

A HISTORY OF SPECIES INTRODUCTIONS IN GWAII HAANAS AND GULF ISLANDS NATIONAL PARK RESERVES IN BRITISH COLUMBIA, CANADA: IMPLICATIONS FOR MANAGEMENT

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Abstract: Since the earliest period of European contact, many species have been purposefully or accidentally introduced to the coastal islands of British Columbia. Gwaii Haanas, a National Park Reserve and Haida Heritage Site located in Haida Gwaii (Queen Charlotte Islands), and Gulf Islands National Park reserve, located in southern British Columbia, offer 2 contrasting case studies to illustrate both introduction history and current management challenges. Some species are perceived negatively by local communities while others have become highly valued in the local landscape for aesthetic and utilitarian reasons. In many cases, significant ecological impacts have resulted from these introductions. Given the mandate of Parks Canada to ensure the maintenance or restoration of ecological and commemorative (cultural) integrity, several management challenges must be overcome to deal with these invasive species. This paper provides an overview and comparison of historic and current management challenges for these 2 sites.

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Human travel and global trade are resulting in an increased mixing of species across biogeographical and political boundaries. The impacts of introduced species have moved to the forefront of conservation and public health concerns as we recognize the increasing rate and geographic scale of both deliberate and unintentional species introductions across the globe. Next to habitat destruction and fragmentation, introduced species are considered the most important global threat to biodiversity (Vitousek et al. 1997). Many introductions have been undertaken solely for human benefit with little regard for ecological consequences. Changes created by the arrival of introduced species pose many management challenges (e.g., practical, aesthetic, economic, and ecological). Some changes can be beneficial to local people by providing new food sources or new opportunities for economic activities. If newly arrived species become established and abundant, however, they usually have an adverse impact on some native species with potentially far-reaching ecological effects. Some of the native organisms affected may also have economic, social, or cultural significance.

Many introduced species fail to survive in a new environment but others thrive. Introduced species can successfully establish themselves and then overcome otherwise intact, pre-existing native ecosystems. A new arrival is often freed from the predators or parasites of its native habitat, or it can take advantage of an ecosystem already disturbed by humans. The United States Office of Technology Assessment (1993) reported 4,500 and 2,300 introduced plant and animal species, respectively, that are considered “free living” in the United States. Of these, 15% or about 1,000 species are considered harmful or “invasive,” and 79 of those species cause \$97 billion in losses (T. Mosquin. 1997. Management guidelines for invasive alien species in Canada’s national parks, National Parks Branch, Parks Canada, Ottawa). While the economic implications are significant in both Canada and the United States, in many cases, the ecological effects are poorly understood. There is, however, an increasing realization of the associated ecological costs and the loss of native biodiversity (IUCN 2001).

Because of their isolation, islands are especially vulnerable to the effects of introduced species and species that are introduced can have a disproportionate effect. This is exacerbated by the fact that many islands and island groups are

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considered biodiversity hotspots (Myers et al. 2000). Many oceanic islands around the world are undertaking major efforts to eradicate or control invasive introduced species with dramatic ecological rebounds where eradication is successful (Mosquin 1997). Some introduced species remain in localized populations around human settlement, while other more invasive species are widely dispersed. With respect to the 2 parks discussed in this paper, several introduced species with the widest range and most potentially destructive impacts on native flora and fauna have been studied. Many others, however, have received little attention, and their effects on the environment are poorly understood. Management and control programs have been initiated for a few species, although these are complex and often controversial.

Parks Canada is the Canadian government agency responsible for managing and protecting Canada's national parks, historic sites, and marine conservation areas. In our national parks, the protection and conservation of representative ecosystems is a key objective. The national parks system plan strives to represent all 39 natural regions identified across the country. At this point, 26 regions are represented by 41 national parks, while 13 remain unrepresented. The agency derives its mandate from the Canada National Parks Act, which states that the legislated management priority is the maintenance or restoration of ecological integrity through the protection of natural resources and natural processes. Parks Canada defines ecological integrity as "a condition where the structure and function of an ecosystem are unimpaired by human-induced stresses and are likely to persist." The protection and management of ecosystems is carried out in a manner that promotes the continuation of ecological processes and assures future genetic, species, and ecosystem diversity.

Our policy dictates the use of scientific information to support decision making. In order to do so, our programs strive to: (1) identify and address information gaps; (2) monitor long-term ecosystem trends in disturbed and natural or benchmark areas; (3) work in cooperation with others within the parks and their larger ecosystems to undertake protection and restoration initiatives; and (4) undertake outreach, communications, and the promotion of environmental stewardship.

To develop solutions to problems identified by research, findings must be placed within the existing political and cultural context. Gaps

between ecological theory and practical conservation have resulted in an inability to address critical problems caused by invasive species (Byers et al. 2002). Inadequate information and understanding of the issues can often result in poorly formulated perceptions, as shown by Porter (1997), and intransigent positions with respect to management. The best way to find solutions is to ensure that all interests have access to all available information before actions plans are formulated. Communication can be improved by providing information in formats that are targeted to specific audiences and in ways that are accessible to the general public. Of course, 2-way communication is needed with researchers and managers open to receive information provided by interested and knowledgeable parties. Subsequent actions are more likely to be successful when a broad consensus has been achieved.

Parks Canada has a long history with respect to management of native and introduced hyper-abundant species. Most recently, a significant research and management effort has been directed toward introduced species on the islands of the Pacific Coast. In this paper, I provide an overview of introduced vertebrate species in 2 park reserves recently established on Canada's Pacific coast—Gwaii Haanas and Gulf Islands (Fig. 1)—and compare these national parks looking at historical invasion patterns as well as current management intervention successes, failures, and future challenges. This review is based on information that has been compiled from a summary of published and unpublished materials, local knowledge gathered through interviews, or relevant records and files in government and private archives.

