

Laskeek Bay Research

14

2005



Edited by
Tony Gaston

LASKEEK BAY RESEARCH

14

**LASKEEK BAY CONSERVATION SOCIETY
SCIENTIFIC REPORT, 2005**

Edited by

ANTHONY J. GASTON

August 2006

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Picture: Humpbacks in Laskeek Bay, courtesy Timothy J.F. Lash

LASKEEK BAY CONSERVATION SOCIETY

The Laskeek Bay Conservation Society is a volunteer group based in the Queen Charlotte Islands. The society is committed to increasing the appreciation and understanding of the natural environment through:

sensitive biological research that is not harmful to wildlife or its natural habitat

interpretation and educational opportunities for residents of and visitors to the Queen Charlotte Islands

Since 1990, the Society has operated a field research station at East Limestone Island and is carrying out a diverse long-term monitoring, research and interpretation programme in the surrounding islands and waters of Laskeek Bay. We actively involve volunteers from our island communities, many other locations in British Columbia, as well as from overseas. For further information contact:

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BACKGROUND

The goals and objectives of the Society are:

- 1. To undertake and support research and long term monitoring of wildlife populations of the marine and terrestrial ecosystems of Haida Gwaii, especially the Laskeek Bay area.*
- 2. To provide opportunities for non-scientists, especially students and local residents of Haida Gwaii, to participate as volunteers in our field programs, and to offer training to impart necessary field research skills.*
- 3. To promote better understanding of the marine and terrestrial ecosystems of Haida Gwaii, especially the Laskeek Bay area, by providing information to youth, local residents, and to the public in general in the form of publications, meetings, and exhibits.*
- 4. To promote the conservation of native species and to develop public awareness of the changes caused by introduced species to Haida Gwaii.*
- 5. To support and assist other programs aimed at providing better knowledge, management and conservation of ecosystems on Haida Gwaii.*

INTRODUCTION

Since 1990, the Laskeek Bay Conservation Society has carried out field research each summer on East Limestone Island and adjacent islands, and in the waters of Laskeek Bay. The scientific work of the Society has been carried out in collaboration with researchers and management agencies having ongoing interests in the ecology and conservation of Haida Gwaii. The research programme is coordinated and directed by a Scientific Advisory Committee that works closely with the Society's Board of Directors to develop research that is relevant to the conservation needs of Haida Gwaii and consistent with the goals of the Society.

Research activities include population monitoring of marine birds and marine mammals and ecological research on intertidal invertebrates, plants, and forest birds. The Society is a participant in the Research Group on Introduced Species, an umbrella organization devoted to studies of exotic species in Haida Gwaii and their impact on indigenous ecosystems. Research in Laskeek Bay focuses especially on the impacts of introduced mammals, including deer, raccoons and squirrels.

Our research programme is designed to provide long-term information on the biology and ecology of Haida Gwaii ecosystems. Ongoing monitoring, using simple, standard techniques that enable year-to-year comparisons to be made, and allowing the direct participation of volunteers, is the cornerstone of the Society's approach. By monitoring a variety of indicator species in ocean, inter-tidal and terrestrial ecosystems, we can obtain an overall measure of their health. Because marine waters may be subject to cyclical or directional changes operating at the scale of decades, such observations become most valuable when they are tracked consistently over many years. Such long-term monitoring is becoming increasingly important in the context of global climate change. In addition, the possibility of offshore oil developments in Hecate Strait makes the Society's long-term data on marine birds especially valuable. If such developments proceed, the Society's information on population status and trends will be vital in monitoring impacts.



Sunset over Laskeek Bay, June 2006 (photo: Tony Gaston)



Forest interior, Laskeek Bay (photo: Tony Gaston)

ACKNOWLEDGEMENTS

With the generous contributions from the following groups and individuals, the Laskeek Bay Conservation Society has been able to provide its scientific monitoring and education programs, raising awareness and understanding of the marine and terrestrial ecosystems of Haida Gwaii:

- South Moresby Forest Replacement Account
- Gwaii Trust
- Environment Canada's Science Horizons Youth Internship Program
- Canadian Wildlife Service, Environment Canada
- Coast Sustainability Trust
- World Wildlife Fund
- Human Resources Development Canada
- School District #50 & the Community Links Program
- BC Gaming Commission
- Gwaii Haanas National Park Reserve and Haida Heritage Site
- Blue Water Adventures (t-shirt purchases and donations)
- Maple Leaf Adventures (t-shirt purchases and donations)
- Our countless private donors

We would also like to acknowledge the following for loans or permits:

- Canadian Wildlife Service (equipment loans)
- Research Group on Introduced Species (equipment loans & support)
- Council of the Haida Nation (permission)
- Ministry of Water, Land and Air Protection (research permit)
- Gwaii Haanas National Park Reserve/Haida Heritage Site (research permit)
- Environment Canada, Bird Banding Office (banding permit)

Thanks also to the following individuals and groups who gave generously of their time and services to the Society:

LBCS Directors for their time and efforts in keeping the Society running year after year

Dr. Tony Gaston for his valuable advice and guidance throughout the field season

Graeme Ellis (Pacific Biological Station) for providing a camera and film to document whales, even though there was less cooperation this year from the whales

This year's crew of local and international volunteers for all their enthusiasm, hard work, good humour and good company.

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Project Limestone teachers and students for their dedication to the project and for teaching us just as much as we teach them.

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The *s/v Island Roamer* and *s/v Maple Leaf* for bringing such lively and interesting visitors and for their endless promotion of LBCS.

South Moresby Air Charters for the pick up/drop off of volunteers/staff all season long



Villous Cinquefoil *Potentilla villosa*, a common member of the rocky shoreline community in Laskeek Bay
(photo: Tony Gaston)

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Pelagic Cormorants *Phalacrocorax pelagicus* roosting on the eastern tip of the Skedans Islands, June 2006 (photo, : Tony Gaston)

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Deer Fern *Blechnum spicant*, showing last winter's browse on old leaves, new leaves untouched
(photo: Tony Gaston)

EAST LIMESTONE ISLAND FIELD STATION: REPORT ON THE 2005 FIELD SEASON

Jennifer Rock

Laskeek Bay Conservation Society, Box 867, Queen Charlotte City, BC, V0T 1S0

This year marked the 16th field season on East Limestone Island. Our interpretation and research programs welcomed 262 visitor and volunteer days. Three local school groups participated in Project Limestone and we also hosted students from Langara College, a post secondary school in Vancouver. For a second consecutive year, the Ancient Murrelet banding program was limited to chick banding. The timing of chick departures was similar to previous years, peaking on 23 May. We caught 462 Ancient Murrelet chicks in our funnels, the second lowest number of chicks caught to date. Black Oystercatcher surveys were carried out in Laskeek Bay south to Juan Perez Sound. In total, 78 nest sites were deemed active at some point in the season with either eggs or chicks and we banded 27 chicks. We also described Black Oystercatcher chick diet based on 3351 prey remains identified at 29 nest sites. Limpets, mussels, and chitons made up 97% of the prey fed to Black Oystercatcher chicks. We counted 326 active Glaucous-winged Gull nests distributed among three colonies: most were located on the Lost Islands (79%). For the first time, we found Pigeon Guillemot chicks in the nestboxes at Lookout Point on East Limestone Island. We banded eight Pigeon Guillemot chicks from five nestboxes and at Cassin's Tower we monitored the growth of and banded a single Cassin's Auklets chick. Marine mammal sightings were consistent with previous years and we recorded 65 sightings from nine species. Ten wildlife trees were active with Red-breasted Sapsuckers (5), Hairy Woodpeckers (3), and Chestnut-backed Chickadees (2). We also followed two active Bald Eagle nests and a Northwestern Crow nest that fledged three chicks.

INTRODUCTION

The East Limestone Island camp was opened on 22 April and shut down on 23 July, making a 93 day field season. The field staff comprised: Jen Rock (Camp Supervisor / Biologist), Ceitlynn Epnors (Interpreter / Assistant Biologist) and Jake Pattison (Assistant Biologist). Alex Rose, a graduate student from University of Santa Cruz, was on Limestone from mid April to mid June studying the effects of introduced species on Song Sparrows.

EDUCATION AND INTERPRETATION PROGRAM

Project Limestone

2005 marked the 15th year of Project Limestone - a program whereby local students and teachers participate

in our Ancient Murrelet banding program. The school groups receive an afternoon orientation to the island, the research projects carried out on Limestone, and the biology and ecology of Ancient Murrelets. At night the school groups return to assist with the Ancient Murrelet chick banding. Students retrieve chicks from the funnels, bring them to the banding shelter, and assist with weighing the bird bags and recording measurements and band numbers. The students' excitement and enthusiasm for the Ancient Murrelets and Project Limestone is obvious and many students name their visit to Limestone Island as a highlight of the school year.

Despite very stormy weather during the peak of the Ancient Murrelet breeding season four local school groups and a total of 31 students and nine teachers/leaders visited Limestone Island. One group from G.M Dawson Secondary School visited on 17 May. Two groups from Queen Charlotte Secondary School visited

Limestone Island during the nights of 25 and 27 May. One group from the Living and Learning School visited Limestone Island during the evening of 20 May, after weathering three days of storms which impeded travel from Vertical Point to Limestone Island. Unfortunately, a second group from the Living and Learning School was not able to make it to Limestone Island due to the storms. We received great feedback from the students this year. Over half of the students were first time visitors to Limestone and all vowed to return in subsequent years. In total, 357 students have participated in Project Limestone since its inception in 1991.

Volunteers

Volunteers come to Limestone Island for one or more weeks. Living in camp and working alongside field staff, they are involved in all aspects of the research programs and camp life. This year 20 volunteers joined the Limestone Island team, 18 of whom were from BC, one from Alberta and one from Ontario. Nine of this year's volunteers were from Haida Gwaii! Two volunteers each stayed for two weeks, most others stayed for one week, and a few repeat volunteers or Directors stayed for a couple of days. Stacey Shantz and Tysen Husband, two local youth, joined the Limestone Island team 15- 23 July as summer work exchange students. There was a total of 143 volunteer days this summer and 1 week without volunteers.

Visitors

Three tour boats visited Limestone Island for a total of four visits this season. The s/v Maple Leaf visited on 16 May, the s/v Island Roamer visited on 24 and 26 May and the s/v Anvil Cove visited on 23 May. Altogether, 31 guests and 7 leaders came ashore on Limestone Island. Unfortunately, one visit by the Maple Leaf was cancelled due to stormy weather. Like Project Limestone, the tour group visitors participate in an afternoon interpretive tour and then return in the evening to participate in the Ancient Murrelet Banding program. Tour boat guests often cite the visit to Limestone Island as a highlight of the trip. Each tour boat was either on its way to or from a multi-day excursion in Gwaii Haanas.

Limestone Island also provided interpretive tours to three student groups from Langara College 16-18 June. The visit to Limestone Island was part of Langara College's Haida Gwaii Studies program - an intensive and integrated four course package that explores the

culture, biology and geology of Haida Gwaii. Five leaders and 28 students visited Limestone Island. The interpretive tour provided an introduction to the research done on Limestone Island, to seabird biology and to island ecology. The tour also allowed the students to observe the real world relevance and applications of their academic work- a key learning objective of the Langara College program.

RESEARCH & MONITORING PROGRAMS

Ancient Murrelets (*Synthliboramphus antiquus*) *Adult Banding and Burrow Monitoring*

In 2005, as last year, there was no adult banding, or burrow and nestbox monitoring on Limestone Island. Since the 1990s there has been an apparent reduction in recruitment of new breeders on East Limestone Island. By suspending adult capture work and burrow monitoring the LBCS has sought to eliminate the possibility that these activities contributed to this decline.

Although we did not carry out any directed adult capture work, during chick banding, we opportunistically checked adults encountered on the ground for bands. If birds were banded, we recorded band information and condition of the brood patch and if they were not banded, we released the bird immediately. This season, we caught three banded Ancient Murrelet adults. All three birds were originally banded on Limestone Island as breeding adults in 1990, 1993 and 2002. Ancient Murrelets age at first breeding is between two and four years, meaning that the adult banded in 1990 was at least 17 years old this year.

Predation

Throughout the season we observed the usual feather piles and body parts leftover from predators such as Common Ravens, Bald Eagles and Peregrine Falcons. We found no burrow diggings or headless murrelet carcasses, both of which can be indicative of the presence of raccoons in the colony.

We recovered three bands from the remains of dead Ancient Murrelets (presumably predated). All individuals were originally banded as adults, two at East Limestone Island, one in 1997 (as a breeding adult), and one in 2003 (as a non-breeding adult). The third band was recovered on Reef Island and had been banded there in 1997.

Chick Banding

Following the usual protocol, we weighed and banded chicks passing through the six plastic funnels at North and Cabin Cove. Our first banding night was on May 7 and we shut down after June 6 which was the first night that no chicks arrived at the funnel mouths (Fig. 1). We closed the funnels between 2230-0230 from May 7-19 and adjusted to 2300-0230 for the remainder of the season. In total, we caught 462 chicks in the six funnels in addition to 11 chicks that were collected either after 0230 or outside of the funnels (Table 1).

Of the 473 chicks caught and processed, we banded 468 chicks.

Chick departures peaked on May 23 with 38 chicks passing through the funnels (Fig. 1). This is the lowest peak count since 1990, reflecting also, the second lowest total for chicks caught at the six funnels since 1990 (Fig. 2).

