Towards a Decision Support Tool to Address Invasive Species in Garry Oak & Associated Ecosystems in BC

Garry Oak Ecosystems Recovery Team

Canada

Nature Conservancy Canada

Conservation de la nature Canada

Towards a Decision Support Tool to Address Invasive Species in Garry Oak & Associated Ecosystems in BC

Prepared for

GOERT Invasive Species Steering Committee
C/o Capital Regional District Parks
490 Atkins Avenue
Victoria, BC V9B 2Z8

Prepared by

Carol Murray and Christine Pinkham
ESSA Technologies Ltd.
1435 Brooke Street
Victoria, BC V8S 1M4

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[1] The Habitat Stewardship Program for Species at Risk is a partnership-based conservation initiative sponsored by the Government of Canada. The Program is managed cooperatively by Environment Canada, the Department of Fisheries and Oceans and Parks Canada, and administered by Environment Canada. http://www.ec.gc.ca/press/2001/011107_b_e.htm

[2] http://www.natureconservancy.ca/files/index.asp

[3] http://www.goert.ca

List of Acronyms

AAFC	Agriculture and Agri-Food Canada
APRS	Alien Plants Ranking System
CDC	Conservation Data Centre
CFIA	Canadian Food Inspection Agency
CFS	Canadian Forest Service
CRD	Capital Regional District
DST	Decision support tool
GEF	Global Environment Facility
GOE	Garry oak and associated ecosystem
GOERT	Garry Oak Ecosystems Recovery Team
GVRD	Greater Vancouver Regional District
ISSC	Invasive Species Steering Committee
IUCN	World Conservation Union
PMP	Pest Management Plan
RAG	Recovery Action Group
UNEP	United Nations Environment Programme

Introduction

Garry oak ecosystems (GOEs) are among British Columbia's most valuable and most threatened ecosystems. They are of tremendous importance to the biodiversity of British Columbia, as they are home to over 90 species that have been designated as "at risk" in the province (Garry Oak Ecosystems Recovery Team 2002) — and almost one quarter of these are also listed as being "at risk" on a national scale. However, less than 5% of their original habitat in British Columbia remains in a near-natural condition (Fuchs 2001). Although land-use conversion, decreasing patch size and increasing patch isolation, and changing fire regimes have all contributed to degradation of these ecosystems, biological invasions are also a significant problem, and Scotch broom and other invasive shrubs pose perhaps the most serious threat (Fuchs 2001).

At the same time, global warming may lead to a northward progression of Garry oak and related ecosystems, replacing areas currently dominated by Douglas-fir ecosystems (Garry Oak Ecosystems Recovery Team 2002). Comprehensive ecosystem conservation and restoration efforts will be needed to maintain the natural elements of Garry oak ecosystems today so that they are available to adapt to new habitat as the climate changes in the future.

In May of 1999, delegates to the First International Garry Oak Symposium in Victoria unanimously passed two resolutions: to recognize the Garry oak meadow ecosystem as a nationally endangered ecosystem, and to develop and implement a recovery plan to provide direction for protecting, sustaining, and restoring Garry oak ecosystems. In response to the second resolution, the Garry Oak Ecosystems Recovery Team (GOERT) was founded. It is a partnership of a number of governmental and non-governmental organizations, including membership from regional, provincial and federal government agencies, a regional district board, First Nations, non-governmental organizations, academic institutions, and private enterprises. As part of the recovery program, the Invasive Species Steering Committee (ISSC) of the GOERT has embarked on a project to prepare and compile information towards the development of a decision support tool (DST) to address invasive species in Garry oak and associated ecosystems. ESSA Technologies Ltd. was hired November 5, 2001 to research and prepare a report containing four chapters:

- Chapter 1: "Review of Current Status of Decision Support Tools for Invasive Species in BC";
- Chapter 2: "Gaps in Decision Support Tools/Methodologies",
- Chapter 3: "Decision Support Framework",
- Chapter 4: "Top Ten GOE-Threatening Exotic Plant Species."

The draft report was submitted December 14, 2001, and contained a full draft of Chapter 1, an outline of Chapters 2, 3 and 4, and draft ranking criteria for Chapter 4. This final report contains the final full versions of the four chapters.

This project comprises the first step towards the development of a DST for invasive species management in Garry oak and associated ecosystems. Funding is currently being requested by the Garry Oak Ecosystems Recovery Team for the next steps in DST development.

1.0 Review of Current Status of Decision Support Tools for Invasive Species in BC

1.1 Methodology

ESSA contacted individuals and organisations considered likely to have knowledge of decision support tools and methodologies for managing invasive species in British Columbia. Contacts were made by either email or telephone. During the initial inquiry, we gave each contact a brief description of the project and then asked if they used decision support tools/methodologies, or knew of any decision support tools/methodologies currently being used in BC, to guide management decisions regarding invasive species. We indicated interest in knowing about the full technological spectrum, from tools as simple as paper-based matrices to complex computer-based models. We also asked for suggestions of whom else we might contact for this type of information. We also contacted selected individuals and asked them what strategies or "rules of thumb" they and their colleagues use to make management decisions on invasive species in the absence of for formal decision support tools.

In addition to contacting specific individuals, we (and with the assistance of those mentioned below) posted these same questions to the following listservs:

- Aliens-L provided by The Information Management Group, World Conservation Union, Gland, Switzerland and posted by Carol Murray of ESSA.
- NatureServe Datamanager Listserv posted by Beth Rogers of the Conservation Data Centre (CDC) of the BC Ministry of Sustainable Resource Management. The CDC belongs to the NatureServe network and is one of 75 independent centres for the collection of data about the plants, animals, and ecological communities of the Western Hemisphere. Their listservs are restricted to members only.
- NatureServe Ecology and Botany Listservs posted by Matthew Fairbarns of the Conservation Data Centre.

Lynn Boyd, of Agriculture and Agri-Food Canada, also conducted a search of their CAB and BIOSIS databases.

We conducted telephone interviews with individuals who used, or had detailed knowledge of, tools for the management of invasive species. The following questions were asked:

- Who developed/created it?
- Who is directing/requesting/guiding/administering its use?
- Who is actually using it?
- For what ecosystems, and for what invasive species?
- Where is this tool being used?
- How long has it been in use?
- Is it successful, either in its implementation or in its results?
- How does it work?

- Can we see it somehow?
- Who can we contact for more information?
- What does the tool NOT do, that you wish it did?

We also performed Internet searches for potential contacts and decision support tools in British Columbia.

Appendix 1 lists the individuals that we contacted, sorted alphabetically by organisation. This list is not restricted to contacts in British Columbia. We have included all individuals who have been contacted and/or responded to postings on the Listservs or emails forwarded by other individuals we had contacted.

Section 1.2 provides information on the decision support tools/methodologies that are in use in British Columbia. Decision support tools/methodologies that are in use outside of BC are summarised in Section 1.3. We provide a brief description of the roles of various levels government in managing invasive pests in BC in Section 1.4.

1.2 Decision Support Tools/Methodologies in Use in British Columbia

We have found evidence of relatively few decision support tools in use for invasive species management in British Columbia. Most of the individuals involved in management of invasive species management rely upon their own expertise for making management decisions, or informal decision support strategies such as discussing approaches/issues with colleagues. While a number of individuals expressed interest in the use of these tools, they do not have the resources for research and development of such tools.

We contacted over 80 people, and had an 80% rate of response to our inquiries. Out of 66 people who replied to our inquiries, only 9% were aware of any kind of tool in use in British Columbia for invasive species management. Just under 30% of respondents were able to direct us to tools in use outside of BC (Section 1.3), and 64% of respondents referred us to other contacts.

As with the vast majority of people we contacted, Dr. Judith Myers of the University of British Columbia was unaware of any decision support tools for managing invasive species in BC. She did spend some time thinking about what such a system would be like and provided the following information:

> *"I assume that there might be some type of a decision tree that takes into consideration the density of the invasive species, its impact on the natural community or economic impact, the length of time it has been there, its potential for spread, the type of habitat - disturbed, undisturbed, roadside, riparian etc., potential for manual or chemical control, potential for biological control, potential for eradication, history in other areas. There are various studies that have looked at whether one can predict the invasiveness of plant species. My take on it is that the attention to invasive species is usually determined by if there are individuals or groups who consider the species to be a pest — knapweed to cattlemen, loosestrife to naturalist groups. If they start lobbying hard enough control programs may be put into place. Often it is perceived impacts rather than measured impacts that are considered. There is little work on the impact of exotic species on other species. Sometimes this is apparent by the near monoculture status of the invasive. This would all be more complicated in the Garry Oak system in which there are a number of exotic species."*

Joel Ussery, a Resource Planner with the Capitol Regional District (CRD), provided the following perspective on what a decision support model should contain:

> *"Some of the key variables to consider in a decision model is the mode of dispersal and growth characteristics of the invader, potential longevity of the invader on the site (e.g., forms a long-lived seed bank) the potential effect(s) on native species, and effectiveness of control (e.g., I don't know of any realistic control for the vetch Vicia sativa)."*

In the absence of a formal decision support tool, managers making decisions on how to manage pests use more ad hoc decision methodologies, ranging from simply using their own expertise developed through education, research and work experience, to more collaborative approaches such as meeting with committees or discussing issues with colleagues.

Information on the decision support tools that we have identified is provided below. The name of the expert who described the tool and a brief description of each tool are provided, along with answers to the questions described in the Methodology. In some cases, not all questions were applicable and have been excluded. Also included are some tools that we came across while conducting our own research. In these cases, a description of the tool is provided. The information is organised in the following categories, from simple to more complex:

- State of Science information (fact sheets, field guides, reports),
- Decision trees (paper based),
- Matrices (paper and computer based), and
- Computer models.

State of Science Information

Field Guide and Fact Sheets on Noxious and Other Selected Weeds of British Columbia

The Crop Protection Program[4] of the BC Ministry of Agriculture, Food and Fisheries "develops and promotes Integrated Pest Management (IPM) strategies in order to prevent, reduce or control the effects of pests and diseases in commercial agriculture". They provide an online Field Guide to Noxious and Other Selected Weeds of British Columbia[5], which was developed to help farmers, ranchers, resource managers and the public identify British Columbia's noxious weeds. They provide fact sheets and weed alerts[6] on noxious weeds and some of the more common nuisance weeds. They have provided this reference information as a tool for proper identification of weeds. Identification of weeds is the crucial first step in gaining knowledge about these plants so that a well-planned control strategy can be developed.

Roy Cranston, a Provincial Weed Specialist with the Crop Protection Program, is currently in the process of completing a project with the Open Learning Agency that profiles the management of noxious weeds. The launch date of this project in tentatively scheduled for March 2002. Components of this project include:

1. "Seven Steps to Managing Your Weeds." This is a simple guide designed for landowners/ managers to guide them through the steps involved in developing a weed management plan.

[4] http://www.agf.gov.bc.ca/croplive/cropprot/

[5] http://www.agf.gov.bc.ca/croplive/cropprot/weedguid/weedguid.htm

[6] http://www.agf.gov.bc.ca/croplive/cropprot/weeds.htm#field

2. "Guide to Weeds of British Columbia." This details the identification, biology, ecology, distribution and management of eighty weed species in British Columbia.
3. A website on British Columbia's weeds.
4. Five public service announcements to be shown ten times each on the Knowledge Network and local cable channels. These announcements will profile different weeds/habitats including Garry oak ecosystems on Vancouver Island.
5. Training sessions for landowners.

Literature on Invasive Species

Literature on invasive species in British Columbia can prove useful for supporting management decisions. The following are just a few examples for Scotch broom, but literature is available for a wide range of invasive species.

- "Scotch Broom, *Cytisus scoparius* L. in British Columbia[7]" (Prasad 1999) provides information on the invasive characteristics of the plant, techniques for management (e.g. manual cutting or pulling, biological control), and control procedures. The control procedures are a series of actions forest managers are recommended to take for controlling broom until an acceptable biological agent is researched and registered in BC. These actions are:
    1. "Carefully inspect road ballast and materials brought from other areas for broom seed.
    2. Bring new invasions to the attention of researchers, forest managers and the local British Columbia Ministry of Forest's District office.
    3. Cut broom and gorse stems as close to the ground as possible before the seed matures, taking care not to disturb surrounding soil. (Hand-pulling is preferable to prevent resprouting, but this is not always practical.)
    4. Remove broom before it has a chance to flower.
    5. Inspect plantations on a regular basis.
    6. Support urban efforts to remove Scotch broom in parks.
    7. Where broom invasion is likely, selective timber extraction should be considered over clearcutting.
    8. On warm, well-drained sites, avoid excessive soil disturbance and exposed mineral soil."
- Prasad, R. 1998. Impact of some exotic weeds (Scotch broom and gorse) on forest crop in British Columbia. Proc. Western Soc. Weed Sci., Hawaii. March 8 –12, 1998.
- Prasad, R. 2000. Some aspects of the impact and management of the exotic weed, Scotch Broom (*Cytisus scoparius* [L.] Link) in British Columbia, Canada. Journal of Sustainable Forestry, Vol. 10, No. 3 / 4, pp. 341 – 347.
- A Masters thesis entitled "Managing Plan Species in Garry Oak Meadow Vegetation Communities: A Case Study of Scotch Broom" (Ussery 1997) is another robust example of the invasive species literature available.
- "Overview of Scotch Broom in British Columbia[8]" (Carson 1998) provides information on field identification, habitat and control measures of Scotch broom.

[7] http://www.pfc.forestry.ca/biodiversity/broom_e.html
[8] http://infoweb.magi.com/~ehaber/bc_broom.html

Pest Management Plans

The City of Victoria uses Pest Management Plans as a decision support tool for dealing with existing pests (i.e. not for prevention). The BC Ministry of Water, Land and Air Protection (WLAP) requires Pest Control Service Licensees in the public sector (e.g. municipalities, school districts, parks departments, colleges) with licences in the Landscape category seeking Public Land Endorsements to submit Pest Management Plans (PMP's) with their licence applications. Further information on this can be found in Section 1.4. Pest Management Plans describe:

- A program for controlling pests or reducing pest damage using Integrated Pest Management (IPM), and
- The methods for handling, preparing, mixing, applying and otherwise using pesticides within the program.

A template for a Landscape Pest Management Plan[9] is provided in Appendix 2. This and the guide[10] for filling it out can be found through WLAP's Vancouver Island Region Pest Management Plan web page[11]. They provide a number of other online resources[12] including IPM manuals (training manuals), Technical Reports (surveys and studies commissioned by the ministry), Pesticide Management Reports, evaluations and plans, brochures and insect identification fact sheets.

Plant Health Risk Assessment Reports

The Plant Health Risk Assessment Unit[13] (PHRA) of the Canadian Food Inspection Agency is responsible for carrying out risk assessments for commodities moving in trade which could carry plant pests. They are also responsible for plant pest organisms which are either established in a limited part of Canada and could spread, or which are not in Canada at all yet (that is, quarantine pests for Canada). They provide these assessments to the Plant Health and Production Division (PHPD) of CFIA. The assessments are used to support risk management decisions related to regulation of quarantine pests and the commodities which carry them. The risk assessment is designed to form a link between scientific data and decision makers by expressing risk in terms appropriate for decision makers. Further information on CIFA can be found in Section 1.4.

A risk assessment report contains the following:

- Pest risk assessment summary;
- Pest facts sheet (including identity, life history, economic and environmental impacts, means of movement and dispersal and pest significance);
- Risk characterisation and estimation (geographic and regulatory status, likelihood of introduction, consequences of introduction); and
- Conclusions including the overall risk rating, level of uncertainty and mitigation measures.

[9] http://wlapwww.gov.bc.ca/vir/pp/ipmweb/pmp/landscapepmp6.doc
[10] http://wlapwww.gov.bc.ca/vir/pp/ipmweb/pmp/pmpland.htm
[11] http://wlapwww.gov.bc.ca/vir/pp/ipmweb/pmp/pmp.htm
[12] http://wlapwww.gov.bc.ca/epd/epdpa/ipmp/pestmgmt.html
[13] http://www.inspection.gc.ca/english/ppc/science/phra/phra_e.shtml

An example of a recent pest risk assessment summary for Sudden Oak Death (*Phytophthora ramorum*) is provided in Table 1.1 below. Copies of the report can be obtained from Leslie Cree at CIFA.

Table 1.1. Pest risk assessment summary for Sudden Oak Death, *Phytophthora ramorum.*

Pest organism	*Phytophthora ramorum* Werres et al. Sudden Oak Death
Status in PRA area	Not reported in Canada
Likelihood of introduction	**Medium** Nursery stock or vegetative propagative material (i.e. budwood, cuttings) of known or suspected hosts, including species of *Quercus, Lithocarpus, Acer, Aesculus, Rhododendron, Vaccinium* and other Ericacaeae, originating in areas known to be infested would be the most likely pathway for long distance, man-made spread. Other pathways include logs with bark, firewood and vegetative material for decorative or other non-propagative purposes. Seed, pollen, soil and other materials originating in the contaminated area could potentially be contaminated with fungal spores thus serving as a further means for introduction.
Consequences of introduction	**High** *Phytophthora ramorum* is the cause of Sudden Oak Death, a disease which is rapidly killing oaks and causing varying degrees of damage to other hosts, including arbutus, rhododendron, huckleberry, bigleaf maple, viburnum and others, in coastal areas of central and northern California and southwestern Oregon. It is associated with a leaf and twig blight of *Rhododendron* and *Viburnum* in Europe. Many of the naturally-infected hosts of *P. ramorum* grow in Canada; other plant species present in Canada have been shown to be susceptible under laboratory conditions. The limited number of sites where *P. ramorum* is confirmed to occur, restricts the predictive value of bioclimatic analyses. It is not known to what extent climatic factors contribute to the potential distribution of *P. ramorum*. If the fungus became established in Canada, Similar effects would result in loss of natural forests and habitats, as well as commercial losses to the horticulture and forestry sectors.
Overall risk rating	**Medium**
Level of uncertainty	**High** Uncertainty results from lack of knowledge of the complete range of hosts of *P. Ramorum*, its life history, climatic factors which influence the fungus' survival and growth, and its longterm economic or ecological impacts.
Mitigation measures	• Prohibition of nursery stock and vegetative propagative material of known host so *P. ramorum* from infested areas. • Prohibition of soil, seed and pollen from areas known to be infested. • Prohibition of wood products, with bark, from areas known to be infested. Treatments for reducing or eliminating contamination of these pathways have not yet been developed. Visual inspection of goods should not be considered reliable protection. Continued communication with scientists and officials in Oregon, California, Germany and The Netherlands is recommended because information pertaining to host range, distribution and potential treatments for wood products or nursery stock is changing rapidly. Phytosanitary requirements should be altered to reflect new information as it becomes available.

(Source: adapted from Canadian Food Inspection Agency 2001).

Decision trees

Weed Management Decision Tree

The Penticton Forest District has developed a Weed Management Decision Tree as part of their Pest Management Plan (Pethybridge 2001, cited in Polster Environmental Services 2002). The tree takes you through a series of steps, each recommending an action or directing users to another step in the tree. A copy of this tree is provided below:

1) Identification of Weed Species
   a) Species is on either the weed list or weed alert bulletin 2
   b) Species not listed..... **no action**

2) Species status
   a) Species is previously known to occur in District.....6
   b) Species has not been previously found in District.....3

3) Land Status
   a) Species on Crown Range.....4
   b) Species on other jurisdiction..... **notify party requesting action**

4) Water Resources
   a) Species is not found adjacent to or in riparian zone, domestic water intake or water body 5
   b) Species found adjacent to or in riparian zone, domestic water intake or water body.
      Treat using any of the methods: cultural or manual based upon the species-specific treatment recommendations.

5) Other Considerations
   a) Infestation is within a known management zone that would potentially restrict herbicide usage. Considerations would include native food gathering sites, wildlife habitat requirements, or other values that require protecting.
      Only use cultural or manual treatment methods based upon the species specific treatment recommendations
   b) No other considerations required.
      Use any of cultural, manual, or chemical treatment methods based upon the species specific treatment recommendations

6) Land Status
   a) Species on Crown Range.....7
   b) Species on other jurisdiction..... **notify party requesting action**

7) Containment Zone Status
   a) Infestation is within a containment zone.....8
   b) Infestation is outside a containment zone.....
      Apply bioagents if available for weed species and release criteria (density of weeds, area infested) are met.

8) Water Resources
   a) Species is not found adjacent to or in riparian zone, domestic water intake or water body 9
   b) Species found adjacent to or in riparian zone, domestic water intake or water body.
      Treat using any of the following methods: cultural, biological, or manual based upon the species-specific treatment recommendations.

9) Other Considerations
   a) Infestation is within a known management zone that would potentially restrict herbicide usage. Considerations would include native food gathering sites, wildlife habitat requirements, or other values that require protecting.
   Only use cultural, biological, or manual treatment methods based upon the species specific treatment recommendations
   b) No other considerations required.
   Use any of cultural, manual, biological, or chemical treatment methods based upon the species specific treatment recommendations

Bark Beetle Management Guidebook – Decision Trees for Bark Beetles

The BC Ministry of Forests has developed a Bark Beetle Management Guidebook,[14] designed to provide a background to bark beetle management and specific practices for managing mountain pine beetle, spruce beetle, and Douglas-fir beetle. The guidebook provides a lot of information on the distribution and host range, life cycles and dynamics, general impacts and management strategies. The guidebook contains three decisions trees, one for Douglas-fir beetle, one for mountain pine beetle and one for spruce beetle. They work in the same manner as the Weed Management Decision Tree mentioned previously. The decision tree for Douglas-fir beetle is provided in Table 1.2 below.

Table 1.2. Decision framework for managing Douglas-fir beetle.