GWAII HAANAS

The San Christoval Mountains form the backbone of Gwaii Haanas, rising to 1,123 m above mean sea level at Mount de la Touche. The protected area makes up 15% or about 150,000 ha of the archipelago of Haida Gwaii (Queen Charlotte Islands) and includes more than 300 islands and islets (Fig. 2) (T. Golumbia. 2001. Gwaii Haanas terrestrial ecosystem conservation strategy, Parks Canada, Queen Charlotte City, British Columbia Canada). The climate of the archipelago is hypermaritime but exhibits a marked difference in precipitation and weather between the west,

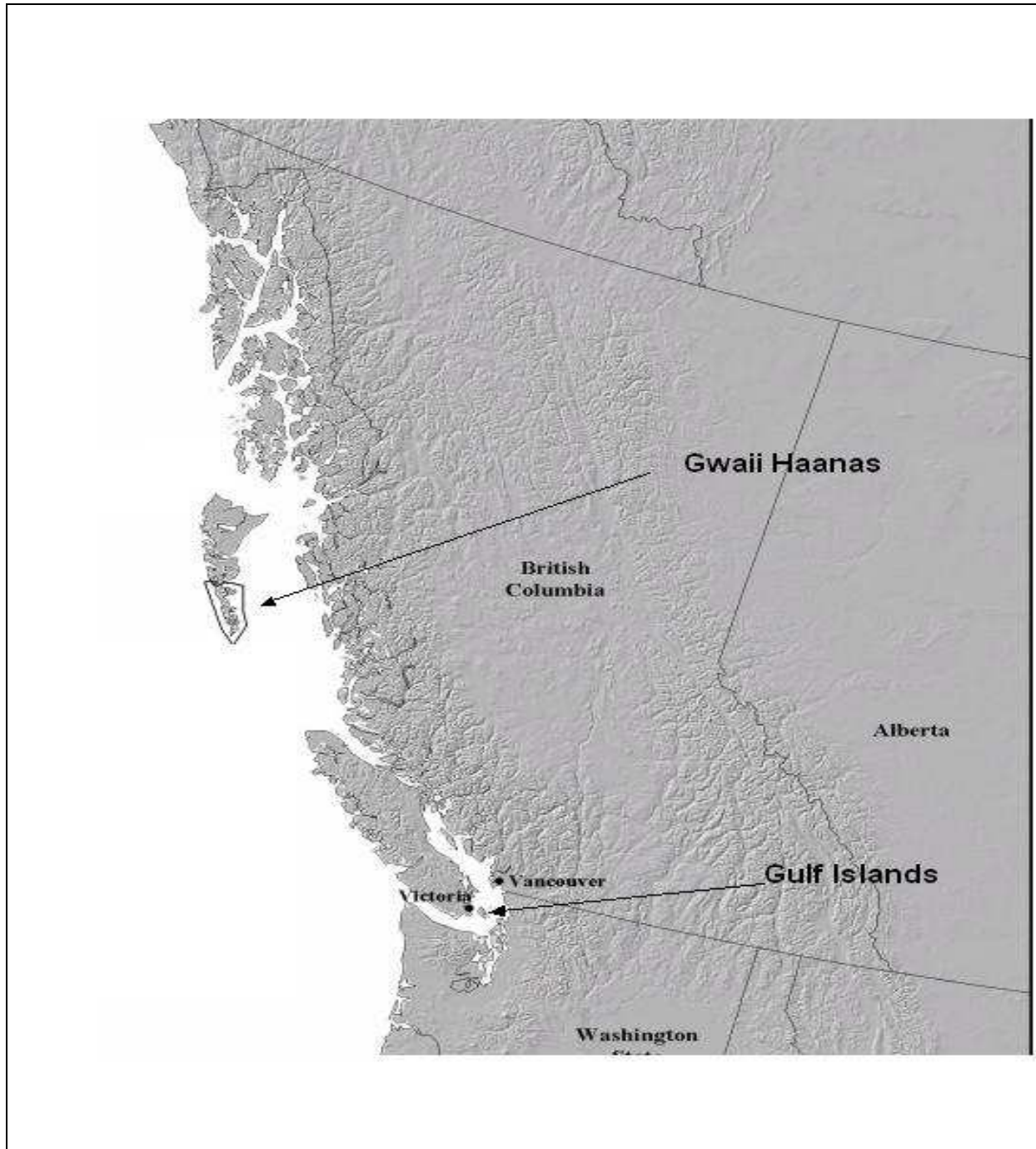


Fig. 1. Pacific Coast of Canada depicting Gwaii Haanas and Gulf Islands National Park Reserves.

and east coasts (Golumbia 2007). The protected area, which was established in 1987, is managed cooperatively with the Council of the Haida Nation. This is the only aboriginal group having jurisdiction on the archipelago. Around the turn

of the 20th century, early explorers and naturalists began documenting the native fauna of Haida Gwaii (Osgood 1901, Dawson 1993). Many of the observed species exhibited endemic characteristics. There are more unique

subspecies on Haida Gwaii than in any other equal-size area in Canada, leading to their title as “The Canadian Galapagos” (J. B. Foster. 1982. The Queen Charlotte Islands: the

Canadian Galapagos, University of British Columbia, Vancouver, Canada). The area also supports an assortment of rare plants that are considered locally or regionally endemic, and

