

**COSEWIC**  
**Assessment and Update Status Report**

on the

**Vancouver Island Marmot**  
*Marmota vancouverensis*

in Canada



**ENDANGERED**  
**2008**

**COSEWIC**  
Committee on the Status  
of Endangered Wildlife  
in Canada



**COSEPAC**  
Comité sur la situation  
des espèces en péril  
au Canada

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## COSEWIC Assessment Summary

### Assessment Summary – April 2008

**Common name**

Vancouver Island marmot

**Scientific name**

*Marmota vancouverensis*

**Status**

Endangered

**Reason for designation**

Fewer than 30 mature wild-born individuals of this Canadian endemic remain in the wild. Despite the apparent initial success of reintroductions, the wild population of this species remains extremely small and could be subject to stochastic events. Ongoing predation remains high and there are potential threats from inbreeding and climate change.

**Occurrence**

British Columbia

**Status history**

Designated Endangered in April 1978. Status re-examined and confirmed Endangered in April 1997, May 2000, and April 2008. Last assessment based on an update status report.



**COSEWIC**  
**Executive Summary**

**Vancouver Island Marmot**  
*Marmota vancouverensis*

**Species information**

The Vancouver Island marmot (*Marmota vancouverensis*) is a colonial ground squirrel related to the hoary marmot *M. caligata* and Olympic marmot *M. olympus*. It is notable for its chocolate brown fur, unique vocalizations, atypical skull characteristics, and highly social nature.

**Distribution**

The Vancouver Island marmot is endemic to Vancouver Island, British Columbia, Canada.

**Habitat**

The natural habitat of Vancouver Island marmots consists of sub-alpine meadows, usually at 900-1500 metres above sea level. Such meadows are believed to have been created and maintained by avalanches, snow-creep or fire, or a combination of processes. Patches of natural habitat on Vancouver Island tend to be both smaller and located farther apart than those occupied by marmots in the B.C. mainland or the Olympic peninsula. Vancouver Island marmots also use man-made habitats. Numerous colonization events occurred in habitats created by clearcut logging of high elevation forests, mining, and ski-run developments.

**Biology**

*M. vancouverensis* is fossorial, herbivorous and hibernates, generally from early October through late April. Females may breed at age two, but most do not breed until age 3 or 4, producing litters of 3-4 pups every two years on average. Both sexes disperse, typically at age two. The maximum observed age is 10 years in the wild, 14 years in captivity.

## Population sizes and trends

Vancouver Island marmots apparently suffered a severe range contraction over the last several decades, although records are insufficient to elucidate when or why this occurred. Annual population surveys since 1979 indicate that marmot numbers at least doubled during the 1980s, with most of this increase occurring in new habitats created by logging of old-growth forests. A minimum of 235 marmots were counted in 1984, but it is likely that the population numbered 300-350 at this time, with most of it in man-made habitats. The population declined precipitously during the 1990s, with only ~70 individuals remaining in the wild by 1997. In 2007 there were about 50 wild-born marmots in the wild, plus a few dozen released marmots (not included in this assessment) and over 100 captive marmots, which are also not included in this assessment.

## Limiting factors and threats

The natural habitat of Vancouver Island marmots is limited. Sub-alpine meadows are small (1-10 ha) and occur infrequently in the otherwise forested landscape. Recent pollen analysis suggests that marmot habitats were much more extensive several thousand years ago. Palaeontological and archaeological records of marmots are found well outside of their historical extent of occurrence.

Habitat created by logging is only temporary as forest regeneration makes conditions unsuitable for marmots. All 10 colonies found in clearcuts during the 1980s and 1990s became extinct by 2000. The median colony longevity in clearcuts was 10 years (range = 5-19 years), which is about 2-3 marmot generations.

The major current threat to Vancouver Island marmots is predation. At least 80% of marmot mortality since 1992 was attributable to predation, largely by wolves (*Canis lupis*), cougars (*Puma concolor*) and golden eagles (*Aquila chrysaetos*). Annual survival rates have declined since the 1980s, losses at individual colonies were often dramatic within single years, and colony-specific survival rates were spatially correlated.

Given the small size of the current wild population, other threats include loss of genetic variation, stochastic demographic or weather effects, and inability to find a mate.

## Special significance of the species

*Marmota vancouverensis* is one of only five endemic species of mammal in Canada.

## Existing protection or other status designations

*M. vancouverensis* was assessed as endangered by COSEWIC in April 1978, April 1997 and May 2000. It is listed as Endangered in Schedule 1 of Canada's *Species at Risk Act* (SARA). The species was listed as endangered under the B.C. *Wildlife Act* of 1980 and under the U.S. *Endangered Species Act*. It is listed as endangered by IUCN. Two marmot habitat areas are protected under the B.C. *Ecological Reserves Act* (Haley Lake Ecological Reserve; 127 ha) or the B.C. *Wildlife Act* (Green Mountain Wildlife Critical Habitat Area, 260 ha).



### COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

### COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

### COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

### DEFINITIONS (2008)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

\* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

\*\* Formerly described as "Not In Any Category", or "No Designation Required."

\*\*\* Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.



Environment Canada  
Canadian Wildlife Service

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Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

**Update  
COSEWIC Status Report**

on the

**Vancouver Island Marmot**  
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2008



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## SPECIES INFORMATION

### Name and classification

The Vancouver Island marmot (*Marmota vancouverensis*: Swarth 1911) is one of 14 species of marmot currently recognized (Barash 1989). It was originally described from specimens collected in 1910 (Swarth 1911, 1912).

### Morphological description

Adults typically measure 67-72 cm from the nose to the tip of the tail (mean = 69.7 cm, SD = 4.0,  $n = 68$ ). Mass varies depending upon time of year. Adult females may increase from 3.5 kg shortly after emergence in late April to 5-5.5 kg by the onset of hibernation in early October. Mass gain is influenced by site conditions and reproductive status, but an average adult female gains 15-18 g per day during the active season. Males tend to be larger but gain mass at similar rates (Figure 1). Marmots lose approximately 30% of body mass during hibernation (Bryant and McAdie 2003).

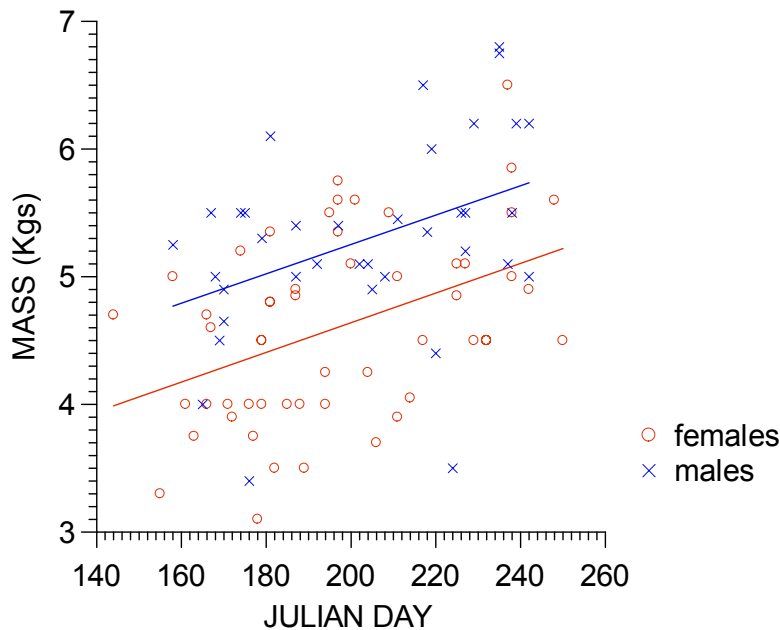


Figure 1. Mass gain by adult marmots ( $n = 68$  captures of females, 70 males in natural meadows, 1987-2003). Updated from Bryant (1998).

The Vancouver Island marmot is notable for its dark chocolate fur colour and contrasting patches of white fur on the nose, belly and top of the head (Nagorsen 2005). New fur is particularly dark and almost black in young of the year. Older fur weathers to tan or cinnamon colour. Because marmots may not fully complete moulting in a given year, older animals often display a variegated fur pattern. The species also has atypical skull morphology (Cardini *et al.* 2005), unique vocalizations (Heard 1977), and high levels of sociality (Blumstein 1999, Blumstein *et al.* 2001).

