MANAGEMENT GUIDELINES FOR INVASIVE ALIEN SPECIES IN CANADA'S NATIONAL PARKS

Prepared for:

NATIONAL PARKS BRANCH
PARKS CANADA, OTTAWA, ONTARIO

by

Theodore (Ted) Mosquin, Ph.D.
Tel: 613-267-4899; Fax: 613-264-8469
Email: <mosquin@ecospherics.com>

ECOSPHERICS INTERNATIONAL INC.
Box 279, LANARK, Ontario K0G 1K0
<http://www.ecospherics.com>

MARCH, 1997

ACKNOWLEDGEMENTS

I wish to thank Mr. Don Rivard, National Parks Branch, Parks Canada for his cordial assistance and suggestions in helping me first to focus on the possible scope of this interesting project and later in providing a critical review. He also provided many articles and several symposia volumes whose contents materially affected the conclusions drawn in this report.

As well, I am grateful to Jean-Guy Chavarie, Chief Park Warden, Forillon National Park and to Denise Comeau and Stephan Marchand, Park Wardens, F.N.P. for their detailed critical review of the initial draft manuscript as well as their many suggestions for improvement, most of which have been gratefully incorporated into the report.

Of the 12 guidelines proposed in this report only No's. 1, 2, 9 and 10 already constitute Parks Canada policy either in part or in whole, although management action on any of these may be extremely limited or even non-existent. Eight of the guidelines are essentially new and hence do not represent the official stance of Parks Canada. Several of these may be controversial. For example, Guideline No. 7 suggests that a way should be found to officially declare amnesty to 'ecologically qualified' alien species. This, and several other guidelines will require some informed discussion and debate, considering their obvious logic and other merits, as described in this report.

Ted Mosquin
March, 1997

TABLE OF CONTENTS

(Continued on next page)

(Continued on next page)

TABLES:

APPENDICES:

****

1.0 INTRODUCTION

Parks Canada has a need for guidelines to assist with the management of problem alien species (definition below) in national parks. Such guidelines do not now exist. The guidelines would enable both policy and operational staff to make a range of decisions about alien species management and that cannot at present be made. These decisions relate to factors such as whether preventative actions are desirable, whether a particular alien species should be of concern, where the species should be placed on a priority list for action, and what sort of control actions, if any, might be desirable, feasible and acceptable.

The main focus of this study was to carry out the background work considered necessary for the drafting of such a "first cut" set of basic management guidelines and to provide an initial formulation of the guidelines together with rationales for each. In the review of the world literature on this subject it was found that no single framework for alien species management for protected areas exists, although particular management recommendations for specific problem species are published in a wide assortment of articles in a rapidly growing body of literature on this subject.

Non-native organisms often pose special problems in nature reserves and protected areas including national parks because such organisms variously impact on or even replace native species. As well, their presence in natural, still-near-natural or recovering ecosystems may also cause significant changes to the structure and the natural or "normal" functioning of the ecosystem of the area of land or water that has been or is now being invaded. In the words of Courtney (1993): "...no natural system can accept a non-native species without adjustments." However, one should not simply assume that these adjustments are only negative. This is because geographical and ecological circumstances can exist where an invasive alien organism appears to make a positive contribution to ecosystem function and integrity, an important matter that needs to be addressed and is considered further below with several examples.

An essential element of this study was the need to define and describe a valuation framework as well as criteria upon which judgements about the "good" or the "bad" of any known alien species must be based. Fortunately, there is a body of accumulated knowledge and insight in the fields of evolutionary geology/ biology, and Ecophilosophy which provides such a valuation framework. Once some of the obvious species and ecosystem values to be gained or lost (as a result

of the effect of the alien) are considered, the justification for eradication or control through management becomes more apparent, and in serious cases, imperative. Hence, this report describes the valuation framework that should logically be the basis for judgements respecting control measures.

The general context in Canada in which this report is written is that human induced disturbance regimes, including habitat or natural area fragmentation are still a net expansion in area as well as in the severity of impact, thus providing numerous new opportunities for the introduction and establishment of problem alien species.

The findings of this study should enable Parks Canada staff, or any other agency or group concerned with the management of protected areas, to better focus on management policy alternatives, define priorities and draft management directives for park planners and operational staff. Indeed, once ecological values gained or lost associated with the presence of an invasive alien are sufficiently assessed, an ecologically based case can usually be made for categorizing, prioritizing and even for justifying "severe" management actions to control or eliminate the problem species.

1.1 The Objectives of this Report

The specific objectives to this study are:

- to describe the problem alien and North American introduced species in Canada;
- to provide an overview of the global problem of alien and other introduced species with particular reference to protected areas, including national parks;
- to review management actions taken by jurisdictions world-wide to deal with exotic and other introduced species in protected areas;
- to propose criteria for the identification and prioritization of problems and management actions;
- to evaluate the appropriateness of the available spectrum of management actions in the context of the *National Parks Act* and the *Parks Canada Guiding Principles and Operational Policies*; and

- to draft a "first cut" set of guidelines for the management of alien and NA introduced species in Canada's national parks (guideline criteria to include a classification of problematic and potentially problematic species).

The literature on alien invasive organisms, including "weeds" is extensive and includes not only articles in academic journals but also the resource literature in trade publications associated with agriculture, forestry and fisheries. There are literally thousands of titles dealing not only with specific problem species but also with a full range of methods of control of these species. While not entirely irrelevant, this literature was beyond the more limited scope of this study, except for some Canadian material (e.g. Crompton et al. 1988). Rather, in this report emphasis is placed on the literature directly relevant to invasive aliens associated with variously protected areas such as national and provincial parks, nature reserves, ecological reserves, and similar areas.

1.2 Defining an Invasive Alien Organism

A science-based definition of what constitutes an invasive alien species is essential to park managers because a credible and realistic definition will have consequences to policy formation, to the consistency of management and control actions and the prioritization of problem invasive species for control programs. The review of the world literature on this topic indicates that a consensus definition of what constitutes an alien organism or species (provided below) has emerged. The broadly accepted definition as well as some exceptions are worthy of brief review if for no other reason than to gain a clear focus and understanding of the definition issue and in order to lay it to rest so that any planning to control, ignore, or encourage invasive aliens in protected areas can move forward within a globally accepted definition.

There are a number of essentially synonymous terms used to describe the kinds of species we are dealing with in this report, vis: "introduced," "aliens," "exotics," "non-natives," "immigrants," "adventives," "neophytes," or "non-indigenous." The 1992 Convention on Biological Diversity uses the term "alien" to describe these kinds of organisms and hence this is the term now predominantly favoured in the ecological and management literature. It is specifically those alien species that either invade the living space of native species in natural habitat and

that can successfully invade and alter natural ecosystems that are considered to be problems for managers of protected areas and hence the adjective "invasive" is commonly used to describe these kinds of organisms. Thus, "invasive alien" is becoming widely used (Stone 1992; White et al. 1993; Environment Canada 1994; Sandlund et al. 1996) and has been has been adopted for general use in this report.

The definition of "alien organism" used herein (and that is being recommended to Parks Canada) follows that agreed to at a workshop of a group of experts who met in February 1994 in Victoria, BC (Environment Canada 1994) to develop recommendations on alien species for consideration in the drafting of the Canadian Biodiversity Strategy (Supply & Services Canada 1995). The group met in response to Article 8(h) of the UNEP Convention on Biological diversity, which Canada has ratified. The Convention Article states that: "Each Contracting Party shall, as far as possible and as appropriate: ...Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species." The experts' definition is:

> *"An alien species is one that enters an ecosystem beyond its historic range, including any organisms transferred from one country or province to another."*

This definition (see Appendix 2), modified from the US National Park Service (see below) implies no positive or negative impact by the alien organism, and includes organisms entering through natural range extension and dispersal, and through deliberate or inadvertent introduction by humans as well as a result of habitat changes caused by human activity. Obviously, an organism that has been extirpated from a park in historic times and later re-introduced would not be considered to be an alien. Two Canadian examples would be the Southern Flying Squirrel re-introduced in the late 1980s to Point Pelee National Park and the Swift Fox re-introduced into the area of Grasslands National Park over the last several decades.

The participants of the workshop described above (Environment Canada 1994) also recognized that an alien species would not only be alien to a natural ecosystem but may also be harmful to associated wild species, natural ecosystems and to the human interest, thus:

> *"Alien species, however, may be injurious. An injurious species or organism is one that causes or has the potential to cause harm to*

native Canadian species or ecosystems through processes including but not limited to hybridization, predation, parasitism, pathology, and competition, and potentially harmful to the human interest, including but not limited to aesthetics, economics, and health."

These definitions exclude humans from recognition as alien species regardless of biological, geographical or historical facts. The workshop participants thus re-enforced the wrong-headed notion described as the "exemptionalist paradigm," which is the simple assumption that humans stand apart from the laws and workings of nature. The belief that humans are independent of the workings of natural laws has implications to the way people interpret human-generated ecological problems in national parks and other protected areas, and places strictures on the management of peoples' activities in such areas.

Of course, it is obvious that an organism does not have to be an alien to be deemed by humans as harmful to their interests and in this regard there are thousands of species out there that automatically fall into this "harmful" category, as for example - all species present in a natural or near natural area that is being considered for conversion to an agricultural field or for a location of a toxic waste dump.

The other puzzling aspect of the report of the Workshop (Appendix 2) is the failure to recognize that some alien invasive species may NOT be harmful and indeed may be beneficial to native species, natural ecosystems and to humans. Just how many Canadian examples might fall into this category would require a "case by case" review by a ecologically knowledgeable resource managers. Some examples are offered later in this report. Such a recognition of "beneficiality" has important policy and management implications and the guidelines (Section 7.0) assume that such a category is legitimate.

For the record, some other definitions of alien (exotic, introduced, etc.) species are of interest. Thus, the US National Parks Service defines alien species in park policy as: *"....those that occur in a given place as a result of direct or indirect, deliberate or accidental action by humans (not including deliberate re-introductions)."* This definition is vaguer and not as explicit as the one adopted above. The US Forest Service defines alien species as ones that are basically 'un-American,' vis: those species *"....not originally occurring in the United States and introduced from a foreign country."* (US Forest Service 1991). Indeed, the

word "alien" is widely used in the USA, applying even to any foreign national legally or illegally in the country. Thus, graduate students from other countries are recognized as "alien students," even though they belong to the same species as the rest of us. Obviously, a chauvinistic use of the term. Some additional examples: Stirton (1979) defines alien plants as those that: *"... invade and oust native vegetation."* Westman (1990) defines an alien species as *"..one that is newly established at a significant distance from its former geographical range,"* and Achuff et al. (1990) define an alien species as one *"...that is not native to the area under consideration."* However many definitions there are in the literature, it seems preferable that the definition to be accepted for operational purposes should be based on common sense, logic and science, rather than the mere opinion of an individual. In this way of thinking, we should adopt a definition that is universally applicable, widely used, and if and when possible, amenable to some sort of historical and scientific testing, which for many species (see below) is not possible.

Using the basic, non-judgmental "Alien Species Focus Group" definition described above, it is obvious that in today's world, both globally and in Canada itself, there are hundreds, indeed sometimes thousands of alien species in a particular area or region (except in boreal and polar regions - see Section 4.0). One reason these estimated numbers are so high is that one cannot exclude invertebrate animals, fungi, macro-algae, and the enormous numbers of microfauna and flora (microorganisms) where knowledge of whether or not a species is alien, is usually unavailable and impossible to obtain (Duffy 1988; Drake et al. 1989; McKnight 1993). It is difficult, and usually not possible to determine the resident status of the myriads of tiny microscopic and submicroscopic organisms in terrestrial and aquatic habitats.

While this country's national parks (and areas near to national parks) often contain many hundreds of introduced animals, plants and microorganisms (Romo & Lawrence 1990; White et al.1993; Mills et al. 1993; Mosquin et al. 1995, pp. 63-69; Haber 1996a, 1996b), only a limited number of these are considered by ecologists and managers to have caused, and/or to continue to cause, significant impacts on native species or natural ecosystems. In this report, an introduced alien is considered to require a judgement of its destructive status only when it invades natural ecosystems and/or affects native species. A "problem invasive species" in this report includes those plants and/or animals that, in the judgement of Parks Canada staff, are now having a significant negative impact upon native species or upon the ecological integrity of natural ecosystems of the parks.

The large majority of introduced species in Canada's national parks, and this applies particularly to plants, are relatively benign in that they can reproduce and survive only in disturbed sites such as highway right of ways, lawns, yards, gravel pits, and other disturbed areas created or maintained by humans. Hence, they are not of direct concern in this report.

1.3 Recognizing the Genetic Uniqueness of Alien Invasives

Any management policy or action respecting the control of invasive alien organisms needs to always recognize that each and every species in nature is genetically unique, having its own particular distribution or occurrence pattern, some distinct aspects to its life cycle and some unique role in interacting with or affecting its immediate associates and neighbours.

While there have been some academic attempts to predict which species or classes of species might become invasives and which ecosystems will be invaded the conclusions are at best tentative and preliminary (Heywood 1989; Rejmanek 1996). The reasons are straightforward: each invading species is genetically unique. As well, every invaded ecosystem is also unique in its "abiotic" (Rowe 1990b) characteristics and its assemblage of species at a particular spot or area as is repeatedly described in the ecological and evolutionary literature.

The ecological uniqueness of plant species has been long recognized by evolutionary biologists and first encapsulated in a classic paper by Gleason (1926) entitled: "The Individualistic Concept of Plant Succession." What this means in a practical sense is that a manager cannot depend upon knowledge gained in controlling one species to apply automatically to any closely related species. Thus, one cannot predict future alien invasives of any protected area except from empirical distribution data taken over time where the expanding range of a newly introduced alien is tracked over a number of years or decades much as has been done for Frog-bit, and a number of invasive plant and animal species (Section 3.0; Appendix 1). In other words, there is no sure way of predicting whether a newly introduced species from a distant area will be invasive of natural ecosystems until it arrives and begins invading. "Nothing is more difficult than to predict what will happen to an exotic," says botanist Warren Wagner of Michigan.

In the summary to the recent Norway/UN Conference on Alien Species (Chairman's Report 1996) the following useful quote on the above isssue is offered:

> "Prediction of the progress and consequences of a biological invasion in a quantitative way is not possible. There are possibilities of making analytical models, but adequate estimates of variables are not possible before an invader has been introduced and has actually spread. However, sufficient independent empirical data (life history, survival rate, fertility rate) are available only for a relatively few species in order to reconstruct "old" invasions."

The practical point is that there is no scientific way to identify "potentially problematic" invasive species and also that each invasive alien present in or near a protected area deserves its own special individual management consideration. Not only are invasive species unique. Ecosystems themselves are complex beyond human description and imagination and there is no scientific way of knowing in advance which part of a similar-appearing ecosystem will be favoured by an invasive alien species and which part will resist the invasion. Hence, from a management perspective (but not from an academic one) it would be counter-productive to pursue this matter or devote any resources to the issue.

1.4 Some Criteria for Assessing Individual Alien Organisms

Whether or not an organism is to be considered a serious invasive usually requires common sense field information.

The California Exotic Pest Plant Council (1986) has offered a practicable set of criteria for assessing whether an invasive alien is to be considered an important "wildland weed" in the State of California and these criteria seem to be universally applicable, at least for plants. The assessments and lists are drawn up by the members of the Council in cooperation with members of the California Native Plant Society. The Council states that:

> "Plants are NOT included as important wildland weeds if they:
> 1) do not spread beyond cultivation;
> 2) are not eradicable (e.g. Mediterranean annual grasses and filarees);
> 3)naturalize only sparingly. and
> 4) are confined to roadsides and agricultural fields."

The Council provides 2 (draft) lists, each of which includes trees, shrubs and herbs, vis:

List 1. Most Important Wildland Weeds. This includes 13 species. The criteria for inclusion in this category are:

- widespread;
- well-established; and
- can dominate a plant community

List 2. Wildland Weeds of Secondary Importance. This list includes 66 species, and the criteria for inclusion here are that the plants are:

- localized;
- in an early stage of invasion;
- lack ability to dominate a community.

Criteria for the importance of alien animals would be *similar to the above* but more complex. While no explicit listing was found in the literature, references to these characteristics exist - buried within specific articles. The criteria for animals would need to be developed by first making a list of a wide range of alien invaders of natural communities and competitors with native species and then encapsulating the estimated degree of impact upon native species and natural ecosystems. This has not been done here (but see Appendix 1 for a basic Canadian list). Some case examples (see Appendix 1 for others) of the range of impacts would include:

- directly usurp nesting sites of native species (e.g. starlings displace bluebirds, red-headed woodpeckers, tree swallows, prothonotary warblers, etc.);
- successfully raid nests of eggs and nestlings of native oceanic birds on islands (e.g. the Norway rat on islands off Canada's east and west coasts);
- competes for food with native species (i.e. the introduced wild turkey in Canada is said to eat food that is readily taken by the native ruffed grouse);
- severely over-graze natural ecosystems, eliminating or greatly altering required habitat for flora and fauna (horses on Sable Island and domesticated herbivorous animals in any natural ecosystems).

2.0 INVASIVE ALIENS AND PROTECTED AREAS: THE GLOBAL CONTEXT

2.1 The General Context and Scale of the Problem

Some understanding of the scale and nature of the global problems posed to native species and natural ecosystems can be of benefit when considering guidelines for protected areas in Canada.

It is the sheer scale and increasing tempo of the movement of species to and from very distant parts of the world combined with both the economic impact of some of these 'successful' introductions and their observed disruptions of native species and natural ecosystems that is at the root of the rapidly increasing concern with the subject of invasive alien organisms. This involves enormous trans-boundary and intercontinental movements on an unprecedented scale.

Some measure of the importance of the topic comes from the growing world academic research and management literature on invasive aliens and the outcries of scientists and managers who know about or are faced with the consequences. The literature includes a number of books and symposia as well as large numbers of focussed individual articles (Elton 1958; Duffy 1988; Drake et al. 1989; Natural Areas Association 1992; McNight 1993; Clout 1995; Hengeveld 1996; Eighth Grazing Land Forum 1993; Sandlund et al. 1996; Chairman's Report 1996). As well, there are now at least nine List Servers on the Internet (Aliens Internet Lists Servers, 1996) dealing wholly or in part with this topic. One list server (ALIENS-L) started in October 1996 had some 500 participants by mid November. Major international conferences have addressed this growing problem (Drake et al. 1989; McNight 1993; Sandlund et al. 1996; Chairman's Report 1996).

The world-wide increase in concern is clearly linked to the mounting scale of deliberate and unintentional introductions and movement of thousands of species daily by travel, growing commerce (including free trade) and tourism/ recreational activities. The scale of the daily transfer of organisms is such that the chances of a native species from some part of the world being introduced to an environment in another part of the world where it can thrive is now higher than ever. Given enough time, virtually every species that can survive somewhere in the world will eventually find its way there either by deliberate introduction or inadvertently. In cases where the species can invade wildlands and natural

ecosystems (including suitable marine environments), it will have its effects upon native species and cause deviations from norms of ecological integrity of these places. This global phenomenon provides an good working example of Murphy's Law: 'If something can happen, it will.'

The scale of the global spread of invasives into distant marine, terrestrial and freshwater ecosystems has prompted the emergence of phrases such as the "biological homogenization of the world" (Culotta 1991). Another sign of the times is the recognition of this problem by the Convention on Biological Diversity, the holding of an associated UN Conference on alien species (Sandlund, et al. 1996; Chairman's Report 1996). In Canada some attention has been directed to this issue by Environment Canada (1994) and in the text of the Canadian Biodiversity Strategy (Environment Canada 1995) but in a practical sense, budgets and actions are at zero. The continuing "export" of organisms from very distant (but climatically similar) parts of the world to Canada is an issue that is already serious for some of our national parks and protected areas and that promises to become more serious as the tempo of global transport accelerates.

For many countries, the organized data on invasive aliens in natural ecosystems is non existent or very sketchy. However, for several areas of the world a great deal of documentation exists as well as a practicable body of direct experience with management and even eradication techniques. These data taken together provide a basis for an understanding of the Canadian situation and for preparing this report. The better known geographical areas are the mainland United States, Canada, New Zealand, Australia, Hawaii, South Africa and Europe as a whole. Where summary reports were found, these have been examined during the course of this study; otherwise the material in this report derives from reviewing a wide assortment of articles by both academic and management journals.

In the United States two recent documents summarize the nature, extent and many of the specific impacts of the entire range of invasive aliens in the country and these underline the pervasive nature and scale of this problem in the USA. All ecosystems, except possibly the boreal and alpine regions have received lesser to major changes as a direct result of many of these introductions. Thus, the Office of Technology Assessment released a report in (OTA 1993) which documents some 4,500 non-indigenous plant and 2300 animal species of foreign origin that have established free-living populations in the United States (this figure apparently includes Alaska and Hawaii). At least 15 percent of the species identified trigger severe harm, and just 79 invasive aliens caused documented

losses of US $97 billion in control costs and losses of marketable goods (Eighth Grazing Land Forum, 1993; Nature Conservancy 1996). The US Department of the Interior (LaRoe et al. 1995) produced what is essentially a "state of the environment report" and which summarized the numerous negative impacts of alien species on natural ecosystems and on some native species in different parts of the country and in principal sectoral ecosystems. The Nature Conservancy (1996) has produced a fresh review and evaluation of the situation in the US. The conservancy notes that alien invasive species have been implicated in the decline of 42 percent of those species listed as threatened or endangered by the U.S. Fish & Wildlife Service, and that of the 40 North American freshwater fishes that have become extinct over the past century, the American Fisheries Society has documented that introduced species were a contributing factor in 68 percent of these extinctions. The Conservancy notes that as a group the most endangered organisms in the U.S.A. are freshwater aquatic animals. And finally: "60% of the land stewards for The Nature Conservancy's more than 1,500 preserves reported in a recent survey that exotic plants are among their top management dilemmas with 12 percent indicated that they are their single most severe problem." Species introduced into the USA and that can live somewhere north of the international border usually spread to Canada, and if a national park happens to be suitable habitat, we can be assured of an arrival sooner or later, usually sooner.

