



ANNUAL REPORT

2022



MARMOT
RECOVERY FOUNDATION

ACKNOWLEDGEMENTS

The Marmot Recovery Foundation would like to thank the organizations and individuals that made this project possible. We gratefully acknowledge the support of landowners Mosaic and Mount Washington Alpine Resort. The Ministry of Forest (MOF, West Coast Region) provided funding, infrastructure and field gear. BC Parks shared their knowledge of Strathcona Provincial Park, and Haley Lake Ecological Reserve. Special thanks to the Calgary Zoo/Wilder Institute and Toronto Zoo for their immense contributions to the reintroduction program. The Marmot Recovery Foundation offers their sincere gratitude and appreciation to field crew members Chelsea Brager, Shayn McAskin, Jacob Cook, Tannin Standing, and Paul Farrugia and marmot keepers Tawny Molland and Julia Kobetitch for their dedication, safety focus, teamwork and perseverance through an unusual and challenging field season. We thank the Recovery Team and Captive Management Group for their indispensable direction and support towards project goals. Vancouver Island University kindly lent us technician and Vancouver Island Marmot expert Mike Lester to assist with field team training and feeder deployment at Nanaimo Lakes colonies. Finally, we want to acknowledge the contribution made by the Calgary Zoo/Wilder Institute and the Vancouver Island University field teams. The Calgary Zoo team, led by Kelly Swan, helped us monitor six colonies this season. At Mount Washington, Dr. Jamie Gorrell's team monitored daily movements of marmots, giving greater insight into this important colony and the behaviour of the marmots.

The Marmot Recovery Foundation's work is funded by the Province of British Columbia Ministry of Forests (MOF), Mosaic Forest Management, and individual Canadian donors. In 2022, grants were provided by Habitat Conservation Trust Foundation, the Forest Enhancement Society of BC, Peter Townsend Trust, Environment and Climate Canada, and the Fish & Wildlife Compensation Program.

The Foundation would also like to acknowledge operating support, including access to private lands, supplies, and personnel from Mount Washington Alpine Resort, Mosaic Forest Management and MOF.

This report was prepared by Kevin Gourlay, Malcolm McAdie, and Adam Taylor.

EXECUTIVE SUMMARY

The endangered Vancouver Island marmot (*Marmota vancouverensis*, Swarth 1911) is one of only five endemic land mammals in Canada (Nagorsen 2004). The Vancouver Island marmot is recognized as a protected species under the B.C. *Wildlife Act* and is on the B.C. Red List of species at risk. Nationally, it is listed under Schedule 1, Endangered, on the Species-at-Risk Act. Internationally, the International Union for Conservation of Nature (IUCN) lists the species as Critically Endangered. A recovery program for the marmot was launched in 1996, and 2022 was the twenty-sixth year of intensive recovery efforts.

During the 2022 field season, the Foundation conducted core recovery activities intended to: (i) increase the number of marmots in the wild and protect the persistence of existing colonies, (ii) support wild reproduction, and (iii) relocate marmots found in unsuitable habitat. The Wilder institute helped the Foundation to monitor marmots at several colonies while also investigating the relationship between supplemental feeding and reproduction in the wild. The Vancouver Island University field team helped the foundation monitor wild-living marmots at Mt. Washington while also investigating marmot movements and behavior on the landscape. Data from these teams have been incorporated into the results reported here.

In total, 23 captive-bred marmots and five wild-born marmots were released to augment ten priority colonies. Twenty-eight feeders were installed at 13 colonies to improve the reproductive potential of >100 marmots. Nine natural colonies produced >27 pups. There were 24 mortalities detected in 2022. Nine marmots were brought into captivity during the summer and retained for a captive winter hibernation due to predation risk or other reasons. The future of these marmots depends upon the needs of the captive breeding population. Healthy marmots not needed for the breeding program will be re-released to contribute to the persistence and growth of the wild population. Since 2003, the captive-breeding program has resulted in the release of 587 captive-bred marmots into the wild. Currently there are 137 marmots in captivity, including 33 or more potential breeding pairs for 2023.

Wild population counts of adult marmots was similar to the previous year. However, fewer yearlings and significantly fewer pups were observed this year, resulting in lower overall counts than the previous year. Approximately 204 marmots were observed in the wild by the end of the season, distributed across 27 colonies in two main regions. Survey effort was similar to the previous year at most colonies, with the notable exception of extralimital sites, which were not surveyed this year.

This report presents the results from the 2022 field season.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	2
EXECUTIVE SUMMARY	3
TABLE OF CONTENTS.....	4
LIST OF TABLES.....	5
LIST OF FIGURES.....	6
1. INTRODUCTION	7
2. ABOUT THE VANCOUVER ISLAND MARMOT.....	7
3. ABOUT THE RECOVERY EFFORT.....	8
4. WILD-LIVING POPULATION	9
4.1. Summary of the 2022 Wild-living Population.....	10
4.2. New Colonies Discovered in 2022.....	13
4.3. Mortalities.....	13
4.4. Reproduction	16
4.5. Dispersals Discovered in 2022	17
4.6. Snowpack	18
4.7. Hibernation and Post-emergence survival.....	19
4.8. Summer, Fall Weather	19
4.9. Observations of Marmot Habitat.....	19
5. SUMMARY OF “IN THE WILD” RECOVERY EFFORTS.....	26
5.1. Captive-bred releases	26
5.2. Translocations	28
5.3. Trapping and Implants	29
5.4. Managing Marmots in Unsuitable Habitat	30
5.5. Supplemental Feeding	31
5.6. Habitat Improvement	33
5.7. Invasive Species of Concern.....	34
5.8. Monitoring	35
5.8.1. Methodologies	35
5.8.2. Remote camera results	36
5.8.3. Summary of monitoring effort by location	38
5.8.4. Community contributions to monitoring.....	40
6. TONY BARRETT MOUNT WASHINGTON MARMOT RECOVERY CENTRE	41
6.1 Background	41
6.2 Operations in 2022.....	41

6.3	Outlook for 2022	44
7.	SUMMARY OF CAPTIVE BREEDING PROGRAM	45
7.1	Background	45
7.2	Reproduction	45
7.3	Hibernation.....	45
7.4	Mortalities.....	46
7.5	Releases	46
7.6	Current numbers.....	47
8.	RESEARCH PARTNERSHIPS.....	52
9.	FIELD SAFETY SUMMARY.....	53
9.1	Minor Incidents	53
9.2	Close calls	53
10.	RECOMMENDED APPROACH FOR 2023.....	55
10.1.	Proposed Supports for the Wild Population.....	55
10.2.	Proposed Monitoring and Inventory	56
10.3.	Proposed Actions for the Captive Breeding Program	57
10.4.	Biosecurity Measures.....	57
11.	FIVE YEAR REVIEW OF IMPLEMENTED RECOVERY ACTIONS	59
11.1.	Releases and Translocations.....	59
11.1.1.	Fates of Captive Bred Marmots released to the Nanaimo Lakes and Mount Washington	59
11.1.2.	Stepping Stone releases in Strathcona Provincial Park.....	61
11.1.3.	Captive Breeding Capacity	63
11.2.	Habitat Improvement, Enhancement, Restoration.....	63
11.2.1.	Supplementing Feeding	63
11.2.2.	Tree Ingress Removal.....	63
11.3.	Monitoring the wild-living marmot population.....	64
11.3.1.	Radio telemetry	64
11.3.2.	Visual Surveys and Camera Traps.....	65
12.	FUTURE DIRECTIONS.....	66
	REFERENCES.....	67

LIST OF TABLES

Table 1. Summary of 2022 wild-living marmots, including augmentation and hill counts by age class. *indicates pups were trapped and brought into captivity, therefore not reported here.....	10
Table 2. New colonies discovered in 2022.....	13
Table 3. Summary of the mortalities detected in 2022 and their suspected causes.	14

Table 4. Weaned pups counted in 2022.	16
Table 5. Overwinter survival and mortality in 2022.	19
Table 6. Observations of habitat conditions at marmot colonies in 2022.....	20
Table 7. Captive-bred marmots released or re-released in 2022.....	27
Table 8. Numbers of captive-bred marmots released 2003-2022.....	28
Table 9. Marmots translocated in 2022.....	29
Table 10. Transmitter implants of wild-living marmots in 2022.....	30
Table 11. Marmots brought into the TBMWMRC from the wild in 2022.....	31
Table 12. Supplemental Feeding Sites in 2022.	32
Table 13 Habitat Improvement in 2022. All work was conducted in the Nanaimo Lakes region.....	33
Table 14 Footage captured by select remote cameras in 2022.....	37
Table 15 A comparison of monitoring effort in 2022 compared to the average of the previous three years.....	38
Table 16 Significant reports from the public in 2022.....	40
Table 17 Sources of wild captures (1997 to 2019) –no individuals were specifically captured for the captive program from 2020 to 2022.....	49
Table 18 Annual Summary of captive releases (2003 to 2022 – 20 years).....	50
Table 19 Annual summary of releases and translocations (1997 to 2022). Red = captive-releases, yellow = translocations, and blue = pre-conditioned marmots (captive-marmots released to a site and subsequently translocated after surviving at least one year in the wild).....	51

LIST OF FIGURES

Figure 1. Distribution of the Vancouver Island Marmot in the wild (November 2022), including occupied, unoccupied and data deficient colony sites in the (a) Strathcona and (b) Nanaimo Lakes regions.....	9
Figure 2. Mean population counts for the Nanaimo Lakes & Strathcona regions (2003-2022).....	12
Figure 3. Mean population counts for the wild-living Vancouver Island Marmot population (2003-2022).	12
Figure 4. Snow water accumulation at the Jump Creek water station in the Nanaimo Lakes region (2021-22; MOF 2022).	18
Figure 5. Snow water accumulation at the Wolf River Upper water station in the Strathcona region (2021-22; MOF 2022).....	18
Figure 6 Tree growth in marmot habitat on Heather Mountain - Main Meadow. Photo by Shayn McAskin.	23
Figure 7 Tree growth in marmot habitat on Green Mountain – Snow Bowl. Photo by Shayn McAskin. ...	23
Figure 8 Tree growth in marmot habitat on Douglas Peak – China Bowl. Photo by Shayn McAskin.	24
Figure 9 Tree growth in marmot habitat on Mt. Castlecrag – Main Meadow. Photo by Kevin Gourlay....	24
Figure 10 Tree growth in marmot habitat on Haley – Main Meadow. Photo by Shayn McAskin.	25
Figure 11 Tree growth in marmot habitat on Flower Ridge– Main Meadow. Photo by Kevin Gourlay.....	25
Figure 12. Causes of captive marmot mortality (total = 130, four post-mortems pending)	46
Figure 13 Distribution of Captive Releases	47
Figure 14. Captive marmot population numbers from July 1997 to December 2021.....	48
Figure 15 Year-end Captive Total to 2022	48
Figure 16 Fates of Captive bred marmots released to the wild between 2018 and 2020	60
Figure 17 Fates of Captive bred Marmots released in 2021.....	61
Figure 18 Fates of marmots translocated to Strathcona Provincial Park 2018 to 2021.....	62

1. INTRODUCTION

This report is primarily intended for partners in the Vancouver Island Marmot recovery effort to facilitate planning of 2023 recovery actions. Others may find it informative or useful for research. In this report, you will find descriptions of the approach, methodology and results of activities conducted by the Marmot Recovery Foundation during the 2022 field season. These results include data collected by the Foundation's field crews, as well as observations from the Wilder Institute and Vancouver Island University research teams. Collectively, this document refers to all these groups as "field teams". The information shared here is current and accurate to the best of our ability. If you are looking for additional information about recovery planning for the Vancouver Island Marmot, please refer to the Provincial Recovery Plan (Vancouver Island Marmot Recovery Team 2017), Federal Recovery Strategy (Environment and Climate Change Canada 2019), or visit the Foundation's website. Within this report, any mention of the "Recovery Plan" refers to the Provincial document, unless otherwise noted.

2. ABOUT THE VANCOUVER ISLAND MARMOT

The Recovery Plan describes the species as follows:

"The Vancouver Island Marmot (*Marmota vancouverensis*) is British Columbia's only endemic mammal species; it lives only in mountainous areas on Vancouver Island. For 7–8 months of the year (approximately early October to May), family groups of Vancouver Island Marmots hibernate in underground burrows called hibernacula. During the 4–5 month active season in which they breed, raise young, and regain weight, marmots continue to use their underground burrow systems for resting, avoiding summer heat, and protection from predators. They also spend considerable time above ground foraging, resting, sunning, and interacting with other marmots. Marmots typically live in colonies and when above ground, they rely on alarm calls to warn others in the colony that a predator is nearby. The main predators of the Vancouver Island Marmot are Golden Eagles, Cougars, and Grey Wolves," (Executive Summary, p.v).

"Because of their reliance on alpine and subalpine habitat, Vancouver Island Marmots are not distributed uniformly on the landscape. On a small spatial scale, marmots live in colonies that typically include one to two family groups (Nagorsen 2005). Multiple colonies can live on a single mountain. Within this document, the term "site" is synonymous with "mountain." Marmots living at the same site can, therefore, disperse or move between colonies without leaving the alpine or subalpine habitat; marmots dispersing between sites must travel through lower-elevation forest habitats. Because alpine and subalpine areas on mountains are separated by areas of unsuitable marmot habitat, it is thought that Vancouver Island Marmots have a metapopulation structure (Bryant 1996); marmot colonies on the same mountain form a subpopulation, and subpopulations are linked by occasional dispersal. The subpopulations that are (or could be) linked by these dispersal events comprise the metapopulation. Dispersal events do not occur between marmot metapopulations because they are isolated by distance. Two metapopulations of Vancouver Island Marmots currently exist, one in the Nanaimo Lakes area of south-central Vancouver Island and one further north in the Strathcona region," (Section 3.2, p.3).

3. ABOUT THE RECOVERY EFFORT

The Vancouver Island Marmot initially was designated as endangered in 1978 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Additional protections have been provided by Canada's Species at Risk Act, and British Columbia's Wildlife Act, Forest and Range Practices Act, Private Forest Land Management Act, and Oil and Gas Activities Act. Intensive recovery efforts have been ongoing since 1996 to increase the population size and distribution. Perhaps the most critical recovery activity was the initiation in 1997 of a captive-breeding and reintroduction program that continues to date. There are presently three facilities that breed marmots for the recovery program: the Calgary Zoo, the Toronto Zoo, and the purpose-built Tony Barrett Mount Washington Marmot Recovery Centre operated by the Marmot Recovery Foundation. Since 2003, the captive-breeding program has released 554 captive-bred marmots and re-introduced 11 wild-born marmots to the wild, contributing to the re-establishment of 19 extinct colonies in the species' historic range.

The Recovery Plan describes as its goal the establishment of two or more persistent, geographically distinct metapopulations of Vancouver Island Marmots within the species' historic range. It also specifies seven key objectives:

1. Increase the number of marmots through augmentation and, if possible, by increasing survival rates and reproductive rates in the wild.
2. Maximize opportunities for successful dispersion between colonies.
3. Maintain a large and genetically diverse captive-breeding population that can produce adequate numbers of release candidates to support population recovery.
4. Prioritize the maintenance of genetic variability in the global population until recovery goals are met.
5. Reduce knowledge gaps surrounding: (a) natural levels of variability in survival and reproductive rates in the wild; (b) factors that determine key demographic rates; and (c) the best method to monitor population size and key demographic rates long term.
6. Develop and implement a plan for reducing intensive management as metapopulations recover.
7. Develop and implement a sound strategy to ensure sufficient resources are available to support recovery efforts until recovery goals are met.

Objectives 1-3 are the focus for this report of 2022 activities, results, and observations.

4. WILD-LIVING POPULATION

The known, wild-living population of Vancouver Island Marmots is currently distributed in two metapopulations and a single, isolated colony. The Strathcona metapopulation (Figure 1a) includes eleven occupied colonies and 40% of the wild-living marmot population. The Nanaimo Lakes metapopulation (Figure 1b) includes 14 occupied colonies and 58% of wild-living marmots. Steamboat Mountain, in west-central Vancouver Island, is believed to include approximately 2% of the wild-living population.

The Foundation classifies a colony site as “unoccupied” when there was no marmot sign detected on its most recent two surveys. Colonies were classified as “data deficient” when Foundation staff felt there was insufficient data to assess their occupancy. Some data deficient colonies have not been surveyed for several years.

