Photo Ryan Tidman

ANNUAL REPORT

2021

MARMOT
RECOVERY FOUNDATION

ACKNOWLEDGEMENTS

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A special thank you to Cheyney Jackson, the Foundation's Field Coordinator in the 2021 season. After 14 years of chasing marmots on the mountains, Cheyney has decided to pursue new adventures. The outlook for the future of the Vancouver Island Marmot is greatly improved in no small part due to her tireless efforts. We look forward to receiving Cheyney's input and advice as a member of the Recovery Team.

The Marmot Recovery Foundation's work is funded by the Province of British Columbia Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), Mosaic Forest Management, and individual Canadian donors. In 2021, 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.

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The Marmot Recovery Foundation gratefully acknowledges the life gifts of Margaret Hill and Irene Horne. Their donations have had a profound impact on our work, and the continued recovery of the Vancouver Island marmot is a part of their legacy. On behalf of everyone in the Foundation, thank you.

This report was prepared by Chelsea Brager, Cheyney Jackson, 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 2021 was the twenty-fifth year of intensive recovery efforts.

During the 2021 field season, the Foundation participated in several 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 (previously the Calgary Zoo's Centre for Conservation Research) helped the Foundation to monitor marmots at several colonies while also investigating the relationship between supplemental feeding and reproduction in the wild. Data from that team have been incorporated into the results reported here.

In total, 25 captive-bred marmots and seven wild-born marmots were released to augment twelve priority colonies. Thirty feeders were installed at 14 colonies to improve the reproductive potential of >71 marmots. Fourteen natural colonies produced >79 pups. There were 33 mortalities detected in 2021. Four marmots were rescued from unsuitable or ephemeral habitat, and were then released to new colonies later in the summer. An additional five marmots were brought into captivity during the summer and retained for a captive winter hibernation due to predation risk. 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 529 captive-bred marmots into the wild. Currently there are 97 marmots in captivity, including 27 potential breeding pairs for 2022.

Wild population counts increased substantially from the previous year, with approximately 258 marmots distributed across 25 colonies in two main regions and at one isolated colony. The global COVID-19 pandemic continued to impact survey effort in 2021; colonies that are difficult to access were particularly impacted. It is possible that population counts would have been larger if effort had matched pre-pandemic levels of 2019 at these sites.

This report presents the results from the 2021 field season.

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1. INTRODUCTION

While this report is primarily intended for partners in the Vancouver Island Marmot recovery effort to facilitate the planning of activities for 2022, others may find it informative or useful for research. In this report, you will find descriptions of the approach, methodology and results from activities conducted by the Marmot Recovery Foundation during the 2021 field season. These results include data collected by the Foundation's field crews, as well as observations from the research teams supported by the Wilder Institute and Vancouver Island University. 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 in order 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. 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 17 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 in 2021.

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 nine occupied colonies and 40% of wild-living marmots. The Nanaimo Lakes metapopulation (Figure 1b) includes 12 occupied colonies and 57% of wild-living marmots. Steamboat Mountain, in west-central Vancouver Island, is believed to include approximately 3% of the wild-living population. The Foundation classified 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.