Hence, it makes sense that governments begin taking action through new legislation, policy development, management directives, guidelines to enable the problem to be addressed where possible. Particularly, such a range of fresh initiatives would be necessary with respect to alien invasives in protected areas. Actions need to be coordinated, and international in scope, considering the scale of this problem and carried out within a basic understanding the global context and the ways in which invasives elsewhere affect Canada's interests. Clearly some effective formal mechanisms are required if nations are to work together at a level above and beyond national or regional initiatives. In the United States the "National Invasive Species Act was passed by Congress in 1996 (mainly to address alien species in ship ballast) and a new book summarizing the economic and ecological scale of the problem in the United States has been published by the Nature Conservancy in October (and the text is also available on the Internet). Recent symposia cited above and particularly the most recent (Sandlund et al. 1996) demonstrate the slow movement in this direction. In February and March 1997 hundreds of concerned scientists in the United States and from around the world signed a letter to the Vice-President of the United States requesting far

greater action on a new strategy to prevent and manage invasions of invasive alien species (text of letter: see Appendix 3).

These publications, conferences, new laws, and other initiatives show the monumental scale of the problem in different parts of the world and worries and concerns that exist out there regarding the consequences to other species and sometimes to entire ecosystems. Additional examples are included in the literature cited section (Section 10), but obviously, only a relatively small number of these "ecological horror stories" can be included here and an extensive literature review would bring many additional hundreds more to light.

The impact of alien invasives on tropical and subtropical oceanic islands is well known and an extensive literature on the subject exists. Major efforts are bing made to eradicate unwanted aliens from large numbers of oceanic islands, and particularly rats, rabbits, cats and goats, and these efforts are increasingly successful for ever larger islands with dramatic results to the recovery of native species and ecosystems. Some of the literature on these islands is reviewed in Section 10 of this report. However, Canadian island archipelagos along the Atlantic and Pacific coasts are fundamentally different from tropical and subtropical islands in that in Canada, all islands were glaciated and their flora and fauna, with minor exceptions, are recent in origin, and with genetics similar to their mainland species, and with very few few endemics. The various ways in which Canada's problems with invasive aliens differ from those of other regions of the world are examined in the next section.

3.0 DESCRIPTION OF THE PROBLEM ALIEN INVASIVE ORGANISMS IN CANADA AS A WHOLE

3.1 The State-of-Knowledge on Canadian Alien Species

In comparison to many other countries, a great deal has been published about the time of introduction, distribution, spread and impacts of invasive alien species in Canada, especially for vertebrates. Some of this information is summarized and discussed in Appendix 1 which includes literature references for various species. Some general taxonomic books also provide summaries of distributions, recent spreads and the like. Particularly useful are Birds of Canada

(Godfrey 1986), Mammals of Canada (Banfield 1974) and Amphibians & Reptiles of Canada (Cook 1984) and a wide range of floras, as well as more specific articles. However, not surprisingly, little indeed is known about the alien-versus-native status of the overwhelming numbers of invertebrate species, particularly insects, arachnids, fungi, algae and bacteria found in Canadian waters, soils and as parasites on different species.

Some of the better studied cases where maps or other information on the gradual spread of a new introduction are available are: the House Sparrow and Starling (Cadman et al. 1987), Leafy Spurge, *Euphorbia escula* (Best et al. 1980; White et al. 1993), Glossy Buckthorn, *Rhamnus frangula* (Catling & Porebski 1994); European Frogbit, *Hydrocharis morus-ranae* (White et al. 1993; Catling and Porebski 1995), Purple Loosestrife (White et al 1993), and the Pacific Treefrog, *Hyla regilla*, in the QCI (Reimchen, 1990-good map).

There are also many articles in various publications documenting the incremental spread of invasives aliens such as the starling, gypsy moth, coyote, garlic mustard, zebra mussel and many others. Hence, assuming some agency is monitoring the spread of newly introduced alien species or expanding native species, it is often possible to anticipate the arrival of the species in a protected area. The spread of the Zebra Mussel is one recent case where such predictions are possible. However, tracing the spread of any known alien species would be a formidable task, usually impracticable considering the enormous size and complexity of land and water areas (hence, guideline No. 1 - see Section 8.0).

Management actions taken against invasive species that occur in areas contiguous with protected areas such as national parks cannot be separated from the regional and broader geographical context within which variously protected areas are nested. Thus, the management of (actual or potential) alien invasives needs to be discussed with adjacent jurisdictions and also in the context of the broader and more fundamental issue of the ecology and biology of the invasive species itself.

However, while a particular invasive can often be ignored in lands outside the Park, the requirement that national parks must retain or restore ecological integrity of their ecosystems means that legally Parks Canada is expected and required to take this matter seriously and to actively address the issues of prevention, control or eradication through policy, budget and management actions in the field. This report should be seen as a preliminary effort toward this end.

3.2 Impact on Protected Areas of Non-Invasive Aliens Growing in Disturbed Habitats

As noted in Section 1.0 this report concerns itself only with invasive alien organisms that can and do invade natural ecosystems and/or compete with, replace, parasitise or predate upon native species. However, disturbed habitats such as roadsides, lawns or lands adjacent to parks provide some special situations. One such special case exists where non-invasive 'alien weeds' (e.g. food species such as alien grasses and forbs) along highway rights-of-way and other disturbed areas in a park attract native animals and thus affect their population levels in the protected area. Native elk and big horn sheep grazing in such disturbed areas along the Trans-Canada Highway would be examples of such *indirect* impacts of these alien roadside weeds on native fauna.

Another example along the main highways of Banff National Park (this would apply to all Parks in southern Canada where there are disturbed roadsides, campsites, town sites, etc.) concerns the indirect impact on ecological integrity of natural areas due to the super-abundance of the common dandelion. This allegedly alien species is extremely abundant in roadsides and lawns in town sites of the park in late May and early June. When fields of dandelions come into flower, their millions of flowers offer a cornucopia of quality nectar and pollen easily accessible (on a conspicuous flat, UV-reflecting, landing platform) to any and all flower pollinators (bumblebees, leaf cutting bees, flower flies) living in the area. In these circumstances, the native pollinating bees and wasps abandon foraging on the native flora to visit only the dandelion flowers. This is thought to cause a significant reduction in seed set of native flowering plants in and close to areas where dandelions are common (Mosquin 1971). No doubt many other cases of the indirect effect on natural areas of proximal non-invasive weeds exist but studies appear to be few and far between.

Another example would be where a Honey Bee (an aggressive alien species) colony is located at the border of a park or protected area. These active bees forage for several miles at least, and are documented as competing directly with native bees thereby affecting the native bees' food supply and hence their population levels and possibly causing local extirpations of native bees (and even some extinctions) as has been found to be the case in Australia where the honey bee is widely naturalized pest (unable to re-locate two excellent references). Of interest here perhaps is that back in the summer of 1968, this author had the good

fortune of spending the entire spring and summer studying pollination ecology of the flora & pollinating insect fauna in the Bow Valley (including Sunshine Meadows) where not a single specimen of the domesticated honey bee was seen among the rich native (i.e. ecologically integral) pollinating fauna.

No doubt there is an abundance of cases where the alien inhabiting a disturbed site has some subtle or indirect effect on the naturalness of the adjoining natural ecosystem and which only careful *in situ* field research would be able to identify and elucidate. The above examples show that sometimes distinguishing between the effects of a problem invasive species (i.e. one invading natural ecosystems) and a non-invasive species (ie. one that does not invade natural ecosystems) is not a clear-cut matter.

3.3 Linkage between Alien Invasives and Geography

Guidelines for alien species management in parks and other protected areas need to be framed within the context of Canada's geographical position and the recognized diversity and nature of ecozones of the country. This is because both the seriousness of the problem across the width and breadth of Canada as well as the potential or probability of new alien invasives arriving successfully in the future are strongly linked to our geography and our climate.

As a general and useful rule the impact of invasive aliens is greatest in subtropical and warm temperate regions of the world and particularly so on warm oceanic islands where unique faunas and floras have evolved in the security of isolation and where the effects of invasive aliens can be rapid and dramatic (Drake et al. 1989; McKnight 1993; Sandlund et al. 1996).

In Canada as in other parts of the world, certain habitats and ecosystems are far more susceptible to invasives than others. As a generality, the problem of alien invasives in natural systems is sometimes serious in parts of southern Canada but is essentially non-existent in the North. Thus, as far as is known, natural (undisturbed) tundra ecosystems of Canada contain not a single exotic species. While "weeds" from more southern regions are present, these are of no concern in this report since they occur only in places heavily disturbed by human settlement, such as roadsides, docks, villages, trails and the like. Thus, for practical purposes, there is no need for contemplating management guidelines for existing alien species in all those national parks or portions thereof where tundra ecosystems dominate except possibly a guideline to ignore the presence of alien

species in any parks or portions thereof where tundra ecosystems dominate.

The linkage between climatically determined vegetation zones and the success of alien invasives is recognized in some literature. Thus, Usher (1988) who summarized the results of studies in 28 reserves around the world (Duffey, 1988) noted that: "The most important generalisation is that all nature reserves, except those in Antarctica, appear to have invasive species." However, while there is a small tundra zone in Antarctica, none of the reserves examined by Usher (1988) were located in the Tundra zone of North America nor in any of the extensive Boreal ecozones of the Northern Hemisphere.

3.4 North American Versus Invasives from other Continents

Two categories of invasive alien organisms are sometimes recognized in Canada: those that are native to North America but that have extended their ranges due to human activities, and those that originate from other parts of the world.

A number of papers indicate the importance attached to the question of the natural historical range of a species that is being considered for re-introduction into a park or removal from the park. However, it is not always easy and straightforward to determine whether an organism was present in an area in "historic times." Three examples wills serve to illustrate this point. First, 500-year old fossil remains of Bison in Alaska (Peak et al. 1987) are considered to be a relevant factor in determining their status as a native or an alien in national parks in Alaska. Because of these fossils, the US National Park Service treats (the "re-introduced") bison in Alaska parks as native. This decision to accept recent fossil evidence of a valid criterion for "nativeness" is important to Parks Canada since obviously, the bison of 500 years ago in Alaska could only have travelled there through Yukon.

Another example is that of the native versus alien status of the giraffe in southern Africa. Thus, Goodman & Tomkinson (1987) examined the former distribution of the giraffe and conclude that the probability that it ever occurred in Zululand prior to their introduction is extremely small. They suggest it be classified as alien to Zululand, and note that this has implications to management.

A third example concerns mountain goats in Olympic National Park, Washington. Thus, Carlquist (1990) and Houston & Schreiner (1994) describe the historical research that has gone into attempting to determine whether mountain

goats were ever native the Olympic Mountains prior to their deliberate introduction in the 1920s and concluded that the goats should properly be classed as aliens. A management plan is in place (Carlquist 1990; Houston et al. 1991). However, a management controversy as to whether to remove them is continuing in the US.

Many other similar case examples exist from around the world in a wide range of vertebrate and invertebrate groups (Drake et al. 1989; McNight 1993; Sundlund et al. 1996) and where research into the "resident status" of a species is essential to offer guidance as to what sort of management actions (if any) might be justified.

In Canada, and particularly for plants and the larger vertebrates, a wealth of historical information on resident versus alien status exists and this is reported in a number of publications (Scott & Crossman 1973; Banfield 1974; Youngman 1975; Godfrey 1986; McAllister 1990; White et al. 1993; Mosquin et al. 1995, pp.63-66). Depending on species, some of these publications include historical information outlining what is known about the timing and reasons for introductions as well as range maps showing past and present distributions and including extensive references to particular reports and studies. The information from these publications has been essential to this study and has been summarized as necessary in Appendix 1. Each of the alien species entered in the appendix meet the essential basic definition for categorization as an invasive alien organism because in the areas where they are now found they are entirely naturalized and very much a part of the invaded natural ecosystem of an area or region.

The alien organisms that can and do invade natural systems or impact directly on native species across Canada (Appendix 1) are conveniently grouped here into three categories (Tables 1, 2 and 3). Species in each category should be the subject to special and unique consideration with respect to management. The categories are:

3.4.1 Alien Species Introduced from Other Continents

Included in this group are species native to continental areas outside of North America and introduced to terrestrial, freshwater or marine parts of Canada where they now thrive and appear to significantly affect some aspect of natural ecosystems and native species. These are included in the following table (see

Appendix 1 for details & references):

TABLE 1. NON-NORTH AMERICAN ALIEN SPECIES INVADING NATURAL ECOSYSTEMS AND/OR IMPACTING ON NATIVE SPECIES IN CANADA'S PARKS AND OTHER PROTECTED AREAS (list incomplete, especially for fishes and invertebrates)

- chestnut blight
- Dutch elm disease
- white pine blister rust
- butternut canker
- European birch
- Scotch pine
- common buckthorn
- glossy buckthorn
- leafy spurge
- reed canary grass
- garlic mustard
- purple loosestrife
- smooth brome
- Canada thistle
- frog-bit
- Eurasian milfoil
- white mulberry
- Scotch broom
- downy chess
- crested wheat grass
- helleborine
- brown trout
- carp
- sea lamprey
- Norway rat
- wild turkey
- ring-necked pheasant
- chukar partridge
- gray partridge
- starling
- house sparrow
- European hare
- horse
- gypsy moth
- honey bee
- European wasp
- spiny water flea
- cluster fly
- zebra mussel

3.4.2 Native North American Species but Introduced to and Alien in Regions because of Human Activities and/or Actions

These are species that are native to continental North America but have extended their range into new regions of the country either via deliberate human transport or because of habitat changes caused by human activities such as agriculture, forestry, eutrophication and urbanization. However, while the historical evidence for "extensions of range" of native species due to human actions are often very clear, it needs to be emphasized that this is a grey area for

the large majority of native North American Species.

An important question is this: Should people distinguish between natural range extensions versus "human assisted" ones?: When they can, then yes. The reality is that out there in the natural landscape there are thousands of species trying to live wherever they can and are in a state of perpetual dispersion, migration or local extirpation. What happens to such organisms when humans alter the habitat in an area where these species are native? The species may or may not move to extend its range. If it does (even a few kilometres) then the individuals in the extended range would be aliens while those in the historically natural range would not.

One is reminded of the very large numbers of reports of range extensions in the *Canadian Field- Naturalist* or in *Le Naturaliste canadien*. Many of these (especially plants and other non-migratory species) records simply mean that no person has ever collected at the marginal site before. So, it is not worth the effort, in my view, to try to document whether these cases are natural or assisted since uncertainty (and hence, lack of credibility) would remain.

Complicating the picture further is the consequences to the distribution of native species as a result of global climate change. Both extensions of range and local extirpations would be expected. So, "track it if you can" would appear to be an essential element of monitoring the problem alien species, native or not. In these circumstances, to devote budget to tracking known or suspected expansions from historical range would surely be difficult (impossible) to justify.

Table 2 does not include any of these dozens (probably hundreds) of species, but rather only those native species where range extensions have obviously been caused by human actions and that have been historically documented.

And finally the logic of including some species in this group can be questioned. Thus, this report is concerned with "problem" alien species - i.e. ones that invade natural ecosystems or impact on particular native species. In the case if the Loggerhead Shrike, this prairie species has come to nest in a few spots in southern and eastern Ontario. However, it can do this only because the natural ecosystems in these areas (forest) no longer exist.

Similar species would be the coyote and brown-headed cowbird which survive and thrive in their extended ranges due to the creation by humans of open

and fragmented habitat which is an abnormal habitat (e.g. in eastern and Atlantic Canada).

TABLE 2. NATIVE NORTH AMERICAN SPECIES WHOSE RANGE IN CANADA HAS BEEN EXTENDED BY HABITAT CHANGES THOUGHT TO BE DUE TO HUMAN ACTIVITIES, AND INCLUDING DELIBERATE INTRODUCTIONS. (Not including, *inter alia*, extensions due to winter bird feeding (e.g. mourning dove, cardinal, blue jay, house finch and others)

- black locust
- evening grosbeak
- brown-headed cowbird
- loggerhead shrike
- coyote
- racoon
- striped skunk
- beaver
- mule deer
- moose
- grey squirrel
- fox squirrel
- mink
- red squirrel
- snowshoe hare
- red fox
- eastern cottontail
- beaver
- wild turkey
- American toad
- Pacific tree frog
- striped chorus frog
- wood frog
- northern leopard frog
- green frog
- bullfrog

A fascinating historical account could be prepared on each of the above species, something outside the scope of this report although some useful annotations are provided in Appendix 1.

3.4.3 Native Canadian Species but Deliberately Introduced into Islands off Canada's Atlantic and Pacific Coasts.

Another unique group of alien species (included in Table 2 above) includes those that are native to mainland Canada but have been deliberately introduced to certain islands off Canada's Atlantic and Pacific coasts. The largest of these islands are Newfoundland, PEI, Cape Breton, Anticosti, Vancouver Island

and Queen Charlotte Islands archipelago (see Appendix 1 for details on specific species) plus some other smaller islands off the both coasts. Species in this category are included in the Table 3 below.

TABLE 3. : NATIVE CANADIAN SPECIES DELIBERATELY INTRODUCED TO ISLANDS OFF CANADA'S ATLANTIC AND PACIFIC COASTS AND WHERE THEY ARE DEEMED TO BE "ALIEN INVASIVES"

- racoon
- striped skunk
- beaver
- mule deer
- moose
- grey squirrel
- mink
- red squirrel
- snowshoe hare
- red fox
- eastern cottontail
- beaver
- wild turkey
- willow ptarmigan
- American toad
- Pacific tree frog
- striped chorus frog
- wood frog
- northern leopard frog
- green frog
- bullfrog

For each of the above, some historical information on their introductions to these islands, together with references, is provided in Appendix 1.

4.0 THE SPECTRUM OF MANAGEMENT ACTIONS TAKEN WORLD-WIDE TO DEAL WITH ALIEN SPECIES

An eclectic spectrum of management or control actions has been developed and used world wide against invasive aliens, with adaptations to local realities and conditions. No doubt, some methods, such as "weeding" date back to the dawn of agriculture; others have been developed through sophisticated research. Most of these methods are "generic," in that they are effective for a wide range of similar or related species. Only some (e.g. use of pheromone attractants) are species-specific.

Not only can the many methods be used to control or eradicate alien invasives; they are also used with equal or more devastating effect to destroy natural ecosystems to make place for agriculture, and in crop management systems where the intent is increase agricultural production.

Inevitably, except in the most extreme kinds of actions, the nature of the action differs fundamentally depending upon taxonomic group. This is not surprising since the biological organization, behaviour, and chemistry of organisms in various kingdoms, phyla and other taxonomic levels of life right down to species is to different degrees unique and requiring different methodologies including integrated control methods which involve combinations of actions. Thus, depending on the organism, any preventative measures, eradication or management protocols can be fundamentally different. Even within each major taxonomic group such as an Order, Family or Genus, certain actions are feasible for certain species but not so for others.

Depending on the circumstances of the particular organism and/or ecosystem, some actions can be carried out quickly; others involve processes (such as succession or persistent predation) and can conceivably take years, decades and centuries to achieve the desired objective (i.e. eliminate the undesirable alien). Some are morally objectionable to certain individuals or sectors of society, others are not - a subject dealt with in Section 6.0 of this report.

4.1. Categorisation of Actions

Actions are grouped into prevention, mechanical, chemical, biological, indirect and integrated. Each is considered in turn with some examples that appear to be most relevant to alien species management for protected areas. A detailed search of the world literature would no doubt yield additional kinds of actions, particularly ones that are species-specific.

4.1.1 Prevention

Preventing the introduction and spread of alien species in protected areas is a vital element of management. Existing laws can be used. Personnel need to be in place to identify problems and enforce laws. Prevention needs to include efforts by jurisdictions outside the national parks. This matter is further

considered in Guidelines No. 1 & 2.

4.1.2 Mechanical Methods

These methods include the use of machines, hand picking, soil tillage, deliberate fire, shooting, trapping,

- **Hand removal of Plants:** The weed control system used by generations of rural farmers, including European farmer settlers in Canada for farm fields small and large, and is still used by home gardeners, is the hand pulling of weeds, such as mustard from large acreages. Such 'search and destroy' approaches to the removal of alien plants can take place in natural areas such as parks. Although they are labour intensive, organized volunteers can usually readily be found. Such an approach was used at Point Pelee National Park in 1989 (Dunster 1990a; 1990b) when a total of 263.5 person hours was devoted to removing 12 alien herbaceous aliens and restoring some sites with native species. Randall (1993) notes that hand pulling by volunteers is effective in controlling yellow star thistle, *Centaurea solstitialis,* populations on a nature reserve in southwest Oregon.

