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Introduced mammals, vegetation changes and seabird conservation on the Scott Islands, British Columbia, Canada

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Summary

The Scott Islands, British Columbia, Canada, support the largest aggregation of breeding seabirds in the eastern Pacific Ocean south of Alaska. However, large seabird populations were eradicated by American Mink and Raccoons introduced to Lanz and Cox islands in the 1930s, while the ecological consequences of the introduction of European Rabbits to Triangle Island in the 1920s are unknown. We have seen dramatic changes in the vegetation on Triangle Island in recent decades, chiefly a decrease in Tufted Hairgrass cover and a concomitant increase in Salmonberry

of the world's breeding population of Cassin's Auklet , a small seabird that selects grass-covered habitat but avoids tall Salmonberry for nesting, the vegetation changes raise serious concerns for a species that has experienced dramatic population declines in recent years. Restoration of seabird nesting habitat by removing American Mink and Raccoons from Lanz and Cox islands will be vital for long-term seabird conservation in the Scott Islands.

Introduction

Introduced mammals have dramatically altered ecological processes on many of the world's islands, including sites that support some of the largest assemblages of breeding seabirds (Howald . 2007, Donlan and Wilcox 2008, Jones . 2008). Their effects are many and varied. Predatory species kill adult birds and their offspring, ultimately eradicating ecologically important species and disrupting nutrient transfer from sea to land (Croll . 2005, Fukami . 2006). Herbivorous species can also have strong effects on island ecosystems, as when their browsing or grazing alters vegetation dynamics and accelerates rates of soil erosion, potentially causing landslides, and leading to the loss of seabird breeding habitat (Donlan . 2002, Frenot . 2005, van der Wal

. 2000, Donlan . 2003).

Among important issues for seabird conservation on Canada's Pacific coast, problems with troduced mammals on breeding colonies stand out (Rodway 1991, Hartman . 1997). The ott Islands, a small archipelago of five main islands plus associated rocks (Figure 1), support the rgest aggregation of breeding seabirds in the north-eastern Pacific Ocean south of Alaska odway 1991). However, three of the five islands support introduced mammals. Lighthouse epers brought European Rabbits to Triangle Island in the 1920s, while

fur farmers brought American Mink [illegible] to Lanz Island and Raccoons [illegible] to Cox Island in the 1930s (Carl[illegible]. 1951). Subsequently, American Mink now occur on Cox

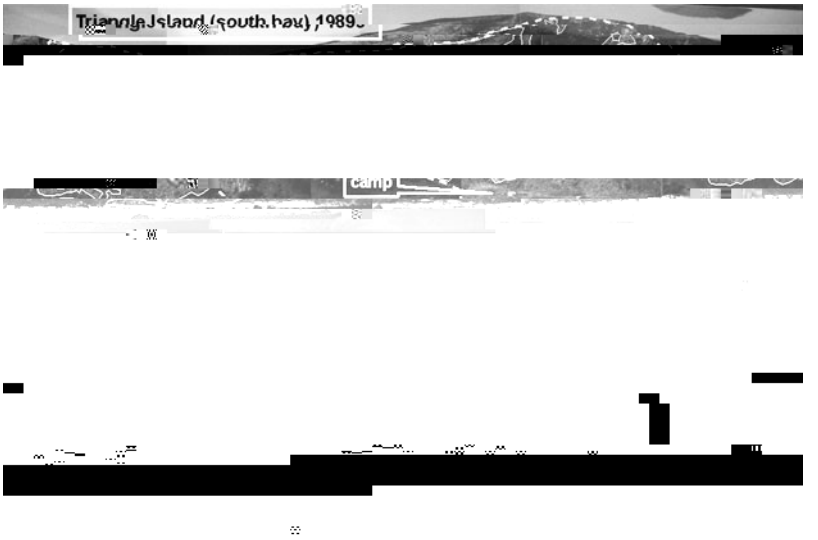


Figure 2. Comparative photos of the South Bay slope on Triangle Island in 1989 (top) and 2006 (bottom), showing the decrease in Tufted Hairgrass cover and increase in Salmonberry cover. Tufted Hairgrass areas are outlined in a solid white line on both photos, within a comparable area outlined in a dashed white line. Areas of Tufted Hairgrass were determined from examination of colour versions of the photographs.