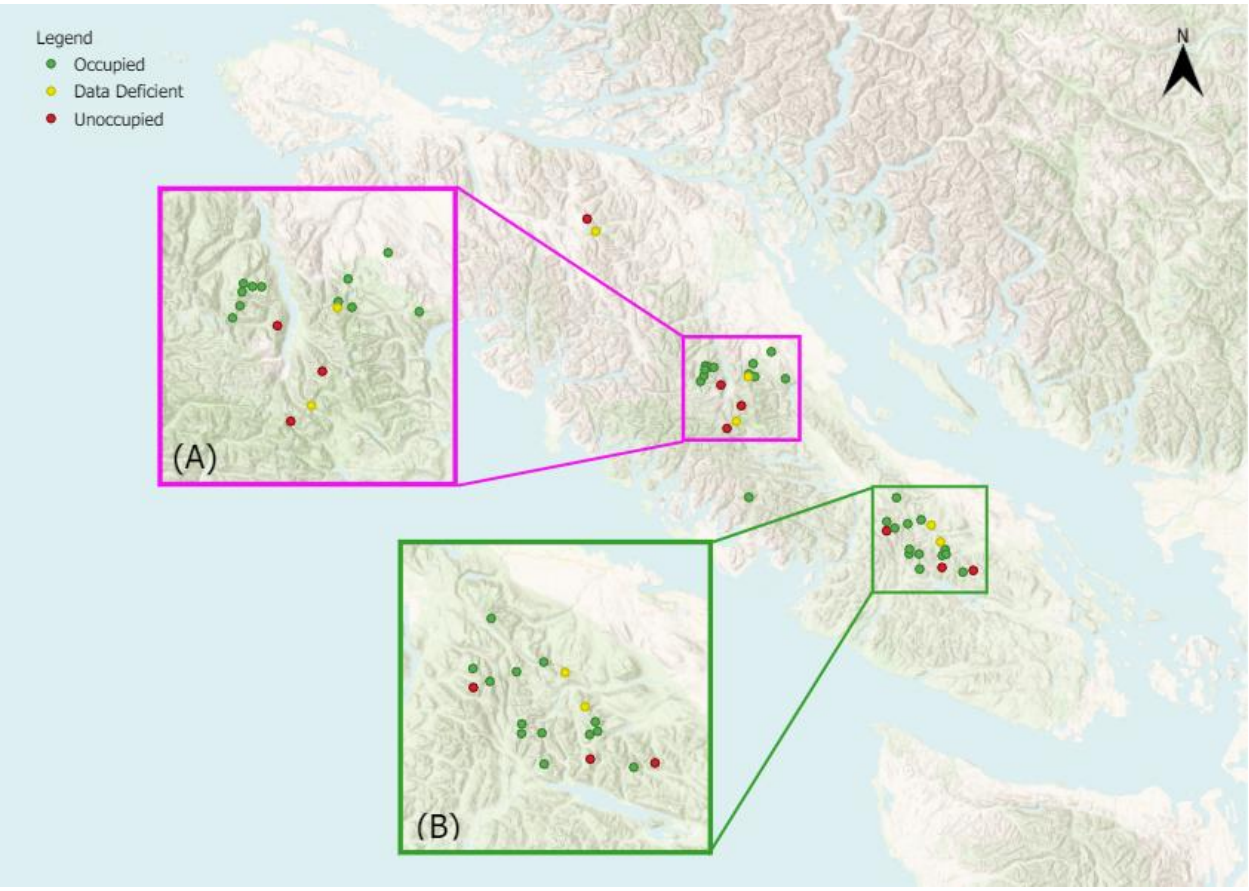

Figure 1. Distribution of the Vancouver Island Marmot in the wild (November 2021), including occupied, unoccupied and data deficient colony sites in the (a) Strathcona and (b) Nanaimo Lakes regions.

4.1. Summary of the 2021 Wild-living Population

At the metapopulation level, the 2021 field season resulted in a much higher count and distribution to that in 2020. The Nanaimo Lakes region continued to hold a greater proportion of the wild population than the Strathcona region (57% vs 40%), a larger number of adults (n=63 vs n=58), and produced nearly double the pups (n=46 vs n=27). Yearling counts were as expected based on 2020 pup counts; the Nanaimo Lakes region saw 39 yearlings from the 39 pups counted at the end of 2020, while the Strathcona region saw 18 yearlings from the 19 pups counted at the end of 2020. Each region included a small number of large and successful colonies, but the vast majority of colonies remained small in size. Survey effort in

2021 was over double (190%) of that in 2020 (619 person-days vs 326 person-days), with the increase in effort concentrated at Vancouver Island University and Calgary Zoo study sites (see table 1).