  This is clearly one of the most "ecologically friendly" approaches to the elimination of an alien species. As well, work by organized gangs of volunteers is available at virtually no cost. The work is "empowering" in the sense that participants can immediately see the results of their work, even though any program would need to continue until seed banks of the target species have been exhausted - a tall order but not impossible for a determined group working over a number of years.

- **Fire:** While burning of terrestrial ecosystems (prairie, savannah, chaparral, forest with a dry season, etc.) has been a method used by humans in deforestation and pasture development over enormous regions of the Earth, this method can be used to great advantage in reducing and sometimes eliminating the preponderance of alien species in projects whose purpose is the restoration of natural prairie ecosystems (Romo & Lawrence 1990; Morgan et al. 1995). For Parks Canada, this method would be applicable to Grasslands National, Riding Mountain, and other

parks which have prairie components.

- **Shooting, snaring, trapping, etc. :** Whether one is intending to manage problem alien species or those native species whose populations have exploded due to human activities (Section 5.2), these well-known methods have been extensively used over hundreds of years. A few examples of the use of these methods would be:
  - reducing (native) deer populations at Point Pelee, Rondeau, Long Point and other special areas;
  - use of helicopter gun ships to reduce (alien) Himalayan Thar populations in the mountains of New Zealand (CCCM 1993);
  - aerial shooting of entire families of (native) elephants in Kruger National park in South Africa, and possibly in other areas.

- **Tillage:** This is a powerful approach (but thus far little-used) method for the eradication of alien species and reduction of seed banks in former agricultural areas which are designated for restoration to its natural condition. It involves the use of plows, cultivators, harrows over several years (i.e. summer fallow). This approach has been used extensively to set the stage for the "re-prairification" of small areas (fields, roadside rights-of-way) in the western United States and Canada (references in Morgan et al. 1993). It can also be used to prepare for the natural regeneration of forest (Keever 1983; Weaver 1980/81).

4.1.3 Biological Methods

Biological control includes a number of techniques centred around the purposeful use of a living organism - predator with the aim of controlling a particular undesirable alien invasive. To achieve control or eradication with living organisms one needs a biological control agent which could be a parasite, parasitoid, pathogen, predator, herbivore insect, antagonist or a competitor (Oduor 1996). Control strategies using living organisms include:

- introduction (classical biological control) of a herbivore or parasite from the 'pest's' area of origin;

- inoculation - repeated releases (of sterile males, for example) so as to prevent pest build-up;

- inundation - where large numbers of natural enemies are cultured and released during critical periods in the life cycle of the crop or other alien species;

- conservation - where measures are taken to conserve and enhance the numbers of natural enemies already present in an area thus decreasing the mortality of the affected species; and

- augmentation - where natural enemies of a pest are at too low a level and the numbers are augmented by artificial rearing and release.

Some examples where biological control has been extremely successful are: Prickly Pear Cactus and rabbits in Australia; water hyacinth in Sudan, the cassava mealybug in Africa (cited in Oduor, l.c.); and the control of Water Lettuce, *Pistia, stratiotes,* (by one weevil) in South Africa. The weevil is currently in process of being introduced into the Seychelles to control Water Lettuce there. In Canada, biological control (by introductions of host-specific herbivore insects or parasites) has been attempted for Leafy Spurge, Purple Loosestrife, Gypsy Moth and some other organisms and there is a growing literature.

The bacterium, *Bacillus thuringensis,* which is effective against members of the Lepidoptera. It has been very via aerial applications for decades in efforts to control population explosions of the (native) spruce budworm.

However, biological control through the introduction of alien species has its risky downside. Thus, there exist dozens of examples of ecological disasters in many parts of the world which resulted from such introductions. A few are:

- the Cane Toad, introduced from Africa to Australia
- mongoose in the Carribean

4.1.4 Chemical Methods

Herbicides/Pesticides: By far, this is the most widely used method for eradicating unwanted animals and plants in agricultural areas. At Point Pelee National Park

"Round-up" and similar chemicals have been used to kill stumps of the black locust *(Robinia pseudo-acacia)*. Herbicides may be used to "spot spray" perennial patches of alien grasses in prairie ecosystems under restoration in prairies for brome.

Anti-coagulant Poisons: Single-dose anticoagulant poisons such as brodifacoum in special bait formulations, and the development of bait stations and aerial application methods for eradicating rodents from islands (Clout 1986). This has been an effective approach to eliminate all rabbits from tropical oceanic islands (Temple 1990). The particular bait station technique was developed in New Zealand and is currently being used by Mark Drever (Simon Fraser University) to eradicate rats from Langara Island (approximately 3000 ha in size and) in the QCI.
Before the introduction of rats, Langara Island was home to the largest sea bird colonies in western North America. Rats are also found in the park islands at the tip of South Moresby (at Cape St. James,) and this method can now be effectively used to permanently eliminate them.

Immunization. An example here is the deliberate immunization of racoons and skunks in Ontario to prevent the spread of an alien invasive - the rabies virus.

Impeding Reproductive Ability: This is the use of hormones to lower reproductive potential of a species by chemically or surgically impeding the reproductive ability of individual animals. This technique has not found common usage because it is new, largely untried, and like live-trapping and removal, requires large numbers of animals to be treated. One method involves implanting a hormone releasing device which interferes with a female's ability to conceive and carry young. Any of these methods could have the positive feature of greater public acceptability but they can be prohibitively expensive.

Pheromones: Considerable research has take place on pheromone attractants for pest species. Some of this has been carried out on aliens, as for example on the gypsy moth.

4.1.5 Indirect Methods

Community Succession: Depending on the ecosystem, different variations of community succession can be used as a technique to eliminate alien species and replace them with ones that are native to the area. These variations can range from simply leaving an area alone (old field succession in forested areas), planting with native (or alien) cover crops, or planting directly with native species which, over the years will come to dominate and influence the rate and nature of succession. There is an extensive an growing literature on this, some of which is cited in this report. The use of this technique can be active or passive depending on local circumstances and the need to obtain the desired objective (elimination of alien species and replacement with what would be the natural or normal ecosystem for that site). Cost can be considerable if time lines are short.

For formerly forested areas of eastern Canada, evergreen plantations are often established on former farm lands. Within a dozen years, these may form dense closed shade canopies, effectively shading out alien grasses and forbs. Depending on the availability of seeds from adjacent natural areas, succession by in-seeding can be quite rapid or take many decades while the "full transformation" of the ecosystem may well take several hundred or more years.

4.1.6 Integrated Methods

Increasingly, the trend today is to employ "integrated pest control methods" and there is an extensive literature. This means that several of the above approaches can be knowledgeably combined to achieve the desired control or eradication of the alien organism. This is not always possible or desirable, however and each case needs to be examined to explore the potential effectiveness and public acceptance. It seems evident that specialist expertise is required to outline options, estimate costs and assess possible consequences.

4.2 Appropriateness of Available Spectrum of Management Actions

As the management of national parks is governed by legislation and policy the extent to which any of the above actions against an alien species are appropriate is examined in light of the National Parks Act and Parks Canada Guiding Principles and Operational Policies.

4.2.1 In the Context of the National Parks Act

The National Parks Act is very general in its Articles but requires that national parks be managed for the "maintenance of ecological integrity." Hence, the meaning of ecological integrity demands some understanding something within the easy reach of any person with average intelligence, fortunately. Hence, this concept is discussed briefly below with references to key literature. Deviations from ecological integrity would be considered to be undesirable and invite budget allocations for correction as well as corrective management action.

4.2.2 In the Context of Parks Canada Guiding Principles and Operational Policies

Parks Canada Guiding Principles and Operational Policies (Supply & Services, 1994) provide some general and explicit context for management of alien species in the national parks and national marine conservation areas. Relevant quotes are provided herewith:

- In the preface (p. 8) we find the following general vision: *"Heritage places must be managed in a manner that sustains them and respects their intrinsic values. Heritage places contribute to .... conservation strategies by maintaining ecological integrity and biodiversity of natural areas....."*

- And: *"...efforts will be made to manage areas in their natural state."*

- Under the national parks policy section (p. 35) we read that: *All practical efforts will be made to prevent the introduction of exotic plants and animals into national parks, and to eliminate or contain them where they already exist."*

- Under the national marine conservation areas policy (p. 56) we read that: *"Where marine ecosystems or components thereof have been seriously degraded, Parks Canada will initiate restoration programs in cooperation with others."*

- And further (page 56): *"The introduction of exotic plants or animals into the wild in marine conservation areas will not be permitted."*

As the above directions are quite explicit, Parks Canada management

directives for alien species have not been written. However, of the five management directives covering natural resource management (pesticides; bear management; freshwater sport fishing; use of drugs to immobilize wildlife; fire management; rare, threatened & endangered species; environmental assessment) only one alludes to alien species as follows:

The Management of Pesticides by Parks Canada (Management Directive No. 2.4.1) written in 1995 states that: "The use of pesticides should be proposed only after manual, mechanical or biological control measures have been assessed and found not to be effective, and when responsibility centre managers are satisfied that...the target organism is not naturally occurring and...the insect infestation or plant disease threatens the survival of a species recognized by Parks Canada as threatened or endangered...

So, one can conclude from the above that Parks Canada staff already has some guidelines for what to do and what not to do. But there exists a wide latitude for alien species management (removal, prevention of introduction, etc.) In both the terrestrial parks and marine conservation areas. Certainly any blanket use of pesticides would kill many native, non-target species and therefore it would be violation of policy to contemplate this particular kind of action.

Otherwise, there appears to be nothing in legislation, policy or directives which would prevent almost any means available by machines or science to successfully remove problem alien species and keep them out. Only the constraint of ecological integrity coupled with budget allocation priorities prevent or limit such action. But obviously, due to public perceptions of what is appropriate in a protected area certain kinds of "nasty" actions will be inappropriate and unrealistic politically, unless of course the groundwork in public education and understanding is laid down in advance, another budget and program priority item. This matter is further considered below.

4.3 The Necessity of Understanding Prime Values

The notion that National Parks are places whose purpose is to serve as sanctuaries for nature's wild species and natural ecosystems is a strong one. The reference in the National Parks Act to managing national parks in a manner "...so as to leave them unimpaired for the enjoyment of future generations." reflects this generally held view and provides some legal back-up for this valuation perspective. At least in theory, a kind of "let it be" value system for both wild species and for their natural habitats is a recognition of their intrinsic values.

These are ecocentric and biocentric values and are expected to be defended and promoted by park managers when contemplating specific management actions that will affect native species and natural ecosystems of the parks and conservation areas.

Since the areas we are focussing on in this report are special places - parks and other protected areas, the use of what to many people are morally objectionable, "nasty" (Temple 1990) or "severe" actions such as killing cuddly warm-blooded, furry animals with poisons, guns, snares, clubs, even by helicopter gun ships or automatic weapons in small planes appear to many in the public to be morally wrong and objections can be strong due to suffering and bloodshed associated with such actions. Thus, public objections to the control or removal of alien organisms, particularly if they are large, warm blooded vertebrates can cause unfortunate and ecologically damaging reversals to ecologically sound administrative and political decisions. Here are some examples of where sound ecological decisions were made regarding removal of alien invasives (or native over-abundant species) in Canada but were strongly opposed by the public, mainly on moral grounds.

- the decision to remove all horses from Sable Island in the late '50s. This was met with stiff public sympathy for the horses and caused a reversal in a federal government decision to restore the island's ecology;

- the public outcry which occurred when the total removal of alien horses living on the Sutcliffe miliary Reserve was proposed;

- in Ontario, public opposition to the reduction in deer populations (a native species) at Rondeau, Pelee and Long Point;

- in Hawai`i: where efforts using any means possible to remove feral pigs, including hunting with dogs and shooting was opposed on the grounds of "excessive cruelty to pigs." This, despite the fact that the pigs were totally transforming flora and dependent fauna in protected areas.

- the baby seal "white coat" clubbings off northern Newfoundland.

While the above examples include both alien and native species, the public reaction in each case needs to be anticipated and addressed beforehand. Of course,

some humans object to killing - period, and such views would need to be set aside for the sake of saving the greater good.

4.4 The Imperative of Defining the Moral High Ground

Any program to eradicate larger warm blooded vertebrate species from a protected area using morally offensive methods requires that the agency make crystal clear to the public in advance the ecological reasons that such action is important. No agency benefits from a public uproar opposing actions which obviously may cause pain and suffering even when the action is essential to save or restore ecosystem values that are of far greater importance. To a large extent such public outcries are based upon a lack of awareness on the part of the public of fundamental/prime values that are at stake if action were not taken.

Fortunately for protected area managers, there exists an emerging, scientifically grounded (in geology, evolution, ecology) valuation system upon which management decisions about the "good" and the "bad" of almost any native or alien species can be based. The system requires that the most important (prime) ecological values be comprehended so that the "media" case can be made for controlling the species whose presence or overabundance (due to human actions) is seriously impairing these prime ecosystem values.

It is the ecocentric valuation perspective that provides the essential guiding valuation framework and which enables managers to make the case for optimizing ecological integrity of any protected area by identifying the negative variables that require corrective attention. Ecocentrism is a value system and attitude which reveals that humans are necessarily part of larger, encompassing ecological processes and systems. Ecocentrism recognizes that the planetary system and its major sectoral ecosystems and their health are elements of our world infinitely more important than humans. If and when these controlling and determining systems are retained, respected and protected, humans and their societies become elevated in importance and health; if these systems are valued only for their instrumental or utility aspects, misery and social breakdown are the logical ultimate ends, as we see even today in so many (overpopulated) countries of the world where ecological integrity is devalued and so systematically destroyed, as for example in the miserable regions of Bangladesh, India, parts of Africa and Asia and increasingly so in most countries.

To utilize ecocentrism in the management of alien species, managers must be thoroughly aware of the basic elements of ecosystem norms/standards for an

area to be managed because it is deviations from these time-tested norms and standards that enable logical, purposeful, and publicly defensible decisions to be made and defended. The impact of a problem alien species on the ecosystem constitutes one such deviation but sometimes not the worst one.

So, getting back to "appropriateness," if something is very high value, then more "extreme" and "violent" management actions are justified in protecting the thing of value. For a control program to be successful, key community decision makers need to understand this primal ethical dimension so that their active support can be obtained.

The definition of ecological integrity provided by Stephen Woodley (Woodley et al. 1993) is consistent with the above geological, evolutionary and historical reality. The definition is:

> "*Ecological integrity is defined as a state of ecosystem development that is optimized for its geographical location, including energy input (and output) available water and nutrients and colonization history. For national parks this optimal state has been referred to by such terms as natural, naturally evolving, pristine and untouched. It implies that ecosystem structure and functions are unimpaired by human-caused stresses and that native species are present in viable population levels."*

A number of recent essays/book chapters are recommended for any manager seeking to gain an essential grounding on this topic, so critical to comprehending the underlying reasons for wishing to move the planet and its systems, place by place, piece by piece toward greater, indeed optimal ecological integrity (within the circumstances or our time). These writings (with literature references) are:

- Rowe, Stan, 1990. *Ethical Ecosphere*. This is a chapter (pages 138-142) in a collection of essays published in the book, *Home Place*, by Newest Books. A variant of this essay, *Environmental Ethics - Ethical Ecosphere*, was also published in The Trumpeter 6(4): 123-126.

- Rowe, Stan, 1992. *What 'on Earth' is Environment?* Trumpeter 6(4): 123-126.

- Rowe, Stan, 1994. *Ecocentrism: the Responsive Chord*. Trumpeter

11(2)106-107.

! Mosquin, Ted, Peter G. Whiting and Don E. McAllister, 1995. *Standards/ Norms for Biodiversity.* This is Chapter 3 in the book entitled: *Canada's Biodiversity; the Variety of Life, its Status, Economic Benefits, Conservation Costs and Unmet Needs.* The chapter describes the components of biodiversity - genes, species, ecosystems, functions and the "abiotic" world and for which deviations from norms (deviations from ecological integrity) can be measured or estimated.

According to Eric Ribbens, Biology professor at St. John's University in Minnesota: "Ecosystem integrity is a far better basis on which to delineate how ethical treatment should be determined." (Cited in Holdcamp 1996). As well, a number of interesting articles examine the question of how to judge "naturalness" (Bonnickson 199? ; Anderson 1991).

To conclude, it is the relatively "wild" and "uncontaminated" condition (the evolved standard/norm) of ecosystems and their organisms that would now be present in an area or region had major human influences not so swiftly modified or eliminated these evolved ecosystems in an area or region. A valuation system that is founded on what we know about how the world came to be cannot ever be credibly challenged or questioned. In the words of Berry (in Meeker-Lowry 1988) "the integral functioning of the natural world is the supreme model of managerial success."

5.0 CLASSIFICATION OF PROBLEMATIC ALIEN SPECIES IN CANADA'S NATIONAL PARKS

The categorization of individual alien species given in this section is based on the subjective judgement of the author of this report. It is based in large part upon the author's personal knowledge of each species and associated literature and on a judgement of known ecological consequences of its presence. The classification should be seen as a 'first cut' effort subject to addition, deletions, fine tuning, and the like. Considering the great diversity and number of alien species in southern Canada, and the fortuitous location of Canada's national parks, this table can be greatly expanded through systematic review of the resident

status and the effect of the species on an existing park or a future park in the region. The priority sequence as well as the groupings also reflect judgements made by some other authors (e.g. White et al. 1993 for plants). The classification would benefit from input by parks field staff, ecologists and individual field botanists and naturalists across the country. The key criterion for drawing up this initial classification must be this: what is known or suspected of the degree to which an invasive alien has negative, more or less neutral, or positive effects on native species and the structure and function of the natural ecosystem that has invaded and where it would not have been present except thanks for the deliberate or inadvertent consequences of human activities? Table 4 provides a first cut (with brief rationales and/or notes) as to the reasons for each placement.

5.1. Rationale for Prioritization of Canadian Alien Species

Table 4 provides a summary of the author's subjective assessment of the kind of the practicable categories into which known invasive aliens in Canada's national parks should be grouped for management purposes. This table should be seen as a basis for discussion.

Priority 1 organisms have had the greatest, largely negative impact upon native species and natural ecosystems. In this group we have the Chestnut blight, a fungal disease. Yet, considering the immense ecological importance of this tree in the past, it is puzzling that no effort has been made by Ontario or Canada to select blight resistant seedlings, despite the known fact that there are dozens of scattered individual trees in southern Ontario and adjacent States which are partially or wholly resistant to the blight and which produce copious seed crops (for use in a breeding and selection program) periodically. As for the other species listed as Priority 1, the literature on their impacts is extensive.

Priority 2 alien species are ones whose negative impact is fairly well recognized, but the negative impact of each of these is seen as decidedly less apparent. A valuation framework needs to be clarified in order to which of these species should be moved to Priority 1 or Priority 3.

Priority 3 alien species are unusual in that they are identified for amnesty because the island areas they occupy are nothing but natural extensions of their continental ranges. Until deliberately introduced, their absence in these islands and island archipelagos off Canada's Atlantic and Pacific coasts is seen as being merely accidents of post glacial history. As well, each, as far as can be judged

occupies a niche in its island home not occupied for the most part by other species. All species, whether their populations are on the mainland or the islands have some negative impact on some other species and this is considered within the normal parameters of life. For the above reasons, the presence of populations of these species on these islands is hardly worthy of further Parks Canada action or attention. Again, there is no logical reason why the notion of amnesty should not be applicable to species other than humans and their immediate domesticated animals.

Priority 4 species are targeted for a risk/benefit study before their management status is firmly settled. It should be noted, however, that species like the Mule Deer and the Racoon on QCI are known to have very significant negative consequences to local ecosystems. However, while they occur naturally on nearby mainland British Columbia, their positive input into the ecology of QCI is not known.

Priority 5 species are clearly ones that are here to stay and could not be eradicated except with enormous effort and expense except possibly some of them could be temporarily eradicated from small areas.