## Genetic description

*M. vancouverensis* is closely related to the hoary marmot *M. caligata* and Olympic marmot *M. olympus*, which occur on the British Columbia mainland and the Olympic peninsula of Washington State respectively (Barash 1989). Recent DNA studies (Steppan *et al.* 1999, Kruckenhauser *et al.* 1999) report limited (3-5%) genetic differences among the three species, suggesting recent divergence. Nagorsen (2005) suggested that the close affinity likely meant that marmots colonized Vancouver Island after the retreat of the Cordilleran-Wisconsin glaciers, 10,000 to 13,000 years ago.

Vancouver Island marmots display lower levels of genetic variation than other species, but are not highly inbred. Microsatellite data confirm that Mount Washington marmots are genetically isolated from those in the Nanaimo Lakes region (Table 1). There is genetic differentiation among colonies, with significant positive overall  $F_{ST}=0.23$  (95% range =0.09 - 0.43; Hartl 1981) mostly due to the presence of private alleles in the Mount Washington colony.

**Table 1. Genetic differentiation of 8 marmot colonies based on 9 microsatellite loci. Data above the diagonal are Nei's genetic distance ( $D$  values), and those below the diagonal are Wright's fixation coefficients ( $F_{ST}$ ). Significant  $F_{ST}$  values are indicated by an asterisk:  $P < 0.05$ . The data illustrate significant genetic differences between marmots at the northern Mount Washington colony and 7 colonies in the Nanaimo Lakes region. From Kruckenhauser *et al.* (2007).**

	Big Ugly	Franklin	Green	Haley Lake	Road K44a	Pat Lake	Sherk Lake	Mt. Wash
Big Ugly	---	0.12	0.03	0.03	0.05	0.08	0.05	0.39
Franklin	0.35*	---	0.14	0.09	0.07	0.11	0.03	0.40
Green	0.13	0.34*	---	0.04	0.03	0.03	0.08	0.42
Haley Lake	0.14	0.27*	0.16*	---	0.05	0.05	0.04	0.39
K44a	0.15	0.20*	0.09	0.16*	---	0.00	0.02	0.41
Pat Lake	0.31*	0.30*	0.12	0.21	0.02	---	0.05	0.47
Sherk Lake	0.21*	0.12*	0.25*	0.16*	0.07	0.18*	---	0.37
Washington	0.77*	0.68*	0.69*	0.71*	0.64*	0.76*	0.67*	---

## DISTRIBUTION

### Global range

*Marmota vancouverensis* is endemic to Vancouver Island, Canada.

### Canadian range

Apart from captive animals (Bryant 2005), *Marmota vancouverensis* is restricted to Vancouver Island, British Columbia, Canada (Nagorsen 1987, 2005).

Before reintroductions began in 2003, Vancouver Island marmots occurred only on five mountains in the Nanaimo Lakes region of central Vancouver Island, and on Mount Washington, approximately 95 km to the northwest (Figure 2). If all occurrences are treated as a single "extent of occurrence", the resulting minimum convex polygon equals approximately 840 km<sup>2</sup> (B.C. Conservation Data Centre 2006).

Records based on tagging (Bryant 1990, 1998), radio-telemetry (Bryant and Page 2005) and DNA analysis (Kruckenhauser *et al.* 2007) suggest that the colonies in the Nanaimo Lakes region were connected through occasional dispersal movements. However, genetic results suggest that marmots on Mount Washington have been isolated for at least several generations. Based on a 1x1 km grid around known hibernacula, the area of occupancy is <22 km<sup>2</sup>.

## HABITAT

### Habitat requirements

Vancouver Island marmots require three essential habitat features: 1) suitable soil structure for burrow construction, 2) suitable grass-forb vegetation to eat, and 3) microclimatic conditions that permit summer foraging and winter hibernation.

Natural habitat consists of subalpine meadows that generally occur at 900-1500 m (Bryant and Janz 1996). These meadows are thought to be created and maintained by avalanches or snow-creep, fire or a combination of processes (Milko and Bell 1986), and tend to be both small and uncommon on Vancouver Island compared to the B.C. mainland or the Olympic peninsula (Fonda and Bliss 1969, Kuramoto and Bliss 1970). Bryant (1998) used GIS to conclude that natural sub-alpine meadows comprised ~1% of the ~1000 km<sup>2</sup> Nanaimo Lakes core area of marmot distribution. Meadow habitat is even rarer south of Lake Cowichan and in areas such as Strathcona Provincial Park (Bryant 1993).

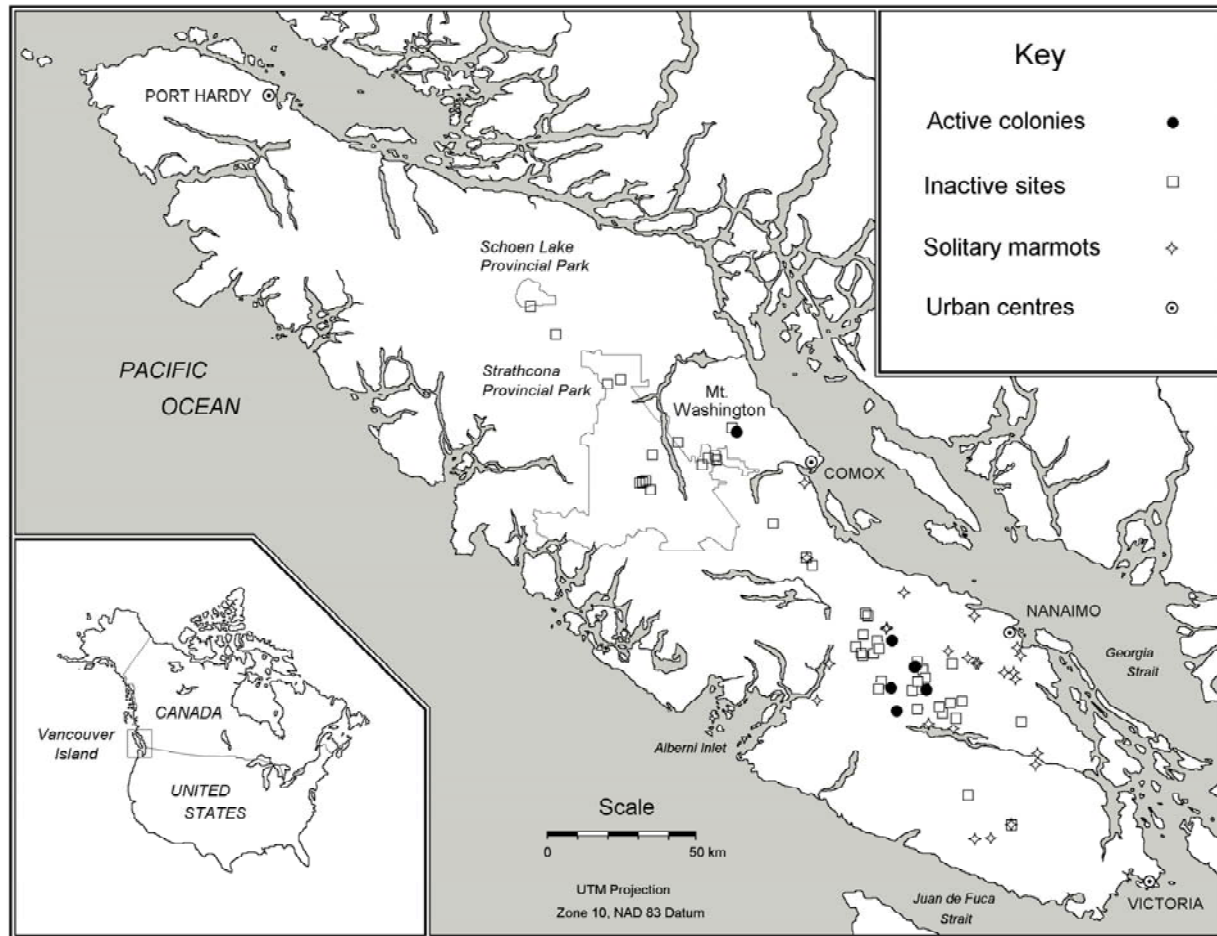


Figure 2. Present and historical distribution of Vancouver Island marmots. Inactive sites illustrate colony records from 1896-2006. Solitary marmots likely represent dispersing individuals.