The Foundation followed up on reports from the 2020 field season, confirming that the distribution and/or density of marmot colonies is in the process of increasing within 2021. Field crew visited Strathcona Provincial Park and confirmed two new colonies: one at Morrison Spire between Limestone Cap and Marble Meadows, and one around Boston Lake on Mount Becher. In the Nanaimo Lakes region, one new colony was discovered at Mount Landale (previously extirpated), and field crew observed that marmots at one of the larger existing colonies (Mount McQuillan) had expanded into new habitat on the mountain. The Foundation will continue to monitor these colonies to achieve a better understanding within 2022.

Table 1. Summary of 2021 wild-living marmots, with additional details about select focal colonies. Note that totals for each region and the wild total include additional colonies not reported here.

	Augmentations		Counts				
	Releases	Translocations	≥2yo	1yo	0yo	Total	
REGION, Colony	**N**	**N**	**Mean**	**Mean**	**Mean**	**Low**	**High**
NANAIMO LAKES	**11**	**0**	**61**	**36**	**46**	**133**	**153**
Arrowsmith	0	0	11	4	11	24	26
Butler	2	0	2	1	4	6	7
Douglas	2	0	2	0	2	4	4
Green	0	0	0	0	0	0	0
Gemini	3	0	5	1	4	8	11
Haley	4	0	3	5	0	7	8
Landale	0	0	2	2	9	11	14
McQuillan	0	0	13	7	7	25	28
Moriarty	0	0	2	0	5	7	7
STRATHCONA	**8**	**6**	**57**	**17**	**27**	**88**	**113**
Becher	0	0	5	1	4	9	10
Castlecrag	0	0	9	1	4	14	14
Greig Ridge	0	2	3	4	0	6	8
Marble Meadows	0	2	9	5	10	17	28
Washington	8	2	15	3	7	21	28
EXTRALIMITAL	**2**	**0**	**6**	**2**	**0**	**5**	**10**
Steamboat	2	0	6	2	0	5	10
WILD TOTAL	25	8	87	36	67	226	276

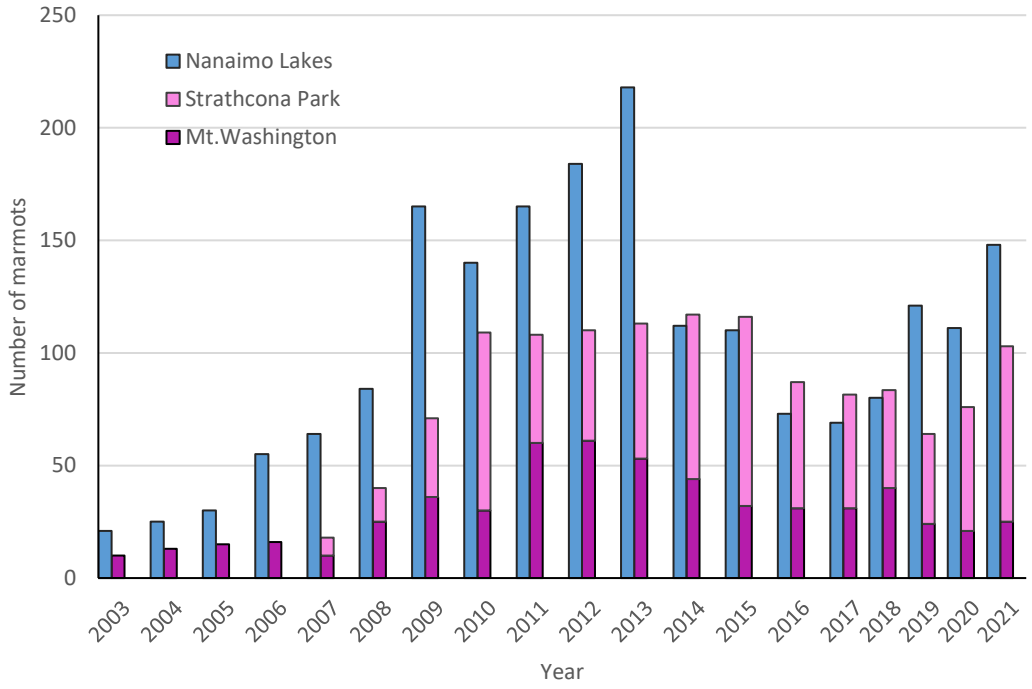

Figure 2. Mean population counts for the Nanaimo Lakes & Strathcona regions (2003-2021).