TABLE 4. CLASSIFICATION OF INVASIVE ALIENS IN CANADA'S PARKS

(based on author's subjective cost/benefit assessment)

PRIORITY 1 (THE DIRTY DOZEN). INITIATE RESEARCH AND/OR LOCAL MANAGEMENT ACTION ASAP (very severe negative impact on native species and natural ecosystems)

Name	Information
Chestnut Blight	Appendix 1
Common Buckthorn	Appendix 1
Leafy Spurge	Appendix 1
Scotch Broom	Appendix 1.
Garlic Mustard	Appendix 1.
Smooth Brome (in prairies)	Appendix 1. Grasslands NP
Crested Wheat Grass	(in prairies)

Frog-bit	Appendix 1
Eurasian Water milfoil	S. Ont. Que. & S. BC.
Norway Rat (now possible to eliminate from even larger islands)	On islands off Canada's Atlantic and Pacific Coasts, including shorelines of the mainland where seabirds nest.
Brown-headed Cowbird	in areas where it is alien
Carp	across southern Canada
PRIORITY 2. THINK MORE ABOUT IT (Significant negative impact)	
Butternut Canker	Appendix 1
Reed Canary Grass	Appendix 1
Canada Thistle	(western mountains; prairies)
Red Fox	(where alien)
Sea Lamprey	in Great Lakes
Glossy Buckthorn	S. Ontario & eastward
PRIORITY 3. DECLARE AMNESTY (accept as natural in the community and manage as if the species were a native like any other (similar to a naturalized Canadian with all necessary papers)	
Moose	in Newfoundland
Bison	in Yukon
Mink	in Newfoundland, and any other Canadian offshore islands into which it has been introduced
Striped Skunk	in PEI
Snowshoe Hare	in Newfoundland
Beaver	QCI, Anticosti and possibly other islands
Mink	in Nefoundland

Willow Ptarmigan	on Scatarie Island, N.S. right next to Cape Breton Highlands N.P.
American Toad	in Newfoundland
Pacific Tree Frog	in QCI
Striped Chorus Frog	in Newfoundland
Wood Frog	in Newfoundland (it is native in Labrador)
Northern Leopard Frog	In Newfoundland, Vanc. Island, and Anticosti
Green Frog	in Newfoundland and Vanc. Island
Flowering-rush (Butomus)	S. Ont & Que. & PEI
Helleborine	across southern Canada
PRIORITY 4. DESIGNATE FOR A RISK/BENEFIT STUDY (Assess its effect on native species and the integrity of natural ecosystems)	
Mule Deer	in QCI
Racoon	in QCI and PEI
Bullfrog	Where alien. Appendix 1.
European Hare	Southern Ontario
Eastern Cottontail	in southern BC
Grey or Black Squirrel	in southern BC, Sask and NS
Wild Turkey	where alien only
Periwinkle (the marine snail)	Atlantic coast
Tartarian Honeysuckle	prairies and eastern Canada
Honey Bee	within foraging range of protected areas
PRIORITY 5. LIVE WITH THEM (except for small areas, control & eradication unfeasible)	

Dutch Elm Disease	In range of American Elm
White Pine Blister Rust	White & Whitebark Pine areas
Purple loosestrife	across Canada
Downy Chess	prairies & drylands
Evening Grosbeak	where alien
Chukar Partridge	Appendix 1
Gray Partridge	Appendix 1
Ring-necked Pheasant	Appendix 1
Starling	Appendix 1
House Sparrow	Appendix 1
Coyote	where alien
Brown Trout	across Canada
Gypsy Moth	across Canada
Zebra Mussel	Appendix 1
European Wasp	across Canada
European Skipper	Appendix 1
Cabbage Butterfly	across Canada
Spiny Water Flea	Appendix 1
Cluster Fly	across Canada

5.2 The Strange Case of Classifying "Alien Natives"

This seems to be the place to raise a bothersome conceptual question. There is a widespread agreement that when alien invasive organisms impact negatively on natural ecosystems the 'naturalness' of an area has been affected. However, one needs to take a closer analytical look at the word 'alien.' Sometimes human activities cause a species that is ***native*** to increase vastly in

numbers (although the reverse can happen). When that species then drastically affects its fellow native species causing major population losses, or when its large numbers cause a drastic alteration of natural habitat which then becomes unsuitable for some native species which require the habitat for survival and thus causing the extirpation or even extinction of some of these natives, then surely the ecological impact on a natural area can be far greater than that of any invasive alien organism. When this situation develops, an abnormal or "alien" ecosystem can be the result.

Thus, a species does not necessarily have to be an alien in an area to be subject to severe management action for the sake of securing the ecological integrity of protected areas. Such severe control measures were recently used to reduce the total numbers of White-tailed Deer at Point Pelee National Park.

Some other native Canadian species whose populations are greatly increased by human actions are the blue jay, brown headed cowbird, evening grosbeak, ring-billed gull, and others. Individuals of these species are far more abundant than they would otherwise be had it not been for the widespread prevalence of winter bird feeding. Likewise the Ring-billed Gull is many times more abundant than it would otherwise be without the winter food it obtains from human garbage dumps. Here are some details.

- **White-tailed Deer.** In the almost complete absence of predators (black bears, gray wolves), this species can undergo explosive population growth when they are free from hunting as in some protected areas of southern Ontario (Hutchinson et al. 1988, and see extensive Literature Cited and Bibliography in the Hutchinson report). Thus, in Rondeau Provincial Park, Long Point National Wildlife Area, and more recently at Point Pelee National Park, deer populations have reached such high densities as to transform heavily forested habitat into a semblance of open grassland or savanna similar in appearance to over grazed cow pastures. The negative consequences are elimination of required habitat for many rare native plant species and the elimination of forest-requiring habitat for several dozen bird species, particularly neo-tropical songbirds which are in serious decline (Mosquin et al. 1995). The point not to be lost is that here we have a native species which has a far greater negative impact in creating a degraded, abnormal or "alien" ecosystem than do many invasive aliens.

- **Blue Jay.** Here is another example of a native Canadian species whose

superabundance in parts of Southern Canada seems clearly linked to the popularity of winter bird feeding in both urban and rural areas. It is the opinion of the author of this report that the pleasuresome and disarmingly benign human activity of winter bird feeding has vastly increased the resident populations of blue jays across the country from Alberta to Newfoundland. The birds are aggressive in securing food at any artificial feeder, and will repeatedly raid and empty any feeder in short order, carrying food off to distant trees where it is wedged into bark and wood cracks for eating at a later date. Hence, population numbers of these predatory birds may be many times higher than would be the "normal" population in the absence of artificial food. The consequences to the host of neo-tropical bird eggs and fledgelings can only be imagined and numerous photos exists of their nest robbing proclivities. In Lanark County, where it is not unusual to see a dozen blue jays at a glance, entire flocks take to cruising the tree and shrub canopies when neo-tropicals such as warblers, vireos, tanagers, pewees, flycatchers and veeries are nesting. Thus, a seemingly benign human activity (winter feeding) creates major ecological sinks for many species of increasingly rare and threatened neotropical birds.

! **Cattails:** In areas of low or normal eutrophication cattail stands are not particularly dense. However, where eutrophication is taking place, cattails will become so dense as to eliminate other native species. This "alien" abundance not the norm for marsh ecosystems of southern Canada (Keddy pers. comm.)

! **Brown-headed Cowbird:** This parasitic species has greatly expanded its range from the Great Plains across eastern North America and Eastern Canada where it has become abundant due to agricultural activities and fragmentation of the landscape. In these regions female cowbirds parasitize large numbers of nests. Each female cowbird lays some 45 eggs per season in nests of a wide range of small songbirds, many of which continue to decline for this and other reasons.

! **Ring-billed Gull:** Abnormally large populations of this predatory bird now prey on and reduce populations of a variety of birds in many settled areas of Canada where these gulls have become super-abundant in the

summer months.

Some other species could be added to this list, as for example the Mule Deer and the Racoon both deliberately introduced to the Queen Charlotte Islands and both of which drastically alter the forested ecosystem and the composition of animals in tidal flats throughout the islands.

7.0 PROPOSED GUIDELINES

Management guidelines for an invasive alien organism need to reflect what is known about its geographical, ecological, behavioural and physiological attributes so that these can be taken into account insofar as possible during conservation planning, when drafting management directives, or when carrying out possible field actions aimed at controlling or eliminating the alien invader. Canada's unique geographical position (covering temperate and cold regions of the northern half of North America with island archipelagos off our Arctic, Pacific and Atlantic coasts) will mean that guidelines for this country will differ in some important ways from those of warm temperate and subtropical areas of the world, and certainly very different from those that would apply to isolated tropical and subtropical islands around the world.

Another helpful rule would be to recognize and be aware that management thinking and actions will necessarily be very different indeed for invasive aliens in each of the five Kingdoms of life [Procaryotae (bacteria), Protoctista (algae and protozoa), Eumycota (fungi), Plantae (plants), and Animalia (animals).

By their nature "guidelines" are always voluntary and this means that they may or may not be implemented. This is just as well because the scale of the problem of invasive aliens is such that it is entirely unrealistic that budgets would be available to meet the total costs needed to be incurred to control or eradicate even the really destructive alien species in Canada's protected areas.

Certain prescriptions may control or eliminate several alien species at one time (e.g. bring about full canopy development in former naturally forested ecosystems, or, using cultural methods to eliminate numerous exotic aliens in a former prairie ecosystem as a restoration methodology). However, on the whole, management agencies will often focus their efforts on one species at a time. For reasons explained earlier, the Guidelines described and defined here are intended to apply not only to Canadian protected areas, and particularly National Parks, but

to adjacent land and water areas as well.

Guideline No. 1. Monitor in Cooperation with other Agencies and Countries

An essential element in an alien species management program would be to have the capability to detect as soon as possible the location of newly introduced alien species that may invade a park or protected area in the future. This is no easy matter, considering the size of Canada and adjacent parts of the United States and also the range of terrestrial, freshwater and marine ecosystems into which alien species are first introduced and from which they later spread to protected areas (e.g. gypsy moth, garlic mustard). Not only the two countries but also the provinces and states within each are often very much concerned with the ecological and economic damage done by alien species (see Appendix 3, for example). Hence, if the rate of introductions of alien species is to be arrested or at least slowed down, then it is logical that a continent-wide monitoring system be established and maintained involving many jurisdictions.

Once the introduction of a potentially problematical species is reported by a jurisdiction, it may be possible to eradicate the alien before it has spread beyond the feasibility of control.

Not only is there a need to monitor for new introductions, but as well, the monitoring should logically include keeping track of the continuing spread of already well-established problem alien species, regardless of whether management action is contemplated, feasible or undertaken. This would be a formidable task but with modern database and communications technology, the feasibility of such an (inter-institutional) arrangement.

Early detection by monitoring, and depending on the ecological and biological characteristics of a newly discovered alien species in a protected area, it may be possible to eradicate the founding population. This is the case when the population is easily identified, small and local. For example, if the first plants of the Garlic Mustard had been discovered at Point Pelee National Park, the great buildup of a seed bank and the spread of the species could likely have been contained using a cadre of organized volunteers over a number of years. In other cases, particularly if nearby invasive populations are highly mobile and difficult to locate or find, the colonization of all suitable natural habitats in the protected area will be inevitable, as for example in the case of the Zebra Mussel, the Carp or in the case of the coyote spreading into Fundy National Park and other protected areas in the Atlantic provinces. So, again, whether or not early

detection is effective depends on the nature of the invading species.

At the level of individual parks and protected areas, the practicable approach would simply be to have a keen and knowledgeable naturalist be on the lookout for such invasives on a more or less continuous basis.. When an organism is discovered it may be possible to eliminate it before it spreads, although this is sometimes not possible, depending on species (see 6..

The case for early detection is obvious, but does imply that a knowledgeable and perceptive naturalist needs to be on the constant lookout for new, potentially destructive invasives.

Whether or not time and dollars should be spent monitoring a particular invasive alien should obviously be linked to the calculated chances that the data obtained will actually achieve some desirable end. Possibly, monitoring for its own sake can be justified in academic research or when using volunteer effort. Official decisions to spend time monitoring is clearly something that depends on local circumstances and the seriousness of a possible threat from an invasive species. However, in cases where a decision has been made to eradicate an invasive, whether long established or recently arrived, monitoring at sensible intervals would be a logical requirement. Monitoring is particularly necessary when attempting to eradicate destructive aliens from islands as in the case of rat poisoning programs on bird islands along Canada's east and west coasts.

Guideline No. 2: Prevent Introduction

This guideline is closely linked to No. 1 above. It is a specific application of the adage: "A stitch in time saves nine." Obviously, down-the-road costs of eradication, monitoring and containment (and of economic and ecological impacts) can be avoided by preventing introduction in the first place.

The context for this guideline is global (Section 2.0) and this is widely recognized (Drake et al. 1989; Sandlund et al. 1996; Chairman's Report 1996; Nature Conservancy 1996). The Convention on Biological Diversity itself provides evidence of an awareness of the international scale of this problem among nations. Thus, the primary rationale behind the "National Invasive Species Act" passed in the USA in 1996 is that of *preventing* the introduction of additional invasive alien species via ship ballast. But the USA is only one country. Obviously, similar legislation in other countries - targeting specific areas of human activity (e.g. tourism, trade) rather than specific species would be a logical approach to reducing the risks of successful invasions of new species.

However, while means of spread of invasives around the world are known, the scale of human movement and goods these days is so great that the difficulty of enforcing any legislation or regulations would restrict the effectiveness of this approach.

Since the prevention of introduction of new alien invasives is something that concerns a broad segment of society, then obviously, any input from Parks Canada should be part of a larger organized initiative involving the provinces and private sector groups. Monitoring around vulnerable points of entry has been suggested (Clout & Lowe 1996), but this would not be effective along the long Canada-US border where forests and farmland are essentially contiguous.

This guideline implies some considerable knowledge of flora and fauna both in the park and elsewhere in the country and the world and of potential invaders lurking there - a big order. Considering the monumental scale of movement of alien species (3000 species on the move at any one time) it follows that prevention is most critical at an international level. One example of an emerging strategy for possible international action is the agreement among nations to approve Article 8 (h) of the Convention on Biological Diversity (quoted in Section 1.0) which is aimed at addressing the problem of improving the management of alien invasives among and within nations at the global level. Since the country is so large, and since invasives are a varied lot and usually arrive in places far removed from protected areas, at least in Canada, it is probably unrealistic to place much stock in the feasibility of prevention as such. However, in cases where a known invasive first makes its appearance in or near a protected area, obviously control or even eradication may be possible, although efforts may need to be organized and consistent over a number of years, implying staff requirements or the organization of volunteer effort.

There is no particular winning strategy that is necessarily best to prevent new introductions. As an example, Mills et al. (1993), in discussing alien organisms in the Great Lakes, note that:

> "...as long as species are inoculated into lakes, new species will become established regardless of the state or condition of the ecosystem. Potential invaders exist for every state or condition of a lake. Enhanced water quality and improved habitat conditions in the lakes could favour invasion by pollution intolerant species; or the opposite conditions could favour pollution-tolerant species.....Consequently the only effective means to prevent large-scale introductions into ecosystems like the Great Lakes is through

vector management."

Prevention would mean more management of people, their movement and the goods they carry with them, not a likely prospect considering the world today and powerful trends toward greater travel and commerce among people and nations. A list of options that could lead to a reduction in the numbers of alien species introductions over time is presented in the Canada Country Study of Biodiversity (Mosquin et al. 1995:140-141)

Guideline No. 3. Avoid and Minimize Ecosystem (Habitat) Disturbance

It is widely demonstrated in the conservation biology literature that alien organisms will more readily invade disturbed places and fragmented landscapes than 'stable' natural ecosystems and indeed this is the prime reason why many hundreds of "weeds" (Frankton 1955; Crompton et al. 1988; White et al. 1993) in Canada are almost never found in natural ecosystems. Hence, the avoidance of new disturbances and the healing of past injuries (e.g. road removal, reforestation, etc.) in damaged natural ecosystems should be an essential cornerstone of any credible policy to limit invasions of alien species into parks and other areas whose purpose, after all, is to preserve wild native species and natural ecosystems. Core protected areas, the larger the better would meet the requirements of this guideline. The policy of "hardening" heavily used trails to encourage or require pedestrians to keep out of natural habitat is widely used by Parks Canada today as a technique to minimize ecosystem disturbance.

However, some invasives do not require disturbed or fragmented habitat to invade (e.g. garlic mustard, coyotes, starlings, helleborine, and fungal diseases such as chestnut blight, Dutch elm disease, etc.) and this is another reason for prioritizing the list of organisms according to their potential to invade undisturbed and unfragmented natural areas.

Guideline No. 4. Determine Resident Status

An essential guideline is to determine whether or not a particular species is an alien to the region or the protected area. While status is often obvious, or easy to determine by consulting a taxonomist in the group, at other times the residency status can be in dispute and management policy in limbo as well as actions. Appendix 1 lists over a dozen alien invasives whose resident status is not a

foregone conclusion. A determination of "native status" will have consequences to management attitude and policy. However, as described in section 3.4.2 for large numbers of species the determination of resident versus alien status for specific populations is inherently not possible. This uncertainty applies not only to many "North American" species at the limits of their ranges but also to species whose resident status cannot be determined with certainty (earthworms, many insects, numerous microfauna and flora).

The traditional way to make a status determination is through a review of the taxonomic literature on an organism's present and historical distribution. There is now general agreement among conservation biologists and ecologists that it is the "pre-human-impact" historical range of a species that is the essential criterion to apply in determining whether of not any species at a particular location should be considered an alien or not.

To conclude, a park manager or policy maker concerned with alien species management needs to know the historical geographical range of the species, and particularly whether a park of protected areas is included in this historical range. If it is, the species should be classed as native; if it does not, it should be classed as alien.

Notwithstanding accurate determination of status, and as already discussed earlier in this report, the correct categorization of an organism as an alien does not necessarily mean that the species should be considered as a "organisma non grata" in the ecosystem (see rationale for "Priority 3 species in Table 4, and also Guideline No. 7). For each species known to be alien, additional ecological and biological factors need to be considered as already discussed.

Guideline No 5. Recognize the Genetic Uniqueness of Invasive Aliens

An essential requirement of alien species management is to recognize that whatever taxonomic group an organism belongs to, each and every species in nature has unique genetic characteristics (Section 1.3) with regard to its preferred habitat and hence interacts uniquely with other species. As well, its impact on ecosystem structure and function is also predicted to be singularly unique in its "invasibility" characteristics.

In view of the above, the prescriptive approach to the management of each such species should be specific to that species.

Guideline No. 6. Select Species for Cost-Benefit Assessment

When in doubt about the effect of an alien species upon native species or upon the invaded ecosystem, an assessment may be carried out to determine whether the species causes or has the potential for causing harm to native species or ecosystems through processes such as hybridization, predation, parasitism, pathology, interference with communication among other species, competition, and the like. Alternatively, if the species absent an ecosystem is this because of natural/fortuitous reasons, does it fill an unused habitat niche, or provide added food for obviously important native species and functions in the ecosystem. This assessment can be carried out independently of any assessment of the potential benefit or harm to the direct human interest, including but not limited to aesthetics, economics, and health. In this way the management decision to eradicate a known alien species would not be made simply on the basis of "whatever feels right." As this guideline may sometimes be controversial, it is suggested that a special "status report" be prepared for such species or groups of similar species examining the pros and cons of the particular case using both the ecosystem and human based values as noted above. A list of such species is provided in Table 4 (Priority 4 group).

Guideline 7. Declare Amnesty for Qualified Organisms

The notion of an authority (king, president, nation, etc) granting amnesty to a person for compassionate or other reasons is a powerful one in human societies and carries with it a strong conviction of moral rightness. The idea of forgiveness helps to shape fundamental values of what is right and wrong and has long term consequences to the way we live and think. There is every reason to extend the notion of ethical worth to other organisms and this is the basic thrust and logic of this guideline. It simply makes sense and particularly, as in this case, the organisms selected for inclusion are ones that are either relatively neutral or appear to be of obvious benefit to ecosystems in their geographically extended homelands where they appear to fit naturally into the natural ecosystems. Table 4 (Priority 3 group) lists some species that the author of this report believes should best be granted an official amnesty. Many species, around the world would also fall into this category, as for example (in this author's opinion) the Mountain Goat in Olympic National Park, Washington, USA (see discussion in section 3.4)

Official declarations of amnestry would save such species from any further (unproductive) talk or discussion about removal. A procedure should be

developed to officially declare such species to be accepted as being subject to management obligations similar to those applied to native species. Should this guideline be accepted as "ecologically reasonable," the next step would be to establish a formal a small technically competent group to make formal decisions on a species by species basis, much like the operations of COSEWIC.

For homocentric readers who may feel that amnesty declarations should only apply to humans, it is noted that for many decades the principle of the Conservation of Latin names has become universally accepted by taxonomists for all groups of organisms regardless of technical factors such as time of publication, confusion due to synonymy and the like. In this case, as with any official amnesty declaration or recognition, a competent and knowledgeable group makes the decision.

Guideline No. 8. Set Priorities

Obviously, if many undesirable fires are burning one should act to put out the one that is doing or likely to do the greatest damage (except if it is too late - as in the Priority 5 group of Table 4). Similarly, prioritizing the list of specific species for management action is an essential element of control or eradication. Some criteria for setting priorities are identified by Westman (1990) and by Clout & Lowe (1976). According to Mooney (1996) who summarizes the writings of these authors:

> "Control of established introduced species would be decided on the basis of logical priorities relating to biodiversity threat, side effects of control, and the feasibility of achieving and maintaining control. Highest priority would be accorded for control of an extremely invasive species which immediately threatens the extinction of native species or ecosystems and for which acceptable control methods exist. Low priority should be accorded for the control of an introduced species which does not threaten any surviving native species or ecosystems or for species which cannot be feasiblely controlled with available methods. In the choice of control methods, specific approaches are preferable to broad-spectrum ones, ethical methods to questionable ones, and non-persistent toxins to persistent ones. Control success should be measured in recovery of the species or ecosystems for which protection is sought, not merely in the number of target pests killed, or area treated."

Guideline No. 9. Control and Manage Established Problem Species

Since alien species that are already established are usually well known, it is logical that eradication efforts can be immediately directed at these. This is considered to be an important guideline of The Nature Conservancy (1996).

Most national parks already have lists of invasive aliens and obviously there is no particular need to wait before allocating budget and personnel resources to control or eradicate them following the prioritization exercise noted above.

Some unusual situations may arise when contemplating control. For example, no control has ever been attempted (at least in Canada) of the chestnut blight (see Appendix 1) whose devastating impact is well know. Yet, numerous large trees are found today scattered along the northern periphery of its range in Ontario and Michigan which are partially resist to the blight and set copious seed. But no breeding program has ever been undertaken. In other species governments have been extremely slow in pursuing biological control research, a method which on the long run is not only inexpensive, but potentially effective.

