to be an important habitat component of the rare Yuma Skipper butterfly. Controlling native strains of this species may have a detrimental affect on this limited wildlife species.

Phragmites is found in both eastern and western Washington. There are some remnant populations of the native Pacific Northwest genotype, but most *Phragmites* found in Washington is the invasive genotype. The non-native genotype is aggressively invading in some locations such as along the Snake River and in the Winchester Wasteway. It is probably not possible to eradicate the non-native genotype from Washington, but outlier populations should be eradicated and wider-spread infestations should be contained and prevented from further spread.

CONTROL METHODS

Listed below are a range of options, or a combination of options, that may be suitable for site specific control of *Phragmites*. These control methods are listed in order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

Phragmites is not very widespread in the state of Washington, and very few wetlands have large infestations. Early detection and prevention is still an effective control option for most areas. WSDA continue to survey and identify the native and non-native populations and to map *Phragmites* sites in the state. Please call local county noxious weed control boards, or WSDA, to report new sites.

MECHANICAL CONTROL

Hand pulling: Hand pulling is only suitable for seedlings and young plants that have not established much top growth or developed an extensive root system or rhizomes. Larger, older plants generally cannot be hand pulled or even dug out because some rhizomes will be left to propagate new plants.

Mowing: Mowing is possible on sites that can accommodate a tractor and mower or in smaller stands, weed whackers can be used. In many areas, *Phragmites* is growing with its feet in the water and may be difficult to access. It may take a heavy duty tractor mounted mower to cut mature *Phragmites*, with its large coarse stems. Younger plants are easier to mow. To be effective, start mowing plants at the end of July before seed heads form, cutting the plants as low as possible. A single mowing may stimulate more production from root crowns and rhizomes. Repeated mowing of at least several times each year, for a minimum of two growing seasons is needed to reduce growth. According to the Nature Conservancy, it may take up to eight cuttings per year to kill perennial grasses. However, mowing does reduce plant energy reserves each time since plants must re-grow and over time the plant depletes it carbohydrate reserves. Mowing will reduce stand density and minimize seed production. Herbicide application to these smaller weakened plants will result in better coverage, increasing potential effectiveness and may require lower chemical volumes.

Cutting: Cutting off the seed heads of *Phragmites* is probably not an effective use of time because seeds do not appear to be important for *Phragmites* propagation. Many seeds are considered to be sterile.

CULTURAL CONTROL

Site Modification: If *Phragmites* occupies most of a wetland or pond shoreline or has grown into tall dense, monoculture stands, site modification can be considered. However, this greatly alters the wetland because plants, roots, and the surrounding soil are physically removed; deepening or creating water areas several feet deep. Site modification is not recommended in high quality wetlands or if listed plants or animals use the site because the site is permanently modified.

Large heavy floating equipment is used to dig out and remove plants, roots, and shoreline soil. What remains are steep banks that slope down rapidly into deeper water. All plant material must be removed from the site because any rhizome fragments can produce new plants if left in a moist environment. Site modification increases the open water area and

reduces the potential for *Phragmites* re-establishment. By reducing available habitat for this weed, both monitoring and future control will be easier.

The considerable site disturbance will require re-vegetation. Maintain a vigorously growing desirable plant community on the site to ensure against invasive by *Phragmites* or other noxious weeds by planting appropriate native nursery stock or seed.

Burning: Although burning is not an effective control technique used alone, burning can be useful in reducing the very dense biomass overstory of monoculture stands. These sites may dry enough in late winter or early spring so they can be burned. At this time the soil will be cool and moist allowing the top material to burn without killing any desirable plant seed still remaining in the soil. Once this dense plant cover has been removed, access will be improved for herbicide application on new plant growth.

Grazing: In some situations grazing may be used on new weed growth to further reduce plant vigor, open the site for desirable plants, and increase effectiveness of spot herbicide application. Grazing is effective only on new *Phragmites* growth, because it becomes unpalatable when it is more than two feet high.

CHEMICAL CONTROL

Herbicide Treatment: Herbicide application can be very effective in killing *Phragmites*. However, because of its size, both horizontal and vertical density, and extensive rhizomes and stolons, it may be very difficult to get adequate herbicide coverage and follow-up treatment will be necessary. For aquatic applications, glyphosate (Rodeo® or similarly aquatic-registered glyphosate formulations) and imazapyr (Habitat®) are labeled for this grass. Glyphosate and imazapyr are non-selective systemic herbicides. Ideally these herbicides should be applied to *Phragmites* after the tasseling stage when the plants are translocating nutrients to their roots. Glyphosate is most effective if applied in late summer through late fall. A successful control option used on wildlife refuges appears to be the application of glyphosate late in the growing season, followed by burning or mechanical removal of the dead vegetation the following spring. Retreatment is necessary every two to three years

On seedlings and small patches of mature plants a backpack sprayer or wicking may work best. In large monotypic stands, aerial application may be the most economical method to apply herbicides. The Nature Conservancy in Indiana reports success using 1.5% Rodeo® applied from backpack sprayers with five foot wand extensions (to reach the tall plants). They treat just before the plant senesces in monotypic stands of up to twenty acres. They have gotten 97 percent mortality after one year of treatment. The treated vegetation is burned the following spring to make follow-up treatment easier and to promote the germination of native seeds. (http://tncweeds.ucdavis.edu/moredocs/lytsa01.html)

In areas without monotypic stands where overspray may kill desirable species, plants can be cut and a 25 percent solution of Rodeo® can be dripped (or injected with a large hypodermic needle) into the hollow stem. This technique has been reported by The Nature Conservancy to result in 50-75 percent mortality. Although this application

method is very labor intensive, it preserves remaining desirable plants and can protect rare plant species.

Other management methods such as cutting, mowing, burning, and/or grazing can reduce top growth and make *Phragmites* re-growth more accessible.

BIOLOGICAL CONTROL

Please refer to the following website for a good overview of insects that feed on *Phragmites*: http://www.invasiveplants.net/*Phragmites*/phrag/insects.htm. The information presented below is taken from this site.

Research into biological control agents for *Phragmites* is just beginning and no official bio-control insect releases have been made in the U.S for *Phragmites* management. However, some experts feel it may be possible to isolate insects that will only attack the weedy *Phragmites* genotype. Researchers have identified at least 140 European insects which feed on or in other ways affect the invasive *Phragmites* genotype. Of these insects, 50 percent use this plant for a major part of their life cycle and 40 percent use *Phragmites* almost exclusively. Twenty-one species from this European group have been identified in some states in the eastern U.S. The source of their introduction is unknown, although some insects were probably introduced in shipping materials in ports.

The study and screening of insect impact on desirable and native plants continues for species that show promise of having a major impact on *Phragmites*. Several European insects are being evaluated as potential control agents for *Phragmites*. These insects were selected based on their life history and impact of *Phragmites* populations in Europe. These potential bio-control agents include:

- *Archanaria geminpuncta*, a shoot-boring moth;
- *Phragmataecia castaneae*, a large shoot and root mining moth;
- *Chilo phragmitella*, another shoot and root mining moth;
- *Schoenobius gigantella*, a moth that mines underwater shoots; and
- *Platycephala planifrons*, attacks shoots early in the year and stunts growth. This is one of the most damaging species found during a European survey.

Garden Loosestrife

(*Lysimachia vulgaris*)

Washington State Department of Ecology

Plant Characteristics:

Garden loosestrife is a tall, erect, perennial plant growing from a root mass that includes long stolon-like rhizomes, extending 15 to 20 feet or more. These plants can reach three to four feet in height. The three to five inch long lance shaped leaves grow in an opposite or whorled pattern along the stem. The leaves are dotted with orange or black glands. Each stem produces yellow primrose-like flowers that occur in a cluster at the top of the plant. These flowers are bright yellow, have five petals, with seed produced in a dry capsule. Garden loosestrife flowers during July through September, but the plant may not flower during the first few years of growth. When the plant produces flowers, it is probably mature and has developed at least some rhizomes.

Distribution and Impacts:

Garden loosestrife grows in moist soil in wetlands, on lakeshores, riverbanks and other areas with permanent moisture. It spreads rapidly, probably because its rhizomes and stolons are generating new plants. Garden loosestrife seems to dominate where it occurs and may be able to out compete both native plants and other noxious weeds such as purple loosestrife. Its distribution is still limited in Washington and it is classified as a Class B weed. There is limited management information available for controlling garden loosestrife.

For further information and additional photographs, please refer to the following websites:

King County Noxious Weed Control Board:
http://dnr.metrokc.gov/wlr/lands/weeds/gdnlstrf.htm

Washington State Department of Ecology:
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua007.html

Washington State Noxious Weed Control Board:
http://www.nwcb.wa.gov/weed_info/gallery/gardenloosestrife.html

MANAGEMENT PLANS

Integrated Pest Management, as defined by RCW 17.15, is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet programmatic pest control objectives.

When following this IPM plan, be sure that site-appropriate control methods are used.

CONTROL METHODS

Listed below are ranges of options, offering a combination of options, that may be suitable for site-specific control of garden loosestrife. These control methods are listed in the following order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

Early detection and prevention is the preferred control method when new sites, or when very small sites are found. As a Class B noxious weed, garden loosestrife does have a somewhat limited distribution in our state. Be familiar with garden loosestrife. If you are not sure about plant identification, please call the local county noxious weed control program for plant identification.

Please notify your local county noxious weed control program with suspected sites. While distribution is limited, there are reported sites from both eastern and western Washington. When garden loosestrife is established, the sites can be dense.

This showy plant was introduced as a garden ornamental and may still be offered for sale. As a Class B noxious weed, control is required by all landowners. As a quarantine species, it is illegal to buy, sell, offer for sale, or transport in the state of Washington. Plant quarantines are a preventative measure to keep new infestations from spreading from garden ornamentals.

MECHANICAL CONTROL

Hand pulling: Like many rhizomatous species, garden loosestrife can typically be successfully hand pulled only when the plants are one to two years old. At this stage it should still be possible to remove all of the roots and rhizomes so resprouting will not occur. It is very difficult to fully remove the root system of older plants using this method and failure to remove all of the rhizomes may result in new plants being generated at each node. It may be possible to dig older plants out, but this is labor intensive and probably not practical on anything more than a very small infestation of several plants.

Covering (solarization): Garden loosestrife produces long extensive rhizomes. Therefore covering plants with plastic sheeting may only be effective on small, relatively recently established infestations (areas smaller than 20-30 feet on a side). If covering appears to be a feasible control option, start in the spring by cutting all top growth from the existing plants and an area around them. Use two or more layers of heavy black plastic sheeting and seal the edges with rocks, boards, or natural materials to prevent any light from entering. On the water side heavy rocks may need to be used. Leave the cover in place for at least two to three growing seasons. While the covers are in place, periodically check the area around the cover for seedlings or growth from rhizomes. All new plants should be removed immediately and the rhizomes pulled out and cut off under the covering without letting light into the sealed area.