Step #	Consideration	YES – go to:	NO – go to:
1.	Sketch Map		
2.	Walkthrough/probe as necessary		
3.	Is access available for harvesting or other treatment?	4	10
4.	Are there resource management issues?	5	8
5.	New attack or high susceptible timber?	6	Monitor
6.	Resource management concerns validated by inspection with stakeholders?	7	Harvest based on priorities/trap trees in leave blocks
7.	Management desired?	Develop management plan utilising trap trees, single tree treatments, and harvesting	Monitor
8.	New attack or highly susceptible timber?	9	Monitor/salvage
9.	Economic to harvest?	Sanitation harvesting/trap trees in leave blocks	Monitor/single tree treatment
10.	New attack or highly susceptible timber?	11	Monitor
11.	Resource management concerns?	12	Develop access for sanitation
12.	Resource management concerns validated by inspection with stakeholders?	Develop management plan/apply treatments as appropriate	Develop access for sanitation/other treatments as appropriate

(Source: adapted from BC Ministry of Forests 1995).

[14] http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/beetle/betletoc.htm

Matrices

Gypsy Moth Site Comparison Matrix

The British Columbia Plant Protection Advisory Council (see Section 1.4 for more information on this organisation) has developed a matrix with criteria designed to provide objective rationale behind management decisions regarding gypsy moth.

Who developed/created it?	The Gypsy Moth Committee of the British Columbia Plant Protection Advisory Council (BCPPAC).
Who is directing its use?	Peter Hall, Chair of the Gypsy Moth Committee, and a Provincial Entomologist with the BC Ministry of Forests.
Who is actually using it?	The Gypsy Moth Committee to evaluate treatment recommendations and to justify these recommendations.
For what ecosystems, and for what invasive species?	Gypsy moth in any ecosystem.
Where is this tool being used?	British Columbia, specifically in Victoria, Burnaby, Delta and Sechelt.
How long has it been in use?	It has been in use for over one year, having been developed in 2000.
Is it successful?	Yes.
How does it work?	The site comparison matrix consists of a simple list of factors such as seasonality and host availability in the left-hand column, and sites across the top. The matrix is colour coded to allow the decision maker to weigh various options in different circumstances.
Can we see it somehow?	A copy of the matrix is reproduced in Figure 1.1 below. Please contact Peter Hall for a copy of the original.
Who can we contact for more information?	Peter Hall Email: Peter.Hall@gems6.gov.bc.ca Telephone: (250) 387-8742
What does the tool NOT do, that they wish it did?	Nothing; the tool works as designed to **aid** decision making.

	Site / Factors	Victoria	Burnaby	Delta	Sechelt
1	Seasonality				
2	Host availability				
3	Existing population size				
4	Presence of 2nd life				
5	Artificial transport				
6	Rate of expansion (1 yr)				
7	Area of expansion (1 yr)				

High Low

1. Seasonality refers to the climatic suitability of an area for survival of gypsy moth.
2. Host availability refers to the estimated amount of suitable host foliage to sustain gypsy moth and allow it to successfully complete development.
3. Artificial transport refers to the risk of movement of gypsy moth life stages (particularly egg masses) out of an area to infest new areas.

(Reproduced with the permission from Peter Hall.)

Figure 1.1. Gypsy Moth Site Comparison Matrix.

Exotic Plant Species Control Matrix

A simple paper-based matrix for determining the best time of the year for removing exotic species has been developed at the Swan Lake-Christmas Hill Nature Sanctuary in Saanich. The matrix shows what exotic plants are removed during which months. It is provided in Table 1.3, reproduced from a fax provided by Willie MacGillivray.

Who developed/created it?	Willie MacGillivray, Site Manager of the Swan Lake-Christmas Hill Nature Sanctuary
Who is actually using it?	No one else is using it at this time, and technically he does not actually "use" (refer to) it, as he is the expert who developed it.
For what ecosystems, and for what invasive species?	It was developed for floodplain and Garry oak ecosystems and the transition area between the two. It can be used for Himalayan blackberry, Scotch broom, English ivy, purple loosestrife, poison hemlock, oyster plant, Canada thistle, morning glory and money plant.
How does it work?	The matrix is simple with a list of exotic species in the left-hand column and months of the year across the top. The best months for removal of each species are shaded.
Can we see it somehow?	A copy of the matrix has been provided.
Who can we contact for more information?	Willie MacGillivray, (250) 479-0211

Table 1.3. Control schedule of several exotic plant species found within the Swan Lake-Christmas Hill Nature Sanctuary.

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Himalayan Blackberry (*Rubus discolor*)												
Scotch Broom (*Cytisus scoparius*)												
English Ivy (*Hedera helix*)												
Purple Loosestrife (*Lythrum salicaria*)												
Poison Hemlock (*Conioselinum pacificum*)												
Oyster Plant (*Tragopogon porrifolius*)												
Canada Thistle (*Cirsium arvense*)												
Morning Glory (*Convolvulus sp.*)												
Money Plant (*Lunaria annua*)												

Biological Control Agent Matrix

The Range Section of the BC Ministry of Forests has an interactive matrix[15] that outlines the use of biological agents to control weeds. The matrix provides information on the following weeds:

- Bull thistle *Cirsium vulgare* (Savi) Tenore
- Canada thistle *Cirsium arvense* (L.) Scop.
- Dalmatian Toadflax *Linaria dalmatica* (L.) Miller
- Diffuse tnapweed *Centaurea diffusa* Lam.
- Hound's tongue *Cynoglossum officinale* L.
- Leafy spurge *Euphorbia esula* L.
- Nodding thistle *Carduus nutans* L.
- Plumeless thistle *Carduus acanthoides* L.
- Purple loosestrife *Lythrum salicaria* L.
- Rush skeletonweed *Chondrilla juncea* L.
- Russian knapweed *Acroptilon repens* L.
- Spotted knapweed *Centaurea maculosa* Lam
- St. John's wort *Hypericum perforatum* L.
- Sulphur cinquefoil *Potentilla recta* L.
- Tansy cagwort *Senecio jacobaea* L.
- Yellow toadflax *Linaria vulgaris* L.

Clicking on the name of a weed takes you to a new webpage that provides information on biological agents for that weed. Information on the habitat, availability, life cycle, form of attack (life cycle stage and damage) and collection are provided in tabular format for each biocontrol agent. For example, Table 1.4 provides information on *Galerucella pusilla* (Duftsschmid), which can be used to control Purple Loosestrife.

[15] http://www.for.gov.bc.ca/hfp/pubs/interest/bioagent/bioagent.htm

Table 1.4. Information on biological control agent *Galerucella pusilla* (Duftsschmid) for controlling Purple Loosestrife.

(Source: adapted from the BC Ministry of Forests website).

Availability	Habitat	Adult Emergence	Egg Laying	Larva Development	F1	Adult Life Span	Over Winters
Pending release and distribution	Loosetrife habitat. Wetlands	April	April to end of July on leaves	Feed on leaves and flower buds. Pupate in leaf and upper soil portion	End of May through the summer	1 year	Adults in soil and leaf litter

ATTACK		COLLECTION		NOTES
Stage	**Damage**	**Life Stage**	**Method**	F1 adults that emerge before August mate and lay eggs for 1 month. Egg laying is strongly curtailed by low temperatures.
Larvae	Leaves and buds	Adults	Use appropriate insect sweep net	
Adult	Shoots and tips of young leaves			

Computer models

Gypsy Moth Model

The Canadian Forest Service has developed a phenology model that is used to design area-wide forecasts of target events in the seasonal life history of gypsy moth. The model has been used for:

- Identifying areas where gypsy moth populations are most likely to persist,
- Recommending timing (spray windows) of aerial applications of *Bacillus thuringiensis* var. *kurstaki* (*Btk*), and
- Forecasting moth activity for the deployment and recovery of pheromone traps to evaluate the effectiveness of the spraying.

Who developed/created it? Jaques Régenière, Vincent Nealis and David Gray, Canadian Forest Service

Who is directing its use? Vincent Nealis, Insect Ecologist, Pacific Forestry Science Centre, Canadian Forest Service

Who is actually using it?	The Canadian Forest Service (CFS) uses this model for research development of risk models for gypsy moth in novel environments and under climate change scenarios. The CFS provides all of the output to the BC Ministry of Forests (MoF) and the Gypsy Moth Technical Advisory Committee of the BC Plant Protection Advisory Council (BCPPAC). Anyone may use it by simply downloading the model and providing weather/location inputs. The MoF has used the output for timing their operational spray programs over the past 3 years. The Technical Advisory Committee of BCPPAC uses its output as an element of its risk assessment in annual reviews of trapping data by location.
For what ecosystems, and for what invasive species?	It is currently being used for eastern spruce budworm and the European gypsy moth, and can be adapted for other insects.
Where is this tool being used?	It is being used in British Columbia and across the country.
How long has it been in use?	It is a work in progress, and has been in development for ten years. The model was validated in 1998 with field observations from southern Vancouver Island and has been used in each of the last three years.
Is it successful?	Yes.
How does it work?	The model integrates climate information (such as climatic normals, real-time weather observations), digital elevation models and insect phenology models. It predicts the date of target events such as insect hatching.
Can we see it somehow?	Vincent Nealis does not have a copy for demonstrating on his computer in Victoria. Jaques Régenière of the Laurentian Forestry Centre would be the person to contact.
Who can we contact for more information?	Vincent Nealis, vnealis@pfc.cfs.nrcan.gc.ca, (250) 363-0663 Jaques Régenière, jregniere@lsc.forestry.ca, (418) 648-5257
What does the tool NOT do, that they wish it did?	The quality of the insect phenology model is very good. The quality of the output is dependent of the quality of the input data. The only shortcomings in the model are due to the inability of anyone to be able to accurately predict weather.

1.3 Decision Support Tools and Methodologies in Use Elsewhere

While researching British Columbia, we came across a number of tools/methodologies used for invasive species management outside BC. While this wasn't the focus of our search, we thought it would be helpful to include a brief description of each. One tool that was mentioned quite a few times — and is further mentioned in Chapter 4 — is the Alien Plants Ranking System described below under the United States Geological Survey. The tools are organised alphabetically by country and organisation. We have included information on an Environment Canada workshop held recently under the subheading "Canada".

Australia

Organisation	Contact	Description
Commonwealth Scientific & Industrial Research Organisation (CSIRO)	Nic Bax Nic.Bax@csiro.au www.csiro.au	Five years ago, CSIRO Australia began to develop a quantitative species-based risk assessment model to assess the risk that incoming ships posed to the Australian marine environment through their release of ballast water containing alien species. The Australian shipping industry contributed over $2 million to the implementation of a decision support system using this model. In July of this year, the Australian Quarantine and Immigration Service introduced mandatory ballast water management for all incoming vessels. Vessels classified as having high risk ballast water (determined by origin of ballast water, environmental conditions in receiving port, journey duration) are required to undertake open ocean ballast water exchange.
1st International Workshop on Weed Risk Assessment		"Weed Risk Assessment" (Eds. RH Groves, FD Panetta, JG Virtue) from CSIRO Publishing in Australia is a collation of papers presented at the 1st International Workshop on Weed Risk Assessment in Adelaide, Australia in 1999. There are decision support tools presented for pre-entry assessment and post-entry prioritisation, at a range of geographic scales and land use types, from various countries. It provides a summary of the progress made in the last decade on weed risk assessment techniques.

Canada / North America

Organisation	Contact	Description
Canadian Forest Service (CFS)	David MacLean: macleand@unb.ca	The Canadian Forest Service in New Brunswick has developed a decision support system for dealing with spruce budworm. Reference: MacLean, Porter, MacKinnon and Beaton. 2000. Computers and Electronics in Agriculture. 27:293-314.
Canadian Forest Service (CFS)	http://www.pfc.cfs.nrcan.gc.ca/entomology/mpb/tools/DSS/introduction_e.html	Mountain Pine Beetle Decision Support Tools. Over the past decade, CFS researchers have been developing decision support tools to address questions that need to be answered when managing the mountain pine beetle. These questions and tools are: • Where are the beetles going to attack (Susceptibility Rating Systems, Spread Models)? • When will they get there (Risk Rating Models Spread Models)? • How much damage will they cause (Impact Models)? • What can we do about the situation (Strategy and Tactic Selection Software)? Many of these tools are currently available for use and several others are in various stages of development: • Shore/Safranyik Susceptibility and Risk Rating System (available) • MPB Population Dynamics Model (available) • MPBSim Stand Level Impact Model (prototype available) • MPB Spread Simulation Model – TSA level (available) • Shore et al. (2000) MPB Loss Prediction Model (available) • MPB/SELES Spatial Landscape Infestation Model (in development) • MPB Strategy and Tactic Selection Software (Beetle Management Unit level) (available) • MPB Strategy and Tactic Selection Software (stand level) (prototype) • MPB Website (available)
Environment Canada	Mark Hovorka mark.hovorka@ec.gc.ca	Environment Canada held a National Workshop with the objective of identifying and clarifying invasive alien species issues in Canada, and to draft a national inter-jurisdictional invasive species plan. The workshop was held at the Canadian Museum of Nature, and included 145 representatives of federal, provincial and territorial governments, First Nations, non-governmental organisations, business, industry, and academia. There were no specific discussions on Garry Oak ecosystems or decision support tools used for the management of invasive species in Canada. A summary document of the workshop was to be released in November 2001.

Organisation	Contact	Description
North American Forestry Commission. A joint project between the Canadian Forest Service, the Canadian Food Inspection Agency, Secretaría del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP: Sanidad Forestal), the USDA Forest Service, and the USDA Animal and Plant Health Inspection Service.	Joseph O'Brien jobrien@fs.fed.us http://www.exoticforestpests.org/english/english.htm	Exotic Forest Pest Information System for North America. The Exotic Forest Pest Information System is a database that identifies exotic insects, mites and pathogens with potential to cause significant damage to North American forest resources. It contains background information for each identified pest and is intended to serve as a resource for regulatory and forest protection agencies in North America. The emphasis of the tool is on potential establishment and impact, information on pathways for introduction, and means of dispersal. However, this information may prove useful for the assessment and management of introduced pests, wood products and other commodities from off-shore sources.

United Kingdom

Organisation	Contact	Description
CAB International (CABI) and the US Department of Agriculture, Agricultural Research Service (USDA-ARS)	Lesley King L.king@cabi.org http://www.cabicompendium.org	Invasive Species Compendium (ISC) CABI and the USDA-ARS are developing the concept of an Invasive Species Compendium. The overall aim of an ISC will be to provide an extensive electronic knowledge base to assist decision-making in the detection and management of invasive species. The first step in the feasibility study is a survey to identify user requirements to help prioritise future work. The questionnaire is available online at the website provided. They have provided temporary access to the Crop Protection Compendium (CPC) on the Internet for those not familiar with CABI Compendia (password details are given in the questionnaire).
Centre for Life Sciences Modelling, University of Newcastle upon Tyne	Dr. Peter Lurz p.w.w.lurz@newcastle.ac.uk http://www.ncl.ac.uk/clsm/invasive.htm#italy http://www.biology.qmw.ac.uk/squirrel/	The Centre for Life Sciences Modelling is involved in a number of projects that aim to provide decision support for managers using computer simulations (spatially explicit population dynamics models). These involve, for example, projects on the introduced American mink (threat to native water vole) or the introduced grey squirrel which is causing damage to trees and is regarded a threat to the European red squirrel. The modelling tools are also used to predict the spread of an invasive species.

Organisation	Contact	Description
UK Forestry Commission and the Pacific Forestry Centre of the Canadian Forest Service	Alan Thomson athomson@pfc.cfs.nrcan.gc.ca (250) 363-0632 http://www.pfc.forestry.ca/management/herbicide/	The Herbicide Advisor is a web-based expert system designed to help with forestry and farm forestry management decisions on the appropriate herbicide for control of weeds. The tool asks the user for the situation (forest or farm forest), the weed species, the crop, proposed application time and provides advice on the suitability of each control option. It has not been released to the public but it is posted on the Pacific Forestry Centre's website. There will be an operational trial of the system in England when it is finalised. The ecosystem and herbicide data in the system are from the United Kingdom. BC data and/or non-herbicide approaches could be incorporated into the knowledge-base in the future.

United States of America

Organisation	Contact	Description
Assateague Island National Seashore US Geological Survey (USGS) - NPS Vegetation Mapping	http://biology.usgs.gov/npsveg/ npsveg@nbii.gov	Assateague Island National Seashore has used the USGS-NPS vegetation mapping data to derive a potential nutria (large beaver-like rodent introduced from South America) habitat map for use in their eradication efforts. It is a major problem as it disturbs the root mat of marsh plants when creating swim canals and while foraging. This kills marsh plants and turns salt marsh to wash flats. This is one of many applications of the tool.
Colorado Department of Natural Resources	http://www.coloradoparks.org/cnap/iwm_handbook/iwm_index.htm dnr.parksna@state.co.us	Creating an Integrated Weed Management Plan: A Handbook for Owners and Managers of Lands with Natural Values. The Handbook provides the tools and information necessary for public and private landowners to manage noxious weeds in natural areas, wildlands, and rangelands. It contains a series of steps for the preparation of an integrated weed management plan: property description and inventory, formulation of management goals and objectives, setting weed management priorities, selection of management actions, development of an integrated plan, and monitoring plan development and implementation. All documentation is available for download in PDF format from their website.

Organisation	Contact	Description
National Biological Information Infrastructure (NBII)/USDA Invasive Species toolkit	http://www.invasivespecies.gov/toolkit/control.shtml	There are links to a number of decision support tools used in the control of invasive species. The text below highlights those that have not been mentioned elsewhere in this table and has been copied from their website. "A Model Comprehensive State Management Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species", Great Lakes Commission, January 1996 **"**Explosion in Slow Motion: Invasive Weeds Toolkit**"**, U.S. Department of the Interior, Bureau of Land Management "Guidelines for Coordinated Management of Noxious Weeds: Development of Weed Management Areas", U.S. Department of Agriculture, Agricultural Research Service, The Ecological Areawide Management (TEAM) Leafy Spurge. Note: The guidelines can be downloaded in the form of self-extracting files that are in PDF format. "Pest Damage-Yield Web Database". Developed in collaboration with USDA, EPA, NSF funded Center for Integrated Pest Management, and the American Crop Protection Association. This database has specific purposes and limitations. It is being developed to help provide information necessary for benefits assessments. "Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas", The Nature Conservancy, Wildland Invasive Species Program, by Mandy Tu, Callie Hurd, & John M. Randall, Version date: 4 April 2001 "Weed Control Template from the Wildland Invasive Species Program", The Nature Conservancy. This tool includes an introduction, template, spreadsheets, and a sample plan to assist managers in the development of a weed plan to prioritise and control weed growth and spread.
National Park Service and the University of Nebraska	Ronald D. Hiebert, National Park Service James Stubbendieck University of Nebraska http://www.nature.nps.gov/pubs/ranking/	Handbook for Ranking Exotic Plants for Management and Control The ranking system is a tool to organise exotic plant species based on their present level of impact and their innate ability to become a pest. It is designed to encourage resource managers to logically apply criteria that address the present impact of a species on ecological processes and structure and on other park resources. A manager can then use the resulting species rank and weigh it against the ease or feasibility of control, and the urgency of action or the cost of delay in action can be determined. The information accumulated in its application can serve to document and support management decisions and to justify program funding.

Organisation	Contact	Description
The Nature Conservancy	John Randall & Barry Meyers-Rice The Nature Conservancy Wildland Invasive Species Program Department of Vegetable Crops & Weed Sciences University of California Phone: John (530) 754-8890 Barry (530) 754-8891 E-mail: John jarandall@ucdavis.edu Barry bazza@ucdavis.edu	Site Weed Management Plan Template. The template is designed to help Land Managers develop a comprehensive weed management strategy and to develop an adaptive management strategy for invasive species management. Adaptive Management for invasive species requires the following steps: (1) establish management goals and conservation targets for the site; (2) determine which, if any, species or infestations threaten or have the potential to threaten your management goals and targets - those that do are "weeds"; (3) determine which methods are available to control the weeds; (4) develop and implement a weed management plan designed to move conditions towards the management goals and to abate threats to your targets; (5) monitor and assess the impacts of the weed management actions in terms of the management goals and target protection; (6) start the cycle over again by re-evaluating conclusions made in steps 1-4 and modifying where necessary. Go to http://tncweeds.ucdavis.edu/products/plans/WMPIntro.pdf for a copy of the template.
Virginia Polytechnic Institute and State University, Department of Entomology, Blacksburg, VA 24061	Alexei A. Sharov sharov@vt.edu	Bioeconomic model for managing the spread of exotic pest species with barrier zones. Economic analysis of decisions about eradication, stopping, or slowing their spread may be critical to ecosystem management. The proposed bioeconomic model assumes that the rate of population expansion can be reduced (even to negative values in a case of eradication) if certain management actions are taken along the population front. The area of management can be viewed as a dynamic barrier zone that moves together with the population front. The lower is the target rate of spread, the higher would be both benefits and costs of the project. The model is applied to managing the spread of the gypsy moth (*Lymantria dispar*) populations in the USA. The model shows that slowing the spread of pest species generates economic benefits even if a relatively small area remains uninfested.
U.S. Army Engineer Waterways Experiment Station, Aquatic Plant Control Research Program	http://134.164.46.9/uhtbin/cgisirsi/Wed+Feb+16+15:23:56+CST+2000/0/49.	The US Army Corp of Engineers have developed an information system to help deal with noxious weeds called the Noxious and Nuisance Plant Management Information System (PMIS). The latest is version 4.0. You can order a CD ROM from the URL provided. Visit their online Library Catalogue link and follow that to their search engine and enter PMIS.