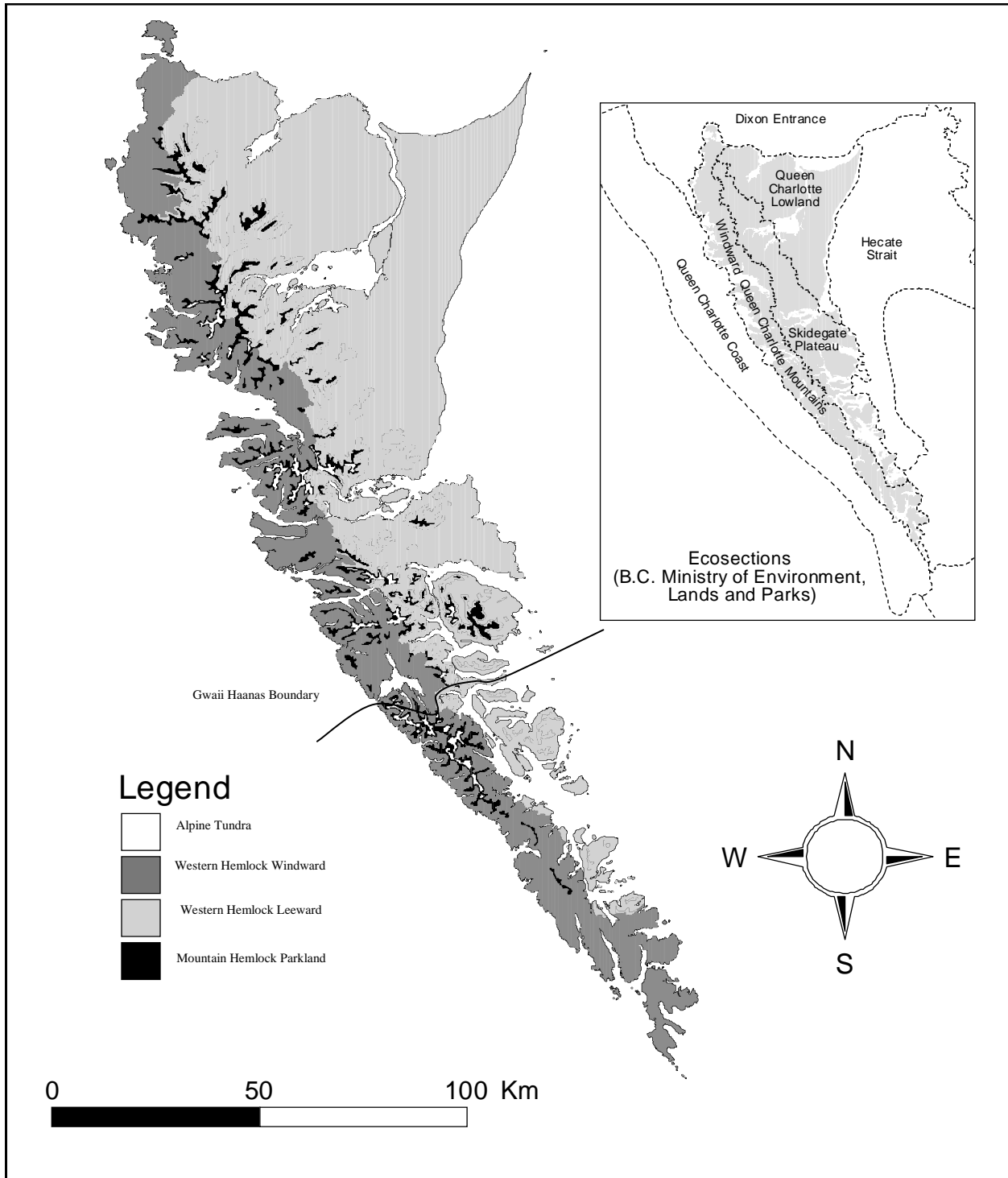


Fig. 2. The Haida Gwaii Archipelago and Gwaii Haanas National Park Reserve and Haida Heritage site.

several species exhibit disjunct distributions (Lindsey 1989). The Gwaii Haanas biodiversity database for the Haida Gwaii region has more than 6,800 species of flora and fauna. Nearly 200 of these species are considered a conservation concern, and many are endemic to the region. At least 217 species are considered introduced.

The 13 native mammal taxa (Table 1) of Haida Gwaii make up a relatively depauperate fauna. Several are considered endemic at the subspecific level (Burler et al. 2004). By comparison, 20 additional species occupy the adjacent mainland (McTaggart-Cowan 1989). Haida Gwaii is home to 280 species of birds (P. J. Hamel, and M. Hearne. 2001. Checklist of the birds of the Queen Charlotte Islands/Haida Gwaii, Gwaii Haanas Parks, Queen Charlotte City, British Columbia, Canada), including 4 endemic subspecies of resident forest birds.

The introduction of nonnative species to Haida Gwaii has been relatively recent when compared to the many thousands of years the native flora and fauna have evolved in isolation. In many cases, mammals were introduced to the islands as a new source of food or a means by which to generate income through trapping. Some animals were brought as pets; some may have arrived accidentally. The Haida most likely also played deliberate or accidental roles by helping introduce species to the islands on their canoe trips to and from the mainland (Foster 1965, 1982).

During the period of European settlement and industrial development in the late 18th century, domestic and wild plants and animals accompanied the settlers. The first known introduction was in 1792, only 20 years after the first recorded European contact. Since this time, 9 mammals have been successfully introduced, resulting in almost half the mammal species diversity present on the islands today (Table 1). In addition, at least 5 species of domestic mammals have established feral populations. The information for amphibians is not as well documented, but at least 2 amphibian species have been introduced.

There have also been recommendations made in the past to introduce species such as capercaillie (*Tetrao urogallus*), quail (*Callipepla californica*), ptarmigan (*Lagopus leucurus*), ibex (*Capra sibirica*), chamois (*Rupicapra rupicapra*), thar (*Hemitragus jemlahicus*), moose (*Alces alces*), goat (*Capra hircus*), and Kodiak bears (*Ursus arctos*) (Robinson 1957) by local rod and gun

clubs and the Game Commission. Recently, there were plans to introduce ferrets (*Mustela putorius*) to control island rats and mountain goats (*Oreamnos americanus*) for sport hunting on the peaks of Moresby Island (Golumbia et al. 2007). There have also been references to the introduction of the common garter snake in the late 1980s, although there have been no confirmed sightings.