Since 1972, marmots or fresh burrows were reported from 47 sites on 15 mountains (Bryant and Janz 1996). Reproduction has been observed at 34 sites on 14 mountains. Except for 2 sites, all colonies active since 1972 were located within the Nanaimo, Cowichan, Chemainus, Nitinat and Cameron River drainages on south-central Vancouver Island. The 2 other colonies were on Mount Washington, separated from other known colonies by ~95 km.

Most natural meadows occupied by marmots during 1972-2006 encompassed only a few hectares; consequently most recent colonies in natural habitats were small, typically containing one or two family groups and fewer than five adults (Bryant and Janz 1996).

### Habitat trends

Prehistoric bones of *M. vancouverensis* recovered from caves or archaeological digs indicate that the geographic range has shrunk over the last few centuries or millennia (Calvert and Crockford 1983, Nagorsen *et al.* 1996). This trend is supported

by data on tree growth (Laroque *et al.* 2001) and pollen deposition (Hebda *et al.* 2005). Vancouver Island marmots were apparently more widely distributed, and presumably more abundant, during warmer and dryer conditions that prevailed over several periods in the past.

### **Habitat protection/ownership**

Most historically occupied (1972-2006) marmot habitat occurs on private land. The landscape surrounding natural habitat patches has been heavily modified by logging (Bryant 1998). Logging began in the region in the late 1940s and accelerated rapidly during the 1960s and 1970s. Less than 15% of the primary forest remains, most of it above 900 m. The result is a landscape with progressive replacement of mature forests with younger ones, combined with a growing number of logging roads and an increasing impact at higher elevations.

Two marmot habitats are legally protected under the B.C. *Ecological Reserves Act* (Haley Lake Ecological Reserve; 127 ha) or the B.C. *Wildlife Act* (Green Mountain Wildlife Critical Habitat Area, 260 ha). Considerable potential marmot habitat is protected within Strathcona Provincial Park (Bryant 1993).

## **BIOLOGY**

### **Life cycle and reproduction**

As for most alpine-dwelling marmots, Vancouver Island marmots are relatively long-lived and reproduce infrequently (Bryant 2005). They are not strictly monogamous; numerous cases of polygyny have been reported (Bryant 1998).

Females may become sexually mature at age 2, but most do not breed until they reach 3 or 4 years (mean = 3.6 years, SD = 1.2,  $n = 16$ ). Mating generally occurs a month after emergence from hibernation in late April or early May. Gestation is 30-32 days (Keeley *et al.* 2003). Litter size at weaning varies from 1-7 (mean = 3.4, SD = 1.1,  $n = 58$ ). Females can wean pups in consecutive years but most skip one or more years between litters (mean between-litter interval = 1.8 years, SD = 0.7,  $n = 20$ ). Sex ratios of weaned pups do not differ from 1:1 in the wild, although they tend to be skewed towards males in captivity. The oldest known breeding female was 10 and the oldest marmot in captivity reached 14 years (Bryant 2005, Appendix 1).

### **Use of burrows**

Vancouver Island marmots construct burrows to hibernate, bear young, hide from predators, and shelter. Burrows (including hibernacula) are commonly re-used over multiple years by the same individuals and social groups (Bryant 1998). Several burrow systems have been occupied for over 30 years. Escape burrows to avoid predators include shallow excavations under a rock or tree root. Burrows used overnight or as

birthing chambers are more elaborate, often with multiple entrances. As with escape burrows, they typically occur under boulders or a tree root system. Hibernacula are presumably deep enough to reach below the frost-line.

## **Herbivory/predation**

Martell and Milko (1986) identified plants eaten from fecal samples collected at 3 colonies. They concluded that marmots depend on oatgrass (*Danthonia intermedia*) and sedges (*Carex* spp.) in early spring, and shift to forbs (especially *Lupinus latifolius* and *Eriophyllum lanatum*) in summer and fall. Spreading phlox (*Phlox diffusa*) is important in early summer.

Diet at other colonies is unknown. Known food plants at low elevation clearcut sites include grasses, *Anaphalis margaritacea*, *Fragaria* spp., *Epilobium angustifolium*, and *Lupinus latifolius* (Bryant 1998). Lupines (*Lupinus latifolius*) are eaten on ski runs at Mount Washington (J. Werner pers. com.).

Known predators of Vancouver Island marmots include cougars (*Puma concolor*), wolves (*Canis lupus*) and golden eagles (*Aquila chrysaetus*). Bryant and Page (2005) reported that predators accounted for at least 75% of the mortality of radio-tagged marmots from 1992-2005.

## **Physiology**

Wild Vancouver Island marmots typically hibernate for approximately 210 days (mean immergence = 1 October, 95% CI = 28 September-3 October,  $n = 49$ ; mean emergence = 28 April, 95% CI = 26-30 April,  $n = 43$ ; Bryant and McAdie 2003). During torpor body temperature is close to 5° C. Spontaneous arousals occur for one or a few days every 10-14 days. Active-season body temperatures fluctuate between 34-29° C. Marmots adjust body temperature with posture (Melcher *et al.* 1990) and use burrows and “resting” boulders to avoid overheating.

## **Dispersal/migration**

The metapopulation structure is pronounced compared to other mountain-dwelling marmots (e.g., Stephens *et al.* 2002). Dispersal events occur infrequently but radio-tagged 2 year olds of both sexes can make movements of 1-27 km within a few days (A. Bryant unpub. data).

Based on resightings of ear-tagged animals (Bryant 1998), maximum dispersal distance was 11.2 km. Records of solitary marmots in low elevation habitats suggest many possible dispersal distances greater than this. Bryant and Janz (1996) compiled 22 records of solitary marmots during 1972-1995, including 1 found on the beach at Courtenay (12 July 1974), 1 photographed on Mount Demers (25 July 1977), and 1 in a vegetable garden at Coombs (7 July 1980). Marmots show up in unusual places, including a woodshed in Youbou (25 June 1986), a horse stable in Nanaimo (25



September 1991), a new subdivision at Bell's Bay on the west coast (May 1992), and a boat dock at Lake Cowichan (18 May 1993). Some of these (e.g., Bell's Bay, Cassidy, Duncan and Cedar) likely represent dispersal events > 25 km.

### **Interspecific interactions**

Marmots commonly react to small raptors, deer and elk that pose no threat by whistling or by fleeing into burrows. They respond similarly to predators. Apart from that, they do not interact with other species.

### **Adaptability**

Much has been written about the “adaptability” of *M. vancouverensis* to a human-modified landscape (Munro *et al.* 1985). Many marmots lived and reproduced successfully in man-made habitats; however, these habitats likely acted as population sinks (Bryant 1996, 1998). Populations that colonized ski-runs on Green Mountain or mine tailings at Mount Washington during the 1980s became extinct. Marmots have persisted on ski runs at Mount Washington, possibly because human activities deter predators there. Despite large amounts of potential habitat created by logging above 700 m, only a small fraction was ever colonized, and the overall distribution of *M. vancouverensis* has shrunk in the last several decades.

Vancouver Island marmots in captivity exhibit reproductive and behavioral traits comparable to wild counterparts (Bryant 2005, Blumstein *et al.* 2006). Captive-born marmots apparently adjust successfully when returned to the wild, eating grasses and flowers, gaining mass, whistling when predators approach, digging burrows and hibernating at appropriate times (Bryant 2007). Sample sizes are still too small to calculate survival rates, but some captive-born marmots have survived for up to 3 years and reproduced.