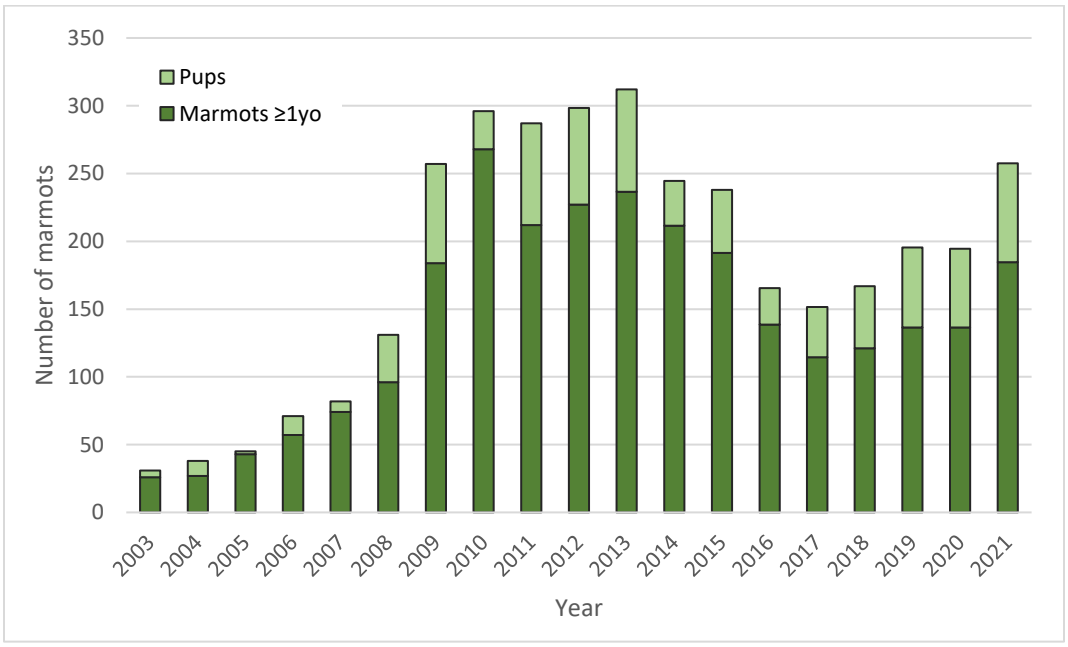

Figure 3. Mean population counts for the wild-living Vancouver Island Marmot population (2003-2021).

4.2. New Colonies Discovered in 2021

A total of three new colonies were discovered in 2021 – two located within the Strathcona region and one within the Nanaimo Lakes region. Visits within 2021 allowed the Foundation to confirm marmot occupancy, however future visits are required to develop a broader understanding of habitat use, age class distribution, and resident counts at all three colonies.

In Strathcona Provincial Park, Mount Becher had no historical records of occupancy. The Foundation investigated this area following hiker reports in the spring of 2021. Upon investigation, field crew discovered several untelemetered individuals occupying an avalanche slope above Boston Lake, roughly 700 m northeast from the summit of Mount Becher. The presence of one yearling and several pups, alongside the presence of several historic marmot refugia, suggests that this area has likely been occupied for at least 3 years, with 2 successful hibernation and reproduction events.

Morrison Spire, also in Strathcona Provincial Park, was the second new colony in this region confirmed by field crew in 2021. This area saw previous release efforts from the Foundation with no successful sign of hibernation or occupation. This area is adjacent to two well-established colonies along Greig Ridge, located between the Limestone Cap and the Marble Meadows colony. While no pups were observed, several adults and one yearling were sighted in this area. Several well-established burrows and fresh signs of excavation were observed in this area as well. The Foundation is not yet confident whether all residents are untelemetered due to Morrison Spire's proximity to two well-established colonies. Additional visits to this colony in 2022 are required to further develop an understanding of occupancy.