Management Actions

Within Gwaii Haanas, conservation issues related to terrestrial, aquatic, and estuarine ecosystems are noted in the Terrestrial Ecosystem Conservation Strategy (Golumbia 2001). Two of the 3 most important conservation issues are the effects of introduced deer on forest ecology, and the effects of other introduced mammalian predators on native fauna. Several of these species have been addressed with research initiatives and implementation of management actions. The following information summarizes 3 examples involving rats, raccoons, and Sitka black-tailed deer.

The black and the Norway rats are known to occur on 25 Haida Gwaii islands (Carl and Guiguet 1972, Bertram and Nagorsen 1995, Golumbia et al. 2007). Rats have been implicated in a drastic reduction of seabird populations on several islands (K. Summers, and M. Rodway. 1988. Raccoon-seabird interactions [with notes on rats and marten] on Moresby Island, Queen Charlottes: a problem analysis, Ministry of Environment, Wildlife Branch, Smithers, British Columbia, Canada; Bertram 1989; Bailey and Kaiser 1993; Gaston 1994; Harfenist 1994; Kaiser et al. 1997). Beginning in 1993, operations have been undertaken to eradicate rats from 4 islands with no subsequent detections (Kaiser et al. 1997; T. Golumbia. 2002. St. James Island rat eradication program final report, Parks Canada, Queen Charlotte City, British Columbia, Canada). Six additional islands were treated successfully in 2003.

The introduction of raccoons to Haida Gwaii from Vancouver Island was undertaken by the provincial game commission in the early 1940s to provide a source of fur for trappers (McTaggart-Cowan 1989). Poor demand for pelts resulted in a lack of trapping pressure. With no natural predators, the raccoon population grew rapidly and spread over most

Table 1. Native (*) and introduced (I) vertebrates (excluding birds and fishes) thought to occur in (1) the Gwaii Haanas National Park Reserve and Haida Heritage Site, and (2) Gulf Islands National Park Reserves in British Columbia, Canada. Each introduced species name is followed by the date of introduction to Gwaii Haanas (when known).

Group	Common name	Scientific name	Gwaii/Haida	Gulf Islands
Amphibian	Bullfrog	<i>Rana catesbeiana</i>		I
	Long-toed salamander	<i>Ambystoma macrodactylum</i>		*
	Northwestern toad	<i>Bufo boreas</i>	*	*
	Pacific treefrog (1964)	<i>Hyla regilla</i>	I	*
	Red-legged frog (2002)	<i>Rana aurora</i>	I	*
	Rough-skinned newt	<i>Taricha granulosa</i>		*
	Wandering salamander	<i>Aneides vagrans</i>		*
Reptile	Common garter snake	<i>Thamnophis sirtalis</i>		*
	Gopher snake	<i>Pituophis melanoleucus catenifer</i>		*
	Northern alligator lizard	<i>Elgaria coerulea</i>		*
	Northwestern garter snake	<i>Thamnophis ordinoides</i>		*
	Sharp-tailed snake	<i>Contia tenuis</i>		*
	Western garter snake	<i>Thamnophis elegans</i>		*
Mammal	Beaver (1936)	<i>Castor canadensis</i>	I	I
	Black bear	<i>Ursus americanus vancouveri</i> <i>Ursus americanus carlottae</i>	*	*
	Black rat (1919)	<i>Rattus rattus</i>	I	I
	Black-tailed deer (1878)	<i>Odocoileus hemionus</i> <i>columbianus</i> <i>Odocoileus hemionus sitkensis</i>	I	*
	California myotis	<i>Myotis californicus caurinus</i>	*	*
	Common shrew	<i>Sorex cinereus</i>		*
	Dawson's caribou (extinct)	<i>Rangifer tarandus dawsoni</i>	*	
	Deer mouse	<i>Peromyscus keeni prevostensis</i> <i>Peromyscus keeni keeni</i> <i>Peromyscus maniculatus</i> <i>austerus</i>	* * *	*
	Dusky shrew	<i>Sorex monticolus elassodon</i> <i>Sorex monticolus prevostensis</i> <i>Sorex monticolus isolates</i>	* * *	*
	Ermine	<i>Mustela erminea haidarum</i> <i>Mustela erminea anguinae</i>	* *	*
	European red deer (1919)	<i>Cervus elaphus elaphus</i>	I	
	Fallow deer	<i>Cervus dama</i>		I
	Feral cats – no date	<i>Felis catus</i>	I	I
	Feral cattle (1893)	<i>Bos taurus</i>	I	
	Feral dogs – no date	<i>Canis familiaris</i>	I	
	Feral goats (1976)	<i>Capra hircus</i>	I	I
	Feral rabbits (1884)	<i>Oryctolagus cuniculus</i>	I	I
	Gray squirrel	<i>Sciurus carolinensis</i>		I
	House mouse (1901)	<i>Mus musculus</i>		I