Guideline No. 10. Pursue Restoration Vigorously

The idea behind this guideline is to get native species to ***replace*** existing alien invasives. Many small and large areas within Canada's national parks and other protected areas have had their native species removed entirely to make way for agricultural fields, rights of way, gravel pits, town sites and the like. In such areas, there is inevitably an abundance of alien invasives, although only a few may enter nearby natural ecosystems. This is also considered to be an important guideline by The Nature Conservancy (1996). Examples in Canada where restoration has been pursued would be the re-introduction of the southern flying squirrel to point Pelee and the kit fox to GNP . But seeding natives will serve to remove exotics. This is certainly the case for old fields

Restoration should take advantage of a number of innate characteristics of plant communities, particularly canopied forests. As is widely known, shade intolerant trees, shrubs or herbs will not survive in areas where canopied forest is the dominating ecosystem. Thus, in all regions of Canada which are or were naturally forested (such as abandoned upland fields and meadows across Southern Ontario) any shade intolerant alien species in those meadows can be eliminated by encouraging the early development of a full canopy overhead. The inadvertent application of this guideline has resulted in the eradication of Black Locust from

areas of Point Pelee National Park south of the Visitors Centre (Mosquin 1988).

The deliberate planting of old fields with native evergreen and/or deciduous tree species is widely recognized as a method through which a more natural ecosystem can emerge through succession. Patience and initial tending are required, however, and depending on location and tree species planted, the process can take many years before any alien species in the old fields succumb to the effects of shading. Some selective elimination of persistent invasives is usually required in the early stages of this action.

For prairie ecosystems, the methodology for achieving natural or near-natural prairie is outlined in detail by Morgan et al. (1995). This unique and useful manual is an essential re-prairifying areas of former prairie in places like Grasslands National Park. Techniques in eastern forests are different - need long term process since trees take long to grow -plantation route.
Cite the Manitoba prairie thing here. Also common sense. Plantations approach in forests, etc. So native species will automatically replace aliens by out competing them. E.g. Black Locust. Th locust is a perfect example of where native specie can b planted and tended and bingo the locust vanishes.

Guideline No. 11. Develop National Educational Initiatives on Values/Ethics of Ecosystem Conservation and Restoration

As it is imperative to obtain public understanding and support for efforts to eradicate certain alien invasives, and educational program focussing on willdife3 and ecosystem values to be lost or gained when contemplating the eradication of a particular alien. This is particularly essential when large or cuddly warm blooded vertebrates are to be controlled or eradicated. Experience indicates that unless such information exists and the public understands the fundamental values associated with ecosystem protection and restoration, public opposition can be vocal and fierce. Sable Island horses, white-tailed deer at Rondeau, Long Point and Pelee are some examples where such a priori education should be planned and carried out in advance. Recently, a poisoning program to eliminate rats from Langara Island in the QCI resulted in the deaths of a half dozen ravens over which considerable public protests ensued.

Guideline No. 12. Learn the Necessity of "Living with It" - at least for now

The idea of "giving up" on alien species control is anathema to some. For

example, Coblentz is reported to have admonished a meeting in Europe some years ago by saying: "Never, never let exotics be legitimized!" (Culotta 1991). Of course, it makes no sense to give up on really ecologically and economically destructive species (sea lamprey in the Great Lakes, zebra mussels, purple loosestrife and many others listed in Table 1 (Priority 1 and 2 groups in particular)

An interesting example of the 'never give up' attitude is described by Macdonald & Fitzpatrick (1988) who note that for Kruger National Park in South Africa, Park staff have declared some species to be essentially impossible to control, but nevertheless the article recommends that "control strategies" for these species be developed. To find out just what approaches have been and are being used, the original article would need to be consulted. The budget and manpower allocated to these control programs would be of interest.

However, this author believes that it is pointless to continue to be seriously concerned with the alien species (or populations) that are relatively benign or possibly even advantageous in their new homes. Hence, the prioritization of species provided in this report.

Modern research can take surprising turns, and the case of the development of blood coagulants for mammals is a case in point. Use of these chemical is making it entirely feasible to eradicate feral cats and rats from many (even larger) oceanic islands, something that was impossible some decades ago.

In the ideal world, people can continue to monitor, do research, evaluate, etc., the progress of alien species, while recognizing current limitations. While hoping that future research and development will make possible and feasible some new methods of control and eradication.

8.0 CONCLUSIONS

A Global Strategy on Alien Invasive Species is now being prepared by the Scientific Committee on Problems of the Environment (SCOPE) in consort with the IUCN Invasive Species Specialist Group. This is to take several years. The development of this SCOPE document is a necessary step in the direction of reducing the scale of invasions world wide. It can be noted that this is the 11th hour and enormous damage has already been done to marine, freshwater and terrestrial resources and ecosystems by the many thousands of species already solidly "naturalized" in distant lands and waters. However, likely, there are large numbers of destructive aliens that, by chance, have not yet arrived in areas where

they would readily thrive. Hence, the concern worldwide.

In the United States, the Office of Technology Assessment (OTA 1993) stresses that prevention of introduction of alien organisms is the best strategy, but recognizes that "zero entry" is an unrealistic goal. Integrated control programs that use available chemical pesticides, biologically based measures, and genetic engineering remain a necessary part of alien species management. The OTA has criticized Federal alien species policy as a "largely uncoordinated patchwork of laws, regulations, policies and programs," noting that at least 20 agencies are involved. Federal laws leave obvious and subtle gaps, which most States do not fill. OTA's report discusses needs for a more stringent national policy, better management of alien organisms and diseases, growing problems with alien weeds, damage to natural areas, education, emergency action, funding, and gaps in legislation and regulation. Options for Congressional action are raised and their pros and cons discussed. This would be a useful report for Parks Canada. The letter to Vice-President Al Gore (Appendix 3) is part of this increasing awareness as is the effort of the world's nations to begin to address this problem through the Convention on Biological Diversity. It remains to be seen, however, whether significant actions will follow from the millions of words that have been spoken and printed.

9.0 LITERATURE CITED AND CASE EXAMPLES WITH IMPLICATIONS TO MANAGEMENT GUIDELINES

Achuff, Peter L., Arthur W.Bailey, and Lawrence M.. Brusnyk, 1990. Non-native plant management in western region national and historic parks: issue analysis and recommendations. Consultant report to Canadian Parks Service, Environment Canada by D.A. Westworth & Associates Ltd., Edmonton, Alberta. 128 pp. The authors note that: "The main purpose of this study is to develop a general strategy for the management of non-native plants in ten Western Region national and national historic parks (Banff, Elk Island, Ft. Langley, Ft. St. James, Jasper, Kootenay, Mt. Revelstoke, and Glacier, Rocky Mountain House, Waterton Lakes and Yoho." .. In the Executive Summary, the ff. statistics are found: "The 130 non-native plant species were divided into four management priority categories based on their biological characteristics, legislative categories, and degree of threat to park resources. Category 1 (very high priority for control) includes six species: leafy spurge, ox-eye daisy, scentless chamomile, spotted knapweed, tansy, and toadflax. Category 2 (high priority) includes nine species: bladder campion, Canada thistle, field scabious, hound's tongue, Klamathweed, tall buttercup, white cockle, and white and yellow clovers."
[Comment: nowhere did Achuff et al. say that any of these species were invading and degrading natural ecosystems in these parks.]

Achuff, Peter L., 1991. Non-native Plant Management in Western Region National and Historic Parks: Issue Analysis and Recommendations, Phase II. Consultant report to Canadian Parks Service, Environment Canada by D.A. Westworth & Associates Ltd., Edmonton, Alberta. 128 pp. This is a general report. The author notes that: "Control measures should be based on CPS policy which favours techniques that duplicate natural processes as closely as possible and permit the use of herbicides only after manual, mechanical or biological control measures have been assessed and found not to be effective..."

Aduor, George, 1996. Biological Pest Control and Invasives. In: Sandlund et al., 1996 (reference below). pp. 116-122.

Aiken, S.G., P.R. Newroth, and I Wile, 1979. The biology of Canadian weeds, 34. *Myriophyllum spicatum* L. Can. J. Science 59: 201-215.

Alex, J.F., R. Cayouette, and G.A. Mulligan, 1980. Common and Botanical Names of Weeds in Canada. Agric. Can. Publ. 1397. 132 pp.

Aliens Internet Listervers, 1996. Tue, 29 Oct 1996 22:37:44 +1300. Prepared by: Dick Veitch <dveitch@ns.planet.gen.nz>
Reply-To: aliens-l@ns.planet.gen.nz
Interest in this list of lists has been high, so here it is for everybody:

ALIENS-L, established for the Invasive Species Specialist Group of IUCN. It is intended that ALIENS-L serves as an information sharing platform for people who are interested in invasive species of plant and animal - introductions, impacts, eradications and control. To be added to the list: send a message to majordomo@ns.planet.gen.nz In the body of the message (not the subject line) type SUBSCRIBE ALIENS-L On the next line type 2 dashes, or ensure that there is no text that will follow the above command by switching off your automatic signature.

WADERS-L, for anyone interested in waders (shorebirds). Address a message to LISTSERVER@UCT.AC.ZA In the body of the message type SUBSCRIBE WADERS-L YOURNAME Type nothing else in the message. Switch off your automatic signature.

SEABIRD, for anyone interested in seabirds and marine ornithology. Address a message to LISTSERVER@UCT.AC.ZA In the body of the message type SUBSCRIBE SEABIRD YOURNAME Type nothing else in the message. Switch off your automatic signature.

MARINE PESTS for those interested in species that are introduced to the marine environment. Address a message to MAJORDOMO@ML CSIRO.AU In the body of the message type SUBSCRIBE MARINE-PESTS YOUREMAILADDRESS Type nothing else in the message. Switch off your automatic signature.

WEEDS to encourage idea sharing on noxious weeds that impact on U.S.

agriculture. They hope to hear from weed specialists, the nursery industry, environmental and natural resources organizations, agronomists, farmers, scientists in academia and the government sector, and regulatory officials in the plant health arena. Sponsored by and housed at the headquarters offices of the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) in Riverdale, Maryland, U.S.A. Address a message to MAJORDOMO@ INFO.APHIS.USDA.GOV. In the body of the message type SUBSCRIBE WEEDS. Type nothing else in the message. Switch off your automatic signature.

WWD-L is a discussion group on a database of weeds of the world (agricultural and environmental) Address a message to MAISER@PLANTS.OX.AC.UK In the body of the message type SUBSCRIBE WWD-L Type nothing else in the message. Switch off your automatic signature.

INFOTERRA is intended for exchanging information on environmental topics; posing queries to the Infoterra network; requesting information from the United Nations Environment Programme; and raising environmental awareness in general. Address a message to MAJORDOMO@ CEDAR.UNIVIE.AC.AT. In the body of the message type SUBSCRIBE INFOTERRA YOUR@EMAIL ADDRESS. Type nothing else in the message. Switch off your automatic signature.

IRRO-L was set up under initial impetus from the United Nations Environment Programme to provide access to all types of information relevant to the release of animals, plants and microorganisms into the environment. Address a message to LISTSERV@BDT.ORG.BR In the body of the message type SUBSCRIBE IRRO-L YOURNAME Type nothing else in the message. Switch off your automatic signature.

BIODIV-CONV is devoted specifically to the Convention on Biological Diversity and its effective implementation. Address a message to MAJORDOMO@ IGC.APC.ORG In the body of the message type SUBSCRIBE BIODIV-CONV YOUR EMAILADDRESS Type nothing else in the message. Switch off your automatic signature.

BENE is designed to foster enhanced communications and collaborations among those interested in biodiversity conservation and ecosystem protection, restoration and management. Address a message to LISTPROC@STRAYLIGHT. TAMU.EDU In the body of the message type SUBSCRIBE BENE YOURNAME Type nothing else in the message. Switch off your automatic signature.

Anderson, Jay E., 1991. A conceptual framework for quantifying naturalness. Conservation Biology 5 (3): 347- 352.

Asquith, Adam, 1995. Alien species and the extinction crisis of Hawaii's invertebrates. Endangered Species Update 12 (6): 9 pages. A devastating account of the extent of extinctions of insects, snails, spiders, and others (Text of article on the Internet).

Banfield, W.F. 1974. The Mammals of Canada. National Museum of Natural Sciences, Ottawa and University of Toronto Press. 438 pp.

Bonnicksen, Thomas M., (date?). Standards of Naturalness: The National Parks Management Challenge. Landscape Architecture. pp. 120 & 134.

Boudouresque, Charles F., 1996. The Red Sea-Mediterranean Link: Unwanted Effects of Canals. In: Sandlund et al. (reference below). 107-115,

Brockie, RE, LL Loope, MB Usher, and O Hamann, 1988. Biological invasions of island nature reserves. In: Duffey, Eric (Ed.) Biological Invasions of Nature Reserves. Elsevier Applied Science 44 (1&2): 9-36. This interesting paper summarizes the impacts of species introduced by humans upon the natural flora and fauna of these islands and the consequences of various conservation and restoration efforts in more recent time. Islands are:

- Campbell Island, NZ
- Island of Rhum, Scotland
- Salvage Islands, Portugal
- Aldabra Island, Seychelles
- Galapagos Islands, Ecuador

[The discussion in this paper is relevant to islands such as QCI,

Newfoundland, and many smaller islands off Canada's east and west coasts. Impressive bibliography].

Brown, James H., 1989. Patterns, modes and extents of invasions by vertebrates. In: Biological Invasions, a Global Perspective. Edited by J.A. Drake et al. (see below), pp.85-109.

Buckle, James, 1971. Recent introduction of frogs to Newfoundland. Canadian Field-Naturalist 85(1): 72-74.

Cadman, M.D., P.F.J. Eagles, and F.M. Helleiner, 1987. Atlas of the Breeding Birds of Ontario. Federation of Ontario Naturalists and the Long Point Bird Observatory, University of Waterloo Press. 617 pp.

California Exotic Pest Plant Council, 1996. List 1: Most important wildland weeds. (http://www.igc.apc/ceppc/worst.html). 3 printed pages.

Campbell, F.T. 1995. Killer pigs, vines, and fungi: Alien species threaten native ecosystems. Endangered Species Update 12: 3-5

Carlquist, Brad, 1991. Effective management plan for the exotic mountain goats in Olympic National Park. Natural Areas Journal 10(1): 12-18.

Carlton, James T., 1996. Invasions of the world's seas: six centuries of re-organizing the Earth's marine life. In: Sandlund et al. Norway/UN Conference on Alien Species. (See below). 99-102.
This paper summarizes the results of six centuries of invasive marine organisms and the extent to which marine life has been re-organized and impoverished as a result. From the earliest times the ship was a floating 'biological island' as indeed it still is today. Extensive marine shorelines around the world have been ecologically restructured as a result of the organisms transported by ships. Many fouling organisms clung to the outside of these vessels. Carleton calls ballast water an 'international biotic conveyor' and notes that by some calculations some 3000 species are being transported ***per day*** around the world. Here are but a few examples of 'successful' long distance marine introductions.

- An isopod native to the mangroves of the Pacific was introduced into mangroves of the Americas in the late 1800s. It bores into prop roots, killing them. This single isopod has "reset' the seaward history of America's mangrove ecosystems, greatly reducing their extant and the size of the nursery beds for young marine life.

- the periwinkle was introduced from Europe to the shores of North America where it revolutionized the ecological structure of marine shorelines.

- the Japanese oyster has been long introduced into European shores and the American east coast oyster has been transplanted to the west coast.

- A comb jelly (ctenophore) arrived in the Black Sea presumably via ballast water. This carnivore has brought about the complete collapse of the economically important Azov and Black Sea anchovy fishery.

- the North Pacific starfish (seastar) has been introduced to southern Australia.

- Shipworms (bivalve molluscs) bored deep into the wooden hulls of early sailing vessels which took the European shore crab...to America in the early 1800s and the American mud crab....to Europe in the late 1800s.

- Shipworms and the tiny boring crustaceans known as 'gribbles' (isopods of the genus Limnoria) that destroy wooden piers and pilings around the globe, are perhaps the 'biological ghosts' of maritime history.

- Sundet (1996) describes how the large King Crab was deliberately introduced from the Bering Sea to the shores of northern Europe, drastically altering the predator/prey dynamics of marine shoreline life. The management of this species is now of major concern (Chairman's Report 1996).

- Boudouresque (1996) describes how the cutting of the Suez Canal in 1869 was the cause of some 300 species of Red Sea and Indo-West Pacific origin invading and settling in the Mediterranean with only a few species

moving in the opposite direction.

- Ogutu-Ohwayo (1996) describes the enormous ecological changes that have taken place following the introduction of the large predatory Nile Perch into Lake Victoria, and particularly causing the extinction of native fish. However, the total metric tonne harvest of fish has gone up from some 40,000 mt to some 450,000. Some 30 large native fishes have been exterminated by the Perch.

- Carleton (l.c.) describes how ocean going ships over the centuries with their cargoes of humans also carried "mature plants, rodents, plant seeds, and insects, the latter two groups mixed in with ballast rock and sand."

- One of worst case stories the impact of exotic species on natural ecosystems world wide is that of freshwater fishes. A global overview of these impacts is provided by Courtenay (1993) who notes that deliberate introductions date back to prehistoric times in eastern Asia and to Roman times in Europe. He lists 74 alien fish species introduced into the USA alone from other parts of the world. A similar story is repeated for virtually all larger lakes around the world.

di Castri, Francesco, 1989. History of biological invasions with special emphasis on the Old World. In: Biological Invasions, a Global Perspective. Edited by J.A. Drake et al. (see below), pp.1-30.

Catling, Paul M. and Z.Sue Porebski, 1994. History of invasion and current status of glossy buckthorn, *Rhamnus frangula*, in Southern Ontario. Can. Field-Nat. 108 (3): 305-310.

Catling, Paul M. and Z.Sue Porebski, 1995. The spread and current distribution of European frog-bit, *Hydrocharis morus-ranae* L., in North America. Can. Field-Nat. 95 (2): 236-241.

CCCEA (Canterbury Conservancy Conservation Management Series), 1993. Himalayan Thar Control Plan. Department of Conservation, Te Papa Atawhai, Christchurch, N.Z. 68 pp.

Chairman's Report, 1996. Norway/UN Conference on Alien Species. The Tronheim Conferences on Biodiversity. Conclusions and Recommendations from Presentations and Discussion. 1-5 July 1996. 36 pp. (See related citation below: Sandlund et al. 1996).

Cheater, M. 1992. Alien Invasion. Nature Conservancy, Sept./Oct. 24-29.

Choi, Y.D. and N.D. Pavlovic, 1994. Comparison of fire, herbicide, and sod removal to control exotic vegetation. Natural Areas Journal 14: 217-218.

Clout, M. 1995. Introduced species: the greatest threat to global biodiversity? Species 24: 345-36.

Clout, Michael N., and Sarah J. Lowe, 1996. Reducing the impacts of invasive species: the role of IUCN Invasive Species Specialist Group. In. Sandlund et al. 1996 (cited below) pp. 34-38. [some discussion of guidelines].

Clout, Michael N., 1986. Biological conservation and invasive species: the New Zealand experience. In: Sandlund et al. 1996 (cited below). pp. 161-166.

Coblentz, Bruce E. 1990. Exotic organisms: a dilemma for conservation biology. Conservation Biology 4(3): 261- 265.
Abstract: "Human-induced problems in resource conservation fall into three categories: (1) inappropriate resource use; (2) pollution; and (3) exotic organisms. Problems of resource use and pollution are correctable; exotic organisms are frequently permanent and may be the most pervasive influence affecting biodiversity in may systems, particularly on oceanic islands. Invasive exotic organisms often have effects far in excess of what might be predicted by equilibrium island biogeographic theory; a single exotic species may cause numerous extinctions in addition to altering the physical environment. Exotic organisms frequently cause environmental crises. In such cases, calls for more research are commonplace, but research results may be an unfordable luxury, providing information only for the eulogy. Programs to eradicate exotic organisms provide an opportunity to combine good science and good conservation into functioning conservation biology."
[In the text, he has a quote regarding action: "If you are going to talk, talk;

if you are going to shoot, shoot." This is taken from TUCO (The Good, the Bad, and the Ugly). He says that many academic scientists view exotic organisms only "as vehicles with which to test theories of island biogeography, the predictability of successful invasion, population growth models, competition, and evolution." The author's main work in the past several decades has been: "to relentlessly pursue the control of feral animals on islands."]

Cole, F.R., Medeiros, A.C., Loope, L.L., and Zuehlke, W.W., 1992. Effects of Argentine ant on arthropod fauna of Hawaiian high-elevation shrubland. Ecology 73 (4): 1313-1322.