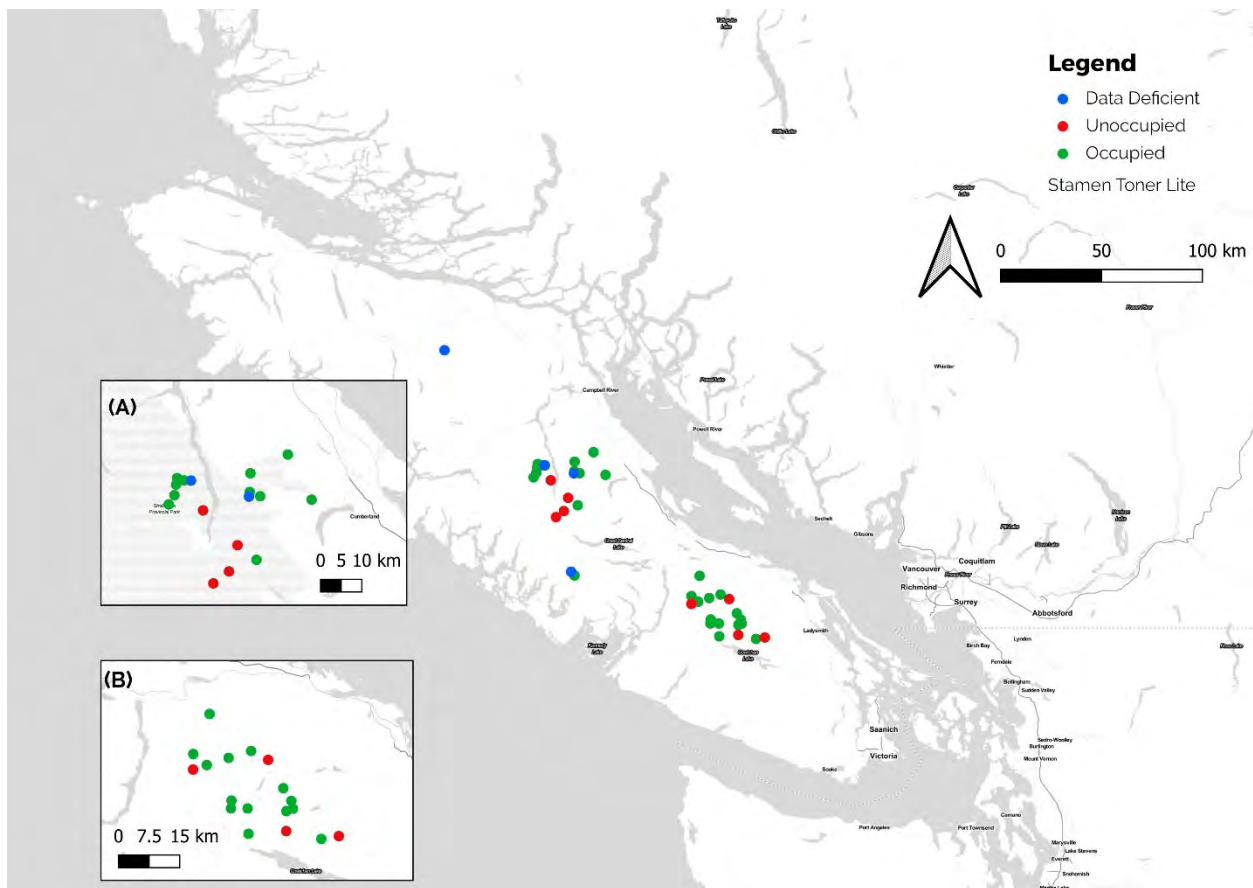


Figure 1. Distribution of the Vancouver Island Marmot in the wild (November 2022), including occupied, unoccupied and data deficient colony sites in the (a) Strathcona and (b) Nanaimo Lakes regions.

4.1. Summary of the 2022 Wild-living Population

At the metapopulation level, the 2022 field season resulted in a similar count of >1yo marmots and slightly increased distribution to that in 2021. The Nanaimo Lakes region continued to hold a greater proportion of the wild population than the Strathcona region (58% vs 40%), a larger number of adults (n=68 vs n=55), and produced the majority of the pups (n=24 vs n=4). Yearling counts were lower than expected based on 2021 pup counts; the Nanaimo Lakes region saw 25 yearlings from the 46 pups counted in 2021, while the Strathcona region saw 22 yearlings from the 27 pups counted in 2021. Each region included a small number of large and successful colonies, but the vast majority of colonies remained small in size. Survey effort in 2022 was 158% of the average over the previous three years (789 person-days vs 500 person-days), with the increase in effort concentrated at Vancouver Island University and Calgary Zoo study sites and other infrequently surveyed colonies (see table 15).

The Foundation observed an increase in the distribution and/or density of marmot colonies in 2022. Following a hiker report from summer 2022 and the Foundation confirmed marmot occupation at a colony in Strathcona Provincial Park near the Red Pillar. This new colony is currently the only extant colony south of Buttle Lake, and shows evidence of long-term occupation. This exciting discovery is an indication that connectivity between larger established colonies within the park may be improving. Field crews also confirmed that the two previously discovered colonies in 2021 remain occupied in 2022. In the Nanaimo Lakes region, additional habitat expansion was observed at Mount Landale, McQuillan, Douglas Peak, and Mt. Arrowsmith.



Photo 1 Release. Nick Thornton/Mount Washington Alpine Resort

Table 1. Summary of 2022 wild-living marmots, including augmentation and hill counts by age class. *indicates pups were trapped and brought into captivity, therefore not reported here

	Augmentations		Counts						
	Releases	Translocations	≥2yo	1yo	0yo	Unk. Age	Total		
REGION, Colony	N	N	Mean	Mean	Mean	Mean	Low	High	
NANAIMO LAKES	14	1	68	25	22	5	110	127	
Arrowsmith			11	4	2		17	17	
Big Ugly			7	2	2	1	12	12	
Butler			3			1	3	4	
Douglas	2		5	2	2		8	9	
Gemini	2		4	2			4	7	
Green	2		1	1			2	2	
Haley	2		2		4		6	6	
Heather	2		3	2			3	5	
Hooper	2		4	2		1	6	7	
Landale			3	1	4		8	8	
McQuillan			6	5		1	11	13	
Moriarty			4	1	6		10	11	
P Mountain	2	1	6	1	2		9	9	
Sadie Peak			4			1	5	5	
Cutblocks (combined)			3	2	0*	1	4	7	
Location Unknown			3	1			2	5	
STRATHCONA	9	4	55	22	0	4	72	88	
Albert Edwards		2	9	3			11	12	
Becher			2	1			3	3	
Castlecrag			6	1			6	7	
Flower ridge							0	0	
Greig Ridge		1	2	1			2	3	
Marble Meadows			8	6			13	14	
Morrison Spire						3	3	3	
Red Pillar			2	3			5	5	
Sunrise			4	1			5	5	
Tibetan			1				1	1	
Washington	9	1	16	6*	0*		22	22	
Wheaton lake						1	1	1	
Location Unknown			6				0	11	
EXTRALIMITAL			1			4	0	10	
Steamboat			1			4	0	10	
WILD TOTAL	22	6	124	46	22	13	182	225	

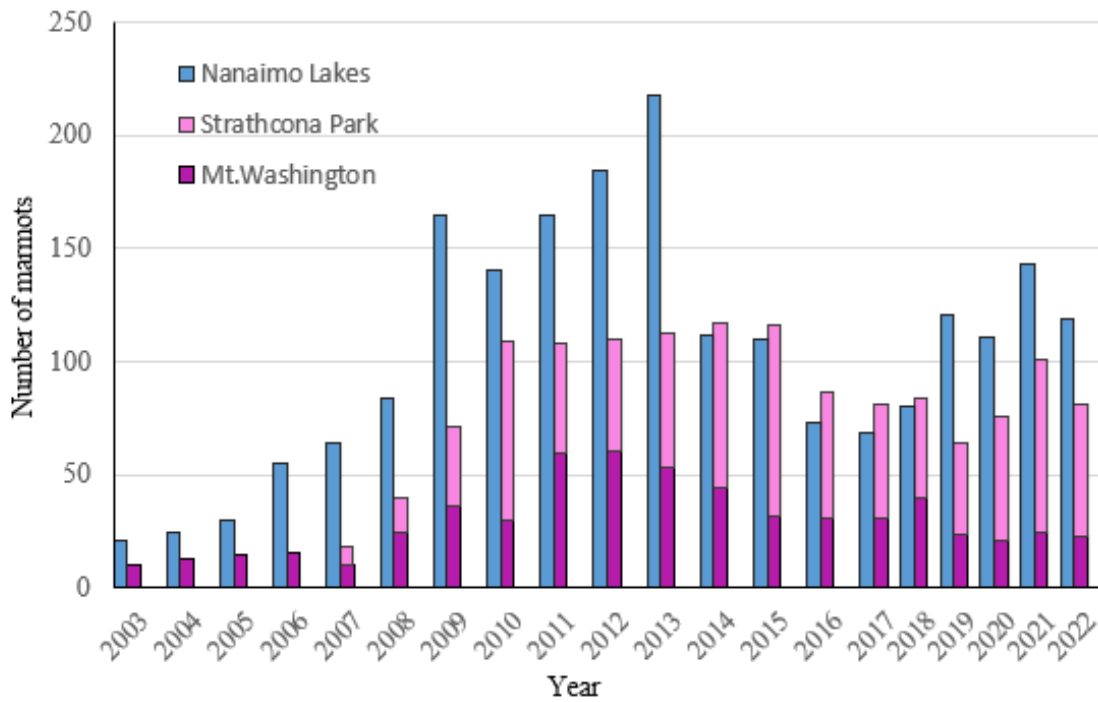


Figure 2. Mean population counts for the Nanaimo Lakes & Strathcona regions (2003-2022).

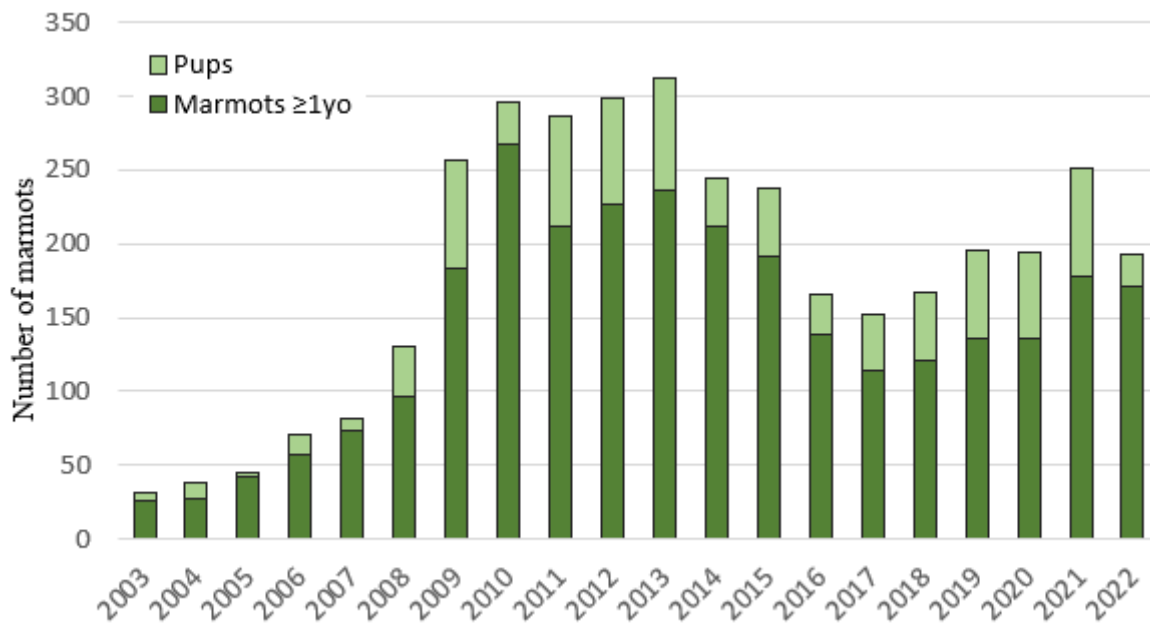


Figure 3. Mean population counts for the wild-living Vancouver Island Marmot population (2003-2022).

4.2. New Colonies Discovered in 2022

A single new colony, the Red Pillar, was discovered in 2022, located at the southern extremity of Strathcona Provincial Park. Hikers reported observing marmots in a small talus field off the main trail used to access the summit. Upon returning, the hikers submitted several clear photographs of marmots using the Foundation’s website. Foundation staff followed up on the report on a multi day survey, resulting in additional marmot observations and documented additional occupied marmot habitat nearby. The discovery of multiple age-classes of marmots, well established burrows, and marmot bones suggest historic occupation at this site. Future visits are required to develop a broader understanding of habitat use, age class distribution, and resident counts at this colony.

Table 2. New colonies discovered in 2022.

Region	Colony	# Adults	# Yearlings	# Pups	Notes
Strathcona Provincial Park	Red Pillar	2	3	0	All individuals observed are untelemetered. No records of recent occupancy. Reported by hikers in the summer of 2022, MRF staff confirmed in Fall 2022. Active marmot habitat in two main sublocations on either side of west ridge, with signs of historic marmot refugia throughout both areas.

4.3. Mortalities

The Foundation detected 24 mortalities during the 2022 field season (Table 3), including nineteen in the Nanaimo Lakes region and five in the Strathcona region. Ten mortalities were of marmots recently released or translocated. An additional five mortalities were detected that could have occurred before 2022. Three of twelve recovered mortalities are believed to be hibernation related, while selective consumption of the remainder suggested cougar or avian predation. Cougars continue to be the primary predator of marmots. Prior to 2009, wolves accounted for a significant number of predations. The Foundation cannot explain why this has changed.

The Foundation determines the suspected cause of mortality of telemetered marmots by promptly locating and recovering the remains of the marmot after it has been detected on an inactive signal. The location and pattern of consumption of the remains, in addition to other signs, give an indication to the cause of mortality. Please contact the Foundation for a more exhaustive explanation of our process of determining cause of mortality.

Table 3. Summary of the mortalities detected in 2022 and their suspected causes.

2022 Mortalities					
Region	Location	Marmot	Date Detected	Suspected cause of mortality	Notes
Nanaimo Lakes	Arrowsmith	Unknown Yearling	June 20 2022	Hibernation	Emaciated (400g) unknown yearling recovered at entrance of emergence hole.
	Bell Creek	Diego2	June 15 2022	Unknown	Dispersed from Gemini, not recovered.
	Douglas	Rosseau	Aug 22 2022	Unknown	2022 captive release. Not recovered
	Gemini	Benson2	Aug 24 2022	Unknown	2022 captive release. Not recovered
	Green	Zeballos	Aug 9 2022	Unknown	2022 captive release. Not recovered
	Haley Lake	Maddie	Sept 6, 2022	Cougar predation	2021 wild born implant. Transmitter recovered.
	Haley Lake	Hershey2	June 8 2022	Cougar predation	2021 wild born implant. Transmitter recovered
	Haley Lake	Natasha2	June 17 2022	Cougar predation	2021 captive release. Transmitter recovered 1m from hibernaculum.
	Haley Lake	Pepper	June 15 2022	Hibernation	2021 captive release. Pinned in burrow. Transmitter not recovered.
	Haley Lake	Mohun	Aug 11 2022	Unknown	2022 Captive release, transmitter not recovered.
	Haley Lake	Ellen	Aug 4 2022	Cougar predation	2022 captive release. Transmitter recovered.
	Heather	Thetis	Aug 8 2022	Unknown	2022 captive release. Not recovered
	Heather	Winona	Aug 18 2022	Cougar predation	Established older female, transmitter recovered near hibernaculum.
	Hooper	Aster2	July 23 2022	Unknown	Not detected spring 2022 until discovered on slow. Not recovered.
	Hooper	Dalwhinnie2	Aug 22 2022	Unknown	2022 captive release. Not recovered

	LDL Cut block	Blossom2	July 15 2022	Cougar Predation	Established older female. Transmitter recovered by side of the road.
	Moriarty	Unknown Pup	Sept 14 2022	Cougar Predation	Remains found along game trail entering meadow.
	P Mountain	Pendleton	Aug 10 2022	Unknown	2022 captive release. Not recovered
	Sadie	Triscuit	Aug 22 2022	Unknown	Not recovered
Strathcona Provincial Park	Washington	Nairobi	June 15 2022	Hibernation	Signal dropped to slow in burrow, remains were pushed out of burrow and recovered.
	Washington	Matchlee	Aug 29 2022	Unknown	2022 Captive-release, dispersed, not recovered.
	Washington	Sutton	Aug 3 2022	Unknown	2022 captive release, not recovered.
	Washington	McQuilla	Aug 5 2022	Cougar predation	2022 Captive-release, transmitter recovered.
	Washington	Judy2	Aug 10 2022	Avian predation	Established older female. Articulated skeleton in open, with soft tissues (except for g.i.t) mostly consumed
Total		24 marmots			
Historic Mortalities discovered in 2022					
	Albert Edwards	Unknown	Oct 14 2022	Unknown	Old marmot bones discovered at entrance of hibernaculum.
	Haley Lake	Towhee	Unknown	Unknown	Transmitter discovered in meadow. Missing since 2019.
	McQuillan	Unknown	July 25 2022	Unknown	Old marmot bones discovered at entrance of hibernaculum.
	Red Pillar	Unknown Marmot	Sept 14 2022	Unknown	Old bones from multiple marmots found near meadow.
	Washington	Unknown marmot	Unknown	Unknown	Recovered by Mount Washington staff within reservoir piping system.

4.4. Reproduction

The Foundation counted 9 litters and 28 weaned pups in 2022. Low reproduction was expected this year, since there had been strong reproduction in each of the three previous years, and most breeding females are expected to skip a year before producing another litter. Deep late-season snow pack which occurred just as marmots were emerging from hibernation and breeding likely also contributed to the relatively low reproduction seen this year. By removing many potential food sources, deep snow may have resulted in females with lower body condition that were then less likely to breed and produce a litter.

Table 4. Weaned pups counted in 2022.

Region	Location	# of litters	# of pups	Notes
Nanaimo Lakes	Arrowsmith	1	2	Beehive bowl
	Big Ugly	1	2	Main meadow
	Douglas	1	2	China Bowl
	Haley	1	4	Presumed dam was predated
	Landale	1	4	Summit gulley
	Moriarty	1	6	Dead pup recovered on game trail
	P Mountain	1	2	Main meadow
	LDL Cutblock	1	2	Trapped and brought into captivity after presumed dam was predated. Not included in Hill Counts.
Strathcona	Washington	1	4	Trapped and brought into captivity after presumed dam was predated. Not included in Hill Counts.
Total	9 colonies	9 litters	28 pups	

4.5. Dispersals Discovered in 2022

The term “dispersal” is used to describe wild-living marmots known to have moved by their own means from one location to another. This is different from the translocation of marmots, whereby the Foundation moves a marmot between locations, although those marmots may subsequently disperse from their release location. In those cases, the dispersal is recorded as having started at the marmot’s release site. Sometimes dispersals end in the mortality of a marmot before it reaches a new colony, or are truncated by the capture of the marmot in unsuitable habitat. Currently, Vancouver Island Marmot transmitters do not have satellite capabilities, and so all dispersals involve marmots moving untracked through the landscape for some distance and period of time.