Table 1
Summary of chick departures, peak nights and totals from funnels for Ancient Murrelet chick banding on Limestone Island, 1990-2004

Year	Opening night	First night	Last night	Peak night	Peak count	Total days	Total chicks
1990	12-May	12-May	15-Jun	22-May	65	35	873
1991	08-May	08-May	06-Jun	26-May	48	30	561
1992	12-May	12-May	03-Jun	21-May	73	23	674
1993	09-May	10-May	15-Jun	18-May	70	37	653
1994	07-May	07-May	08-Jun	22-May	52	33	618
1995	07-May	10-May	11-Jun	22-May	64	33	617
1996	10-May	11-May	09-Jun	19-May	48	29	588
1997	08-May	11-May	11-Jun	24-May	41	31	527
1998	07-May	11-May	22-Jun	20-May	55	43	495
1999	09-May	11-May	11-Jun	21-May	54	31	567
2000	11-May	11-May	11-Jun	20-May	62	31	595
2001	08-May	10-May	15-Jun	18-May	54	37	560
2002	07-May	09-May	03-Jun	21-May	65	26	566
2003	10-May	11-May	07-Jun	21-May	52	28	523
2004	08-May	08-May	02-Jun	16-May	45	26	445

No chicks were banded from burrows, as burrows were not monitored this year. The mean weight of chicks from the funnels was comparable to past years at 26.6 ± 3.4 g (\pm SD). No chicks were found with ticks this season.

Gathering Grounds

Adult Ancient Murrelets were counted on the gathering ground to the west of Low Island each night from May 2 to June 20 at approximately 2 hours before sunset. Poor weather and visibility prevented counts on 2 nights in June and counts were not done from June 14-16 while all camp members were in Juan Perez Sound for the Black Oystercatcher survey. The peak count occurred on May 16, the same night that the peak number of chicks were

banded, with 163 birds recorded (Figure 3). The peak count for June was 87 birds on June 1 (Fig. 3).

Point Counts

Beginning on 16 May, we conducted nightly point counts noting the number of individuals calling and the number of calls heard at each of two sites at North and Cabin Cove. These five-minute counts were conducted between 0200 and 0230 until the end of chick banding on 6 June. Birds assumed to be calling for chicks on the water were excluded. The number of calls was highest between 25 May - 2 June, but this period did not coincide with high counts on the gathering grounds. The relationship between these two indices remains obscure.

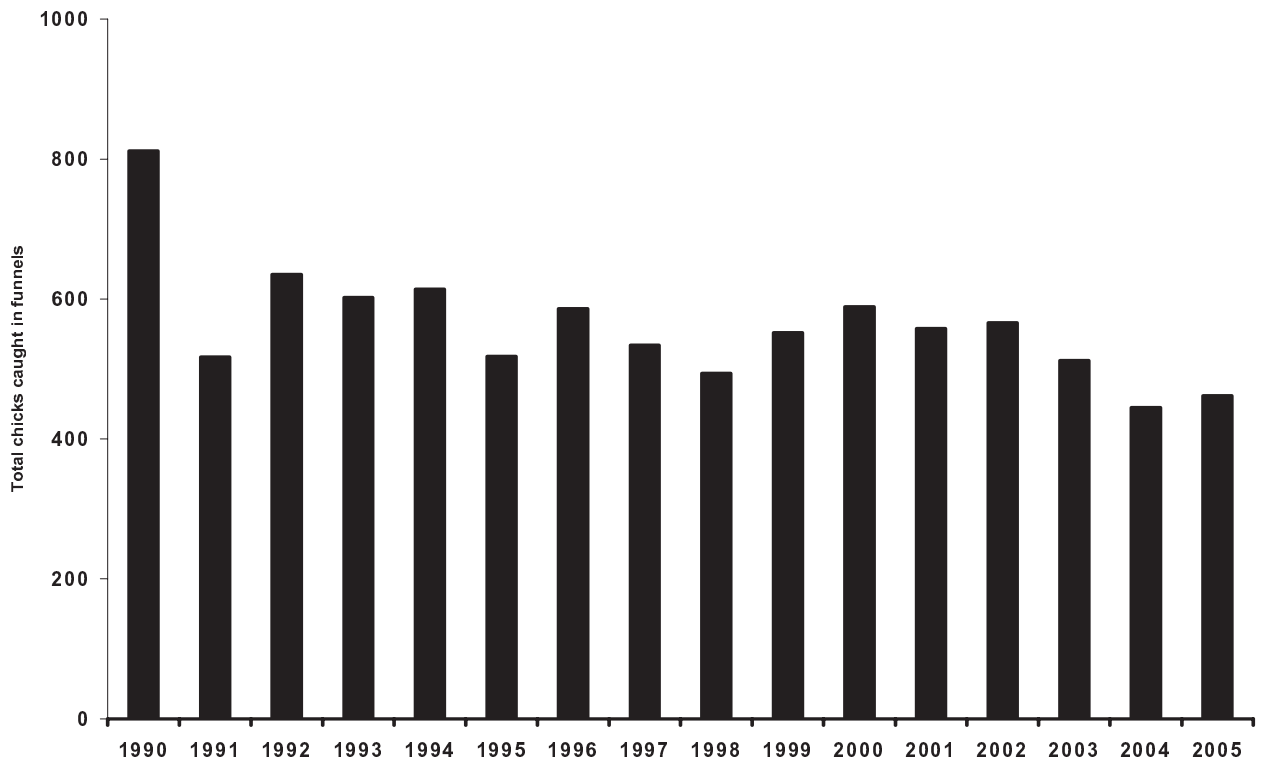


Figure 1
Annual counts of Ancient Murrelets chicks caught in funnels on East Limestone Island 1990-2005.

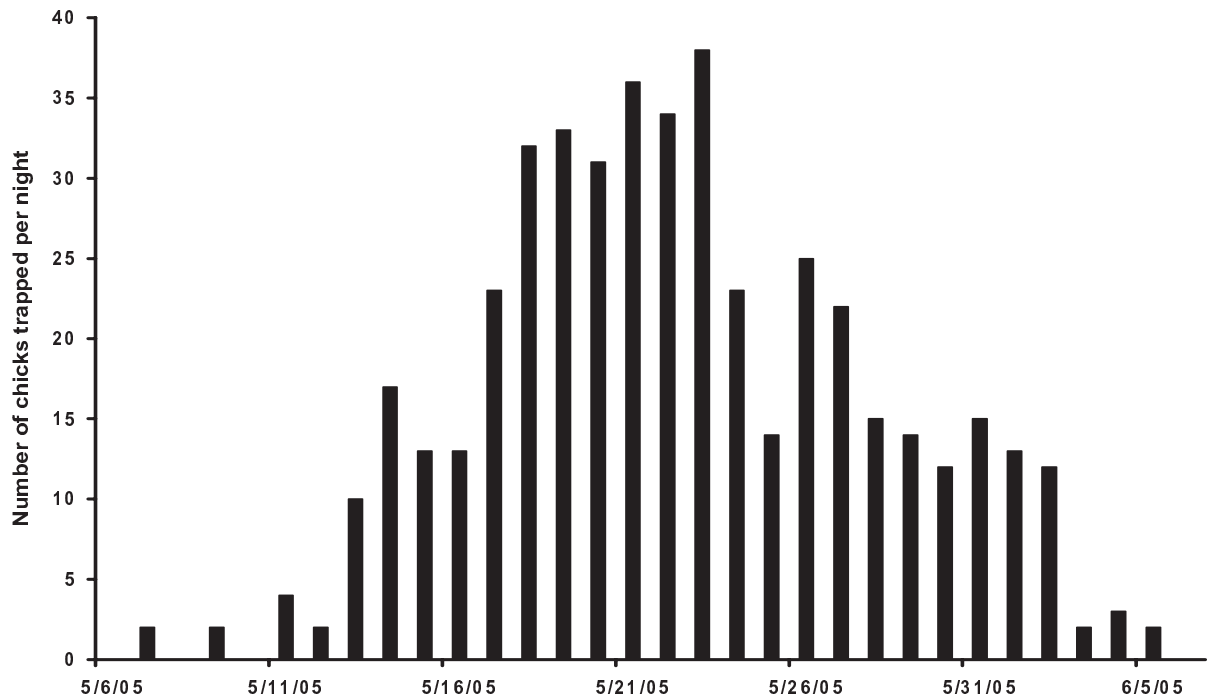


Figure 2
Number of Ancient Murrelet chicks caught in funnels per night from 8 May - 3 June on East Limestone Island

Black Oystercatchers (*Haematopus bachmani*)

Banding

Black Oystercatchers are conspicuous shorebirds that are common along the rocky shores of Haida Gwaii. Because they rely on marine shorelines for nesting and foraging habitat, their breeding success is closely associated with the health of intertidal ecosystems. Consequently, long-term monitoring of Black Oystercatcher reproductive success and chick diets can help detect changes in the inter-tidal environment. The Laskeek Bay Conservation Society has been monitoring Black Oystercatcher population and reproductive success in Laskeek Bay since 1992. Throughout the breeding season, we visit Black Oystercatcher breeding territories to count and measure eggs and chicks.

In 2005, we found 27 Black Oystercatcher sites in Laskeek Bay, containing either eggs or chicks. In total, 46 eggs were laid. Subsequent visits revealed that 22 sites failed while the remaining five nests hatched 10 chicks (range: 1-3 chicks). Two new breeding territories were monitored this year, both located on Louise Island, one at Nelson Pt. (LOU-1) and the other on the point due west of Nelson Pt, 'Squatter Pt.' (LOU-2).

The Black Oystercatcher banding program continued this year. Once chicks reached 100 grams in mass they were banded with colour combinations indicating where they were banded and the year of banding (left leg – locality colour; right leg – year colour / standard metal band). This season, five chicks were banded with a dark green darvic band indicating 2005 as hatch year and a white darvic band indicating Laskeek Bay as nest site location. By mid July, two of the banded chicks disappeared and a third was depredated, leaving only two banded chicks at sites on Reef Islets (Reef –4 and Reef –8). Two nests remained active with eggs at the time of camp closure in mid July, with 1 egg and 2 eggs respectively. These late clutches could indicate either inexperienced breeders or replacement clutches.

This season we spotted nine banded adults at breeding sites in Laskeek Bay (Table 2). Three of the re-sighted birds were banded as adults and three were banded as chicks. Re-sighting our banded birds is important as it lends insights into basic Oystercatcher biology for example: survival, age at first breeding, long term pair bonds, philopatry, and nest site fidelity.

For a second year, the Black Oystercatcher program at LBCS was expanded to include areas in Gwaii

Haanas National Park Reserve / Haida Heritage Site. This expansion includes islands and islets south of Laskeek Bay: on the east side of Lyell, Darwin Sound, including the north end of Juan Perez Sound. Banding colour codes for the different localities were: Richardson Passage = yellow and Juan Perez Sound = dark blue.

We conducted our surveys on two separate occasions using the same protocol employed in Laskeek Bay. On 12-15 June we conducted our first trip, visiting 53 potential breeding territories and finding 41 active nest sites with 66 eggs and 17 chicks. None of the chicks were big enough to band as most were just a couple of days old.

On 2-July, 17-19 July we re-visited the known BLOY territories in Gwaii Haanas and found 29 active sites. Seventeen of the previously active nests had failed while five territories had become active since our last visit, active either eggs or chicks. The 29 active sites included 15 eggs and 26 chicks, 17 of which were big enough to band. Also, on this second trip, we discovered 7 additional breeding territories, five of which were active: five chicks from four sites were banded and one site contained two eggs.

In summary, we visited 60 potential breeding territories in Gwaii Haanas (not including the Lost Is.), 51 of which were active at some point in the season and 22 chicks were banded.

Diet

For many bird species, reproductive success is closely linked to food availability and therefore, baseline information on diet is key to understanding changes in productivity. Adult Black Oystercatchers feed chicks exclusively with marine invertebrates obtained from the intertidal zone and because chicks stay at breeding territories until fledgling (~40d), chick diet composition is relatively easily determined by examining the shell remains of invertebrate prey found at nest sites.

In Laskeek Bay, we collected 1134 prey remains from five nest sites which were later identified and measured to get an idea of both diet composition and prey size. Mussels and limpets made up the majority of prey

delivered to Black Oystercatcher chicks, along with a smaller amount of chitons (Figure 4).

Table 2
Banded adult Black Oystercatchers seen in Laskeek Bay in 2005.

Band Combination	Location seen(nest site)	Year Banded	Banded as Adult or Chick
W-W	South Low (SLW-8)	1994	Chick
W-Bk /M	Skedans(SKE-6)	2000	Chick
W-M	Skedans(SKE-6)	unknown	Chick
UB-Bk/M	South Low(SLW-5)	unknown	unknown
M-Bk/M	Reef Is.(REE-1)	unknown	Adult
M-Bk/M	Reef Is.(REE-2)	unknown	Adult
M-Bk/M	Reef Is.(REE-7)	unknown	Adult
UB-M	Cumshewa Is.(CUM-2)	unknown	unknown
UB-Bk/M	Lost Is.(LOS-4)	unknown	unknown

The average sizes of the three main prey types were 47.6 ± 5.4 mm, 27.2 ± 1.3 mm and $59.4 \text{ mm} \pm 2.2$ mm for mussels, limpets and chitons respectively.

Black Oystercatcher chick diets in Gwaii Haanas were analyzed solely for composition and we were able to identify 2217 prey remains at 24 nest sites.

Results were consistent with findings in Laskeek Bay where mussels, limpets and chitons were the three main types of prey fed to Black Oystercatcher chicks (Figure 4).