[This is a case of gradual spread from a point source on an oceanic island. Many similar cases of the documented spread of an invasive alien exist for continental areas. It is the management response that is of interest. The authors describe the example of the Argentine ant now established in portions of the high-elevation shrubland of Haleakala National Park, Maui, Hawaii, over the past 25 years. They note that:

"this ecosystem lacks native ants but possesses many locally endemic and rare arthropod (insects, spiders & kin) species. Pitfall trapping and under-rock surveys were conducted to determine the effects of this ant on the local arthropod fauna. More than 180 taxa were sampled, mostly Arthropoda. Presence of the Argentine ant is associated with reduced populations of many native and non-native arthropod species, including important predator species and major pollinators of native plants. Effects of ant invasion were particularly severe at higher elevations of Haleakala volcano where endemic species normally exist in low densities. Some taxa, primarily alien species, were more abundant in the presence of ants. Invasion of the Argentine ant has locally reduced the abundance of many endemic species in the shrubland ecosystem. Although the spread of this ant species is slow...it appears to have the potential to invade a much larger area of Haleakala National Parks than it now occupies. **Active management of Argentine ant populations will be necessary if the endemic fauna is to be preserved**."

This is a case where good field research on a small species yielded useful data to shape (future!) management action. Also, as this ant spreads, future control or elimination will become ever more expensive and hence is yet another example where control actions should be initiated ASAP]

Conant, Roger, and Joseph T. Collins, 1991. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Peterson Field Guide Series. Houghton Mifflin, Boston. 450 pp.

Cook, F.R., 1984. Introduction to Canadian Amphibians and Reptiles. National Museum of Natural Sciences, Ottawa. 200 pp.

Couch, R. and E. Nelson, 1985. *Myriophyllum spicatum* in North America. In: Proceedings of the First International Symposium on Water milfoil (*Myriophyllum spicatum*) and related Haloragaceae Species. The Aquatic Plant Management Society Inc., Vicksburg, Mississippi. Pp 36-39.

Courtenay Walter R., 1993. Biological pollution through fish introductions. *In:* McKnight, Bill N. (Ed.), Biological Pollution: The Control and Impact of Invasive Exotic Species (cited below).

Cowie, I.D., and Werner, P.A., 1993. Alien plant species invasive in Kakadu National Park, tropical Northern Australia. Biological Conservation 63 (2): 127-135.

[The authors provide a useful example of modern day thinking about exotics in protected areas. They conducted a survey of the distribution and abundance of invasive alien plant species in Kakadu National Park in Australia's tropical Northern Territory to provide a basis for management. They note that: "Some 5.8% (89 species) of the vascular flora of Kakadu were considered invasive aliens. The majority of these species were either rare in distribution or widespread but with low mean cover values.. Most were associated with human activities, roadways, and other disturbed ground - habitats comprising a small proportion of the Park. In natural habitats, the most severe infestations occurred in riparian communities, especially those frequented by the feral Asian water buffalo.. The most commonly found species were the annuals *Hyptis suaveolens, Sida acuta, Sida cordifolia, Alysicarpus vaginalis* and *Euphorbia hirta* and the perennial vine *Passiflora foetida*. However, the species considered the most damaging to the integrity of the Park's biota were those capable of dominating relatively undisturbed native plant communities, especially the vulnerable wetlands. The most important of these perennial weeds remains *Mimosa pigra* in wetlands, under control in the Park but occurring in

abundance elsewhere in the region. Also important are *Brachiaria mutica* and *Salvinia molesta* in wetlands and *Pennisetum polystachion* in the uplands. If fundamental changes to the nature and conservation status of this World Heritage Park are to be avoided, an ongoing commitment to controlling invasive alien species (especially *Mimosa*) both inside and outside of the Park is required." Conclusion by me: if there is a serious problem, you have to make a commitment to control or eradication or 'live with it'.]

Crompton, C.W., J. McNeill, A.E. Stahevitch and W.A. Wojtas, 1988. Preliminary Inventory of Canadian Weeds. Research Branch, Agriculture Canada. Technical Bulletin 1988-9E. 292 pp.

Culotta, Elizabeth, 1991. Biological immigrants under fire. Science 254: 1444-1447.

Doren, Robert F., 1992. The Exotic Pest Plant Council. The George Wright Forum 9 (1) 15-19.
[This paper is an example of actual action being taken against some invasive aliens. It discusses the most serious plant pests in the State of Florida: *Melaleuca quinquenervia, Casuarina* sp, *Shinus terebinthifolius*, and *Mimosa pigra*. Since 1986 the following serious coordinated actions were taken:
- production of a "Rogue's Gallery video" 13 minutes.
- The Exotic Pest Plant Council developed a manual of the 23 most serious plant exotics that invade natural systems. A complete list for Florida has been developed and the species ranked as to their destructiveness to natural areas. this outlines the experiences of managers and scientists. The author notes that: "In 1985, EPPC developed a plan to establish a 'buffer zone' to protect Everglades National Park from invasion by *M. quinquenervia* and other exotic pest plants now present east of the park in the area known as the East Everglades. This plan and the relationships developed within EPPC, have recently resulted in joint funding by the State of Florida the Dade County Dept of Environmental Resource Management and Everglades National Park. Thus far the project has resulted in the treatment of all *Melaleuca* found within a 4.8 km strip east of the park and treatment of all *Casuarina* within a 1.6 km strip. Many of

these areas have been re-treated for re-sprouts and for seedlings that have appeared in the years since the since the initial treatment. A half million was spent and then in the years 91, 92 and 93, 1.15 million. Much additional work has been done, including removal of disturbed farming substrate from 60 acres (soon to be 4000) to eliminate the artificial habitat for these trees caused by farming. The total cost of this restoration is around 100 million."The EPPCs responses to some especially severe exotic pest plant problems provides a forum for restorationists struggling with alien species -- and a model for interagency cooperation."]

Dowhan, R. 1978. Exotic Plant Removal, Point Pelee National Park. Internal Report of Parks Canada. 4 pp. + Map.

Drake, J.A., H.A. Mooney, F.diCastri, R.H. Groves, F.J. Kruger, M.Rejmanek and M. Williamson, (Editors), 1989. Biological Invasions: A Global Perspective. John Wiley & Sons, New York, Toronto. 525 pp. [Includes some 22 contributions].

Drost, A., and Gary M. Fellers, 1995. Non-native animals on public lands. In: LaRoe et al (cited below) pp. 440-442.
[The authors describe the problems posed by major invasive species on state and federal public lands. A survey of 937 national parks, national forests, national wildlife refuges, USBLM field areas, and state and private land management areas identified 205 exotic animals as species of management concern. Introduced mammals were the group must often reported as problematic, followed by non-native fishes. Of the species identified, 73 were targeted for control or eradication, with feral cats the focus of the greatest number of management efforts].

Duffy, Eric (Ed.), 1988. Biological Invasions of Nature Reserves. Biological Conservation, Special Issue 44 (1&2): 1-135. The International Council of Scientific Unions (based in Paris) maintains a committee: Scientific Committee on Problems of the Environment (SCOPE). The Committees struck up the "Working Group on Nature Reserves" to examine the ecology of invasive plants, animals, fungi and microbes, concentrating particularly on those which have successfully invaded non-agricultural regions and which have disrupted natural ecosystem processes. The

program aims to answer three specific questions, namely:

1) What are the factors which determine whether a species will be an invader or not?
2). What are the site properties; which determine whether an ecological system will be prone to, or resistant to, invasion?
3) How should management systems be developed to use the knowledge gained from answering questions 1 and 2?

The six papers (by Usher et al.; Brockie et al.; Macdonald et al.; Macdonald & Frame; Loope et al., and Usher) are included in this list of references.

Dunster, Katherine, 1990a. Exotic Plant Species Management Plan; Point Pelee National Park. Consultant report to Parks Canada, Ontario Region, 131 pp.

Dunster, Katherine, 1990b. 1989 Volunteers Vegetation Management Project, Point Pelee National Park. Consultant report to Parks Canada. 60 pp.

Eighth Grazing Lands Forum 1993. An explosion in slow motion: noxious weeds and invasive alien plants on grazing lands. Eighth Grazing Lands Forum. Sponsored by a coalition of 29 organizations, Federal agencies and professional societies. Washington. 63 pp. Information at Internet location: <grasslands-mg@oes.orst.edu>, or D Hannaway (503)737-5863.

Elton, C.S. 1958. The Ecology of Invasions. John Wiley, New York.

Environment Canada, 1994. Alien species focus group final recommendations. Biodiversity Convention Office, Environment Canada, Ottawa. 3 pp. Internet location <http://www.doe.ca>. (and see Appendix 2).

Environment Canada, 1995. Canadian Biodiversity Strategy: Canada's Response to the Convention on Biological Diversity. Biodiversity Convention Office, 80 pp.

Fensham, RJ. 1996. Land clearance and conservation of inland dry rainforest in north Queensland, Australia. Biological Conservation 75 (3): 289-298.

[In Queensland, national parks have been established to secure protection for important remnants of the dry rainforest (17 to 23 degrees S). Several serious exotic species affect the forest and particularly *Lantana camara* which greatly increases flammability of the vegetation according to Fensham (1996). The author notes that: "Provided that further land clearance is restricted, it is suggested that dry rainforest conservation is compatible with cattle grazing given appropriate active management. However, the preservation of dry rainforest will require management of the broader landscape, and small reserves that do not contain extensive areas of surrounding habitat may not be secure on the long term." This is a case where an alien species is a problem because it increases fire potential. (same as that African grass in Costa Rica (see the Janssen book)].

Frankton, Clarence, 1955. Weeds of Canada. Canada Dept. of Agriculture, Ottawa, Ontario. Publication No. 948. 196 pp.

Gleason, H.A., 1926. The individualistic concept of plant succession. Bulletin of the Torrey Botanical Club 53: 7-26.

Godfrey, W. Earl, 1986. The Birds of Canada. National Museum of Natural Sciences, National Museums of Canada. 595 pp.

Goodman, P.S., and A.J. Tomkinson, 1987. The past distribution of Giraffe in Zululand, South Africa, and its implications for reserve management. South African Journal of Wildlife Research 17(1): 28-32.
["The evidence of past distribution of giraffe in Zululand is critically re-examined. On the basis of this, it is concluded that the probability of giraffe having ever occurred in Zululand prior to their introduction is extremely small. As a consequence of this, and according to the definition of an indigenous species favoured by us, we suggest that giraffe should be classified as an alien to Zululand. This classification has implications affecting management of giraffe in Natal Parks Broad areas, and possibly affecting policy in relation to alien species. These implications are discussed."]

Guidelines for the co-ordinated management of noxious weeds in the Greater Yellowstone Area of Idaho, Montana and Wyoming.

[No information available on this report, but the guidelines might be useful].

Haber, Erich, 1996. Literature update on the biology and control of invasive exotic plants in Canada [to December 1995]. Prepared for The Canadian Wildlife Service, Environment Canada, Ottawa. 41 pp.

Haber, Erich, 1996. Invasive plants of Canada, 1996: national survey results. Produced for the Biodiversity Convention Office, Environment Canada, Ottawa. 31 pp.

Harty, Francis M., 1993. How Illinois kicked the exotic habit. In: McKnight 1993 (reference below). pp. 195-209.
[some excellent examples of bloopers in the past and the changeover to more enlighted management thinking and policies]

Hengeveld, Rob, 1996. Problems of biological Invasions - a global overview. In: Sandlund et al. Proceedings of the Norway/UN Conference on Alien Speices (cited below). pp. 18-29.

Heritage Resource Centre, 1994. Ecological Monitoring and National Parks. Edited by A Skibicki, A. Stadel, D. Welch & J.G. Nelson. Proceedings of a Workshop held at Univ. of Waterloo, 17-20 January, 1994. Working Paper No. 7. With Parks Canada, Ottawa. 373 pp.

Hester, F.E. 1991. The U.S. National Park Service experience with exotic species. Natural Areas Journal 11(3): 127-128.

Heywood, Vernon H., 1989. Patterns, extents and modes of invasions by terrestrial plants. In: Biological invasions, a global perspective. Edited by J.A. Drake et al. (see below), pp.31-60.

Hobbs, Richard J. 1992. Disturbance, diversity and invasion: implications for conservation. Conservation Biology 6 (3): 324-338.

[The roles of a variety of disturbances, nutrient inputs, fragmentation, and trampling--in grasslands and other ecosystems are considered. In the

future, nature reserve managers will have to consciously direct the disturbance regimes un areas under their supervision.]

Holdcamp, Wendee, 1996. The Exotic Species Dilemma. <http://manatee.envirolink.org/Eolink/new.html>

Holm, L.G., D.L Plucknett, J.V. Pancho, et al. 1977. The world's worst weeds: distribution and biology. University of Hawaii, Honolulu. [not examined].

Houston, Douglas B., Edward G. Schreiner, Bruce B. Moorehead, and Richard W. Olson, 1991. Mountain goat management in Olympic National Park: a progress report. Natural Areas Journal 11(2): 87-92.

Houston, Douglas B., and Edward G. Schreiner, 1995. Alien Species in National Parks: Drawing lines in space and time. Conservation Biology 9(1): 204-209. [This paper suggests that the US National Park Service should "consider the advantages of narrower policy guidelines for defining alien and native species; a policy without defined temporal and spatial bounds might lead to a 'whatever feels right' approach to the management of particular species. This could eventually undercut the value of parks as baseline ecological reserves. We recognize that framing workable guidelines will not be easy and that the attention of ecologists, paleontologists, and conservation biologists will be required." Another potentially useful quote: "The concern of the National Park Service with alien species may be understood more fully when viewed in the broader context of national parks management goals."]

Hutchinson, B.C., T. Mosquin and W.B. Ranta, 1988. White-tailed Deer Management Plan for Point Pelee National Park. Consultant Report to Parks Canada, Ontario Region. 72 pp. + Appendices. [Extensive bibliography on deer ecology and management].

Kaiser, J. 1986. Exotic species of plants that are potential weeds in natural areas. In: Proceedings of the Annual Meeting of the Ontario Chapter, Canadian Land Reclamation Association, Jordan Harbour, Ontario.

Keever, Catherine, 1983. A Retrospective View of Old-field Succession after 35 Years. The American Naturalist 110 (2): 397-404.

Kendall, Katherine C., 1995. Whitebark Pine: Ecosystem in Peril. In: LaRoe et al. (Cited below) pp. 228-230.

Kunzmann, M. R., S. Buckmann, J. F. Edwards, S C. Thoenes, & others. 1995. Africanized Bees in North America. In: LaRoe et al. (Cited below) 448-451.

LaRoe, Edward T., Gaye S. Farris, Catherine E. Puckett, Peter D. Doran and Michael J. Mac, 1995. Our Living Resources. A Report to the Nation on the Distribution, Abundance, and Health of US. Plants, Animals, and Ecosystems. US Department of the Interior, 530 pp.

Lumsden, R.D. and J.L. Vaughn, eds. 1993. Pest management: biologically based technologies. Proceedings of Beltsville Symposium XVIII, Agricultural Research Service, U.S. Dept of Agriculture, Maryland 2-6 May, 1993. 435 pp.[not examined]

Langdon, Keith R., and Kristine D. Johnson, 1992. Alien forest insects and diseases in Eastern USNPS units: Impacts and interventions. The George Wright Forum 9 (1): 2-14.
[This paper identifies some alien forest insects and diseases of concern. These include: (a) White pine blister rust introduced by reforestation agencies in about 1888; (b) Butternut Canker which comes from Europe or Asia where most *Juglans* have it. Time of introduction is not known. An interesting quote from this paper : “The use of biological control agencies has been successful against many alien insects, but not against many fungi. Classical bio-control reunites an alien pest with its natural predators and parasites from which it was released by being imported into the new continent without them or by having been lost during the initial colonization. It is not a panacea but should be applied to more forest pests. The process is expensive and takes years to develop before organisms are ready to be released with confidence that their introduction will not be detrimental to non-targets.”].

Loope, L.L., P.G. Sanchez, P.W. Tarr, W.L. Loope, and R.L. Anderson, 1988.

Biological invasions of arid land nature reserves. In: Duffey (1988) see reference above. pp. 95-118.
[Case descriptions of invasions in Death Valley National Monument, Canyonlands & Arches National Park, Organ Pipe Cactus National Monument, Skeleton Coast Park (in Africa's Namib Desert) and Channel Islands National Park. These are areas with severe water stress for most of the year. In the Channel islands, wherever introduced goats and rabbits have been removed native shrubs begin to replace alien invasives. Control of invasives is through chemical and mechanical methods. The example of control of a Eurasian Tamarix is discussed and the authors note that: "...the invasive genus Tamarix affects dozens of reserves in southwestern USA , some very severely. Since the genus belongs to a family not native to North America (so that its natural enemies would not be likely to affect native American plant species), it would appear to be an outstanding candidate for biological control. The greatest barrier to development of a biocontrol program .. may be opposition from apiculturists, who feel that Tamarix spp. Are important pollen producers for their commercial hives of *Apis mellifera*..". The criterion of when to justify the search for biocontrols may be applicable to some Canadian protected areas.]

Macdonald, IAW and Fitzpatrick P., 1988. The history, impacts and control of introduced species in the Kruger National Park, South Africa. Transactions of the Royal Society of South Africa 46 (4): 251-276.
[Kruger National Park seems to be one of the few protected areas where control and elimination of exotics was supported by both budget and policy. The history and environment of this protected area (19,485 km^2) is described, and the growth in awareness posed by is documented. The abstract for this article states... "Protected since 1898 and proclaimed as a national park in 1926, the first major policy decisions and control programmes for introduced species were initiated in the 1950s. Eight introduced pathogenic micro-organisms, 113 higher plants, two molluscs, one ant, one fish, one bird and two mammals have become "invasive" in the park. Only the micro-organisms and seven of the higher plants (comprised of 3 floating aquatic macrophytes, one tree one shrub, one cactus and one herb) are considered to have serious ecological impacts on the Park. The control programs that have been carried out are described: seven of the 25 invasive species of trees and shrubs and three of 88 plant

species of other growth forms have been eliminated. With current technology, control is considered feasible for a further 13 and one species respectively. Intentional and accidental introduction by man and waterborne dispersal into the Park down the major influent rivers are of major importance. Infestations of introduced plants are negligible in the frequently fired savanna vegetation while the rivers, river beds and riverine fringes have heavy infestations. Fire and ungulate herbivory are considered important factors limiting plant invasions. Control of certain introduced plant species along these rivers has proven to be difficult if not impossible, and the growth in the allocation of manpower and funds to these control programs is documented. The importance of devising control strategies for these water-dispersed species is stressed." It is of interest that Park staff have declared some species to be essentially impossible to control, but nevertheless the article recommends that "control strategies" for these species be developed. To find out just what approaches have been and are being used, the original article would need to be consulted. The budget and manpower allocated to these control programs would be of interest].

Macdonald, I.A.W and G.W. Frame, 1988. The invasion of introduced species into nature reserves in tropical savannas and dry woodlands. In: Duffey 1988; (cited above) pp 67-93.

Macdonald, I.A.W, D.M. Graber, S. DeBenedetti, RH Groves, and ER Fuentes, 1988. Introduced speces in nature reserves of mediterranean-type nature reserves. In: Duffey 1988 (cited above).

Macdonald, Ian A.W., Lloyd L. Loope, Michael B. Usher and O. Hamann, 1989. Wildlife conservation and the invasion of nature reserves by introduced species: a global perspective. In: Drake et al. (cited above) pp. 215-255.

MacFarland, C. 1991. Goats on Alcedo Volcano in the Galapagos Islands: Help Needed. Conservation Biology 5(1): (Letters to the Editor).

Malacki, R. 1994. Insect biological weed control: an important and under utilized management tool for maintaining native plant communities threatened by exotic plant introductions. In: Transactions of the North American

Wildlife and Natural Resources Conference, 1994. pp. 400-404.

Martin, Richard 1989. Voices cry out for intervention in the wilderness. Insight 5(22): 18-25, A summary of this paper reads: "The Leopold Report, issued in 1963, called for increased emphasis to be placed on the preservation of the primitive qualities of the national parks. Since the report appeared, the Park Service has phased out artificial intrusions like elaborate tourist facilities, and has phased in practices more conducive to wilderness preservation. Among the new approaches are the use of shuttle busses to reduce traffic, campsite reservation and trailhead quota systems, and the reintroduction of many threatened species. Resource management now means hands-off, except where intervention is need to promote troubled species or habitats. Some outside observers assert that the parks' policies are threats rather than aids to wilderness. They cite the decline of native species due to exotic encroachment, an overabundance of certain animals, and the small funds available for research. The critics call for a boost in research money, the professionalization of the ranger corps, increased involvement in decisions affecting adjacent lands, and an overall revision of natural regulation policy." [Not reviewed, but the reference to exotic species in parks is what caused it to come up in the data search].

Maunder, John E., 1983. Amphibians of the Province of Newfoundand. Canadian Field Naturalist 97(1): 33-46.

Mayhood, D.W. 1991. What is ecological integrity? Appendix in: Managing the fishes of Jasper National Park 1991-2000. Report prepared for Canadian Parks Service, Jasper, Alberta, by Freshwater Research Limited, Calgary, Alberta. 52 pp.(+ the appendix on ecological integrity).

McAllister, Don E., 1990. A List of the Fishes of Canada. Syllogeus No. 64. National Museum of Natural Sciences, Ottawa. 310 pp.

McKnight, BN. (Ed.) 1993. Biological Pollution: The Control and Impact of Invasive Exotic Species. Indiana Academy of Science, Indianapolis. 261 pp. Twenty papers presented in a symposium held at Indiana-Purdue Uiniversity at Indianapolis on October 25 & 26, 1991. (Some papers reviewed and cited in this report).