Marmot	Origin	Receiving Colony	Time frame	Notes
Mitty	Douglas	McQuillan	Late season 2021 to early 2022	Last detected in July 2021 on Douglas, signal was detected again June 2022. Trapped and telemetry replaced in McQuillan main meadow.
Camas	Gemini	Green	Late season 2021 to early 2022.	Camas was detected away from Gemini in fall 2021, and was pinned down at Green Mtn near an unknown adult in May 2022.
Camas	Green	Unknown	July 2022 to hibernation 2022	In July, Camas was detected dispersing off Green to the west. In September was detected from Big Ugly and Fourth Lake, towards the Shaw Lake area.
Diego2	Gemini	Haley	Early season 2022	Not pinned Fall 2021, detected on fast spring 2022 near Haley Lake in Bell creek, subsequently detected on slow spring 2022, not recovered.
Walter	Douglas	Unknown	Late season 2021, early season 2022	On Douglas late season 2021. Signal detected early season 2022 toward McQuillan, with bearings suggesting further west towards Mt Spencer.
Ginger 3	Douglas (China Bowl)	McQuillan	2021 to early 2022.	Signal suggested Ginger3 had dispersed towards McQuillan from Douglas in Late 2021.
Ginger 3	McQuillan	Douglas (SE Talus)	Summer to fall 2022.	Ginger3 was detected from McQuillan back towards Douglas in early 2022, potentially near Father and Son lake. Pinned in October 2022 to a new sub-location on the backside of Douglas.

4.6. Snowpack

The 2021-2022 winter season saw higher late season snow levels than the historic 25-75 range. This peak snow pack coincided with marmot emergence, and may have hindered early season foraging for marmots and had a negative impact on reproduction, resulting in the low observed pup counts.

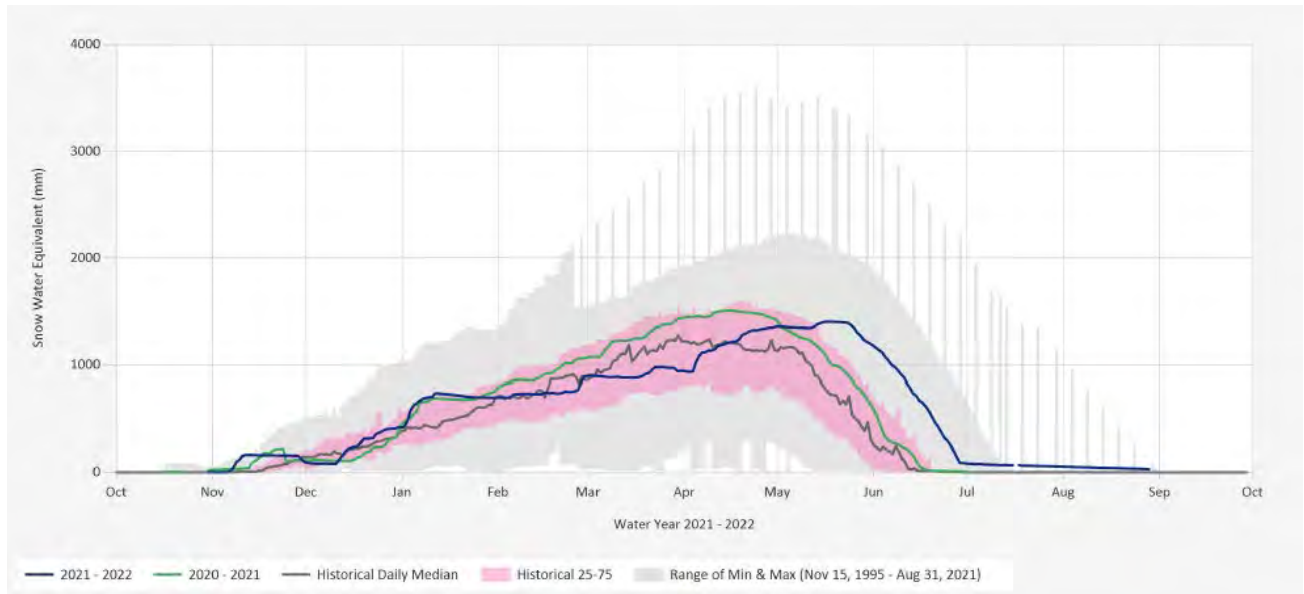


Figure 4. Snow water accumulation at the Jump Creek water station in the Nanaimo Lakes region (2021-22; MOF 2022).

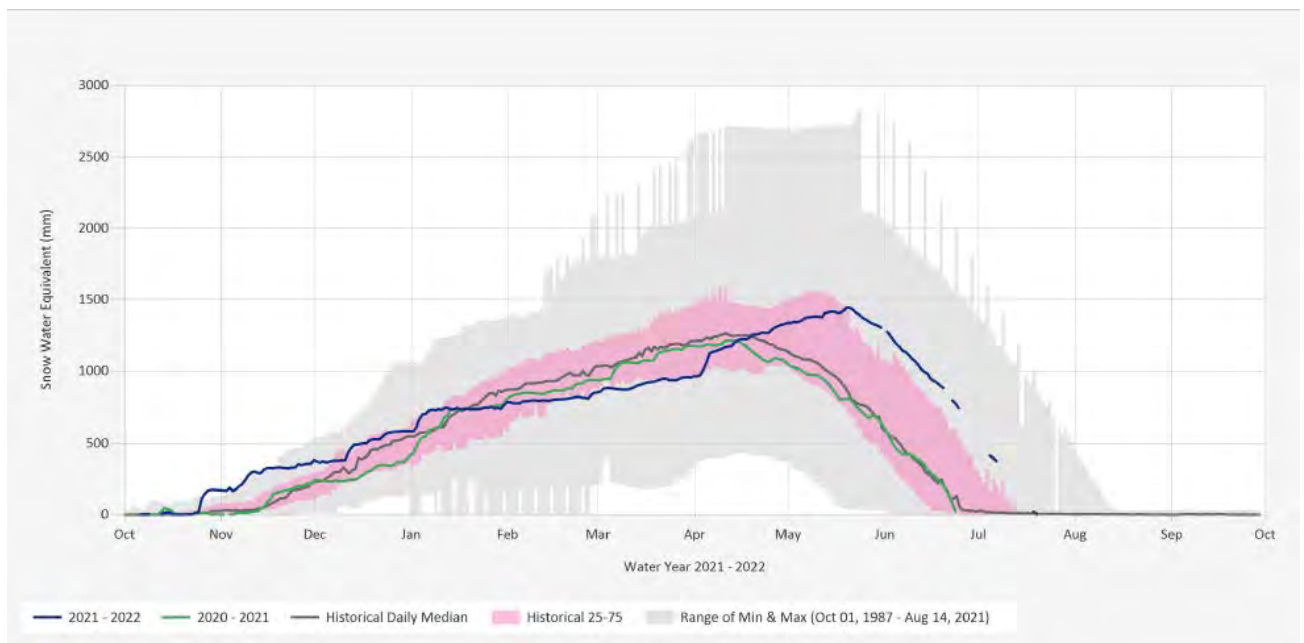


Figure 5. Snow water accumulation at the Wolf River Upper water station in the Strathcona region (2021-22; MOF 2022)

4.7. Hibernation and Post-emergence survival

The Marmot Recovery Foundation defines a marmot as having survived hibernation when it was detected on active telemetry signal (fast), or not active but tracked to a burrow, on or after September 15, 2021, and on active signal (fast) again by mid-June 2022. By this definition, 88% of monitored marmots in the wild survived hibernation (22 of 25).

Table 5. Overwinter survival and mortality in 2022.

Population	Suspected Overwinter Mortalities	Overwinter Survival for Monitored Population (x of y)
Nanaimo Lakes	Pepper, Diego2	78% (7 of 9)
Strathcona	Nairobi	94% (15 of 16)
Extralimital Sites	Unknown	Unknown
TOTAL		88% (22 of 25)

4.8. Summer, Fall Weather

All of Vancouver Island reached drought level 5 for a period of three to four weeks from late September to late October. Marmots were observed above ground and detected on active telemetry signals well into late October. It is unclear what effect this had on the marmot population.

Although precipitation levels were considerably lower than seasonal average for much of the late summer and fall, field staff noted that marmot meadows were not exceptionally dry, and that vegetation was much greener in alpine meadows than at lower elevations. It is possible that air moisture condensation allowed herbaceous alpine plants to receive enough moisture to prevent early senescence, and therefore marmot forage was not drastically reduced.

4.9. Observations of Marmot Habitat

Field teams continued to note that tree ingress is a problem at many colonies (Table 6). Tree ingress degrades historic marmot habitat in two ways: (1) immature trees become established and obstruct sightlines from marmot refuges and lookout boulders, and (2) as trees become established, they provide significant stalking cover at the ground level, an impact already documented at several colonies (Table 6). Both issues improve the hunting success of predators, especially cougars, and may result in poor survival outcomes for marmots at these locations. This tree ingress is symptomatic of climate change-induced succession of high-elevation habitat from the subalpine and alpine ecosystems on which marmots rely to forest ecosystems.

Tree ingress significantly impacts marmot habitat and eventually replaces it altogether. In early stages, young trees facilitate predation as discussed above, and make colonies more vulnerable to extirpation. Marmot habitat is already highly constrained, and declining habitat quality or habitat loss will make recovery of the species more difficult and costlier. Ideally, the Foundation or another entity would conduct habitat improvement activities before predation or vegetation succession becomes a significant problem for a colony. Early action also means the clearing work is more efficient because trees are smaller and less numerous.

Table 6. Observations of habitat conditions at marmot colonies in 2022.

Region	Site	Sublocation	Notes
Strathcona	Castlecrag Mountain	West Shelf, Main Meadow	Recommended focal site for future habitat improvement efforts. 2022 field observations saw dense forests below well-used hibernacula in both sublocations. Tree ingress is an ongoing concern within this sublocation and efforts should focus on restoring sightlines from marmot habitat features, with a particular focus on those impacted by dense forests downslope.
		Talus Bowl	Recommended focal site for future habitat improvement efforts. 2022 field observations saw dramatic infilling of subalpine forests.
	Flower Ridge	Price Pass	Recommended focal site for future habitat improvement efforts. 2022 field observations saw heavy, dense tree cover within the main drainage system once occupied by marmots at this sublocation. Future actions should prioritize addressing tree ingress within this area, particularly upslope where denser forests are.
		Cream Lake	Recommended focal site for future habitat improvement efforts. Although not surveyed in 2022, 2021 field observations saw dramatic tree ingress within the talus fields directly adjacent to Cream Lake. While there is only one release site adjacent to this area, it is recommended restoring sightlines from this habitat feature by thinning out young trees nearby.
Nanaimo Lakes	Arrowsmith	South Meadow	Recommended focal site for future habitat improvement efforts. 2022 field observations continued to see heavy tree ingress in the direct vicinity of well-used hibernacula, with some burrows completely enclosed by dense forest. Based on these observations, efforts should focus on 1) restore sightlines from marmot habitat features completely enclosed by dense forest and 2) address young tree growth around marmot habitat features near tree ingress hot spots (i.e. towards the present-day treeline).
	Douglas	China Bowl	2022 focal site for habitat improvement – tree ingress report available. Concerns in this area was a stand of young trees bordering the main talus field, blocking sightlines from burrows into adjacent forest. Treatment efforts were focused on this area to improve line of sight towards areas where predators may be sourced from.

	Gemini	Main Meadow	2021 focal site for habitat improvement – tree ingress report available. Significant tree ingress remains, and this site remains a recommended focal site for future treatments. Two distinct stands of dense trees formed within the Main Meadow, dividing this sublocation into three micro meadows..
	Green	North Green	Recommended focal site for future habitat improvement efforts. 2022 field observations continued to see moderate tree ingression that has the potential to degrade sightlines from one of the hibernacula. Based on this, priority actions should focus on addressing tree ingression along the periphery of nearby contiguous forest.
		Snowbowl	2022 focal site for habitat improvement – tree ingress report available. 2021 field observations saw considerably heavy tree ingression, with very minimal talus field habitat available. Based on these observations, tree ingression was addressed at the periphery of remaining talus field habitat.
		Summit West	2022 focal site for habitat improvement – tree ingress report available. 2021 field observations saw heavy tree ingression around known marmot habitat features. Past mortality events suggest addressing tree ingression along the southwest periphery of this sublocation, where mortality locations are most concentrated.
	Haley Lake	Main Meadow	Recommended focal site for future habitat improvement efforts. 2022 field observations continued to see moderate tree ingression, particularly upslope towards the summit’s ridgeline. These observations alongside previous mortality locations suggest that tree ingression in the upper south corner of Haley Lake’s main meadow should be prioritized for future restoration efforts here.
		Bell Creek	Recommended focal site for future habitat improvement efforts. 2022 field observations continued to see moderate tree ingression towards the center of the meadow, particularly within the north end of this sublocation. Future restoration efforts should focus on removing tree ingression within meadow habitat, and thin established patches of forest at it's periphery and towards areas of known marmot travel (e.g. the upper ridgeline).

	Heather	Main Meadow	2022 focal site for habitat improvement – tree ingress report available. 2022 field observations saw heavy tree ingress at all areas of the meadow. Tree ingress removal focused in the upper bowl due to accessibility, restoring historic marmot features which had been completely engulfed in tree stands.
	Hooper	Main Meadow	Recommended focal site for future habitat improvement efforts. 2022 field observations saw heavy tree ingress within micro-meadows – both the main meadow, as well as in micro meadows adjacent to drainage features at lower elevations. Future restoration efforts should prioritize building upon previous restoration efforts in 2017 by addressing tree ingress at the periphery of the sublocation. Where resources are available, addressing tree ingress adjacent to drainage features at lower elevations should also be a priority. Previous mortality locations may suggest heavy marmot travel within these areas as well.
	Moriarty	LDL Meadow	2021 focal site for habitat improvement – tree ingress report available. This site remains a focal priority site for future work due to the extent of the tree ingress remaining. Concerns in this area focused on a stand of trees bordering the south side of three well-used hibernacula. Previous habitat improvement efforts were made here in 2017 – wherein trees on the north side of the 3 hibernacula were treated.
	McQuillan	Main meadow	2022 focal site for habitat improvement – tree ingress report available. This years restoration efforts focused along the edges of dense forest growing below the main meadow, as suggested by 2021 field observations. Field staff observed marmots utilizing lower talus field below the main meadow and forested section, suggesting that marmots may use these forested areas as travel corridors.
		West Talus	Recommended focal site for future habitat improvement efforts. 2022 field observations saw considerable tree ingress along the periphery of this sublocation, as well as especially dense forest patches. Future restoration efforts should focus on thinning dense forest in known travel corridors, as well as heavy tree ingress within talus fields.



Figure 6 Tree growth in marmot habitat on Heather Mountain - Main Meadow. Photo by Shayn McAskin.



Figure 7 Tree growth in marmot habitat on Green Mountain – Snow Bowl. Photo by Shayn McAskin.



Figure 8 Tree growth in marmot habitat on Douglas Peak – China Bowl. Photo by Shayn McAskin.



Figure 9 Tree growth in marmot habitat on Mt. Castlecrag – Main Meadow. Photo by Kevin Gourlay.



Figure 10 Tree growth in marmot habitat on Haley – Main Meadow. Photo by Shayn McAskin.



Figure 11 Tree growth in marmot habitat on Flower Ridge– Main Meadow. Photo by Kevin Gourlay.

5. SUMMARY OF “IN THE WILD” RECOVERY EFFORTS

Recovery work is supported by a number of partners and stakeholders, including the Provincial Government, private landowners, the Calgary and Toronto Zoos, and the Recovery Team. The Marmot Recovery Foundation’s efforts for the 2022 field season aimed to increase the overall number of marmots in the wild, protect the persistence of existing colonies through augmentation and the promotion of breeding opportunities, and support the growth and future breeding capacity of the wild colony on Mt. Washington. Following observations of high spring snowpack and several emaciated marmots, the Foundation expanded the supplemental feeding program. The Foundation also worked to assist research partners in answering recovery-related questions. Below is discussion of the activities conducted in working towards those goals.

5.1. Captive-bred releases

Release sites were selected based on monitoring data and feedback on augmentation priorities from the Recovery Team. In 2022, the Foundation released captive-bred marmots to promote the persistence of small colonies with past reproductive success, as well as to increase the breeding capacity of a source colony that could produce future translocation candidates. To give captive-bred marmots the best chance to survive to breeding age (Lloyd et al. 2018), the Foundation released no captive-bred marmots directly into Strathcona Provincial Park. Instead, 14 captive-bred marmots were released to support seven key colonies in the Nanaimo Lakes region. Nine captive-bred marmots were released on Mount Washington to become future resident breeders. One of these individuals was previously released in 2021 and then recaptured due to predation risk and overwintered at the facility. Another individual was brought back into captivity in fall 2022 after returning to the facility, and is a re-release candidate for 2023.



Photo 2 Nick Thornton/Mount Washington Alpine Resort

Table 7. Captive-bred marmots released or re-released in 2022.

Region	Release site	Birth Facility	Date	Total # Released	# Males	# Females	Names (age, sex, D=deceased)
Strathcona	Washington	TZ, CZ, TBMWMRC	July 5	5	2	3	Talamore (1yo, M) Jess (1yo, M) Maquilla (1yo, F, D) Sutton(1yo, F,D) Esmeralda (2yo, F, re-release)
	Washington	CZ, TBMWMRC	July 6	4	2	2	Bluebell (2, F) Septimus (1, M) Matchlee (1, F, D) Everett (1, M, brought back into captivity)
Nanaimo Lakes	Haley	CZ, TBMWMRC	July 14	2	1	1	Mohun (1, M, D) Ellen (1, F, D)
	Green	TZ, CZ	July 14	2	1	1	Talisker_2 (1, F) Zeballos (1, M, D)
	Gemini	TBMWMRC	July 14	2	1	1	Benson 2 (2, M, D) Effie (1, F)
	Douglas	CZ	July 14	2	1	1	Rosseau (1, F, D) Frink (1, M)
	Heather	CZ	July 14	2	1	1	Thetis (1, M, D) Bedwell (1, F)
	Hooper	TZ, TBMWMRC	July 14	2	1	1	Dalwhinnie_2 (1, F, D) Anderson (1, M)
	P-Mountain	TZ	July 14	2	1	1	Hawkeye (2, M) Pendleton (1, M, D)
TOTAL	8 colonies			23	11	12	

Table 8. Numbers of captive-bred marmots released 2003-2022.