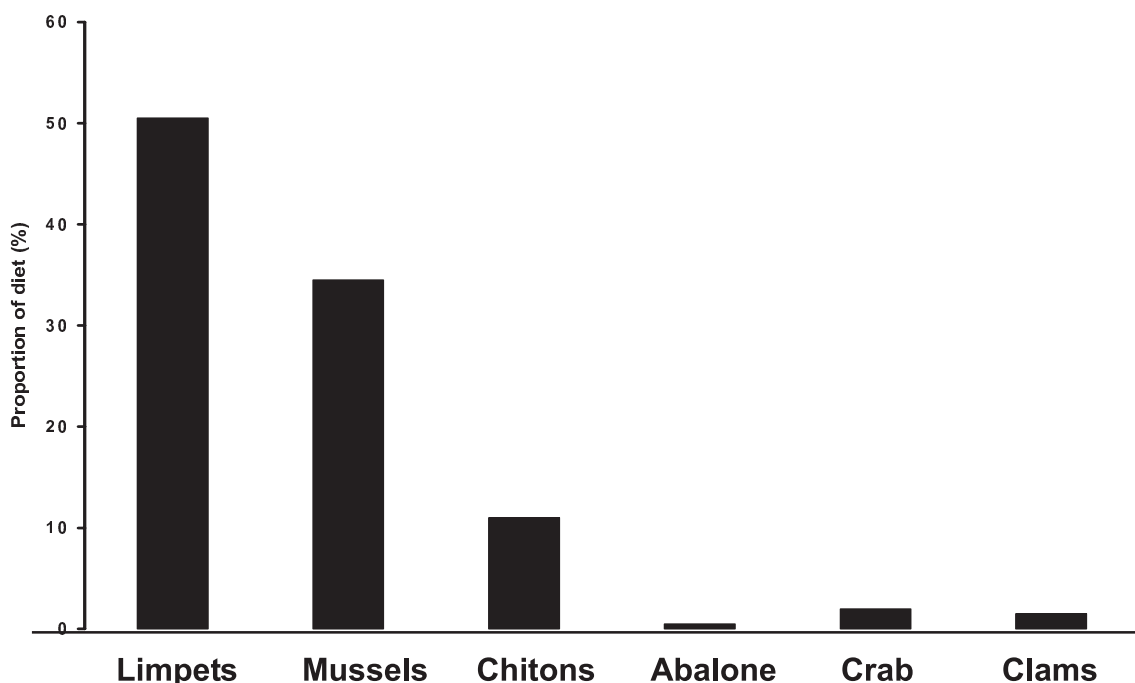


Figure 3
Composition of Black Oystercatcher chick diets determined from 3351 prey remains identified at 29 nest sites located in Laskeek Bay and Gwaii Haanas, 2005.

Glaucous-winged Gulls (*Larus glaucescens*)

On May 24 laying had just begun on Kingsway Rock and we counted 110 adults, 65 empty nests and two nests with one egg each. From June 20-25, we censused all of the Glaucous-winged Gull colonies in Laskeek Bay taking note of the number of adults, nests and describing the contents of each nest. No nests were found at either Skedans or Cumshewa Islands and we counted six nests at Low Island.

Of interest this year was the notable increase in the number of nests at Lost Islands (Fig. 4) as well as a small increase at Kingsway Rock. In total, we counted 326 Glaucous-winged Gull nests in Laskeek Bay: 72% comprised three eggs, 18% two eggs and 7% one egg. The remaining 3% of all nests counted contained either three chicks, two eggs and one chick or one egg and two chicks.

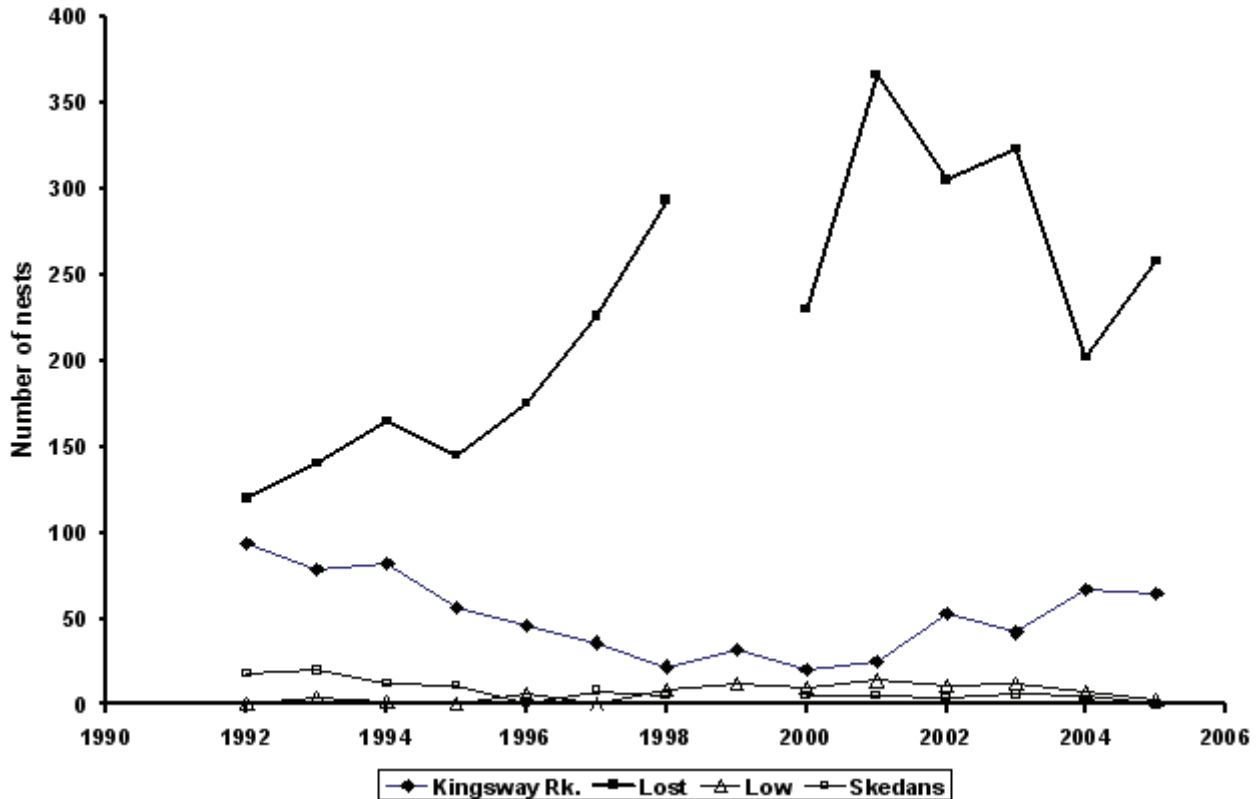


Figure 4
Number of active Glaucous-winged Gull nests in Laskeek Bay 1992-2005

Pigeon Guillemots (*Cephus columba*)

In 2001, ten wooden nest boxes were installed at Lookout Point in hopes that Pigeon Guillemots would nest inside. Since their installment, the ELI crew has been checking the boxes at the end of each season for signs of breeding activity and this year, we found eight chicks in five nestboxes (range:1-2 chicks). This news is exciting as the nest boxes are experimental in design and this year is the first year that chicks have been found. On 23 July, we weighed, measured and banded the eight Pigeon Guillemot chicks.

Cassin's Auklets & Fork-tailed Storm Petrels (*Ptychoramphus aleuticus* & *Oceanodroma furcata*)

This season, we monitored breeding activity at 61 burrows located at Cassin's Tower and the North Shore. We visited the two sites every three days and checked for knockdowns at burrow entrances. Telltale smells at burrow entrances allowed us to identify some of the burrows as either Cassin's Auklets or Storm Petrels. At Cassin's Tower we monitored 47 burrows and based on smell, 23 were Cassin's Auklets, seven were Storm

Petrels and the occupants of the seventeen remaining active burrows could not be determined. On the North Shore, we monitored 13 burrows and based on smell, five nests were Cassin's Auklets and the occupants of two of the burrows could not be determined. By mid-season, six of the 13 burrows on the North shore were no longer active.

We attempted to grub all of the burrows suspected to be Cassin's Auklets and were successful at accessing the contents of one nest at Cassin's Tower. We banded the chick and monitored its growth every five days until it fledged around June 25. In addition to the nests at Cassin's Tower and North Shore, we counted approximately five plus another 12 Cassin's Auklet burrows at the Lookout and South side of the Island. Burrows at both of these sites were located under rocks and thus were chicks inaccessible.

Mid-way through the season, a ladder was constructed at Cassin's Tower. The ladder is a great improvement over the previous scramble method of reaching the top of the Tower.

Marine Surveys

Seabirds

By carrying out regular, systematic surveys at sea we are able to monitor the number of marine birds and marine mammals in the area. One species of particular interest is the Marbled Murrelet as it is provincially red listed and is designated as threatened by the Committee on the Status of Endangered Wildlife in Canada.

In 2005, we conducted four nearshore surveys (3 and 23 May, 8 and 27 June) and two Hecate Strait surveys (May 25 and June 26). The peak count of Marbled Murrelets this season was the 23 May when 110 individuals were counted on a nearshore survey.

We counted sixteen different bird species during nearshore surveys including: Rhinoceros Auklets, Pigeon Guillemots, Pelagic and Double-crested Cormorants, Common Murres, Pacific Loons, Glaucous-winged Gulls, Ancient Murrelets, White-winged Scoters, Buffleheads, Marbled Murrelets, Long-Tailed Ducks, Bald Eagles, a Black-legged Kittiwake, a Red-necked Phalarope and a Sooty Shearwater.

A definite highlight of the season was a Hecate Strait survey we conducted on 25 May. The survey started out with a Horned Puffin sighting and as we travelled east into the Hecate, we were soon surrounded by an estimated 1000 Sooty Shearwaters, including 616 that were counted on our transects. Over the course of our two Hecate Strait surveys we counted nine different bird species including: Marbled Murrelets, Rhinoceros Auklets, Pigeon Guillemots, Common Murres, Sooty Shearwaters, Glaucous-winged Gulls, Ancient Murrelets and Common Loons.

Marine Mammals

In 2005, there were 65 marine mammal sightings of nine species (Table 3). The sightings occurred during sea surveys, sea-watches as well as opportunistically from the cabin.

We reported 15 Humpbacks this season, which is fewer than previous years (Table 3). However, passing boats reported that Humpbacks were common in areas south of Laskeek Bay suggesting that overall, the numbers passing through Haida Gwaii were not necessarily low.

We encountered Killer whales five times this season. Twice we spotted single individuals travelling on their own and on three occasions we saw a group of three whales. Most sightings were brief, with the exception of 27 June, when we followed three whales into the Skedans Islets Lagoon and were able to follow the whales for about an hour. During this encounter, we took photos of each of the three whale's saddle patches and dorsal fins which, in the future, will help with individual identification.

The highest count of Steller sea lions at haul-outs on Reef and Skedans Islands occurred on 3 May, with 373 and 42 individuals counted at each site respectively. The s/v Maple Leaf reported a California Sea Lion sighting on 9 May at Skedans. We kept our eyes and ears open on subsequent visits but were unable to locate the California Sea Lion. No branded individuals were reported this year.



Steller sea lions, Skedans Islands, June 2006
(photo: Tony Gaston)

Table 3

Summary of marine mammals sightings noted throughout the field season on East Limestone Island, 2001-2005. Counts are the result of sightings made during sea surveys, sea-watches as well as opportunistically from the cabin or boat

Species (common name)	Scientific name	2005	2004	2003	2002	2001
Dall's porpoise	<i>Phocoenoides dalli</i>	1	0	0	29	0
Northern elephant seal	<i>Mirounga angustirostris</i>	0	0	1	0	2
Fin whale	<i>Balaenoptera physalis</i>	0	0	1	0	4
Grey whale	<i>Eschrichtius robustus</i>	1	1	3	2	0
Harbour porpoise	<i>Phocoena phocoena</i>	3	12	5	21	19
Harbour seal	<i>Phoca vitulina</i>	679	1177	635	316	105
Humpback whale	<i>Megaptera novaeangliae</i>	15	19	152	49	140
Killer whale	<i>Orcinus orca</i>	11	13	21	29	16
Minke whale	<i>Balaenoptera acutorostrata</i>	0	2	0	0	0
Pacific white-sided dolphin	<i>Lagenorhynchus obliquidens</i>	8	0	325	22	93
California sea Lion	<i>Zalophus californianus</i>	1	1	0	0	0
Steller sea Lion	<i>Eumetopias jubatus</i>	1849	2987	3107	5277	1633

Wildlife Trees

Early in the season we monitored 54 snags for cavity nesting birds. After visiting each tree at least three times, we determined ten trees to be active with Red-breasted Sapsuckers (five nests), Hairy Woodpeckers (two nests) or Chestnut-backed Chickadees (three nests). Of the ten active trees, seven were Sitka spruce and three were Western hemlock. Five of the active trees were new to the list, having not been monitored in previous years. This year, we did not observe any banded birds nesting in wildlife tree cavities.

At the end of the season, we recorded the locations of wildlife trees on Limestone using a G.P.S. unit. We hope to produce a more accurate map of our wildlife tree locations.

Daily Bird Checklist

Our daily checklist of birds on East Limestone and surrounding Laskeek Bay totalled 70 species identified in 2005. The maximum species count for one day was 40, which we counted on May 25. Sightings of interest for the season include: a Red-necked Grebe, a Green-winged Teal, Buffleheads, Long-tailed Ducks, Wandering Tattlers, a Spotted Sandpiper and on June 26, we saw an Ancient Murrelet family out by Reef Island, two adults accompanied by a juvenile bird.

Some of our more unusual sightings on Limestone occurred after a stretch of storms in May when we spotted two Albatross soaring among the waves out by Reef Island and a Savannah Sparrow seen two days in a row in Crow Valley.

Birds of Prey

Two Bald Eagle nests were active this year, tree #7 and tree #8. Tree #8 was a new nest site and is situated along the Ridge Trail. Bald Eagle nests were determined active based on a combination of adult activity at the nest sites, signs of guano around the base of the trees and chicks calling. Because both of the Bald Eagle nests were difficult to see, we were unable to determine how many chicks were produced at each nest.