Meeker-Lowry, 1988. Economics as if the Earth really Mattered; a Catalyst Guide to Socially Conscious Investing. New Society Publishers, Santa Cruz, Calif. 282 pp.

Mills, E.L., J.H., Leach, C.L., Secor, and J.T. Carlton, 1993. What's Next? The Prediction and Management of Exotic Species in the Great Lakes (Report of a 1991 Workshop). Great Lakes Fishery Commission, Ann Arbor, MI. 22 pp. [A brief appraisal of some facts and issues the issues associated with troublesome invasive species, policies, research and management strategies for prevention of future introductions and control of aliens already present in the Lakes along with recommendations].

Minister of Supply & Services, 1994. Parks Canada Guiding Principles and Operational Policies/ Canadian Heritage. 125 pp.

Moore, SE, GL Larson and B Ridley. 1986, Population control of exotic rainbow trout, *Salmo gaerdneri*, in streams of a natural area park. Environmental Management 10 (2): 215-220.
[Showed that in over a half dozen years one can significantly reduce rainbow trout and increase native brook trout in park streams.] This paper describes a case of the rehabilitation of the native brook trout in small streams and lakes of the Great Smoky Mountains National Park using backpack electrofish shockers. The work, done between 1976 and 1981 focussed on four small remnant brook trout populations and removed rainbow trout and to evaluate population responses of the brook trout. The authors note that: "Rainbow trout were greatly reduced in density after up to six years of electrofishing, but were not eradicated. Rainbow trout recruitment, however, was essentially eliminated. Brook trout populations responded by increasing in density (including young-of-the year) but rates of recovery differed among streams. The maximum observed densities in each stream occurred at the end of the project. The findings suggest that electrofishing had a major negative impact on the exotic species, which was followed by positive responses from the native species in the second and third order study streams. The technique would probably be less effective in larger (fourth-order) park streams, but as an eradication tool the technique may have its highest potential in small, first order streams. Nevertheless, the technique appears useful for population control without

causing undue impacts upon native aquatic species, although it is labour intensive, capture efficiency is greatly influenced by fish size and stream morphology. To completely remove the exotic fish from selected streams, different technologies will have to be explored and developed." Possibly this is method or use the mountain parks?

Morgan, John P., Douglas R. Collicutt and Jacqueline D. Thompson, 1995. Restoring Canada's Native Prairie: A Practical Manual. Prairie Habitats, Box 1, Argyle, Manitoba R0C 0B0. 84 pp.
[Any projects whose goal is the elimination of alien species from an area through management sometimes requires the deliberate re-introduction of native species formerly present at the site. This book, which applies to areas of former prairie, covers the topics of planning, species selection, acquiring seeds, seed processing, plant propagation, site preparation, seeding, alternative techniques, special restoration sites, seed sources, equipment and other practical matters that need to be known to guide a person or agency in prairie restoration. Applicable particularly to Grasslands National Park.]

Morrison, M.L., T. Tennant, and T.A. Scott, 1994. Laying the foundation for a comprehensive program of restoration for wildlife habitat in a riparian floodplain. Environmental Management 18 (6):939-955.
[This is a study of species loss and gain carried out in the Sweetwater Regional Park, San Diego County, California. Report concludes:
- there has been a substantial loss of native amphibians and reptiles including 4 amphibians, three lizards and 11 snake species;
- the small-mammal community was depauperate and dominated by the exotic house mouse and the native western harvest mouse. It appeared that either the house mice are exerting a negative influence on most native species or that they are responding positively to habitat degradation. There has apparently been a net loss of 13 mammal species, including nine insectivores and rodents, a rabbit and three large mammals;
j - for birds there has been a net loss of 12 breeding bird species (absolute loss of 18 and a gain of 6). A restoration plan is described that provides for creation and maintenance of willow riparian, riparian woodland, and coastal sage scrub vegetation types, guides for separation of human activities and wildlife habitats, and management of feral and exotic species

of plants and animals.[the above taken only from an Abstract.. Possibly could contain some guidelines for control of aliens]

Mosquin, T. 1971. Competition for Pollinators as a Stimulus for the Evolution of Flowering Time. Oikos 22(3): 398-402.
["A study was made of the activities of pollinating insects in relation to the flowering phenology of plants near Banff, Alberta in 1968. From snow-melting time (early May) to the end of May, pollinating insects were abundant and competed actively for relatively scarce pollen and nectar resources. Then, in early June some "cornucopian species" (*Salix* spp. and *Taraxacum officinale* L.) began flowering abundantly offering virtually unlimited supplies of nectar and pollen. Pollinating insects abandoned the spring flowers and were attracted to these cornucopian species. It is postulated that in the presence of cornucopian species natural selection would favour the evolution of earlier- or later-flowering populations of all those species that compete with the cornucopians for pollinators. It was found that in the spring, insects competed for flowers but that after the cornucopian species had completed their flowering (throughout the summer), flowers competed for pollinating insects." This paper has been widely cited in the pollination ecology literature. It relevance is discussed in the body of this report].

Mosquin, T. 1988. Monitoring the Carolinian Forest of Point Pelee National Park. Part I (of 2 Parts). Consultant Report to Parks Canada. 190 pp. + Maps.
[Provides essential management guidelines for the aliens: Black Locust, White Mulberry].

Mosquin, T., P.G Whiting and D.E McAllister, 1995. Canada's Biodiversity: The Variety of Life, its Status, Economic Benefits, Conservation Costs and Unmet Needs. Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa, Ontario. 293 pp.
[Provides a preliminary overview of the problem of invasive alien organisms in natural ecosystems across Canada.].

Natural areas Association, 1992. Compendium on Exotic Species, Articles 1-43. Natural Areas Association, P.O. Box 900, Chesterfield Missouri.

Nature Conservancy (The), 1996. America's Least Wanted: Alien Species Invasions of U.S. Ecosystems. http://www.tnc.org/science/library/pubs/dd/ (Also published in hard copy)

Nuzzo, V.A., 1991. Experimental control of garlic mustard, [*Alliaria petiolata* (Bieb.) Cavara and Grande] in northern Illinois using fire, herbicide, and cutting. Natural Areas Journal 11: 158-157.

Nuzzo, V., J. Kennedy, and G. Fell, 1991. Vegetation Management Guideline: garlic mustard, *Alliaria petiolata* (Bief.) Cavara and Grande. Natural Areas Journal 11: 158-167.

Office of Technology Assessment, 1993. Harmful Non-indigenous Species in the United States. U.S. Congress OTA-F-565. Report available from the Superintendent of Documents, U.S. Gov. Printing Office, Box 371954, Pittsburgh, Penn. 1520-7954. 391 pp.
[Extensive summary and review of alien species in the USA]

Ogutu-Ohwayo, Richard, 1996. Nile Perth in Lake Victoria: effects on fish species diversity, ecosystem functions and fisheries. In: Sandlund et al.(cited below).

Peak, J.M., D.G. Miquelle & R.G. Wright 1987. Are Bison Exotic in the Wrangell-St. Elias National Park and Preserve? Environmental Management 11(2): 149-153.
[The authors report that the effect of past distributions of animal populations now extinct in an area from unknown causes is considered relative to their status as exotic or native in national parks. They describe the example of bison on the Copper and China River drainages in Alaska which was introduced prior to establishment of Wrangel-St. Elias National Park and Preserve. Youngman (1975) records that in 1951, the Canadian Wildlife Service released 5 bison - three cows and 2 bulls into the Braeburn Lake area of the Yukon (gift from the United States Government, introduced from Alaska, originally from Montana) and these have apparently died out (van Zyll de Jong personal comm.). In the 1980's many animals were introduced from the herd at Wood Buffalo National Park and these are apparently thriving and increasing number in the area

between Whitehorse and Haines Junction].

Randall, John M., 1993. Weeds and natural areas management. In: Eighth Grazing Lands Forum (cited above). Pp 42-46.

Reimchen, T.E., 1990. Introduction and Dispersal of the Pacific Treefrog, *Hyla regilla*, on the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 105(2): 288-290.

Randall, J.M. 1995. Assessment of the invasive weed problem on preserves across the United States. Endangered Species Update 12: 4-6

Romo, J.T., and Donna Lawrence, 1990.A Review of Vegetation Management Techniques Applicable to Grasslands National Park. Consultant report to Canadian Parks Service, Val Marie, Saskatchewan. 61 pp. + appendix.

Rosen, Philip C. and Cecil R. Schwalbe, 1995. Bullfrogs: Introduced Predators in Southwestern United States. In: Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Department of the Interior, Washington. 452-454.
[Describes the extreme impact that this predatory species has upon native frogs, snakes, etc.]

Rowe, Stan, 1990a. Ethical Ecosphere. Chapter in book by author entitled Home Place, Essays on Ecology. Pp. 139-143.

Rowe, J. Stan, 1990b. What on Earth is Environment? Trumpeter 6(4): 123-126.

Rowe, Stan, 1996. From Shallow to Deep Ecological Philosophy. The Trumpeter 13 (1)26-31.

Sandlund, Odd Terje, Peter Johan Schei and Aslaug Viken, 1996. Proceedings: Norway/UN Conference on Alien Species. Directorate for Nature Management and Norwegian Institute for Nature Research. Trondheim, Norway. 233 pp. (See associated Chairman's Report 1996 - cited above).

Scott, W.B. and E.J. Crossman, 1973. Freshwater Fishes of Canada. Royal Ontario Museum, Toronto. 966 pp.

Strobel, G.A. 1991. Biological control of weeds. Scientific American 265: 72-78.

Sundet, Jan H., 1996. The King Crab (*Paralithodes camtchaticus* in the Barents Sea. In: Sandlund et al. 1996 - see above). pp. 103-106.

Supply & Services Canada, 1995. Canadian Biodiversity Strategy. Ottawa. 80 pp.

Temple, Stanley A., 1990. The nasty necessity: eradicating exotics. Conservation Biology, 4(2): 113-115.

Tyser, RW, and Worley, CA., 1992. Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana, USA. Conservation Biology 6 (2):253-262.
[Summary: This paper is an account of transect studies of the presence of alien plant species in park grasslands at different distances from secondary and primary roads and from park trails. The most common invasive aliens are the grasses Timothy and Kentucky Blue Grass, although 15 alien species were recorded. In sites adjacent to primary and secondary roads: "alien species richness declined out to the most distant transect, suggesting that alien species are successfully invading grasslands from the roadside areas. In study sites adjacent to back country trails, absence of a comparable decline and unexpectedly high levels of alien species richness 100 m from the trailside suggest that alien species have been introduced in off-trail areas." Authors point out the obvious, that "fescue grasslands in nature reserves of this region are vulnerable to invasion by alien flora. They recommend management action by saying: .."Given the prominent role that roadsides play in the establishment and dispersal of alien flora, road construction should be viewed from a biological rather ;than an engineering perspective. Nature reserve managers should establish effective roadside vegetation management programs that include monitoring, quickly treating keystone alien species upon their initial occurrence in nature reserves, and creating buffer zones on roadsides leading to nature reserves." Of course, roads and trails are avenues of invasion and these need to be minimized. But in Grasslands National Park

(and possibly Prince Albert) we have a situation where some of the most invasive of alien species were planted by farmers and ranchers]

Usher, MB, 1986. Invasibility and wildlife conservation: Invasive species on nature Reserves. Philos. Trans. Royal Soc. London. Biological Sciences 314:675-710 [Abstract only seen].
["Nature reserves are often considered to be assemblages of natural or semi-natural communities. However, in many parts of the world they also contain exotic species that interact with the native flora and fauna. An International Working Group has been endeavouring to understand the management of invasive species in natural landscapes. Data for four invasive species within the British Isles are analysed. The case studies investigated include Indian balsam (*Impatiens glandulifera*), a rhododendron (*Rhododendron ponticum*), mink (*Mustela vison*) and coypu (*Myocastor coypus*). The rates of spread have been variable, usually increasing after an establishment phase. The discussions concentrate on assessing the impact of these invasive species , on deciding whether control measures are feasible and/or desirable, on deciding whether or not nature reserves are less prone to invasion than other habitats, and on assessing wildlife conservation values when invasive species are present."].

Usher, M.B., F.J. Kruger, I.A.W. Macdonald, L.L. Loope, and R.E. Brockie, 1988. In: Duffey 1988, (cited above); pp.1-8.

US Forest Service, 1991. Forest service manual. Title 2600 - Wildlife, fish, and senstive habitat management. US. Forest Service, Washington, D.C.

Veblen, Thomas T., 1992. Ecological impacts of introduced animals in Hahuel Huapi National Park, Argentina. Conservation Biology 6(1): 71-84.
["To determine the effects of livestock and exotic deer in Nahuel Huapi National Park, Argentina, the animals were monitored along the vegetation gradient from the rainforests to the Patagonian steppe. Variations in vegetation composition were analysed using detrended correspondence analysis and two-way species indicator analysis. Data were presented on vegetation compositional gradients, browsing patterns, tree growth patterns, and pairs stand comparisons. Results indicated that deer and

livestock have significantly altered the structure and composition of the native vegetation, especially in the woodland areas toward the eastern and drier end of the rainforest-to-steppe gradient." This sort of research information may be of value in drafting guidelines for the management of overabundant native ungulates in parks where natural ecosystems are being degraded much in the same manner as would be done by cattle and where former predators are now absent - e.g. at Pelee, etc.]

von Broembsen, Sharon L., 1989. Invasions of natural ecosystems by plant pathogens. In: Drake, et al. 1989 (cited above) pp. 77-83.

Wagner, Warren Herb, 1993. Problems with biotic invasives: A biologists viewpoint. In: McKnight (1993) (Cited above).
[Wagner notes that "...the manner of dispersal of newly arrived organisms is highly diverse and illustrates one face of the overall problem of reducing the biology of invasives to a few simple factors. There is no such *contingency* involved among organisms that we regard as invasive, that their study has to be essentially a case by case analysis. **No two situations are alike**..." The author provides some good insights and useful generalizations having implications to general management policy].

Weaver, S.E. 1980/81. Old Fields Management Plan, Point Pelee National Park. Agriculture Canada, Harrow, Ontario.

Westman, Walter E. 1990a. Managing for biodiversity; unresolved science and policy questions. Bioscience 40(1):26-33.

Westman, Walter E., 1990b. Park Management of Exotic Plant Species: Problems and Issues. Conservation Biology 4(3): 251 - 260.
[Abstract: "Vegetation management policies in public parks in the US call for the removal of exotic species to the extent feasible. The underlying goal is to preserve samples of wilderness by restoring plant communities to the "natural state" that existed prior to extensive human influence. With limited budgets, park managers are necessarily selective in targeting exotic species for control. If the focus is on the more readily controlled species, however, park landscapes may gradually become populated by more resistant exotics. Further, because plants exhibit some redundancy in

ecosystem function, exotic plant species can substitute in part for natives in performing a range of ecosystem functions, including wildlife support and soil binding. Consequently the removal of exotics can result in significant perturbations to certain ecosystem functions during the period of transition to native cover. The individualistic paradigm of plant distribution implies that the impact of exotic plant species on invaded communities will vary. Choosing which species to remove requires careful evaluation of the impact of the removal on ecosystem structure and function. The effective balancing of park management goals for wilderness maintenance and recreational use requires clearer recognition of the adaptive response of ecosystems to invasion and a rethinking of the basis for prioritizing which species are to be removed.". The author of this report fully agrees with the last sentence in particular. Hence the notion of amnesty for select invasives is necessary.]

Whelan, C.J., and M.L., Diliger, 1992. Invasive, exotic shrubs: a paradox for natural area managers. Natural Areas Journal 12: 109-110.

White, D.J., E. Haber and C. Keddy, 1993. Invasive plants of natural habitats in Canada. Canadian Wildlife Service, Environment Canada, and Canadian Museum of Nature, Ottawa 121 pp.

Woodley, Stephen, 1993. Monitoring and Measuring Ecosystem Integrity in Canadian National Parks. *In:* Woodley, Stephen, Ecological Integrity and the Management of Ecosystems. St. Lucie Press. 220 pp.

Wright, R.G., 1992. Wildlife Research and Management in the National Parks. University of Illinois Press, Champaign. 224 pp.
["The bulk of the text discusses the management of various animals (including ungulates, bears, and alien species) within and around the park properties. Attention is given to the conflict between wildlife research for its own sake and as a tool for park management." Not reviewed, but should be as there probably are some useful case examples summarized. Not in Parks Canada library].

Youngman, P., 1975. Mammals of the Yukon Territory. National Museums of Canada, National Museum of Natural Sciences, Ottawa. 192 pp.

APPENDIX 1

LIST OF ALIEN SPECIES THAT INVADE NATURAL ECOSYSTEMS IN DIFFERENT PARTS OF CANADA (ALIEN ORGANISM DEFINED IN SECTION 1.2) (PRELIMINARY LIST; 'FIRST CUT')		
Name of Alien Species	**Some Effects Upon Native Species and/or the Natural Ecosystems if known or suspected**	**References and/or Comments**
EUMYCOTA: FUNGI		
Chestnut Blight *Cryophenectria parasitica* (on host tree: American Chestnut)	-Loss of organic biomass and major nut crops for bacteria, fungi, animals -Loss of major canopy tree (for nesting, feeding animals) - Loss of snag habitat for dozens of species of animals in many Classes	Restoration of the host species (American Chestnut) likely possible through breeding programs and selection of partially resistant variant trees which occur sporadically and reproduce by seed throughout the range of Chestnut.)(von Broembsen 1989; Mosquin et al. 1995)
Dutch Elm Disease *Ophiostoma ulmi* (on host tree: American Elm)	similar effects on host tree as forested ecosystem as above - loss of elm seed for birds - loss of major canopies in ash/red maple swamps and edges of rivers, lakes and streams	Host tree survives throughout its range at reduced population levels, younger ages, but actively reproducing by seed (von Broembsen 1989; Mosquin et al. 1995)

White Pine Blister Rust *Cronartium ribiola*. Parasitic on *Pinus strobus* (White Pine) in Eastern Canada, and on *Pinus albicaulis* (Whitebark Pine in B.C.	Causes death of numerous host trees: Present in all White Pine areas causing occasional death of trees Whitebark Pine has been decimated along the border with Washington by 90%	Introduced from Europe in 1888 (von Broembsen 1989; Langdon & Johnson 1992) (extensive literature) (Kendall, 1995)
Butternut Canker *Seriococcus claviginetijuglandacearum* (on host tree: Butternut).	similar effects on native species and ecosystems as Chestnut Blight but as Butternut was not ever common, the total effect has been much lower.	Some trees are apparently not susceptible. Time of introduction not known (Langdon & Johnson 1992)
PLANTAE: PLANTS		
European Birch	invading natural bogs in southern Ontario	?
Black Locust *Robinia pseudoacacia*	Native of eastern USA. It can persist in parts of southern Canada only in disturbed sunny sites.	(Mosquin 1988)
Scotch Pine *Pinus sylvestris*	Native of northern Europe & Asia.	Known to naturalize locally in and around plantations
Glossy Buckthorn *Rhamnus frangula*	Native of Europe. This species forms dense stands with impenetrable canopies, often shading out native species. It entirely replaces other shrubs and many herbs in acid (boggy) wetlands.	Soper & Heimburger (1982); White et al. (1993). Very invasive in parts of eastern Ontario.

Common Buckthorn *Rhamnus cathartica*	- creates dense hedgerows along fences and often 100% shrub canopy layer in forest - probably creates good cover for nesting birds - fruit actively eaten by . Robins in October	White et al.(1993).
White Mulberry *Morus alba*	-hybridizes aggressively with the native red mulberry (*Morus rubra*) endangering the latter.	Ambrose (1987); Mosquin (1988). A major proble in Point Pelee Nat. Park, where only a very small number of "pure" red mulberry survives.
Leafy Spurge *Euphorbia esula*	- replaces native forbs and grasses in open areas, dry rangeland and native prairies and mountain lowlands of the US and Canadian west	(White et al. 1993). Not yet a problem in GNP but invasive in prairies of SW Sask. Achuff et al. (1990) considered this species to be a "Priority 1" species for control in western national parks.
Reed Canary Grass *Phalaris arundinacea*	- Extremely invasive along waterways and in southern wetlands of Ontario, growing in essentially pure stands	(White et al. 1993) (extensive literature). A major threat to protected area wetlands and shorelines
Garlic Mustard *Alliaria petiolata*	- forms stands so dense as to replace native herbaceous vegetation	(White et al. 1993)
Smooth Brome *Bromus inermus*	Replaces native prairie in some sites	(Mosquin et al. 1995)

Canada Thistle *Cirsium arvense*	Replaces native prairie in sites that are suitable; where abundant, major source of nectar; host species for some butterfly larvae	(extensive literature). Achuff et al. (1990) considered this to be a “Priority 1" alien species for control in western national parks.
Frog-bit *Hydrocharis morus-ranae*	shades out submergent vegetation by forming dense mats at the surface; removed dissolved oxygen from waters as it decays	(Catling 1988; Catling & Porebski 1995)
Eurasian Milfoil *Myriophyllum spicatum*	Replaces virtually all other aquatic macrophytes in wetlands, streams which it colonizes.	(Aiken et al. 1979; Couch & Nelson 1985; White et al. 1993).
Scotch Broom *Cytisus scoparius*	replaces native flora; major successful competitor for moisture in dry sites of SW BC.	Introduced in the 1800s? (Mosquin et al. 1995)
Downy Chess *Bromus tectorum*	Aggressively competes with native grasses and forbs in dry regions of the prairies and souther B.C.	Likely, introduced by the Spaniards in the 1600s, and then spread northward (Mosquin et al. 1995).
Crested Wheat Grass *Agropyron cristatum*	Agressively competes with native species in southern prairie provinces. Major problem in GNP	(Romo & Lawrence, 1990) Actively planted by ranchers to replace native prairie
Flowering Rush *Butomus umbellatus*	effect not known; possibly both positive and negative.	(White et al. 1993)
Tatarian Honeysuckle *Lonicera tatarica*	Casual invader of woodlands	(White et al. 1993)
ANIMALIA: ANIMALS		

Norway Rat	Major impact on marine shoreline nesting birds and on colonial seabird colonies on Canada's Atlantic and Pacific Coasts.	Introduced from Europe.
Coyote	Spread on its own to Nova Scotia, PEI and Newfoundland	expansion appears to be caused by forest clearing by human activities
Mule Deer	Causes major overgrazing of herbs & grasses and virtual elimination the shrub canopy of the Red Huckleberry, *Vaccinium parvifolium,* except in inaccessible places.	introduced to QCI for hunting (Banfield 1974). Swims from island to island.
White-tailed Deer	May cause severe over-grazing in the absence of predators such as Black Bears or the Gray Wolf (see text)	introduced to PEI (1949) Anticosti (1896); "There has been a rapid expansion of this species northward" (Banfield 1974) so it may be alien in some parks S of 60 deg. N.
Moose	Effect on habitat and other native species appears to be mainly positive, or at least minimal.	introduced to Newfoundland, Cape Breton, coastal Labrador, and Anticosti Island (Banfield 1974)
Bison	This is a native species and its effects should be considered natural/normal.	Introduced to Yukon from Alaska (where they were introduced from Montana) in 1951 and several times later. Now established.