Year	Nanaimo Lakes	Strathcona region	Extralimital Sites	Total
2003	2	0	0	2
2004	7	2	0	9
2005	13	1	0	14
2006	25	2	0	27
2007	24	9	4	37
2008	30	23	6	59
2009	28	22	18	68
2010	2	77	6	85
2011	26	36	4	66
2012	0	34	0	34
2013	0	16	0	16
2014	0	28	0	28
2015	0	24	0	24
2016	0	13	0	13
2017	6	5	0	11
2018	9	5	0	14
2019	6	2	2	10
2020	6	6	0	12
2021	15	8	2	25
2022	14	9	0	22
TOTAL	213	322	42	576

5.2. Translocations

The Foundation defines “translocation” as the purposeful capture and removal of a wild-living individual from one location, and their release back into the wild. In most cases, translocated marmots are moved from one wild location to a different one over the span of a day, a few days, or a few weeks, with the marmots spending the interval at the Recovery Centre on Mt. Washington. In some cases, wild-born marmots must sometimes be captured from the wild to spend a winter hibernating at the Recovery Centre on Mt. Washington. When those marmots are re-released to the wild, the Foundation includes them in the translocation counts because they have already gained experience living in the wild..

Since 2012, Strathcona Park colonies have been augmented through the translocation of marmots from the wild colony on Mt. Washington, or from unsuitable habitat elsewhere. These marmots were either young wild-born residents, or captive-bred ‘stepping-stone’ marmots that were first released on Mt. Washington in preparation for eventual translocation to other colonies. In 2022, three yearlings (all males) were translocated to Albert Edwards and Greig Ridge as a pair and a single marmot, respectively. Additionally, a single yearling female was translocated from Mt. Washington to P Mountain in Nanaimo Lakes after overwintering in the facility due to predation risk.

On Mt. Washington, the Foundation translocated one yearling male, born and captured on the ski hill. In total, Mt. Washington received nine released captive-bred marmots and one translocated wild-born marmot this season.

Table 9. Marmots translocated in 2022.

Region	Release site	Source	# translocated	Names (D=deceased)	Notes
Strathcona	Washington	Washington	1	Joey (1yoM, wild-born)	Wild born yearling from Washington
	Albert Edwards	Washington	2	Trooper (1yoM, wild-born) Theo3 (1yoM, wild-born)	Wild-born yearlings from Washington
	Greig ridge	Washington	1	Ace (1yoM, wild-born)	Wild-born yearling from Washington
Nanaimo Lakes	P-Mountain	Washington	1	Marmot Minnie (1yoF, Wild-born)	Brought into captivity as a pup Sept. 2021 to protect against predation.
TOTAL	4 colonies		5		

5.3. Trapping and Implants

The Foundation surgically implants radiotelemetry transmitters in a subset of the wild-living population to facilitate the monitoring of their survival status and location. The monitoring data gathered as a result of these implants facilitates a variety of management decisions about the allocation of resources, such as the distribution of supplemental feeders, selection of sites needing augmentation, identification of successful colonies able to provide wild-living marmots for translocation, and the rescue of marmots from unsuitable habitat.

In 2022, all transmitters were implanted by the Foundation’s veterinarian, Dr. Malcolm McAdie. Implanted marmots (see Table 10) were aged 1yo or older, and surgeries were conducted in or after June to allow marmots to regain some body condition following their hibernation. The Foundation conducted seven implant sessions over the field season, including three sessions at Nanaimo Lakes colonies, two sessions at Mt. Washington, and two sessions at other Strathcona colonies. In total, 12 marmots were captured and implanted, of which nine were first-time captures. Dr. McAdie also implanted each of the twenty-three captive-bred marmots and five translocation marmots prior to their release into the wild.

Table 10. Transmitter implants of wild-living marmots in 2022.

Region	Site	Implanted marmots	New implants	Replaced transmitters	Total	Notes
Nanaimo Lakes	Big Ugly	Bubbers, Nonnie	2	0	2	All re-released.
	McQuillan	Mitty, Jiggers, Pretzel	2	1	3	All re-released.
Strathcona	Mt. Washington	Hobbs, Simone, Manny, Mr. T	3	1	4	All re-released.
	Castlecrag	Cortez, Omati	1	1	2	All re-released.
	Marble Meadows	Orlagh	1	0	1	Re-released
Total			9	3	12	

5.4. Managing Marmots in Unsuitable Habitat

The Foundation continues to manage marmots living in unsuitable habitat based on their unique circumstances and projected timeframe for the habitat issues. In 2022, three situations arose (see Table 11).

In the first situation, wild-born pups were trapped and brought into captivity after their presumed dams were predated. Two pups in the LDL cut block and four pups on Mt. Washington were trapped and brought into captivity to protect against predation.

In the second situation, a captive-bred yearling male was released onto Mt. Washington in 2022 but had been seen returning to the captive-breeding centre to interact with other marmots. This individual was re-captured later in the summer and brought into captivity to overwinter and will be re-released next year.

In the third situation, two wild born yearlings were trapped at Mt. Washington in the early spring with poor body condition. These yearlings were retained to build their body condition and overwinter at the facility, and are candidates to be translocated into Strathcona Provincial Park in 2023.

The capacity of the Foundation to respond to situations of marmots in unsuitable habitat has been greatly improved over the past two years, with year-round operations in place at the Marmot Recovery Centre. In 2022, there were no marmots captured from the wild with the intent to augment the breeding program.

Table 11. Marmots brought into the TBMWMRC from the wild in 2022.

Region	Source Colony	Name (age, sex if known)	Proposed Future	Notes
Nanaimo Lakes	Cutblock – LDL trailhead	Rowley (pup)	Re-release	Presumed Dam was predated, brought into captivity to protect.
	Cutblock – LDL trailhead	Russel (pup)	Re-release	Presumed Dam was predated, brought into captivity to protect.
Strathcona	Washington	Mayzie (1,F)	Re-release	Retained in captivity to increase body condition
	Washington	Lorna (1,F)	Re-release	Retained in captivity to increase body condition
	Washington	Everett (1, M)	Re-release	Kept returning to facility after being released. Will be kept in an enclosure for hibernation then re-released.
	Washington	Kendra (pup)	Re-release	Presumed Dam was predated, brought into captivity to protect.
	Washington	Deebo (pup)	Re-release	Presumed Dam was predated, brought into captivity to protect.
	Washington	Cooper (pup)	Re-release	Presumed Dam was predated, brought into captivity to protect.
	Washington	Lilibet (pup)	Re-release	Presumed Dam was predated, brought into captivity to protect.

5.5. Supplemental Feeding

Anecdotal evidence suggests that supplemental feeding may improve the overwinter survival and reproduction of Vancouver Island Marmots. Despite the potential impact on recovery efforts, the Foundation has never had the capacity to properly investigate these relationships. In 2018, the Calgary Zoo’s Centre for Conservation Research (now Wilder Institute) initiated a pilot study to test potential methodology for a study on supplemental feeding and its benefits to marmot reproduction. After a shortened season due to funding cuts in 2020, the Calgary Zoo Research team was able to return for a full field season in 2021 and 2022 with two research teams. From May to July, Calgary Zoo field staff collected data, trapped marmots for health monitoring, as well as installed remote cameras and empty feeders at their study sites. Throughout July and August, they swapped camera cards and batteries and re-filled each feeding site up to eight times during the month of August.

The Foundation provides supplemental food (also Mazuri leaf-eater biscuits) to marmots in the spring, when snow limits the amount of available food for marmots, and bears are less likely to discover and empty the feeders. In 2022, the Foundation installed spring supplemental feeders at seven colonies in the Strathcona region, and four colonies in the Nanaimo Lakes region. Most colonies received just one or two feeders, and those feeders were not refilled. The exception was Mt. Washington, where five feeders were installed, but not refilled due to bear activity. The Foundation used remote cameras to document activity by marmots and other species of interest at the feeders.

After observing high snowpack and several post-emergence marmots with poor body condition, supplemental food was provided to an additional colony in the Nanaimo lakes region in the hope that it may provide some benefit while traditional marmot food sources were covered by snow. Marmots consumed the provided food, but we cannot draw firm conclusions between increased body condition, survival, or reproduction and supplemental food availability.

Table 12. Supplemental Feeding Sites in 2022.

Region	Site	Team	Time frame	Feeders	Fills per feeder	Minimum # of Marmots	Notes
Nanaimo Lakes	Arrowsmith	MRF, CZWI	June, August	2	8-9	8	Jewel Bowl
	Arrowsmith	CZWI	August	2	8	2	South Meadow
	Haley	CZWI	August	3	12	10	
	Heather	MRF	June	1	1	5	
	Hooper	MRF	June	1	1	2	
	P Mountain	CZWI	August	3	8	9	Main Meadow
	P Mountain	CZWI	August	1	4	2	SW Meadow
Strathcona	Sadie	MRF	June	1	1	5	
	Albert Edwards	MRF	June	2	1	6	
	Castlecrag	MRF	June	2	1	14	
	Greig Ridge	MRF	June	1	1	6	
	Marble Meadows	MRF	June	2	1	17	
	Sunrise	MRF	June	1	1	8	
	Tibetan	MRF	June	1	1	1	
	Washington	MRF	May	5	1	21	
TOTAL	13 colonies			28	130	116	

5.6. Habitat Improvement

In some years, the Foundation has conducted habitat improvement activities at colonies with the goal of increasing local survival rates and preserving long-term habitat suitability. Recent habitat improvement has included the removal or partial limbing of ingressing trees in marmot habitat. These trees and low branches provide stalking cover to terrestrial predators. By regaining long, continuous lines of sight, marmots may have a better opportunity to detect and evade predators.

For the second year in a row, the Foundation was granted funding for habitat improvement projects during the months of October – November. With the use of chainsaws and help from the Nature Trust of B.C. and Ministry of Forests Ecosystems Branch staff, we were able to complete over 60 person-days of habitat improvement work; considerably more than the Foundation has completed in past efforts. All habitat improvement occurred within the Nanaimo Lakes region, following a specific set of Best Management Practices for methodology. This included mitigation efforts to avoid short-term and/or long-term damage to known burrows and/or hibernacula. Further details on methodology, best management practices, and photo analysis results can be found within the Foundation’s “Tree Change in Vancouver Island Marmot Colonies: Best Management Practices, Past Efforts, & Photo Analysis” report.



Photo 3 Nov 8 Restoration Work. Kevin Gourlay

Table 13 Habitat Improvement in 2022. All work was conducted in the Nanaimo Lakes region.

Colony	Hectares improved	Description of Work
Green	2	A total of 15 person-days of clearing effort focused on six tree stands over three main sublocations in core marmot habitat. Marmot occupation and captive releases to this site in 2022 made it a priority for restoration effort. Work was a continuation of previous efforts completed prior to 2017. All treatment stands were within core marmot habitat, and clearing effort greatly improved sightlines within the meadow.
Douglas	1	A total of 10 person-days of effort was conducted within China Bowl in four focal tree stands as a continuation of clearing effort started in 2021. Work in the upper meadow consisted of removing very small, young saplings that had potential to reduce the amount of meadow habitat available. Effort in the other areas focused on removing the dense sapling layer and thinning lower branches on larger trees to restore sightlines into areas where predators could be stalking around the perimeter of the bowl.
Heather	1	A total of 25 person-days of effort focused clearing on multiple large tree stands along the upper meadow in one sublocation to increase sightlines through core marmot habitat. Clearing effort in this area exposed many historic marmot burrows which had become overgrown by coniferous vegetation, and will hopefully restore marmot occupation in the upper meadow.
Mount McQuillan	2	A total of 10 person-days of effort focused clearing within the main meadow as a continuation of work started in 2021. Two stands were of priority, including the remainder of the trees within the meadow itself, and the thicker trees lining the bottom perimeter of the meadow. This was an important stand to address as it had potential to grow and decrease the size of the meadow, as well as obscure the use of the travel corridor to the lower basin where marmots were also observed.

5.7. Invasive Species of Concern

Yellow-bellied marmots (*M. flaviventris*) are a species of colonial marmot found in western mainland Canada and the United States. Although *M. flaviventris* can live in mountains at high elevations, in British Columbia they are often associated with low-elevation habitat in the Thomson Okanagan and Kootenay regions. In these areas, they often occupy a range of natural and artificial habitat, including orchards, farmlands, and golf courses where they are frequently viewed as a pest species. As urban centres in these areas have expanded, *M. flaviventris* has also been found to thrive in more developed areas of towns and cities.

Unlike the Vancouver Island Marmot, *M. flaviventris* is not native to Vancouver Island, but they have been sighted on the Island with increasing frequency in recent years. This is likely part of a province-wide problem in which marmots have been unintentionally transported from colony locations to non-historic habitat, traveling in bus baggage compartments, vehicle engine bays, and shipments of equipment and

agricultural supplies. Of particular concern to the Foundation is the capacity for *M. flaviventris* to introduce novel diseases and pathogens that could potentially decimate Vancouver Island Marmot colonies. Transmission could result from direct contact, or via an intermediate host, such as the soles of hiking boots. The Recovery Plan assesses the risk of Invasive & other problematic species, genes & diseases as medium-to-high impact with slight to serious severity (Vancouver Island Marmot Recovery Team 2017).

On Vancouver Island, *M. flaviventris* have been sighted at various urban and rural locations from Victoria up to Courtenay. In 2022, the Foundation received two reports of *M. flaviventris*, both in the Greater Victoria region (n=2). The Foundation shared these reports with WildArc and the District of Saanich. It was later reported to us that both individuals were successfully trapped, and were planned to be translocated to the mainland.

5.8. Monitoring

The Foundation monitors the status of Vancouver Island Marmots in the wild in order to make strategic and informed decisions about recovery efforts. Monitoring provides information about colony locations, rates of survival and reproduction, causes of mortality, and the age- and sex- structure and size of colonies. This information directly influences the selection of release sites and release candidates, the installation of spring supplemental feeders, and the identification of habitats needing improvement to facilitate colony growth and persistence. Information about annual mortality and reproduction forms the basis of our understanding of the species' population and conservation status.

5.8.1. Methodologies

Effectively monitoring marmots can be challenging due to the difficulties accessing their sub-alpine habitat, the marmot's semi-fossorial behaviour and activity patterns. For this reason, the Foundation used several approaches to monitoring. Prior to marmots being released or translocated, all marmots were implanted with radio-telemetry transmitters (Holohil A1-2TH) that have a battery life of ~4 years. These transmitters send out a pulse that changes speed in response to temperature; living marmots are warm, and their transmitters send out a faster pulse than those of deceased or hibernating marmots. This facilitated survival and location monitoring of these marmots which enabled the Foundation to evaluate a marmot's post-release success. The Foundation also implanted a subset of wild marmots, which provided the same survival and location data.

For a typical telemetry survey, 2-4 crew members hiked into marmot habitat and used receivers and antennas to scan through a set of frequencies specific to individual marmots. When crew heard a pulse indicating that a signal was detected on one such frequency, the number of pulses per minute indicated whether the marmot was alive (≥ 30 ppm), possibly alive (29ppm) or dead/hibernating (≤ 28 ppm). If a dead marmot was accessible for recovery, field teams attempted to track the transmitter to its resting location to collect information about the cause and timing of the mortality and recover the transmitter for refurbishing and reuse. Historically, telemetry has also been conducted from an aerial platform such as a helicopter or fixed-wing plane. Aerial telemetry conducted from helicopters has been an important monitoring tool for the Foundation, particularly for colonies in Strathcona where a significant proportion of the population is telemetered and needs to be monitored closely to evaluate release success.

Visual surveys of marmot colonies formed a significant component of the responsibilities of annual, seasonal field crew hired by the Foundation. During a visual survey, one or more team members sat at vantage points near a marmot sublocation and used binoculars and/or a spotting scope to count and age

marmots based on their size, pelage, and presence or absence of ear tags. Crew used telemetry to identify the known individuals in the area (whether observed or just detected) and then summarized the number of untelemetered tagged and untagged individuals that were observed. Visual surveys were particularly important for detecting and counting pups at a sublocation, and informed the Foundation's estimates for reproductive success each year.

Field crew typically conducted surveys in the morning (6-10am) or if on overnight trips, during the late afternoon and evening (3-9pm). The duration of surveys varied greatly from a few minutes to the better part of a day, depending on the priority of other recovery activities that need to be conducted that visit. On day-trips, most visual surveys lasted for 1-3 hours and at several sublocations depending on the size of the field team. On overnight trips, field crew often surveyed a colony for closer to 8 hours in a single day. It took several day-trips over the course of a field season for the Foundation to feel confident in the estimate of a colony's size and composition; overnight trips typically provided the Foundation with a faster and more comprehensive understanding of colony size and composition, but were very crew-intensive.

Wildlife cameras were another monitoring tool employed by the Foundation, and were deployed at marmot hibernacula and burrows and at supplemental feeders to capture video and audio footage of marmots. Cameras were also used to confirm that unsuitable habitats have not been recolonized by marmots, and to identify predators in or near marmot habitat, although these scenarios were less common. Cameras proved essential at remote colonies such as those in Strathcona that could not be accessed for regular, on-the-ground surveys. The Foundation used the unique appearance of marmots, particularly their molt pattern, size, and the presence or absence of ear tags, to count pups and identify and age individuals. The Foundation also evaluated marmot behavior in the videos, because this can provide clues about the social structure of the colony. Videos were reviewed quickly during the field season, and in greater depth in the off-season (November and December).

In 2022 the Foundation greatly benefitted from the regular presence of teams from Vancouver Island University and Calgary Zoo/Wilder Institute. Under the direction of Dr. Jamie Gorrell, the Vancouver Island University team monitored all telemetered marmots in the Mount Washington colony five days a week. The Calgary Zoo/Wilder Institute visited six colonies regularly in the Nanaimo Lakes area, plus numerous exploratory trips into other sites. See Table 15 for more information on how this impacted search effort.

In 2022, aerial telemetry was conducted for several colonies within Strathcona Provincial Park. While effort surmounted to only two days of aerial telemetry, it allowed the Foundation to confirm the status of several hibernating telemetered marmots within this region.

For a greater level of detail about monitoring methodologies, please contact the Marmot Recovery Foundation.

5.8.2. Remote camera results

Motion-triggered cameras were deployed at 20 colonies: 12 natural and two cut block colonies in the Nanaimo Lakes region, and six colonies in the Strathcona region. In total, over 100 marmots were monitored by cameras during the 2022 field season. The camera installed on Greig ridge failed shortly after installation and thus the Foundation does not have strong counts from this colony. The monitoring objectives for each camera varied between sites and changed with the time of year. Primary objectives included feeder use, colony counts, pup counts, and site occupancy, as well as the capture of footage of other species that use marmot habitat.