The Northern Saw-whet pair did not return to nest in tree #81 and unfortunately, we were unable to determine where the Saw-whets were nesting this year. There were a few accounts of owl activity early in the season including three occasions when a Northern Saw-whet Owl was seen perched on funnels at both North and Cabin Cove during Ancient Murrelet chick banding. On July 6, five Northern Saw-whets were observed in the forest during mid-day. Four juvenile birds sat quietly perched for about 45 minutes and then became quite vocal. Within moments, an adult bird arrived

delivering a small mouse or vole to the juvenile birds. This was the only occasion that the family was observed.

This year, we did not find any signs of nesting Peregrine Falcons, Red-tailed Hawks, Sharp-shinned Hawks or Common Ravens. Northwestern Crows nested up on the ridge trail in a tree easily spotted from the path. We counted three chicks at the crow nest and all three fledged in early June.

Plants

In 2005, we did not include any new additions to the Limestone Island plant list, however, we did note a new location for the rare Richardson's Geranium (*Geranium richardsonii*). Richardson's Geranium is not known to occur elsewhere in coastal B.C. and so far, this species has been recorded at four locations on East Limestone Island. Other rare plants such as cut-leaf anemone *Anemone multifida* and showy Jacob's ladder, *Polemonium pulcherrimum* continue to do well on cliffs and other areas that deer cannot access.

Wall lettuce *Lactuca muralis*, an invasive flowering plant was detected in four areas on East Limestone and in efforts to control its spread, we removed all accessible specimens. Unfortunately, wall lettuce appears to be well-established in two hard to reach areas, along the south edge of the island and the cliffs in Crow Valley. The clusters found in Cabin and North Cove areas were removed and those sites will be closely monitored. See also Appendix 1 for additional notes by Marlene Specht.

Introduced Species

In 1998, three deer exclosures were erected on East Limestone Island to demonstrate the recovery of the forest understory in the absence of deer browsing. Unfortunately, when we arrived in late April, fallen trees had damaged all three deer exclosures and deer had browsed the vegetation inside. The exclosures have since been repaired and the vegetation is recovering. Deer on East Limestone are a common sight on the Island and this year we saw at least two fawns, with no reports of the collared deer.

Introduced raccoons have can devastate seabird colonies by predated on eggs, chicks and adults. In order to monitor for the presence of raccoons on the Limestone Islands and neighbouring Louise Island (Vertical Pt. area), we conducted two nighttime surveys

at low tide, scanning the intertidal zone using a spotlight. On 3 June, our first survey, we spotted four raccoons on Louise Island and on 18 June we did not see any raccoons. Raccoon surveys are best conducted during the Ancient Murrelet breeding season and June 18 is a little late, however, poor weather and tide conditions prevented the second survey from occurring any earlier. In addition to our boat surveys, we walked the shoreline on East Limestone throughout the field season, keeping an eye out for behaviours indicative of raccoon activity ie: suspicious diggings and predations or latrines. We did not find any evidence of raccoon activity on Limestone Island this year.

CONCLUSIONS

Although Ancient Murrelet chick numbers are slightly higher than 2004, this year's chick total indicates that the number of chicks passing through Limestone funnels remain low compared to the early 1990s. Concerns persist that previous adult capture work has potentially deterred prospecting birds resulting in reduced recruitment. It remains to be seen, however, whether chick numbers will recover now that adult trapping has ceased. Alternatively, other factors may be at work which of course, underlines the importance of continuing our long-term monitoring efforts. For further thoughts on this problem, see Tony Gaston's paper in this report.

APPENDIX

Notes on Some Plants of East Limestone Island, 9 and 10 July, 2005 by Marlene Specht

I visited east Limestone island on 9-10 July 2005. The main flowering season of many of the plants was over, but there was still much of interest. In the forest interior, *Listera caurina* (northwestern twayblade) and *Moneses uniflora* (single delight) were in flower, and along the rocky shoreline were showy, flowering plants of *Campanula latsepala* (common harebell) and *Mimulus guttatus* (monkey flower). *Prenanthes alata* (western rattlesnake-root) was just coming into flower on moist cliff-faces. Observations were made on the northern half of the island. A number of plants which are rare or uncommon on the island were observed:

Anemone multifida (cut-leaf anemone) – a single, small non-flowering plant on a rocky ledge along the northeastern shore
Arctostaphylos uva-ursi (kinnikinnick) – on rocks north of the biffy
Castilleja unalaschensis (Unalaska paintbrush) – plant with a single, late flower-head, on a high, rocky ledge along the northeastern shore
Chamaecyparis nootkatensis (yellow-cedar) – a single tree on the north side of Boat Cove; cones present
Dodecatheon pulchellum (few-flowered shootingstar) – small plants in 3 locations along

northeastern, rocky shoreline; also on the cliffs in Anemone Cove, large plants with a few late flowers and abundant seedpods
Epilobium ciliatum (purple-leaved willowherb) – small plant on rocks near northernmost tip of island, on east side
Fragaria chiloensis (coastal strawberry) – along northeastern rocky shoreline, high on cliff ledges
Fritillaria camschatcensis (northern rice root) – 2 locations along northeastern shoreline, 1 plant in with seedpod; plants with seedpods in Anemone Cove
Geranium richardsonii (Richardson's geranium) – 4 locations on the northeastern shore (tentative identification of plants at a distance, up on the cliffs and out of flower)
Goodyera oblongifolia (rattlesnake plantain) – a single plant with 2 rosettes, non-flowering, near North Trail
Lactuca muralis (wall lettuce) – small colonies in Cabin Cove and North Cove
Listera caurina (northwestern twayblade) – colonies in flower along trails in forest interior
Senecio sylvaticus – Cabin Cove

VASCULAR PLANTS FROM THE ISLANDS OF LASKEEK BAY, 1990-2005

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SUMMARY

During 1990-2005, we studied the vascular flora of ten islands in Laskeek Bay, Haida Gwaii. We found 171 vascular plants, less than a quarter of those found on the entire archipelago. They comprised 5% trees, 14% shrubs, 56% wildflowers, 16% grasses and 9% ferns. The highest number of species was found on Reef Island (249 ha, 135 species) and the lowest on West Limestone Island (16 ha, 47 species). The larger islands supported more forest interior species than the small islands. Among the islands less than 20 ha in extent, the smallest and furthest offshore supported the greatest diversity of plants, presumably because of an absence of deer.

INTRODUCTION

During the period since the Laskeek Bay Conservation Society began field research on East Limestone Island there has been a continuing interest in the vascular plants of the area. Previous reports have dealt in detail with those found on East Limestone Island (Smith and Buttler 1998, Smith 2003) and on the status of the previously unnoticed Menzies' pipsissewa, *Chimaphila menziesii* (Smith and Buttler 1999). In this paper we detail all species found on the Laskeek Bay islands during the past 15 years and comment on their distributions.

STUDY AREA

Laskeek Bay includes 15 islands large enough to support vegetation other than purely shoreline plants. We studied ten of these, ranging in size from South Low Island (4.5 ha, maximum elevation 15 m) to Kunga Island (353 ha, maximum elevation 200 m). Lost Islands, a group of three small islets, barely separated at low tide, are here treated as a single island.

The ecology of the Laskeek Bay islands has been described by Stockton et al. (2005), Stockton (2006) and Gaston et al. (2006). The vegetation of the larger islands is temperate coniferous forest, dominated by Sitka spruce *Picea sitchensis* and western hemlock *Tsuga heterophylla*. Varying amounts of western

redcedar *Thuja plicata* and shore pine *Pinus contorta* also occur. None of the ten islands studied has been commercially logged and all maintain primary forest cover. Small areas of non-forest habitat occur along shorelines, especially where they are exposed to the southeast, the prevailing direction of storm winds. Those areas support either a diverse sward of forbs and low shrubs, or a rather uniform tussock grass meadow of Nootka reedgrass *Calamagrostis nootkaensis*.

Black-tailed deer *Odocoileus hemionus*, introduced into the Haida Gwaii archipelago in the past 120 years, occur on some islands in Laskeek Bay. The deer have had an important impact on the vegetation of all islands that they have reached (Pojar & Banner 1984, Pojar 1999, Stockton et al. 2005, Gaston et al. 2006). Estimates of the duration of deer presence on the different islands in Laskeek Bay have been made from comparative analyses of shrub stem age structures and the dating of fraying scars (Vila & Martin 2005). South Low, Low and Lost islands show no sign of deer, past or present. West and South Skedans islands showed evidence of deer for less than 20 years. Reef, Kunga, East and West Limestone and Haswell islands all showed evidence of deer presence for 50 or more years. West Limestone Island, West and South Skedans islands, and South Low and Low islands are part of a British Columbia Wildlife Management Area. Kunga Island and Lost Islands fall within the perimeter of Gwaii Haanas National Park Reserve and Haida Heritage Site.

METHODS

Plant records were kept on Reef and East Limestone islands on a casual basis during 1990-1996, when field parties were present to conduct other biological work. In 1997-2005, systematic vegetation surveys on the study islands were carried out as part of a project to monitor the impact of introduced deer and the vegetation recovery following culling of the deer population on Reef Island (Gaston et al. 2006). All islands were surveyed extensively for vascular plants by 2-5 people during June of 1997-2001. Repeat surveys were carried out in 2003 and 2005. Intensive surveys of 10 m (shoreline) and 25 m (interior) diameter circular plots, randomly spaced throughout the islands, were made on all islands during this period. The intensity of surveys was similar for all islands except for Kunga Island, where visits were of shorter duration (2-5 days annually) and involved only two people. East Limestone Island was the most intensively studied. The latter island was known from surveys during 1990-1996 to support several plant species otherwise rare in Haida Gwaii. Further surveys were undertaken each summer from 1997 onwards (Smith & Buttler 1999, Smith 2003). Identifications were made with the help of Hitchcock and Cronquist (1973) and Pojar and Mackinnon (1994). Voucher specimens of were preserved and identifications confirmed by staff at the Central Experimental Farm, Ottawa.

For analysis we divided the vascular plants into five types: trees, shrubs, wildflowers (non-woody plants with showy flowers), graminoids (grasses, sedges and rushes) and ferns and allies (including clubmosses), following the classification of Pojar and Mackinnon (1994). Island area was measured as the area above high tide. For some analyses, we compared the three largest islands (>40 ha) with the five small offshore islands (Low, South Low, Lost, West and South Skedans; all <10 ha and >1 km remote). Because of the known effect of deer browsing on species richness we distinguished among three types of islands: those where deer have never been reported (deer-free), those with deer, but where deer had been present for <20 yr (moderately deer-affected) and those where deer have been present for >50 yr (heavily deer-affected).

RESULTS

Species richness

We found 171 species of vascular plants on the study islands, of which 5% were trees, 14% shrubs, 56%

wildflowers, 16% graminoids and 9% ferns and allies (Table 1). Twelve species were not native to Haida Gwaii, nine wildflowers and three grasses. The potato *Solanum tuberosum*, found only on Reef Island, was almost certainly introduced for cultivation by the Haida. This species was omitted from further analyses. All of the species we identified had been previously recorded in the archipelago.

Reef Island, the second largest, supported the most species (135 spp., 79% of the Laskeek Bay total), while the lowest number was found on West Limestone Island, an inshore island, heavily deer-affected, with heavy forest canopy (47 spp., 27% of the total). The large islands (Reef, Kunga and East Limestone) among them aggregating 685 ha, supported 95% of the species recorded. The five small offshore islands, together aggregating 35 ha, supported 86 species (50% of the total).

Effect of island area

As would be expected, numbers of species recorded increased with island area (Fig. 1). Among species found only on the large islands, there were 3 trees (yellow cedar *Chamaecyparis nootkatensis*, bitter cherry *Prunus emarginata*, and western yew *Taxus brevifolia*; 33% of total), 4 shrubs (17%), 18 wildflowers (19%), 9 grasses (33%) and 6 ferns (40%). All of the introduced species were found on the large islands.

The species missing from the smaller islands were not a random sample of the flora, but included a high proportion of species associated with the forest interior. The small offshore islands supported only 5 species (31%) of ferns, compared with 15 species (62%) of shrubs, 48 species (51%) of wildflowers and 13 species (48%) of graminoids. Species missing from all the five small, offshore islands were the shrub, red osier dogwood *Cornus stolonifera*, the wildflowers, goat's beard *Aruncus dioicus*, bunchberry *Cornus canadensis*, queen's cup *Clintonia uniflora*, groundcone *Boschniakia hookeri*, coral root *Corallorhiza maculata*, pinesap *Hypopitys monotropa* and showy Jacob's ladder *Polemonium pulcherrimum*, four species of ferns and all three species of clubmosses. All these species are characteristic, in our study area, of forest interior situations. In addition, six out of the twelve non-native species were found only on the large islands. Early hairgrass *Aira praecox* was the only non-native species

found on any of the three deer-free islands, although both wood groundsel *Senecio sylvaticus* and bull thistle *Cirsium vulgare* were found on all other islands. Of the seven species found only on small offshore islands, one was the shrub, Sitka mountain ash *Sorbus sitchensis* and six were wildflowers: seabeach sandwort *Honkenya peploides*, beach lovage *Ligusticum scoticum*, tufted saxifrage *Saxifraga caespitosa*, entire-leaved gumweed *Grindelia integrifolia*, woolly hawkweed *Hieracium triste* and tufted vetch *Vicia cracca*, all characteristic of meadows or forest edges (Pojar & Mackinnon 1994).