Cutting: If it is not possible to control the mature plants, cutting off the flowers and seeds may prevent seed set for the year.

CULTURAL CONTROL

Water Level Management: Lowering the water level in a garden loosestrife infested pond or lake could potentially be an effective treatment technique for widespread infestations where other management methods are not practical and where water levels controls exist that would allow this to occur. Because garden loosestrife usually roots in moist soil at the waters edge or in very in shallow water, lowering the water level and drying up these sites could result in plant death. This would also kill most existing desirable shoreline vegetation. Lowering water should only be considered for sites with dense nearly monoculture stands of garden loosestrife that covers much of the shoreline. Although there is no information available on the success of this method for garden loosestrife control, the water levels would most likely need to be lowered for at least two years. This would allow the previously wet emergent plant zone to completely dry out. Because garden loosestrife can grow in upland sites, it is important to ensure that this zone stays as dry as possible. Water level draw down may be a better method in eastern Washington where summers are hotter and drier. With the water level down, it may be possible to more easily implement other control measures such as mowing or herbicide application. Once water levels are allowed to return to their traditional levels, it will be important to remove newly sprouting garden loosestrife plants. It may be necessary to revegetate the area with appropriate native wetland species. It is unknown if raising water to at least two feet above plant rooting level would have any effect on garden loosestrife.

Grazing: Grazing is a similar process to mowing and can remove weed top growth, weaken plants, and reduce seed production. It is unknown whether garden loosestrife is palatable to grazing animals, but this control method may be worth trying in situations where grazing is practical. However grazing animals in wetlands also contributes nutrients and fecal bacteria to waterways and animals may trample and alter wetland characteristics. Choose sites appropriate for this control activity.

Fencing is critical to concentrate grazing on the weedy site and this can be accomplished with permanent or temporary fencing which must be adequate to contain the animals.

Grazing animals create site disturbance, which provides an opportunity to sow seed from desirable plant species so that the animals can trample it in. The resulting new plants may help compete with garden loosestrife regrowth or germination. Grazing treatments may be needed annually over several years to reduce weed abundance. Grazing will weaken weed growth, seed production, and naturally fertilize the site. Weed regrowth is still produced but weakened plants are more susceptible to other control measures such as herbicide treatment.

CHEMICAL CONTROL

Herbicide Treatment: Little research has been done on specific herbicide effects on garden loosestrife. However, it is likely that these plants would respond to glyphosate, triclopyr, 2,4-D, and imazapyr application. To avoid damaging desirable vegetation, apply aquatic herbicides with hand held sprayers on new individual plants, to plants forming small to large open stands, or to small monoculture stands of less than a half acre. For individual plants or small stands, using a wicking or wiping method of application can result in selective control of the target weed. Adding a colored dye to the spray mix marks treated plants and helps prevent over application and minimizes the number of missed plants.

One herbicide application will not be enough to control a garden loosestrife infestation even if all mature plants are killed because new plants will sprout from seeds. At least three to four years of active control will be required, followed by close annual monitoring to detect and remove seedlings.

Glyphosate (Rodeo® and other glyphosate brands with aquatic labels) may be used to control garden loosestrife in aquatic situations. Best results are obtained when the herbicide is applied when the plants are actively growing at or beyond the bloom stage of growth. Fall treatments must be applied before a killing frost. Application after flowering starts and some seed cases have formed will not prevent development of at least some viable seed. Glyphosate is not selective and will damage most other plant species. When desirable vegetation is nearby, applicators should try to minimize its loss by focusing their application just on the targeted plants. Apply up to 4 pints per acre of glyphosate as a broadcast spray; or a 1 to 1.5 percent solution when using hand held equipment.

Because glyphosate is non-selective this is a better choice of herbicide when treating a monoculture of garden loosestrife where there are few non-target plants to be damaged. As mature plants are killed and native species return, a selective herbicide such as

triclopyr or 2,4-D can be used to target garden loosestrife while having little impact on native broad leaved species. However, if carefully wicked or wiped onto individual plants, glyphosate can be made selective through application techniques.

Triclopyr (Renovate® 3) is a selective herbicide that will damage broad leaf herbaceous plants, trees, and shrubs, but should not affect grasses, sedges, rushes, or similar monocotyledonous plants. Renovate 3® is the only triclopyr formulation that has an aquatic label. Renovate 3® should be effective if applied to seedling garden loosestrife plants through full bloom growth stage. For best effect apply from bud to mid-flowering stage of growth. Thorough wetting of the leaves and stems is necessary to achieve good control. If using a back pack sprayer, a 1 – 1.5 percent solution of Renovate® is recommended on the label. For broadcast applications, 6 to 8 quarts of Renovate® per acre is recommended. Follow-up applications should be made the following year. Like glyphosate, triclopyr should be applied selectively to target plants to prevent damage to existing desirable competing broad leaf vegetation.

2,4-D herbicides are selective chemicals that will damage broad leaf herbaceous plants, trees, and shrubs, but should not affect grasses, sedges, rushes or similar monocotyledons plants. However, there are use restrictions on 2,4-D in eastern Washington. In addition a recent court decision limits the use of 2,4-D near salmon-bearing waters. Buffers and other conditions to limit drift are in effect, so check with WSDA before applying 2,4-D.

BIOLOGICAL CONTROL

To our knowledge no biological control agents have been researched or released for garden loosestrife control and no research activity has been planned. This plant is cultivated and prized as a garden flower in many areas, so bio-control research may never become an option.

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Knotweeds

Japanese knotweed (*Polygonum cuspidatum*)
Giant knotweed *(P. sachalinense)*
Himalayan knotweed *(P. polystachyum)*
Bohemian knotweed (*P. bohemicum*)

Washington State Noxious Weed Control Board

Plant Characteristics:

These knotweed species and their hybrids are tall shrub-like, perennial herbaceous plants that are listed as Class B Noxious Weeds. The basal root crown will produce 30-50 stout bamboo-like shoots that may reach to 15 feet tall or more (giant knotweed). The hollow shoots may be an inch or more in diameter with swollen nodes three to five inches apart that are reddish-brown in color. The leaves are produced on upper stems and on the limited side branching. The leaves size and shape vary between species. Japanese knotweed leaves have a truncated base; giant knotweed has huge elephant ear shaped leaves; and Himalayan knotweed has elongate triangular-shaped leaves. The smooth-edged leaves are green and occur singly at each node in an alternate pattern.

Tiny white or greenish flowers appear in open sprays near stem ends during July and August and produce a small winged fruit. The tiny seeds (about one tenth of an inch long) are transported by water, short distances by wind, and in attached mud. The seeds are not thought to be fertile from these knotweed species, but the seeds of hybrids are considered fertile. The Nature Conservancy has germinated knotweed seeds in the laboratory. Plants arise from fibrous roots and produce a spreading rhizome system, possibly from each major shoot, that may extend to 25 to 40 feet or much more. The rhizomes can penetrate more than seven feet into the soil. Individual plants may be 8-15 or more feet in diameter and often occur in large clumps of several hundred square feet to several acres or occupy an entire shoreline. These plants die back after a hard frost, but bare stalks often remain through the winter.

Knotweeds regrow very rapidly in the spring, often reaching 15 feet by June (giant knotweed). Japanese knotweed typically grows to ten feet with the smaller Himalayan knotweed only reaching four to six feet. Himalayan and Japanese knotweeds are known

to form a viable hybrid called Bohemian knotweed (*Polygonum bohemicum*). Growth of the knotweed plants starts in April or earlier in warmer regions, or as late as June in higher elevations. New plants can establish from seeds, broken off stem parts, or from any node along rhizomes. As little as a half inch plant piece can start a new plant. Young knotweed shoots resemble red asparagus.

Himalayan knotweed in Clallam County (WSDA).

Distribution and Impacts:

These knotweed species occur in almost any environment with at least temporary damp soil to get plants established, such as riparian zones along rivers and streams, disturbed uplands, crop field edges, city lots, forest edges, etc., usually with fairly high rainfall. Knotweeds prefer sunny locations, but can exist in nearly complete shade with reduced growth. Due to early emergence in spring and a rapid growth rate, knotweeds out compete native plants by shading them out. Knotweeds can tolerate a wide variety of environmental conditions.

MANAGEMENT PLANS

Integrated Pest Management, as defined by RCW 17.15, is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet programmatic pest control objectives.

When following this IPM plan, be sure that site-appropriate control methods are used.

A knotweed control guide *Controlling Knotweed in the Pacific Northwest* was developed by The Nature Conservancy, Metro, Portland Parks, and the Northwest Chapter of the

Society for Ecological Restoration in February 2002. Information from this manual was used extensively in the following section about knotweed control and eradication.

Knotweeds are very difficult plants to control because they have an extensive rhizome system and an incredible ability to resprout. Except for small patches that may be able to be controlled non-chemically, any management of these species will likely require some herbicide use. Knotweeds are becoming increasingly problematic along riparian corridors in western Washington. An infestation along the Hoh River was traced back to a single ornamental planting where broken off plant parts entered the river and established new plants downstream. When dealing with these riparian infestations, it is imperative to start at the upstream edge of the infestation and work downstream. While not as common in eastern Washington, there are reports of knotweeds along some rivers. It is not considered possible to eradicate these knotweeds species from Washington, but it may be possible to eliminate them from high quality riparian areas, particularly areas where knotweeds may be degrading salmon rearing habitat.

For further information and additional photographs, please refer to the following websites:

Japanese Knot Weed Alliance:
http://www.cabi-bioscience.org/html/japanese_knotweed_alliance.htm

The Nature Conservancy:
http://tncweeds.ucdavis.edu/moredocs/polspp01.pdf

Clark County Weed Control Board:
http://www.co.clark.wa.us/environ/Knotweed.pdf

King County Noxious Weed Control Board:
http://dnr.metrokc.gov/wlr/lands/weeds/weedid.htm

CONTROL METHODS

Listed below are ranges of options, or a combination of options, that may be suitable for site-specific control of knotweeds. These control methods are listed in the following order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

The knotweeds are very widespread throughout western Washington, and they continue to spread. Learn to identify these knotweed species and remove any new infestations. In eastern Washington known sites are mainly ornamental plantings in private yards, and prevention is still an option.

MECHANICAL CONTROL

Mechanical Removal: This technique can be used on single plants to larger infestations, but will be costly to contract suitable equipment. Remove all top vegetation and rhizomes out to at least 50 feet from each plant. It is critical to remove all vegetation including rhizomes and stems, because they will generate new plants from each node, if they remain in contact with moist soil. Once this operation is completed, revegetate with appropriate native plants that cast heavy shade on the ground. Plan for at least annual monitoring for new plants from missed plant parts and seed, and treat or remove immediately.