Island, Sartine is a treeless island that supports a large breeding population of several hundred thousand Cassin's Auklets, but unlike Triangle, Sartine is free of rabbits or any other non-native mammals. Comparable (though not identical) baseline vegetation and seabird data were available from 1989 on Triangle Island and from 1987 on Sartine Island (Rodway , . 1990). These earlier surveys, combined with surveys in 2004 (Triangle) and 2006 (Sartine), facilitated this comparison.

Materials and methods

The methods used to survey vegetation and seabird populations on the Scott Islands in the 1980s have been described in detail elsewhere (Rodway , . 1990).

As part of a long-term programme to estimate and track trends in seabird populations in British Columbia, fifteen 10 m × 10 m permanent monitoring plots were established within the boundaries of the main part of the Cassin's Auklet breeding colony on Triangle Island in 1989. These plots were located along regularly-spaced transects which were part of a colony-wide census of the island conducted in that same year. The number of Cassin's Auklet burrows contained in each plot and the percentage and species composition of ground cover were recorded by teams of 3–4 people. Within each plot, the species or category type of vegetation (grass, herbs and forbs, Salmonberry) and its percentage ground cover were visually estimated, and distinct boundaries between vegetation types were drawn on a gridded map of the plot. To make the process easier, teams subdivided each plot into four 5 m × 5 m sections, counted burrows and estimated ground cover in each section, then summed totals across the whole 100 m^2 plot.

The monitoring plots were first surveyed between 2 July and 16 August 1989, marked with metal stakes at each corner, and their locations drawn on a topographic map of the island. In later years, the plots were georeferenced with a Garmin GPS unit. The plot surveys were repeated from 11 June to July 4, 2004.

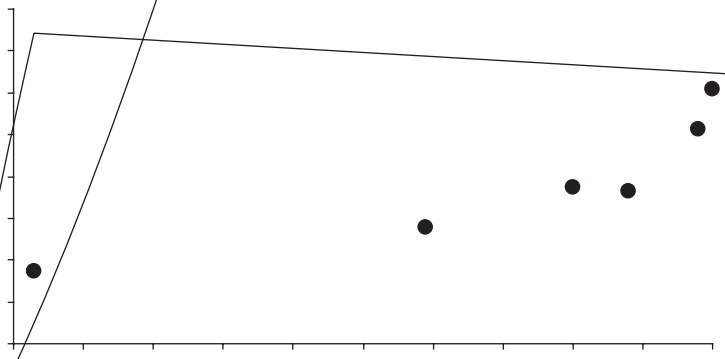
On Sartine Island, vegetation cover and Cassin's Auklet burrow numbers were quantified in a total of 187 1 m × 1 m plots located at 5 m intervals along a system of seven regularly-spaced transects from 9 to 13 July 1987. The starting point for each transect and its compass bearing were described and mapped on an outline of an aerial photo of the island. We resurveyed six of the seven transects on Sartine Island on 3–5 August 2006 (it was not safe to resurvey transect 6, given a rock slide in the interim). In addition, we visited Lanz and Cox islands on 5–21 July 1987 when most of the coastline of each island was explored on foot. Areas of the coastline on the two islands which were identified as potential seabird nesting habitat in 1987 were revisited on 9–12 August 2006.