Effects of deer on small islands (<25 ha)

Highest numbers of shrub and wildflower species (15 and 36 species) were recorded on the smallest island, the deer-free South Low Island, while lowest numbers of wildflowers occurred on the two largest islands, Haswell and West Limestone (21 and 19 species, respectively), both heavily deer-affected. Species found on at least two deer-free islands, but on none of the smaller islands with deer, were the shrub, thimbleberry *Rubus parviflorus*, and the wildflowers, cow-parsnip *Heracleum lanatum*, American wintercress *Barbarea orthoceros*, Siberian miner's lettuce *Claytonia sibirica*, and fringe cup *Tellima grandiflora*. Species missing from the heavily deer-affected small islands (Haswell, West Limestone), but found on other small islands were all wildflowers: spreading stonecrop *Sedum divergens*, fireweed *Epilobium angustifolium*, western strawberry *Fragaria chiloensis* and monkey flower *Mimulus guttatus*. Although the moderately deer-affected islands were similar in species richness to deer-free islands, they showed substantial effects of deer browsing in the form of dead and dying shrubs, especially red huckleberry *Vaccinium parvifolia*, snowberry *Symphoricarpos albus*, and sword fern *Polystichum munitum*. This applied particularly to West Skedans Island, where the interior was, until recently, dominated by sword fern.

Effects of limestone on species richness

Although heavily deer-affected, East Limestone Island supported more species (103) than predicted by its 41 ha area (Fig. 1) and substantially more than the five small offshore islands (86 species), which had an aggregate area almost as large. Native plants not found on other islands of Laskeek Bay were: yellow cedar *Chamaecyparis nootkatensis*, eight species of wildflowers (cut-leaved anemone *Anemone multifida*, queen's cup *Clintonia uniflora*, broad-petalled gentian

Gentiana platypetala, Richardson's geranium *Geranium richardsonii*, slender sandwort *Minuartia tenella*, showy Jacob's ladder *Polemonium pulcherrimum*, self-heal *Prunella vulgaris*) and the fern *Asplenium trichomanes*. As its name suggests, East Limestone Island lies on a limestone outcrop that not only affects soil chemistry, but also affords numerous refuges for plants in the form of steep cliffs and limestone karst features that keep them out of reach of deer.

Other records from Laskeek Bay

A survey of several islands in Laskeek Bay by P. Krannitz (pers. comm.) and others in September 1995 yielded several additional plant species records. On Titul Island, off the north end of Kunga Island, they found roseroot *Sedum integrifolia*, not recorded by us, and silver hairgrass *Aira caryophyllea*, which we found only on East Limestone Island. In addition, they found two other species that we did not record, nodding trisetum *Trisetum cernuum*, on Kunga, Titul and South Skedans islands, and large-awned sedge *Carex macrochaeta* on South Low Island.

DISCUSSION

As expected, the flora of these small and relatively isolated islands proved to be very limited compared to the archipelago as a whole. However, as documented previously (Smith and Buttler 1998), East Limestone Island is an important station for several plants otherwise rare or absent from Haida Gwaii.

Our observations show that the effect of island size on species richness in Laskeek Bay operates mainly through an increase in forest interior species on the larger islands. Shrubs and wildflowers characteristic of shorelines and forest edges were well represented on the smallest islands. Among the small islands, more species were found on the most remote islands, which were deer-free (Low, South Low and Lost), than on the least remote, which were heavily deer-affected. The deer-affected islands were especially lacking in wildflowers and shrubs. The diverse shrub and wildflower communities of the deer-free islands indicate the strong effect that is being caused by deer browsing on plant diversity. Many of the plants missing or uncommon on deer-affected islands, but widespread and abundant on the deer-free islands are among the most attractive, in terms of flower size and colour (red

columbine *Aquilegia formosa*, many-flowered shooting star, monkey flower – note that these are commoner at east Limestone island, where they find refuge on cliffs, than on other deer-affected islands).

On the larger islands, especially Reef Island, we found most of the species in Laskeek Bay. However, species strongly affected by deer (i.e. those absent from small, heavily deer-affected islands), tended to be found on the larger islands only on cliff faces, where they were out of reach of the deer. At Reef Island, a small valley on the south coast was completely inaccessible to deer, being surrounded by steep cliffs on the landward side. This valley supported luxuriant stands of red elderberry *Sambucus racemosa*, thimbleberry, cow-parsley, Siberian miner's lettuce, red columbine and fringe cup. The list includes several species found on deer-free islands but not on other small islands. Without this valley and the deer-free refugia provided by cliff ledges, it is likely that we would have found substantially fewer species on Reef Island.

CONCLUSIONS

Because the most isolated islands have avoided colonisation by deer, they continue to support plants that have been extirpated on deer-affected islands of similar size. The same species persist on larger islands because those islands are large enough to support diverse terrain and a higher chance of refuges created by cliffs and gullies. Consequently, the small inshore islands, easily colonised by deer (West Limestone and Haswell islands) are those with the lowest complement of species. There is some indication from our results that colonisation by non-native species is more likely on deer-affected islands, although the absence of non-natives from the deer-free islands could also be because of their isolation.

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Table 1
Presence or absence data for all vascular plants recorded on the study islands during 1990-2005

	RE(1)	EL(2)	KU(3)	HA(4)	WL(5)	WS(6)	SS(7)	SL(8)	LO(9)	LT(10)
Trees										
Red alder <i>Alnus rubra</i>	1	1	1	1	1	1	1	1	1	1
Yellow cedar <i>Chamaecyparis nootkatensis</i>			1							
Pacific crab apple <i>Malus fusca</i>	1	1	1	1	1	1	1	1	1	
Sitka spruce <i>Picea sitchensis</i>	1	1	1	1	1	1	1	1	1	1
Shore pine <i>Pinus contorta</i> var. <i>contorta</i>		1			1					
Bitter cherry <i>Prunus emarginata</i>			1							
Western yew <i>Taxus brevifolia</i>			1							
Western redcedar <i>Thuja plicata</i>	1	1	1	1	1	1	1		1	1
Western hemlock <i>T. heterophylla</i>	1	1	1	1	1	1	1	1	1	1
Shrubs										
Sitka alder <i>Alnus crispa</i> ssp. <i>sinuata</i>		1	1	1	1	1	1	1	1	1
Saskatoon <i>Amelanchier alnifolia</i>	1	1	1	1	1	0	0	1	0	1
Kinnikinnick <i>A. uva-ursi</i>	1	1	1	1		1		1		1
Bunchberry <i>Cornus canadensis</i>	1									
Red osier dogwood <i>Cornus stolonifera</i>				1						
Salal <i>Gaultheria shallon</i>	1	1	1	1	1	1	1	1	1	1
Black twinberry <i>L. involucrata</i>	1	1	1	1		1	1	1	1	1
False azalea <i>Menziesia ferruginea</i>	1	1	1	1						
Devil's club <i>Oplopanax horridus</i>			1							
Stink currant <i>Ribes bracteosum</i>	1		1							
Black gooseberry <i>Ribes lacustre</i>	1	1	1		1			1		
Trailing black currant <i>R. laxiflorum</i>	1	1	1		1	1	1	1	1	1
Nootka rose <i>Rosa nutkana</i>	1	1	1		1	1		1	1	1
Thimbleberry <i>Rubus parviflorus</i>	1	1	1					1	1	1
Salmonberry <i>Rubus spectabilis</i>	1	1	1	1	1	1	1	1	1	1
Scouler's willow <i>Salix scouleriana</i>	1	1	1	1	1	1	1	1	1	1
Sitka willow <i>Salix sitchensis</i>	1	1								
Red elderberry <i>S. racemosa</i>	1	1	1		1	1	1	1	1	
Sitka mountain ash <i>Sorbus sitchensis</i>										1
Snowberry <i>Symphoricarpos albus</i>	1	1	1		1	1		1	1	1
Alaskan blueberry <i>Vaccinium alaskaense</i>	1	1	1	1						
Red huckleberry <i>V. parvifolium</i>	1	1	1	1	1	1	1	1	1	1
Wildflowers										
Yarrow <i>Achillea millefolium</i>	1	1	1	1	1	1	1	1	1	1
Silver burweed <i>Ambrosia chamissonis</i>		1					1			
Pearly everlasting <i>Anaphalis margaritacea</i>	1									
Cut-leaf anemone <i>Anemone multifida</i>			1							
Sea-watch <i>Angelica lucida</i>	1	1	1	1				1	1	1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Red columbine <i>Aquilegia formosa</i>	1	1	1		1			1	1	1
Hairy rockcress <i>Arabis hirsuta</i>	1	1	1					1		
Western dwarf mistletoe <i>Arceuthobium campylopodum</i>				1						
Arnica <i>Arnica spp.</i>		1								
Goatsbeard <i>Aruncus dioicus</i>	1		1							
Douglas' Aster <i>Aster subspicatus</i>	1	1	1			1	1	1		1
America wintercress <i>B. orthoceras</i>			1					1		1
Vancouver groundcone <i>Boschniakia hookeri</i>			1							
Fairyflipper <i>Calypso bulbosa</i>	1	1	1							
Common harebell <i>C. rotundifolia</i>	1	1	1		1	1	1	1	1	1
Western bittercress <i>Cardamine occidentalis</i>			1		1					
Few-seeded bittercress <i>Cardamine oligosperma</i>			1	1	1					
Unalaska paintbrush <i>C. unalascensis</i>		1	1				1		1	1
Field chickweed <i>Cerastium arvense</i>		1	1	1	1	1	1		1	
Menzies' pipsissewa <i>Chimaphila menziesii</i>	1		1		1					
Canada thistle <i>Cirsium arvense</i>	1	1	1							
Edible thistle <i>Cirsium edule</i>	1	1	1							
Bull thistle <i>Cirsium vulgare</i>	1	1	1	1	1	1	1			
Siberian miner's lettuce <i>C. sibirica</i>	1	1	1					1	1	1
Heart-leaved twayblade <i>Listera cordata</i>	1		1	1	1					
Alp lily <i>Lloydia serotina</i>										
Nootka lupine <i>L. nootkatensis</i>	1			1					1	1
Skunk cabbage <i>Lysichiton americanum</i>		1	1							
False lily-o-t-valley <i>M. dilatatum</i>	1	1	1	1	1	1	1	1	1	1
Field mint <i>Mentha arvensis</i>		1	1							
Yellow monkey-flower <i>M. guttatus</i>	1	1	1			1	1	1	1	1
Slender sandwort <i>Minuartia tenella</i>			1							
Single delight <i>Moneses uniflora</i>	1	1	1			1				
Small-leaved montia <i>Montia parvifolia</i>		1	1	1	1	1				
Pacific water-parsley <i>Oenanthe sarmentosa</i>	1		1							
Common Butterwort <i>Pinguicula vulgaris</i>										
Sea plantain <i>Plantago maritima</i>	1	1	1	1	1	1	1	1	1	1
Sea blush <i>Plectritis congesta</i>	1					1		1	1	1
Showy Jacob's ladder <i>Polemonium pulcherrimum</i>				1						
Villous cinquefoil <i>P. villosa</i>	1	1	1	1	1	1	1	1	1	1
W. rattlesnake-root <i>P. alata</i>	1	1	1	1	1	1	1	1	1	1
Self-heal <i>Prunella vulgaris</i>		1								
Western buttercup <i>R. occidentalis</i>	1	1	1				1	1	1	1
Creeping buttercup <i>Ranunculus repens</i>		1								
Little buttercup <i>Ranunculus uncinatus</i>		1								
Curled dock <i>Rumex crispus</i>	1	1				1	1		1	
Coastal pearlwort <i>Sagina maxima</i>	1	1	1	1	1	1	1	1	1	1
Tufted saxifrage <i>Saxifraga caespitosa</i>									1	
Alaska saxifrage <i>S. ferruginea</i>	1	1	1	1		1		1	1	1
Spreading stonecrop <i>S. divergens</i>	1	1	1			1	1	1	1	1
Wood groundsel <i>Senecio sylvaticus</i>		1	1	1	1	1	1	1		
Shore bue eyed grass <i>S. littorale</i>	1	1				1		1	1	1
Potato <i>Solanum tuberosum</i> (1)										
Canada goldenrod <i>Solidago canadensis</i>		1								
Prickly sow-thistle <i>Sonchus asper</i>	1		1							
Cooley's hedge nettle <i>Stachys cooleyae</i>		1								
Crisp sandwort <i>Stellaria crispa</i>	1	1	1		1	1	1			1
Clasping twistedstalk <i>Streptopus amplexifolius</i>			1		1					
Common dandelion <i>Taraxacum officinale</i>		1				1	1	1		
Fringecup <i>Tellima grandiflora</i>	1	1	1					1		1
Foamflower <i>Tiarella trifoliata</i>	1	1	1							