Keen's myotis	<i>Myotis keenii</i>	*	
Little brown myotis	<i>Myotis lucifugus alascensis</i>	*	*
Long-legged myotis	<i>Myotis volans longricus</i>		*
Marten	<i>Martes americana</i>	*	*
Mink	<i>Mustela vison</i>		*
Muskrat (1924)	<i>Ondatra zibethicus</i>		
Norway rat (1922)	<i>Rattus norvegicus</i>		
Nutria	<i>Myocastor coypus</i>		
Raccoon (1940s)	<i>Procyon lotor pacificus</i>		
Red squirrel (1947)	<i>Tamiasciurus hudsonicus</i>		*
River otter	<i>Lontra canadensis</i>	*	*
Rocky mountain elk (1929)	<i>Cervus elaphus nelsoni</i>		
Silver-haired bat	<i>Lasionycteris noctivagans</i>	*	*
Townsend's big-eared bat	<i>Plecotus townsendii townsendii</i>		*
Townsend's vole	<i>Microtus townsendii tetramerus</i>		*
Western long-eared myotis	<i>Myotis evotis</i>		*

of Graham and Moresby Islands, and many of the smaller islands (Harfenist et al. 2000). In 1995, an interagency collaboration developed a management plan and monitoring protocol to address raccoon presence (Harfenist et al. 2000). A risk assessment was undertaken to focus monitoring and control of raccoons at seabird colonies at greatest risk from raccoon predation. All raccoons discovered on the selected islands and on adjacent shorelines were eliminated, and results indicated significant benefits for conservation of seabirds and their habitats (Gaston and Masselink 1997). Although these control methods appeared effective for seabird colonies, continuous control efforts are needed. Restoration of affected colonies and the management of raccoon impacts on other terrestrial and intertidal species must still be addressed (Golumbia 2001).

The Research Group on Introduced Species (RGIS) is a multinational and interdisciplinary research group formed in 1995 to explore changes in the ecology of Haida Gwaii caused by introduced species. Currently, the main focus of the research has been on the impacts of Sitka black-tailed deer, which were brought to the islands in 1878 (Golumbia et al. 2007). Researchers found that deer browsing caused changes to groundcover and plant diversity as well as forest tree recruitment and regeneration (Vila et al. 2007). Additional studies linked deer

browsing impacts to reductions in abundance, diversity, and reproductive success of songbirds (Martin et al. 2007) and soil arthropods (Allombert et al. 2007). In addition to the loss of nesting and cover habitat, food resources have also been reduced.

In October 2002, RGIS hosted a conference where researchers could share the results of their work with the island communities and with others interested in introduced species and their management. A broad range of perspectives were presented including concerns related to: (1) aspects of Haida culture and traditional lifestyle that are threatened as deer browse reduced access to food, medicine, and fiber plants; (2) the importance of deer as a food source for islanders; and (3) the impact of deer on forest management (e.g., delayed tree regeneration resulting in increased costs). Participants agreed that, given the resource value of deer, any attempt to eradicate deer on the islands would be extremely difficult and undesirable. Instead, serious consideration was given to managing deer in a way that reduced deer browsing impacts and enhanced biodiversity. The following goals were developed as the next steps toward managing deer and other introduced species on these islands: (1) maintaining and restoring native biodiversity, species at risk, and culturally significant plants and animals (including deer) in the island

ecosystems; (2) reducing the impacts of deer on the native ecosystems; (3) establishing a locally based forum to recommend management initiatives related to all introduced species while providing a clear vision and consensus; and (4) communicating, educating, and continuing dialogue on issues of biodiversity and the impacts of introduced species.

In collaboration with RGIS, the Council of the Haida Nation and the British Columbia Ministry of Water Land and Air Protection commissioned a report that established restoration priorities and strategies associated with introduced species impacts (C. Engletoft. 2002. Restoration priorities associated with introduced species impacts on Haida Gwaii/Queen Charlotte Islands: perspectives and strategies, Council of the Haida Nation Forest Guardians and British Columbia Ministry of Water, Land, and Air Protection, Queen Charlotte, British Columbia). This initiative brought together interests and knowledge from discipline experts, land managers, and local people through a series of workshops and interviews. The report provides an overview of species introductions, a synthesis of local perspectives, and the framework for a strategic restoration plan.

Three significant outcomes of these initiatives can be noted. First, there was formation of an introduced-species task force (Golumbia and Rowsell 2007). This transition to a locally based lobby and action task force maximized the likelihood that this initiative builds momentum and results in some concrete restoration actions on the ground. Second, there was the designation and protection of culturally significant plant communities directed by Daamaan Xil, a group of Haida elders “taking care of the plants,” and the Council of the Haida Nation Forest Guardians. Last, there was successful lobbying of local hunters to modify hunting regulations from a traditional, sustainable harvest model to more ecosystem-based regulations reflecting the need for lowered deer densities to reduce impacts in local forests.

GULF ISLANDS

Following almost 10 years of negotiations between federal and provincial governments along with several nongovernmental organizations and private landowners, the Government of Canada

and the Government of British Columbia signed an establishment agreement for the Gulf Islands National Park Reserve of Canada in May 2003. The transfer of various provincial parks, ecological reserves, and Crown lands to Canada make up approximately half of the new park. The other half of the park is land that has been purchased since 1995 under the Pacific Marine Heritage Legacy program, a Canada-British Columbia agreement promoting protection of terrestrial and marine environments on the Pacific Coast.

The typical vision of Canada’s national parks is of a vast wilderness. The Gulf Islands National Park, however, has been assembled in a matrix of intensive human use. The protected area consists of small parcels of land scattered across 16 islands and many smaller islets (Fig. 3). The land area totals 3,500 ha in addition to 2,600 ha of subtidal lands. The final boundaries could change as a result of first nations land claims and the potential of ongoing land acquisition within a designated “core area of interest” in the Gulf Islands south of Active Pass, north of Boundary Pass, and west of Haro Strait on the Canada–U.S. marine border and adjacent to the San Juan Islands. The park is protecting lands in an area with a relatively dense regional human population of over 6 million and some of the highest real estate prices in Canada. This unique area has the only Mediterranean-type climate in Canada, and it represents the Strait of Georgia lowlands natural region. The area also contains a great number of designated species and ecosystems at risk. In addition to protection and conservation measures, the national park reserve offers a variety of opportunities for the public to learn about and experience this exceptional coastal island landscape and the cultures of the people who live there.