Hand pulling and digging: Hand pulling knotweeds is an option only if the soil is soft, the plants are young, there are only a few plants, and the effort is persistent and ongoing for an extended time period. Once the plants have developed extensive roots and rhizomes they will be nearly impossible to completely remove. Any rhizomes remaining in the soil will produce new plants at each node. Also any knotweed vegetation must be disposed of in such a manner that it cannot take root because even small plant fragments can root if they are in moist soil. In England, compost containing knotweed rhizomes is considered to be an environmental contaminant!

In soft soil or sand, pull up the plant by the root crown, trying to remove as much of the rhizomes as possible. About a week after this effort, search for and pull up any resprouting plants and as much of the rhizome as possible. Search for resprouts at least 20 feet around the location of the original plant. Continue this effort until frost and then start again in the spring. The Nature Conservancy reports that it can take up to three years of consistent effort to eradicate a small patch of plants using this method.

Plants and rhizomes of knotweeds might possibly also be dug out, but this is a slow labor intensive process and probably not practical with anything more than a very small infestation of several plants. Tilling also produces many resprouts but could be used in combination with a hand pulling effort.

> The Four T's - If you control knotweed manually, be sure to practice the four T's: be Timely, Tenacious, Tough and Thorough. This advice applies to other noxious weeds with rhizomes.
> --The Nature Conservancy, from "*Controlling Knotweed in the Pacific Northwest*"

Cutting/Mowing: It is possible to eradicate small patches of knotweed with repeated and persistent cutting of the plants. The patches must be mowed or cut twice a month between April and August and then at monthly intervals until frost. Like pulling/digging this effort will need to be maintained for at least two to three years. Using a hand pruner, lopper, or weed eater cut the stalks as close to the ground as possible. Do not let the regrowth exceed six inches in height before cutting the stalks to the ground. Stack the cut stalks where they will dry out and not root (away from moist ground). When using a weed eater, ensure that scattered plant parts do not land moist areas where they can take root.

Covering: There have been anecdotal reports of successful control of small patches of plants using a combination of cutting, hand pulling, and/or tilling, followed by covering. After cutting the plants down to ground level, cover the area with several layers of black plastic or several layers of cardboard. Extend the area of coverage to at least 20 feet or more around the outside of the plant and check at intervals to make sure that shoots are not coming up outside of the cover or through the cover. Knotweeds have been known to grow through asphalt! The cover needs to be left in place for at least one full year and probably longer. Inspect the site on a frequent basis to locate new growth or seedlings and remove immediately to maintain major management gains.

CULTURAL CONTROL

Burning: Japanese knotweed is not killed or even much impacted by burning, however, burning removes dense herbaceous litter and opens access to dense stands for other treatments, such as herbicide application or grazing. Burning should be considered only for stands of one half acre or larger and planned carefully relative to surrounding features and improvements.

Grazing: The knotweed alliance website indicates that the young shoots of Japanese knotweed are palatable to sheep, goats, cattle and horses and grazing may be used in suitable situations to keep the plant under control. Goats will eat most plants down to stems too woody for ingestion. Grazing will not eradicate Japanese knotweed and the plant will continue to grow once grazing ceases. Grazing may be suitable for quarter acre and larger infestations when the plants have put up enough top growth to support the livestock. Contain the animals on the area by fencing. When all weed growth has been grazed, remove the animals and let the plants develop new shoots. When growth becomes abundant enough to support grazing again, let the animals eat it down a second time. Continue this throughout the growing season and at least through next summer. This may kill some plants and greatly weaken others, as well as, breakup the dense mat of rhizomes extending out from each plant. Under an IPM plan, grazing could be followed by herbicide application to kill existing re-growth, then re-vegetation with suitable native plants to create dense shade. Plan on at least annual monitoring for re-growth from seed, rhizomes or broken off stems and treat or remove immediately.

CHEMICAL CONTROL

Herbicide Treatment: Glyphosate (Rodeo® and other glyphosate brands with aquatic labels) has been used to effectively control Japanese knotweed in aquatic situations. Glyphosate is not selective and will damage most other plant species. When desirable vegetation is nearby, applicators should try to minimize its loss by focusing their application just on the target plants.

Foliar application, using backpack sprayers or similar methods, is more efficient on larger monoculture stands of more than a few plants to several acres in size. To achieve the best chance of complete kill, apply herbicide in the spring to plants that are less than 4 feet. The plants need to be large enough to ensure that there is adequate leaf surface. Spray to wet and try to avoid dripping of the herbicide from the leaves. Larger plants will not be killed with just one herbicide application and killing these plants with foliar application may take several applications over several growing seasons. Although the late bud stage

of growth is considered to be the most effective time for herbicide application for knotweed species, waiting that long also means dealing with a huge plant.

Cut stem application can result in up to 95 percent mortality according to the Clark County Noxious Weed Control Board. In the summer or fall, cut each stem within one to three joints of their base (internodes). Add herbicide into the exposed hollow stem cavity following label recommendations. Cut stem application is labor-intensive, both to cut each stem and to apply herbicide, but it will assure that the herbicide is only applied to target weeds and not to other desirable vegetation. It has also been shown to be an effective way to kill this extremely persistent weed. Dispose of the cut stems away from moist environments where they might take root.

Stem injection of Japanese knotweed for some formulations of glyphosate has been approved for the 2004 growing season. Two holes are made through the first or second node of each stem using an ice pick-like probe to penetrate each cane. A syringe or commercial injection gun can be used to deliver a metered dose of herbicide to the stem through one of the holes. Having a second hole, allows any liquid in the stem to escape as the glyphosate is injected. The Clark County Weed Control Board reports that the plant takes up the herbicide within 20 minutes of injection. They also report that each stem appears to be supported by a separate rhizome. This means that to kill the entire plant, each stem must be injected! For large plants, the Weed Board suggests injecting the outer most stems, coming back later to remove the dead stems and then injecting the remaining stems. Although, like the cut stem method, this is labor intensive, 100 percent kill has been reported. It also ensures selective control of just the target species.

An aquatic labeled formulation of triclopyr has been approved for use in Washington in 2004. The Nature Conservancy reports that triclopyr will control Japanese knotweed, but there are no specific control recommendations for Japanese knotweed on the Renovate3® label. *Controlling Knotweed in the Pacific Northwest* advises that for successful translocation to occur, some herbicides should be used at the lowest effective concentration in order to avoid damaging the above ground tissues of the plant before the herbicide is well dispersed in the root system. This guide indicated that triclopyr (Garlon 3a) at five percent solution appeared to give good top-kill on Japanese knotweed but resulted in mediocre long-term control on large patches. However, there are reports of successful control using triclopyr at rates as low as ¾ percent in high volume application. In Nature Conservancy field experiments, a 3-5 percent triclopyr application (Garlon 3a) eradicated about 50% of small patches after two treatments. In controlled experiments comparing treatments on small patches (30-200 stems), triclopyr (Garlon 3a) provided 90+ percent control in one year and 100 percent control within 2 years. Renovate3® is the aquatic labeled formulation of Garlon 3a and presumably should provide similar results. Always use the aquatic labeled formulation under an NPDES permit when you may get herbicide into the water.

A formulation of imazapyr labeled for aquatic use has been approved for use in Washington in 2004. Because imazapyr is known to translocate readily to rhizomes, this non-selective herbicide will likely play a role in knotweed management in the future.

BIOLOGICAL CONTROL

Japanese knotweed has been considered an attractive ornamental plant and has been deliberately planted. It is increasingly being recognized as an aggressive weed in North America and in the United Kingdom and there is interest in bio-control research. A number of insects are found to utilize Japanese knotweed in its native range and fungus infections also impact this plant. A combination of fungus and insects appear keep the knotweed species under control in Japan. Work on biological controls is in the early stages with surveys needed in the native range of this plant. Some surveys for natural insect enemies were started in the northeastern U.S. in 2000. At this point much work needs to be done on biological control for this to become a control option.

Purple and Wand Loosestrife

(*Lythrum salicaria and L. virgatum*)

Purple Loosestrife (*Lythrum salicaria*)

Plant Characteristics:

Purple loosestrife is a European native that has been widely introduced throughout North America. It is an emergent noxious weed (Class B) that grows in shallow, fresh or brackish water in wetlands and along streams, lakes, or ditch banks, in water from about 14 inches deep to approximately 12 inches above the water table.

It is a large, dark green, perennial plant that produces 30 or more, five to twelve foot tall stems. Growth originates each year from a spreading woody root mass that sometimes has a tap root. The square stems, viewed in cross section, usually have four to six nearly flat sides. The leaves grow 1.5 to 4 inches long and are opposite at each node. The leaf pairs occur at 90 degrees from the one below, but lower on the stems the leaves sometimes grow in threes. The leaves are longer than wide and taper to a narrow point, somewhat resembling a willow leaf. Each stem is topped by a long, narrow, cylindrical, tapering spike-like flower cluster 4 to 16 inches long. Hundreds of small magenta flowers, with usually six petals, ¼ to 5/8 inch long make a showy display.

Purple loosestrife blooms from June to October depending on the local climate. Flowers are produced on a long flowering stem, and the flowers on the bottom of the stem mature before the flowers on the top of the stem. The lowest flowers may produce mature seed while the upper flowers are still in bloom.

Each stem produces hundreds of tiny seeds, and robust plants can produce over 2 million seeds. Each seed is about equal in size to ground pepper. These seeds can travel a few feet out from stems as the seed capsule dries and snaps open. However, most seed

transport is probably by water movement, in mud sticking to people, equipment, or animals; or by being eaten and excreted by animals.

New plants often get started from broken off plant parts because each node can develop roots if it lands in a moist environment. The lower stems and root crowns have adventitious buds that can generate new plants if the top receives damage.

The best time to survey for purple loosestrife is in July and August when the plants are blooming since the magenta flowers are easy to spot at a distance. For large populations, aerial surveys provide good information, whereas ground surveys are more feasible for tracking small populations and finding newly established populations. Start looking for seedlings in June (http://tncweeds.ucdavis.edu/esadocs/documnts/lythsal.pdf).

The best time to control purple loosestrife is in late June and July when it is flowering but the plants have not yet gone to seed. Once flower petals start to drop from the bottom of the spike, the plant begins to produce seed. Control activities can continue during this time, but requires greater care so that seeds are not shaken from the plant.

Distribution and Impacts:

Purple loosestrife is widely distributed throughout Washington. In many cases it was deliberately planted as a garden ornamental or for bee keeping since it flowers in late summer. Once established, purple loosestrife readily spreads into wetland habitats where it forms dense monocultures that exclude native plants. It provides little food or habitat for waterfowl and wildlife. Because purple loosestrife is widespread and well-established in Washington, it is not possible to eradicate this plant from the state. However, it may be possible to eradicate it from specific sites such as high quality wetlands or lake shores.

Wand Loosestrife *(Lythrum virgatum)*

Wand loosestrife, photo courtesy of Auburn University, Department of Horticulture.