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Stinging nettle <i>Urtica dioica</i>	1	1	1							
American brooklime <i>Veronica beccabunga ssp. americana</i>				1	1					
Tufted vetch <i>Vicia cracca</i>							1			
Giant vetch <i>Vicia gigantea</i>	1		1	1	1	1		1	1	1
Violet <i>Viola spp.</i>	1		1							
Grasses, sedges and rushes										
Dewey's sedge <i>Carex deweyana</i>	1	1	1		1		1			
Gmelin's sedge <i>Carex gmelinii</i>	1		1							
Lynghby's sedge <i>Carex lynghbyei</i>	1									
Merten's sedge <i>Carex mertensia</i>	1			1						
Sitka sedge <i>Carex sitchensis</i>	1			1			1	1		1
Early hairgrass <i>Aira praecox</i>	1	1	1	1		1	1	1	1	1
Silver hairgrass <i>Aira caryophylla</i>			1							
Alaska brome <i>Bromus sitchensis</i>	1					1		1	1	1
Nootka reedgrass <i>C. nutkaensis</i>	1		1	1	1	1	1	1	1	1
Wood reedgrass <i>Cinna latifolia</i>	1									
Tufted hairgrass <i>Deschampsia elongata</i>		1	1							
Blue wildrye <i>Elymus glaucus</i>	1		1							
Dunegrass <i>Elymus mollis</i>	1	1	1		1	1	1	1	1	1
Western fescue <i>Festuca occidentalis</i>		1		1						
Red fescue <i>Festuca rubra</i>	1	1	1	1	1	1	1	1	1	1
Bearded fescue <i>Festuca subulata</i>	1	1	1		1		1			
Meadow barley <i>H. brachyantherum</i>	1		1		1	1	1	1	1	1
Common velvet-grass <i>Holcus lanatus</i>				1						
Alaska oniongrass <i>Melica subulata</i>				1						
Bluegrass <i>Poa sp.</i>		1								
Alaska alkali grass <i>P. nutkaensis</i>				1	1	1	1	1	1	1
Arctic rush <i>Juncus arcticus</i>	1	1	1	1			1	1	1	1
Common rush <i>Juncus effusus</i>	1		1							
Sickle-leaved rush <i>Juncus falcatus</i>	1									
Many-fl. wood-rush <i>L. multiflora</i>	1	1	1	1	1	1	1	1	1	1
Small-fl. wood-rush <i>L. parviflora</i>	1	1	1	1	1		1			
Piper's wood-rush <i>Luzula piperi</i>	1		1							
Ferns and allies										
Maidenhair fern <i>Adiantum pedatum</i>		1	1	1						
Maidenhair spleenwort <i>Asplenium trichomanes</i>				1						
Deer fern <i>Blechnum spicant</i>	1	1	1							
Spiny wood fern <i>D. expansa</i>	1	1	1	1	1	1	1			1
Oak fern <i>Gymnocarpium dryopteris</i>		1								
Lady fern <i>Athyrium filix-femina</i>	1	1	1	1				1	1	1
Parsley fern <i>Cryptogramma crispa</i>	1									
Licorice fern <i>P. glycyrrhiza</i>	1	1	1	1	1	1	1	1	1	1
Sword fern <i>Polystichum munitum</i>	1	1	1	1	1	1	1	1	1	1
Bracken <i>Pteridium aquilinum</i>	1						1	1	1	1
Wallace's selaginella <i>S. wallacei</i>	1		1							
Narrow beech fern <i>T. phegopteris</i>	1									
Horsetail <i>Equisetum spp.</i>	1		1							
Running clubmoss <i>Lycopodium clavatum</i>				1						
Fir clubmoss <i>Lycopodium selago</i>	1		1							
Stiff clubmoss <i>Lycopodium annotinum</i>				1						

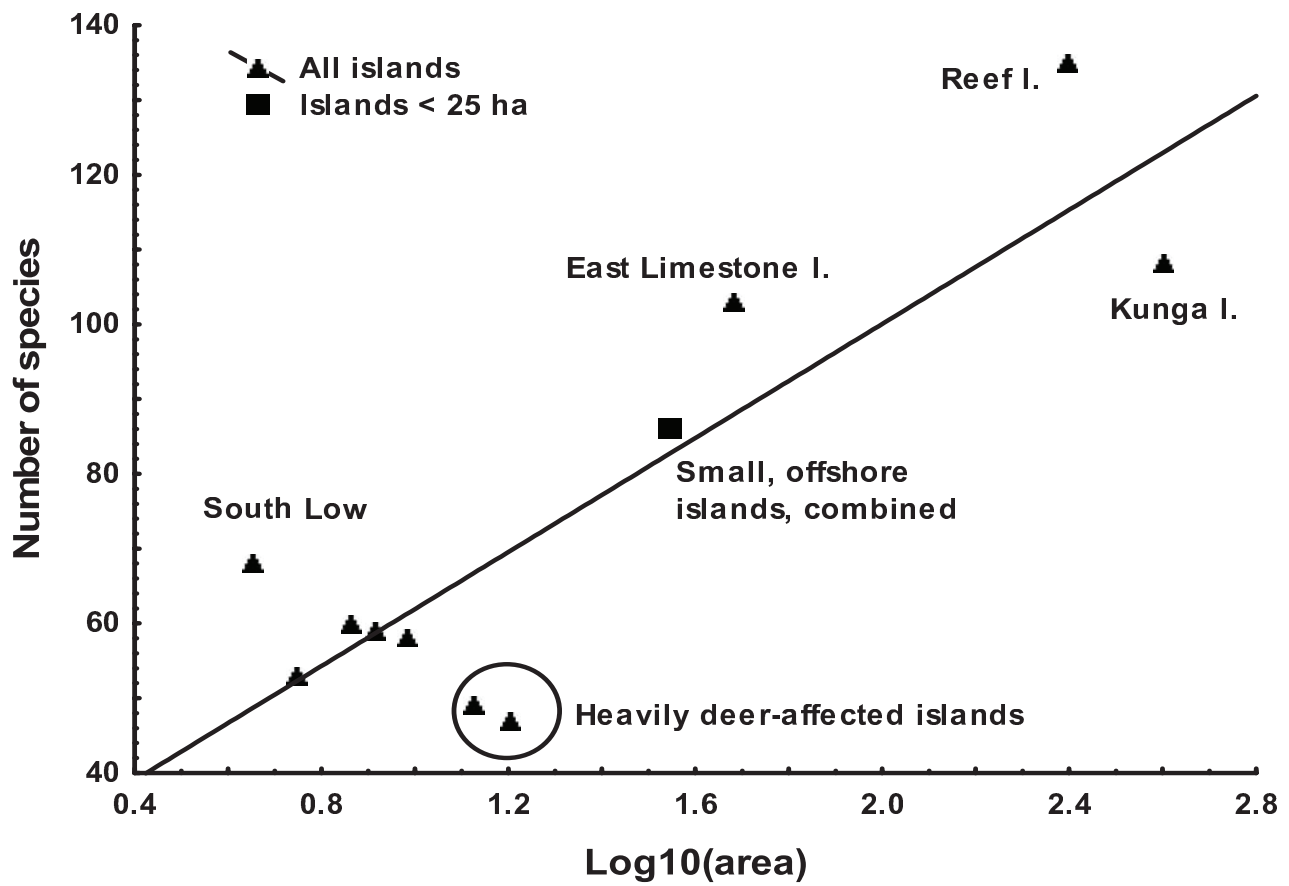


Figure 1
Numbers of species identified in relation to island area

RESEARCH GROUP ON INTRODUCED SPECIES - ABSTRACTS OF PAPERS PUBLISHED IN PEER-REVIEWED JOURNALS

BIRDS:

(1) Gaston, Anthony J., Jean-Louis Martin, and Sylvain Allombert. 2005. **Oceanography affects breeding biology for the terrestrial avifauna of a temperate coastal rainforest.** *Avian Conservation and Ecology* 1: 4. [online] URL: <http://www.ace-eco.org/vol1/iss1/art4/>

We studied the timing of breeding and juvenile/adult ratios among songbirds in temperate rainforest over four years on the Haida Gwaii (Queen Charlotte Islands) archipelago, British Columbia. Timing of breeding, measured by the first capture of juveniles, or by direct observations of hatching, varied by approximately 19 d between the earliest (1998) and latest (1999) year. In 1998, the proportion of juveniles among birds trapped increased steeply as soon as young birds began to appear. In other years the rate of increase was slower. In 1999, the peak proportions of hatching year individuals among foliage gleaning insectivores (Orange-crowned and Townsend's warblers and Golden-crowned Kinglet) were lower than in other years, with almost no young Orange-crowned Warblers at all captured. May air temperatures in Haida Gwaii in 1999 were the lowest in 20 years, while those in 1998 were above average: the other two years were closer to normal, although 2001 was almost as cold as 1999. These temperatures closely followed patterns of Sea Surface Temperatures created by the 1997/98 El Niño (warm) event and the subsequent strong La Niña (cool) event. Although rainfall also differed among years, the pattern of variation in timing of breeding and in the proportion of hatching year individuals trapped, fitted the temperature data better. We conclude that SST changes off northern British Columbia, through their effects on air temperatures, had a strong effect on the breeding of forest birds, to the point of causing nearly complete reproductive failure for one species in 1999.

(2) Allombert, Sylvain, Anthony J. Gaston and Jean-Louis Martin. 2005. **A natural experiment on the impact of overabundant deer on songbird populations.** *Biological Conservation* 126 (2005) 1–13.

Declines in songbird populations have been identified both in North America and in Europe. Several explanations have been proposed but few studies have evaluated the possibility that deer overabundance might affect songbird populations, and none have identified general rules to predict such an impact. We used a group of islands in the Haida Gwaii archipelago (British Columbia, Canada), where islands without deer co-exist

near islands with deer, as a natural experiment to test if the dependence of each species on understorey vegetation was a good predictor of deer impact. Forest bird assemblages were compared on six islands that either had no deer, had deer for less than 20 years or for more than 50 years, and on an enlarged set of 31 islands for which vegetation data and an index of deer impact were available. In the six islands data-set, songbird abundance on islands browsed for more than 50 years was 55–70% lower than on deer-free islands. There was a significant decrease in alpha diversity on islands browsed by deer, but gamma diversity remained unchanged. Bird species with the highest dependence on understorey vegetation were most affected and their abundance decreased by 93%. Bird communities flipped from being 73% dependant on understorey vegetation on deer-free islands to 79% not dependant on understorey vegetation on islands with deer for more than 50 years. A canonical correspondence analysis on the 31 island data-set allowed us to further separate the interactions between bird abundance and distribution, vegetation features and deer presence. We propose that deer overabundance results in a decrease in songbird habitat quality through decreased food resources and nest site quality and may explain part of current continental-scale decreases in songbird populations.

(3) Martin, Jean-Louis and Mathieu Joron. 2003. **Nest predation in forest birds: influence of predator type and predator's habitat quality.** *Oikos* 102: 641–653.

We used the introduction of a generalist nest predator, the red squirrel *Tamiasciurus hudsonicus*, and of a large herbivore, the Sitka black-tailed deer *Odocoileus hemionus sitkensis*, to the islands of Haida Gwaii (Queen Charlotte Islands, British Columbia, Canada) to study how predator assemblage and habitat quality and structure influenced nest predation in forest birds. We compared losses of natural nests to predators on islands with and without squirrels. We selected nine islands with or without squirrel or deer and used 506 artificial nests put on the ground or in shrubs to further analyse variation of nest predation with predator assemblage and habitat quality for the predators. For both natural and artificial nests predation risk was higher in presence of squirrels. But predation risk varied within island categories. In presence of squirrels it was highest

in stands with mature conifers where it fluctuated from year to year, in response to fluctuations in squirrel abundance. Vegetation cover around the nest had little effect on nest predation by squirrels. Where squirrels were absent, nest predation concentrated near predictable food sources for corvids, the main native predators, and increased with decreasing vegetation cover, suggesting that removal of the vegetation by deer increased the risk of predation by native avian nest predators that use visual cues. Predation risk in these forests therefore varies in space and time with predator composition and with quality of the habitat from the predators' perspective. This temporal and spatial variation in predation risk should promote trade-offs in the response of birds to nest predation, rather than fine-tuned adaptations to a given predation pattern.

B: FORESTRY

(4) Martin, Jean-Louis and Christophe Baltzinger. 2002. **Interaction among deer browsing, hunting, and tree regeneration.** *Can. J. For. Res.* 32: 1254–1264. The intentional removal or addition of species or specific human impacts on ecosystems trigger changes that can help us understand species interactions. In many temperate forests, deer populations are increasing and so is the need to understand how they influence ecosystems. We took advantage of the introduction of Sitka black-tailed deer (*Odocoileus hemionus sitchensis* Merriam) to the Queen Charlotte Islands (Haida Gwaii), British Columbia, Canada, to study how hunting pressure affects the impact of deer on tree regeneration after logging. We show that although the regeneration of western redcedar (*Thuja plicata* Donn ex D. Don) is drastically reduced in presence of deer, regeneration is better and browsing stress lower, in areas where deer are more exposed to hunting. Similar effects of accessibility for hunters are observed on browsing stress of Sitka spruce (*Picea sitchensis* (Bong.) Carrière). Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) is not significantly affected, and its regeneration is not correlated to hunting. We suggest that the effect of hunting on tree regeneration could be explained by the incidence of hunting on deer behaviour rather than by the actual number of deer killed by hunters. These results suggest that the future occurrence of redcedar stands in second-growth forests on this archipelago may depend on the amount and distribution of deer hunting.

(5) Vila, Bruno, Thierry Keller and Frédéric Guibal. 2001. **Influence of browsing cessation on *Picea sitchensis* radial growth.** *Ann. For. Sci.* 58 (2001) 853–859.

Picea sitchensis is an ecological and economical component of North America north temperate rain forest. In Haida Gwaii which is one of the most productive forest land of British Columbia archipelago (Canada), it is an important and a valuable commercial species. The present study aims at precisising [*sic*]deer browsing consequences on growth regeneration of *Picea sitchensis*. Using ring-width series, an empirical model is built which describes browsing impact on radial growth and removal of these pressure. Taking into account deer pressure and browsing upper limit when building predictive height growth models proves valuable for comparing growth pattern of different species under browsing pressure and deducing changes in forest dynamics.

(6) Vila, Bruno, Frédéric Guibal. 2001. **Assessing browsing influence in forest understory using dendrochronology on Haida Gwaii archipelago (British Columbia, Canada).** *Dendrochronologia* 19: 139 – 151.

The impact of introduced deer (*Odocoileus hemionus sitchensis*) on understory vegetation is assessed by analyzing browsed and non browsed individuals of a shrub (*Gaultheria shallon*) and a tree species (*Picea sitchensis*). Browsing is expressed in terms of morphology change, diameter growth patterns differences and traumatic anatomical characteristics occurrence on cross-sections. At the impacted site, an upper browsing limit at a height of 1.10 m is evidenced. Abrupt growth change associated with scars are evidenced on shrubs but deer impact on shrub growth is not directly assessed because of high inter-shrub variance among ring-width series. Deer impact can be assessed taking into account particular anatomical features as pith position, pith and stem form, wedging rings and scar occurrence for which impacted and non impacted populations differ statistically. Samples from the impacted population display non circular cross-sections with altered wood areas, eccentric piths and several discontinuous or wedging rings. As regards with spruce, browsing pressure decreases apical growth and induces at severely browsed individuals a shrubby port. Narrow ring patterns are caused by browsing; these patterns are followed by a sudden growth change occurring when herbivore pressure stops. That involves

a lengthening of the recruitment period in windthrows which results in a delay of the habitat closing processes.