Because the protected area has been assembled within this matrix, there is a complex of social and political influences. Every boundary of the 26 parcels has a different owner and/or jurisdiction. The marine interface is equally complex with numerous interests including recreational and commercial mooring, boating, finfish and shellfish extraction, utility corridors, and international shipping lanes. First nations issues are also at the forefront. As a policy and as a focus of the Gulf Islands program, establishment of good working relationships with aboriginal people in the region is a priority. The Southern Gulf Islands

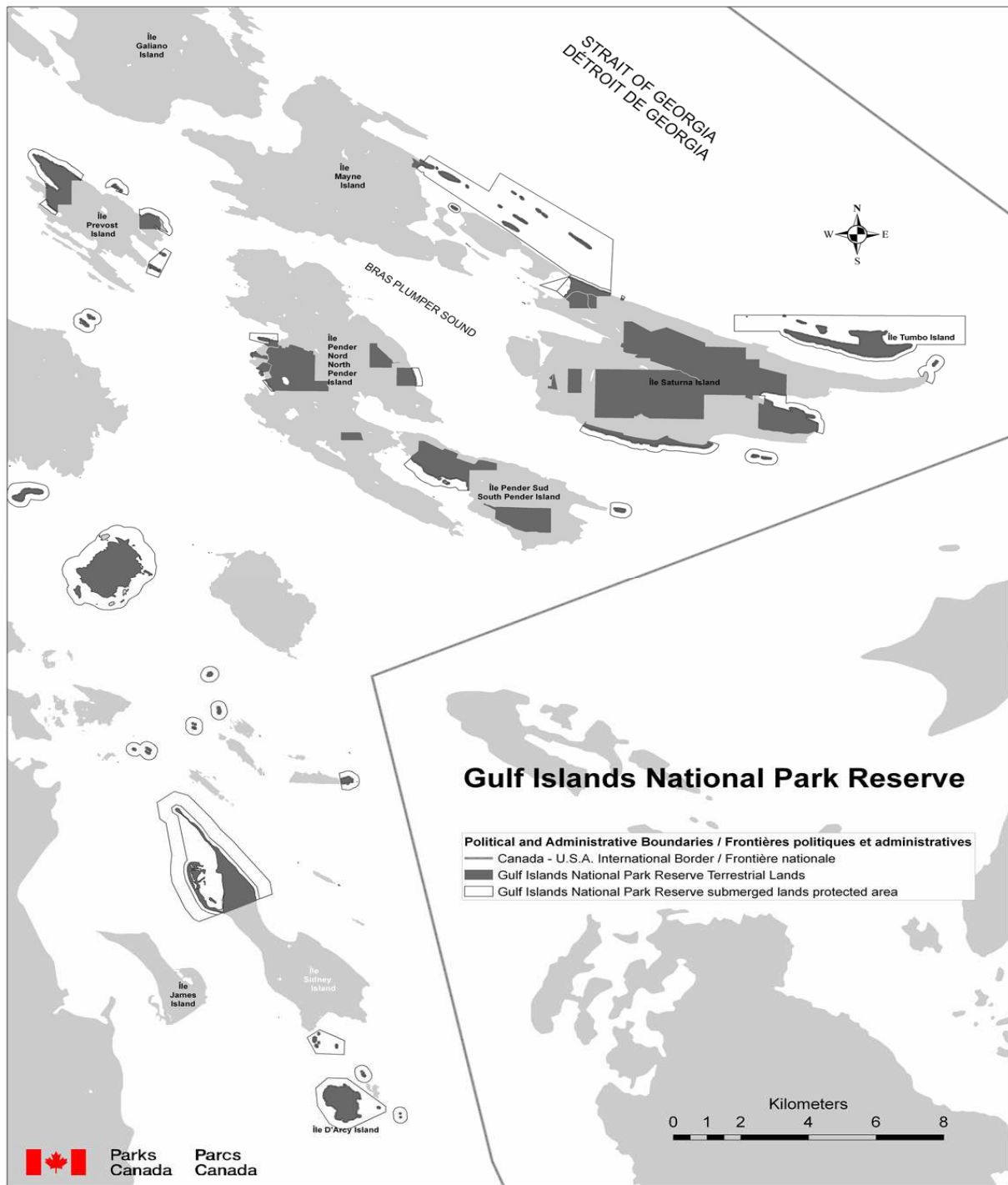


Fig. 3. The Southern Gulf Islands and Gulf Islands National Park Reserve. Park lands are depicted in dark shade.

are subject to the interests of 18 aboriginal bands ranging from midway up Vancouver Island across to the mainland in the Vancouver area.

In terms of vertebrate fauna, there have not been any extensive surveys. A review of the literature indicates that 29 species, excluding birds and fish, are either known to exist or most likely exist on the southern Gulf Islands. By comparison, at least 12 introduced species of mammals and 1 amphibian are known to occur on 1 or more of the islands within the park (Table 1). These species listings are derived from regional lists (Nagorsen 1990, Gregory and Campbell 1984, Green and Campbell 1984). In reality, each island supports its own suite of species, although this level of information is unavailable.

A number of the larger populated islands tend to have more available information with respect to species introductions. Much of the information exists as stories and anecdotes because, unlike Gwaii Haanas, most introductions were initiated by individuals rather than government-sanctioned programs. Raccoons, in particular, are notorious in local recollections. Although the Pender Islands do not have squirrels or raccoons, Mayne Island does. On a few occasions, raccoons have been transported to Pender Island from Mayne Island in an attempt to initiate a colony. These attempts have been unsuccessful. Urban raccoons rescued from the city of Victoria have been liberated to D'arcy and Little D'arcy Islands. Other small mammals known to be introduced on some islands include gray squirrel, red squirrel, mink, beaver and nutria, house mouse, and the black rat. Chipmunks are known to occur on some islands, but it is unclear whether they are introduced.