Results

At Triangle Island, our surveys of the set of 15 100-m² monitoring plots in 1989 and 2004 revealed that the average area covered by grass decreased from ~68 to ~38 m² (paired- $_{14}$ = 5.87, < 0.001), while the average area covered by Salmonberry increased from ~13 to ~33 m² (paired- $_{14}$ = 3.94, = 0.001, Figure 3). The remaining changes were due to increases in ferns and various forbs on several plots. Over the same period, the average number of Cassin's Auklet burrows per plot decreased from 208 to 143 (paired- $_{14}$ = 4.38, < 0.001). Within individual plots, the change in the number of burrows was not correlated with changes in cover of either grass or Salmonberry (both r^2 < 0.01). However, the auklets' consistent use of grass-covered areas for burrowing was evident: a second order polynomial fit to the data pooled across the two time periods (r^2 = 0.65, = 30, = 24.74, < 0.001; number of burrows per 100-m² plot = 115.1 + 0.03 × grass cover² - 1.14 × grass cover) showed that the number of burrows per plot increased from ~100 in plots with no grass cover to ~300 in plots with 100% grass cover (Figure 4). There was also a weaker negative linear relationship between the number of burrows and Salmonberry cover (r^2 = 0.19, = 30, = 5.83, = 0.02; number of burrows per 100 m² plot = 204.20 – 1.23 × Salmonberry cover).

Within the 187 (1987) or 175 (2006) 1-m² plots at Sartine Island, the median area under grass cover decreased from 0.95 m² to 0.70 m² (Mann-Whitney

Discussion



., 2003). Thus, the possibility exists that recent vegetation changes witnessed on Triangle Island are a response to declining levels of activity and disturbance by burrow-nesting seabirds.

Climatic changes can also affect plant community dynamics on islands, and in some situations even override the more direct effects of invasive herbivores (Donlan, ., 2003). Over the period from 1970 to 2005, summers in the Scott Islands have become warmer (~1 °C increase in the average air temperature from April to August inclusive) and drier (~200 mm less total average precipitation), based on weather records at Cape Scott, 30 km east of Sartine Island (Figure 7). Many studies, most of them in high latitude and high altitude environments, have shown that climatic changes can alter the competitive interactions among species within plant communities (Dormann and Woodin 2002, Klanderud and Totland 2005). Climatic changes of similar magnitude to those occurring in coastal British Columbia have been linked to vegetation changes on seabird islands elsewhere, including decreases in native tall-tussock grasses (Donlan, ., 2003, Chapuis, ., 2004). Further research will be needed to determine the balance of factors, which

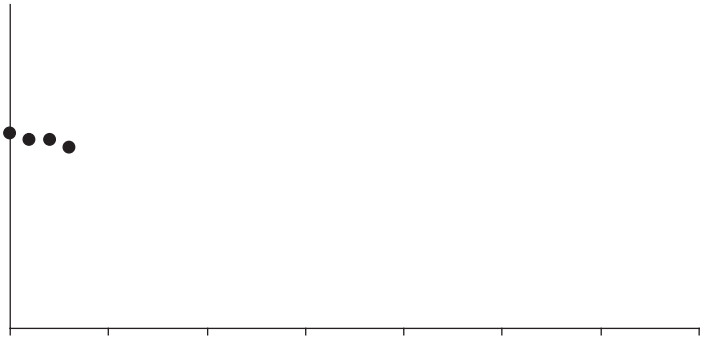
Table 1. Vegetation cover (percentage of total area) within 1 m² plots located at 5 m intervals along six transects on Sartine Island surveyed in both 1987 and 2006. Transect 6 was not surveyed in 2006 because it was unsafe to access.

Transect	Year	No. plots	% Grass		% Salmonberry	
			Median	Range	Median	Range
1	1987	27	100	70–100	0	0–20
	2006	25	100	10–100	0	0–60
2	1987	17	80	80–95	0	0–0
	2006	14	70	5–100	0	0–0
3	1987	48	100	0–100	0	0–10
	2006	39	80	10–100	0	0–60
4	1987	53	50	0–100	50	0–100
	2006	53	30	0–100	60	0–100
5	1987	18	80	40–100	0	0–0
	2006	18	40	0–100	0	0–100
7	1987	24	95	40–100	0	0–0
	2006	26	85	10–100	0	0–0

might act independently, interactively or synergistically, that are altering the competitive environment for plants in the Scott Islands.

Regardless of the causes of the changes in the plant community, we believe that they have seri-

decrease in tussock grass and increase in Salmonberry will certainly reduce the carrying capacity



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