## **POPULATION SIZES AND TRENDS**

### **Search effort**

In 1972 local hunters became interested in Vancouver Island marmots, which until that date were known from only a handful of museum specimen records. Since then much of Vancouver Island has been searched for marmot colonies. Routledge and Merilees (1980) surveyed 97 mountains and classified each in terms of habitat suitability for marmots. The last “new” wild marmot colony was discovered in 1985. The probability of finding new occupied habitat patches is high, particularly given recent releases and use of radio-telemetry. However, the probability of finding large new populations of marmots or large habitat patches is low.

Systematic annual population counts began in 1979 (Munro *et al.* 1985). Marmots were classified as adults, yearlings or pups (young-of-the-year) based on size and pelage (Bryant 1996). Intensity and extent of surveys varied from year to year. The smallest effort occurred in 1975, when a single colony was visited on one day. The greatest effort occurred in 1997, with 242 visits to 37 colonies. Population counts over 34 years provide data on minimum numbers of adults, yearlings and pups at 49 colonies and 1569 site-year combinations.

Bryant and Janz (1996) estimated the accuracy of these surveys by comparing raw count results with known numbers of marmots at five intensively studied colonies where most individuals were ear-tagged (Bryant 1996). They concluded that count success is highly variable. On days with excellent weather, experienced observers and a known population of marked animals, detection varied from all individuals to none. Smaller colonies are easier to census than larger ones, and success also depends on time of day, with mornings generally being better than afternoons. Marmots become increasingly difficult to detect after August (both because of vegetation growth and changed activity patterns). Reproductive females with pups tend to be quite predictable, while males and two-year-olds make larger daily movements and are less so. Although > 9 visits are necessary to obtain a near-complete count of marmots in a colony, 2 to 4 counts usually detect 65-75% of the animals present (Figure 3).

Based on this analysis, Bryant and Janz (1996) concluded that for sites visited once, observers probably counted 40-60% of adults actually present, depending upon time of year. For most site-year combinations (2 or more visits in June and July), observers probably saw 66-78% of adults, and 75-89% of young. Confidence limits on these estimates are unreliable because of differences in coverage, visibility, observer experience, and count intensity.

Surveys have changed over time, both because of increasing reliance on telemetry and due to declining populations. It is easier to count small numbers of radio-tagged marmots at a given site than to count >30 untagged marmots, or to read ear-tags using a spotting scope (Bryant 1996). Thus, count success has increased over time and population estimates since 2000 likely approach a true census.

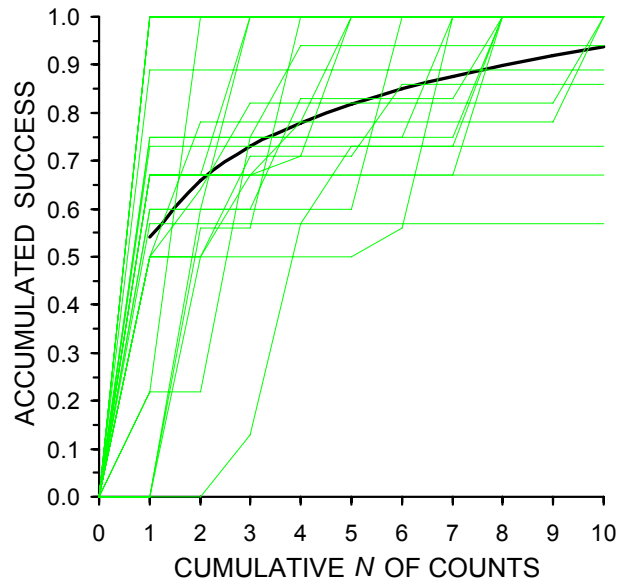


Figure 3. Accuracy of marmot counts. Transformed values for daily counts at colonies with known numbers of adults were randomly re-sampled to create 100 trials of 10 counts each (for clarity, results from only 25 trials are shown). The cumulative success curve (bold line) was fitted using linear regression (log-transformed x values, slope = 0.397 and constant = 0.540). On average, 2 counts resulted in detection of 66% of the adults actually present, but 9 counts were required to account for >90% (Bryant and Janz 1996).

## Abundance

Given the variation in count intensity and coverage, raw annual counts are not particularly informative. Early efforts to “correct” these count results relied on calculation of observed/expected ratios and a correction factor based on count effort (Bryant 1997). Recently, locally weighted regression (Cleveland 1979) was used to interpolate missing values, using colony-specific data obtained from previous and subsequent years for the same site (Bryant 2000). This practice avoids the assumption that trends at sampled colonies reflect trends at colonies not visited in a given year. Approximately 29% of the resulting site-specific population values (a marmot-year is a marmot seen alive at one site in one year) needed to be interpolated. Sampling intensity and coverage was particularly good in 1980-1986 ( $n = 1285$  marmot-years, 9% interpolated) and 1995-2006 ( $n = 565$  marmot-years, 4% interpolated). Relatively poor coverage and intensity occurred before 1980 ( $n = 791$  marmot-years, 73% interpolated) and from 1987-1994 ( $n = 1231$  marmot-years, 36% interpolated).

A correction factor based on count intensity was applied to the aggregate actual and interpolated colony-specific values to arrive at probable numbers of marmots (Figure 4). The correction factor varied from 1.19 to 1.66 (mean = 1.40, similar to alpine marmots: 1.25: Cortot *et al.* 1996). Because young-of-the-year typically emerge in July there is little time for repeated counts and the same approach could not be employed. Instead a constant multiplier (1.20) was used, based on average litter size at five

intensively studied colonies divided by the average litter size at other colonies for which numbers of repeated counts were smaller, and at which some pups were likely missed (Bryant 1998).

This approach does not substantively change previous estimates of population sizes or recent dynamics (Bryant and Janz 1996). The population increased from 100-150 during the 1970s to 300-350 during the mid-1980s, in large part due to colonization of at least ten clearcut sites (Bryant 1998). Marmots inhabiting natural habitats declined while numbers in clearcuts were still increasing.

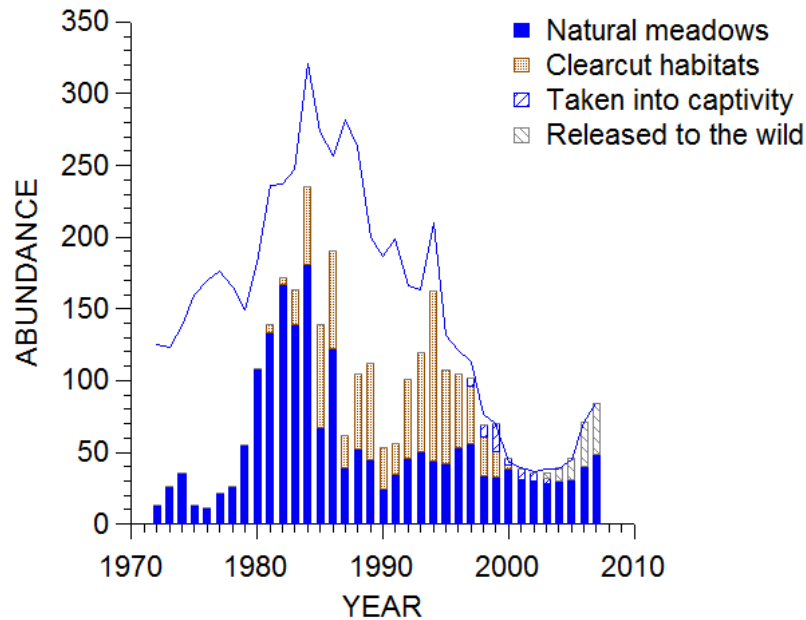


Figure 4. Annual count results and probable numbers of wild marmots, 1972-2007. Data for pups and adults are pooled. The solid line represents estimated annual abundance after colony-specific interpolation and application of a correction factor based on numbers of repeated counts per site-year combination. Note that actual and interpolated estimates merge after 2000 due to increased reliance on telemetry. (A. Bryant unpublished data)

The number of wild individuals has been affected by ongoing recovery efforts, as 56 wild-born marmots were removed from 1997 through 2004 to establish a captive population (Bryant 2005). Most animals were captured as pups ( $n = 31$ ) or yearlings ( $n = 8$ ), because it was reasoned that younger marmots would more readily habituate to captivity. In addition the intent was to minimize disruption of wild colonies by not removing reproductive adults. Marmots inhabiting clearcut habitats were preferentially targeted ( $n = 30$ ). Thus management efforts were partially responsible for the population decline from 1997 though 2004. Wild populations were augmented by releasing both captive-born marmots and wild-born marmots transplanted from other colonies in order to provide a mate for solitary individuals (Table 2). As of 2007 at least 4 captive-born marmots and 3 transplanted marmots have produced litters in the wild.