With a continuing decline in the popularity and general acceptance of hunting in populated areas, all the islands appear to be experiencing an increase in deer populations. In addition to native black-tailed deer, fallow deer are found on several islands. These deer were originally introduced to James Island and Sidney Island in the 1930s and are also found on Little D'arcy Island (Moody and Moody 1994). A population occurs on Mayne Island after being released from a deer farm. With a long history of human settlement and agriculture, there are many instances of feral livestock occurring throughout the archipelago. Goats, turkey (*Meleagris gallapauo*), peafowl (*Pavo* sp.), rabbit, fox

(*Vulpes* sp.), and mink, as well as sheep and cattle, are known to occur. Goats, in particular, are known to graze heavily on coastal bluffs and herbaceous ecosystems. Impacts from other species are not well documented.

Management Actions

A short time has passed since the establishment of the Gulf Islands National Park, and the level of understanding with respect to introduced vertebrates and their management is limited. Published and gray literature on this topic is limited for this geographic area. As a result, most of the material presented here is based primarily on a small number of informal interviews with knowledgeable people from the region. Sidney Spit, now part of the national park reserve, is located on Sidney Island. About 15% or 120 ha of the island is park land, while the remaining 715 ha are currently owned by a private consortium known as Sallas Forests Limited Partnership. This group is promoting a model of sustainable forestry with residential development, common forest development areas, and conservation zones.

With respect to fallow deer management, only 2 documented studies have been initiated. The first (Moody 1987) examined the fallow deer of the island and their effects on vegetation. The work focused on population estimates and deer condition analysis involving food habits and diet along with a general description of deer effects on native vegetation. In conjunction with this work, browsing exclosures were established, although the results over 2 years were inconclusive. Based on this preliminary work, 4 permanent exclosures to facilitate long-term monitoring of vegetation response to browsing were established (K. A. Palmer. 1988. Deer exclosure establishment and monitoring plan for Sidney Spit Marine Park, British Columbia Parks, North Vancouver, Canada). Under the jurisdiction of B.C. Parks, several deer management actions have been implemented over the past several years. The area was closed entirely to deer hunting in 1975 in response to increasing user conflicts and concerns for public safety. However, following increasing concerns over high deer numbers and related impacts, a limited entry hunt was initiated in 1996.

To address public safety concerns, the park was officially closed to the public from October to

March, during which time hunters were permitted. In addition to the limited entry hunt, a first nations harvest also occurred during this time. Sallas Forests has been managing their fallow deer populations since 1981 to reduce browsing stress on regenerating forest species in both their working forests and conservation areas. Limited hunting by the partners and invited guests removes a small number of deer. However, the most effective control method has been a live-capture operation in which deer are corralled and captured in fenced areas, disease tested, and then shipped off the island to mainland game farms. The total population of fallow deer has been estimated to be as low as 700 animals (Simmons *in situ* A. L. Maurer. 1989. Sidney Spit Provincial Marine Park wildlife viewing development plan, Wildlife Branch, Ministry of Environment, Victoria, British Columbia, Canada) and as high as 1,200 animals (G. Bowden. 1989. Letter to R. Simmons, British Columbia Parks, Vancouver, Canada). Recent estimates suggest a 2003 population of approximately 1,100 animals. As many as 650 animals have been captured in fall and spring live-capture operations and over 7,000 deer have been removed in the past 25 years.

Because the Sidney Spit area is now a National Park Reserve, sport hunting is no longer permitted. This is related to a general prohibition on hunting cited in the National Parks Act as well as concerns over user conflict and public safety. First nations harvests for food and ceremonial purposes will still be accommodated. Parks Canada staff are collaborating with Sallas Forests in developing a deer management strategy to reduce deer numbers and allow native vegetation to recover. To assess vegetation response from deer removal, vegetation plots and exclosures were revisited in 2004. Preliminary results indicate that significant browsing pressure across the island occurs outside the exclosures affecting species abundance and diversity (T. Golumbia, Gulf Islands National Park Reserve, unpublished data).

In addition to the deer management programs on Sidney Island, there has been some successful eradication of introduced species on several smaller islands. Feral sheep were removed from the 220-ha Portland Island in the 1980s by the British Columbia provincial park service after extensive impacts on vegetation were noted. There has not been any follow-up survey, but casual observations indicate that there has been good vegetation recovery. Gray squirrels were

known to exist on Sidney and Newcastle Islands in small numbers but have been successfully removed before the population erupted.

The presence of feral goats on Saturna Island has a long history dating back to an introduction shortly after 1890 with numerous releases since then (Shank 1971). Shank estimated the population at 125–175 individuals, although this estimate is now more than 30 years old and no recent population data are available. Feral goats are dispersed along Brown Ridge eastward to Narvaez Bay. Much of this range is now included within the national park. Heavy grazing and browsing pressure has been observed, particularly along Brown Ridge. These bluffs are recognized as a sensitive and rare ecosystem in the region supporting many rare plants. The presence of these goats, however, may actually be enhancing the conservation of rare plants by exerting grazing pressure on invasive, introduced species such as rose campion (*Lychnis coronaria*) and Scotch broom (*Cytisus scoparius*) (H. Janzen. 2003. Vascular plants of South Saturna bluffs. British Columbia, Canada). In the absence of fire, a natural disturbance process in this system, goats may provide sufficient disturbance through grazing and browsing to maintain these grassy bluffs and prevent encroachment by trees. Changing human demographics with increased settlement has led to a general reduction in hunting pressure, resulting in increased densities of native Columbian black-tail deer, which also contribute to the reduction in herbaceous and shrubby vegetation.

The local residents have a love-hate relationship with the goats and deer. Many recognize the damage caused by excessive grazing and browsing, particularly with respect to their gardens and orchards. Many would prefer to see the goats and deer either disappear completely or, at a minimum, held in check to prevent such damage. However, the goats are revered by some as a local icon, while others recognize the value of browsing pressure in maintaining herbaceous ecosystems and reducing fuel loads in the absence of fire. Parks Canada anticipates local and regional demands for restoration and conservation of rare ecosystems and endangered plant species. Given the status of the local goat herd, the hyper-abundant deer population, and the complex issues that must be addressed before initiating any management action, this will be a challenging conservation program.