Plant Characteristics:

This species is difficult to distinguish from purple loosestrife; however wand loosestrife is not as tall as purple loosestrife which can reach twelve feet in height. Stems on mature wand loosestrife plants are generally three to five feet tall. Wand and purple loosestrife sometimes hybridize developing an intermediate form with some characteristics of both species. These hybrids can share the weedy characteristics of their parents (http://www.weedpatch.com/hidden/wp_pages/ART/articles.asp?RECORD_KEY=ID&ID=54). All eradication and control methods and management for the smaller wand loosestrife are the same as for purple loosestrife.

For further information and additional photographs, please refer to the following websites:

USGS, Northern Prairie Wildlife Research Center:
http://www.npwrc.usgs.gov/resource/1999/loosstrf/loosstrf.htm

Ecology and Management of Invasive Plants Program, Dr. Bernd Blossey, Cornell University:
http://www.invasiveplants.net/invasiveplants/InvasivePlants/PurpleLoosestrife/PurpleLoosestrife.asp

Washington State Department of Ecology:
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua009.html

Many additional links at Invasivespecies.gov:
http://www.invasivespecies.gov/profiles/purplstrf.shtml

MANAGEMENT PLANS

Integrated Pest Management, as defined by RCW 17.15, is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet programmatic pest control objectives.

When following this IPM plan, be sure that site-appropriate control methods are used.

For example, it is probably not appropriate to physically alter a high quality wetland site to remove purple loosestrife. For dense wide-spread infestations, biological control is very appropriate as long as the plants are contained by establishing loosestrife-free borders around the infestation.

In general, eradication may not be a practical goal for any individual weed population, unless the population is:

a) relatively small, no more than three acres in size,

b) young, no more than about one to three years old, or

c) established plants are limited, and they occur over a very small area. (According to a University of California Davis website, populations extending over three acres or more will be difficult if not impossible to completely eradicate using presently known methods. They suggest that these large populations be contained at their present position).

Purple loosestrife in Grant County, photo courtesy of Dr. Gary Piper, WSU.

Variations from these situations will result in seed build up in the soil, which may produce new plants for years. Also, outlier plants are easy to miss if the weed population is extensive and these missed plants will sustain the population. A committed effort over at least several years will be required to attain success with any control strategy.

Preventing the expansion of a large population of purple loosestrife can be accomplished through hand-pulling new plants along the periphery or applying herbicide on plants extending beyond the main body of the population.

CONTROL METHODS

Listed below are a range of options, offering a combination of options that may be suitable for site specific control of purple loosestrife. These control methods are listed in order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

Early detection and prevention is the preferred control method when new sites, or when very small sites are found. While purple loosestrife is widespread throughout Washington, there are wetlands and waterways that do not have purple loosestrife. Early detection will prevent purple loosestrife from establishing in natural areas. Be familiar with purple loosestrife. If you are not sure about plant identification, please call the local county noxious weed control program for plant identification.

Purple loosestrife is a dramatic, showy plant that was often introduced as a garden ornamental. Education and outreach over the years has reached many gardeners, but sometimes purple loosestrife still shows up in gardens (private and public), and sometimes it is found for sale. As a Class B noxious weed control is required by all landowners. As a quarantine species, it is illegal to buy, sell, offer for sale or transport in the state of Washington. Plant quarantines are a preventative measure to keep new infestations from originating from garden ornamentals.

MECHANICAL CONOTROL

Hand pulling: Hand pulling is appropriate for isolated young plants or for the removal of seedlings that may have germinated after other control measures. Purple loosestrife can generally be successfully hand pulled only during the first or second year after establishment. At this stage the plants typically have not developed their full woody root mass. Careful hand pulling can remove most of the roots so that any remaining material should not generate a new plant. Hand pulling is easiest when the water is at or just above the surface of the soil.

Hand pulling is usually not effective for older plants because the root mass cannot be completely removed. Breaking off the stems during an unsuccessful hand pulling effort can stimulate adventitious buds to produce new shots. Even digging out mature plants may not be successful, since the root mass is large and heavy and new shoots will readily develop from remaining large roots or broken off plant parts left in a moist site. However,

it is sometimes possible to dig out older plants by teasing the roots loose with a cultivator.

The Nature Conservancy reports that hand pulling in winter (in western Washington) is more effective than summer pulling because 1) the area is much wetter and plants uproot more easily and completely; 2) less biomass has to be removed and disposed of; and 3) the area can be revisited the following summer for removal of remaining roots that have re-sprouted. By pulling in the winter volunteers were able to effectively remove quite large plants. After two years of winter hand pulling at a specific western Washington wetland site, the area was mostly clear of purple loosestrife.

Covering (solarization): Covering plants with a material such as heavy black plastic sheeting or 100 percent shade cloth can help eliminate small patches of purple loosestrife by preventing photosynthesis and producing high undercover temperatures. Covering will also affect any non-target plants that are covered.

This technique may be used on small, dense infestations of about ten to twenty feet in size which contain mostly target weeds; although Thurston County Weed Board staff reported that they had successfully controlled a much larger area of purple loosestrife by covering it with landscape fabric. They found that native hard hack species colonized the area even through the fabric, whereas loosestrife growth was almost completely suppressed. The few purple loosestrife plants that returned were easily hand removed.

Covering can be done with any opaque material that eliminates all light. The cover should be installed in early spring before the plants have produced much top growth. Remove any above ground vegetation from the site using a weed whacker or similar cutting device before laying the sheeting over the weeds. Cover the edges with rocks, wood, or natural materials. Use at least two layers of plastic sheeting because wind or other disturbances can cause tearing of the top sheet. If the cover is torn, the weeds may recover. The area covered should exceed the plant area by at least a meter in each direction.

The cover must be left in place for at least one full growing season. At the end of this period, all seedlings and some mature plants will have died, but some plants will survive and appear as short white shriveled stems. If left, these plants may survive. Hand removal may be effective or let these greatly weakened plants start growth, and as the weather warms; treat them with a very small amount of herbicide.

Mowing: Mowing purple loosestrife can effectively weaken tall plants if the plants are cut close to the ground (most of their leaves above mowing height). This forces the plants to produce new shoots by using root carbohydrate reserves for initial stem production. Mowing once or more during the growing season can greatly reduce seed production. Mowing may also enhance the effectiveness of other control techniques by weakening the plant and making it more susceptible to these measures. It is important to time the mowing to occur just before the plant flowers. Mowing too early may result in regrowth and flowering. Mowing too late in the season, may result in seed set. Mowing dense monoculture stands will create a lot of biomass on the ground. This biomass will discourage new seedling development the following year by shading the ground. Mowing should not affect lower growing desirable vegetation in open weed stands.

Many environments where purple loosestrife grows are not suitable for mowing because of water, saturated soil, site contours, etc. Mowing is only practical on sites that are relatively level, dry on the surface, and/or can support a tractor and a heavy-duty mower. Mowing purple loosestrife works most efficiently on monoculture stands of one half acre or more. On more open stands, the machine time relative to the volume of weeds cut may not be cost effective. Mowing costs several hundred dollars per acre or more depending on access, time to do the mowing, and whether the equipment has to be rented and transported to the site. Mowing using brush whackers may also work on smaller infestations of purple loosestrife as long as care is taken to not inadvertently spread the infestation over a wider area through dispersal of plant parts.

Mowing once or more per year can work well as a long term control if done every year and may result in a decreasing weed population over time. Mowing integrates well with herbicide application because even one mowing greatly weakens plants, allows the application of a lower herbicide rate, and increases the herbicide effectiveness. Mowing prior to herbicide application also reduces the total amount of herbicide needed by reducing the amount of vegetation that must be sprayed. However, when applying herbicide, there must be enough vegetation to capture and translocate the herbicide to the rhizomes to be effective. Wait until some regrowth occurs before applying.

Cutting: A single mature purple loosestrife plant can produce over two million seeds per year. If it is not possible to kill or remove mature plants, removing the flower spikes can prevent seed production and seed set. Along with the flower spike, previous year's dry seed heads should also be removed because they may still contain seeds. Cutting the stems to the ground also inhibits growth. At sites where plants have already gone to seed, remove all of the flowering spikes first by bending them over a plastic bag and cutting them off into the bag. Further cutting of stems or pulling can then take place without fear of spreading the tiny seeds. (http://www.seagrant.umn.edu/exotics/purple.html)

Proper disposal of plant material is important. Put all plant pieces in plastic bags (vegetation rots quickly in plastic) and take the bags to a sanitary landfill site. Be sure the landfill site doesn't require the bags to be broken open for composting. Composting is not advised, because purple loosestrife seeds may not be destroyed and the thick, woody stems and roots take a long time to decompose. If facilities exist in your area, incineration is an effective way to dispose of plant material. Be aware that clothes and equipment may transport the small seeds to new areas. Thoroughly brush off clothes and equipment before leaving the site. (http://www.seagrant.umn.edu/exotics/purple.html)

CULTURAL CONTROL

Water Level Management: Water level management can be effective in weakening or killing dense, monoculture stands of purple loosestrife. As a major drawback, water management will also directly affect desirable competing vegetation, although some native plants are more drought or flooding resistant than others. If water in a wetland or pond can be drained or its level increased for a growing season or two, this can greatly weaken established plants. Even a short period of water management to disrupt the growth cycle of weeds may complement other control methods, like mowing or herbicide application.

Site Modification: This method is suitable for use on large, dense, or open weed stands growing in open water wetlands where permits can be obtained. However, mechanical removal greatly modifies the wetland because plants, roots, and the surrounding soil are physically removed; deepening or creating water areas several feet deep. This method is not recommended in high quality wetlands or if listed plants or animals use the site because the site is permanently modified.

Site modification can be done with large floating machines that excavate plants and sediments and collect them on a barge for removal. This process changes wetland contours, lowers bottom elevation, and removes purple loosestrife growing sites. This treatment leaves steep shores and deeper water, which limits any future weed occurrence to a narrow band along the waters edge. Monitoring and potential future control efforts can then focus on these small, narrow areas with a better chance to prevent weed reoccurrence. The technique will affect all aspects of the site including desirable plant potential. Follow-up may be necessary to assure all plant parts are removed. Equipment contracting will be expensive. Some re-vegetation of disturbed areas will be necessary after weed removal has been completed.

Burning: Fire has generally not been used to control loosestrife, mostly due to problems with burning in wetlands and the lack of continuous fuels to carry a fire. In areas with cold dry winter weather, burning purple loosestrife vegetation may be possible in the late winter where burning permits can be obtained. Winter burning does not damage desirable vegetation or purple loosestrife but it does reduce the dry biomass. The exposed new growth may be more accessible for mowing or herbicide treatment.

Grazing: Grazing is a similar process to mowing and can remove weed top growth, weaken plants, and reduce seed production. Grazing can be effective on open or monoculture stands of several acres. However grazing animals in wetlands also contributes nutrients and fecal bacteria to waterways and animals may trample and alter wetland characteristics. Choose sites appropriate for this control activity.