**Table 2. Annual numbers of marmots taken into captivity, transplanted, and released. Adapted from Bryant (2007).**

Year	Into captivity <sup>1</sup>			N captured as pups	Transplanted <sup>2</sup>		Released <sup>3</sup>		Total	N subsequently recaptured
	♂	♀	Total		♂	♀	♂	♀		
1996			-		3	3			6	
1997	2	4	6	2♀					-	
1998	6	2	8	3♂					-	
1999	9	10	19	6♂, 4♀					-	
2000	3	2	5	2♂, 2♀		2			2	1♀
2001	3	4	7	2♂, 3♀	1				1	
2002	4	2	6	2♂, 2♀					-	
2003	4		4	2♂	2		2	2	6	1♀
2004		1	1	1♀			5	4	9	
2005			-				11	4	15	
2006			-				20	11	31	1♂
Totals	31	25	56	17♂, 14♀	6	5	38	21	70	1♂, 2♀

Notes:

- 1) wild-born marmots (excluding 3 recaptures of previously released marmots).
- 2) wild-born marmots with little or no time spent in captivity prior to release.
- 3) captive-born or wild-born marmots that spent at least one winter in captivity prior to release.

### Fluctuations and trends

Vancouver Island marmot colonies fluctuate in size from year to year. While the overall population trend is generally negative since the mid-1980s, individual colonies exhibited divergent population trajectories (Figure 5). For example, numbers of marmots at the Green Mountain summit colony remained relatively stable until the early 2000s, while larger (Heard 1977, Milko 1984) colonies at Haley Lake and Bell Creek declined dramatically after 1994. The population at the Butler Peak “west roads” clearcut increased from 2 in 1982 to over 30 by 1988 followed by a rapid decline and near-extinction by 2000, when the last survivor was transplanted.

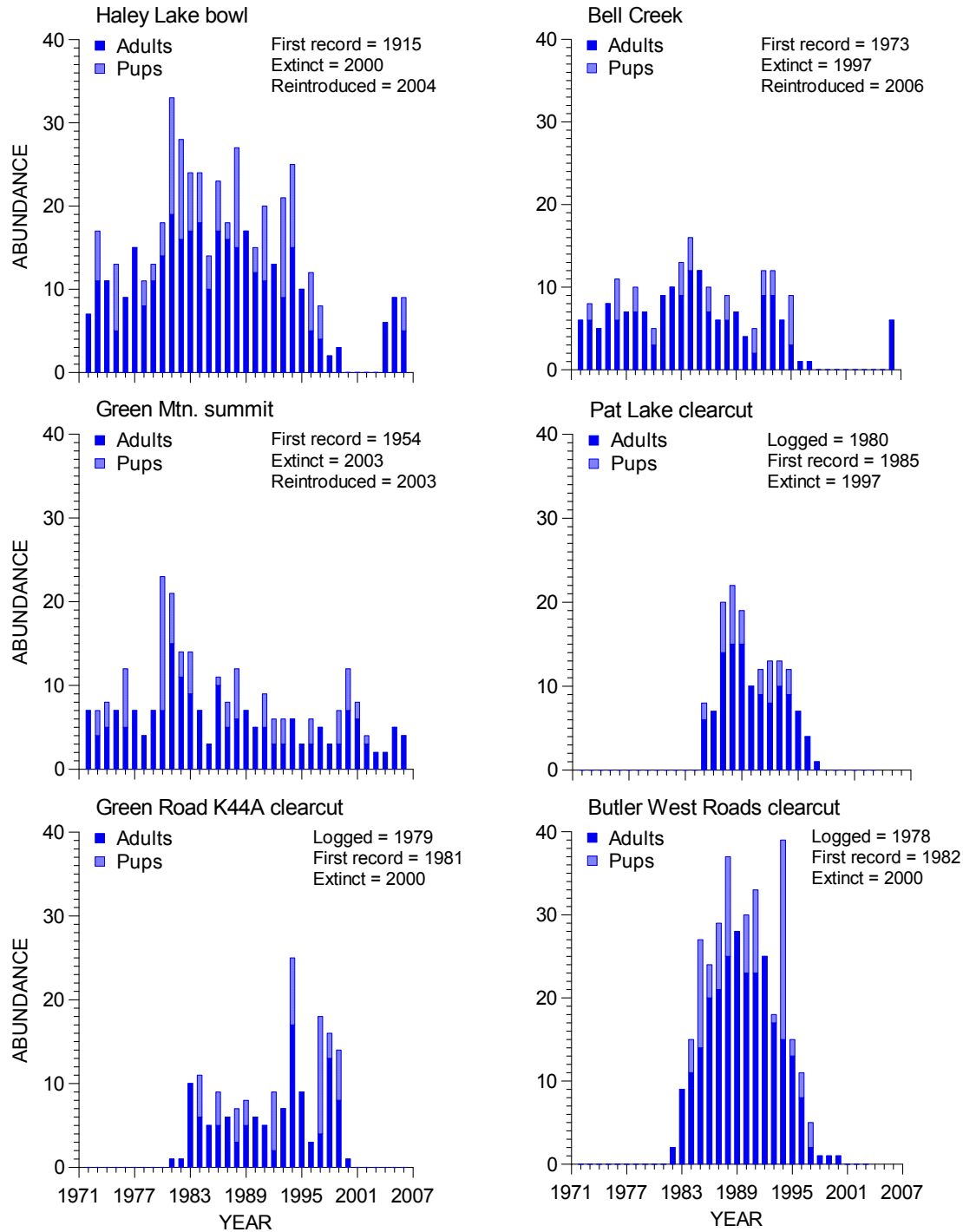


Figure 5. Population trends at six well-studied colonies, 1972-2006. Data represent either the highest daily count of marmots in a year, or the number known to be alive based on mark-recapture or radio-telemetry. No correction factors were applied. Data updated from Bryant and Janz (1996) and Bryant (1998). (A. Bryant unpublished data)

There are a variety of reasons for colony-specific population trends. Birth “pulses” occur because most colonies are small (Bryant and Janz 1996) and adult females do not produce litters every year (Bryant 2005). Fluctuations also occur because of changes in survival and dispersal rates. For example, the Haley Lake colony declined rapidly from 1994 to 1996. Simultaneously the populations at Green Mountain K44A and Sherk Lake clearcuts grew after new immigration occurred. There is no common year after which declines occurred at most colonies. However, colony-specific survival rates were spatially correlated, i.e., colonies in close proximity tended to show similar patterns (Bryant 2000).