Cameras recorded marten exploring the entrances to, and sometimes entering, marmot burrows on Mt. Gemini, Green Mountain, Albert Edward, Castlecrag, and Sunrise Lake. Ermine, a smaller mustelid species, were also recorded at LDL trailhead, Moriarty, and Sunrise Lake. Although the Foundation occasionally records footage of marten exploring marmot burrows, they are not usually predators of Vancouver Island Marmots. However, both marten and ermine are certainly capable of killing pups, and the Foundation has documented at least one past incident where a marten appeared to have killed a vulnerable 2yo marmot as she emerged from hibernation.

Cougars were recorded by cameras at four colonies, Arrowsmith, Haley Lake, Albert Edwards, and Sunrise Lake, in 2022.

Table 14 Footage captured by select remote cameras in 2022.

Region	Colony	Timing	# Adults	# 1yo	# Pups	Other species	Notes
Nanaimo Lakes	Arrowsmith	June 21-Oct 11	6	1	0	Bear, Marten, Cougar	Both CZWI and MRF had cameras deployed here.
	Gemini	June 21-Sept 30	3	1	0	Bear, Deer, Marten	
	Green	June 23-Nov 1	1	0	0	Marten	
	Heather	June 1 -July 8	2	1	0	Bear	
	Hooper	June 1 – Aug 24	4	1	0	Bear	
	Cutblock – Area K	June 22 – Sept 6	2	1	0	Bear, Grouse, Squirrel, Bat	
	Cutblock – LDL trailhead	June 17 – Aug 4	1	1	2	Ermine	
	Landale	Aug 15- Aug 24	2	0	1		
	Sadie	June 26– Aug 23	1	1			
	Moriarty	June 30-Nov 14	2	1	6	Marten, Ermine	CZWI camera search effort.
	P Mtn	July 5- Sept 20	3	3	2	Bear, Marten	CZWI camera search effort.
	Big Ugly	June 17-Sept 22	5	1	1	Bear	CZWI camera search effort.

Region	Colony	Timing	# Adults	# 1yo	# Pups	Other species	Notes
	Haley Lake	June 27-Sept 22	3	2	3	Marten, Bear, Cougar	CZWI camera search effort.
	Douglas	June 30-Oct 18	2	2	2	Bear, Marten	CZWI camera search effort.
Strathcona	Albert Edward	June 13 – Oct 13	9	2	0	Grouse, Cougar, Marten	
	Castlecrag	June 13-Oct 20	5	0	0	Marten	
	Greig Ridge	June 13-Aug 2	1	0	0		Camera failed shortly after install
	Marble Meadows	June 13 – Oct 20	7	1	0		
	Sunrise lake	June 13 – Oct 20	4	1	0	Bear, Ermine, Marten	
	Tibetan	June 13-Aug 2	1	0	0		
TOTAL	20 colonies		64	20	17		

5.8.3. Summary of monitoring effort by location

The Foundation continues to take biosecurity measures to protect the marmots and our staff from pathogens, but these measures had less impact on our monitoring efforts in 2022 compared to the previous two years.

The Calgary Zoo/Wilder Institute and Vancouver Island University research teams both returned for full field seasons in 2022. Having these teams monitoring seven important colonies allowed the Foundation to focus efforts on colonies that were data deficient in 2021 and seek out new colonies that had not been previously documented. This included more thorough surveys of Flower Ridge (Strathcona) and Landale (Nanaimo Lakes), confirming the occupation of a new colony in Strathcona, and identifying a new site in the Nanaimo Lakes (El Capitan) that will need additional survey effort in the future.

Table 15 A comparison of monitoring effort in 2022 compared to the average of the previous three years.

Region	Site	Average rolling three-year Effort (Person Days)	2022 Effort (Person Days)	% of three-year average effort	Notes
Nanaimo Lakes	Arrowsmith	48	69	143%	CZWI study site
	Big Ugly	41	54	131%	CZWI study site
	Butler	8	11	132%	

Region	Site	Average rolling three-year Effort (Person Days)	2022 Effort (Person Days)	% of three-year average effort	Notes
	Douglas Peak	34	43	125%	CZWI study site
	Gemini	14	11	77%	
	Green	5	15	281%	
	Haley/Bell	45	61	137%	CZWI study site
	Heather	10	6	62%	
	Hooper	0	6	N/A	Not surveyed 2019-2021
	Landale	3	20	600%	
	Limestone	3	7	233%	
	McQuillan	8	33	413%	
	Moriarty	34	20	58%	CZWI study site
	P Mtn	32	31	98%	CZWI study site
	Sadie Peak	7	6	90%	
	Whymper	0	4	N/A	Not surveyed 2019-2021
	Cutblocks- all	29	27	94%	
Strathcona	Albert Edwards	0	2	N/A	Not surveyed 2019-2021
	Becher	5	19	407%	
	Castlecrag	7	13	177%	
	Flower Ridge	5	6	129%	
	Greig	3	0	0%	
	Marble Mdws	8	12	144%	
	Marble Peak	5	3	60%	
	Morrison Spire	1	0	0%	
	Red Pillar	0	6	N/A	Not surveyed prior to 2022
	Sunrise	3	0	0%	
	Tibetan	4	0	0%	
	Mt. Washington	130	304	234%	
Extralimital	Steamboat	7	0	0%	
Total	30 locations	500	789	158%	

5.8.4. Community contributions to monitoring

Reports from the community at large, particularly those who work or recreate in or near marmot habitat, make important observations that can improve recovery efforts. Since 2017, the Foundation has made greater outreach efforts to solicit observations, and looks forward to building more partnerships with hiking and outdoor recreation organizations in the future. In 2022, the Foundation received 28 marmot reports, including a number of significant observations.

Table 16 Significant reports from the public in 2022.

Region	Location	Nature of Report(s)	Significance
Nanaimo Lakes	LDL Cut block	Hiker report, photographs.	Documented pups in the cut block, which were later trapped after the predation of their dam.
	Mt. Arrowsmith	Hiker reports, photographs, location data	Increased Foundation understanding of habitat use at this location.
	Heather Mtn	Backcountry user report	Confirmed occupation at site.
Strathcona	Mt Drabble	Hiker report, location data	Report to follow up on in season. Not a known occupied location
	Becher	Hiker report, photographs	Increased Foundation understanding of habitat use at this location.
	Red Pillar	Hiker report, photographs, location data	Documented new colony location
	Mt. Washington	Hiker reports, photographs.	Many reports from visitors documenting resident marmots.
Clayoquot Plateau	Triple Peak	Biologist report of whistles	Report to follow up on in season.
Invasive Species	Victoria-area, Comox Valley	Reports, photographs	Several reports of Yellow-bellied marmots in the Greater Victoria area and one in the Comox Valley.

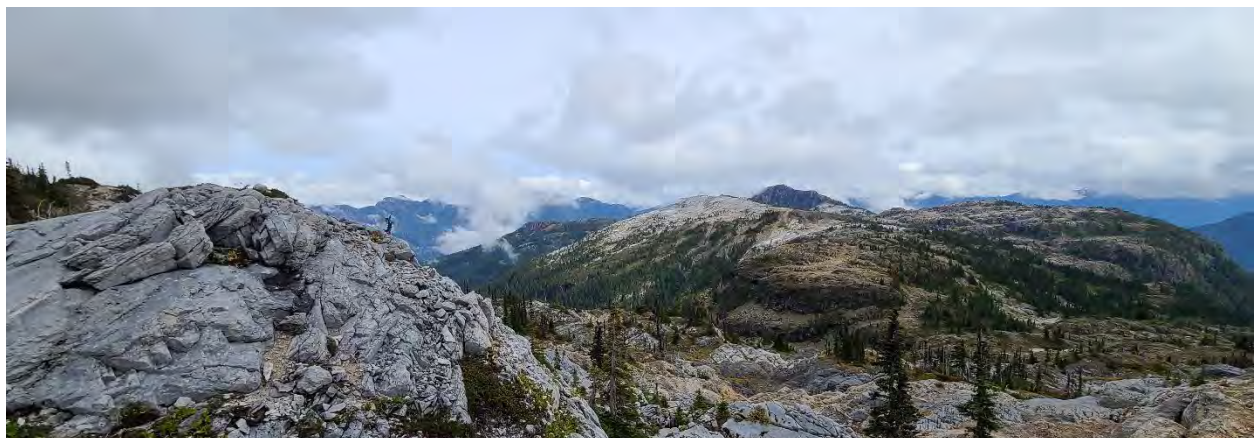


Photo 4 Marble Meadows. Adam Taylor

6. TONY BARRETT MOUNT WASHINGTON MARMOT RECOVERY CENTRE

6.1 Background

The Tony Barrett Mount Washington Marmot Recovery Centre ("the Centre") received its first marmots on October 15, 2001, and in 2022 the facility completed its 21st year of operation. From 2001 to 2012 the Centre functioned as a quarantine, pre-release, and breeding center. Captive reintroductions (which began in 2003) resulted in significant growth of the wild population, and because of this success, the captive program was intentionally downsized in 2012. From 2013 to 2017 the Centre was used as a seasonal quarantine, pre-release (i.e., VIM coming from the other captive facilities in the spring and being prepared for release) and staging facility (temporary holding of VIM prior to translocation, primarily from the wild Mount Washington colony to sites in Strathcona). Inventory conducted in the years following 2012 indicated that the wild population's status remained precarious and at risk and therefore the Centre was recommitted to overwintering release marmots during the winter of 2017 / 18 and returned to being a year-round, multipurpose facility (including hibernation and preparation of release marmots, maintenance of breeding pairs and future breeders) in 2019.

Year-round operation of the Centre has significantly increased the program's capacity for captive breeding and releases, and it has also given MRF staff greater flexibility in responding to management situations (for example recapturing wayward releases or marmots under predation threat, holding marmots unsuitable or not ready for release or temporary holding of translocation marmots). The establishment of remote monitoring at the Centre (including internet access CCTV cameras, real-time temperature sensors and a power outage alert system) has allowed us to safeguard its winter operation with a significantly reduced on-site presence, while ensuring the safety of the hibernating marmots. Staff from the Mount Washington Alpine Resort have continued to play an essential role in snow management and staff support.

6.2 Operations in 2022

In September 2021, two marmots from the Centre were transported to the Calgary Zoo, two were flown to the Toronto Zoo and a total of 15 marmots were received from Calgary and eight from Toronto (total = 27 moves). Marmots were moved to the zoos to establish optimal breeding pairs (based upon recommendations by the MRF Studbook keeper) and marmots were moved to the Centre to establish breeding pairs, to stage marmots for subsequent release, and to hold young individuals intended for future breeding.

At the beginning of the 2021 / 22 hibernation there were 66 marmots at the Centre. There were two hibernation mortalities during the winter of 21 / 22 (a female in early hibernation and a male in very late hibernation), both deaths involved older individuals, and were not unexpected.

In the spring of 2022, there were 17 potential breeding pairs (where the male and female were two years of age or older) at the Centre and this resulted in 32 pups from eight litters (tied for the Centre's third best reproductive year). Two of the 32 pups failed to survive to weaning age. The body of one pup was quite decomposed at the time of discovery in a nest-box, and the body of the other was not recovered (both were from the same litter). An additional pup from a different litter was found

deceased in a nest-box after weaning. Currently 29 (12 males, 17 females) of the 2022 the Centre pups survive.

Unilateral, facial abscesses were identified in four of the Centre's pups. These were subsequently treated and resolved satisfactorily. Although facial abscesses are an occasional occurrence (and have been identified in all captive facilities), this number of cases is unusual. It is suspected that VIM pups are susceptible to this problem at about three months of age when they are in the process of replacing their deciduous premolars. A change in the texture of their pelleted ration in 2021, which was crumblier and tended to create a more persistent, paste-like mass in their mouths, and consumption of spilled pellets, probably contributed to the number of cases. Trays were placed under food bowls to facilitate containment and removal, and reduce the possibility of marmots consuming older, spoiled, or soured pellets from the enclosure substrate.

Six wild-born pups are also currently hibernating at the facility. This includes 4 from a litter at Mount Washington and 2 from a litter at the Labor Day Lake Trailhead cut block. All six individuals were captured after their mothers had been predated. Most of these individuals will be re-released or translocated in 2023.

Two wild-born yearlings are also at the facility. These two females were captured at Mount Washington and were deemed to be too small for implant surgery (the late spring of 2022 with cold conditions and persistent snow cover resulted in small size and relatively poor body condition of wild yearlings and some adults). The two yearlings are being held in temporary captivity so they can gain sufficient size and condition. Due to other summer operations, there was not time to implant and release these individuals in 2022. They will be released in 2023 at Mount Washington to augment the breeding population at this site.

25 marmots were released from the facility in 2022 including:

- 2 x two-year-old captive-born males (one held over due to dental issue, one held due to breeding in 2021)
- 2 x two-year-old captive born females (one recaptured in 2021 due to predation risk at Mount Washington and re-released in 2022, one held due to potential breeding in 2021)
- 19 x captive born yearlings (10 males and 9 females)
- 2 x wild born yearlings (1 male and 1 female) – overwintered at facility due to high predation risk at Mount Washington

In July, a yearling, captive-born male was rescued from the half-filled water reservoir adjacent to the facility. The plastic liner had prevented him from escaping. Mitigation was subsequently undertaken to prevent marmots and other animals from remaining trapped in the reservoir. The male was re-released at Mount Washington and was recaptured a second time in early October after returning to the facility. He is being held at the TBMWMRC over the winter and will be re-released in 2023.

In the fall of 2022, three marmots were moved to Calgary Zoo from the Centre, and two were moved to Toronto Zoo. A total of 18 marmots were received from Calgary and 12 from Toronto (total = 35 moves).

Nest-box cameras allowed TBMWMRC to monitor marmot litters in 2022.



Photo 5 Newborn Pups, May 23, 2022



Photo 6 Two weeks old, June 8, 2022



Photo 7 Three weeks old, June 14, 2022

6.3 Outlook for 2022

In November of 2022 there were 102 marmots at the TBMWMRC, including:

- 64 pups (all surviving 2022 pups from the Calgary Zoo, the Toronto Zoo and the TBMWMRC). 49 to 52 of these will be release-candidates in 2023. Exact numbers will depend upon reproductive performance of the captive population in 2023.
- Four older marmots are also eligible for release in 2023 depending upon their health and reproductive status.
- 2 wild female yearlings and 6 wild pups being temporarily held over the winter (one pup may be retained in the captive breeding program)
- 15+ breeding pairs
- One of the 2021 captive-born pups at TBMWMRC was found to be quite stunted and had bilateral cataracts. She only weighed 720 grams at her final hibernation weighing in February 2022. Over the active season she put on significant weight and acquired normal yearling size. She is not a release or breeding marmot but could have a future role as an ambassador marmot or provide support of hibernating pups. In the summer of 2022, she effectively served as a surrogate mother for the four orphaned pups captured from Mount Washington.
- One of the older females was found to be a hibernation mortality during a routine nest-box check in early December 2022. This left 101 surviving marmots at TBMWMRC at the end of 2022.

7. SUMMARY OF CAPTIVE BREEDING PROGRAM

7.1 Background

The captive program began with six wild captures in 1997 and it has now been in existence for twenty-five years. The Toronto Zoo has been involved with the program for the entire 25 years (1997 – present) and the Calgary Zoo for 24 years (1998 – present). The Mountain View Conservation and Breeding Centre in Langley, BC participated from 2000 to 2014. As previously mentioned, TBMWMRC has been operational since 2001.

A total of 55 wild marmots were originally captured from the wild between 1997 and 2004 and these became the foundation of the breeding program. Due to the apparent success of the program and growth of the wild population, the captive program was intentionally downsized in 2012. There were no releases into Nanaimo Lakes (NL) and the focus shifted to augmenting Strathcona. The NL population subsequently declined and in 2016 the Recovery Team approved the capture of additional wild marmots to reinvigorate the demographic and genetic integrity of the captive population. An additional 31 wild-born individuals were strategically or opportunistically captured between 2016 and 2019 (no wild captures in 2020). In 2021 a two-year-old female was opportunistically captured at Mount Washington due to the late season predation risk. She successfully bred in the spring of 2022 and has been retained in the captive program. In 2022 two wild pups were captured from the Labor Day Lake (LDL) cut block due to the death of their mother – one of these individuals may be retained in the captive program. To date, a total of 88 wild marmots (including one LDL pup) have been captured for the captive program.

7.2 Reproduction

2022 represented the 25th potential breeding season and the 23rd consecutive year of successful breeding in captivity (2000 – 2022). The program has produced 759 weaned pups (415 males, 338 females and 6 unknown) or 8.6 pups for every wild marmot captured for the program. In the spring of 2022, there were 96 captive marmots, including 33 breeding pairs (where the male and female are both 2 years of age or older). The Toronto Zoo produced 3 litters and 12 pups (from 7 pairs), the Calgary Zoo produced 5 litters and 18 pups (from 9 pairs) and TBMWMRC produced 8 litters and 30 pups (from 17 pairs).

Overall, this amounts to a total of 16 litters and 60 weaned pups (with 2 weaned pup mortalities). The 48% success rate of breeding pairs in 2022 represents the program's second highest annual total and the number of pups is tied as our third most successful year.

7.3 Hibernation

There were three hibernation mortalities during the winter of 2021/22 (1 at Toronto Zoo, 2 at the Centre). All three mortalities involved older marmots with pre-existing health concerns. From the winter of 1997/98 to the winter of 2021/22 there have been a total of 2,078 individual marmot hibernations in captivity with 33 mortalities. Therefore, 2,045 or 98.4% of the captive hibernations have

been successful over 25 winters. During these 25 winters there has been 1 pup hibernation mortality and no mortality in yearlings. Over the 25 winters there have been four mortalities in non-adults (adult = 3 years of age or older). Excluding these four mortalities, the average age of hibernation mortality is 10.2 years of age.