CONCLUSIONS

In most cases, little forethought went into recognizing the consequences of species introductions on these island ecosystems. Partnership with government has been a common element with the introduction of many vertebrates. Until the 1960s, this was a key role of the Provincial Game Commission. Introductions were often in response to lobbying from local residents or interest groups. More recently, residents with good intentions, and perhaps limited understanding, have taken it upon themselves to populate various islands with wildlife that have become overabundant or no longer desirable elsewhere. Some species are universally seen as pests, while others have high aesthetic value or serve as a source of livelihood from trapping or hunting for food. Without an open exchange of information and ideas between all interested or affected parties, meaningful strategies for dealing with introduced species will not be achieved. Engaging local support at the outset maximizes the fusion of local know how and understanding with science expertise, and offers a conduit for outreach to the local communities.

The ecosystems of Gwaii Haanas and the Gulf Islands are changing because of impacts from these introduced species. These changes may be pronounced and widespread or less obvious and localized depending on the species and its range. Current research has provided a more definitive picture of some species, particularly in Gwaii Haanas. Yet, in many cases, we still do not understand the extent of these new arrivals in terms of colonization history, current distribution and abundance, and ecological effects. Other confounding factors complicate management because the very presence of introduced vertebrates may be controlling the spread of invasive introduced plant species and facilitating the persistence of rare plant populations in some areas.

Compilation of historical records for species introductions helps to bridge the gap between recorded documentation and local knowledge. Both sources are relevant and important in piecing together this larger picture. Local memories are often the source of much insight. Scientific records and documented reports can provide a window in time from which to view the management philosophy of the day, and we will continue to discover new information and new

species range expansions. As a result, records will need to be revised and updated. The existing database on introduced-species distributions is relatively complete for Gwaii Haanas but is only in its infancy for the Gulf Islands. Both databases will need to be maintained and updated as new information surfaces. Similar data are required for introduced flora and other lesser-recognized fauna. These records will be useful in tracking past, current, and future distributions and for design of control, eradication, or restoration efforts.

The best way to prevent the negative impacts of introduced species is to prevent their arrival. If they get into the ecosystem, it is best to eradicate them. If, however, they become established, it is best to manage the populations to densities low enough to reduce negative effects (Simberloff 2007). More proactive measures, such as exclusion of further introductions, may be most effective from a conservation concern but are likely to be most difficult to implement. Invasion pathways and the frequency of species introductions are dependent on patterns of trade and travel. This is exacerbated by the current trends to liberalize regulatory regimes and the fact that containment or prevention measures will be only as good as the measures taken by the least-effective party (Perrings et al. 2002). Although global and international in context, this issue also has local consequences because there is often more than 1 clear line of authority on these issues and limited capacity, or often interest, to deal with issues of quarantine or control.

Looking ahead and thinking about prevention, it will be important to look at an expanding sphere. The isolated nature of Haida Gwaii means that human vectors for future introductions are limited to shipping and air cargo from only a small number of ports. Conversely, the Gulf Islands have numerous access points with considerably more vessel and vehicle traffic. The fragmented nature of the protected areas making up Gulf Islands National Park Reserve will also increase its susceptibility to invasion.

To enhance prevention for all areas, it is important to also link up adjacent regions to track species introductions and common issues. For example, the southern Gulf Islands and San Juan Islands abut opposing sides of an international boundary that is permeable to both native and nonnative species. A linkage of databases to track range extensions and new invasions along the Pacific Coast would allow us to take preventative

actions and learn from each others' mistakes, and to develop complementary strategies where appropriate. The Island Conservation and Ecology Group has initiated this linking process (G. Howald, Island Conservation and Ecology Group, Vancouver, British Columbia, Canada, personal communication), and we look forward to working with them and others.

Alternatives for management are often controversial. One could argue that the introduction of species over time may be an inevitable step in the natural progression toward a more homogenous global ecosystem. Ecological conditions could be allowed to evolve with the hope that the introduced species will reach equilibrium. Yet, to do nothing is contrary to the goal of maintaining ecological integrity because certain species may be eliminated and ecosystems simplified (Golumbia 2000). In the current age of enhanced global trade and free movement of goods and people around the globe, the future potential for species introductions is great. This era is being coined the "Homogocene" by many researchers with an interest in the global effects of introduced species (IUCN 2001).

In addition to the biological or ecological sciences, social values and cultural perspectives must be considered in the development of management strategies. The introduction of large carnivores is a good example by which to illustrate the human dimensions of introduced species management and hyperabundance of herbivores in general. For most, the idea of increasing numbers or reestablishing the range of wolves (*Canis lupus*) or cougars (*Felis concolor*) is not acceptable, particularly when it is being considered in response to an overabundance of deer. Wolves and cougars have perceived negative values, while deer have perceived positive values. Like "Smokey the Bear" and the role of fire in many forested ecosystems, this "Bambi" syndrome is well entrenched in our social fabric and lends little support to the importance of those ecological processes being affected by this imbalance. Conversely, we have learned that proposals to eradicate rats from isolated islands are well received, most likely because of the negative perception with respect to these rodents.

In comparing an isolated and relatively wild northern archipelago such as Haida Gwaii with the more populous Gulf Islands in their context of urban North America, the values and perceptions of interested parties can be quite different. Right

of access and resource extraction demands are more prevalent in the former, while intense responses by interest groups (e.g., animal rights groups) and a general misunderstanding of natural processes may be expected in proximity to the urban environment. Aspects of managing introduced species can lead to high levels of frustration because of the complex nature of the ecology and the social fabric within which we must all work. However, advances are being made as awareness and understanding of these important issues increases.

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