Fencing is critical to concentrate grazing on the weedy site, especially if the animals prefer to graze adjacent uplands. This can be accomplished with permanent or temporary fencing, which must be adequate to contain the animals.

Goats relish loosestrife and will denude it in one growing season. Sheep prefer grasses but eat purple loosestrife and common reed (*Phragmites australis*) occasionally or when grassy forage becomes limited. Cows will help control purple loosestrife through grazing and trampling, but it is not a preferred food. Cows prefer grasses (including *Phragmites australis*) and nibble on the loosestrife and shrubs indiscriminately. (Eastern Invasives Management Network, http://tnc-ecomanagement.org/images/weeds2_delawareriver_clw.pdf)

Grazing animals create site disturbance which provides an opportunity to sow seed from desirable plant species so that the animals can trample it in. The resulting new plants may help compete with purple loosestrife regrowth or germination. Grazing treatments may be needed annually over several years to reduce weed abundance. Grazing will weaken weed growth and seed production and naturally fertilize the site. Weed regrowth is still produced but weakened plants are more susceptible to other control measures such as herbicide treatment.

Competitive Planting: Competitive planting has been attempted in several wildlife refuges (Balogh 1985, Rawinski 1982). Rawinski (1982) sowed Japanese millet (*Echinochloa rumentacea*) with purple loosestrife and found that the millet seedlings outcompeted the loosestrife seedlings. The millet must be planted immediately after marsh drawdown has occurred. However, Balogh (1985) found that Japanese millet does not regenerate well and would have to be replanted every year. Balogh (1985) attempted a replacement treatment using native seed. *Polygonum lapathifolium* was seeded with purple loosestrife and the Polygonum outcompeted the loosestrife. However, the following spring purple loosestrife started growing first due to its overwintering rootstock. Competitive planting has limited application within a natural area, but may be useful to control or contain loosestrife populations on buffer property. (http://tncweeds.ucdavis.edu/esadocs/documnts/lythsal.pdf)

CHEMICAL CONTROL

Herbicide Treatment: To avoid damaging desirable vegetation, apply aquatic herbicides with hand held sprayers on new individual plants, to plants forming small to large open stands, or to small monoculture stands of less than a half acre. For individual plants or small stands, using a wicking or wiping method of application can result in selective control of the target weed. Adding a colored dye to the spray mix marks treated plants and helps prevent over application and minimizes the number of missed plants. On dense stands over one half to one acre and larger, it is more efficient and effective to use ground based power equipment.

Aerial application by helicopter may be needed when treating restoration sites that are inaccessible, remote, difficult to traverse, isolated, or otherwise unsuited to ground application, or in circumstances where invasive exotic weeds dominate native plant populations over extensive areas and efforts to restore native plant diversity are being conducted.

One herbicide application will not be enough to control a purple loosestrife infestation even if all mature plants are killed because new plants will sprout from seeds. At least three to four years of active management activities will be required, followed by close annual monitoring to detect and remove seedlings.

Glyphosate (Rodeo® and other glyphosate brands with aquatic labels) has been used to effectively control purple loosestrife in aquatic situations. Best results are obtained when the herbicide is applied when the plants are actively growing at or beyond the bloom stage of growth. Fall treatments must be applied before a killing frost. Application after flowering starts and some seed cases have formed will not prevent development of at least some viable seed. Spraying even later in the season will not prevent most current year's seed production. If possible, remove the seed heads from these plants. Glyphosate is not selective and will damage most other plant species. When desirable vegetation is nearby, applicators should try to minimize its loss by focusing their application just on purple loosestrife plants. Apply up to four pints per acre of glyphosate as a broadcast spray; or a 1 to 1.5 percent solution when using hand held equipment.

Because glyphosate is non-selective this is a better choice of herbicide when treating a monoculture of purple loosestrife where there are few non-target plants to be damaged. As the stands open up and native species return, a selective herbicide such as triclopyr or 2,4-D can be used to target purple loosestrife while having little impact on native broad leaved species. However, if carefully wicked or wiped onto individual plants, glyphosate can be made selective through application techniques.

Imazapyr (Habitat®) is newly registered for aquatic use. Like glyphosate, it is non-selective and systemic. It appears to move rapidly into the rhizomes making it potentially very effective in controlling rhizomenous species. The label calls for the application of one pint per acre to actively growing vegetation to control purple loosestrife. At this time Habitat® is the only imazapyr formulation that has an aquatic label.

Triclopyr (Renovate3®) is a selective herbicide that can damage broad leaf herbaceous plants, trees, and shrubs, but should not affect grasses, sedges, rushes, or similar monocotyledonous plants. Renovate 3® is currently the only triclopyr formulation that has an aquatic label. According to label information Renovate 3® can be effective if applied to seedling purple loosestrife plants through full bloom growth stage. For best effect apply from bud to mid-flowering stage of growth. Thorough wetting of the leaves and stems is necessary to achieve good control. If using a back pack sprayer, a 1-1.5 percent solution of Renovate® is recommended on the label. For broadcast applications, six to eight quarts of Renovate® per acre is recommended. Follow-up applications should be made the following year. Like glyphosate, triclopyr should be applied selectively to target plants to prevent damage to existing desirable competing broad leaf vegetation. The Nature Conservancy reports that control results using triclopyr have been inconsistent in the field.

2,4-D herbicides are selective chemicals that will damage broad leaf herbaceous plants, trees, and shrubs, but should not affect grasses, sedges, rushes or similar monocotyledons plants. According to The Nature Conservancy, 2,4-D is most effective in controlling first-year seedlings and preventing seed production in mature plants. It does not kill mature plants and it should be applied before flowering in May. However, there are use restrictions on 2,4-D in eastern Washington. In addition a recent court decision limits the use of 2,4-D near salmon-bearing waters. Buffers and other conditions to limit drift are in effect, so check with WSDA before applying 2,4-D.

BIOLOGICAL CONTROL

Bio-control: See this website for a good overview of biological control of purple loosestrife:
(http://www.invasiveplants.net/InvasivePlants/PurpleLoosestrife/PurpleLoosestrife.asp)

Galerucella larvae feeding on purple loosestrife leaf (Dr. Gary Piper, Washington State Univ.)

Purple loosestrife is native to central Europe. Several insects were collected there and screened for their specificity to purple loosestrife. These insects included:

- *Hylobius transversovitlatus*: A small beetle that attacks the roots and leaves of purple loosestrife;
- *Galerucella calmariensis*: A very small beetle that attacks flower heads and leaves of purple loosestrife;
- *G. pusilla*: Similar to *G. calmariensis* above;
- *Nanophyes marmoratus*: A small gall fly that attacks the flowers and seeds of purple loosestrife;
- *N. brevis*: Similar to *N. marmoratus* above, but not released in Washington, due to the presence of a nematode contamination; and
- *Bayeriola salicariae*: A gall midge not released in Washington and also not as host-specific as the other insects.

These insects were screened both for their effect on purple loosestrife and for their potential to feed on similar native and economically important plants. All insects were found to be very specific to purple loosestrife or had minimal impact on native *Lythrum* species or similar plants. The midge gall (*Bayeriola salicariae*) was initially dropped from further testing because it was shown to attack some native *Lythrum* and related species; however, it was later released in the eastern United States and the mid-western states. The other five insects were found to be very specific to purple loosestrife with enough potential to damage this weed. The two *Galerucella* species, *Hylobius*, and *Nanophyes marmoratus* were approved for general release in Washington in the early nineties.

Adult *Galerucella* beetle (Dr. Gary Piper, Washington State Univ.)

The two *Galerucella* beetles and the *Hylobius* beetle were initially introduced on the Washington Department of Fish and Wildlife's Desert Wildlife Area, in central Grant County. It took approximately four years for the *Galerucella* populations to build and start having a noticeable effect on purple loosestrife. However, after this time, they devastated the purple loosestrife populations each year over wider areas greatly reducing weed coverage and dominance. To date, the *Galerucella* beetles have been more successful in damaging purple loosestrife than the *Hylobius* beetle.

Before and after photo's of purple loosestrife taken in Grant County. The picture on the left was taken in 1995 and the picture on the right in 1998 after *Galerucella* attacked the plants ((Dr. Gary Piper, Washington State Univ.).

Once well established in purple loosestrife stands, the small *Galerucella* beetles can be collected easily from these sites. Look under the leaves for one to two millimeter long brown beetles. Shake these insects into a container that has some purple loosestrife leaves. To release these insects on a new site, gently empty the container and the leaves onto new plants. Collectors use plastic milk jugs with funnels taped to the mouth or they cut the top off of a 2-liter plastic pop bottle, invert it and tape it. This makes it harder for the beetles to escape once they're in the bottle.

Galerucella collection in the Winchester Wasteway of Grant County (WSDA).

It may take several growing seasons for insect populations to build before they start having an effect on target weeds. Scheduled insect collections generally occur each year in late May and early July at the Washington Department of Fish and Wildlife's Desert Wildlife Area. Contact the Washington State Department of Agriculture or your County Noxious Weed Control Board for more information on collection dates and locations. All are invited to make collections for release on purple loosestrife infestations anywhere in Washington or in other states. However, biological control is suitable for extensive infestations of purple loosestrife. It is not a suitable technique for isolated plants or small populations. In these situations, it is better to remove or kill the plant through other methods. Varying degrees of success of insect establishment have been reported from releases made around Washington. In areas of fluctuating water levels, weed coordinators have not reported much success in establishing insect populations. It sometimes takes several tries before a breeding population can become established in an area.

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Reed Canarygrass

(*Phalaris arundinacea*)

Washington State Department of Ecology

Plant Characteristics:

Reed canarygrass, a class C noxious weed, is a large, densely-growing, perennial grass reaching three to six feet tall and rising from a sturdy base with extensive fibrous roots and stout rhizomes. The leaves are flat and one to three quarter inches wide and occur to half or more of culm height. The flower heads are compact panicles three to six inches long that gradually open as flowering progresses through June and July. Reed canarygrass produces high number of seeds which often build up as a seed bank. Reproduction occurs by seed and from spreading rhizomes.

Reed canarygrass often produces monoculture stands. When established in most herbaceous plant communities, this tall plant overtops and crowds out other vegetation. It grows in fully saturated or partially/temporarily saturated soils, associated with a high water table, stream or ditch banks, lake or pond shores, and shallow water wetlands. Reed canarygrass can tolerate temporary and extended flooding, but does not usually start growing in standing water. It may often be found along ditches, roadsides, dikes, wetlands, and other places where saturated soil commonly occurs. Once established, reed canarygrass can creep out into open water, partly floating. This tangle of roots, stems, and leaves can interfere with water flow in a ditch or stream and through silt collection, actually reduce waterway volume. This grass is palatable to livestock in spring and early summer.