Organisation	Contact	Description
U.S. Geological Survey in partnership with the National Park Service, Ripon College and the University of Minnesota.	Dr. Ron Hiebert ron.hiebert@nau.edu http://www.npwrc.usgs.gov/resource/2000/aprs/aprs.htm	Alien Plants Ranking System (APRS) Version 5.1 is a computer-based tool designed primarily for grassland and prairie parks in the central United States. It is designed to help managers to target management efforts on the most problematic invasive non-native plants. It provides an analytical tool to separate the innocuous species from the invasive ones (typically around 10% of the non-native species). APRS not only helps identify those species that currently impact a site, but also those that have a high potential do so in the future. Finally, the system addresses the feasibility of control of each species, enabling the manager to weigh the costs of control against the level of impact.
U.S. Geological Survey Gap Analysis Program (GAP) and the University of Wyoming's Spatial Data and Visualization Center (SDVC)	www.sdvc.uwyo.edu/wbn	BEST (Biodiversity Expert Systems Tool) is a recently developed biological decision support tool that was demonstrated at a symposium celebrating the 125th anniversary of Yellowstone National Park in Bozeman, Montana. BEST was designed to make biodiversity considerations more routine in county land use planning. It can be used to identify potential conflicts between development proposals and the flora and fauna of a tract. BEST integrates both GAP data and local government data (e.g., parcel maps and zoning regulations) into a point-and-click geographic information systems (GIS) interface usable by people with little knowledge of GIS or biology. BEST was created for a pilot county within the Greater Yellowstone area.
U.S. Geological Survey, Forest and Rangeland Ecosystem Science Centre, Colorado Plateau field station	Katheryn Thomas Kathryn_A_Thomas@usgs.gov	Since 1997 the USGS in Arizona has been working with land managers to develop a system for sharing information on the location and size of exotic plant species infestations. The Southwest Exotic Plant Mapping Program (SWEMP) resulted in the development of a regional database that is updated yearly with the submitted field observations of federal, tribal, state and private. Maps of species distribution are developed yearly and displayed interactively on the web. The Southwest Exotic Plant Information Clearinghouse (SW-EPIC), which includes both SWEMP and the Alien Plant Ranking System, was developed to provide a ready source of information on the biology and ecology of exotic plants in the southwest. The National Park Service, USGS, and Northern Arizona University cooperated to develop this unified web-based information centre. SW-EPIC is now poised to provide data collection and distribution services that gives important information to concerned parties for action at the local level, vision across administrative boundaries at the regional level, and data for policy and strategy development at the national level.
University of Maryland, Center for Environmental Science.	Dr. Lisa A. Wainger wainger@cbl.umces.edu	Dr. Wainger is developing a spatial decision support system to assist managers of natural lands in deciding how to allocate limited treatment funds among sites infested with harmful invasive plant species. The system helps users compare the costs, benefits and risks of treating sites using factors specific to the site, its surrounding landscape, and the species being controlled. A multi-objective framework is used to assess the risks of not treating sites now and to compare treatment outcomes in terms of cost-effectiveness and risk management. Questions of which sites to treat, which methods to use, and what intensity and scale of treatment to apply at any site are addressed. Funding has been inconsistent and so even though they have developed the DSS structure, they have only preliminary software code for parts of the system.

Organisation	Contact	Description
University of Montana	Peter Rice biopmr@selway.umt.edu http://invader.dbs.umt.edu	The INVADERS database is a web-based, strategic weed management tool. It is designed to support programmatic decision-making. It allows vegetation program managers to view distribution data showing regional scale weed spread patterns over long time periods. Its purpose is to provide weed regulatory and natural resource management agencies with an updateable database and data management software to support proactive weed management strategies and development of weed identification training programs. It can also be used to determine which alien weeds are spreading most rapidly over a multi-state region before they cause severe economic losses and environmental damage requiring perpetual control over large geographic areas. The INVADERS web site contains actual examples of how land management and weed regulatory agencies are using these data to improve their weed management programs. Noxious weed listings are provided for all US states and six southern tier Canadian provinces.
United States Army, prepared by the Nature Conservancy of Washington	Patrick Dunn (360) 956-9713 pdunn@tnc.org	The Nature Conservancy wrote a report for the Army of the United States entitled “Prairie Habitat Restoration and Maintenance on Fort Lewis and within the South Puget Sound Prairie Landscape”. This paper provides some strategies on controlling Scotch broom at different stages in its life cycle. Table 1.5 below summarises the recommended control techniques.

Table 1.5. Efficacy of recommended control techniques for different ages of Scotch broom.

Treatment \ Age	Seedlings	Young (1 – 2 years)	Mature (3 – 5 years)	Old (> 5 years)
Prescribed Fire	**Yes**. Requires sufficient fine fuels interspersed in broom seedlings.	**Yes**. Resprouting is common, especially with spring burns.	**Yes**. Burning earlier in this stage minimised seed bank. Resprouting is common.	**Yes**. Stimulates seed bank, which can be a positive or negative characteristic.
Mechanical	**No**.	**Yes**. Hand-pulling or weed wrench is viable if numbers are low.	**Yes**. Resprouting is common, but can be used to minimise seed production.	**Yes**. Best when plants are stressed. Mortality can be high. Good preparation for future prescribed burn.
Chemical	**Yes**. Backpack spraying of limited sized patches.	**Yes**. Wipe-on foliar application should be tried.	**No**. Foliar sprays require larger amounts of herbicide. Treat mechanically and follow with chemical wipe-on.	**No.** Other treatments are effective with less side-effects.

(Source: adapted from Dunn 1998.)

Multinational

Organisation	Contact	Description
Global Invasive Species Programme (GISP) coordinated by the Scientific Committee on Problems of the Environment (SCOPE), the World Conservation Union (IUCN) and Center for Agriculture and Biosciences International (CABI)	http://jasper.stanford.edu/gisp/ http://www.cabi-publishing.org/Bookshop/book_detail.asp?isbn=0851995691 to purchase. Edited by R Wittenberg and M J W Cock, CABI Bioscience Centre.	The goal of the GISP is to improve prevention and management of biological invasions. The book "Invasive Alien Species: A Toolkit of Best Prevention and Management Practices" represents a key outcome of the program. It has been assembled by a team of international experts. Features include: case studies from around the globe, with some emphasis on islands, a focus on biodiversity, but with some consideration of traditional agriculture and forestry and advice on national management plans, including risk analysis.

1.4 Roles of Government in Managing Invasive Pests

This section highlights key legislation with respect to the management of invasive pests in Canada and discusses the roles and responsibilities of government. This section is organised by level of government (cross-border, federal, provincial and municipal) and then alphabetically by agency. The information contained here is from Internet sources and personal communication with staff of the various levels of government. This section focuses on regulations and government organisations that are relevant to this project. It is not intended to be a comprehensive survey of all roles/levels of government.

Cross-border Organisations

British Columbia Plant Protection Advisory Council

The British Columbia Plant Protection Advisory Council (BCPPAC) is a group of individuals, representing provincial and federal government and industry, working together to preserve the health of plants in British Columbia. The BCPPAC has a number of subcommittees that report to the advisory council. The various subcommittees carry out risk assessments of pests, their potential for establishment if introduced, and management practices. A number of people we have contacted for this study are involved with BCPPAC. The council has committees looking at the following:

- Apple ermine moth
- Balsam wooly adelgid
- Blueberry pests (Blueberry scorch virus)
- Chrysanthemum white rust
- Eastern filbert blight
- European brown snail
- European elm bark beetle
- Forest and dunnage pests
- Gypsy moth
- Grapevine diseases
- Japanese beetle
- Little cherry disease
- Tree fruit pests (Apple maggot and Cherry bark tortrix)

Other pests that were discusses at their last meeting in December, 2001 included:

- Viburnum leaf beetle
- Day lily gall midge
- Lace bug on Pieris
- European chafer on turf
- Sudden oak death
- Plum pox virus

They also play a role in biocontrol of weeds as they approve or reject the release of federally approved natural weed control agents to British Columbia.

North American Plant Protection Organisation

The North American Plant Protection Organisation[16] (NAPPO) is a regional body under the United Nations Food and Agriculture Organisation (FAO). NAPPO is recognised as the authority on phytosanitary issues under the North American Free Trade Agreement (NAFTA). NAPPO's mission is to coordinate the efforts among Canada, the United States and Mexico to protect their plant resources from the entry, establishment and spread of regulated plant pests, while facilitating intra/interregional trade.

They provide a Phytosanitary Alert System which:

- Provides pest alerts and news of emerging plant pests of significance to North America, and
- Is intended to facilitate awareness, detection, prevention and management of exotic species in North America.

It is anticipated that results from use of the System will include more focused domestic plant pest surveys; port of entry inspections that flag specific pests and pathways; better information for decision making on permits, risk assessments, and regulations; and increased lead time to prepare response and eradication plans. The intent of the System is to proactively reduce exotic pest outbreaks in NAPPO countries.

[16] http://www.nappo.org/menu_e.shtml

North American Forestry Commission

The North American Forestry Commission[17] (NAFC) was established in 1958. It provides a policy and technical forum for Canada, Mexico and the United States to discuss and address forest issues on a North American basis. The NAFC carries out its mandate by supporting research and natural resource management activities through seven working groups that explore issues of concern to the three countries. These working groups include:

1. Atmospheric change,
2. Fire management,
3. Forest products,
4. Insects and diseases,
5. Silviculture,
6. Forest inventory and monitoring, and
7. Forest genetic resources.

Each NAFC country is represented by the head of its national forest management agency. Biennial sessions are held in each country on a rotating basis. The week long sessions address forestry and natural resource matters, advance scientific knowledge in specific topic areas, promote cooperation and facilitate the exchange of information. The most recent commission meeting was hosted by Canada in St. Andrews, New Brunswick, in June of 2000. The next commission meeting will be held on Big Island, Hawaii, in October 2002. The Commission is developing a database[18] for the management of exotic forest pests introduced to North America. See Section 1.2 for further information.

Federal Government

Agriculture Canada

Agriculture and Agri-Food Canada's (AAFC) mandate is to provide information, research and technology, and policies and programs to achieve security of the food system, health of the environment and innovation for growth. The Canadian Food Inspection Agency (CFIA), an agency of AAFC, regulates food safety (along with Health Canada), animal health and protects plants. Further information on CIFA can be found below.

AAFC's pest management strategies for the control of rangeland weeds and invasive agricultural pests include biocontrol as an alternative method for control. AAFC, in collaboration with the International Institute of Biological Control, contributes to the safe introduction of biological control agents. The Lethbridge Research Centre is expanding and will soon be the largest and most comprehensive site for biocontrol research in Canada, and a leading facility for biocontrol internationally. This will include an 880 square metre biocontainment facility for the safe study of foreign biocontrol agents, and added rearing facilities and resources for biocontrol of crop and rangeland insect pests, livestock insect pests, plant diseases and weeds.

Canadian Food Inspection Agency

The Canadian Food Inspection Agency (CFIA), an agency of AAFC, regulates food safety (along with Health Canada), animal health and protects plants. The CFIA works to protect Canada's fish, plants and animals from diseases and pests. CFIA also works to prevent foreign diseases and pests from getting into the country.

[17] http://www.fs.fed.us/global/nafc/welcome.html
[18] http://www.exoticforestpests.org/

CIFA is responsible for the administration and enforcement of over 10 different Acts including:

- The *Plant Protection Act* and *Plant Protection Regulations*
- The *Fish Inspection Act*
- The *Seed Act*

The purpose of the *Plant Protection Act* is "to protect plant life and the agricultural and forestry sectors of the Canadian economy by preventing the importation, exportation and spread of pests and by controlling or eradicating pests in Canada." There are a number of *Plant Protection Regulations* under this act. The *Fish Inspection Act* applies to "the shipment of fish or marine plants from one province to another as though the shipment from a province were an export and the shipment into a province were an import." The *Seed Act* provides guidelines for the content of noxious weed seeds in crop seed, and transportation of crop seed in Canada.

According to Doreen Watler, National Manager of Plant Health Risk Assessment (PHRA), the PHRA is responsible for carrying out risk assessments for commodities moving in trade which could carry plant pests, and for plant pest organisms which are either established in a limited part of Canada and could spread, or which are not in Canada at all yet (quarantine pests for Canada). The assessments are used to support risk management decisions related to regulation of quarantine pests and the commodities which carry them. Their risk assessments guidelines were developed (with substantial Canadian input) by the International Plant Protection Commission. Assessments carried out under these guidelines are recognised under the World Trade Organisation (WTO) as meeting the requirements of the Sanitary and Phytosanitary rules.

The PHRA provides the risk assessments to the Plant Health and Production Division (PHPD) of CFIA. The PHPD uses the risk assessments done by the PHRA as a tool to support risk management decisions. The PHPD consults with affected parties and has discussions on the possible mitigating measures that could be taken to address the risks identified. This culminates in the issuance of a D-memo, if required.

The Forestry Section of the PHPD is responsible for development of forest policies that prevent the introduction and spread of regulated pests into Canada. This is achieved through the development and refinement of policy directives and import requirements targeting the control of known and newly discovered invasive pests and their related commodity pathways of introduction. The Forestry Program Team consults closely with Canadian companies, industry associations, federal and provincial government agencies and scientific bodies to maintain and develop export programs for Canadian forestry products. In addition, Forestry Team members participate in working groups and discussions with national and regional plant protection agencies, and the International Plant Protection Convention, to establish phytosanitary and certification standards.

For example, CFIA policy directive memo D-98-09 contains the plant protection requirements governing the movement within Canada, export from Canada to the United States, and import from the United States of nursery stock, Christmas trees, forestry products with bark attached, and all outdoor household articles, military & recreational and personal vehicles and equipment which can harbour any life stage of the North American gypsy moth, *Lymantria dispar*. Further information on D-98-09[19] can be found on CIFA's website. CIFA has established regulated areas for gypsy moth in British Columbia. Two areas were established in the fall of 1998 - one near Nanaimo and the other in the Victoria area. These regulated areas were reduced in size to a 1 km radius around the location of traps that detected residual moth

[19] http://www.inspection.gc.ca/english/plaveg/protect/dir/d-98-09e.shtml

populations in the summer of 1999 in the Duncan, Brentwood Bay, Highlands and Saanich areas. A description of these areas can be found in the appendix of D-98-09.

Natural Resources Canada - Canadian Forest Service

The mission of the Canadian Forest Service (CFS) is "to promote the sustainable development of Canada's forests and competitiveness of the Canadian forest sector for the well-being of present and future generations of Canadians." Forest resource management in BC is primarily the responsibility of the provincial government. The CFS is the main federal forest research organisation. It addresses the issue of introduced forest pests by providing government, industry, non-governmental organisations and the public with:

- "Compilations and syntheses of fundamental ecological information on potential alien forest pests and methods for detection, identification and monitoring,
- Assessments of the potential for the establishment and spread of alien forest pests in Canadian forests and of their impacts on Canada's forest ecosystems, economy, and communities,
- Systems for predicting the establishment and spread of alien pests, and
- Mitigative and preventive measures, including silvicultural options, natural control products, and decision-support systems."

They have published a paper entitled Alien Forest Pests – Context for the Canadian Forest Service's Science Program (Canadian Forest Service 1999[20]). This paper is the third in a series of context papers intended as guides to the current and future directions of the CFS's science program. It defines alien forest pests and describes why the CFS, in cooperation with its wide range of partners, addresses alien forest pest and related issues through research, monitoring, and assessment activities.

The Pacific Forestry Centre (PFC), based in Victoria, conducts research on identifying and monitoring invasive alien forest pests and protecting species and ecosystems at risk. Current relevant projects[21] include:

- Exotic Insect Interceptions from Wooden Dunnage and Packing Material (see below),
- Exotic Wood-boring Beetles in British Columbia: Interceptions and Establishments,
- Gypsy Moth - Forest Pest Leaflet,
- Pest Data Archives for BC, and
- Scotch Broom, *Cytisus scoparius* L. in British Columbia.

The CFS collaborates with CFIA in detecting, identifying, and assessing known and potential alien forest pests. In 1997, CFIA and CFS conducted a survey on exotic insect interceptions at major Canadian ports of entry. Numerous quarantine and potential quarantine pests have been intercepted in wooden articles and wood packing/crating materials from Asia, Europe and South America. Canadian Plant Protection officials are working with their counterparts from the United States and Mexico to prevent the introduction of quarantine pests from wooden articles and packing material into North America by harmonising regulations.

[20] http://www.nrcan-rncan.gc.ca/cfs-scf/science/context_pests/index_e.html
[21] http://www.pfc.forestry.ca/biodiversity/

Note that the Pest Management Methods Network of the Canadian Forest Service no longer exists. They have reorganised their website.

Environment Canada - Canadian Wildlife Service

National Botanical Services - Invasive Plants of Canada Project (IPCAN)

The IPCAN project was established through funding from Environment Canada for compiling information on the biology, distribution and control of invasive exotic plants and for developing databases for computer mapping and analysis. The databases provide a historical perspective on the origins and rate of spread of invasive species and also allow for the determination of possible correlations with climatic and other environmental and land use factors using geographic information systems (GIS). The website[22] contains fact sheets on exotic species, documents and links.

One of their reports, Impact of Invasive Plants on Species and Habitats at Risk in Canada,[23] is available online and provides information on impacts, identification, control, distribution and pictures of non-native plant species specific to Canada. In the year 2000 they conducted a survey of Invasive Plants of Canada.[24] This survey provides an overview of people and projects in Canada. It was initiated to compile information on projects in which sectors, such as government departments, universities, national conservation organisations, botanical gardens and museums, can engaged to further our understanding of the biology, spread and control of invasive species. The survey also recorded information on educational activities that promoted a better understanding of the problems associated with the spread of invasive species. One of the primary goals of the survey was also to determine the location of some of the most active centres of research on and/or management of invasive plants.

Parks Canada

The purpose of the Canada National Parks Act[25] is to consolidate the *National Parks Act*. This includes but is not limited to:

- Provide a procedure for the future establishment of new parks and the enlargement of existing ones,
- Add several new parks and park reserves and adjust the land descriptions of certain existing parks,
- Enhance protection for wildlife and other park resources, and
- Provide for the continuation of traditional resource harvesting activities in keeping with comprehensive land claim agreements and federal-provincial agreements to establish parks.

When managing parks, the maintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, is the first priority (Section 8 (2)).

[22] http://infoweb.magi.com/~ehaber/ipcan.html
[23] http://infoweb.magi.com/~ehaber/impact.html
[24] http://infoweb.magi.com/~ehaber/survey2000.html
[25] http://www.canada.gc.ca/gazette/part3/pdf/g3-02304.pdf

Parks Canada plans on incorporating a (draft) national directive on invasive alien species into its national strategy (Polster Environmental Services 2002). This strategy will include control and removal of invasive species, participation in inter-agency initiatives and communication with the public.

Health Canada

Health Canada is the federal department that is responsible for helping the people of Canada maintain and improve their health. The Pest Management Regulatory Agency[26] of Health Canada is responsible for providing safe access to pest management tools (products and sustainable pest management strategies), while minimising risks to human and environmental health. Decisions to apply approved pesticides reside with provincial governments. The Pest Control Products Act[27] regulates "products used for the control of pests and the organic functions of plants and animals." The Pesticide Residue Compensation Act[28] provides compensation to farmers whose agricultural products are contaminated by pesticide residue.

Provincial Government and Organisations

The government of British Columbia provides an HTML version[29] of their statutes and regulations.

British Columbia Ministry of Agriculture, Food and Fisheries

The mission of the British Columbia Ministry of Agriculture, Food and Fisheries (MAFF) is to "foster a competitive, economically viable and environmentally responsible agriculture and food system throughout British Columbia". With respect to resource management, they are focussed on maintaining the quality and availability of land and water for the province's agriculture and food industries.

The *Weed Control Act*[30] states that "an occupier must control noxious weeds growing or located on land and premises, and on any other property located on land and premises, occupied by that person". The Act lists weeds that have been classified as noxious within all regions of the province and within boundaries of specific regional districts (Tables 1.6 and 1.7). Polster Environmental Services (2002) provides information on the designation, concerns, description, habitat/range and management for each of these species as well as weblinks and references. If a noxious weed is found, an inspector may issue a "Notice to Occupier to Control Weeds" to a land occupier to control the weeds within a specific time period. If the weeds are not controlled, action will be taken under the Act and the occupier will be assessed the cost of weed control.

[26] http://www.hc-sc.gc.ca/pmra-arla/english/index-e.html
[27] http://www.hc-sc.gc.ca/pmra-arla/english/legis/pestcont-e.html
[28] http://www.hc-sc.gc.ca/pmra-arla/english/legis/pestresd-e.html
[29] http://www.qp.gov.bc.ca/statreg/
[30] http://www.qp.gov.bc.ca/statreg/reg/W/66_85.htm

Table 1.6. Alphabetical list of weeds (by common name) classed as noxious within all regions of British Columbia (adapted from Schedule A of the *Weed Control Act*).

Common Name	Scientific (Latin) Name
Annual Sow Thistle	*(Sonchus oleraceus)*
Canada Thistle	*(Cirsium arvense)*
Common Crupina	*(Crupina vulgaris)*
Common Toadflax	*(Linaria vulgaris)*
Dalmatian Toadflax	*(Linaria dalmatica)*
Diffuse Knapweed	*(Centaurea diffusa)*
Dodder	*(Cuscuta* spp.*)*
Gorse	*(Ulex europaeus)*
Hound's-tongue	*(Cynoglossum officinale)*
Jointed Goatgrass	*(Aegilops cylindrica)*
Leafy Spurge	*(Euphorbia esula)*
Perennial Sow Thistle	*(Sonchus arvensis)*
Purple Nutsedge	*(Cyperus rotundus)*
Rush Skeletonweed	*(Chondrilla juncea)*
Scentless Chamomile	*(Matricaria maritima)*
Spotted Knapweed	*(Centaurea maculosa)*
Tansy Ragwort	*(Senecio jacobaea)*
Velvetleaf	*(Abutilon theophrasti)*
Wild Oats	*(Avena fatua)*
Yellow Nutsedge	*(Cyperus esculentus)*
Yellow Starthistle	*(Centaurea solstitialis)*

Table 1.7. Alphabetical list of weeds (by common name) classed as noxious within the boundaries of the corresponding regional districts (adapted from Schedule A of the *Weed Control Act*).