(7) Vourc'h, Gwenaël, Bruno Vila, Dominique Gillon, José Escarré, Frédéric Guibal, Hervé Fritz, Thomas P. Clausen and Jean-Louis Martin. 2002. **Disentangling the causes of damage variation by deer browsing on young *Thuja plicata*.** *Oikos* 98: 271–283.

Long-lived trees experience different levels of damage due to mammalian herbivores. To untangle the mechanisms that underlie this variation, we combined chemical with dendrochronological analyses to study variation in browsing on Western redcedars (*Thuja plicata*) on Haida Gwaii (British Columbia, Canada). Since the last glaciation, Haida Gwaii forests had lacked large herbivore browser until Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) were introduced at the beginning of the 20th century. Dendrochronology yielded information on radial growth and plant annual responses to environmental stresses including herbivory. Secondary metabolite content and plant nutritional quality provided insights into proximate causes of food choices made by herbivores. We sampled lightly- and heavily-browsed young trees at four sites: three clear-cut sites with high browsing pressure and one old-growth forest site where browsing pressure had, until recently, been lower. Heavily-browsed young trees had lower concentrations of secondary metabolites and were of lower nutritive value than lightly-browsed trees at all sites. Under high browsing pressure, tree growth patterns suggested that all young trees were initially severely browsed until some trees, currently scored as lightly-browsed, started to escape deer. At the old-growth site, both lightly- and heavily-browsed trees tended to have lower overall average secondary metabolite concentrations than those of all other sites, a trend possibly related to greater canopy closure. Lightly-browsed trees were older than heavily browsed ones which resulted, during the period of lower browsing pressure, in higher growth rate and a same pattern of change in growth from one year to the next year. This suggests that, under low browsing pressure, selection of young trees related to chemical defence was weak and that growth differences due to other factors than browsing could be expressed. Under strong browsing pressure, however, all young trees had equally low growth rates until trees with better genetic potential to produce effective defences were able to escape deer. This suggests that selection by deer could occur on a long-lived tree.

(8) Vila, Bruno, Gwenaël Vourc'h, Dominique Gillon, Jean-Louis Martin, Frédéric Guibal. 2002. **Is escaping deer browse just a matter of time in *Picea sitchensis*? A chemical and dendroecological approach.** *Trees* 16: 488–496

We combined chemical and dendroecological analyses to understand the mechanisms that are involved in escaping deer browse by young Sitka spruce (*Picea sitchensis*) exposed to browsing by Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) on Haida Gwaii (British Columbia, Canada). We compared chemical defences (terpenes), nutritive compounds (nitrogen, non-structural constituents, cellulose, and lignin), as well as age and radial growth of two young spruce categories growing side by side: (1) stunted spruces that were heavily browsed, shorter than the browse line, and (2) escaped spruces that were taller than the browse line but still browsed below the browse line. Escaped and stunted spruces did not differ in terpene concentrations, or in nutritive compound contents, suggesting that they had similar palatability. Escaped spruces were older than stunted spruces. Stunted and escaped trees had similar slow growth when young, suggesting no difference in initial browsing between the two spruce categories. For escaped spruce, there was a dramatic increase in radial growth at about 12–13 years old, suggesting that the apex of the trees had escaped deer browse. Because the two categories of spruces were equally accessible and did not differ in chemical defences or in nutritive compounds, and because escaped spruces were older than stunted trees and had a similar slow radial growth in their first 12–13 years, we conclude that morphological differences between stunted and escaped browsed trees are due to age and that it is only a matter of time before spruce escape deer on Haida Gwaii.

(9) Vila, Bruno, Franck Torre, Frédéric Guibal, Jean-Louis Martin. 2003. **Growth change of young *Picea sitchensis* in response to deer browsing.** *Forest Ecology and Management* 180: 413–424.

Taking advantage of the introduction of the black-tailed deer to the Queen Charlotte Islands (British Columbia, Canada), used dendrochronological analyses to understand the consequences of deer browsing on Sitka spruce growth. We compared shape, radial growth, height growth and age of young spruce in three sites. We identified two types of trees growing side by (1) stunted and heavily browsed spruce, smaller than the browsing limit and (2) escaped spruce that were taller than the browsing limit but still browsed in their lower part. The compact and heavily ramified shape in stunted

spruce was the result of repeated and intense browsing. In escaped spruce this was also the case below the browsing limit (1:16m _ 0:07 m), in sharp contrast with the normal shape that escaped spruce resumed above the browsing limit. We show that the release of browsing pressure, once the tree reaches the browsing limit, is characterised by an abrupt increase in radial growth. Before release, trees show growth stagnation characterized by narrow rings (0.5 mm per year) and small annual height increments (<5 cm per year). After release, trees show a growth stabilisation characterised by wider rings (3 mm per year) and larger annual height increments (20 cm per year). We use this pattern to estimate frequency and age at release and their possible variation over time. Differences between stunted and escaped spruce are highly significant and indicate that, despite of browsing, most if not all will ultimately reach the browsing limit and escape. Heavy deer pressure (30 deer per km²) delays spruce sapling recruitment about 8 years. This delay varies in relation to site quality and seems to have increased over time, suggesting an increase browsing pressure.

(10) Vila, Bruno, Franck Torre, Jean-Louis Martin Frédéric Guibal. 2003. **Response of young *Tsuga heterophylla* to deer browsing: developing tools to assess deer impact on forest dynamics.** *Trees* 17: 547–553.

We used dendroecology to describe and understand the consequences of deer browsing on regenerating western hemlock (*Tsuga heterophylla*). We compared tree shape, growth rate, height and age at four different sites in Haida Gwaii (British Columbia, Canada) that had trees representative of the range of deer impact on trees: (1) trees showing no sign of browsing, (2) escaped trees which were still browsed below the browse line and (3) stunted and heavily browsed trees. Repeated and intense browsing resulted in the small size, compact heavily ramified shape of stunted trees and in the short compact and ramified lower branches of escaped trees. These contrasted with the shape of non-browsed trees, a shape that was also found in escaped trees above the browse line. Before release, all browsed trees experienced stagnation in growth characterised by narrow rings (0.3 mm/year) and a small annual height increment (2.5 cm/year). At release, growth rate increased and stabilised: rings were wider (1.3 mm/year) and annual height increments were greater (10.5 cm/year). Nonbrowsed trees had a mean ring-width of 1.3 mm/year and an annual height increment of 22 cm/year. Delay in tree recruitment caused by deer varied from site to site. It had been

about 15 years for the escaped trees and is estimated at 30–40 years for the stunted trees. Spatial variation in deer impact may reflect spatial variation of browsing pressure resulting from local differences in the availability of preferred forage or to differences in tree chemical defences/nutritional values.

(11) Vila, Bruno, Frank Torre, Frédéric Guibal, Jean-Louis Martin. 2004. **Can we reconstruct browsing history and how far back? Lessons from *Vaccinium parvifolium* Smith in Rees.** *Forest Ecology and Management* 201: 171–185.

We assessed the impact of browsing by black-tailed deer (*Odocoileus hemionus sitkensis*) on a common long-lived shrub (the red huckleberry, *Vaccinium parvifolium*) on Haida Gwaii (British Columbia, Canada). We studied how deer impact can be used as a marker of deer abundance and fluctuation and a means to reconstruct the recent history of deer browsing over a significant section of the archipelago. We compared islands with and without deer to understand processes involved in these changes. We compared shrub features such as number of stems and regenerating sprouts, age and height of stems and stem age-structures between deer-free and deer-affected islands and analysed their spatial and temporal variation. Deer, by browsing regenerating sprouts, stopped stem replacement. On deer-affected islands the number of stems per individual shrub was 2–4 times lower than on deer-free islands. The number of regenerating sprouts was 8–15 times higher. Stems were, on average, 2–3 times older. There was no variation in these characteristics among deer-free islands. They varied both spatially and temporally among deer-affected islands revealing spatial and temporal variation in deer impact. Deer impact has been prevalent for at least 40–50 years before this study in all sites with deer but one. In the latter, the most distant from the point of introduction, severe impact seemed to date to less than 10 years before this study. On Reef Island, Ramsay Island and Burnaby Island, deer impact was prevalent 10–20 years earlier than on Louise and Haswell Islands, although the two latter were much closer and more easily accessible from the point of introduction. Using independent information, we interpreted this pattern as the result of differences in climate and habitat rather than of a delay in colonisation. Effects of isolation on dispersal, pattern of land use or access to alpine summer range are all likely to affect delay between colonisation and severe impact.

(12) Vila, Bruno, Frédéric Guibal, Franck Torre and Jean-Louis Martin. 2004. **Assessing spatial variation in browsing history by means of fraying scars.** *Journal of Biogeography* 31: 987–995.

Aim: We used fraying scars to understand spatial variation in browsing history. Information on browsing history is an essential background in studies on the long-term effect of deer browsing on the flora and fauna and of its variation in space. **Location:** We focused on two small neighbouring islands of Haida Gwaii (British Columbia, Canada), Reef Island and South-Skedans Island, colonized by introduced black-tailed deer (*Odocoileus hemionus sitkensis*). **Methods:** We searched for sites where trees with fraying scars were clustered. We studied the trees that deer selected (species, size) and the characteristics of scars (number, position, size). Using a cross-dating procedure, we dated fraying scars with dendrochronology, obtaining an accurate estimate of the year the scar was formed. **Results:** On Reef Island, *Thuja plicata* was the tree species chosen for fraying. On South-Skedans Island, where *Thuja plicata* is missing, deer chose *Salix* sp. and *Alnus rubra*. Deer chose only trees with a circumference of less than 50 cm. About two to three fraying scars were recorded per tree. All of them extended between 30–40 and 70–80 cm from the ground and were between 5 and 6 cm in width. On Reef Island, 95% of the scars were formed during the last 50 years. On South-Skedans Island, 95% were formed over the last 10 years. Age distribution of scars showed a constant increase of the number of scars over time. It indicated that deer had colonized Reef Island 53 years prior to this study but were absent or rare on South-Skedans Island until 13 years prior to this study. **Main conclusions:** These results indicate different colonization dates and thus different length of browsing histories for the islands studied and provide the historical background necessary to analyse the involvement of deer in the current differences in the flora and fauna observed between islands.

(13) Vila, Bruno, Frédéric Guibal, Franck Torre and Jean-Louis Martin. 2005. **Can we reconstruct deer browsing history and how? Lessons from *Gaultheria shallon* Pursh.** *Ann. For. Sci.* 62: 153–162.

We identified and analysed browsing signatures left by Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) on Salal (*Gaultheria shallon*) to reconstruct deer browsing history. Radial growth analyses showed negative abrupt growth changes on islands with deer probably linked to defoliation. Deer browsing pressure

was best assessed by the incidence of morphological changes caused by browsing in section form, lobes, pith form, pith position or the presence of decaying wood and by changes in stem age structures. Salal stems were twice older (30 years) on islands with deer than on islands without deer (16 years). On islands with deer deficit of stems in the youngest age classes suggested that deer impact has been strong on these shrubs for at least 20 years in the northern sites and for about 10 years in the southern ones.

(14) Vila, Bruno, Thierry Keller and Frédéric Guibal. 2001. **Influence of browsing cessation on *Picea sitchensis* radial growth.** *Ann. For. Sci.* 58: 853–859. *Picea sitchensis* is an ecological and economical component of North America north temperate rain forest. In Haida Gwaii which is one of the most productive forest land of British Columbia archipelago (Canada), it is an important and a valuable commercial species. The present study aims at precisating deer browsing consequences on growth regeneration of *Picea sitchensis*. Using ring-width series, an empirical model is built which describes browsing impact on radial growth and removal of these pressure. Taking into account deer pressure and browsing upper limit when building predictive height growth models proves valuable for comparing growth pattern of different species under browsing pressure and deducing changes in forest dynamics.

(15) Vourc'h, Gwenaël, Jean-Louis Martin, Patrick Duncan, José Escarré, Thomas P. Clausen. 2001. **Defensive adaptations of *Thuja plicatata* to ungulate browsing: a comparative study between mainland and island populations.** *Oecologia* 126: 84–93.

Forests on the Haida Gwaii (HG) archipelago (British Columbia, Canada) evolved for about 10,000 years in the absence of large-mammal browsing. The introduction of black-tailed deer (*Odocoileus hemionus sitkensis*) from the mainland prior to 1901 provides an opportunity to evaluate changes in the adaptive defensive responses of plants to herbivory. We compared (1) food choice by deer and (2) chemical defence (terpene concentrations) between HG and mainland red cedars (*Thuja plicata*) using (1) nursery-grown seedlings never exposed to deer, (2) branches from trees that grew before the introduction of deer (“old trees”) and (3) saplings exposed to deer herbivory on the mainland and on HG. We used the first two plant categories to test the hypothesis that plants that evolve

under low herbivory levels have lower anti-herbivore defences. We used saplings to study the consequences of the dramatic increase in browsing on HG. During food experiments, deer preferred HG seedlings and old tree branches compared to those from the mainland. Total monoterpene concentrations were much higher than diterpene concentrations in all plant categories. Within plant categories, multivariate analysis showed that terpene profiles differed significantly between HG and mainland red cedars: HG seedlings and old trees had lower monoterpene levels. These results suggest that some monoterpenes may be determinants of deer food choice and that the defences of HG plants are less effective than those of mainland plants. The deer used branches from HG and mainland saplings indiscriminately. However, terpene profiles differed significantly between HG and mainland saplings, with multivariate analysis suggesting a higher defensive response in browsed HG saplings. Monoterpene profiles were different in lightly and heavily browsed saplings from HG, suggesting that under the current browsing regime, individuals with the greatest constitutive defences, or with greatest potential for induced defences, grow better and are selected on HG.