Distribution and Impacts:

Reed canarygrass occurs around the world in temperate climates. It grows as a pasture grass in areas with at least 24 inches annual rainfall or irrigation. Farmers often plant it for hay or pasture and it has been used to protect stream or ditch banks from soil erosion. Reed canarygrass readily escapes from cultivation and its very aggressive nature allows invasion into any suitable site with saturated soil or a high water table, not shaded by

trees or shrubs. Reed canarygrass in the Pacific Northwest is a mix of European and mid-west strains although there is some disagreement about whether this species is native to the area (Society for Ecological Restoration 2001)

For further information and additional photographs, please refer to the following websites:

Society for Ecological Restoration, Northwest Chapter:
http://216.119.67.178/rcgrass/rc_docs.htm.

The Nature Conservancy:
http://tncweeds.ucdavis.edu/esadocs/phalarun.html

MANAGEMENT PLANS

Integrated Pest Management, as defined by RCW 17.15, is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet programmatic pest control objectives.

When following this IPM plan, be sure that site-appropriate control methods are used.

Reed canarygrass is widely distributed throughout Washington and in some areas is considered a desirable pasture grass. In other areas, it is considered a nuisance, but is not a serious problem. Because reed canarygrass is widespread in Washington, it is not considered possible to eradicate it statewide However it may be possible to eradicate it from specific sites where it is causing problems such as interference with fish passage, localized flooding, or outcompeting desirable native wetland species. Reed canarygrass generally causes these problems in western Washington streams, although it can also invade and degrade high quality wetlands and lake shores. It is important to select control methods that are appropriate to the site because some control methods may do more damage to the site than the weed itself.

CONTROL METHODS

Listed below are a range of options, or a combination of options, that may be suitable for site specific control of reed canarygrass. These control methods are listed in order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

Landowners, especially in western Washington, should avoid deliberately planting reed canarygrass. However this species is a very wide-spread and aggressive weed that has invaded many suitable sites without human intervention. Inventory and survey critical habitat areas at least once a year to detect initial infestations in weed free areas. Immediate control actions are the most effective and the least costly.

MECHANICAL CONTROL

Hand pulling: Hand pulling reed canary grass is suitable only if the plants are immature. Mature plants cannot be effectively hand pulled because they have developed extensive rhizomes that are difficult to completely remove. When these underground stems are broken or damaged they can produce a new plant at each node. In an area without reed canarygrass or at the edges of an expanding stand, seedlings can be pulled before rhizomes form if care is taken to get most of the root. The best time to hand pull reed canarygrass is in mid-spring when the plants develop secondary leaves and become tough enough to stay connected to their roots during pulling. Once rhizome formation begins, hand pulling will not reduce weed numbers.

Covering (solarization): Small infestations of reed canarygrass (10 to 20 feet across) can be covered with opaque material to prevent photosynthesis and to produce high under-cover temperatures. Covering can be done with any opaque fabric that eliminates all light (heavy-duty black plastic sheeting or 100 percent shade cloth works well). This material should be installed in early spring before the plants have produced much top growth. Cut the plants before laying the material over the weeds and secure the edges with rocks or wood. Use at least two layers because wind, sun, or other disturbances can cause tearing of the top sheet. If the fabric is torn or dislodged, the plants may recover.

Once installed, with the edges sealed, the cover must be left in place for at least one full growing season. Periodically check to see if the plants have died. Covering is best used for monoculture infestations because all plants, including desirable natives will also be killed or damaged.

Shading: Reed canarygrass needs full sun to flourish so increasing shade from woody plants will help prevent its establishment or will retard its vigorous growth. Plant the appropriate native riparian trees and shrubs along stream and river corridors, lake shores, and in suitable wetland sites. However, it can be difficult to establish new plantings in areas where beavers are found. It may be necessary to protect new plantings from animal damage until they become fully established.

Mowing: According to literature produced by The Nature Conservancy, mowing or cutting by itself does not kill perennial grasses unless it is repeated 5-8 times per year for several years in a row. Occasional mowing (once or twice a year) will generally increase shoot density in perennial grasses. Close mowing or clipping can be used to prevent seed production for that year and can also be used as pre-treatment prior to herbicide application. Because reed canarygrass is a tough, densely-growing plant, mowing must be done with a tractor and heavy mower. Mowing should be done just as the seed heads are forming. At this growth stage the plant has allocated maximum resources into vegetative growth and the beginnings of seed production. Mow the plants as short as practical. This will cause the plants to start leaf and culm growth again, greatly weakening their vigor. To be most effective, mow each time the plant growth reaches early seed head development stage. This control method can be an effective part of a well-planned IPM program, when followed by herbicide application, water level control, burning, or other complementary control techniques.

CULTURAL CONTROL

Water Level Management: Reed canarygrass has a high level of tolerance for flooding and also temporary drought caused by decreased water levels. This technique is only effective if the water levels can be raised several feet for an entire growing season or longer. However, mature plants which are tall enough to emerge above the water level will be unaffected. Flooding works better to control seedlings. Lowering the water level may be even less effective unless the site can be entirely dried up for an equal length of time. The ground water height must be lowered below the rooting depth of at least 24 inches to have much effect on this grass. Either water level regime will have a negative effect on desirable competing vegetation that may exist on the site. Therefore, this technique has potential only in areas completely dominated by dense reed canarygrass monocultures where water level controls are available.

Site Modification: Site modification is suitable for constructed wetlands or already highly modified sites where permits can be obtained. Heavy machinery is used to change the site by deepening the water and leaving steep banks or shoreline. The changed site contours eliminates reed canarygrass habitat (and other native wetland species habitat too) except for narrow areas along the shoreline. Site modification is not a suitable method for high quality wetland habitats.

Site modification will cost at least several hundred dollars per acre, but should result in long term control. It will be necessary to revegetate the site after excavation is completed and the establishment of desirable native plants will provide competition for new weed invasions. However, monitoring must continue and be combined with rapid control action, when new weeds are identified. These activities will help protect the site from potential rapid reed canarygrass reestablishment.

Burning: Burning is most effectively used to reduce the large amounts of vegetation produced by reed canarygrass each year. Spring burning generally does not kill reed canarygrass, but by removing the dried vegetation does allow more access to the site for follow-up management and monitoring. Eliminating litter and opening the site to new weed growth may also improve the effectiveness of herbicides or make the new growth more available for grazing. Burning is best used for large monoculture stands that have existed for at least several years. If burning can be done in early flower formation stage or in the fall this technique will kill some plants and open dense infestations. However, burning may also increase the size, vigor, and density of reed canarygrass. The Nature Conservancy observed this phenomenon after a dormant season burn in November in an eastern US fen site (http://www.ceinfo.unh.edu/forestry/documents/WPUFCI03.pdf). Although not highly effective in either killing weed plants or reducing their density, burning can prepare the site for other weed control measures as part of an IPM plan.

Grazing: Cattle, sheep, and goats can be grazed on reed canarygrass from first growth in early spring until the culms start to form in late spring. After this, the leaves and stems of some strains of reed canarygrass can become very coarse and unpalatable. Grazing can be used on open stands of scattered plants to solid, monoculture stands. However, livestock will graze all palatable plants and this may impact desirable species in open reed canarygrass stands. This treatment will be most effective on monoculture stands because these contain almost no other desirable plants.

Most removal of new growth will occur if the animals can be fenced into the weed stand, so grazing can be concentrated on the target plant. Grazing animals can reduce the grass to very short stubble. Grazing has similar impacts to mowing and will weaken the plants as they try to produce top growth. Grazing differs from mowing in that it can be used earlier in the season. Animals will continue to graze as long as they are left on the site, although there must be enough forage to support their nutritional needs. Grazing will greatly weaken the weeds ability to re-grow and produce seeds. If grazing can be continued or repeated two or more times through a growing season, from spring to fall, for three to five years, it will greatly reduce stand density. In monoculture stands intensive grazing will eliminate many plants and leave an open stand of scattered plants with many less palatable, but more desirable sedges, rushes, and other plants remaining. If re-vegetation is necessary, seed can be distributed before the last grazing treatment, so the animals can trample the seed in.

Grazing will not remove all existing reed canarygrass plants. However, it can fit well into an IPM plan by weakening weeds for further treatment with herbicides, water level changes, or other treatments. Burning the heavy residual plant litter in the early spring will promote new grass growth and maximize the animals' ability to graze the grass down to nearly soil level. Complementary control techniques used under an IPM plan can improve overall management effectiveness. However grazing animals in wetlands also contribute nutrients and fecal bacteria to waterways.

Competitive Planting: Native grasses and forbs are the best plants to use as competitors to reed canarygrass. Seeds can be collected and raked into the soil after reed canarygrass control efforts. Planting appropriate native trees or shrubs can help shade the area, reducing habitat for this sun loving species.

CHEMICAL CONTROL

Herbicide Treatment: Glyphosate, (Rodeo® or equivalent glyphosate formulations), can be applied any time growth occurs, from spring to early fall. However, treatment is most effective when glyphosate is applied just at flower formation or in the fall from mid-September to the first frost. Using a hand held sprayer or wick applicator will make this non-selective herbicide more selective to the target plants by careful application to individuals in scattered stands. If a monoculture has formed, boom spraying may provide more uniform coverage. Apply 3-4.5 pints per acre in a broadcast spray or as a ¾ percent solution when using hand held equipment, but always check the label for the most up-to-date information. If desirable vegetation is growing as an under story in a reed canarygrass stand, the herbicide may be applied with a wick applicator set at an elevation that applies the chemical to the target weeds but not on the shorter desirable plants. Because of its dense growth form and extensive rhizomes, more than one herbicide application may be necessary to get a satisfactory kill. The Nature Conservancy reports that small, isolated patches can be killed with only one application of glyphosate, but that large infestations will require two to three applications to be fully effective.

Imazapyr (Habitat®), also a non-selective herbicide was recently registered for aquatic use. The label recommends using 3-4 pints per acre on actively growing reed canarygrass plants.

BIOLOGICAL CONTROL

Because reed canarygrass has economic value for pastures, hay, and erosion control under some conditions, biological control has not been studied and no insects are approved for Washington release. It is unlikely that these control organisms could distinguish between desirable stands and those considered noxious weeds.

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Saltcedar

(*Tamarix ramosissima*)

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http://www.csdl.tamu.edu/FLORA/imaxxtam.htm

Plant Characteristics:

Saltcedar grows as a perennial, deciduous, tall shrub or small tree with many ascending branches from its base. Mature plants vary in height from five to twenty feet or more. These trees can produce a taproot that can be more than 20 feet long, depending on site conditions. Saltcedar leaves are small scale-like bracts and the flowers appear in cylindrical clusters of small pink or white blooms that appear to hang from the branches. Saltcedar has a gray-green coloration and with its narrow branches and minimal leaf surface area, it is often difficult to see when mixed with other vegetation, particularly as seedlings or young plants. It grows in seasonally saturated soils that often have a high salt content. Typically plants occur on banks of streams or ditches; lake, pond and wetland shores or in areas with high water tables.