Weed	Regional district(s)
Blueweed (*Echium vulgare*)	Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Okanagan-Similkameen, Thompson-Nicola
Burdock (*Arctium* spp.)	Bulkley-Nechako, Cariboo, Columbia-Shuswap, Fraser-Fort George, Kitimat-Stikine, North Okanagan, Okanagan-Similkameen, Peace River, Thompson-Nicola
Cleavers (*Galium aparine*)	Peace River
Common Bugloss (*Anchusa officinalis*)	Kootenay-Boundary
Common Tansy (*Tanacetum vulgare*)	Bulkley-Nechako, Central Kootenay, Columbia-Shuswap, East Kootenay, North Okanagan
Field Scabious (*Knautia arvensis*)	Bulkley-Nechako, Kootenay-Boundary, Thompson-Nicola
Green Foxtail (*Setaria viridis*)	Peace River
Hoary Alyssum (*Berteroa incana*)	Kootenay-Boundary

Weed	Regional district(s)
Hoary Cress (*Cardaria* spp.)	Columbia-Shuswap, North Okanagan, Thompson-Nicola
Kochia (*Kochia scoparia*)	Peace River
Marsh Plume Thistle (*Cirsium palustre*)	Bulkley-Nechako, Fraser-Fort George
Meadow Knapweed (*Centaurea pratensis*)	Columbia-Shuswap
Night-flowering catchfly (*Silene noctiflora*)	Peace River
Orange Hawkweed (*Hieracium aurantiacum*)	Bulkley-Nechako, Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Thompson-Nicola
Oxeye Daisy (*Chrysanthemum leucanthemum*)	Cariboo, North Okanagan, Peace River, Thompson-Nicola
Perennial Pepperweed (*Lepidium latifolium*)	East Kootenay, Thompson-Nicola
Plumeless Thistle (*Carduus acanthoides*)	Central Kootenay
Puncturevine (*Tribulus terrestris*)	Okanagan-Similkameen
Quackgrass (*Agropyron repens*)	Peace River
Russian Knapweed (*Acroptilon repens*)	North Okanagan
Russian Thistle (*Salsola kali*)	Peace River
Scotch Thistle (*Onopordum acanthium*)	North Okanagan
Sulphur Cinquefoil (*Potentilla recta*)	Colombia-Shuswap, North Okanagan, Okanagan-Similkameen, Thompson-Nicola
Tartary Buckwheat (*Fagopyrum tataricum*)	Peace River
White Cockle (*Lychnis alba*)	Peace River
Wild Chervil (*Anthriscus sylvestris*)	Fraser Valley
Wild Mustard (*Sinapsis arvensis*)	Peace River

The Crop Protection Program[31] "develops and promotes Integrated Pest Management (IPM) strategies in order to prevent, reduce or control the effects of pests and diseases in commercial agriculture." They provide an online "Field Guide to Noxious and Other Selected Weeds of British Columbia," developed to help farmers, ranchers, resource managers and the public identify British Columbia's noxious weeds. Roy Cranston, a Provincial Weed Specialist with the Crop Protection Program, is currently in the process of completing a project with the Open Learning Agency that profiles management of noxious weeds. See Section 1.2 for further information.

Ministry of Forests

The British Columbia Ministry of Forests is responsible for management of the timber, range and recreation resources of British Columbia's unreserved public (Crown) forest land. They manage this land for many uses, including recreation, forage, timber, and wilderness, and, in cooperation with other agencies, for water, fish, wildlife, tourism, heritage, and minerals.

[31] http://www.agf.gov.bc.ca/croplive/cropprot/

The *Forest Practices Code of British Columbia Act* establishes the "objective of sustainable use for forest management — meeting present and future needs, respect for land, balancing social and economic needs and conserving biodiversity and restoring environmental damage". The Act creates the legal authority and enforceable standards that govern the carrying out of forest management activities e.g. silviculture, fire and forest health, range and recreation. It establishes forest practice requirements for tenure holders respecting soil conservation, roads, timber harvesting, silviculture and range use. The Act also provides for licensing of botanical forest product buyers, protection of recreation resources and the control of insects and diseases. It establishes compliance and enforcement powers, including fines and administrative remedies and review and appeal procedures.

Part 4, Division 1, Section 52 (1)(2) of the Act:

- defines a noxious weed as in the *Weed Control Act*, and
- asserts that persons carrying out forest practices must do so in accordance with regulations and standards, at a time and in a manner that will limit the spread of noxious weeds.

Part 5, Division 7, Section 106 (1) of the Act states:

> If a designated forest official determines that on:
> (a) private land, or
> (b) Crown land that is subject to an agreement under the Forest Act,
> there are insects, diseases, animals or abiotic factors that are causing damage to a forest, the district manager may, in a notice given to the owner or the holder of the agreement, order measures to be undertaken within a specified time to control or dispose of the insects, diseases, animals or abiotic factors and the person must comply.
> (2) Any order under subsection (1) must be consistent with the *Wildlife Act* and the *Pesticide Control Act*.

The Range Section of the Forest Practices Branch develops provincial policies, standards, and procedures for managing range resources and allocates their use by the livestock industry through grazing and hay-cutting agreements. One of their responsibilities includes the development of policies and procedures for noxious weed control and the Weed Control Program.[32] The goal of the Weed Control Program is to minimise the spread of/or eliminate weeds species not native to North America, which are threatening British Columbia's forest and range resources. This is done through an Integrated Pest Management (IPM) approach, using all available tools at their disposal.

The Range Management Guidebook[33] describes what noxious weeds are, and outlines strategies for preventing their spread to new areas in forest operations. It also describes how noxious weeds are part of a range use plan. The Site Preparation Guidebook outlines that site preparation prescriptions must consider other management issues such as the spread of noxious weeds. It includes controlling noxious weeds as a stand management objective.

The program works cooperatively with national and international governments and non-government agencies concerned with weed control, and includes: BC Ministry of Forests, BC Ministry of Agriculture, Food and Fisheries, numerous county weed agencies, BC Cattleman's Association, Alberta and Saskatchewan governments, Agriculture and Agri-Food Canada, universities and other research groups,

[32] http://www.for.gov.bc.ca/hfp/noxious/introduc.htm
[33] http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/range/rangetoc.htm

Centre for Agriculture and Biosciences International in Switzerland, Montana Dept. of Agriculture, US Department of Agriculture.

The Silviculture Practices Section of the Forest Practices Branch has a mandate to ensure a balanced consideration of all forest values from stand establishment to pre-harvest planning. They are directly involved in developing and revising the legislation in areas relating to regeneration, stand management, and forest health, as well as developing contract procedures for silviculture operations. The Forest Health Unit[34] is responsible for:

- Bark Beetle Management
- Gypsy Moth and Other Defoliator Management
- Annual Pest Condition Summary
- Disease Management
- Pest Impact Estimation
- Mammal Damage Management
- Landscape Level Forest Health
- Forest Health Legislation
- Estimating Unsalvaged Losses

The Forest Health Unit has taken the lead role in managing infestations of North American gypsy moth (*Lymantria dispar*) in British Columbia. The Ministry is working together with the Ministry of Environment, Lands and Parks, the Ministry of Agriculture and Food, the Canadian Food Inspection Agency (CFIA), local Health Regions, and the municipal governments of communities where gypsy moth have been located. They provide a lot of information on the gypsy moth on their website,[35] including a fact sheet on the potential impacts of gypsy moth in Garry oak ecosystems.[36]

The Unit also provides a lot of information on the four major bark beetles in British Columbia, the mountain pine beetle, spruce beetle, Douglas-fir beetle and Western Balsam bark beetle. The *Forest Act* and *Ministry of Forests Act* authorise the Ministry of Forests to control pests (not necessarily with pesticides).

Ministry of Sustainable Resource Management

The Conservation Data Centre[37] (CDC) is part of the Registries and Resource Information Division. They collect and disseminate information on the rare and endangered plants, animals and plant communities of British Columbia. They have identified BC's most vulnerable vertebrate animals, vascular plants and natural plant communities. Invertebrate animals, mosses and lichens are currently being identified. The CDC provides two types of lists, Tracking lists and Red and Blue lists. The tracking lists contain information on species/communities they are actively collecting information on. Species/plant communities are assigned to Provincial Red or Blue list on the basis of the Provincial Conservation Status Rank (SRANK) assigned by the Conservation Data Centre. The CDC tracks the occurrence of introduced vascular plant species in British Columbia. Their list of these plants includes 675 taxa with an abundance rank for each (Polster Environmental Services 2002)

The CDC is one of 83 programs in North America affiliated with NatureServe[38] in Arlington, Virginia. NatureServe staff and member programs work together to develop and provide knowledge about the world's natural diversity. They provide the context, analysis, and interpretation that transforms biological

[34] http://www.for.gov.bc.ca/hfp/forsite/Forest_Health.htm
[35] http://www.for.gov.bc.ca/hfp/gypsymoth/
[36] http://www.for.gov.bc.ca/hfp/gypsymoth/garryoak.htm
[37] http://srmwww.gov.bc.ca/cdc/
[38] http://www.natureserve.org/

data into conservation knowledge. They are currently building a decision support tool to work with the CDC's database.

Ministry of Transportation

BC *Transportation of Dangerous Goods Act* provides information regarding the storage and transportation of pesticides.

Ministry of Water, Land and Air Protection

Integrated Pest Management (IPM) Program

The Ministry administers the British Columbia *Pesticide Control Act* (1997) and *Regulation*, which:

- regulates the sale, use and handling of pesticides in the province
- promotes an Integrated Pest Management (IPM) approach to managing pests

Their goal is to have pesticides used only in the context of an IPM program. The act and supporting regulations are administered by Integrated Pest Management staff from regional offices around the province. Pesticide Use Permits and Pest Management Plans are issued or approved under this legislation. It also makes provision for training and certification of pesticide applicators and dispensers, as well as licensing of service and vendor companies.

Pest Management Plans are defined under this legislation to describe:

- a program for controlling pests or reducing pest damage using integrated pest management
- the methods for handling, preparing, mixing, applying and otherwise using pesticides within the program

Pest Control Service Licensees in the public sector (e.g., municipalities, school districts, parks departments, colleges, etc.), and licenses in the Landscape category seeking Public Land Endorsements, must submit Pest Management Plans (PMP's) with their license applications. This also applies to public agencies using contractors to apply pesticide to lands under their jurisdiction. These plans will be evaluated by Ministry staff as part of the review and decision-making process for Public Land Endorsements.

The Ministry also promotes IPM by:

- writing IPM manuals for pesticide certification training, and
- providing information to the public and businesses on managing pests using IPM.

They provide a number of online resources[39] including IPM manuals (training manuals and pest management plan guides), Technical Reports (surveys and studies commissioned by the ministry), Pesticide management reports, evaluations and plans, brochures and fact sheets.

[39] http://wlapwww.gov.bc.ca/epd/epdpa/ipmp/publications.html

Municipal Government

City of Victoria

In 1992, the Parks Division of the City of Victoria initiated an Integrated Pest Management[40] (IPM) program with a primary goal of reducing the use of chemical pesticides. The Parks Division manages pests by applying IPM principles and practices that:

- "Maximise the use of naturally occurring forces and non-toxic chemicals (i.e. Insecticidal soaps, etc.)
- Minimise the potential for pest problems, therefore avoiding the need for curative measures
- Minimise the risk to human health and the environment
- Minimise the reliance upon chemical pesticides."

As a result of the IPM program, The City has decreased the use of chemical pesticides by more than 97% (comparing the total chemical product used by weight per year prior to the IPM program versus after the establishment of the IPM program). Weed control is still the key area for improvement in pesticide use within the City of Victoria, with just over one half of the remaining pesticide use in the City consisting of herbicides. New technology such as the use of hot water based weed control applicators will provide additional non-chemical choices in the area of vegetation management.

They will be developing a Natural Areas Management Plan in 2002 and hope to include a management framework for invasive species. They are very interested in the outcome of this project.

Capital Regional District

The Capital Regional District Parks Master Plan[41] 2000 was developed to provide a vision and a purpose for CRD Parks. The stated purposes of the Regional Parks are to:

- "establish and protect a network of regional parks in perpetuity that represent and help maintain the diverse range of natural environments in the Capital Regional District.
- To provide opportunities for outdoor experiences and activities that foster appreciation and enjoyment of, and respect for, the region's natural environments."

Management of invasive species is part of this plan, as non-native species are threatening native vegetation. Guidelines for managing non-native vegetation and wildlife include:

- "Control invasive introduced plant species that threaten the long-term viability of ecosystems and species of conservation significance.
- Maintain and manage vegetation to conserve, enhance and restore native plant communities, to preserve and protect populations of rare, threatened, endangered and sensitive plant species and their habitat, and, where possible, to protect biological diversity and achieve a high representation of native vegetation.
- Work with the responsible federal and provincial government agencies to help maintain viable populations of wildlife and fish within regional parks.

[40] http://www.city.victoria.bc.ca/cityhall/departments_compar_prkipm.shtml
[41] http://www.crd.bc.ca/parks/pdf/masterpl.pdf

- Protect rare, threatened and endangered wildlife and their habitat.
- Manage non-native and feral animals to minimise conflicts with native wildlife species."

In the year 2000 they released a Report on the Environment[42] to inform the public and decision-makers about environmental conditions in the CRD and how conditions had changed over the past decade.

The CRD uses volunteers and provides volunteer training for the removal of invasive species (Polster Environmental Services 2002).

Greater Vancouver Regional District (GVRD)

The mission of GVRD Regional Parks[43] is "to protect and care for a legacy of diverse ecosystems, wildlife and features which represent the region and provide outstanding opportunities for outdoor recreation, education and community participation." They manage invasive species in their Regional Parks. All other pest management within the GVRD is up to the individual municipalities. The GVRD does not have any official processes or regulations for choosing which plant species they target. Control of invasive species is done primarily by volunteers.

[42] http://crdinfo.crd.bc.ca/report_files/cover172.htm
[43] http://www.gvrd.bc.ca/services/parks/

2.0 Information Gaps in Decision Support Tools in BC

As reported in Section 1.2, we found evidence of relatively few formal decision support tools or methodologies in use for invasive species management in British Columbia. Most of the individuals we contacted who are involved in management of invasive species told us they rely upon their own expertise for making management decisions, or informal decision support strategies such as consultation with colleagues. Of the 66 people who responded to our inquiries, only 9% were aware of any kind of tool in use in BC.

These findings suggest there are significant gaps in the field of decision support tools for invasive species in British Columbia, across all geographic areas and ecosystem types. These gaps are particularly wide with respect to Garry oak and associated ecosystems (GOEs) — we were only able to identify one tool designed specifically for GOEs in BC (or elsewhere, for that matter). According to Fuchs (2001), there is very little information that has originated from Garry oak ecosystems with respect to managing invasive plants in British Columbia. There are a few studies currently in progress that are examining ecosystem restoration, which includes the control of invasive plant species. There has generally been little research done on the impact of exotic species on other species[44].

We identified four main categories of tools and methodologies that are used to support decision making for invasive species management in British Columbia, beyond *ad hoc* use of personal expertise and consulting with colleagues:

- State of Science information (fact sheets, field guides, reports),
- Decision trees (paper based),
- Matrices (paper and computer based), and
- Computer models.

Table 2.1 provides a brief summary of the tools we identified, and more detailed information can be found in Section 1.2. Only one of these tools, the Exotic Plant Species Control Matrix, developed by Willie MacGillivray of the Swan Lake-Christmas Hill Nature Sanctuary, was created specifically for Garry oak and associated ecosystems. While the rest are not specific to GOEs, they do apply to species such as Scotch broom (*Cytisus scoparius*) and Gypsy moth (*Lymantria dispar*) that are, or are likely to become, an issue in Garry oak and associated ecosystems. Most of the tools that we came across are focused on weed or insect management, pests that are primarily of economic concern in the province.

We have not done a thorough or exhaustive search for decision support tools in use for invasive species in other jurisdictions. Information on decision support tools and methodologies outside of BC is presented in Section 1.3, and reflects what we came across during our research for Section 1.2, or were referred to by people we contacted.

[44] Judith Myers, University of British Columbia, pers. comm., December 11, 2001.

Table 2.1. Summary of tools currently available in BC for supporting management decisions for invasive species.

Name	Species	Description
State of Science Information		
Field Guide and Fact Sheets on Noxious and Other Weeds of British Columbia	All noxious weeds (listed in Tables 1.6 & 1.7) plus approximately forty common weeds.	The guide and fact sheets were developed to help farmers, ranchers, resource managers and the general public identify British Columbia's noxious weeds.
Literature on Invasive Species	A range of species.	There are a number of research papers, reports and pamphlets that discuss field identification, habitat and control measures of invasive species.
Pest Management Plans	A range of species.	Pest Management Plans describe Integrated Pest Management (IPM) plans for controlling pests or reducing pest damage and the methods for using pesticides within the program. They also provide a template for creating such plans.
Plant Health Risk Assessment Reports	A range of species. Sudden Oak Death is provided as an example.	Prepared by the Canadian Food and Inspection Agency (CIFA). The assessments are used to support risk management decisions related to regulation of quarantine pests and the commodities that carry them. The risk assessment is designed to form a link between scientific data and decision makers by expressing risk in terms appropriate for decision makers. Further information on CIFA can be found in Section 1.4.
Decision Trees		
Weed Management Decision Tree	A range of species. Identification of the weed is one of the steps in the tree.	The tree takes users through a series of step (including identification of weed species, species status). Each step recommends an action or directs users to another step in the tree.
Decision Trees for Bark Beetles	Douglas-fir beetle, mountain pine beetle and spruce beetle. Douglas-fir beetle is provided as an example.	Works in the same manner as the Weed Management Decision Tree.
Matrices		
Gypsy Moth Site Comparison Matrix	Gypsy moth.	A matrix chart with criteria designed to provide objective rationale behind management decisions.
Exotic Plant Species Control Matrix	Himalayan blackberry, scotch broom, English ivy, purple loosestrife, poison hemlock, oyster plant, Canada thistle, morning glory and money plant.	Matrix for determining the best time of the year for removing exotic species.
Biological Control Agent Matrix	A range of weeds. See Section 1.2.	Interactive online matrix that outlines which biological agent(s) to use for controlling weeds.
Computer Models		
Gypsy Moth Model	Gypsy moth.	Phenology model that is used to develop area-wide forecasts of target events in the seasonal life history of gypsy moth.

It has become clear that there is a lot of interest in the use and development of decision support tools for invasive species management in BC, but respondents indicated a scarcity of resources or personnel to develop these tools. It is interesting to note that when we were inquiring about decision support tools, computer models seemed to be the first thing to come to mind for many people. Simple decision trees or matrices can be very effective tools, and are typically much less expensive to develop. The tendency for people to associate the idea of decision support tools with complexity and computer programming may reflect a need — and an opportunity — to develop and demonstrate the effectiveness of simpler materials.

3.0 Decision Strategy Framework

This chapter describes the decision strategy framework for a tool to help resource managers and volunteers to make decisions regarding management of invasive species as part of efforts to restore Garry oak and associated ecosystems (GOE).

3.1 Purpose of the Framework

The Invasive Species Steering Committee (ISSC) of GOERT has identified a need for a decision support tool (DST) to help make decisions regarding whether, and how, to manage invasive species in Garry oak and associated ecosystems. It is important to understand the difference between a decision *support* tool and a decision *making* tool. The DST will provide the user with guidance regarding invasive species management options, and either provide or direct them to other sources of information that may help. It will still be up to the user to consider the information at hand to make a final informed decision. There is bound to be uncertainty. Rather than being cause for inaction (although there will be times when "no action" is the best decision, all things considered), uncertainty should be viewed as an *opportunity to learn* through adaptive management, an approach designed specifically for such situations.

This framework lists the questions the DST should ask users, describes the factors that users should consider when trying to answer these questions, and provides or cites other sources of information that may help in reaching their answers. It also provides a structure for this information, organising it into logical components, and provides context for these within some overall general principles. The main focus of this framework is to guide future development of the DST.

3.2 Target Audience for the DST

The DST is intended for several audiences:

- Members of the Invasive Species Steering Committee within the Restoration and Management Recovery Action Group (RAG) of GOERT, in order to coordinate wider adaptive management programs with other RAGs and other recovery partners (e.g. government agencies, non-government organisations, and private landowners),
- Ecosystem managers who have on-the-ground experience with GOEs,
- Local non-governmental groups (e.g. ecosystem "Friends Of" groups) interested in GOEs, under the leadership of someone knowledgeable about GOEs, and
- Private landowners interested in managing GOE sites on their property, who have some knowledge of GOEs or will work in association with someone knowledgeable about GOEs.