Over 70% of the hibernation mortalities are associated with age-related conditions, including cardiovascular disease (52%) and neoplasia (17.2%). Presumably, older, compromised marmots get to a point where they are unable to cope with the extreme physiological demands imposed by hibernation.

7.4 Mortalities

There have been 134 captive mortalities since the program began in 1997. The causes include 38 cardiovascular, 31 infectious / inflammation, 25 neoplasia, 17 iatrogenic / management (4 quarantine), 7 cardiovascular / neoplasia, 6 congenital / early onset, 2 intervertebral disc degeneration, 3 unknown, 1 mesenteric torsion, with 4 post-mortems pending.

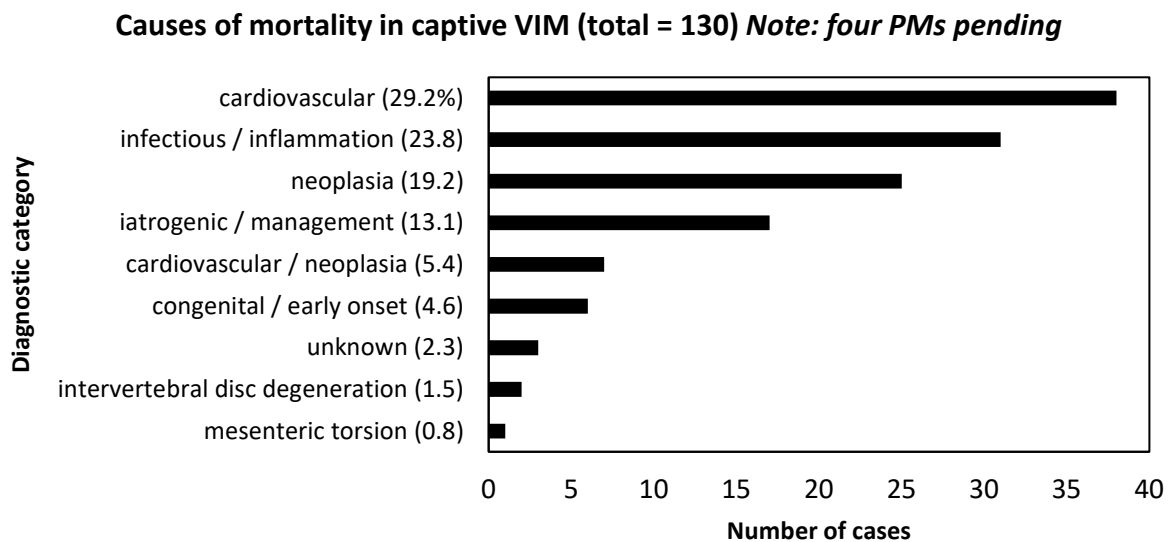


Figure 12. Causes of captive marmot mortality (total = 130, four post-mortems pending)

7.5 Releases

Releases of captive marmots began in 2003 and from 2003 to 2022 (20 seasons) a total of 587 captive marmots have been released to the wild (11 wild-born and 576 captive-born marmots). This represents 6.5 captive-born pups for every wild capture. A total of 80.1% of captive-born pups have been released to the wild (not including 2022 pups). Over 20 seasons, an average of 29.4 marmots have been released per year (range 4 to 85). Of the 576 captive-born pups that have been released, 140 were born in Toronto, 157 were born in Calgary, 98 at the Mountain View Conservation and Breeding Society and 181 at TBMWMRC. Of the 587 releases, 219 went to Nanaimo Lakes (37.3%), 139 to Mount Washington

(23.7%), 22 to Mount Cain / Mount Schoen (3.7%), 20 to Clayoquot (3.4%) and 187 to Strathcona (31.9%). It should be noted that captive-born marmots are no longer released directly into Strathcona Park. Captive marmots are released into the wild at Mount Washington (where survival is normally high) and then translocated to Strathcona if they survive their first wild hibernation.

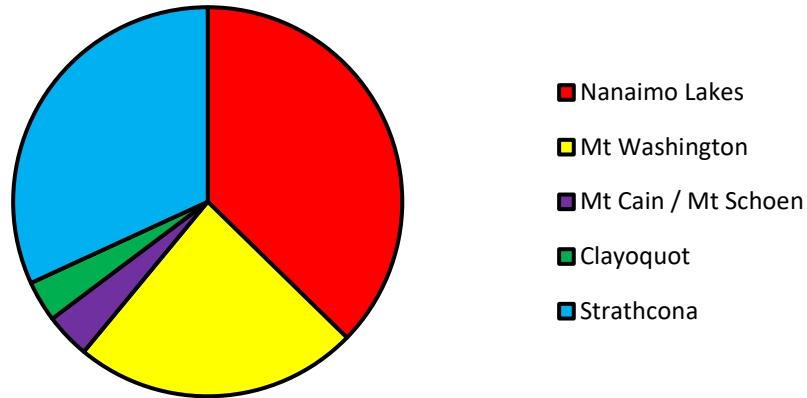


Figure 13 Distribution of Captive Releases

7.6 Current numbers

There are currently 137 marmots in captivity including 101 marmots at TBMWMRC (including 15+ breeding pairs), 16 marmots at Toronto Zoo (8 pairs) and 20 marmots at the Calgary Zoo (10 pairs). 51 to 57 of the marmots at TBMWMRC will be release-candidates in the summer of 2023. Exact numbers will depend upon individual marmot health, individual reproductive performance, and overall reproductive performance of the captive population in 2023.

Captive VIM population numbers (1997 to 2021)

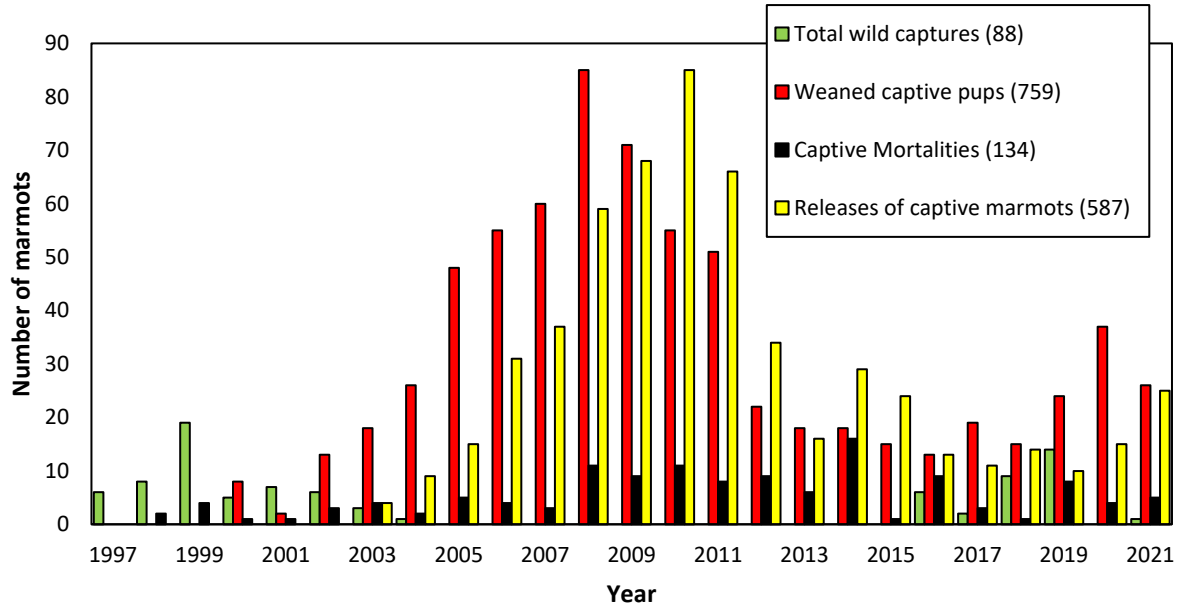


Figure 14. Captive marmot population numbers from July 1997 to December 2021.

Year end captive total (1997 to 2022). Note the total of 131 does not include 6 wild marmots that are being temporarily held in captivity.

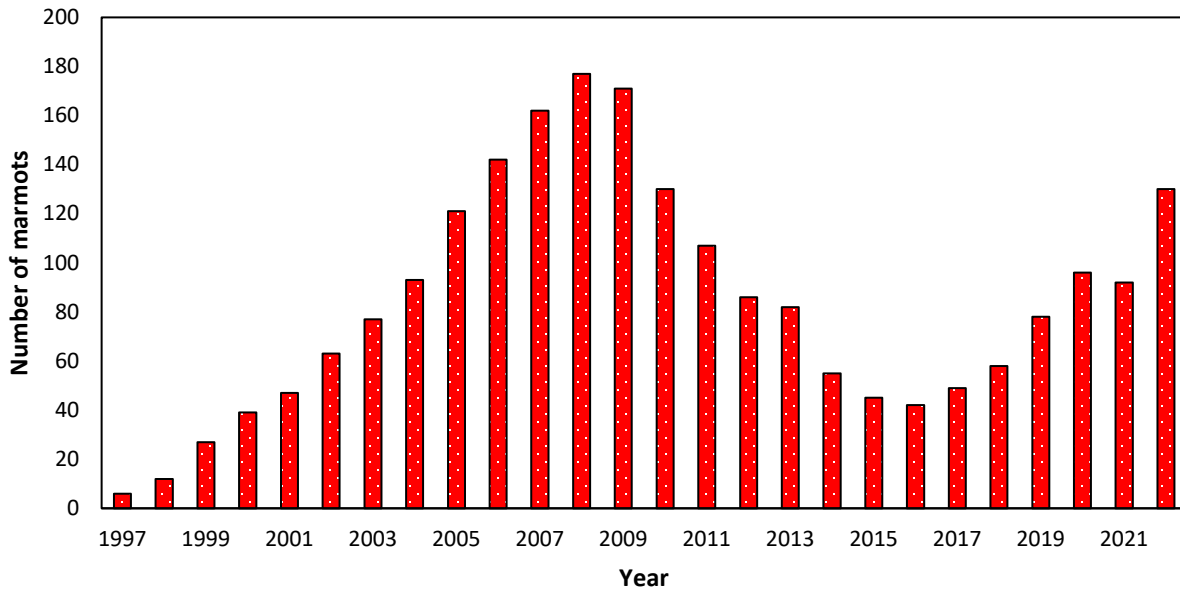


Figure 15 Year-end Captive Total to 2022

Table 17 Sources of wild captures (1997 to 2019) –no individuals were specifically captured for the captive program from 2020 to 2022.

COLONY SITE	COLONY TYPE	ADULTS	2 YEAR OLDS	YEARLINGS	PUPS	TOTAL
SHERK LK	LOGGED	4	3	1	4	12
K44	LOGGED	2	0	2	8	12
MT FRANKLIN	LOGGED	2	0	1	1	4
D13	LOGGED	1	0	0	0	1
PAT LK	LOGGED	1	0	0	0	1
MT WASH	SKI HILL	5	1	2	11	18
KNIGHT LAKE	LOGGED	0	0	0	2	2
NW BAY	LOGGED	1	0	0	5	6
LDL TRAILHEAD	LOGGED	0	0	0	1	6
WHISKEY CK	EXTRALIMITAL	0	1	0	0	1
TOTAL - OTHER		16	5	6	32	59
GREEN SUMMIT	NATURAL	0	2	1	2	5
“P” MTN	NATURAL	0	0	0	4	4
BIG UGLY	NATURAL	0	0	1	2	3
MT MORIARTY	NATURAL	1	0	0	2	3
HEATHER MTN	NATURAL	0	0	0	2	2
HOOPER	NATURAL	0	0	1	1	2
HOOPER N.	NATURAL	0	0	0	1	1
McQUILLAN	NATURAL	0	0	0	1	1
HALEY LAKE	NATURAL	0	0	0	2	2
ARROWSMITH	NATURAL	0	0	0	2	2
MARBLE MEADOWS	NATURAL	0	0	0	2	2
CASTLECRAG	NATURAL	0	0	0	2	2
TOTAL - NATURAL		1	2	3	23	29
OVERALL TOTAL		17	6	9	54	88

Table 18 Annual Summary of captive releases (2003 to 2022 – 20 years)

YEAR	NUMBER OF RELEASES	% OF PREVIOUS YEAR	ADULTS	2 YEAR-OLDS	YEARLINGS	PUPS	RECAPTURES
2003	4		3	1	0	0	1
2004	9	225	2	7	0	0	0
2005	15	167	2	6	7	0	0
2006	31	207	5	9	17	0	1
2007	37	119	3	12	22	0	0
2008	59	159	6	17	30	6	0
2009	68	115	9	5	48	6	0
2010	85	125	16	12	46	11	0
2011	66	78	19	6	29	12	0
2012	34	52	5	5	24	0	0
2013	16	47	0	0	16	0	0
2014	29	175	9	3	17	0	0
2015	24	83	10	0	14	0	0
2016	13	54	0	0	13	0	0
2017	11	85	0	0	11	0	0
2018	14	127	0	0	14	0	0
2019	10	71	0	0	10	0	0
2020	13	150	0	0	13	0	0
2021	27	208	0	2	25	0	0
2022	22	81	0	3	19	0	0
TOTAL	587		89	88	375	35	2

Table 19 Annual summary of releases and translocations (1997 to 2022). Red = captive-releases, yellow = translocations, and blue = pre-conditioned marmots (captive-marmots released to a site and subsequently translocated after surviving at least one year in the wild).

Year	Nanaimo Lakes			Mount Wash	Mount Cain / Schoen		Strathcona			Clayoquot		Annual total of captive releases	Annual total of wild-born translocations	Annual total of pre-conditioned
	Captive-release	Wild-born translocation	Pre-conditioned	Captive-release	Captive-release	Pre-conditioned	Captive-release	Wild-born translocation	Pre-conditioned	Captive-release	Wild-born translocation			
2003	4	1	0	0	0	0	0	0	0	0	0	4	1	0
2004	7	0	0	2	0	0	0	0	0	0	0	9	0	0
2005	13	0	0	2	0	0	0	0	0	0	0	15	0	0
2006	29	0	0	3	0	0	0	0	0	0	0	31	0	0
2007	24	0	0	0	4	0	9	0	0	0	0	37	0	0
2008	29	1	0	10	6	0	14	0	0	0	0	59	1	0
2009	27	0	0	0	12	1	22	0	0	6	0	68	0	1
2010	2	0	0	0	0	0	77	0	0	6	0	85	0	0
2011	26	0	0	17	0	0	19	0	0	4	0	66	0	0
2012	0	0	0	17	0	0	17	9	4	0	1	34	10	4
2013	0	0	0	16	0	0	0	16	11	0	0	16	16	11
2014	0	0	0	15	0	0	14	13	8	0	0	29	13	8
2015	0	0	0	13	0	0	11	12	4	0	0	24	12	4
2016	0	0	0	9	0	0	4	8	5	0	0	13	8	5
2017	6	1	3	5	0	0	0	3	0	0	0	11	4	3
2018	9	2	0	5	0	0	0	8	1	0	0	14	10	1
2019	6	8	2	2	0	0	0	4	1	2	0	10	12	3
2020	6	0	0	7	0	0	0	3	0	0	0	13	3	0
2021	17	0	0	8	0	0	0	4	0	2	0	27	4	0
2022	14	1	0	8	0	0	0	3	0	0	0	22	4	0
TOTAL	219	14	5	139	22	1	187	83	34	20	1	587	98	40
Number of years	15	6	2	16	4	1	9	11	7	5	1	20	13	9
20	238			139	23		304			21		725		

8. RESEARCH PARTNERSHIPS

The Marmot Recovery Foundation relies on science to make sound, evidence supported decisions as we work to recover the wild population of the Vancouver Island Marmot. While the Foundation is not a research organization, it collaborates with research partners to answer questions which will advance recovery efforts. In 2022, the Foundation collaborated on the projects noted below.

- Food Supplementation (Wilder Institute / Calgary Zoo Centre for Conservation Research)
- Endoparasites of captive and wild marmots (Kevin Gourlay and Jamie Gorrell, Vancouver Island University)
- Home range estimates of free-ranging marmots (Haley Andersen and Jamie Gorrell)
- G.I.T. Microbiome (Pauline Van Leeuwen, Laurentian University)
- Stress evaluation using hematology, etc. and stress effects of post release survival (Sarah Falconer, Laurentian University)
- Genetic basis of melanism in different marmot species (Kendall Mills and Link Olsen, University of Alaska)
- Diet, lipid metabolism, body composition, and hibernation (Jessica Aymen, University of Guelph)
- Genetic evaluation of degenerative heart conditions (Jaimie Warren and Doug Whiteside, University of Calgary)
- Diet metagenomics (Jasmine Janes, Vancouver Island University)
- Marmot nutrition (Sarrah Gourlie, Captive Management Group nutrition advisors at Toronto Zoo)
- Morbidity and mortality (Malcolm McAdie)
- Seasonal changes in vegetation and its impact on habitat suitability and predation risk (Julia Kobetitch/Royal Roads University)

Research published in 2022 that involved the Foundation's collaboration includes:

- Aymen, J., Delnatte, P., Beaufrère, H., Chalil, D., Steckel, K. E., Gourlie, S., Stark, K. D., & McAdie, M. (2022). Comparison of blood leptin and vitamin E and blood and adipose fatty acid compositions in wild and captive populations of critically endangered Vancouver Island marmots (*Marmota vancouverensis*). *Zoo Biology*, 1– 14. <https://doi.org/10.1002/zoo.21739>
- Barrett, K.G., Amaral, G., Elphinstone, M. et al. Genetic management on the brink of extinction: sequencing microsatellites does not improve estimates of inbreeding in wild and captive Vancouver Island marmots (*Marmota vancouverensis*). *Conserv Genet* 23, 417–428 (2022). <https://doi.org/10.1007/s10592-022-01429-7>
- McIntyre A. Barrera, Jasmine K. Janes, Jamieson C. Gorrell. Molecular phylogenetics and systematics of two enteric helminth parasites (*Baylisascaris laevis* and *Diandrya vancouverensis*) in the Vancouver Island marmot (*Marmota vancouverensis*). *International Journal for Parasitology: Parasites and Wildlife*, Volume 19, 2022, <https://doi.org/10.1016/j.ijppaw.2022.11.006>.