A phreatophyte is a deep-rooted plant that occurs along rivers or other wet sites and obtains its water from the water table. Saltcedar is an example of a phreatophyte.
--United States Department of Agriculture

Saltcedar reproduces from seeds, root sprouting, and broken off branches or stems that land on moist sites. It has several competitive advantages, including an ability to exude salt solution from its leaves that raises the soil salt content around each plant, high water consumption that can lower the water table, and extremely high production of tiny seeds that disperse by wind or water. Saltcedar seeds may sprout within 24 hours of wetting. Site alteration (through salt exudates) and high seed production allow this plant to eliminate most competing desirable herbaceous and woody species.

The genus *Tamarix* has many species, but they are difficult to identify. Distinguishing characteristics are extremely variable, with some hybridization occurring in the field.

Some scientists recognize many species and others group them all under two or three species names. In Washington, experts have identified aggressively spreading plants as *Tamarix ramosissima.* Another species of Tamarix, *T. parviflora*, has also recently been identified as being capable of spreading to natural areas in Washington. *T. parviflora* has proven to be a significant problem in other states and may soon undergo analysis to determine whether it should be listed on the Washington State Noxious Weed List.

Distribution and Impacts:

Saltcedar is native to southern Europe, northern Africa, and Asia. It was first brought to the U.S. in 1823 as an ornamental plant, but by 1920 it was becoming a problem along riparian areas in southwestern states. It now occurs in most western states where it dominates suitable sites.

Compared to native riparian vegetation, saltcedar has very little wildlife value. Its tiny seeds have low nutrient content and are not an attractive food source for birds. Its open growth form provides little cover or structure for birds or other wildlife. The monoculture stands eliminate most understory vegetation, further eliminating habitat diversity within infestations.

> Saltcedar uses an excessive amount of water. A mature saltcedar plant consumes as much as 800 liters of water per day – 10 to 20 times the amount used by the native species it tends to replace.
> --Cooperrider 1995

For further information and additional photographs, please refer to the following websites:

The Nature Conservancy:
http://tncweeds.ucdavis.edu/esadocs/tamaramo.html

The Tamarisk Coalition:
http://www.tamariskcoalition.org/

MANAGEMENT PLANS

Integrated Pest Management, as defined by RCW 17.15, is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet programmatic pest control objectives.

When following this IPM plan, be sure that site-appropriate control methods are used.

CONTROL METHODS

Listed below are ranges of options, or a combination of options, that may be suitable for site-specific control of saltcedar. These control methods are listed in order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

Saltcedar distribution is somewhat limited in Washington, with about 400 acres in arid natural lands in eastern Washington. It may still be possible to eradiate infestations from these natural areas. An active Saltcedar Task Force continues to work on the problem of Saltcedar in Washington.

Saltcedar was introduced as a wind block for homesteads in arid lands throughout the western states, where it escaped cultivation and is widely established in riparian areas throughout western states. Saltcedar can still be found for sale as a garden ornamental. However, *T. ramosissima* is a quarantine species in Washington State, and it is illegal to buy, sell, transport or offer for sale. This restriction prevents new introduction, preventing subsequent spread to natural areas.

MECHANICAL CONTROL

Plowing: Using a heavy tractor and special plows that hook the roots and drag the entire plant out of the ground can be effective in stands with mature plants. All vegetation, including roots and broken off stems, must be removed and placed in a dry environment. This prevents new plants starting from stems or roots landing on moist ground. The use of heavy equipment can be very expensive and result in much site disturbance. Also, this equipment will not remove all seedlings and scattered young plants. Re-vegetation is required after pulling out large numbers of saltcedar trees.

Root Plowing: Root plowing is another mechanical method that has been successful in managing saltcedar infestations. If properly performed, root plowing can achieve 90 percent control of saltcedar stands. The root plow must be set 12 to 18 inches below the soil surface to ensure cutting below the root crown of saltcedar. If the root crown is removed the plant will not be able to sprout again and form new plants. For root plowing to be effective, the aboveground vegetation should be piled and burned to prevent resprouting of shoots. Root plowing during hot and dry weather can also increase the effectiveness of this control method. Modified root plows which inject herbicides below

the soil surface can increase saltcedar control by as much as 45 percent without injuring many of the cover grasses and other shallow rooting plants. The information about root plowing is taken from: Saltcedar (Tamarisk) by Robert T. Grubb, Roger L. Sheley, and Ronald D. Carlstrom (http://www.montana.edu/wwwpb/pubs/mt9710.html).

Hand Pulling: Young saltcedar plants (up to two years old) can be hand pulled. Hand pulling is not effective for older/larger plants because they are extremely hard to pull and if the taproot is not fully removed, the plant may regrow. Hand pulling efforts need to be repeated for at least three or four years to assure complete removal of newly-germinated seedlings. Because of their color and spindly growth form, young plants are hard to see and therefore easy to miss. The site should be revisited often.

Mowing: Mowing is only feasible for small plants and seedlings because mature plants (shrubs and trees) have large woody stems. Mowing does not kill saltcedar plants because they can readily resprout from the root crown. However, repeated mowing does weaken the plants over time. By removing much of the large aboveground biomass, re-growth is much easier to access for treatment with herbicides.

CULTURAL CONTROL

Water Level Management: If water levels can be controlled at the saltcedar site, flooding may be an effective control. Water levels must be raised so the roots are underwater and then maintained in this condition for at least 24 to 36 months. Grub et al. reported that submergence for 28 months provided 99 percent control of saltcedar where plants were inundated for one entire growing season, and over half of the next two growing seasons. They also reported that dropping the water table along the Gila River in Arizona reduced saltcedar stands.

Burning: Dense monoculture stands of saltcedar can be burned, although the plants will readily resprout from root crowns. However, like mowing, it will provide access to new growth, which could then be more effectively treated with herbicides. Burning has the advantage that the aboveground stems do not need to be removed from the site.

Re-vegetation: Several control methods cause site disturbance that may require reestablishing desirable native plants. Establishing woody plants that shade the ground will give the best chance to keep saltcedar from reinvading the site. Native plants like willow (*Salix* spp.), cottonwood (*Populus trichocarpa*), hawthorn (*Crataegus douglasii*), chokecherry (*Prunus virginiana* or *P. emarginata*), and dogwood (*Cornus stolonifera*) may be suitable revegetation species. Willow, cottonwood, and dogwood can be started from live stem cuttings as long as the cuttings contain at least several nodes or growth points. These cuttings are buried in the soil. Hawthorn and chokecherry can be established by planting bare rootstock or container grown plants. These plants will take about five years to attain a sufficient size to occupy and shade the ground.

If dense, mature stands of saltcedar are removed, the soil may be too salty to support desirable woody species. At least some of the salt accumulation may need to be leached away before it will be possible to plant them. If the salt cannot be removed, planting tall wheatgrass (*Elytrigia elongata*), a large, very salt/alkali tolerant grass, may help modify

the site. This may allow either natural invasion of desirable woody species or planting them as outlined above.

CHEMICAL CONTROL

Herbicide Treatment: A number of terrestrial herbicides have been tried on saltcedar, but only three are effective in killing this plant. They include imazapyr (Arsenal®), triclopyr (Garlon 4), and glyphosate (Rodeo® or equivalent glyphosate products). If herbicides are used in an area where they can enter open water, the aquatic formulation of these herbicides must be used. Arsenal® and Garlon 4 are not labeled for aquatic use, although aquatic formulations of imazapyr (Habitat®) and triclopyr (Renovate3®) are now available.

Foliar Application: Imazapyr, or a mixture of imazapyr and glyphosate, used as a foliar application in late summer or fall should result in 90% or more kill on mature plants and seedlings. Once treated, the plants should not be disturbed for two years to give the herbicide a chance to translocate through both the top foliage and the roots. If these treatments fail to show major plant impact after one year, or if skipped spots appear, re-treatment may be required at the end of one year.

Foliar applications may also kill any existing understory species. In mature saltcedar stands, soil salt accumulation probably excludes most herbaceous species, but saltgrass (*Distichlis stricta*) may be able to survive in these saline conditions. If the foliar herbicide applications kill saltgrass or salt tolerant species, re-vegetation may be necessary to help prevent saltcedar from reestablishing on the site. Re-vegetation may require tilling the surface layer and planting extremely salt tolerant species like saltgrass and tall wheatgrass (*Elytrigia spicata*). Once the soil salinity has diminished, plants such as willow (*Salix* spp.), cottonwood (*Populas trichocarpa*), and other riparian trees and shrubs can be planted.

Cut Stump Application: In cut stump applications, the plant is cut as close to the ground as possible using a chainsaw (for large trees) or loppers (for shrubs). The cut stump is then immediately (within 15 minutes) sprayed with diluted Garlon 4® to prevent vigorous resprouting. (From: Inyo County Saltcedar Control Program (http://www.inyowater.org/Saltcedar/Default.htm). This should result in 90% or greater kill. This treatment is most effective if done in summer or fall. However, cut saltcedar should be removed from the site to avoid resprouting.

Basal Bark Application: In basal bark applications, Garlon 4® (triclopyr) is mixed with special oil that can be applied directly to uncut stem bark. This requires treating the entire stem circumference. For greatest effect, apply on stems three inches in diameter or less in late summer or early fall. It may take up to two years for the herbicide to kill both stems and roots. If these treatments fail to show major plant impact after one year, or if skipped spots appear, re-treatment may be required at the end of one year.

BIOLOGICAL CONTROL

Biological controls are not used for Washington state populations as our distribution is somewhat limited at this time. Research and the following information are available from states where saltcedar is widespread, and where biological controls are a control option.

A number of insects (15) have been found with the potential to impact saltcedar. The saltcedar leaf beetle (*Diorhabda elongata*) removes the leaves, at least partially defoliating the plants. As the plants produce replacement leaves, *Diorhabda* continues to feed depriving the plants of needed nutrients. The beetle seems specifically dependent on saltcedar and causes much plant impact, with an estimate that 75 – 85% of plants will be killed or damaged. It has been cage released and approved for general release in the southwestern states and in Washington.

Trabutina mannipara, a mealy bug that feeds on plant sap and can inject saliva that is toxic to the plant, has undergone testing in Israel and quarantine in Texas. It met all the bio-control requirements, but is found to do best in warm climates without low temperature extremes. This insect has been recommended for release in the United States. Interestingly, this insect is also considered by some to be the source of manna that fed the Israelites in the Sinai Desert.