3.3 Framework Structure

The decision strategy framework, shown in Figure 3.1, is divided into three parts:

A. Characterizing the ecosystem: identifying the ecosystem type and related characteristics of the site,

B. Assessing the impacts and risks: important issues to consider in deciding *whether* to manage invasive species, and which ones, and

C. Identifying management actions: if proceeding to manage invasive species, deciding on *how*.

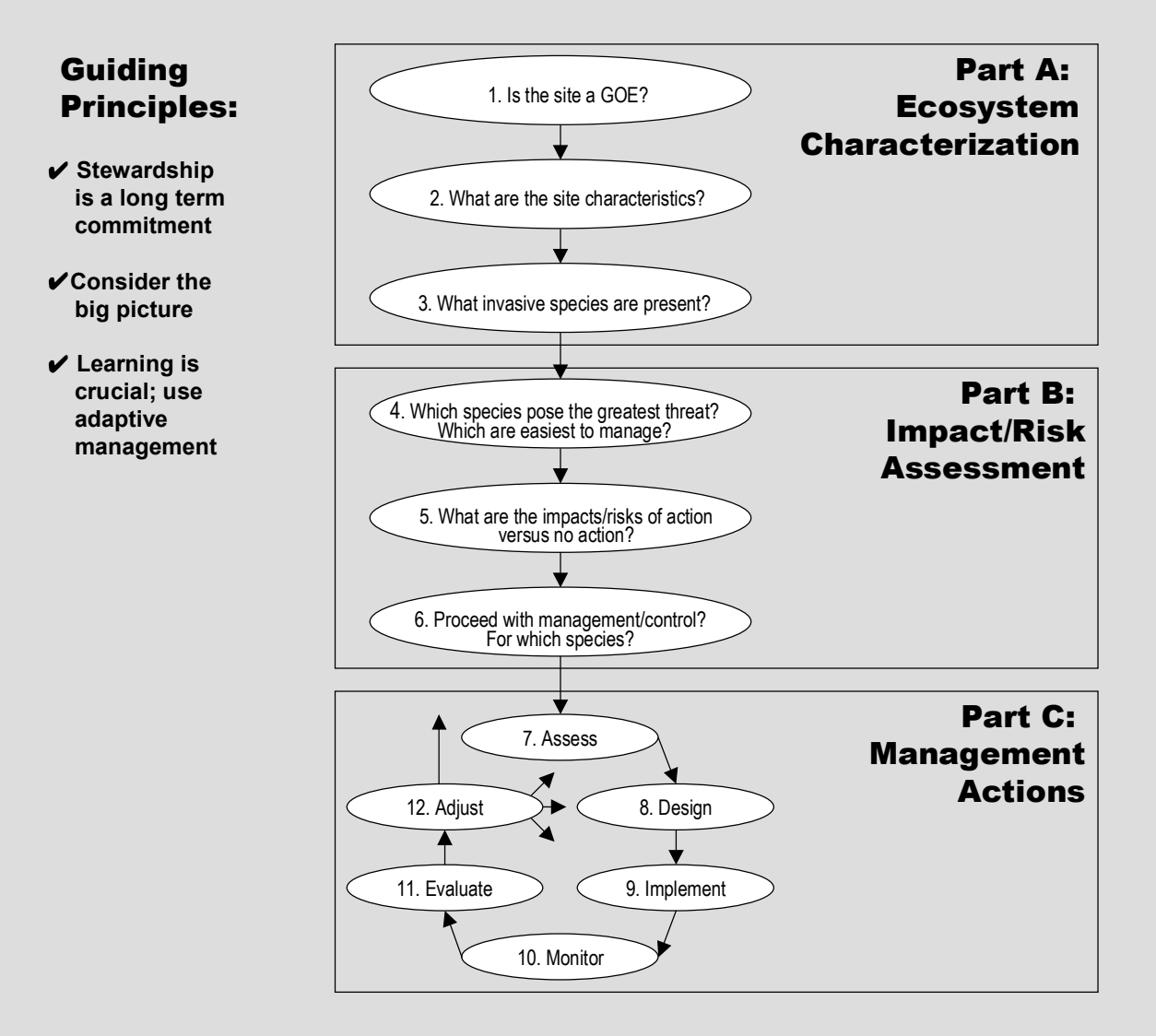

Figure 3.1. Decision Support Strategy Framework.

Guiding Principles

There are several guiding principles that a user should keep in mind, regardless of what part of the DST framework they are using. These principles are relevant at all levels, and should be considered in all decisions.

1. **Stewardship requires a long-term commitment.** In most cases, management of invasive species is not simply a single-action task. Control measures will likely need to be repeated and monitoring will be necessary, sometimes for years into the future. Users of the DST must be prepared to either make this commitment themselves, or pass on the responsibility to others. This requires thorough documentation of decisions, actions and results to provide continuity of management over time.
2. **Consider the big picture.** This applies to both space and time. Spatially this means careful consideration of the site within the larger landscape context. First, consider the site in relation to the surrounding land conditions. Second, consider how the site fits within the suite of GOEs in BC. These may influence whether and how management action should be taken. Temporally this means consideration of what to do after the initial management intervention. For example, after pulling or cutting Scotch broom (*Cytisus scoparius*), what should be done regarding its disposal, and how might the site be regenerated with native species, tended, and then monitored over the longer term?
3. **Learning is crucial.** There is a lot we don't currently know about GOEs regarding how invasive species threaten and affect them, and the effects and success of various management actions. It is therefore critical that as different groups try different management alternatives, this occurs within a structured approach designed specifically to increase learning opportunities. Adaptive management is an approach specifically geared for reducing uncertainty, and should be the framework within which all management actions are undertaken. This framework is illustrated under Part C in Figure 3.1 and further described later in this chapter, also under Part C. The information learned through this approach can be used to update fact sheets, improve best practices, and update the DST.

Part A: Ecosystem Characterisation

In this part of the DST, users will define the characteristics of the site they are considering for invasive species management. Defining these characteristics up front will help answer some of the questions later on in the framework.

1. Is the site a GOE?

This is a simple question, but an important one. GOEs have tremendous species and ecosystem diversity. The ecosystems considered to be "associated" with Garry oak ecosystems include quite a range: transitional forests, rock outcrops, grasslands, vernal pools, coastal bluffs, and maritime meadows. Since some do not actually contain Garry oak trees (*Quercus garryana*), it may not be obvious what types of sites should actually be included when trying to manage and improve "Garry oak and associated ecosystems". It is important for users to determine:

- ❑ Is the site technically a GOE?
- ❑ What ecosystem types are represented within and near it?

The DST should provide or direct the user to the following information to help answer this question:

- The Sensitive Ecosystem Inventory (SEI)[45] is a tool that can be used to help identify the actual geographic location of some GOEs. The SEI identifies remnants of rare and fragile terrestrial ecosystems for the purposes of encouraging land-use decisions that will ensure the continued integrity of these ecosystems. One of the products is a series of maps showing sensitive ecosystems including "woodland", which include stands of Garry oak and mixed stands of Garry oak/Arbutus, Garry oak/Douglas-fir, and Arbutus/Douglas-fir. These maps can be obtained from Clover Point Graphics in Victoria. An example of these maps is provided in Figure 3.2.

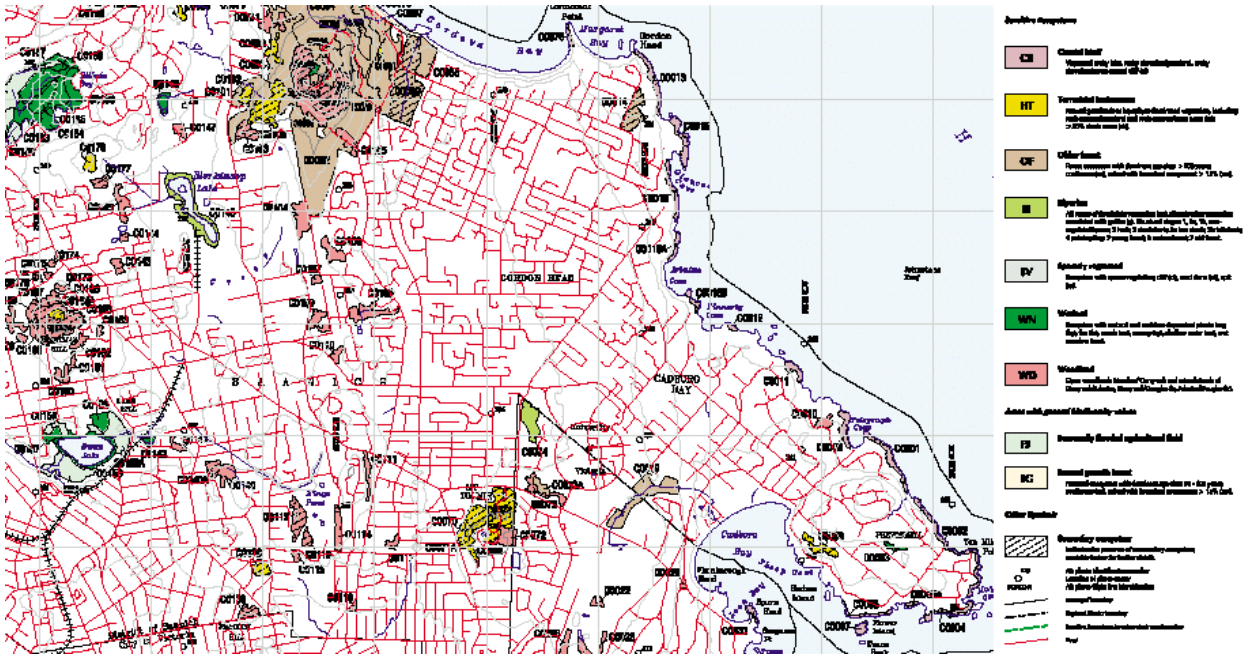

Figure 3.2. Example of the information available on an SEI map.

- The GOE classification system currently being developed by the Inventory, Mapping and Plant Community RAG within GOERT can also help identify and classify GOEs. This classification is still under development, but when completed will provide users with a guide for using floristic (individual plant species composition or groups of species) and physiognomic (structure and form of plant communities) characteristics to identify whether the site is a GOE, and if so, classify it to a more specific type. Representative drawings, sketches or photographs of "typical" examples of each ecosystem type would be a useful addition to the DST, to help users more readily identify the ecosystem types.

[45] http://srmwww.gov.bc.ca/cdc/sei/

2. What are the site characteristics?

The next logical step is to describe the site in more detail, from an ecological and social perspective. Users should identify and document the following information:

- ❏ What are the key ecosystem characteristics of the site?
- ❏ What are the "valued ecosystem components," such as rare/endangered species?
- ❏ Who owns the site?
- ❏ What the site is used for?
- ❏ Who owns the adjacent land, and what is the adjacent land used for?

This information will be critical in undertaking the impact and risk assessment in Part B, and will also be necessary for choosing among management alternatives in Part C.

The DST should provide or direct the user to the following information (or selected excerpts, so users are not overwhelmed) to help answer these questions:

- Essential ecosystem characteristics of GOEs are listed and described in the report entitled "Towards a Recovery Strategy for Garry Oak and Associated Ecosystems in Canada: Ecological Assessment and Literature Review" (Fuchs 2001). This report also lists animal taxa at risk. Portions of this report could be provided in an appendix of the DST.
- The Field Manual for Describing Terrestrial Ecosystems[46] published by the BC Ministry of Water, Land and Air Protection may also provide guidance on how to identify key site characteristics such as moisture regime, nutrient regime, successional status, slope, aspect, surface shape, and how to draw a site diagram. While somewhat detailed, this level of information may prove useful not only for initial ecosystem identification and classification, but also as an aid for monitoring and other follow-up work.
- Lists of rare and endangered plants, animals and plant communities in British Columbia can be obtained from the BC Conservation Data Centre (CDC)[47]. The CDC tracking lists provide information on both the global and provincial status rank for the listed species.
- The Committee on the Status of Endangered Wildlife in Canada (COSEWIC)[48] tracks species at risk (species designated as extinct, extirpated, endangered, threatened, or of species concern) from a national perspective.
- A host of field guides (birds, mammals, plants, insects, etc.) are available that will help users identify native and exotic species of flora and fauna.
- Land ownership information can be obtained through the local BC land title search office. Government Agents[49] also provide computerised title search information to the public. Users can call Enquiry BC toll free at 1-800-663-7867 and be transferred free of charge to the Government Agents office they wish.

[46] http://www.for.gov.bc.ca/ric/pubs/teecolo/fmdte/deif.htm

[47] http://srmwww.gov.bc.ca/cdc/

[48] http://www.cosewic.gc.ca/

[49] http://www.governmentagents.sb.gov.bc.ca/progdesc/land_title.html

3. What invasive species are present?

Since the DST will be designed for invasive species[50], it is important early on in the site inspection for users to determine what invasive species are present at the site, or what invasions are imminent from the surrounding land. Users should be asked to determine:

- ❏ What invasive species are present at the site?
- ❏ What invasive species are nearby on adjacent land?

Most users will be focusing on invasive exotic species, but the framework uses the terminology "invasive species" so that it can also apply to users who wish to manage for invasive species that are not exotic.

The DST should provide or direct the user to the following information to help answer these questions:

- The BC Ministry of Agriculture and Food lists noxious weeds[51] in British Columbia. The list includes those classified as noxious in all regions of BC, as well as those classified as noxious within Regional Districts.
- Field guides are available that will help users identify invasive species, such as "Northwest Weeds: the Ugly and Beautiful Villains of Fields, Gardens and Roadsides" (Taylor 1990). Some field guides do not focus solely on exotic species, but include them and specify which species are introduced, such as the "Field Guide to the Birds of North America" (National Geographic Society 1987).
- Exotic species are discussed in the report entitled "Towards a Recovery Strategy for Garry Oak and Associated Ecosystems in Canada: Ecological Assessment and Literature Review" (Fuchs 2001).
- Numerous lists of invasive species are provided in a draft report entitled "The Role of Invasive Species Management in Terrestrial Ecosystem Restoration" (Polster Environmental Services 2002).
- The Invasive Plants of Canada website,[52] part of Environment Canada's Invasive Plants of Canada (IPCAN) project, contains information on invasive species in BC, including species fact sheets with photos or drawings, that could help users identify invasive plant species.

Part B: Impact/Risk Assessment

The ecosystems, site characteristics and invasive species are identified in Part A, setting the stage for the next step: deciding *whether* to manage for invasive species, and if so, which ones. Part B provides a framework for helping to make that decision by prompting the user to consider the risks and potential impacts.

[50] The DST will be designed for managing invasive species once they are present (or near) the site of interest. It is not intended to be a tool to *prevent* species invasions, although that can be a valuable ecosystem management strategy.

[51] http://www.agf.gov.bc.ca/croplive/cropprot/weedguid/weedguid.htm

[52] http://infoweb.magi.com/~ehaber/ipcan.html

4. Which invasive species pose the greatest threat? Which are the easiest to control/manage?

One of the key questions users must answer is: of the invasive species present (determined in Part A), which pose the greatest threat to the GOE? And in addition to the degree of threat, it is also important for users to ascertain, of the invasive species present, which are most feasible to control or manage? Users should be prompted to consider a range of factors, for each invasive species at the site:

- ❏ What is the magnitude and state of the invasion? Is the site mildly, moderately or highly infested? Is the geographic extent of the infestation large or small? For invasive flora, are the plants big or small?
- ❏ What is their invasiveness? How quickly do they spread, and how? Is it critical for their control to take action within the first few years after initial invasion?
- ❏ How persistent are they in the ecosystem? For example, Scotch broom (*Cytisus scoparius*) is very persistent as its seeds can survive for decades in the soil.
- ❏ How transportable are they to other sites within and outside the ecosystem of concern? What are the possible transport mechanisms?
- ❏ Are they having a negative impact on the native ecosystem? In what way and to what degree?
- ❏ What is the time since establishment – how long have the invasive organisms been there? This is particularly important for plant species, as it helps determine the relative size of the seed bank. The larger the seed bank, the harder the species may be to control.
- ❏ What level of effort (time, person-days, funding) is likely to be required for successful control or management?
- ❏ How well have they responded to management actions elsewhere? Have efforts elsewhere been successful?

Users should be provided, or directed to, the following information sources:

- Appendix 2 of the draft report entitled "The Role of Invasive Species Management in Terrestrial Ecosystem Restoration" (Polster Environmental Services 2002), prepared for the BC Ministry of Water, Land and Air Protection contains a thorough description of invasive species autecology.
- The Alien Plants Ranking System (APRS) Version 5.1[53] is a computer-based tool designed to help managers target management efforts on the most problematic invasive non-native plants in grassland and prairie parks in the central United States (APRS Implementation Team 2000, Hiebert and Stubbendieck 1993[54]). It lists criteria for determining a plant's innate ability to become a pest, and feasibility of control or management, which could help users answer some of these questions.
- The Nature Conservancy's Site Weed Management Plan Template[55] (The Nature Conservancy 2001) contains guidance on ranking weed species that may be helpful in answering some of these questions.
- The GOERT is in the process of preparing a set of invasive species fact sheets for Scotch broom (*Cytisus scoparius*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus proseris/discolora/armeniacs*), Gorse (*Ulex europeus*), Orchard grass (*Dactylis glomerata*),

[53] http://www.npwrc.usgs.gov/resource/2000/aprs/aprs.htm
[54] http://www.nature.nps.gov/pubs/ranking/ranking.htm
[55] http://www.invasivespecies.gov/toolkit/control.shtml

Sweet vernalgrass (*Anthoxanthum odoratum*), Laurel-leaved daphne (*Daphne laureola*), and Common hawthorn (*Crataegus monogyna*).[56] These fact sheets will contain information on autecology, identification tips, identification photographs, and suggested management techniques, and should be provided in the DST.

- The Invasive Plants of Canada website,[57] part of Environment Canada's Invasive Plants of Canada (IPCAN) project, contains information on invasive species in BC, including species fact sheets, that could help users answer some of these questions for invasive plant species at the site.
- Chapter 4 of this report contains a ranking of the "top 10" exotic plant species currently threatening GOEs in BC, and a longer list of candidates, that may help users who are considering management of invasive plant species.
- Ideally, current results from other management programs would be readily available. The GOERT could establish a web site or other mechanism for sharing management plans and results using a format that is consistent and makes it easy to compare management practices.

5. What are the impacts/risks of action versus no action?

This is a value judgement, and can be very subjective. The answer to this question will depend on many factors, including the experience of the DST user, their management goals, and the social climate within which they are operating. In addition, there are tremendous gaps in the current state of knowledge regarding the effects of most invasive species and their management in GOEs. For these reasons, it is neither appropriate nor possible for the DST to provide a rigid set of decision rules. What it can do is provide a list of factors that the user should consider, so the decision of whether to manage for invasive species or not is as informed as possible. The following provides a checklist of standard factors/concerns that users should be prompted to consider:

- ❏ What are the overall management objectives of the site and will these be compromised by invasive species?
- ❏ Is the site under some form of protection? To what degree can the site be protected from other impacts at the same time? It may be a wasted effort to focus management resources and energy on invasive species at a site that faces equal or greater impacts from other pressures or activities.
  - It may be helpful for the DST to include Table 2.3-3 from the report entitled "The Role of Invasive Species Management in Terrestrial Ecosystem Restoration" (Polster Environmental Services 2002), which provides guidance on how to prioritise geographic areas based on the degree of land protection/conservation.
- ❏ Do invasive species pose a threat to species at risk at the site, through competition, predation, habitat alteration or other mechanisms? Ecosystems for which the answer is "yes" are prime candidates for management action and deserve careful consideration.
- ❏ Has the invasive species significantly changed ecosystem structure, function or processes, or is this likely to happen? For example, an infestation of Scotch broom (*Cytisus scoparius*) can change soil nitrogen levels, and significantly alter the shrub layer composition and structure. The greater the potential effect, the stronger the case for management action.

[56] Judith Cullington, pers. comm., December 18, 2001.
[57] http://infoweb.magi.com/~ehaber/ipcan.html

- ❑ Does the invasive species occupy a niche that was formerly occupied by a native species that has since been out-competed? Does the invasive species perform a positive ecosystem function worth keeping? For example, non-native thistles (*Cirsium spp.*) can provide a valuable resource for late season butterflies in a drought.[58]
- ❑ Would the cost and/or effort of taking action now be significantly less than the cost and/or effort of taking action later? Some species become much harder to control over time (for example, those with large persistent seed banks) and spending resources to address them before they become too well established may be a prudent strategy.
- ❑ What is the current "quality" of the site, compared with the management/restoration goal? Ecosystems already greatly altered from their "natural state" may be a lower priority than ecosystems that are relatively undisturbed by contemporary human influence.
- ❑ What is the condition and use of the surrounding land? It may be futile to focus management resources and energy on sites that are surrounded by land already heavily stocked with invasive species, by land that is greatly disturbed and therefore highly susceptible to invasive species, or by land that is heavily developed and therefore unable to contribute to the biological quality of the site (e.g. high density housing, parking lots).
- ❑ What is your ability to follow up at the site? For example, if you want to control for Scotch broom (*Cytisus scoparius*), can you go back and repeat removal efforts to keep the seed bank under control? Do you have the labour and perseverance to return to the site for subsequent control activities? Are you willing/able to make a long-term commitment to management? Will the landowner allow such repeat efforts?
- ❑ What will establish in its place? Are you likely to trade one invasive species for another, or will the niche indeed be filled by "desirable" native species?
- ❑ How "high profile" is the site? Although a site may be of lesser quality from an ecosystem "naturalness" perspective, it may be of higher management priority if it can provide the general public with a good example of the success of invasive species management efforts. Some management effort spent on lower quality yet higher profile sites may generate the public support necessary to generate greater resources for lower profile, higher quality site.
- ❑ If you take action, how susceptible are rare/endangered species to management actions? Could management actions increase the soil disturbance to the point of creating more opportunities for exotics to invade?
- ❑ How will neighbours respond to control/removal activities?
- ❑ Is there a potential for increased site access? For example, one site experienced the emergence of "bandit trails" used by hikers and mountain bikers after removal of Scotch broom (*Cytisus scoparius*).[59] Would this be a good thing or a bad thing, given the management objectives for the site?
- ❑ What might happen if you do not take action? Will there be a cumulative build-up of a long-surviving seed bank? Will there be permanent loss of rare/endangered species? How concerned are neighbours about invasive species and their spread?
- ❑ Considering all of the above, what poses the greater threat: potential negative effects from management actions, or the results of not taking management action?