9. FIELD SAFETY SUMMARY

There were no serious safety incidents in 2022. Field teams continued to take a proactive approach to hazard identification and mitigation, and were quick to report new hazards as they emerged. Close calls were discussed as a team and have now been incorporated into the Foundation's job safety documents for next season.

9.1 Minor Incidents

Distracted hiking incident:

- A technician slipped while hiking in a boulder field on Hooper Mountain and fractured the second phalangeal bone in their pinky finger. The individual was carrying a yagi in one hand and the receiver in their other hand while tracking down a mortality and therefore was not able to balance themselves or concentrate on their footing. They were stepping off of a boulder and slipped backwards onto their backpack. They put their hand out behind them to brace the fall and landed directly on their left hand with their pinky in a bent position. First aid was administered immediately by their college. After communicating with the Field Coordinator, they decided it was not necessary to be evacuated immediately and instead modified their duties to minimize the use of the hand until the arranged helicopter pick-up time. The individual sought medical attention once returning from the backcountry and subsequently received pin surgery and hand therapy. All appropriate documentation was made with Worksafe and reported internally within MRF. Mitigating strategies: Emphasizing minimizing distracted hiking, especially when using the telemetry gear, note taking, and performing other tasks that require the individual to focus on other things than their movements. The use of a hiking pole-mounted yagi and front chest pouches are being trialed as ways to minimize the need to carry objects in your hands while hiking across difficult terrain.

Sickness incident:

- A technician started showing symptoms of illness on the first day of a three-day fly-in trapping trip in Strathcona Provincial Park. The team was in communication with the Field Coordinator providing regular updates on the condition of the individual, and on day two it was determined that their symptoms had deteriorated to the point of needing evacuation. The trapping trip was cut short and a helicopter was sent in that day to extract the team a day earlier than planned. The technician sought medical attention after returning to town and recovered to rejoin the field work several weeks later.

9.2 Close calls

Cornice failure close call:

- Crew were surveying for marmots in the spring on Mt. Becher in an area with overhanging snow hazard. While crew were in the area, a large piece of cornice became dislodged and cascaded downslope towards where crew were working. Luckily there was ample time for crew to respond and move out of the way of the falling snow and no one was struck. This was a good

reminder of the risks of cornice failure in the early spring, and for crew to apply conservative decision making and snow risk assessment and management skills. These skills are part of annual crew training at the beginning of each field season.

There were two resource road driving-related close calls that occurred over the course of the season.

- On the first occasion, the driver of the work vehicle was calling kms and heard a loaded truck calling kms coming towards them on the same road 1-2kms ahead. They pulled over in an area that had lots of room for the truck to pass, however a working grader was approaching the parked vehicle. The grader operator waved the crew to pass them just as the loaded truck came around the corner. Luckily there was ample time to reverse back onto the side of the road and wait for the loaded truck to pass and then move out of the way of the grader. Takeaway, do not assume other road users have their radios on and are listening to road traffic calling. If in doubt, communicate with them over the radio before following directions if you think there may be oncoming traffic.
- On the second occasion, crew encountered a loaded truck on a blind corner coming down Bamfield mainline that was not calling kms. Although trucks are required to call every 2kms on this road, often they don't due to the high amount of traffic without radios travelling to and from Bamfield. Extra precaution should be taken on Bamfield Mainline and North Shore mainline to watch for loaded trucks and other traffic that are not calling kilometers.



Photo 8 Adam Taylor

10. RECOMMENDED APPROACH FOR 2023

The Provincial Recovery Plan for the Vancouver Island Marmot (VIM RT 2017) recommends several recovery objectives for the wild population (Table 4, pages 29-31). This section lists several activities that the Foundation believes will contribute to these objectives. These plans are subject to change at the advice of the Vancouver Island Marmot Recovery Team. In the simplest terms, the Foundation recommends providing support to the wild population when possible and prioritizing long-term recovery actions over short-term gains.

The overall direction for this year should be to build a solid foundation for future recovery efforts, even if this results in some colonies or regions receiving less support than is ideal. This includes three primary recommendations for 2023:

- Release captive-bred marmots strategically to maximize their recovery impact.
- Continue restoring the size and breeding capacity of the Mount Washington colony after heavy predation losses at the colony in 2021.
- Restore marmot habitat to mitigate degradation resulting from climate-change-induced tree creep.

Even with approximately 50 marmots available for release, there will likely be relatively few marmots available for translocation to the small colonies in Strathcona Provincial Park in 2023.

10.1. Proposed Supports for the Wild Population

(i) *Captive-breeding releases*

There are 51 to 57 marmots currently at the Tony Barrett Mount Washington Marmot Recovery Centre identified as potential release candidates for 2023. The Foundation recommends prioritizing release of captive-bred yearlings onto Mt. Washington to support the recovery of this colony and restore its reproductive potential. Because this colony is already populated and there have been past indications of social stress when the colony grew too large, the Foundation will set a limit on the number of new releases for this colony. This means that the majority of captive-bred marmots will also be available for other purposes, such as release to the Nanaimo Lakes region and/or to the extralimital colony on Steamboat Mountain in Clayoquot Plateau.

(ii) *Translocations*

The Foundation will assess translocation candidates in the wild colony on Mt. Washington, including stepping stone candidates and wild-born marmots. Wild-born marmots for translocation could come from Mount Washington or from marmots found in unsuitable habitats. At this time, no marmots are known to occur in unsuitable habitats, such as cutblocks, but there are several potentially occupied sites. These sites will be monitored in the spring once access allows.

(iii) *Trapping and implants*

The Foundation will spend at least six weeks trapping in the Nanaimo Lakes and Strathcona regions, and potentially at Steamboat Mountain, with the goal of increasing the number of active transmitters and improving their representation across colonies. The Foundation will

prioritize trapping at colonies with few functioning transmitters, lots of young marmots that may eventually become dispersers, and colonies that are important to our research partners.

(iv) *Managing marmots in unsuitable habitat*

The Foundation will respond to reports of dispersing marmots that are observed in unsuitable and/or unsafe locations, and if appropriate, will translocate these individuals to active colonies or bring them into the captive program.

(v) *Managing marmots on Mt. Washington Alpine Resort land*

The Foundation will continue to monitor marmots on Mt. Washington, and will maintain strong communications with Resort staff and managers about unsuitable locations where marmots are spending time. Unsuitable locations may include features like roads, bike runs, water reservoirs, buildings and structures, and places with past or ongoing development activities. The Foundation will work with Resort staff to educate visitors about marmots, marmot viewing, and how to keep marmots safe during their time at the Resort. The Foundation will also investigate whether technology can be used to increase marmot safety. For instance, the Foundation could trial ultrasonic devices that would produce a warning sound when equipment or vehicles move down a trail when marmots have been sighted nearby.

(vi) *Supplemental feeding*

The Foundation will install a total of 12-16 spring feeders at Mt. Washington, sites in Strathcona Provincial Park, and in the Nanaimo Lakes region. For each feeder that is installed, the Foundation will also install a motion-detecting remote camera that will record feeder use by marmots and the presence of other species. The Foundation will continue to provide support to the Wilder Institute/Calgary Zoo research team in the form of training, safety monitoring, and data sharing as they conduct another year of their summer supplemental feeding study in the Nanaimo Lakes region.

(vii) *Habitat improvement*

The Foundation will conduct the manual removal of in-growing trees at 6 locations.

(viii) *Predator deterrence*

In 2023, the Foundation plans to develop a methodology for deploying and assessing the effectiveness of foxlights. Foxlights use programmable, irregular flashing lights that may deter predators from spending time near the lights during twilight hours. Research from California has suggested that the effectiveness of foxlights may decline after a few weeks. In hopes of achieving the best results, the foxlights will be deployed in late August when the highest rates of predation typically occur.

10.2. Proposed Monitoring and Inventory

(i) *Inventory*

The Foundation will conduct visits, repeated where possible, to each of the main colonies in the Nanaimo Lakes and Strathcona regions. This may include emergence flights (both helicopter and drone) in the spring to check for marmot presence at colonies believed to have been extirpated, new locations where colonies recently may have become established, and to locate hibernacula at known colonies lacking spatial data, as well as visits with an emphasis

on ground-based inventory in July and August when pups could be seen and counted. Day-trips will be augmented by overnight and multi-day trips at select sites, especially in periods of warm weather when marmots spend significant periods of the day underground. The Foundation plans to expand the use of wildlife cameras to as many colonies as possible. Priority for camera deployment will be colonies that are difficult to access.

(ii) *Mortality recovery*

The Foundation will attempt to recover transmitters and collect evidence from mortality sites in order to infer cause and timing. The Foundation will install wildlife cameras at Haley Lake and other colonies with a significant predator presence to better monitor predator activity and use of habitat.

(iii) *Investigation of new monitoring techniques*

The Foundation will continue to investigate using direction-finding software-defined radio to automate collecting data about marmot movements. We will also continue to explore the use of passive RFID readers in the field for detecting tagged marmots at feeders or hibernacula, as was trialed by the VIU team on Mt Washington in 2022. Furthermore, we will continue to investigate the use of acoustic recorders and telemetry base-stations to improve monitoring efficiency and effectiveness. These technologies have been used successfully with other species, but have not been extensively tested on a project with similar goals and terrain. Acoustic recording devices may improve detection of marmots in unsuitable habitats. Base-stations may be able to record telemetered marmot movements both within and between colonies. Both technologies need additional testing before widespread deployment. We will also continue to explore the applications of Unmanned Aerial Vehicles (UAV) for surveying inaccessible sites, particularly during emergence surveys.

The Foundation will also continue to test the inclusion of temperature loggers on implanted telemetry transmitters to assist with gathering more detailed biological data.

10.3. Proposed Actions for the Captive Breeding Program

(i) *Wild captures*

The Foundation consulted with Studbook Keeper John Carnio for the Captive Breeding program to determine whether new additions to the program would be helpful from a genetic or pairings perspective. In 2023, MRF staff may attempt to capture a small number of wild marmots from the few remaining sites (specifically Big Ugly, P Mountain and Steamboat Mtn) that do not have current genetic representation in the captive population. This action is based upon our basic captive management principles and recommendations from the Studbook keeper. This will act to safeguard the genetic legacy of these sites and will further enhance the overall genetic robustness of the captive population. This action has been endorsed by the Recovery Team and is contingent upon inventory results at these colonies (including survivorship and reproduction).

10.4. Biosecurity Measures

DNA analysis indicates that Vancouver Island Marmots have low genetic diversity, potentially as a result of population bottlenecks, island isolation, or a combination thereof. This low genetic diversity puts the marmot population at greater risk to novel pathogens. To reduce the risk of accidentally introducing a novel pathogen, the Foundation will continue to take biosecurity measures. In the field this will include:

- Sanitizing footwear and changing clothing between locations.

- Wearing masks and gloves when handling marmots, gear that will come into contact with marmots, or working in close proximity to marmot habitat features, such as active burrows or look out rocks; and
- COVID-19 vaccinations to reduce spillover opportunities.

In the Tony Barrett Mount Washington Marmot Recovery Centre, additional biosecurity measures will be taken, including:

- Dedicated footwear and overalls inside marmot areas.
- Limiting visitor and non-necessary staff access; and
- Sanitizing footbaths before entering marmot areas.

The Foundation will continuously review and update biosecurity measures in response to emerging threats and best practices.



Photo 9 Preparing a trap. Tannin Standing

11. FIVE YEAR REVIEW OF IMPLEMENTED RECOVERY ACTIONS

The Foundation takes an adaptive management approach to implementing recovery actions, incorporating results from research and past experience to improve methodology, efficiency, and outcomes for the wild-living Vancouver Island Marmot population on an ongoing basis. This section will review how the Foundation has adapted practices in the last 5 years, and assess where additional improvements could be implemented.

The Foundation's recovery activities fall into four broad categories; releasing captive marmots to the wild and translocating wild-living marmots to improve individual and population outcomes; assisting wild-living populations by improving habitat; monitoring the population to inform recovery decisions; and breeding captive marmots to generate release candidates. The first three categories are discussed here. Captive breeding management is conducted in partnership with the Toronto Zoo and Calgary Zoo, and addressed in the Captive Management Group report.

11.1. Releases and Translocations

Significant research has gone into improving outcomes for released and translocated marmots (e.g. Falconer 2021, Lloyd et al 2018, Jackson et al 2016, Jackson 2012, Aaltonen 2009, Bryant et al 2005 and so on), but significant research gaps remain, and a wide range of site and temporal variables influence decision making and outcomes. It is worth noting that captive bred marmots have greater success when released to the Nanaimo Lakes meta-population (Lloyd 2018). What factors create this difference between the two meta-populations has not been researched, but possibly differences in the length of the species' extirpation in the two regions, as well as climate and elevation differences, influence the success rates of captive-bred marmots experience.

In the past five years, there have been two significant changes to captive-bred marmot releases and translocations: implementing the results of the stepping stone study and increasing the capacity of the captive breeding population.

11.1.1. Fates of Captive Bred Marmots released to the Nanaimo Lakes and Mount Washington

Captive bred marmots are typically released at 1 year of age. For these marmots to contribute to population growth, they must reach breeding age. The average age of first breeding for female marmots is 3.6 years old, with some females breeding as early as 2 years old and others beginning at 4 or later (Bryant 2005).

Between 2018 and 2020, 39 captive bred marmots were released in the Nanaimo Lakes region or at Mount Washington. Of those, 36% (n=14) survived to 3 years old, and 26% (n=10) survived to 4 years old.

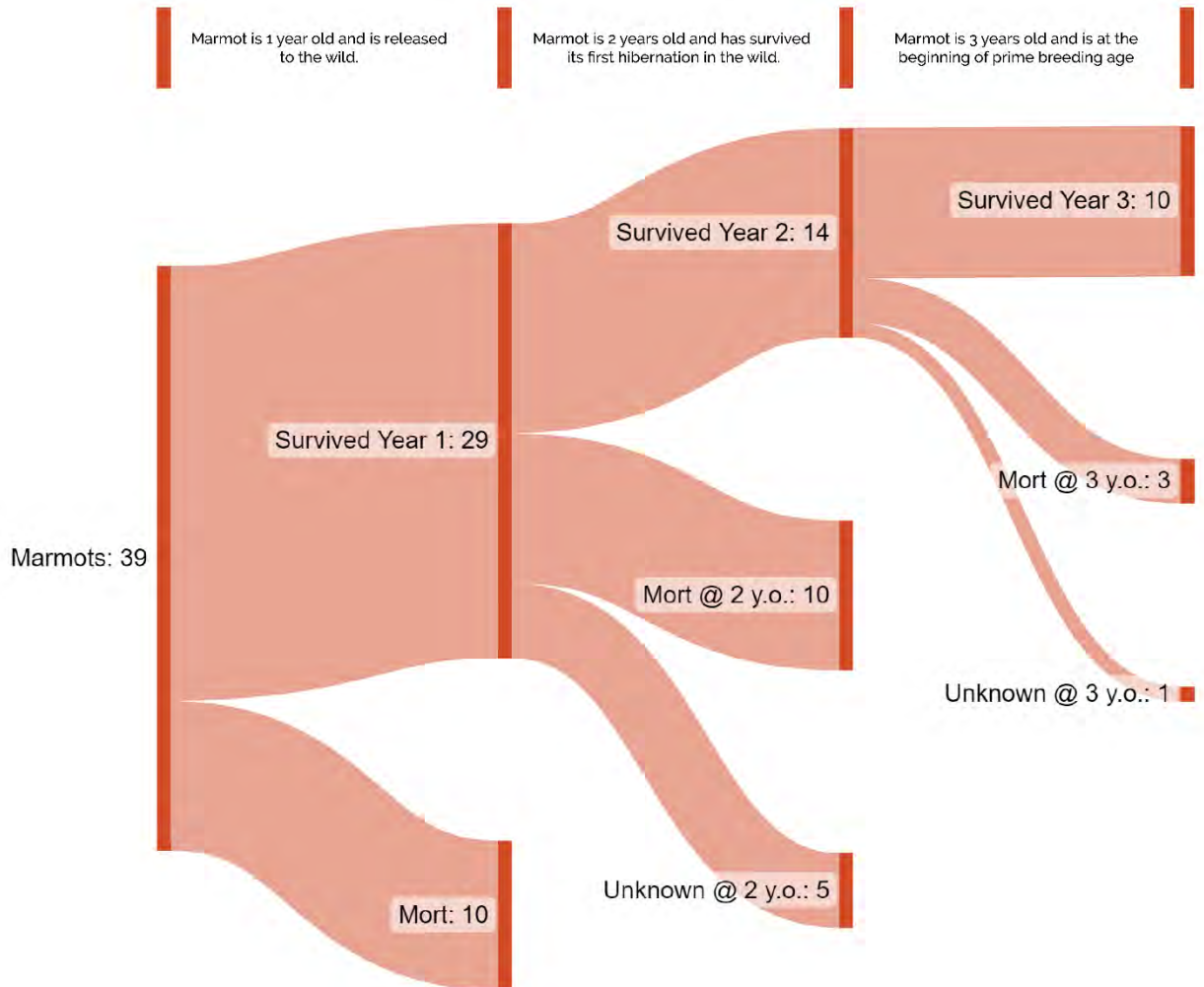


Figure 16 Fates of Captive bred marmots released to the wild between 2018 and 2020

In 2021, 26 marmots were released to the wild in the Nanaimo Lakes region and Mount Washington. That year, at Mount Washington at least two cougars preyed on marmots in the fall, resulting in an unprecedented wave of mortalities. Of the released marmots 31% (n=8) survived to 2 years old, and 61% have died (n=16), primarily as a result of predation. The Foundation has not been able to relocate 8% of the released marmots (n=2) and their fate is unknown. As all these marmots were born in 2020, they have not had the opportunity to turn three years old, or enter prime breeding age.