Coniatus tamarisci, a foliage-feeding weevil, is being tested in quarantine in the USA and is being considered for release. In addition a leaf beetle from Israel (*Cryptocephalus sinaita*), and two gall midges (*Psectrosema* spp.) from France and Kazakhstan are being tested in U.S. quarantine. Top priority insects still being tested overseas include another mealy bug and a moth from Israel, a psyllid and a stem-galling moth from Kazakhstan, a leaf-tying moth, a root-galling weevil and a scale insect from China, and another stem-galling moth, another gall midge and a seed pathogen from France. (http://pest.cabweb.org/Journals/BNI/Bni22-3/Gennews.htm)

Yellow Flag Iris

(*Iris pseudocorus*)

Washington State Department of Agriculture

Plant Characteristics:

Yellow flag iris is a large perennial plant, with mostly upright, basal, sword-like, pointed leaves 20 to 36 inches long. The leaves are flat and sharp-edged. When not flowering, the leaves of yellow flag iris can be mistaken for common cattail. The plant grows from short, stout rhizomes that grow together in a tight cluster, forming a massive root base that can be three to four feet in diameter. The flower stems may be three to five feet tall with one to four large bright yellow flowers or more per stem. Flower stem leaves are usually much shorter or nearly absent. Flowers can be three to four or more inches in height and width. Yellow flag iris is the only iris with yellow flowers in North America. Seeds are produced in pods or capsules that can resemble short green bananas when mature. Reproduction may occur from seeds or rhizomes.

Distribution and Impacts:

Yellow flag iris grows throughout Washington in many soil types, on sites with full sun to partial shade, and survives winter temperatures to well below zero degrees Fahrenheit. Once established it becomes dominant along lake shores, ponds, wetlands, and rocky streams, in water to 25 centimeters deep. Yellow flag iris tolerates high soil acidity and can grow in salt marshes. This plant spreads aggressively and can get started in fully developed stands of other emergent vegetation. Yellow flag iris was recently listed as a "Class C" noxious weed in Washington. Unfortunately there is little information available in the literature on effective control techniques. Some of the methods discussed below have not been tried.

NOTE: Yellow flag iris is poisonous. The sap can cause severe blistering or irritation and if ingested, it can cause vomiting and diarrhea. Its roots are toxic to cattle, pigs, and humans. It causes gastroenteritis in cattle even when dry.

For further information and additional photographs, please refer to the following websites:

Center for Aquatic and Invasive Plants, University of Florida and Sea Grant:
http://aquat1.ifas.ufl.edu/seagrant/iripse2.html

USGS:
http://nas.er.usgs.gov/plants/docs/ir_pseud.html

The Nature Conservancy:
http://tncweeds.ucdavis.edu/esadocs/irispseu.html

MANAGEMENT PLANS

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Yellow flag iris is found in both eastern and western Washington. In many cases it has been deliberately planted along lake shores as an ornamental plant. Once established, yellow flag iris can spread along the lake shores by seeds or slowly colonize the shoreline via rhizomes. It can form monocultures along lake shorelines and has been reported to invade wetlands. While it is not possible to eradicate yellow flag iris from Washington, it may be possible to eradicate it from specific sites such as high quality wetlands or lake shores. Lake residents should be discouraged from planting or propagating this species. Also people should be discouraged from planting this species in stormwater retention ponds and other constructed wetland areas.

CONTROL METHODS

Listed below are a range of options or a combination of options that may be suitable for site specific control of yellow flag iris. These control methods are listed in the following order, and include: Prevention, Mechanical, Cultural, Chemical and Biological Controls.

EARLY DETECTION, PREVENTION, FOLLOW-UP

In natural areas where yellow flag iris is not well established, early detection and prevention is still a control option. Familiarize yourself with plant characteristics and impacts. For more information on plant identification, please contact the local county noxious weed control board.

MECHANICAL CONTROL

Hand pulling: Hand pulling may be effective only for seedlings or immature plants. While it is possible to dig out established plants, it is not practical unless there are just a few mature plants around a waterbody or in a wetland. Once an infestation has developed beyond this point, other methods of eradication or control should be considered.

Care should be taken when pulling or digging yellow flag iris because resinous substances in the leaves can cause skin irritation. Immature plants can be hand pulled as long as the leaves stay firmly attached to the roots. Young plants will not have formed bulky rhizomes and pulling should completely remove most roots. Once the plant is firmly established (during the second year and later), it will be nearly impossible to hand pull and digging is required. Dig out a fairly wide area around the plant so all roots and rhizomes can be removed. Nearly any plant material left in the soil can develop into a new plant.

Covering (solarization): Covering mature plants may be possible with small infestations of only a few plants. Use several layers of an opaque material such as very strong black plastic sheeting because this tough plant may penetrate weaker material. Cover the plants in the early spring before growth starts after removing all the top vegetation. Completely cover each plant or group of plants with the plastic sheeting, sealing the edges with rocks, heavy boards, or natural materials. The seal must be complete, blocking all light from entering for at least one to three growing seasons. Because yellow flag iris usually grows at the waters edge, it may be necessary to seal the water side with heavy rocks.

Cutting: Many people who live along lake shores enjoy the beauty of the yellow flag iris and do not want to eradicate this plant. In fact many lake residents have deliberately planted this showy perennial. Cutting off the seed heads after the plant flowers can help minimize its spread to other areas of the waterbody. Lakeside gardeners will also have to manage the spread of this plant from creeping rhizomes to keep it from taking over their shoreline.

CULTURAL CONTROL

Water Level Management: Yellow flag iris grows best in permanently wet soils, so the ability to lower water levels and dry up lake or pond edges has the potential to weaken or kill these plants. This technique should be considered only in highly modified wetlands or lake shores where a dense nearly monoculture stand of yellow flag iris occurs and an outlet structure exists. Dropping the water level for prolonged periods of time will also kill many desirable emergent plants and alter and impair fish and wildlife habitat. Since the yellow flag iris is drought resistant, the water must be drawn down for an extended time period. If successful in killing established plants, some re-vegetation with desirable native wetland species may be necessary. At least annual monitoring will be required to detect new yellow flag iris plants and get them removed rapidly.

Site Modification: If a wetland, pond, or lake shore has a near monoculture cover of yellow flag iris and permits can be obtained, site modification may be considered. However, this method is suitable only for highly modified wetlands or waterbodies where a high degree of disturbance can be tolerated. Site modification causes substantial

damage to natural wetlands and lakeshores. Heavy equipment can be used to remove plant tops, roots, and surrounding soil and haul it to a dry site. This deepens the water and leaves steep banks. This also removes wetland plant habitat and replaces it with more open and deeper water. Revegetation with suitable native plants will probably be necessary and the newly contoured shorelines should be monitored to remove any new seedlings of yellow flag iris or other noxious weeds.

Grazing: Because this plant is poisonous to herbivores, damage by vertebrate and invertebrate grazers is negligible so grazing by goats or sheep is not a viable control option.

CHEMICAL CONTROL

Herbicide Treatment: Glyphosate (Rodeo® or similar glyphosate formulations with aquatic labels) and imazapyr (Habitat®) may be used anytime plants are actively growing. Glyphosate and imazapyr are non-selective and should be applied with hand held equipment to minimize non-target impacts and water contact. Cutting followed by wicking with glyphosate may be the best treatment method in sensitive areas and will also minimize the amount of herbicide needed. Because yellow flag iris has large rhizomes, one application of herbicide may not kill mature plants. Re-apply the herbicide through mid-fall if the plant is still actively growing and recovery from the initial herbicide application appears likely. Final results may not be apparent till the following spring. If the plants are still alive, retreatment may be necessary. If care is taken to minimize off target impacts, adjacent desirable vegetation may naturally re-vegetate the site. Because yellow flag iris sets seed, at least annual monitoring will be required to find any new plants and rapidly remove them from the site. Nature Conservancy literature indicates that yellow flag iris can be killed with glyphosate applied in a 13 percent active ingredient solution plus a surfactant. This can be applied either directly to the foliage as a spray, wiped on, or applied immediately to cut leaf and stem surfaces.

Please refer to the following website for herbicide application techniques - http://www.se-eppc.org/manual/herbapp.html

BIOLOGICAL CONTROL

No biological control agents have been researched or released for the control of yellow flag iris and we are not aware of any research activities into biocontrol agents. Yellow flag iris and other iris species are cultivated and prized for their flowers in many states, so bio-control research for this species is not likely.

APPENDIX B

Permit Information

1. Herbicide Control Permits

Aquatic Pesticide Permits
http://www.ecy.wa.gov/programs/wq/pesticides/index.html

Aquatic Noxious Weed Control NPDES General Permits
http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/noxious/noxious_index.html

Online Application for Aquatic Noxious Weed Control NPDES General Permits
http://apps.ecy.wa.gov/AquaticPestApp/applogin.asp

WSDA Experimental Use Permits
http://agr.wa.gov/pestfert/pesticides/docs/aquaticeupform4128.doc

2. Other Control Permits

Grass Carp Permits
http://www.wdfw.wa.gov/fish/trnsport.htm

Hydraulic Project Approval (HPA) Permits
http://www.wdfw.wa.gov/hab/hpapage.htm

Hydraulic Project Approval (HPA) Permits for Aquatic Noxious Weeds
http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm

Purple Loosestrife and Quarantine Listed Species Transport Permits
Washington State Department of Agriculture
Greg Haubrich
ghaubrich@agr.wa.gov
(509) 225-2604

APPENDIX C

Additional Information

Washington State Noxious Weed List and Quarantine Lists

State Noxious Weed List http://www.nwcb.wa.gov/weed_list/weed_listhome.html

WSDA Quarantine Lists http://www.nwcb.wa.gov/weed_laws/quarantine.html

General Weed Identification

County Noxious Weed Control Boards and Districts
http://www.nwcb.wa.gov/county_bds/county_noxious_weed_coordinators.htm

Washington State Noxious Weed Control Board http://www.nwcb.wa.gov/

Washington State Department of Agriculture http://agr.wa.gov/

Washington State University Cooperative Extension Offices http://ext.wsu.edu/locations/

Aquatic Weed Identification Contacts

Jenifer Parsons
Jenp461@ecy.wa.gov
(509) 457-7136

Kathy Hamel
Kham461@ecy.wa.gov
(360) 407-6562

Online Resources at Department of Ecology
http://www.ecy.wa.gov/programs/wq/links/plants.html

Integrated Pest Management Information in Washington State

WSDA Integrated Pest Management Site
http://agr.wa.gov/plantsinsects/ipm/default.htm

Department of Ecology Urban Pesticide Education Strategy Team (UPEST)
http://www.ecy.wa.gov/programs/wq/pesticides/upest/index.html

A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans, Department of Ecology
http://www.ecy.wa.gov/programs/wq/plants/management/manual/index.html

Other Resources

Washington State Department of Agriculture Endangered Species Program
http://agr.wa.gov/PestFert/EnvResources/EndangSpecies.htm

Aquatic Plant and Lakes Links
http://www.ecy.wa.gov/programs/wq/plants/links/index.html

APPENDIX D

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