[58] Patrick Dunn, The Nature Conservancy, pers. comm., at February 1, 2002 broom workshop in Victoria.

[59] Willie MacGillivray, Swan Lake-Christmas Hill Nature Sanctuary, pers. comm., at February 1, 2002 broom workshop in Victoria.

6. Will you proceed with management/control? If so, for which species?

This is the first point in the framework where users are asked to make a decision. They must weigh the issues listed under question 5, carefully consider the available information, and decide *whether or not to proceed* with some sort of management or control effort. If the decision is "Yes", users must weigh the issues listed under question 4 to decide *which invasive species* they will manage/control, and then proceed to Part C. These decisions are illustrated in Figure 3.3.

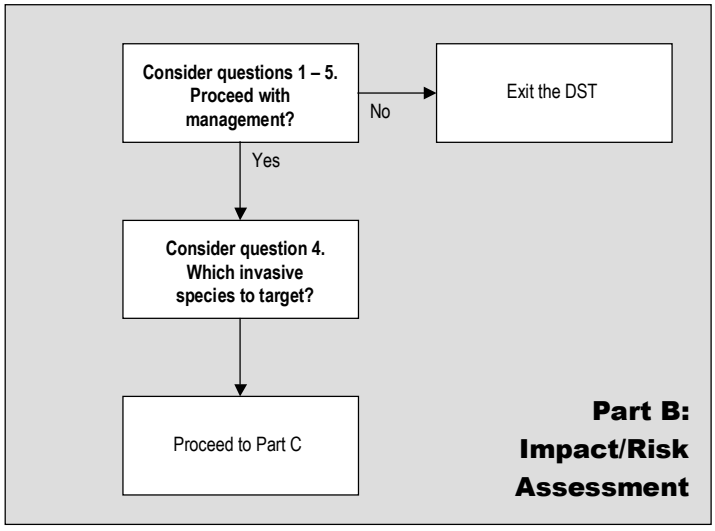

Figure 3.3. Decision tree for Part B of the DST Framework.

Part C: Management Actions

Part B provides a framework for helping users decide whether to manage for invasive species, and if so, which species. Part C provides an adaptive management framework for helping users decide *how* to actually undertake the management/control efforts.

It is critical that the user understand the importance of keeping good records (e.g. documenting management goals, decisions, rationale for these decisions, management actions, participants, process, etc.) as they move through the steps in the adaptive management framework. This relates back to the first Guiding Principle: stewardship requires a long-term commitment, and it may take years to achieve management/restoration goals. There is almost certain to be turnover in management leadership and participants at any given site, and successful long-term management of invasive species — and successful learning — will require continuity as people come and go. Clear and thorough documentation can help provide this continuity.

As guidance when moving through the adaptive management steps, users should be provided, or directed to, the following information sources:

- There are an assortment of primers on adaptive management that could be provided, in whole or in part, in an appendix of the DST:
- An Introductory Guide to Adaptive Management for Project Leaders and Participants[60] (Nyberg 1999)
- Adaptive Management of Forests in British Columbia[61] (Taylor et al. 1997)
- Applying Adaptive Management in British Columbia's Forests[62] (Nyberg and Taylor 1995)
- Statistical Methods for Adaptive Management Studies[63] (Sit and Taylor 1998)
- Adaptive Management and Ecological Restoration (Murray and Marmorek *in press*)
- Information on experimental design options, such as simple before-after, control-impact (BACI) surveys (Schwarz 1998) described in Statistical Methods for Adaptive Management Studies[64] (Sit and Taylor 1998) could be provided in summary form to help users understand the range of options regarding designing management and monitoring plans.
- Available information on control methods should be included in the DST. Examples include:
  - GOERT invasive species fact sheets currently under development,
  - Fact sheet information from the Invasive Plants of Canada website[65], and
  - The Nature Conservancy's Weed Control Methods Handbook[66] (Tu *et al.* 2001), and
  - Information on best practices for control of Scotch broom (*Cytisus scoparius*), compiled during a recent workshop (see Appendix 3).
  - Chapter 1, Sections 1.2 and 1.3 of this report describes some invasive species decision support tools and methodologies currently in use in British Columbia and elsewhere, and contain information that might be helpful to the user (depending on the species they are targeting). For example, Table 1.3 might help users decide when during the year to undertake control techniques for certain species, and Table 1.5 might help users decide what control techniques to use for Scotch broom (*Cytisus scoparius*).
- Chapter 1, Section 1.4 of this report describes the roles and responsibilities of various levels and agencies of government, and can help the user identify where they might be able to go for further assistance and information for the species they are trying to manage.
- Information on invasive species autecology, such as that provided in Appendix 2 of the draft report entitled "The Role of Invasive Species Management in Terrestrial Ecosystem Restoration" (Polster Environmental Services 2002), prepared for the BC Ministry of Water, Land and Air Protection.

[60] http://www.for.gov.bc.ca/hfp/amhome/Pubs/Introductory-Guide-AM.pdf
[61] http://www.for.gov.bc.ca/hfd/pubs/docs/Sil/sil426-1.pdf
[62] http://www.for.gov.bc.ca/hfp/amhome/apply/applyam.htm
[63] http://www.for.gov.bc.ca/hfd/pubs/docs/lmh/Lmh42.pdf
[64] http://www.for.gov.bc.ca/hfd/pubs/docs/lmh/Lmh42.pdf
[65] http://infoweb.magi.com/~ehaber/ipcan.html
[66] http://tncweeds.ucdavis.edu/handbook.html

7. Assess

The first step in the adaptive management framework involves scoping the problem. Before embarking on management actions, there is some planning and assessment that should occur first.

- ❑ Clearly state your management objectives. What is it you intend to achieve through your invasive species control efforts?
- ❑ Ensure you understand the interests and perspectives of the stakeholders (e.g. the site owner, adjacent land owners, local residents, site users).
- ❑ Identify the potential range of management techniques that could be undertaken at the site.
- ❑ Identify the potential range of success and failure indicators that could be measured at the site.
- ❑ Document whether there are different hypotheses regarding the outcomes and success different management techniques.
- ❑ Stratify the site for management priority. In other words, which areas are highest priority for control actions, and which are lowest priority? Where on the site will you focus management efforts? For example, if controlling for Scotch broom (*Cytisus scoparius*), you may wish to focus on low- and medium-infested sites, where you have a greater chance of controlling it before the seed bank accumulates. You may also chose to start on the edges of an infested site and work your way towards the middle.
- ❑ Clearly document any uncertainties regarding which techniques to select, how to apply them, and/or expected results.

8. Design

The next step in the adaptive management framework involves designing a plan of action that the user thinks will best achieve their management goals. If the user has identified significant uncertainty under step 7, this plan of action could involve experimental trials to test different approaches.

The product from this step should be a detailed plan of action, including prescriptions for:

- ❑ The management/control techniques to be used, documenting exactly what to do, where, when, and how;
- ❑ How to dispose of the biomass after invasive species removal;
- ❑ Follow-up activities (e.g. planting seed plugs of native vegetation; repeating control actions again at a later date);
- ❑ Monitoring for compliance (what to measure, how, when, and how often), to see if the management/control prescriptions were followed properly; and
- ❑ Monitoring for success (what to measure, how, when, and how often), to learn if the methods worked.

Users should also clearly document predictions, based on best available knowledge, regarding the expected outcomes. In other words, how do you expect the site to respond to your management/control techniques? Also document the assumptions underlying these predictions. (Comparing these predictions with the actual outcomes is how learning occurs!)

Users should consider the following factors in designing their action plan:

- ❏ Best practices, and available control techniques, based on the current state of knowledge.
- ❏ The size of the area to address. Is the area zoned "high priority" small or large? Are you operating at a landscape scale? Some techniques are better suited to small areas, and others are better suited for landscape-scale applications.
- ❏ The budget available for equipment and supplies. What funds do you have, and what is the duration or time period of the funding? The techniques selected must match the available budget and time frame.
- ❏ The size and skill level of your labour force. How many people will be participating? How experienced are they in the potential control techniques? (For example, do they know how to use a weed wrench? Would you trust them to operate a tagger torch?) How well do they know the biology/ecology of GOEs? Will they recognise camas (*Camassia quamash* and *C. leichtlinii*), or trample them? The techniques selected must match the knowledge and skill level of those who will be participating.
- ❏ Local regulations (e.g. regarding herbicide) and regulatory restrictions (national, provincial, regional, municipal, land covenants).
- ❏ The life history of the target species. For example, if you are controlling for Scotch broom (*Cytisus scoparius*), what is the best timing regarding seed dispersal and regeneration? Is it critical for success to control the species within the first 3 years of invasion?
- ❏ The time of year. Try to optimise the timing for target species biology and effectiveness of the method to be used. For example, if pulling a plant species out by hand, do it at a time when the ground is soft. Be sure to also consider other species — are other species of concern vulnerable at that time of year? Consider when the invasive species' seeds set, when valued species germinate, and when energy reserves in the target plant are lowest.
- ❏ What are the potential impacts of various techniques on other invasive species? For example, if you use fire, will it create conditions favourable to other invasive species?
- ❏ What are the potential social and economic impacts of various techniques? Is there likely to be a large public outcry against the use of herbicides or smoke from a burn? What are the risks of fire spread?
- ❏ Consider multiple strategies on one site (combining techniques).
- ❏ When deciding on what to do with the removed biomass, consider: access, terrain, loss to the ecosystem of taking it off site, impacts to the ecosystem of leaving it on-site, and potential for spreading the species if it is transported off site.

9. Implement

In this step, the action plan is implemented exactly as described in step 8. Users should be instructed to follow their plan, but should also be prepared to be flexible. The key is to document any necessary deviations instead of making ad hoc changes "on the fly". Rationale for changes should also be recorded. (If this is not done, it will confound attempts to evaluate results, assess success, and build on current knowledge.)

10. Monitor

In this step, the monitoring activities are implemented exactly as described in step 8. Two kinds of monitoring should take place:

- ❏ Compliance monitoring: collect data/information to determine whether the implementation (step 9) occurred as planned.
- ❏ Effectiveness monitoring: collect data/information to determine whether the management actions were successful.

Monitoring does not have to be an expensive, overly technical process; qualitative measurements can be effective if they are done consistently and according to a well-defined plan.

11. Evaluate

The DST should prompt the user to evaluate the monitoring results as follows:

- ❏ What has been learned? Compare the predicted results (from step 8) with the results of the effectiveness monitoring (from step 10), to learn whether the predictions and their underlying assumptions were accurate. Qualify conclusions with any documented changes from step 9, and the results of the compliance monitoring, as necessary.
- ❏ Were the management objectives achieved? Compare the results of the effectiveness monitoring (from step 10) with the management objectives (from step 7) to determine whether your management action plan is achieving the desired results. Qualify conclusions with any documented changes from step 9, and the results of the compliance monitoring, as necessary.
- ❏ Is there still key uncertainty regarding how to achieve your management objectives at the site? Is there still more to be learned?

12. Adjust

This is one of the key elements of adaptive management: changing what you do next time as a result of what you learned from past experience. In this step, what has been learned is formally recognised and used to improve policy and practices, and to update domain knowledge. Users should be prompted to consider the following actions:

- ❏ Adjust management plans/prescriptions for the site based on what's been learned, to improve effectiveness of future control and follow-up efforts (i.e. applying what has been learned) and, if necessary, to further reduce remaining uncertainty (i.e. continuing to learn). This means re-doing steps 8–12, and including the new information obtained from the last time.
- ❏ Share the knowledge! Communicate the results elsewhere, so others interested in managing invasive species in GOEs can benefit from what you have learned.
- ❏ Request adjustments to best practices materials and fact sheets, if warranted based on what's been learned.
- ❏ Request adjustments to the DST, if warranted based on what's been learned.

3.4 DST Format

The DST should be user-friendly and simple to understand, minimising the use of technical language and jargon. We believe that given the budgets and resources that are likely to be available to the intended audience, a paper-based tool will provide the most accessible, field-friendly format. We recommend a modular approach, collected into a "field guide" binder that allows for individual components to be updated over time. For example, providing fact sheets or best practices in an appendix allows for these materials to be replaced as knowledge improves, without requiring the whole DST to be reproduced.

We understand there is a desire to provide the tool over the web. This is an excellent idea for the future, but we recommend that the tool be completed first on paper. Moving towards web-based delivery of the tool before it is fully developed may result in too great a focus on delivery technology, at the expense of the development of content. We recommend migration to web-based delivery after the tool is completed, and has been tested in the field.

This does not preclude *posting* the information on the web! The framework diagram, questions and checklist of considerations can easily be posted on the GOERT website to allow anyone with Internet service easy access to the information. Hyperlinks to much of the source information listed earlier in this report are already provided in the electronic version of the report, and it would be easy to include these links — and create new ones — on a website.

4.0 Top Ten GOE-Threatening Exotic Plant Species

It would be helpful in prioritising efforts to manage invasive plant species in GOEs to know: which are the "top 10" exotic plant species that currently threaten GOEs? This chapter describes the methodology used to try to answer this question, and the results.

4.1 Methodology

A review of available tools indicated that the Alien Plants Ranking System (APRS) Version 5.1[67] (APRS Implementation Team 2000, Hiebert and Stubbendieck 1993[68]) seemed to provide the most thorough criteria for ranking exotic plant species. It lists criteria for determining the current level of impact of the species, its innate ability to become a pest, and the feasibility and the urgency of control or management. These criteria were modified for applicability to GOEs in BC, and converted to a 1-5 rating scheme to facilitate ease-of-use in a paper format, with the intention that the ratings would be weighted to match those in the APRS. The resulting draft is shown in Table 4.1.

It was subsequently concluded that some of these questions would be difficult to answer (e.g. it may not be appropriate to provide one answer in question #5 for all species at risk; rating competitive ability in question #14 depends on which plants the exotic species are competing against) and that there is probably not sufficient expertise in BC to fill this template.[69] The decision was made to use a much simpler ranking scheme instead, with only three criteria:

1. Significance of impact,
2. Difficulty of control or management, and
3. Urgency of control or management.

These criteria were combined with a candidate list of exotic species into a simplified ranking template (shown in Table 4.2) and circulated to more than 20 experts in British Columbia. The experts were asked to rank the listed species according to all three criteria, and were asked to add to the candidate list if they thought important exotic species were missing from the list.

[67] http://www.npwrc.usgs.gov/resource/2000/aprs/aprs.htm
[68] http://www.nature.nps.gov/pubs/ranking/ranking.htm
[69] Hans Roemer, pers. comm., January 18, 2002.

Table 4.1. Draft detailed "top 10" rating scheme template.

Species: _____

For each question, please circle the number along the gradient from 1 to 5 that is most applicable. (1 = "best", 5 = "worst").

I Significance of Impact

A. Current Level of Impact

1. In GOEs in BC where it is present, on average what is its distribution relative to the disturbance regime (other than fire)?				
1 (species is found only in sites that are recently or frequently disturbed)	2	3	4	5 (species is found in mature, undisturbed natural communities)
2. What is the areal extent, on average, in GOEs where it is present?				
1 (not found in site, but found on adjacent areas)	2 (found in less than 5% of site)	3 (found in 5-10% of site)	4 (found in 10-25% of site)	5 (found in over 25% of site)
3. What is the numerical dominance of the species, on average, in GOEs where it is present?				
1 (usually observed as single individual)	2	3	4	5 sually observed in numbers greater than the most common native species in the community)
4. On average, in GOEs where it is present, what is the effect on natural ecological processes and the structure of native communities?				
1 (little or no effect)	2 (delays establishment of native species)	3 (causes long term modification or retardation of succession)	4 (invades and modifies native communities)	5 (invades and replaces native communities)
5. On average, in GOEs where it is present, what threat does it pose to species at risk?				
1 (negligible threat)	2	3 (possible moderate threat)	4	5 (significant threat)
6. On average, in GOEs where it is present, what is the overall degree of threat or impact to these ecosystems?				
1 (not yet invading GOEs, and little or no increase in individuals or populations)	2 (present in GOEs, but static or decreasing)	3 (present near but not in GOEs, and only moderate rate of increase)	4 (present in GOEs, and moderate rate of increase)	5 (present in GOEs, and high rate of increase)

B. Innate Ability of Species to Become a Pest

7. How does it reproduce?				
1 (almost entirely by vegetative means)	2	3 (only by seeds)	4	5 (vegetatively and by seed)
8. What is the role of vegetative reproduction?				
1 (vegetative reproduction rate maintains population)	2	3 (vegetative reproduction rate results in moderate increase in population size)	4	5 (vegetative reproduction rate results in rapid increase in population size)
9. What is the frequency of sexual reproduction for a mature plant?				
1 (almost never reproduces sexually)	2 (once every few years)	3 (every other year)	4 (every year)	5 (more than once per year)
10. What is the number of seeds per plant?				
1 (few; <10)	2	3 (moderate; ~500)	4	5 (many; >1,000)
11. What is its dispersal ability?				
1 (little potential for long distance dispersal)	2	3	4	5 (great potential for long distance dispersal)
12. What are its germination requirements?				
1 (requires open soil and disturbance to germinate)	2	3 (can germinate in vegetated areas but in a narrow range or in special conditions)	4	5 (can germinate in existing vegetation in a wide range of conditions)
13. What is the longevity of the seed bank?				
1 (seeds remain viable in the soil for <1 year)	2	3	4	5 (seeds viable in the soil for >5 years)
14. What is its competitive ability?				
1 (poor competitor for limiting factors)	2	3 (moderately competitive for limiting factors)	4	5 (highly competitive for limiting factors)
15. What is its known level of impact in natural areas?				
1 (not known to cause impacts in any other natural area)	2	3 (known to cause low or moderate impact in natural areas in similar habitats and climate zones)	4	5 (known to cause high impact in natural areas in similar habitats and climate zones)

II Difficulty of Control or Management

16. What is the likelihood of successful control of this species?

1	2	3	4	5
(species has been eradicated in a natural area)		(have had limited success with control of this species)		(control of this species has never been achieved in a natural area)

17. On average, what is the saturation of this species in areas surrounding GOEs in BC?

1	2	3	4	5
(not present in surrounding areas)		(sprouts from roots or stumps)		(present in most surrounding areas)

18. What is the effectiveness of community management in controlling this species?

1	2	3	4	5
(protection from disturbance effectively controls species)	(cultural techniques – flooding, burning – can be used to control species		(restoration or preservation practices effectively control species	(none of the options to the left are effective)

19. What is the extent of vegetative regeneration?

1	2	3	4	5
(no resprouting following removal of aboveground growth)		(sprouts from roots or stumps)		(any plant is part of a viable propagule)

20. What is the effectiveness of biological control of this species?

1	2	3	4	5
(biological control feasible)		(potential may exist for biological control)		(biological control not feasible - not practical possible, or probable)

21. What are the side effects of chemical/mechanical control measures for this species to GOE communities?

1	2	3	4	5
(will have little or no impact on community)		(will cause moderate impacts to community)		(will cause major impacts to community)

III Urgency of Control or Management

22. What is the urgency for controlling/managing this species?

1	2	3	4	5
(delay in action will result in little increase in effort required for successful control)		(delay in action will result in moderate increase in effort required for successful control)		(delay in action will result in large increase in effort required for successful control)

Table 4.2. Simplified "top 10" ranking criteria template.

Ranking the Top 10 Exotic Plant Species Currently Threatening GOEs

Your Name: _____

Contact phone #/email: _____

For each species listed, put a number from 1 to 15 in each column identifying how it ranks among the other 14 species regarding each of the criteria. For example:

- In the **Significance of Impact** column put a "1" beside the species that you think is currently causing the most significant impact in Garry oak and associated ecosystems in BC, a "2" beside the species that you think is causing the second most significant impact, etc. Please rank all 15 species.
- In the **Difficulty of Control or Management** column put a "1" beside the species that is most difficult to control/manage, a "2" beside the second most difficult to control/manage, etc. Please rank all 15 species.
- In the **Urgency** column put a "1" beside the species you think we most urgently need to control or manage, a "2" beside the second most urgent species for control or management, etc. Please rank all 15 species. For the species you rank 1, 2 and 3, please also provide your *rationale* in the **Comments** column.

Exotic Plant Species of Concern	Significance of Impact	Difficulty of Control or Management	Urgency of Control or Management	Comments
Scotch broom (*Cytisus scoparius*)				
Laurel-leaved daphne (*Daphne laureola*)				
Common hawthorn (*Crataegus monogyna*)				
Sweet vernalgrass (*Anthoxanthum odoratum*)				
English ivy (*Hedera helix*)				
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)				
Gorse (*Ulex europeus*)				
Non-native thistles (*Cirsium spp.*)				
Velvet-grass (*Holcus lanatus*)				
Hedgehog dogtail grass (*Cynosurus echinatus*)				
Orchard grass (*Dactylis glomerata*)				
Holly (*Ilex aquifolium/europea*)				
Rose campion (*Lychnis coronaria*)				
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)				
Oyster plant (*Tragopogon porrifolius*)				

Please fax by **Feb 15, 2002** to Carol Murray, ESSA Technologies Ltd., Victoria, at (250) 383-1174 (Phone: 383-1190, email: cmurray@essa.com)

Thank you!

4.2 Results

Even with the simplified template, only six experts returned a completed template. This is likely due to the fact that this request was competing with many other tasks and priorities for respondent's time.