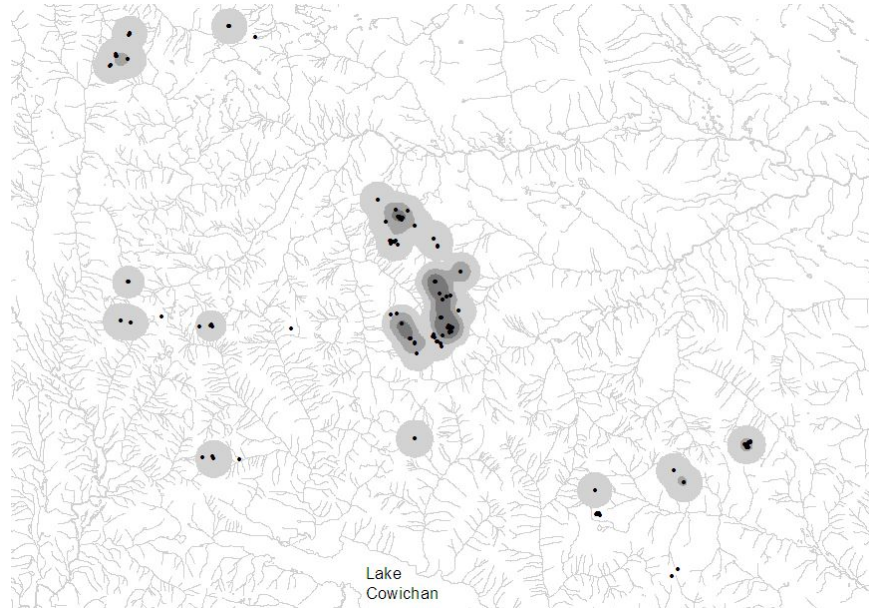
The colonization of clearcut habitats during the 1980s led to dramatic changes in local marmot densities. Most colonization events occurred within 1-2 km of previously existing natural colonies (Bryant 1998), and most new colonies became much larger than those in adjacent natural habitats. Local population densities changed, with numbers of marmots per km<sup>2</sup> increasing to more than 20 in the centre of the range (Figure 6).

By the mid-1980s more than half of the known marmot populations inhabited 4 adjacent mountains, with most animals living in clearcuts on Butler Peak, Haley Lake, Gemini Peak and Green Mountain. Bryant (1998) suggested that high local densities attracted predators. Recent monitoring of radio-tagged cougars and wolves supports this idea, suggesting that some individuals return repeatedly to hunt in the same meadows (D. Doyle pers. com.).

When the marmot population collapsed during the 1990s, often it was areas with the highest density which declined first. The Haley Lake colony (Heard 1977, Bryant 1996) declined from 25 to 10 in 1994-95. The largest colony ever recorded (39 animals in the Butler Peak “west roads” clearcut in 1994) was reduced to 15 individuals in 1995. Conversely, colonies in natural meadows with low densities and without adjacent clearcut colonies were more likely to persist. By the early 2000s the total number of marmots in the Nanaimo Lakes area had fallen to ~30 individuals, with most living in low-density natural colonies on the periphery of their geographic range.

Over the last 16 years (1991-2007) or 3 marmot generations, the estimated total population has declined from about 195 to about 85 (Fig. 4), a 56% decline. Because released marmots are excluded from this assessment, however, the 3-generation estimated decline is nearly 80%. Over the last 3 years, numbers have increased (Fig. 4). There are currently about 150 marmots in captivity, but they are not included in this assessment.

A) 1982-1986



B) 2002-2006

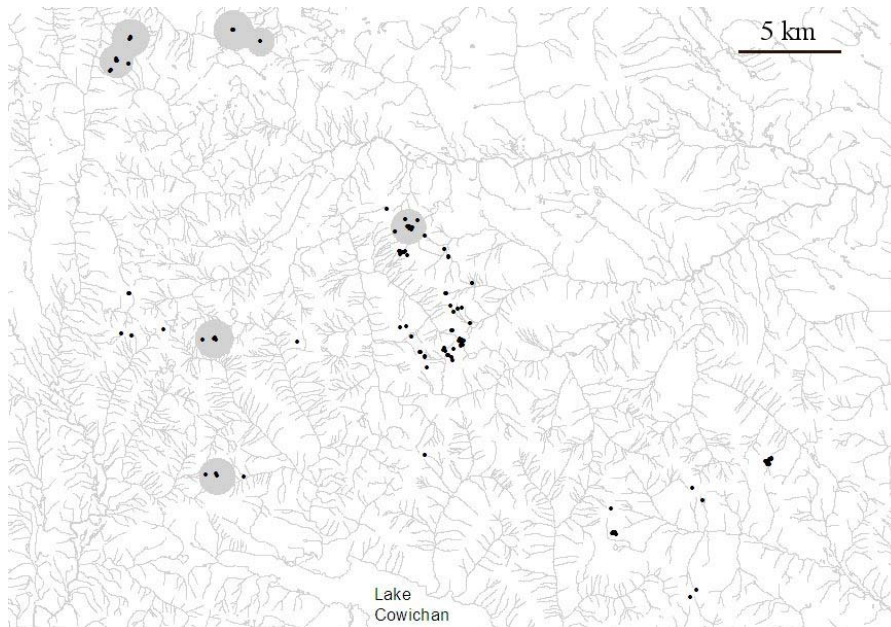


Figure 6. Changes in marmot density and distribution in the Nanaimo Lakes region. The area depicted is 1127 km<sup>2</sup>. Shown are mean densities of adults over two five-year periods, with the lightest to darkest levels of shading corresponding to low (0.1-5 adults/km<sup>2</sup>), moderate (5.1-10 adults/km<sup>2</sup>) and high densities (10.1-20 adults/km<sup>2</sup>). The dots reflect all known breeding or hibernation burrows verified during 1972-2006. (A. Bryant unpublished data)



## Rescue effect

There is no possibility of rescue effect as the Vancouver Island marmot does not exist anywhere else.

## LIMITING FACTORS AND THREATS

The major immediate threat to Vancouver Island marmots is predation, which is also believed to be the proximate cause of recent population declines (Bryant and Page 2005). Count and mark-recapture results suggested that annual survival rates have declined since the 1980s (Figure 7). Losses at individual colonies were often dramatic within single years, and colony-specific survival rates were spatially correlated (Bryant 2000).

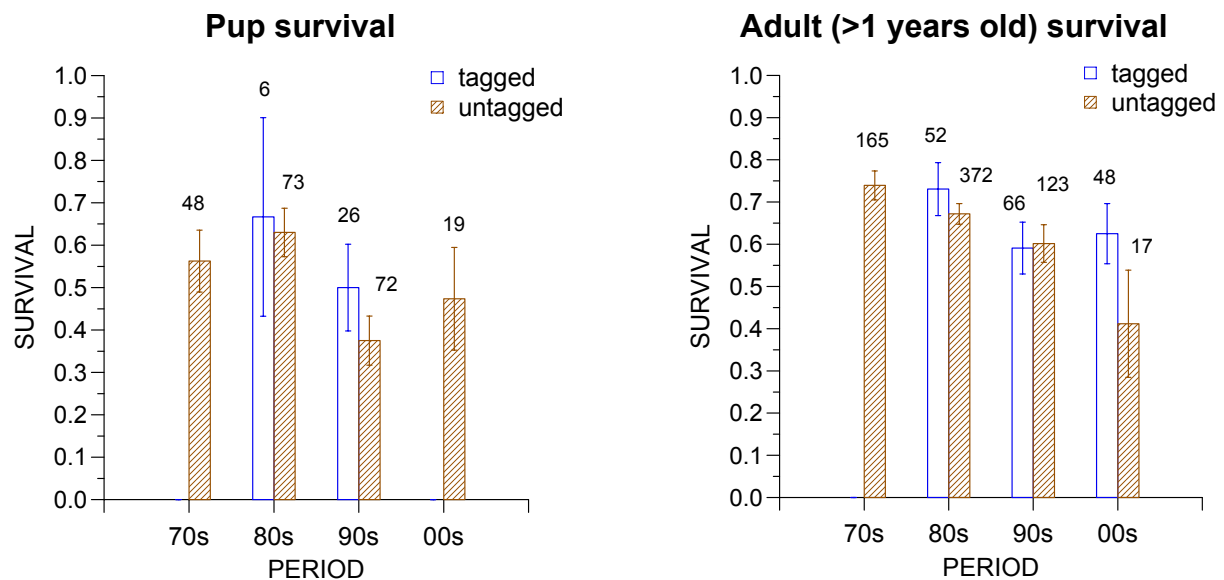


Figure 7. Changes in marmot survival in the Nanaimo Lakes region over time. Data are means (SE) and reflect colonies in natural meadows only. Numbers of marmot-years for both tagged and untagged individuals are shown. Transplanted or captive-released marmots are excluded. (A. Bryant unpublished data)

Indices of cougar and wolf abundance on Vancouver Island have increased dramatically since the early 1980s (unpublished data, B.C. Ministry of Environment, Archibald *et al.* 1991), perhaps as a numerical response to deer populations (Bunnell 1990, Bryant and Page 2005). Increasing predation on marmots may also reflect a functional response by predators. Predators may have hunted more often, or more successfully, in natural habitats surrounded by clearcuts that were also occupied by marmots (Bryant 1998).