Horse	Native of Eurasia. In Sable Island it continues to cause major overgrazing of the ecosystem.	Introduced to Sable Island and escaped from time to time into the wild in Alberta and B.C. where it readily naturalizes.
Mink	effect on habitat and other native species appears to be mainly positive, or at least minimal.	introduced to Newfoundland (Banfield (1974)
Striped Skunk	Probably similar to adjacent New Brunswick and Nova Scotia.	Spread to NS since 1850. Introduced to PEI fur farms and permitted to escape
Raccoon	Probably similar to adjacent mainland areas.	Introduced to PEI and QCI
Red Fox	major impact on small bird & mammal populations especially California Quail and probably Mountain Quail.	Introduced to Vancouver Island for fur farming and now naturalized. In California, where it was also introduced it has been a principal cause of the extirpation of the California quail and other ground nesting birds over large areas, particularly near urban areas.
Muskrat	food for mink, large turtles and shoreline carnivoves, hawks and eagles (Banfield 1974)	Introduced to Vancouver Island and QCI
European Hare	unknown	Introduced to Southern Ontario

Snowshoe Hare	Major positive addition to fauna - food source for all large carnivore terrestrial birds and mammals; meat for humans	Introduced to Newfoundland (Banfield 1974).
Eastern Cottontail	new food source for native carnivores	Introduced to SW BC. (Banfield 1974)
Beaver	floods out upland forest to create wetlands	Introduced to QCI (and Anticosti)
Grey or Black Squirrel	Herbivore. Competes for nesting cavities.	Introduced to NS, Sask, and B.C.
Red Squirrel American	Predates heavily on eggs and nestlings of tree-nesting birds	Introduced to QCI
Fox Squirrel	Herbivore. Sometimes usurp flicker cavities	Introduced to Pelee Island in 1890 (Banfield 1974) from Ohio
Evening Grosbeak	Formerly native of western North America (prior to about 1920); spread into northeast caused by winter bird feeding.	Spread into eastern Canada from the Rockies in the past 50 years, likely as a function of winter bird feeding.
Starling	Usurps nesting cavities of bluebirds, woodpeckers, swallows, etc.	Introduced in 1890 from Europe
Wild Turkey	Competes directly for food with ruffed grouse and other species, especially in spring, summer and fall. It requires supplementary feeding to survive in many parts of Canada..	Native to the United States and Mexico and extreme southern Ontario. Introduced into woodlands in many places across southern Canada including Sydney Island off the B.C. coast.

Chukar Partridge	Ecological effect on other species not known; likely both a competitor for food of herbivores and a source of food for native carnivores.	Introduced into southern BC from its native Eurasia
Gray Partridge	not known but can survive in natural grasslands where protected areas are sometimes located. Probably is a source of food for some native carnivores.	Widely introduced from its native Eurasia into many areas across southern Canada where it is variously naturalized (Godfrey 1986)
Ring-necked Pheasant	known to compete aggressively for territory with the native greater prairie chicken in Illinois (Harty 1993). Possibly an important source of food for native carnivores.	Introduced from China. Naturalized in many protected areas, especially Point Pelee, SLINP and Atlantic provinces and the prairies.
Willow Ptarmigan *Lagopus lagopus*	not known	Introduce to Scatarie Island, N.S. in 1968 where it is reported to be "doing well."
House Sparrow	Usurps nesting cavities for bluebirds, woodpeckers, swallows, chickadees, etc.	Introduced from Europe in 1850.
Brown Trout	An Eurasian species	Introduced across Canada and including Newfoundland (McAllister 1990)

Carp *Cyprinus carpio*	Muddies up marshes, river bays and destroys submergent and floating vegetation, cover, and food for other freshwater species	(Scott & Crossman 1973; McAllister 1990). Now found in every State of the USA.
Sea Lamprey *Petromyzon marinus*	Parasitic, kills and maims large numbers of fishes in the Great Lakes.	(McAllister 1990; extensive literature)
American Toad *Bufo americanus*	probably similar to that on the mainland	Introduced in Cornerbrook area in the 1960s and deliberately spread to other locations in Newfoundland (Maunder 1983)
Pacific Tree Frog *Hyla regilla*	Reimchen notes that a significant ecosystem change has been caused by this species: it now dominates the diurnal and nocturnal bioaccoustical environment each spring but it is not known whether this interferes with the communications among other organisms.	Introduced to QCI in about 1962 and has spread most areas of the eastern half of the islands (Reimchen 1991). Range expansion is continuing.
Striped Chorus Frog *Psudacris triseriata*	probably similar to that on the mainland	Introduced in Cornerbrook area in the 1960s and deliberately spread to other locations in Newfoundland (Maunder 1983)

Wood Frog *Rana sylvestris*	probably similar to that on the mainland; native to Labrador	Introduced in Cornerbrook area in the 1960s and deliberately spread to other locations in Newfoundland (Maunder 1983)
Northern Leopard Frog *Rana pipiens*	similar to mainland	Introduced in Cornerbrook area in the 1960s and deliberately spread to other locations in Newfoundland (Maunder 1983) Introduced to Vancouver Island & Anticosti (Schueler, pers. comm)
Green Frog *Rana clamitans*	tadpoles food for dragonfly larvae (Buckle 1971)	Introduced into Avalon Peninsula sometime prior to 1867, and spread deliberately across the island since (Buckle 1972; Maunder 1983) Introduced to Vancouver Island (Schueler pers. comm)
Bull Frog *Rana catasbeiana*	This is a major predator in southwest USA where it has caused the extinction of several species of frogs and extirpations of small turle, snakes and other species (Conant & Collins 1991); effect on Vanc. Island unknown	Alien to Vancouver Island where it was recently introduced (Schueler, pers. comm.)
Periwinkle	profoundly altered the marine ecology of Canadian & American Atlantic shorelines	Introduced from Europe. Major herbivore on seaweeds (Carleton 1996)

Gypsy Moth *Lymantria dispar*	defoliates entire canopies of large forested regions during peak epidemics (roughly every 7 years)	Introduced ca. 1868 from Europe to Massachusetts.
Zebra Mussel *Dreissena polymorpha*	Super abundant in many Southern Ontario waterways, including bottoms of Lakes Erie and Ontario. Causes the death through starvation of native clam species, larval fishes and other species. It's sheer abundance and the scale of filtering success causes greatly increased light penetration and vegetation growth at bottoms of lakes and streams, changing aquatic habitat drastically.	Introduced in the 1980s to Lake St. Claire, presumably with ballast water. Extensive monitoring literature has been produced charting the course of its spread.
Spiny Water Flea *Bythotrephes cederstroemi*	"Nuisance species throughout the Great Lakes"	Mills et al. 1993;
Cluster Fly	impact not known	Appendix 1
Honey Bee *Apis mellifera*	- competes aggressively with native bees for pollen and nectar; it is the prime cause of the extinction of hundreds of native bee species throughout the world, and particularly in warmer regions where they naturalize	(extensive literature on the impact on native pollinating insects). Any national park within a few miles of a honey bee colony will be affected. Known to have caused extinctions and extirpations of hundreds of competing bee species in Australia.

European Wasp	- preys on native invertebrates - a nuisance and health hazard to humans	
European Skipper	Dense populations often seen in grassy openings and roadsides. Ecological effects not known. Presumably common at Pelee and SLINP	Introduced into the London area on or before 1910 and since spread across southern Ontario and into the adjacent USA.
European Cabbage Butterfly *Pieris rapae*	Food plants include nearly all species of the Mustard Family.	Introduced from Europe to Quebec about 1860 and has since spread across most of the continent. Less common northward in Canada to Hudsonian Zone.

APPENDIX 2.

ALIEN SPECIES FOCUS GROUP
FINAL RECOMMENDATIONS

February 3-4, 1994

PREAMBLE

A group of experts met on 3-4 February, 1994, in Victoria, B.C. to develop recommendations concerning alien species and their existing or potential effect on biodiversity in Canada. These recommendations are designed to contribute to the construction of a Canadian Biodiversity Strategy.

The group met in response to Article 8(h) of The United Nations Convention on Biodiversity, which states that "Each Contracting Party shall, as far as possible and as appropriate: ...Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species."

The group recognizes that Canadian biodiversity has been and continues to be threatened by alien organisms; is concerned that biodiversity is being significantly reduced by certain human activities, including the intentional and unintentional introduction of alien species; and acknowledges the inadequacy of public awareness and of the quantity, utilization, and coordination of knowledge regarding the effects of alien species on biodiversity.

For the purposes of this workshop:

The Convention uses the term 'alien species', but we recognize that this term should be expanded to include all races, varieties, stocks, and genetically modified organisms where novel genetic diversity may be of concern. Throughout this report, we use the broader concept of 'alien organisms'.

An 'alien organism' is one that enters an ecosystem beyond its historic range, including any organisms transferred from one country or province to another. This definition, modified from the U. S. National Parks Service, implies no positive or negative impact by the alien organism, and includes organisms entering through natural range extension and dispersal, and through deliberate or inadvertent introduction by humans.

Alien species, however, may be injurious. An 'injurious species or organism' is one that causes or has the potential to cause harm to native Canadian species or ecosystems through processes including but not limited to hybridization, predation, parasitism, pathology, and competition, and potentially harmful to human interest, including, but not limited to, esthetics, economics, and health. (Modified from the Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act [WAPPRIITA].)

GUIDING PRINCIPLES AND RECOMMENDATIONS

Recognizing that problems concerning alien species transcend jurisdictional boundaries and government and non-government mandates,

Noting that alien species have caused and may potentially cause significant ecological and economic problems,

Stressing that the complexity of biological systems should advise caution where alien organisms are concerned,

And being aware that elimination of alien introductions ('biological pollution') is unattainable, but that steps can be taken to minimize their occurrence and effects, Canada should:

1. Enhance communications among pertinent international, federal, provincial, municipal, first nations, and non-governmental organizations on matters pertaining to the effects of alien species on biodiversity, for example by development of reference networks of experts concerning specific groups of organisms.

2. Charge relevant national and regional bodies with the identification of problems, needs, and solutions for the prevention, detection, and control of intentionally and unintentionally introduced alien species;

3. Establish a coordinating body to provide leadership for protection of Canada's native biodiversity from alien species.

4. Review and integrate, among all jurisdictions, existing Canadian legislation regarding alien species.

5. Improve regulatory mechanisms and enforcement, including, but not limited to:

    a. Enhanced enforcement and quarantine capabilities for all groups of organisms.
    b. Designation of ports of entry for specific taxa to more effectively utilize expertise and facilities.
    c. Improvement of the 'notification mechanism' for receiving and publicizing problems associated with alien introductions.

6. Immediately recognize as critical and implement the Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act and its accompanying regulations.

7. Lead in the development of an international database for alien organisms, beginning with injurious aliens.

8. Enhance or create inventory programs (such as the Biological Survey of Canada), including biosystematics expertise and collections, to provide baseline inventory data for a centralized data base to assist regional detection and monitoring programs.

9. Coordinate research to address gaps in knowledge regarding the spread, impact, detection, identification, and control of alien species. Of particular importance is the need to identify and minimize processes and activities that facilitate the spread and establishment of alien organisms.

10. Document and, where feasible, quantify the effects of alien organisms on the natural biota of Canada.

11. Review and improve protocols for screening standards and risk assessment methods, where required.

12. Determine priorities for allocating resources to the control of particular alien species, based especially on:

    a. Risk the alien poses to rare and endangered species, native habitats, and ecosystems.
    b. Feasibility of control.
    c. Risk of adverse effects from the control methods on native communities, especially effects that might threaten the persistence of native species.

13. Base decisions regarding introduction and/or management (including control and eradication) of alien species on a set of comprehensive objective criteria, including:

    a. Impacts of the alien species on native biodiversity, especially on rare and endangered species and ecosystems, and on islands and fragmented habitats.
    b. Need for control and options available.
    c. Feasibility of control.
    d. Socio-economic implications.

14. Develop and implement Canada-wide education programs, directed at specific target groups, to address alien organisms and their impact on Canada's biodiversity,

a. Considering the diversity of audiences, exemplified by: public, political, technical, scientific, business, industrial, enforcement, and news-media groups.
b. Using case studies demonstrating real costs, including cost of control, of alien introductions.
c. Considering that the term 'biological pollution' may be a useful tool for communicating the threat of alien organisms.
d. Focussing on the school system.
e. Considering short term, intermediate, and long term benefits of education.
f. Using professionals to develop educational packages.

15. Participate in international education efforts regarding alien species.

APPENDIX 3.

SCIENTISTS' LETTER TO U.S. VICE-PRESIDENT AL GORE

Subject: Scientists' Letter to Al Gore: Please Join Us
Date: Tue, 4 Feb 1997 07:02:17 -0800
From: James.T.Carlton@williams.edu (James T. Carlton)
To: aliens-l@ns.planet.gen.nz
Date: Tue, 4 Feb 1997 00:01:51 -0500
Sender: "Ecological Society of America: grants, jobs, news"
<ECOLOG-L@UMDD.UMD.EDU>
Subject: ECOLOG-L Digest - 2 Feb 1997 to 3 Feb 1997
To: Recipients of ECOLOG-L digests <ECOLOG-L@UMDD.UMD.EDU>
Date: Mon, 3 Feb 1997 09:30:45 -0500
From: Phyllis Windle <pwindle@crosslink.net>
Subject: Scientists' Letter to Al Gore: Please Join Us

Below is a letter to Vice-President Gore from scientists and resource managers regarding harmful exotic species. In the finest tradition of American democracy, we are petitioning our government for help.

Specifically, the letter asks that a Presidential Commission evaluate new strategies to prevent and manage invasions. We hope to have many hundreds of signatures when the letter is mailed in March.

If you regulate, manage, or conduct research on harmful exotics, would you like to add your name to ours? George Beck, Jim Carlton, Ron Carroll, Gary Meffe, Hal Mooney, Don Schmitz, Dan Simberloff, Howard Singletary, Peter Vitousek, E.O. Wilson, and I have already signed, all people who have worked on this issue for years and worry that current efforts are too little, too late.

To add your name, please fax or mail the following information to Don Schmitz (fax 904-488-1254) or Jim Carlton (fax 860-572-5329): Name, Title, Organization; Business address, City, State, Zip; Telephone no., Fax no., E-mail address; Signature, Date. YOUR NAME WILL NOT BE ADDED UNLESS WE HAVE YOUR SIGNATURE ON FILE IN HARDCOPY.

Questions? Call Don at 904-488-5631 (schmitz-_d@ngw.dep.state.fl.us) or Jim at 860-572-0711, ext. 5190 (James.T.Carlton@Williams.edu).

We all hope you will help. Thanks! Please DO post and forward this message to colleagues.

Phyllis Windle' College Park, MD

The Honorable Albert Gore, Jr.
The Vice-President of the United States
Office of the Vice-President
Old Executive Office Building, Washington, DC 20501

Dear Vice-President Gore:

We write as a group of scientists, agricultural officials, and environmental experts to request your assistance in, and support for, the formation of a commission whose purpose would be to recommend new strategies to prevent and to manage invasions by harmful exotic species. A rapidly spreading invasion of exotic plants and animals not only is destroying our nation's biological diversity but is costing the U.S. economy hundreds of millions of dollars annually. Biological invasions produce severe, often irreversible impacts on agriculture, recreation, and
our natural resources. In some instances, they even have major human health consequences. The 21st century holds the clear threat of further devastating invasions unless a coordinated national effort is established.

In March, 1993, twenty-five distinguished scientists and resource managers wrote to you identifying the need for an effective national program to combat invasions by nonindigenous plants and animals. You kindly replied that these issues indeed concern your office, and we were pleased to note that these problems had received your attention.

Since 1993, biological invasions by pest and nuisance species from foreign nations, and from one part of the United States to another, have continued almost unabated:

- Recent studies reveal, for example, that San Francisco Bay is invaded by a new exotic species on the average of once every twelve weeks.
- At least 1.5 million acres in Florida have been invaded by non-indigenous plants, leading to a severe reduction in available native habitat.

- Foreign weeds are spreading on Bureau of Land Management lands at over 2,300 acres per day and on all western public lands at approximately 4,600 acres per day.
- Approximately 250 plant species meeting the Federal Noxious Weed Act's definition of a noxious weed remain unlisted and can still be legally imported into the U.S.
- In the Mississippi drainage basin, species richness is expected to decline by 50% within a decade because of zebra mussel spread.
- Exotic species invasion have contributed to the decline of 42% of U.S. endangered and threatened species.

Although the National Invasive Species Act of 1996 was an important step forward, the overall national effort to confront this crisis remains inadequate; it is primarily piecemeal, ad hoc, and reactive. For example, more that 20 federal agencies deal with invasive exotic species, but their policies and actions are uncoordinated and largely ineffective. There is not even a comprehensive data base on the problem. Innumerable state agencies and private organizations also operate in this arena, often entirely unaware of one another's problems and actions. Actions of various managers even inadvertently conflict with one another. Simply coordinating this effort would not only enhance its effectiveness but save millions of federal, state, and private dollars.

A commission could consider many potential ways of responding to this problem. One can imagine, for example, a center analogous to the Centers for Disease Control and Prevention (CDC), a high-level government office (like that of the Surgeon General) that might serve as a bully pulpit on this issue, a much-expanded and well-funded interagency task force, and numerous other possibilities. What is most urgent is to begin a high-level consideration of possible responses, as the situation is deteriorating every day. We are losing the war against invasive exotic species, and their economic impacts are soaring. We simply cannot allow this unacceptable degradation of our nations' public and agriculture lands to continue.

The cogent 1993 report of the Congressional Office of Technology Assessment, Harmful Non-Indigenous Species in the United States, on the extraordinary economic and health costs to this nation of exotic invasions, provides an excellent introduction to these issues. Please contact Don C. Schmitz (904-488-5631), James T. Carton (860-572-5359), Daniel Simberloff (904-644-6739), or Phyllis Windle (301-345-8516) for more information about

this growing problem.

We look forward to your response to this critical matter, and we offer any assistance you may need in further developing a strong and committed response to this national problem.

/signed/

DON C. SCHMITZ, Wetland and Upland Alien Plant Coordinator, FL Dept. of Environmental Protection, Tallahassee, FL 32311

JAMES T. CARLTON, Prof. of Marine Sciences, Maritime Studies Program, Williams College-Mystic Seaport, Mystic, CT 06355

DANIEL SIMBERLOFF, Robt. O. Lawton Distinguished Prof., Dept. Biological Sci., FL State Univ., Tallahassee, FL 32306

PHYLLIS N. WINDLE, Project Director for the U.S. Congress report, "Harmful Non-Indigenous Species in the United States," Office of Technology Assessment, Washington, DC.

E.O. WILSON, Prof. of Sci. and Curator of Entomology, Museum of Comparative Zoology, Harvard Univ., Cambridge, MA 02138.

KENNETH GEORGE BECK, II, Assoc. Prof., Dept. of Bioagricultural Sci. and Pest Mgmt., CO State Univ., Ft. Collins, CO 80523

HOWARD SINGLETARY, Director, Plant Industry Division, North Carolina Dept. of Agriculture, Raleigh, NC 27611

GARY K. MEFFE, Prof. of Ecology, Savannah River Ecology Lab., Aiken, SC 29802

C. RONALD CARROLL, Director, Institute of Ecology, University of Georgia, Athens, GA 30602

HAROLD MOONEY, Prof. of Environmental Bio., Dept. of Biological Sci., Stanford Univ., Stanford, CA 94305

PETER VITOUSEK, Prof., Dept. of Biological Sci., Stanford Univ., Stanford, CA 94305

****