(16) Vourec'h, Gwenaël, Michel DE Garine-Wichatitsky, Alice Labbe, Dimitri Rosolowski, Jean-Louis Martin and Hervé Fritz. 2002. **Monoterpene effect on feeding choice by deer.** *Journal of Chemical Ecology*. 28, No. 12.

A previous study showed that Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) consumption was negatively correlated with monoterpene content in western redcedar (*Thuja plicata*). To test whether these monoterpenes were deterrent to Sitka black-tailed deer, we performed feeding choice experiments with four hydrocarbon (sabinene, myrcene, α -pinene, and *d* C *l*-limonene) and one oxygenated (α , β -thujone) monoterpene solution at their highest natural concentration in western redcedar foliage. To test whether deer response was species specific, we ran similar experiments on European roe deer (*Capreolus capreolus*) and rusa deer (*Cervus timorensis russa*). In all experiments, monoterpenes were repellent. Solutions with α , β -thujone, the major monoterpene in redcedar leaves, were the most repellent of the solutions tested. We then analyzed how black-tailed and roe deer responded to (1) an increase in concentration of the monoterpenes with the weakest repellent effects (hydrocarbon monoterpenes) and (2) a decrease in concentration of the monoterpene with strongest effect (α , β -thujone). Repellency tended to increase with

concentration for hydrocarbon monoterpenes, but remained strong for α , β -thujone. As wild deer regularly feed on plants containing monoterpenes, this raises the question as to how the animals deal with these molecules.

(17) Vourec'h, Gwenaël, J. Russell, and J.-L. Martin. 2002. **Linking deer browsing and Terpene production among genetic identities in *Chamaecyparis nootkatensis* and *Thuja plicata* (Cupressaceae).** *Journal of Heredity* 2002: 93(5).

To investigate whether differential herbivore browsing reflects genetic variation in plant defense expression, variation in needle terpenes and damage caused by black-tailed deer (*Odocoileus hemionus*) was analyzed on yellow-cedar (*Chamaecyparis nootkatensis*) and western redcedar (*Thuja plicata*). In a 100-genet yellowcedar population, three genets that were heavily browsed and had extremely low levels of monoterpenes (0–0.36% dry matter), sesquiterpenes, and diterpenes were compared to unbrowsed genets (0.85–3.83% monoterpenes in dry matter). These differences were maintained in individuals protected from browsing, suggesting genetically based variation in constitutive terpene production. In western redcedar, heavily browsed trees had significantly lower total monoterpene concentrations (1.69% dry matter) than lightly browsed trees (3.32% dry matter). One heavily browsed tree expressed no monoterpenes. No differences were found for diterpenes. In both species, the genotypes with extremely low monoterpene concentrations came from the same openpollinated families.

(18) Vourec'h, Gwenaël, Bruno Vila, Dominique Gillon, José Escarré, Frédéric Guibal, Hervé Fritz, Thomas P. Clausen and Jean-Louis Martin. 2002. **Disentangling the causes of damage variation by deer browsing on young *Thuja plicata*.** *Oikos* 98: 271–283.

Long-lived trees experience different levels of damage due to mammalian herbivores. To untangle the mechanisms that underlie this variation, we combined chemical with dendrochronological analyses to study variation in browsing on Western redcedars (*Thuja plicata*) on Haida Gwaii (British Columbia, Canada). Since the last glaciation, Haida Gwaii forests had lacked large herbivore browser until Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) were introduced at the beginning of the 20th century. Dendrochronology yielded information on radial growth and plant annual responses to environmental stresses including herbivory. Secondary metabolite content and plant nutritional quality provided insights into proximate causes of food

choices made by herbivores. We sampled lightly- and heavily-browsed young trees at four sites: three clear-cut sites with high browsing pressure and one old-growth forest site where browsing pressure had, until recently, been lower. Heavily-browsed young trees had lower concentrations of secondary metabolites and were of lower nutritive value than lightly-browsed trees at all sites. Under high browsing pressure, tree growth patterns suggested that all young trees were initially severely browsed until some trees, currently scored as lightly-browsed, started to escape deer. At the old-growth site, both lightly- and heavily-browsed trees tended to have lower overall average secondary metabolite concentrations than those of all other sites, a trend possibly related to greater canopy closure. Lightly-browsed trees were older than heavily browsed ones which resulted, during the period of lower browsing pressure, in higher growth rate and a same pattern of change in growth from one year to the next year. This suggests that, under low browsing pressure, selection of young trees related to chemical defense was weak and that growth differences due to other factors than browsing could be expressed. Under strong browsing pressure, however, all young trees had equally low growth rates until trees with better genetic potential to produce effective defences were able to escape deer. This suggests that selection by deer could occur on a long-lived tree.

(19) Vourc'h, Gwenaël, John Russell, Dominique Gillon and Jean-Louis Martin. 2004. **Short-term effect of defoliation on terpene content in *Thuja plicata***. *Ecoscience* 10: 161-167.

Insect herbivory or mechanical wounding in conifers can induce monoterpene biosynthesis. Low risk of herbivory coupled with low availability of resources, are hypothesized to favour induced responses and to decrease constitutive defences. We studied the response to defoliation in western redcedars (*Thuja plicata*) from two regions: the Haida Gwaii archipelago, where mammalian herbivores were lacking until black-tailed deer were introduced at the end of the 19th century and previous work indicated that trees were less well defended, and the north coast mainland (British Columbia, Canada). We predicted that higher induced defences in the island population would compensate for reduced constitutive defences. We used one- and two-year-old nursery grown seedlings to test (1) if defoliation would cause a short-term chemical response in island western redcedar and (2) if mainland western redcedars that have always been exposed to large mammalian herbivores respond differently. The

concentration in monoterpene and diterpenes did not vary significantly in response to defoliation over the 5 day period analyzed regardless of the defoliation intensity or the plant's origin.

C: VEGETATION

(20) Stockton, Stephen A., Sylvain Allombert, Anthony J. Gaston, Jean-Louis Martin. 2005. **A natural experiment on the effects of high deer densities on the native flora of coastal temperate rain forests**. *Biological Conservation* 126 : 118–128.

The introduction of Sitka black-tailed deer (*Odocoileus hemionus sitkensis* Merriam) to Haida Gwaii (Queen Charlotte Islands, BC, Canada) in the late 19th century, provided an opportunity to understand the long-term effects of deer populations on the vegetation of temperate rain forests in the absence of their natural predators wolves (*Canis lupus* L.), and cougars (*Puma concolor* L.). Using seven small islands with different browsing histories (no deer, deer for <20 years, deer for >50 years), we tested the long-term forest edge habitats. Overall vegetation cover exceeded 80% in the lower vegetation layers on islands without deer and was less than 10% on the islands with deer for more than 50 years. Although overall plant species richness was similar on islands with or without deer, plant species richness at the plot scale (314m²) was reduced by 20–50% on islands with deer for >50 years. The differences were most pronounced for the species rich edge communities and among herb and shrub species. These results suggest that in the absence of predators, deer have the potential to greatly simplify the forest ecosystem.

(21) Gaston, Anthony J., Stephen A. Stockton and Joanna L. Smith. *In press*. **Species-area relationships and the impact of deer-browse in the complex phytogeography of the Haida Gwaii archipelago (Queen Charlotte Islands), British Columbia**. *Ecoscience*. We studied the biogeography of vascular plants on ten islands in Laskeek Bay, Haida Gwaii (Queen Charlotte Islands), British Columbia. The islands varied in size from 4.5-395 ha, and experienced a range of different browse pressures from introduced black-tailed deer (*Odocoileus hemionus*). We examined how island size interacted with browse pressure in determining the total species counts for individual islands. Numbers of plant species recorded increased with island area. The regression exponent for the log-log plot of species number on island area

was 0.18: at the lower end of the range for such exponents. Many species absent from islands <25 ha in area were characteristic of forest interiors and consequently, part of the increase in richness on larger islands probably was the result of increased forest interior area. Among the islands <25 ha in area, the normal species-area and species-isolation relationships were reversed, with smaller, more isolated, islands supporting more plant species than larger islands and, for a given area, more isolated islands supporting more species, than less isolated ones. This reversal of the normal trend appears to be the result of deer browsing. Small, isolated islands were the only islands without deer and were richer, especially in wildflowers, than the larger, less isolated islands. On large islands, total species complement remains as predicted by area because the effect of deer was mitigated by the presence of deer-free refugia on cliffs and in isolated gullies. We concluded that deer were a major factor structuring the island plant communities and continued protection of island habitats from introduced deer is essential to maintain the native flora of Haida Gwaii.

QUEEN'S UNIVERSITY HAIDA GWAI AVIAN GENETICS PROJECT - ABSTRACTS OF PAPERS PUBLISHED IN
PEER-REVIEWED JOURNALS AND THESES

Bull, Roger D. 2005. **Patterns of genetic differentiation in Orange-crowned Warbler *Vermivora celata* populations across their breeding range.** M. Sc. Thesis, Queen's University, Kingston, Ontario.

The Orange-crowned Warbler *Vermivora celata* is a Neotropical migrant passerine broadly distributed across North America. The breeding range of this species would have been subject to a cycle of contractions and expansions during the Pleistocene glaciations. This may have isolated populations in different glacial refugia resulting in allopatric differentiation. This scenario has been invoked to explain concordant biogeographic patterns seen in many North American taxa. The Orange-crowned Warbler breeds on Haida Gwaii, British Columbia (formerly known as the Queen Charlotte Islands). Largely due to a pattern of morphological endemism in diverse taxa, a glacial refugium is thought to have persisted in the area of this archipelago during the Pleistocene glaciation. To investigate intra-specific genetic structure in the Orange-crowned Warbler on continental and regional scales, I analysed patterns of microsatellite variability among seven breeding localities, encompassing two of the four described subspecies. I found low genetic differentiation among populations ($F_{ST} = 0.022$), with significant continental-scale structuring and weak differentiation within western populations. Weak population genetic structure in the Orange-crowned Warbler is consistent with results for species with similar life-histories and distributions. I did not find evidence of a genetically endemic population of Orange-crowned Warblers in Haida Gwaii. Microsatellite differentiation supports the classification of two of the four currently recognised subspecies (*V. c. celata* and *V. c. lutescens*). Evidence of equilibrium between gene flow and drift supports a hypothesis of restricted contemporary gene flow between *V. c. lutescens* and *V. c. celata*. Further genetic research, including analysis of *V. c. orestera* and *V. c. sordida*, is required to fully elucidate the taxonomy and conservation priorities of this species.

Burg, Theresa M., Anthony J. Gaston, Kevin Winker and Vicki L. Friesen. 2005. **Rapid divergence and postglacial colonization in western North American American Steller's jays (*Cyanocitta stelleri*).** *Molecular Ecology* 14: 3745-3755.

Post-Pleistocene avian colonization of deglaciated North America occurred from multiple refugia, including a coastal refugium in the northwest. The location of a Pacific Coastal refugium is controversial; however, multiple lines of evidence suggest that it was located near the Queen Charlotte Islands (also known as Haida Gwaii). The Queen Charlotte Islands contain a disproportionately large number of endemic plants and animals including the Steller's jay *Cyanocitta stelleri carlottae*. Using five highly variable microsatellite markers, we studied population structure among eight populations of Steller's jay ($N = 150$) from geographical areas representing three subspecies in western North America: *C. s. carlottae*, *C. s. stelleri* and *C. s. annectens*. Microsatellite analyses revealed genetic differentiation between each of the three subspecies, although more extensive sampling of additional *C. s. annectens* populations is needed to clarify the level of subspecies differentiation. High levels of population structure were found among *C. s. stelleri* populations with significant differences in all but two pairwise comparisons. A significant isolation by distance pattern was observed amongst populations in the Pacific Northwest and Alaska. In the *C. s. carlottae* population, there was evidence of reduced genetic variation, higher number of private alleles than northern *C. s. stelleri* populations and higher levels of divergence between Queen Charlotte Island and other populations. We were unable to reject the hypothesis that the Queen Charlotte Islands served as a refugium during the Pleistocene. Steller's jay may have colonized the Queen Charlotte Islands near the end of the last glaciation or persisted throughout the Pleistocene, and this subspecies may thus represent a glacial relic. The larger number of private alleles, despite reduced genetic variation, morphological distinctiveness and high divergence from other populations suggests that the Queen Charlotte Island colonization pre-dates that of the mainland. Furthermore, our results show rapid divergence in Steller's jay populations on the mainland following the retreat of the ice sheets.

Burg, Theresa M., Anthony J. Gaston, Kevin Winker and Vicki L. Friesen. 2006. **Effects of Pleistocene glaciations on population structure of North American chestnut-backed chickadees.** *Molecular Ecology* 15: 2409-2419.

The postglacial recolonization of northern North America was heavily influenced by the Pleistocene glaciation. In the Pacific Northwest, there are two disjunct regions of mesic temperate forest, one coastal and the other interior. The chestnut-backed chickadee is one of the species associated with this distinctive ecosystem. Using seven microsatellite markers we found evidence of population structure among nine populations of chestnut-backed chickadees. High levels of allelic variation were found in each of the populations. Northern British Columbia and central Alaska populations contained a large number of private alleles compared to other populations, including those from unglaciated regions. The disjunct population in the interior was genetically distinct from the coastal population. Genetic and historical records indicate that the interior population originated from postglacial inland dispersal. Population structuring was found within the continuous coastal population, among which the peripheral populations, specifically those on the Queen Charlotte Islands and the central Alaska mainland, were genetically distinct. The pattern of population structure among contemporary chickadee populations is consistent with a pioneer model of recolonization. The persistence of genetic structure in western North American chestnut-backed chickadees may be aided by their sedentary behaviour, linear distribution, and dependence on cedar-hemlock forests

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