The impact of disease on marmots is poorly understood but potentially important. The loss of established colonies from North Hooper (1982-83) and Gemini Peak (1986-87), combined with observed population crashes at Haley Lake and Butler Peak suggests episodic mortality events. These events were consistent with a hypothesis of localized predation, but could also reflect disease (Bryant 2000).

Although Vancouver Island marmots harbour a variety of parasites including fleas, roundworms, tapeworms, ear-mites and coccidia, there is no evidence that parasites exert a significant population effect. Four of six animals relocated from different colonies to a vacant historic location in 1996 died during hibernation, possibly from bacterial infection (Bryant *et al.* 2002). Chronic mange has been diagnosed at Mt. Washington.

Inbreeding could depress reproductive or survival rates. It is unclear to what extent Vancouver Island marmots may be vulnerable to inbreeding depression or genetic drift. Because populations have presumably been low for many generations, deleterious genetic loads might have been purged (Janz *et al.* 2000). There is no evidence that inbreeding depression has reduced reproductive rates (Bryant 2005), although one pair of wild-caught captive marmots produced two pups from two separate litters with congenital defects (M. McAdie pers. com.).

Vancouver Island marmots are obligate hibernators and require specific microclimatic conditions. Climate change might influence hibernation timing (Inouye *et al.* 2000) and the survival of hibernating marmots might reflect snow conditions (Van Vuren and Armitage 1991, Barash 1989). The vulnerability of marmots to predation might increase if they remain active later in the fall or emerge earlier in the spring. Radio-telemetry data indicate no significant change in hibernation timing since the first records in 1992 (Bryant and McAdie 2003).

The extent and distribution of Vancouver Island marmot habitat is apparently limited by climatic conditions (Milko 1984, Milko and Bell 1986). Climate change could alter marmot habitat. The mountains of western North America were characterized by moving tree-lines over the past 10,000 years in response to climate (Rochefort *et al.* 1994). Recent analysis of pollen collected from natural sub-alpine marmot habitats is consistent with the hypothesis that marmot habitats were much more extensive in the recent prehistoric past (Hebda *et al.* 2005). These authors also conclude that global warming might increase the availability of natural habitat. Such long-term climatic changes presumably explain some of the palaeontological and archaeological records of marmots found well outside of their historical extent of occurrence (Calvert and Crockford 1983, Nagorsen *et al.* 1996).

The availability of marmot habitat may also have been influenced by naturally occurring vegetation changes over historical periods (i.e., 1900 to present). Within the past 100 years a warmer and drier climate has resulted in an invasion of subalpine meadows by trees in most of the western mountains including the Cascades, Olympics, and southern Coast Mountains. Using tree-ring measurements at historic and extant marmot colonies, Laroque (1998) found that at least two sites (Gemini Peak and Green

Mountain) experienced tree invasions over a period spanning only a few decades. In contrast, in Strathcona Provincial Park, where marmots apparently disappeared 20-40 years ago, most trees above 1000 m elevation are more than 800 years old, providing little evidence of recent tree invasion despite close overlap of tree-ring sites with marmot records (e.g., Cruikshank Canyon, Circlet Lake, Greig Ridge, Philips Ridge: C. Laroque, University of Victoria, pers. comm.).

The role of fire in creating or maintaining marmot habitat is unclear but this process is likely important at some sites. Fire intervals are relatively short (<300 years) on southeastern Vancouver Island but substantially larger (700 - 3000 years) in western and central regions (Laroque pers. comm; Lertzman *et al.* 1998).

Post-logging succession in clearcuts has had a pronounced effect on marmot colonies. All 10 colonies in clearcuts described by Bryant (1996, 1998) became extinct by 2000. The longest colony persistence in a clearcut was 19 years (1981-2000; Road K44a). The median longevity of colonies in clearcuts was 10 years (range = 5-19 years), or 2-3 marmot generations. Bryant (1996, 1998) found some evidence that survival in man-made habitats was slightly lower than in natural sub-alpine meadow habitats. It seems likely that clearcuts were population "sinks" because forest succession quickly made habitat conditions unsuitable. Of the 10 clearcuts colonized by marmots, six populations went extinct after the last solitary marmot or few surviving marmots were "rescued" for transplant or captive-breeding purposes (Sherk Lake, Pat Lake, Mt. Franklin, Road D13e, K44a, Butler Peak "west roads").

The possible influence of endocrine-disrupting pollutants has been addressed (Lichota *et al.* 2004). Current exposure levels appear unlikely to pose a health risk. Published evidence (Bryant 1996, 1998, 2005) indicates that reproductive rates in Vancouver Island marmots have not declined over time, and are comparable to those of other alpine-dwelling marmot species. There is no evidence of diminished reproductive capacity. However there is strong evidence (Bryant 1998, 2000, Bryant and Page 2005) that survival rates declined from those observed during the 1980s.

### **SPECIAL SIGNIFICANCE OF THE SPECIES**

The Vancouver Island marmot is one of only five endemic terrestrial mammals in Canada (Wilson and Reeder 1993). It is arguably the most critically endangered mammal in Canada.

## EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

In April 1978 *M. vancouverensis* was assessed as endangered by COSEWIC (Shank 1999). That status was reconfirmed in April 1997 and in May 2000, the latter assessment based on applying quantitative criteria to the 1997 report. The species is in Schedule 1 of the *Species at Risk Act* (SARA). The Vancouver Island marmot is also listed as endangered under the B.C. *Wildlife Act* (1980) (Munro *et al.* 1985) and under the U.S. *Endangered Species Act* (Federal Register, Jan. 23 1984). The International Union for the Conservation of Nature also lists the species as “endangered” (Groombridge and Mace 1994).

## TECHNICAL SUMMARY

### ***Marmota vancouverensis***

Vancouver Island marmot

Marmotte de l'île de Vancouver

Range of Occurrence in Canada: Vancouver Island, B.C.

### **Demographic Information**

Generation time (average age of parents in the population)	5.28 years (SD = 1.65, n=297 female-years)
<i>Population trend and dynamics</i>	
Observed percentage of reduction in total number of mature individuals over the last 3 generations	Excluding reintroductions, 80%
Projected percentage of reduction in total number of mature individuals over the next 10 years.	Excluding reintroductions, a life-table analysis suggests a lambda of 0.89 (Appendix 1)
Observed percentage reduction in total number of mature individuals over any 10 years period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline clearly understood?	No
Are the causes of the decline clearly ceased?	No
Observed trend in number of populations	Decline - From >35 to 5 in 25 years
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

### **Number of mature individuals in each population (Autumn 2007)**

<b>Population</b>	<b>N Mature Individuals</b>
Mt. Moriarty = 6 expected =6 alive on 30 April (1 emerged) Green Mtn = 4 expected, minimum=2 alive on 30 April Gemini Peak = 5 expected, minimum=2 alive on 30 April Bell Creek = 5 expected, minimum=5 alive on 2 May (3 emerged) Haley Bowl = 5 expected, minimum=5 alive on 30 April (5 emerged) Butler Peak = 5 expected, minimum=4 alive on 4 May Big Ugly = 2 expected, minimum=2 alive on 30 April Heather Mtn., = 2 expected, minimum=1 alive on 30 April Mt. Hooper = 1 expected, minimum=1 alive on 30 April Mt. Washington = 11 expected, minimum=10 alive on 4 May (2 emerged) TOTAL = About 25-30 wild-born adults, plus captive-bred ones	
Grand Total	About 25-30 wild-born

### **Extent and Area Information**

Estimated extent of occurrence (km <sup>2</sup> )	170 km <sup>2</sup>
Observed trend in extent of occurrence	Increasing through reintroductions
Are there extreme fluctuations in extent of occurrence?	No
Estimated area of occupancy (km <sup>2</sup> )	22 km <sup>2</sup>
Observed trend in area of occupancy	Increasing through reintroductions
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	10
Trend in number of locations	Increasing through reintroductions