Several respondents added candidate plant species to the list, so the species were separated into two groups:

- Species that were considered by all respondents, because they were on the original template (though some respondents left blanks or entered question marks for some of the criteria for species):

  Scotch broom (*Cytisus scoparius*),
  Laurel-leaved daphne (*Daphne laureola*),
  Common hawthorn (*Crataegus monogyna*),
  Sweet vernalgrass (*Anthoxanthum odoratum*),
  English ivy (*Hedera helix*),
  Himalayan blackberry (*Rubus proseris/discolora/armeniacs*),
  Gorse (*Ulex europeus*),
  Non-native thistles (*Cirsium spp.*),
  Velvet-grass (*Holcus lanatus*),
  Hedgehog dogtail grass (*Cynosurus echinatus*),
  Orchard grass (*Dactylis glomerata*),
  Holly (*Ilex aquifolium/europea*),
  Rose campion (*Lychnis coronaria*),
  Morning-glory/bindweed (*Convolvulus arvensis/sepium*), and
  Oyster plant (*Tragopogon porrifolius*).

- Species were added only by one or two respondents, and therefore were not considered or rated by the others:

  Poison hemlock (*Conium maculatum*),
  Common vetch (*Vicia sativa*),
  Snowberry (*Symphoricarpus albus*),
  Hairy cat's ear (*Hypochaeris radicata*),
  Ribwort plantain (*Plantago lanceolata)*,
  Sheep sorrel (*Rumex acetosella*),
  Kentucky bluegrass (*Poa pratensis*),
  Colonial bentgrass (*Agrostis capillaris*),
  Red fescue (*Festuca rubra*),
  Quackgrass (*Elymus repens*),
  Perennial ryegrass (*Lolium perenne*),
  Soft brome (*Bromus hordeaceus*),
  Ripgut brome (*Bromus rigidus*),
  Cheatgrass (*Bromus tectorum*), and
  Barren brome (*Bromus sterilis*).

To analyse the responses the average rankings were calculated for each species in the first group, for each criteria, by summing the total ranks across respondents, and then dividing by the number of respondents. Average rankings of only those species considered by all respondents were assessed to determine the top 10 ranking. Otherwise, average rankings would not be comparable among species. The results are shown

at the end of this chapter. Table 4.4 shows the top 10 ranked species, among those considered by all respondents, according to their *significance of impact*. Table 4.5 shows the top 10 ranked species, among those considered by all respondents, for *difficulty* of control or management. Table 4.6 shows the top 10 ranked species, among those considered by all respondents, for *urgency* of control or management. The source data, for all species from all respondents, are provided in Table 4.7. The completed templates from each expert, with their names replaced by letter codes, are provided in Appendix 4. The letter codes in this appendix correspond to the letter codes in Table 4.7.

Orchard grass (*Dactylis glomerata*) appears to be of greatest concern, as its average ranking was the highest according to each of the three criteria. The average rankings for both Scotch broom (*Cytisus scoparius*) and Gorse (*Ulex europeus*) fell within the top 4 species for each of the three criteria, and the average rank for English ivy (*Hedera helix*) was within the top 6 species for each of the three criteria.

Table 4.3 shows the "top 10" exotic plant species currently threatening GOEs in BC, determined by considering the average rankings across all three criteria for all the species in the first group. As expected from the results of the rankings for the individual criteria, Orchard grass, Scotch broom, Gorse and English ivy are indeed the "top 4"overall. These are the species that should be considered highest priority for invasive plant species management programs in Garry oak and associated ecosystems in British Columbia.

A few respondents also felt that some of the species listed in the second group are of major concern. Hairy cat's ear (*Hypochaeris radicata*) was rated[70] "1" by one respondent for significance of impact, and Common vetch (*Vicia sativa*), Sheep sorrel (*Rumex acetosella*), Kentucky bluegrass (*Poa pratensis*) and Quackgrass (*Elymus repens*) were also rated or ranked "1" for difficulty of control or management. Snowberry (*Symphoricarpus albus*) was not ranked, but was listed by one respondent as being the worst invader of oak woodlands because it is so widespread and shades out native herbaceous species. However, none of the species listed in the second group were rated or ranked "1" for urgency of control or management, supporting the conclusion that the species of greatest concern are those listed at the top of Table 4.3.

Table 4.3. Top 10 species according to average rankings across all three criteria.

Average Ranking Across all 3 Criteria	Species
1.7	Orchard grass (*Dactylis glomerata*)
2.8	Scotch broom (*Cytisus scoparius*)
3.9	Gorse (*Ulex europeus*)
4.4	English ivy (*Hedera helix*)
4.4	Velvet-grass (*Holcus lanatus*)
5.6	Laurel-leaved daphne (*Daphne laureola*)
6.0	Common hawthorn (*Crataegus monogyna*)
6.5	Sweet vernalgrass (*Anthoxanthum odoratum*)
6.7	Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)
7.3	Hedgehog dogtail grass (*Cynosurus echinatus*)

[70] One respondent gave each species a rating of 1, 2 or 3, rather than allocating each species a unique ranking.

Table 4.4. Top 10 species according to average rankings for Significance of Impact.

Average Ranking for Significance of Impact	Species
1.6	Orchard grass (*Dactylis glomerata*)
1.8	Scotch broom (*Cytisus scoparius*)
4.5	English ivy (*Hedera helix*)
4.8	Gorse (*Ulex europeus*)
5.0	Velvet-grass (*Holcus lanatus*)
5.2	Common hawthorn (*Crataegus monogyna*)
5.5	Laurel-leaved daphne (*Daphne laureola*)
5.8	Sweet vernalgrass (*Anthoxanthum odoratum*)
6.6	Hedgehog dogtail grass (*Cynosurus echinatus*)
6.7	Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)

Table 4.5. Top 10 species according to average rankings for Difficulty of Control or Management.

Average Ranking for Difficulty of Control/Management	Species
1.2	Orchard grass (*Dactylis glomerata*)
3.4	Velvet-grass (*Holcus lanatus*)
3.8	Scotch broom (*Cytisus scoparius*)
4.0	Gorse (*Ulex europeus*)
4.3	English ivy (*Hedera helix*)
5.0	Sweet vernalgrass (*Anthoxanthum odoratum*)
6.5	Hedgehog dogtail grass (*Cynosurus echinatus*)
6.8	Laurel-leaved daphne (*Daphne laureola*)
7.2	Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)
8.2	Non-native thistles (*Cirsium spp.*)

Table 4.6. Top 10 species according to average rankings for Urgency of Control or Management.

Average Ranking for Urgency of Control/Management	Species
2.4	Orchard grass (*Dactylis glomerata*)
2.6	Gorse (*Ulex europeus*)
2.8	Scotch broom (*Cytisus scoparius*)
4.2	Laurel-leaved daphne (*Daphne laureola*)
4.2	Common hawthorn (*Crataegus monogyna*)
4.2	English ivy (*Hedera helix*)
4.8	Velvet-grass (*Holcus lanatus*)
6.2	Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)
7.8	Non-native thistles (*Cirsium spp.*)
8.4	Sweet vernalgrass (*Anthoxanthum odoratum*)

Table 4.7. Comparative rankings of candidate plant species from each expert for all three criteria.

Exotic Plant Species of Concern	Significance of Impact							Difficulty of Control or Management							Urgency of Control or Management							ave. across
expert (by anonymous code):	A	B	C	D	E	F	average	A	B	C	D	E	F	average	A	B	C	D	E	F	average	all 3 criteria
Plants considered by all 6 experts:																						
Scotch broom (*Cytisus scoparius*)	4	1	1	1.5	1	2	**1.8**	5	3	2	4	1	8	**3.8**	7	1	1	2	1	5	**2.8**	**2.8**
Laurel-leaved daphne (*Daphne laureola*)	8	7	1	6	6	5	**5.5**	11	5	1	8	7	9	**6.8**	3	8	1	6		3	**4.2**	**5.6**
Common hawthorn (*Crataegus monogyna*)	6	4	2	4	7	8	**5.2**	8	14	2	10	6	10	**8.3**	2	7	1	4		7	**4.2**	**6.0**
Sweet vernalgrass (*Anthoxanthum odoratum*)	1	13	2	3		10	**5.8**	2	10		2		6	**5.0**	8	13	2	7		12	**8.4**	**6.5**
English ivy (*Hedera helix*)	9	5	3	5	2	3	**4.5**	6	6	2	5	3	4	**4.3**	4	4	2	5		6	**4.2**	**4.4**
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	10	6	2	7	4	11	**6.7**	7	9	1	9	5	12	**7.2**	10	3	2	8		8	**6.2**	**6.7**
Gorse (*Ulex europeus*)	11	3	3	1.5	3	7	**4.8**	9	2	1	3	4	5	**4.0**	1	5	2	1		4	**2.6**	**3.9**
Non-native thistles (*Cirsium spp.*)	7	12	3		10	12	**8.8**	10	11	1		8	11	**8.2**	11	7	3			10	**7.8**	**8.3**
Velvet-grass (*Holcus lanatus*)	3	11	2	3		6	**5.0**	3	7	2	2		3	**3.4**	6	6	3	7		2	**4.8**	**4.4**
Hedgehog dogtail grass (*Cynosurus echinatus*)	5	14	2	3		9	**6.6**	4	13		2		7	**6.5**	9	14	2	7		11	**8.6**	**7.3**
Orchard grass (*Dactylis glomerata*)	2	2	1	2		1	**1.6**	1	1	1	1		2	**1.2**	5	2	1	3		1	**2.4**	**1.7**
Holly (*Ilex aquifolium/europea*)	13	10	3	15	5		**9.2**	13	12	2	15	2	13	**9.5**	12	10	2	15		13	**10.4**	**9.7**
Rose campion (*Lychnis coronaria*)	12	15	3		9		**9.8**	12	15	2		10	16	**11.0**	15	15	3			16	**12.3**	**11.0**
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	14	8	3		8		**8.3**	14	4	1		9	14	**8.4**	14	8	3			14	**9.8**	**8.8**
Oyster plant (*Tragopogon porrifolius*)	15	9	3				**9.0**	15	8				15	**12.7**	13	9	3			15	**10.0**	**10.5**
Plants considered only by one or two experts:																						
Poison hemlock (*Conium maculatum*)					11		11.0					11		11.0								
Common vetch (*Vicia sativa*)			2			4	3.0						1	1.0			2			9	5.5	
Snowberry (*Symphoricarpus albus*)																						
Hairy cat's ear (*Hypochaeris radicata*)			1				1.0			2				2.0			2				2.0	
Ribwort plantain (*Plantago lanceolata*)			2				2.0			2				2.0			2				2.0	
Sheep sorrel (*Rumex acetosella*)			2				2.0			1				1.0			2				2.0	
Kentucky bluegrass (*Poa pratensis*)			2				2.0			1				1.0			3				3.0	
Colonial bentgrass (*Agrostis capillaris*)			3				3.0			2				2.0			3				3.0	
Red fescue (*Festuca rubra*)			3				3.0			2				2.0			3				3.0	
Quackgrass (*Elymus repens*)			3				3.0			1				1.0			3				3.0	
Perennial ryegrass (*Lolium perenne*)			3				3.0			2				2.0			3				3.0	
Soft brome (*Bromus hordeaceus*)			2				2.0										3				3.0	
Ripgut brome (*Bromus rigidus*)			2				2.0										2				2.0	
Cheatgrass (*Bromus tectorum*)			2				2.0										2				2.0	
Barren brome (*Bromus sterilis*)			2				2.0										2				2.0	

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Appendix 1: Contact List from Chapter 1

This Appendix lists over 80 individuals that we contacted, sorted alphabetically by organisation.

Agriculture and Agri-Food Canada, Horticulture and Environment - Gene Hogue

Agriculture and Agri-Food Canada, Kamloops Range Research Station - Barb Brooke

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre - Lynne Boyd

Australia Animal and Plant Control Commission – Dr. John Virtue

BC Hydro, Vegetation Management - Gwen Shrimpton

BC Hydro, Vegetation Management - Tom Wells

BC Ministry of Agriculture, Food and Fisheries - Mary Margaret Gaye

BC Ministry of Agriculture, Food and Fisheries, Crop Protection Program - Roy Cranston

BC Ministry of Forests - Robb Bennett

BC Ministry of Forests - Peter Hall

BC Ministry of Forests, Range Section - Susan Turner

BC Ministry of Sustainable Resource Management, Conservation Data Centre - Matt Fairbarns

BC Ministry of Sustainable Resource Management, Conservation Data Centre - Andrew Harcombe

BC Ministry of Sustainable Resource Management, Conservation Data Centre - Beth Rogers

BC Ministry of Water, Land and Air Protection, Fish and Wildlife Science and Allocation Section - Karen Morrison

BC Ministry of Water, Land and Air Protection, Habitat Branch, Terrestrial Ecosystem Restoration Program - Jenny Feick

BC Ministry of Water, Land and Air Protection, Habitat Branch, Terrestrial Ecosystem Restoration Program - Jenny Fraser

BC Ministry of Water, Land and Air Protection, Habitat Branch, Terrestrial Ecosystem Restoration Program - Colene Wood

BC Ministry of Water, Land and Air Protection, Intergrated Pest Management and Strategic Development - Dan Cronin

BC Ministry of Water, Land and Air Protection, Intergrated Pest Management and Strategic Development - Dr. Linda Gilkeson

BC Ministry of Water, Land and Air Protection, Pest Control Branch - David Grace

BC Ministry of Water, Land and Air Protection, Research and Conservation Section - Dave Fraser

BC Ministry of Water, Land and Air Protection, Research and Conservation Section - Laura Friis

BC Ministry of Water, Land and Air Protection, Stock Management Unit - Juanita Ptolemy

BC Ministry of Water, Land and Air Protection, Water Quality Section, Water Protection Branch - Les Swain

BC Parks - Chris Kissinger

BC Parks - Karen MacDowell

BC Parks - Bryan Webster

CAB International, Programme Development - Lucinda Charles

California Department of Food and Agriculture - Steve Schoenig

Canadian Food Inspection Agency - Leslie Cree

Canadian Food Inspection Agency (CFIA), Plant Health - Shane Sela

Canadian Food Inspection Agency, Plant Health and Production Division - Dr. Yudi Singh

Canadian Food Inspection Agency, Policy, Planning and Coordination Directorate - Doreen Watler

Canadian Forest Service, Pacific Forestry Centre - Dr. Lee Humble

Canadian Forest Service, Pacific Forestry Centre - Dr. Vince Nealis

Canadian Forest Service, Pacific Forestry Centre - Dr. Raj Prasad

Canadian Forest Service, Pacific Forestry Centre - Dr. Alan J. Thomson

Canadian Forest Service, Pacific Forestry Centre - Dr. Eric Allen

Canadian Wildlife Service, Habitat Conservation - Dr. Pam Krannitz

Capital Regional District Parks - Louise Blight

City of Victoria - Joe Daly

City of Victoria - Michelle Gorman

Cowichan Valley Regional District - Catherine (Katie) Johnnie

Capital Regional District - Joel Ussery

Cumbria Wildlife Trust - Corrie Bruemmer

Department of Fisheries and Oceans, Pacific Biological Station - Dr. Glen Jamieson

Eastern Ontario Biodiversity Museum - Fred Schueler

Environment Canada, Indicators and Assessment Office - Dr. Risa Smith

ESSA Technologies Ltd. - Sarah Beukema

Fisheries and Oceans Canada, Pacific Region - Pat Lim

Friends of Ecological Reserves - Nature Conservancy - Lynne Milnes

Garry Oak Ecosystems Recovery Team - Marilyn Fuchs

Garry Oak Meadow Preservation Society - Hal Gibbard

Garry Oak Woodland Management Committee, Friends of Government House Gardens Society - Fran Spencer

Grasslands Conservation Council of BC - Bruno Delasalle

Greater Vancouver Regional District, Regional Parks - John MacFarlane

Manitoba Conservation, Wildlife Branch - Jason Greenall

Nature Conservancy of Canada - Tim Ennis

NatureServe - Patrick Crist

Newcastle University, Centre for Land Use and Water Resources - Dr. Peter Lurz

Polster Environmental Services - Dave Polster

School of Environmental Studies, University of Victoria - Dr. Don Eastman

Simon Fraser University, Biological Sciences, Plant Evolutionary Ecology - Dr. Elizabeth Elle

Simon Fraser University, Integrated Pest Management Program - Dr. Alton Harestad

Simon Fraser University, Resource and Environmental Management - Dr. Kenneth Lertzman

Swan Lake Christmas Hill Nature Sanctuary - Willie MacGillivray

The Corporation of the District of Saanich, Parks - Ron Carter

The Land Conservancy of BC - Paula Hesje

The Nature Conservancy - Patrick Dunn

The Nature Conservancy - Dr. Peter W. Dunwiddie

UK Department for Environment Food and Rural Affairs, Central Science Laboratory, Plant Health Group - Richard Baker

UNEP/GEF Biodiversity Enabling Activities - David Duthie

University College of the Cariboo - Karl Larsen

University of British Columbia - Purnima Govindarajulu

University of British Columbia - Dr. Roy Turkington

University of British Columbia, Agricultural Sciences/Zoology - Dr. Judy Myers

University of British Columbia, Agroecology - Dr. Michael Pitt

University of British Columbia, Department of Botany - Andrew MacDougall

University of Guelph, M.Sc. on Eastern Grey Squirrel - Emily Gonzales

University of Maryland, Center for Environmental Science - Dr. Lisa Wainger

University of Montana, Division of Biological Sciences - Peter Rice

Appendix 2: Template for a Landscape Pest Management Plan (BC MWLAP)

The template below can be found by following the link on this BC Ministry of Water, Land and Air Protection, Vancouver Island Region web page: http://wlapwww.gov.bc.ca/vir/pp/ipmweb/pmp/pmp.htm. The guide can be found through a link on the same web page.

BRITISH COLUMBIA

Ministry of Water, Land and Air Protection

Vancouver Island Region

Mailing Address:
2080A Labieux Road
Nanaimo BC V9T 6J9

Telephone: 250 751-3100
Facsimile: 250 751-3103

LANDSCAPE

PEST MANAGEMENT PLANS

Licencee: _____ Licence #: _____
(Agency or company name)

Date: _____

Pest Category: (Check one - use a separate form for each category)

1. ☐ General vegetation; Non-selective control (includes parking lots, sidewalk crevices, etc.)
2. ☐ General vegetation; Selective control (includes weeds in flowerbeds etc.)
3. ☐ Turf; Weeds (turf categories include lawns, playing fields etc.)
4. ☐ Turf; Insects
5. ☐ Turf; Diseases
6. ☐ Greenhouse/nursery; Insects (includes mites)
7. ☐ Ornamentals/trees; Insects (includes mites)
8. ☐ Ornamentals/trees; Diseases (includes greenhouses and nurseries)
9. ☐ Other; specify type

_____

_____

Pest Names(s)/Host (if appropriate): _____

_____

Facility/Site Categories Managed (assign all major facilities/sites you manage to a category):

Class A: _____

_____

Class B: _____

_____

Class C: _____

_____

1. PEST IDENTIFICATION

Methods (describe methods you will use to identify pests): _____

_____

_____

_____

_____

_____

2. MONITORING

Methods (describe methods you will use to monitor pest populations)

Visual inspections: _____

_____

Quantitative samples: _____

_____

Other: _____

_____

Frequency (describe frequency of inspections, collection of samples etc.)

_____

_____

_____

Comments (optional): _____

_____

_____

3. IMPACT ASSESSMENT/ACTION LEVEL

Describe qualitative or quantitative treatment thresholds that will be used for each facility/site category (Class A, B and/or C, as appropriate):

Life stage or approximate time of year (if known) when pest(s) most susceptible to planned treatments:

4. TREATMENTS

Describe the preventive/cultural measures you are using or will use to minimize the impact of the pest for each facility/site category (Class A, B and/or C, as appropriate):

What treatments have you considered: (check all that apply and describe)

Biological

Physical/mechanical

Chemical

Treatment(s) selected for each facility/site category (Class A, B and/or C, as appropriate) and their rationale:

TREATMENTS (cont'd)

Treatment details, timing, and application techniques (if appropriate) for treatment(s) selected:

5. PEST CONTROL EVALUATION

When will you evaluate effectiveness of the pest control program?

What monitoring methods will you use to evaluate treatment effects? _____

General comments (optional): _____

_____

_____

_____

_____

Plan prepared by: (Contact individual responsible for ensuring plans carried out)

_____
Name

_____
Signature

_____
Title

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Appendix 3: Best Practices for Control of Scotch Broom

A 5-hour workshop was held in Victoria on February 1, 2002, to provide a selection of experts the opportunity to discuss how they make decisions regarding whether to control Scotch broom in GOEs, and how they decide what techniques to employ. Much of the information discussed at the workshop is already incorporated into the DST framework in Chapter 3. The participants also generated some broad "rules of thumb" regarding best practices. While there was not enough time to thoroughly document all the conditions and caveats, and therefore this information should be taken only as a rough guide, it does provide a useful starting point for DST users who are trying to decide what techniques to employ to control for broom.

Pulling

- This technique should be used when the root can be pulled out without:
  - disturbing the soil (if there are rocks in the root ball, you are taking too much soil),
  - compacting the soil,
  - breaking the backs of volunteers, or
  - trampling rare/endangered species (avoid this method if valued native plants are growing right beside the broom plants to be pulled).
- Do not use regular weed wrenches; they encourage the pulling of plants that are too big for this method. Size of the plant is key: if you need a regular wrench, the plant is too big for this method. "Mini" weed wrenches can, however, be helpful.
- Pulling can take place from when the rains start until the end of January. The soil is softest during this period, facilitating successful pulling. Later in the season there is a risk of damaging native plants as they begin to germinate.