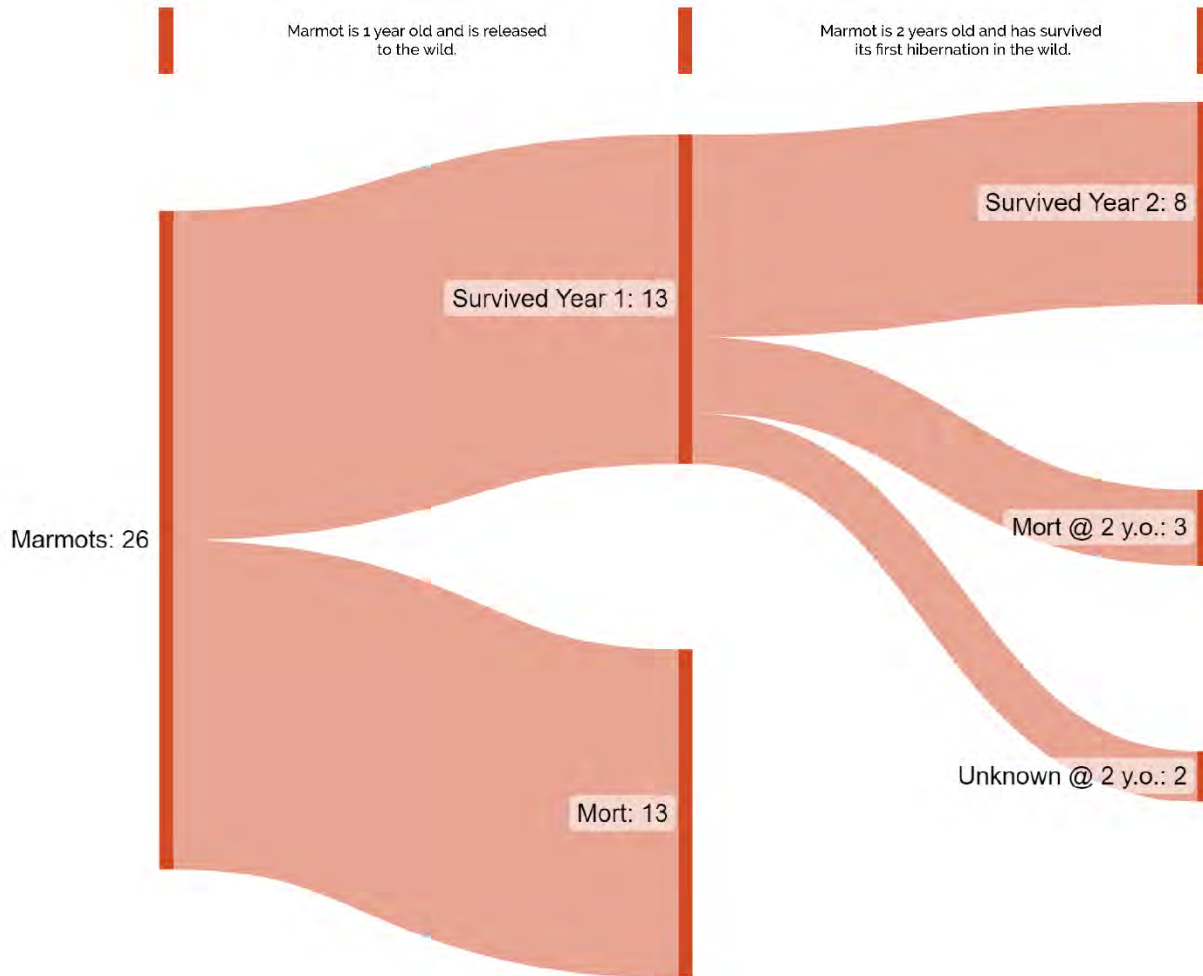


Figure 17 Fates of Captive bred Marmots released in 2021

Marmots released in 2022 and their known outcomes are reported in section 5.1.

11.1.2. Stepping Stone releases in Strathcona Provincial Park

Preliminary results of the Stepping-stone release methodology (Lloyd et al 2018) were available to the Foundation in late 2017. Results indicated that taking a stepping-stone approach to releasing captive bred marmots to the Strathcona meta-population greatly improved outcomes, and that translocated wild-born marmots also had high success rates. By comparison, outcomes for direct released captive-bred marmots in Strathcona Provincial Park were poor. Beginning in 2018, only wild-born or stepping-stone marmots were translocated into colonies in Strathcona Provincial Park.

While sample sizes are very small, marmots released into Strathcona Provincial Park since 2018 have experienced survival rates in line with those found in the study for the wild-born and stepping-stone cohort. During this period, the majority of translocated marmots have been wild-born from inappropriate habitat or Mount Washington (n=15). The low number of stepping-stone marmots (n=1) is due to small cohorts of captive-bred release candidates until 2021, and then an unexpected

predation event at Mount Washington in 2021. In the future, the Foundation expects that larger numbers of stepping-stone marmots will be released in the Strathcona region.

Between 2018 and 2020, 16 wild-born and 2 pre-conditioned marmots were translocated to colonies in the Strathcona region. Of these, 22% (n=4) survived to prime breeding age, we have not been able to determine the fates of 28% (n=5), and 50% (n=8) died before reaching age three. One marmot died during their third-year but was associated with weaned a litter prior to her death. Four marmots were translocated in 2021, all wild-born. Of these 25% are alive (n=1), 25% have died (n=1), and 50% were not relocated in 2022 (n=2). We hope to relocate these marmots next field season.

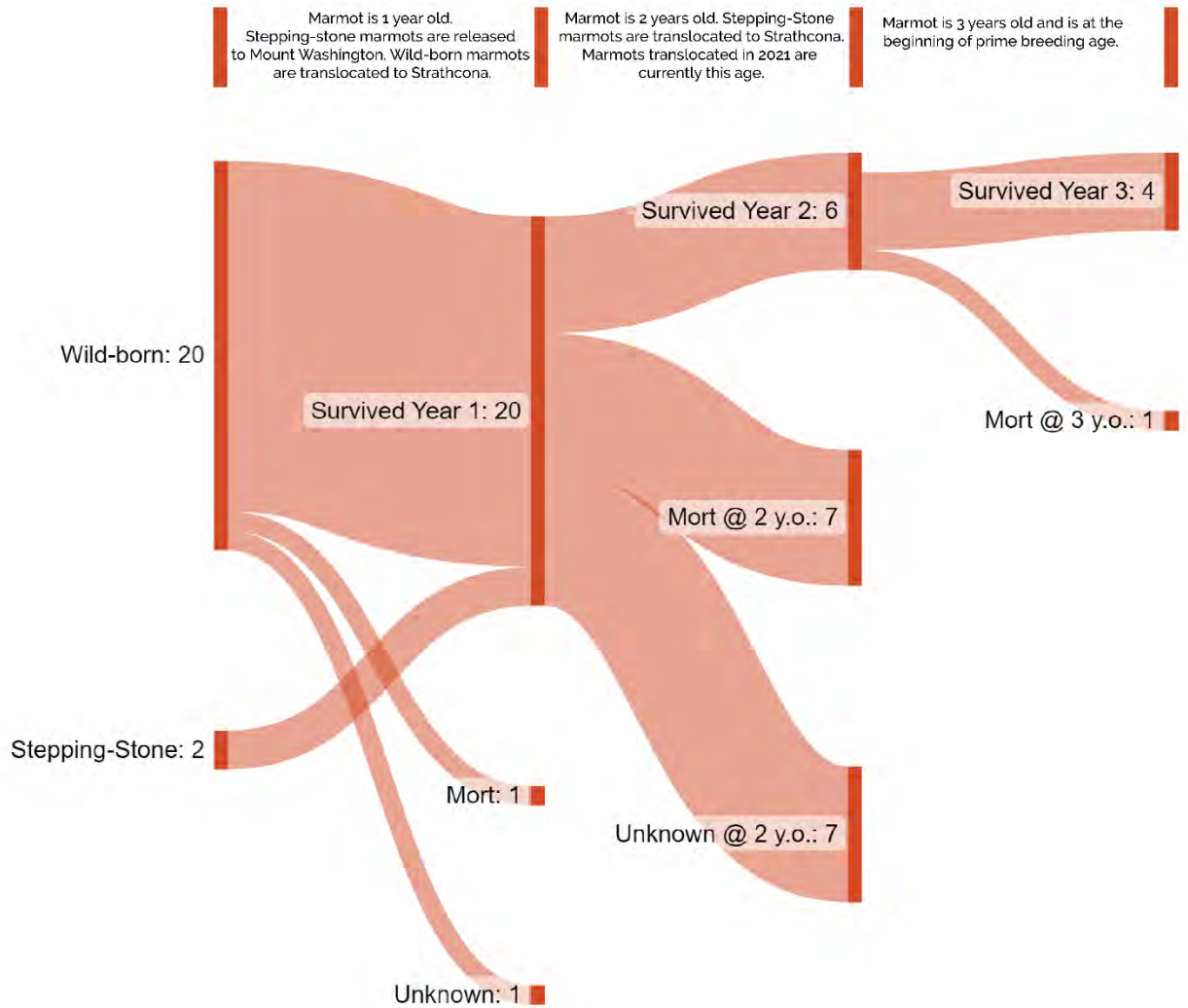


Figure 18 Fates of marmots translocated to Strathcona Provincial Park 2018 to 2021

Marmots translocated in 2022 and their known outcomes are reported in section 5.2.

11.1.3. Captive Breeding Capacity

Beginning in 2018, the Foundation re-opened the Tony Barrett Mount Washington Marmot Recovery Centre for breeding and year-round operation. This change followed the 2015 IUCN Population and Habitat Viability Modelling Report (Jackson et al 2015) that strongly indicated increased captive breeding releases were needed for the population to continue recovering. Due to the relatively long reproductive cycles, it has taken several years for the captive population to begin producing more release candidates. In 2021, 25 marmots were released, more than double the year before. In 2023, approximately 50 release candidates are expected. With approximately 100 marmots in the captive breeding program, the Foundation anticipates that 25 to 50 release candidates will be born each year.

The capacity of all three breeding facilities has been reached. Bringing on a fourth breeding facility would be needed to increase further capacity, but the Foundation has not been able to identify a suitable facility in Canada.

11.2. Habitat Improvement, Enhancement, Restoration

Marmots are ecosystem engineers (Ballova et al. 2019), and enhance habitat for themselves and other species by turning over soil and excavating burrows. In addition to releasing marmots, the Foundation directly enhances and restores marmot habitat in two ways: supplemental feeding and clearing tree ingress.

11.2.1. Supplementing Feeding

The Wilder Institute/Calgary Zoo is undertaking a multi-year study of the impacts of supplemental feeding on body condition, reproduction, and survival in wild-born marmots. Currently no results, even preliminary, are available.

Anecdotally, the Foundation continues to observe higher than expected reproduction at sites that benefit from supplemental feeding. The number of colonies receiving supplemental feeders was expanded in 2021, and again in 2022. In 2022, the Foundation re-designed its feeders so that more feeders could fit on a helicopter, increasing the efficiency with which the feeders can be deployed. Feedback from field crew indicate there is additional opportunity to improve feeder deployment by installing climbing bolts on rock faces which the feeders can be attached to.

Deploying feeders in the early spring is always limited by dangerous snow conditions, which vary from year to year. Although limited by external factors, the Foundation believes supplementary feeding may benefit the marmots' reproductive potential and post-emergence survival. Identifying additional opportunities to provide supplemental food, particularly in the early post-emergence season, will be a priority.

11.2.2. Tree Ingress Removal

Over the past decade, the Foundation has become increasingly concerned by the impact of climate-change induced tree ingress on marmot habitat. Tree ingress can provide stalking cover to predators, and roots can compromise the integrity of hibernacula. Several small tree ingress removal projects have been implemented, beginning in 2017.

In 2022, on contract for the Canadian Wildlife Service, the Foundation used satellite photos to measure tree ingress at colonies suspected of experiencing high levels of new growth. The report found that tree ingress was significant at every colony examined, ranging from 20% to 68% increase in tree cover over a minimum of 40 years (Brager et al. 2022).

More significant tree ingress removal was implemented in 2022 (see section 5.6), and the Foundation believes this work should be implemented at more colonies in the future.

11.3. Monitoring the wild-living marmot population

Monitoring the wild-living population informs all aspects of the recovery effort. Information from monitoring is used to select sites to release marmots, provide supplement feeding, and identify marmots that require translocation from inappropriate habitat.

The Foundation uses radio-telemetry, visual surveys, and camera traps to monitor the wild-living population. Reports from the public supplement our efforts and are particularly helpful in documenting new marmot colonies.

11.3.1. Radio telemetry

All captive and translocated marmots are implanted with radio-telemetry, and some wild-living marmots are implanted, or have old transmitters replaced, each year (see section 5.3 for details on this year's activities). Beginning in 2020, all transmittered marmots were also provided with a PIT-tag, to support future, close range monitoring efforts, such as at feeders or regular habitat features. Beginning in 2021, a sub-set of transmittered marmots were also implanted with a Wee-pit or iButton. These devices log body temperatures and may contribute valuable data on wild hibernation cycles and predation timing in the future.

The Foundation continually monitors developments in GPS and radio-telemetry tags, but so far no viable replacement radio-telemetry technology has been identified. While data from GPS tags would be very valuable, current GPS tags rely on an external antenna, either in a collar or through the skin. Collars are not feasible, as marmots gain and lose a large percent of their body mass each year. As a semi-fossorial species that engages in fastidious communal grooming, any antenna that protrudes through the skin would be chewed off or be a point of potential infection. One GPS tag uses a subdermal antenna, but it has a significant lump, which would be a focus of grooming efforts.

The Foundation is also watching developments in drone-based telemetry. Currently, estimated flight times of telemetry-capable drones in windy, sub-alpine terrain is less than 15 minutes, and the signal detection range for Holohil A1-2TH transmitters is less than 200m. The low flight times and short detection range limit the practicality of using drones for telemetry for sub-alpine terrain in all but the best weather conditions. However, the Foundation is keenly observing this rapidly advancing technology.

11.3.2. Visual Surveys and Camera Traps

The Foundation has been steadily expanding the number of deployed camera traps each year. While visual surveys are still an essential element of monitoring, particularly at new sites, camera traps provide an invaluable record of marmot activity, and often document marmots not observed on field visits. In 2022, the Foundation developed a new protocol to tag and catalog videos, which improves accuracy, consistency between observers, and reduces the time needed to review footage. The Foundation plans to continue to increase the number of cameras deployed, and hopes to continue to refine its review protocol.



Photo 10 Hibernation.

12. FUTURE DIRECTIONS

The Foundation acknowledges that some activities that would greatly benefit the recovery effort have not been possible due to funding constraints, the scope of an activity, or the need for external expertise and/or resources. These activities include, but are not limited to:

- Continued exploration of non-lethal predator deterrent methods, including predator-deterrent lights but also additional technologies or methodologies that have not been explored and/or tested in previous years.
- Research into marmot dispersal and habitat needs for marmots when outside core colony areas. The Foundation has begun testing base stations and direction-finding software defined radio, but significant additional opportunity exists to explore marmot dispersal and landscape use.
- Collection and mapping of information about the marmot's extent of historic occupation, especially in the northern and western portions of the marmot's historic range.
- Further incorporation of advances in our understanding of marmot genetics into the Foundation's management of the captive and wild populations.
- The development of population models that incorporate data collected since 2015 and the Strathcona metapopulation.
- Research into the extent and characteristics of climate change induced habitat change that has occurred in marmot meadows to date.
- Exploration of supplementary or alternative geolocation technologies for re-capture of Vancouver Island Marmot location data.

The Foundation encourages partnership and collaboration in working to address these challenges.

REFERENCES

- Aaltonen K., 2009. Population Ecology of the Endangered Vancouver Island Marmot: Decline and Potential for Recovery. Doctoral dissertation, University of Florida.
- Ballova Z., Pekarik L., Píš V. and Šibík J., 2019. How much do ecosystem engineers contribute to landscape evolution? A case study on Tatra marmots. *Catena*, 182, p.104121.
- British Columbia Wildfire Service. 2022 . Provincial Current Year Fires.
- Brager C and Jackson C., 2022. Tree Change in Vancouver Island Marmot Colonies: Best Management Practices, Past Efforts, & Photo Analysis. Report. Marmot Recovery Foundation.
- Bryant AA. 1996. Reproduction and persistence of Vancouver Island Marmots (*Marmota vancouverensis*) in natural and logged habitats. *Can. J. Zool.* 74:678–687.
- Bryant AA. Page RE. 2005. Timing and causes of mortality in the endangered Vancouver Island marmot (*Marmota vancouverensis*). *Canadian Journal of Zoology*. 83(5): 674-682. doi.org/10.1139/z05-055
- Laroque CP, Lewis DH, and Smith DJ. 2000. Treeline dynamics on southern Vancouver Island, British Columbia. *Western Geography*, 11, 43-63.
- Lloyd NA, Hostetter NJ, Jackson CL, Converse SJ, and Moehrenschrager A. 2018. Optimizing release strategies: a stepping-stone approach to reintroduction. *Anim Conserv.* doi:10.1111/acv.12448
- Environment and Climate Change Canada. 2020. Recovery Strategy for the Vancouver Island Marmot (*Marmota vancouverensis*) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. 2 parts. 16 pp. + 41 pp.
- Falconer, S., 2021. A retrospective analysis of the Vancouver Island marmot (*Marmota vancouverensis*) conservation breeding and release program: Conservation physiology and hibernation. Doctoral dissertation, Laurentian University of Sudbury.
- Ministry of Forests. 2022. River Forecast Centre: Wolf River Upper and Jump Creek snow stations.
- Ministry of Forests - Water Management Branch. 2022. Drought Information Portal. Last updated December 1st, 2022.
- Nagorsen DW. 2004. Canada’s endemic mammals at risk: recent taxonomic advances and priorities for conservation. In Proceedings of the “Species at Risk: Pathways to Recovery” Conference.
- Nagorsen DW. 2005. Rodents and lagomorphs of British Columbia. Royal British Columbia Museum, Victoria, BC.
- Swarth HA. 1911. Two new species of marmots from British Columbia. *University of California Publications in Zoology*. 7(6): 201-204.
- Vancouver Island Marmot Recovery Team. 2017. Recovery strategy for the Vancouver Island Marmot (*Marmota vancouverensis*) in British Columbia. Prepared for the B.C. Ministry of Environment. Victoria, BC.



MARMOT

RECOVERY FOUNDATION

PO Box 2332 Stn A, Nanaimo, B.C., V9R 6X6
Tel: 250 390-0006 | Email: info@marmots.org
www.marmots.org