Are there extreme fluctuations in number of locations?	No
Observed trend in area of habitat	Stable

### Quantitative Analysis

	[0.00% probability of extirpation in _____ years]
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### Threats (actual or imminent, to populations or habitats)

Predation, possibly inbreeding
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### Rescue Effect (immigration from an outside source)

Status of outside population(s)? Canadian endemic. There is an active captive breeding program, presently $n > 140$ , $\lambda = 1.31$ , 30-50 releasable marmots per year.	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Is rescue from outside populations likely?	n/a

### Current Status

COSEWIC: Endangered (April 1978) Endangered (April 1997) Endangered (May 2000) Endangered (April 2008) Province of B.C: Endangered; US Endangered Species Act: Endangered; IUCN: Endangered
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### Status and Reasons for Designation

<b>Status:</b> Endangered	<b>Alpha-numeric code:</b> A2a; C2a(i); D1
<b>Reasons for Designation:</b> Fewer than 30 mature wild-born individuals of this Canadian endemic remain in the wild. Despite the apparent initial success of reintroductions, the wild population of this species remains extremely small and could be subject to stochastic events. Ongoing predation remains high and there are potential threats from inbreeding and climate change	

### Applicability of Criteria

<b>Criterion A</b> (Decline in Total Number of Mature Individuals): The total population has declined by 80% over the last 3 generations if released captive-bred marmots are excluded. Currently, the total population would likely continue to decline without reintroduction of captive-bred marmots.
<b>Criterion B</b> (Small Distribution Range and Decline or Fluctuation): Although the range is very small, the decline may not be continuing (if reintroductions are included – otherwise a life-table analysis suggests a $\lambda$ of 0.89) and there are no extreme fluctuations. The population cannot be considered severely fragmented because dispersal is known among the Nanaimo Lakes colonies – the marmots on Mt. Washington, however, are completely isolated.
<b>Criterion C</b> (Small and Declining Number of Mature Individuals): There are only about 20-30 mature individuals, they would be declining in the absence of reintroductions and all populations are extremely small.
<b>Criterion D</b> (Very Small Population or Restricted Distribution): There are less than 30 adults.
<b>Criterion E</b> (Quantitative Analysis): n/a

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## **PERSONAL COMMUNICATIONS**

Don Doyle, Chair of the Marmot Recovery Team.

Malcolm McAdie, veterinarian in charge of the captive breeding program.

Colin Laroque, former dendrochronologist at the University of Victoria, now a professor in the geography department at Mount Allison University.

Jeff Werner, former master student at UBC, studied marmots for 4 seasons from 2002-2004.

## **BIOGRAPHICAL SUMMARY OF REPORT WRITER**

Andrew A. Bryant specializes in conservation research and endangered species management. He obtained a Bachelor's degree from the University of Waterloo (1984), a Masters degree from the University of Calgary (1990), and a Ph.D. from the University of Victoria (1999).

His past research involved red-shouldered hawks (Ontario), burrowing owls (B.C. and Washington State), hibernating bats (B.C.), old-growth forest songbirds (B.C.), aquatic plants (Quebec), grizzly bears (B.C.), rare butterflies (Ontario), rare insectivorous plants (Nova Scotia), spider monkeys (Costa Rica) and endemic kingfishers (Atiu, south Pacific).

Since 1987 he has primarily focused on the conservation biology of Vancouver Island marmots (B.C.). He currently serves as scientific advisor for the Vancouver Island Marmot Recovery Team.

## **COLLECTIONS EXAMINED**

None.

## APPENDIX 1

Life-table for wild (1987-2006) and captive (1997-2006) populations of Vancouver Island marmots. Life-table nomenclature and calculations follow Caughley (1977; Method 2), and were implemented using PopTools (Hood 2006) with data for ear-tagged individuals (updated from Bryant 1998).

<b>MALES</b>						<b>FEMALES</b>						
<b>WILD</b>	<i>f(x)</i>	<i>dx</i>	<i>qx</i>	<i>lx</i>	<i>Lx</i>	<i>f(x)</i>	<i>dx</i>	<i>qx</i>	<i>lx</i>	<i>Lx</i>	<i>bx</i>	<i>lx*bx</i>
Pups	34	14	0.41	1.00	1000	41	21	0.51	1.00	1000	0.00	0.00
Yearlings	47	17	0.36	0.59	588	46	14	0.30	0.49	488	0.00	0.00
2 year-olds	48	24	0.50	0.64	375	43	16	0.37	0.70	339	0.08	0.03
3 year-olds	52	21	0.40	0.50	188	49	14	0.29	0.63	213	0.53	0.11
4 year-olds	32	10	0.31	0.60	112	46	16	0.35	0.71	152	0.86	0.13
5 year-olds	21	7	0.33	0.69	77	29	6	0.21	0.65	99	0.69	0.07
6 year-olds	14	9	0.64	0.67	51	20	9	0.45	0.79	79	0.78	0.06
7 year-olds	4	1	0.25	0.36	18	9	3	0.33	0.55	43	0.64	0.03
8 year-olds	3	1	0.33	0.75	14	6	1	0.17	0.67	29	1.87	0.05
9 year-olds	1	0	0.00	0.67	9	5	1	0.20	0.83	24	0.68	0.02
10 year-olds	1	1	1.00	1.00	9	3	3	1.00	0.80	19	0.68	0.01
11 year-olds	0	0	0.00	0.00	0	0	0	0.00	0.00	0	0.00	0.00
12 year-olds	0	0	0.00	0.00	0	0	0	0.00	0.00	0	0.00	0.00
13 year-olds	0	0	0.00	0.00	0	0	0	0.00	0.00	0	0.00	0.00
14 year-olds	0	0	0.00	0.00	0	0	0	0.00	0.00	0	0.00	0.00
	257	105				297	104				$R_0=$	<b>0.51</b>
											$\lambda=$	<b>0.888</b>

<b>MALES</b>						<b>FEMALES</b>						
<b>CAPTIVE</b>	<i>f(x)</i>	<i>dx</i>	<i>qx</i>	<i>lx</i>	<i>Lx</i>	<i>f(x)</i>	<i>dx</i>	<i>qx</i>	<i>lx</i>	<i>Lx</i>	<i>bx</i>	<i>lx*bx</i>
Pups	91	3	0.03	1.00	1000	55	2	0.04	1.00	1000	0.00	0.00
Yearlings	57	0	0.00	0.97	967	38	0	0.00	0.96	964	0.00	0.00
2 year-olds	40	4	0.10	1.00	967	27	1	0.04	1.00	964	0.23	0.22
3 year-olds	28	1	0.04	0.90	870	20	1	0.05	0.96	928	0.48	0.44
4 year-olds	23	1	0.04	0.96	839	16	1	0.06	0.95	882	0.50	0.44
5 year-olds	18	0	0.00	0.96	803	14	1	0.07	0.94	826	0.67	0.55
6 year-olds	13	1	0.08	1.00	803	12	0	0.00	0.93	767	0.80	0.61
7 year-olds	9	1	0.11	0.92	741	10	0	0.00	1.00	767	0.73	0.56
8 year-olds	6	0	0.00	0.89	659	8	1	0.13	1.00	767	0.56	0.43
9 year-olds	5	1	0.20	1.00	659	4	0	0.00	0.88	671	1.67	1.12
10 year-olds	2	1	0.50	0.80	527	4	1	0.25	1.00	671	0.50	0.34
11 year-olds	0	0	0.00	0.00	0	3	0	0.00	0.75	504	0.00	0.00
12 year-olds	0	0	0.00	0.00	0	2	1	0.50	1.00	504	0.00	0.00
13 year-olds	0	0	0.00	0.00	0	1	0	0.00	0.50	252	0.00	0.00
14 year-olds	0	0	0.00	0.00	0	1	1	1.00	1.00	252	0.00	0.00
	292	13				215	10				$R_0=$	<b>4.71</b>
											$\lambda=$	<b>1.310</b>