Mowing

- Mowing should be done in the dry season, when other plants are not blooming. This also ensures the mower doesn't sink into the soil, or compact it.
- Consider avoiding this technique if there are rare annuals present.
- Set the mower blade high.
- Obviously, only use this technique if the terrain permits (e.g. if the site is not too steep, and not too rocky).

Cutting with loppers

- Use this technique in low density broom areas.
- Use this technique on plants bigger than your finger. For smaller plants, use the pulling technique, unless the broom is beside native plants of concern. If that is the case, cut those broom plants too, even if they are smaller than your finger.
- Cut before the broom plants flower.
- It is better not to have a clean cut; scrape the bark if you can.
- Cut the plant a bit above soil level; this makes it easer to kill the plant if it re-sprouts.

Brush Saw

- Use this technique in higher density areas.
- This technique works well on any plant a brush saw can be used on. Some plants are too small, but they get nicely damaged.
- Cut the stems a bit higher than the soil surface, to ensure minimal damage to soil.
- Consider putting herbicide on the cut stem, but be aware that this can be slow, and it is easy to miss plants.

Herbicides

- Consider this technique on really disturbed sites where you are starting restoration efforts essentially from scratch.
- Consider this technique on dense patches, where more than 1000 seedlings per square metre sprout back.
- Use backpack sprayers or paint the herbicide on, to minimize drift.
- Use this as a last resort?
- Alternatives: try selective flaming, or a tagger torch.

Selective Flaming

- Use this technique on an explosion of seedlings, post cut.
- Make sure there is no other fuel load, to minimize the risk of fire.
- This technique is easier on a small scale, but still possible on a landscape scale.

Fire

- This technique is most effective, but also most risky, in the dry season.
- Use this technique if there is no fuel load on the site.
- Consider using this technique as a more holistic strategy to restore historic ecosystem processes, rather than a specific broom-control method. Burning should occur every 10-20 years or so.

Biological control

- This technique is still experimental. Some examples:
  - Gall midge is being studied; but is itself an introduced species.
  - Current research is exploring fungus cultures from natural broom blights.
  - Aphids love broom, but an aphid release program would probably not be favoured by the general public.

Multiple techniques

- Consider combining techniques.
- For example, cut or burn a site to stimulate broom seed growth, then hit it again when it grows (e.g. with plastic sheeting, or selective flaming.)

Afterwards

- Consider using seed plugs of native fescue and forbs in the fall to jump-start seeding. (The need for this depends on native seed bank. Take soil samples first, to see what's there.)
- Consider mulching around the plugs to increase survival.
- What to do with "the body"?[71] After a first-pass large-quantity broom removal, consider taking the biomass off site for disposal if possible and practical. On subsequent passes, leave the removed biomass on site.

[71] The impact of broom on soil chemistry is still being researched, and there was quite a bit of discussion regarding different strategies. It was pointed out that removal decreases biomass/nutrients that would normally recycle back into the system. However, there are also concerns about leaving it. There is concern about potential leaching of phytotoxins from piles of broom, and chipping and spreading it may alter natural conditions and affect native flora. Burning piles of broom in the middle of the road is a method employed at one site.

Appendix 4: “Top 10” Ranking Templates from Respondents

From expert "A":

Exotic Plant Species of Concern	Significance of Impact	Difficulty of Control or Management	Urgency of Control or Management	Comments
Scotch broom (*Cytisus scoparius*)	4	5	7	Control of broom well underway
Laurel-leaved daphne (*Daphne laureola*)	8	11	3	small impact but could become substantial
Common hawthorn (*Crataegus monogyna*)	6	8	2	Local populations need to be controlled now before they spread
Sweet vernalgrass (*Anthoxanthum odoratum*)	1	2	8	Has taken over most GOEs and is hard to control but will not cause much more harm than already
English ivy (*Hedera helix*)	9	6	4	Now limited but could spread
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	10	7	10	Localised but widespread in CDF waste areas therefore hard to control because of spread by birds.
Gorse (*Ulex europeus*)	11	9	1	Need to stop this species ASAP
Non-native thistles (*Cirsium spp.*)	7	10	11	Common agricultural weeds not too much threat
Velvet-grass (*Holcus lanatus*)	3	3	6	Similar to other grasses
Hedgehog dogtail grass (*Cynosurus echinatus*)	5	4	9	Similar to other grasses
Orchard grass (*Dactylis glomerata*)	2	1	5	Very tenacious once established causes significant impact and should be controlled soon if possible.
Holly (*Ilex aquifolium/europea*)	13	13	12	Limited impact easy to control
Rose campion (*Lychnis coronaria*)	12	12	15	Limited impact but could become a problem
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	14	14	14	Only on more nutrient rich disturbed sites
Oyster plant (*Tragopogon porrifolius*)	15	15	13	Limited problem

From expert "B":

Exotic Plant Species of Concern	Significance of Impact	Difficulty of Control or Management	Urgency of Control or Management	Comments
Scotch broom (*Cytisus scoparius*)	1	3	1	Changes structure of community and soil nutrient cycles, changes community structure
Laurel-leaved daphne (*Daphne laureola*)	7	5	8	Not much known for management- more common in understories
Common hawthorn (*Crataegus monogyna*)	4	14	7	I don't think it resprouts after cutting but rank would change if it does- changes community structure
Sweet vernalgrass (*Anthoxanthum odoratum*)	13	10	13	Does not seriously impact herbaceous flora in my opinion
English ivy (*Hedera helix*)	5	6	4	Serious impacts where it has grown out of control
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	6	9	3	changes community structure
Gorse (*Ulex europeus*)	3	2	5	changes community structure resprouts more than broom but less common in rocky sites which are our more intact sites (99% of remaining GOEs are rocky)
Non-native thistles (*Cirsium spp.*)	12	11	7	Highly visible but does not impact community composition and structure as much as many of the other species
Velvet-grass (*Holcus lanatus*)	11	7	6	Affects herbaceous community - serious concern if site is to be managed by fire - intensive to control
Hedgehog dogtail grass (*Cynosurus echinatus*)	14	13	14	Does not seriously impact herbaceous flora in my opinion
Orchard grass (*Dactylis glomerata*)	2	1	2	Affects herbaceous community significantly – not perceived by the public – intensive to control
Holly (*Ilex aquifolium/europea*)	10	12	10	More common in understories
Rose campion (*Lychnis coronaria*)	15	15	15	Not very common in the GOEs that I'm familiar with
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	8	4	8	Intensive to control – less common in the GOEs that I'm familiar with
Oyster plant (*Tragopogon porrifolius*)	9	8	9	Intensive to control – less common in the GOEs that I'm familiar with except for Swan Lake where it is more common

From expert "C":

Exotic Plant Species of Concern	Significance of Impact	Difficulty of Control or Management	Urgency of Control or Management	Comments
Woody plants				
Scotch broom (*Cytisus scoparius*)	1	2	1	Most abundant in true GO habitats
Laurel-leaved daphne (*Daphne laureola*)	1	1	1	Still increasing exponentially, more shaded + transitional sites
Common hawthorn (*Crataegus monogyna*)	2	2	1	Still increasing; deeper soils; very hard to get out
Holly (*Ilex aquifolium/europea*)	3	2	2	GO sites generally too dry, but big threat in coniferous forest
English ivy (*Hedera helix*)	3	2	2	As above
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	2	1	2	So far only in the most disturbed GO sites
Gorse (*Ulex europaeus*)	3	1	2	Not a great threat in dry GO sites
Perennial non-woody				
Non-native thistles (*Cirsium spp.*)	3	1	3	Sites occupied by this in the GO ecosystem "beyond help"
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	3	1	3	As above
Rose campion (*Lychnis coronaria*)	3	2	3	Not a common weed, except in Gulf Islands, following grazing
Hairy cat's ear (*Hypochaeris radicata*)	1	2	2	Very pervasive in all of GO
Ribwort plantain (*Plantago lanceolata*)	2	2	2	As above
Sheep sorrel (*Rumex acetosella*)	2	1	2	As above
Orchard grass (*Dactylis glomerata*)	1	1	1	Can choke out everything
Kentucky bluegrass (*Poa pratensis*)	2	1	3	Pervasive, but less disruptive
Colonial bentgrass (*Agrostis capillaris*)	3	2	3	Only locally important after much disturbance
Red fescue (*Festuca rubra*)	3	2	3	Mostly in urban areas
Quackgrass (*Elymus repens*)	3	1	3	Not widespread, but very hard to control; disturbed urban
Velvet-grass (*Holcus lanatus*)	2	2	3	Widespread
Perennial ryegrass (*Lolium perenne*)	3	2	3	Mostly in urban areas
Annual non-woody				
Oyster plant (*Tragopogon porrifolius*)	3	?	3	Only in GO in greatly disturbed urban areas; ruderal sp
Common vetch (Vicia sativa)	2	?	2	Very pervasive
Soft brome (Bromus hordeaceus)	2	?	3	"
Ripgut brome (Bromus rigidus)	2	?	2	Driest, hottest sites only
Cheatgrass (Bromus tectorum)	2	?	2	Very pervasive
Barren brome (Bromus sterilis)	2	?	2	"
Sweet vernalgrass (*Anthoxanthum odoratum*)[72]	2	?	2	"
Hedgehog dogtail grass (*Cynosurus echinatus*)	2	?	2	"

[72] Anthoxanthum can be annual or perennial.

From expert "D":

Exotic Plant Species of Concern	Significance of Impact	Difficulty of Control or Management	Urgency of Control or Management	Comments
Scotch broom (*Cytisus scoparius*)	1 - 2	4	2	Nitrogen fixer - alters ecosystem processes; also dramatically increases fuel loading, which complicates restorative burning efforts
Laurel-leaved daphne (*Daphne laureola*)	6	8	6	Higher priority on this species in forested areas rather than GOEs - only appears in any concentration there in moist, shady areas, which are only a small component of GOEs (though maybe a location for rare plants, given the relative scarcity of this niche?)
Common hawthorn (*Crataegus monogyna*)	4	10	4	Relatively easy to manage but requires persistence. Relatively high significance of impact as it creates a shrub layer where none previously existed.
Sweet vernalgrass (*Anthoxanthum odoratum*)	3	2	7	Am ranking 3 of the 4 grasses (except for *Dactylis glomerata*) at the same level (as 'invasive grasses' category) as I don't know enough about them to break them down further.
English ivy (*Hedera helix*)	5	5	5	Would give ivy a relatively high 'urgency' rating where it appears, but lower in general due to the relatively lower % of sites it affects
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	7	9	8	More common in highly disturbed areas
Gorse (*Ulex europeus*)	1-2	3	1	Replaces broom as #1 significance ranking in drier sites, where gorse is more common (e.g., parts of Metchosin). Urgency of control is based on controlling now before it spreads further.
Non-native thistles (*Cirsium spp.*)	?	?	?	No comment on spp. I'm unfamiliar with.
Velvet-grass (*Holcus lanatus*)	3	2	7	See comments under sweet vernalgrass
Hedgehog dogtail grass (*Cynosurus echinatus*)	3	2	7	" " "
Orchard grass (*Dactylis glomerata*)	2	1?	3?	All grasses very difficult to manage effectively
Holly (*Ilex aquifolium/europea*)	15	15	15	Low priority - more of a forest invasive. Easy to manage (chainsaws) but like hawthorne, requires persistence.
Rose campion (*Lychnis coronaria*)	?	?	?	
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	?	?	?	
Oyster plant (*Tragopogon porrifolius*)	?	?	?	

Butterfly Bush (*Buddleia* sp.) Wouldn't rank it in the top 10, but it's beginning to appear as an invasive in Sunshine Coast area (HT, DA systems for example), and is invasive in other parts of the world.

From expert "E":

Exotic Plant Species of Concern	Significance of Impact	Difficulty of Control or Management	Urgency of Control or Management	Comments
Scotch broom (*Cytisus scoparius*)	1	1	1	Most wide spread in open ground
Laurel-leaved daphne (*Daphne laureola*)	6	7		
Common hawthorn (*Crataegus monogyna*)	7	6		
Sweet vernalgrass (*Anthoxanthum odoratum*)				
English ivy (*Hedera helix*)	2	3		Worse in forests. Difficult to kill
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	4	5		on ground: bird spread.
Gorse (*Ulex europeus*)	3	4		Harder to kill by cutting, but not as wide spread.
Non-native thistles (*Cirsium spp.*)	10	8		
Velvet-grass (*Holcus lanatus*)				
Hedgehog dogtail grass (*Cynosurus echinatus*)				
Orchard grass (*Dactylis glomerata*)				
Holly (*Ilex aquifolium/europea*)	5	2		Worse in forests, like ivy. Both spread by birds.
Rose campion (*Lychnis coronaria*)	9	10		
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	8	9		
Oyster plant (*Tragopogon porrifolius*)				
Poison hemlock (*Conium maculatum*)	11	11		

From expert "F":

Significance of Impact

Exotic Plant Species of Concern	Category Ranking	Numerical Ranking	Comments
Scotch broom (*Cytisus scoparius*)	Very High	2	Alters vegetation structure and disturbance and nutrient regimes. Shades out native herbaceous species. Invades rock outcroppings, deeper soil meadows and open oak woodland.
Laurel-leaved daphne (*Daphne laureola*)	Very High	5	Ranked very high not due to its existing impacts, but due to its potential for altering the structure and composition of oak woodlands. Shade and somewhat drought tolerant. Forms dense stands that exclude native shrubs and herbaceous vegetation. Reproduces by bird-dispersed seed and vigorous sprouting from stems and roots.
Common hawthorn (*Crataegus monogyna*)	Moderate to High	8	Ranked high not due to its existing impacts, but due to potential for invasion of open oak woodlands and meadow areas. Present in limited areas. Can form dense patches that alter the structure of oak ecosystems. Shades out herbaceous species. Reproduces by bird-dispersed seed and sprouting from stems and roots.
Sweet vernalgrass (*Anthoxanthum odoratum*)	Moderate	10	Widespread on rock outcrop and upland meadow areas. Low growth form allows coexistence of native herbaceous vegetation. Literature suggests alleopathy.
English ivy (*Hedera helix*)	Very High	3	Ranked very high because of rapid growth and growth form that shades out all herbaceous vegetation where it establishes and ability to grow up oak trees. Widespread, bird dispersed
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	Moderate	11	Alters structure of meadow areas and shades out herbaceous vegetation. Present in severely degraded areas, not really a primary invader.
Gorse (*Ulex europeus*)	High	7	Although still has very limited distribution, ranked high due to potential for invasion and alteration of stand structure and nutrient and disturbance regimes. Worse than broom in shading out herbaceous species. Litter may acidify soil.
Non-native thistles (*Cirsium spp.*)	Low	12	Wind dispersed, rapidly invades disturbed areas, but not a major problem in the oak ecosystems I have visited.
Velvet-grass (*Holcus lanatus*)	High	6	Present in many oak meadows, but less widespread than orchard grass. Tall, clumping growth form shades out and/or displaces native herbaceous species. Favoured by fire.
Hedgehog dogtail grass (*Cynosurus echinatus*)	Moderate	9	Widespread on rock outcrop and upland meadow areas. Low growth form allows coexistence of native herbaceous vegetation. Literature suggests alleopathy.
Orchard grass (*Dactylis glomerata*)	Very High	1	Widespread invader of meadow areas. Tall, clumped growth form shades out and displaces native herbaceous species.
Holly (*Ilex aquifolium/europea*)	Low	?	Can invade open oak woodlands, but appears to have much lower potential for invasion, displacing native species and causing major alterations to stand structure.
Rose campion (*Lychnis coronaria*)	Low	?	Present in a few rock outcrop/upland meadow areas. Does not appear to be a problem invasive.
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	Low	?	Present only in limited sites. Appears to have low potential for invasion.
Oyster plant (*Tragopogon porrifolius*)	Low	?	Tall, single-stemmed plant. Wind dispersed, but I have only observed this species in relatively low numbers.
Common vetch (*Vicia sativa*)	Very High	4	Widespread, rapid invader, forms dense stands that compete with native herbaceous species. Twining growth form interferes with the growth of native forbs and grasses.

I think the native shrub snowberry (*Symphoricarpus albus*) should be added to the list of problem invasive species. I consider it to be the worst invader of oak woodlands since it is so widespread and shades out all native herbaceous species. It appears to spread primarily from sprouts from underground stems. The open oak woodland with herbaceous understory in Uplands Park shown in old photographs has been almost completely transformed into an oak-snowberry woodland.

Difficulty of Control or Management

Exotic Plant Species of Concern	Category Ranking	Numerical Ranking	Comments
Scotch broom (*Cytisus scoparius*)	High to Very High	8	Widespread, well established and dominant non-native species. Forms dense stands. Persistent seed banker, so potentially decades of follow-up required. Uprooting of medium to large plants damages native flora and stimulates regeneration of broom from seed. Cutting can lead to resprouting if done in winter and early spring.
Laurel-leaved daphne (*Daphne laureola*)	High to Very High	9	Young plants are easy to uproot. Established plants very difficult to uproot and readily and quickly resprout from cut stems.
Common hawthorn (*Crataegus monogyna*)	High to Very High	10	Young plants difficult to uproot. Established plants very difficult to uproot and readily and quickly resprout from cut stems.
Sweet vernalgrass (*Anthoxanthum odoratum*)	Very High	6	Large numbers of individuals. Cannot be mowed or sprayed without damaging native flora. Would need to be hand pulled.
English ivy (*Hedera helix*)	Very High	4	Difficult to completely remove, re-grows readily from roots, area occupied by the plant usually bare soil that can be readily colonised by other weedy species of not planted to desirable species.
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	Moderate	12	Spines and multiple stems make removal difficult. Digging out large shallow root nodules substantially reduces regeneration potential.
Gorse (*Ulex europeus*)	High to Very High	5	Spines and dense stands make this plant very difficult to remove. Fortunately established in very few oak sites. Persistent seed banker, so potentially decades of follow-up required. Uprooting of medium to large plants damages native flora and stimulates regeneration of broom from seed. Cutting can lead to resprouting if done in winter and early spring.
Non-native thistles (*Cirsium spp.*)	Moderate to High	11	Can be present in large numbers. Tap root needs to be dug out. Wind dispersed.
Velvet-grass (*Holcus lanatus*)	Very High	3	Forms dense swards. Cannot be mowed without damaging native flora. Spraying with grass-specific herbicide may be only viable option.
Hedgehog dogtail grass (*Cynosurus echinatus*)	Very High	7	Large numbers of individuals. Cannot be mowed or sprayed without damaging native flora. Would need to be hand pulled.
Orchard grass (*Dactylis glomerata*)	Very High	2	Forms dense clumps. Cannot be mowed without damaging native flora. Clumps can be carefully uprooted by hand when soils are moist. Spraying with grass-specific herbicide may be only viable option.
Holly (*Ilex aquifolium/europea*)	Moderate	13	Young plants can be uprooted. Established plants very difficult to uproot and readily and quickly resprout from cut stems. Not widespread.
Rose campion (*Lychnis coronaria*)	Low	16	Not present in high numbers, should be relatively easy to uproot.

Exotic Plant Species of Concern	Category Ranking	Numerical Ranking	Comments
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	Low to Moderate	14	Difficult to remove due to twining around native vegetation and regrowth from roots. Not widespread.
Oyster plant (*Tragopogon porrifolius*)	Low	15	Not present in high numbers, uprooting will require effort.
Common vetch (*Vicia sativa*)	Very High	1	Extremely difficult to remove due to large numbers, low growth form, and twining around native vegetation.

Snowberry is also a very difficult species to control due to its ability to resprout from cut stems and underground roots.

Urgency of Control or Management

Exotic Plant Species of Concern	Category Ranking	Numerical Ranking	Comments
Scotch broom (*Cytisus scoparius*)	High to Very High	5	Priority for removal in areas of high conservation value, particularly where broom is present in relatively low densities or is just invading.
Laurel-leaved daphne (*Daphne laureola*)	Very High	3	Beginning to invade oak woodlands. Must be prevented from establishing.
Common hawthorn (*Crataegus monogyna*)	High	7	Invading Cowichan Garry Oak Preserve, this invasion must be stopped. May not be a problem in other sites.
Sweet vernalgrass (*Anthoxanthum odoratum*)	Moderate	12	Coexists with native flora in upland oak ecosystems. Not a priority for control.
English ivy (*Hedera helix*)	High	6	Priority is to prevent this species from establishing in new areas. Most oak ecosystems where infestations of ivy are present tend to be quite degraded.
Himalayan blackberry (*Rubus proseris/discolora/armeniacs*)	Moderate	8	Most oak ecosystems where infestations of blackberry are present tend to be quite degraded. Should be prevented from invading new areas.
Gorse (*Ulex europeus*)	Very High	4	Must not be allowed to invade new sites or spread in existing sites where present in low numbers.
Non-native thistles (*Cirsium spp.*)	Moderate	10	Should be addressed where they are present in problem numbers.
Velvet-grass (Holcus lanatus)	Very High	2	Left unchecked, will substantially degrade remnant native flora in meadow ecosystems.
Hedgehog dogtail grass (*Cynosurus echinatus*)	Moderate	11	Coexists with native flora in upland oak ecosystems. Not a high priority for control.
Orchard grass (*Dactylis glomerata*)	Very High	1	Left unchecked, will substantially degrade remnant native flora in meadow ecosystems.
Holly (*Ilex aquifolium/europea*)	Low	13	Should be prevented from invading new areas.
Rose campion (*Lychnis coronaria*)	Low	16	Not a priority.
Morning-glory/bindweed (*Convolvulus arvensis/sepium*)	Low	14	Not a priority. May only be present in a few sites.
Oyster plant (*Tragopogon porrifolius*)	Low	15	Not a priority.
Common vetch (*Vicia sativa*)	High	9	May be very difficult to develop effective control.