Within the Nanaimo Lakes region, Mount Landale was confirmed to be a new colony within 2021 following an investigation of 2020 hiker reports. Previously extirpated, the last records of marmot occupation at Mount Landale were between the 1980's/1990's. While field crew only confirmed the presence of 2 adults and 2 yearlings, several litters of pups were sighted. There is room to suggest a greater number of adults and/or yearlings are present in this colony. This colony has likely been occupied for the last 2-3 years, however additional visits are required to develop a better understanding of age distribution and colony counts.

Table 2. New colonies discovered in 2021.

Region	Colony	# Adults	# Yearlings	# Pups	Notes
Strathcona Provincial Park	Becher	4-5	1	4	All individuals observed are untelemetered. No records of recent occupancy. Reported by hikers in the spring of 2021, MRF staff confirmed in 2021 field season. Active marmot habitat on NE slope above Boston Lake, with

					signs of historic marmot refugia throughout this area.
Strathcona Provincial Park	Morrison Spire	5-6	1	0	Adjacent to two colonies within Strathcona Provincial Park. Despite past efforts to augment this area, consistent occupation was never established. MRF field team confirmed occupancy in August 2021.
Nanaimo Lakes	Landale	2	2	7-10	All individuals observed are untelemetered. No record of recent occupancy. Marmot sighting reported by hikers in 2020, confirmed by MRF staff in 2021 field season. Active marmot areas located in large gully system north of summit, and talus field below ridgeline.

4.3. Mortalities

The Foundation detected 33 mortalities during the 2021 field season (Table 3), including 17 in the Nanaimo Lakes region and 16 in the Strathcona region. Ten mortalities were of marmots recently released or translocated. Two mortalities could have occurred in 2019 or earlier. Sixteen of seventeen recovered mortalities provided evidence about the cause, in all cases selective consumption suggested cougar predation.

There were multiple mortalities detected at seven marmot colonies in 2021 (Douglas Peak, Gemini, Haley, Hooper, Moriarty, Sadie, and Mt. Washington). In 2021, at least two cougars predated 13 telemetered marmots at Mount Washington, and possibly additional untelemetered marmots as well. This level of predation has not been recorded at Mount Washington during the history of the marmot recovery project.

Table 3. Summary of the mortalities detected in 2021 and their suspected causes.

Region	Location	Marmot	Mortality suspected	Cause of mortality	Notes
Nanaimo Lakes	Big Ugly	Lynnie	Sept 7, 2021	Unknown	Likely too early to be hibernation. Not recovered.
	Butler	Leila	Aug 30, 2021	Unknown	Not recovered.
	Douglas Peak	Piero	June 14, 2021	Unknown	Autumn 2020 mortality. Piero dispersed to Douglas from McQuillan in 2020.
	Douglas Peak	Salal	Aug 22, 2021	Unknown	Not recovered.
	Gemini	Phlox	Aug 4, 2021	Predation	Selective consumption indicates cougar.
	Gemini	Parker	Aug 13, 2021	Predation	Selective consumption indicates cougar.
	Haley	Zenya	July 22, 2021	Predation	Selective consumption indicates cougar.
	Haley	Jasper2	Aug 25, 2021	Unknown	Not recovered. Not in main marmot habitats.
	Haley	Oliver2	Aug 25, 2021	Unknown	Not recovered. Not in main marmot habitats.
	Heather	Honey	Aug 9, 2021	Unknown	Not recovered. Not in main marmot habitats.
	Hooper	Gabriola	May 20, July 24, 2021	Unknown	Not recovered.
	Hooper	Yabber	Aug 24, 2021	Unknown	Not recovered.
	Moriarty	Marmalade	Sept 22 2021	Unknown	Not recovered.
	Moriarty	Kel	Aug 5, 2021	Predation	Selective consumption indicates cougar. Video footage of cougar in area.
	Moriarty	The Dude	July 23, 2021	Unknown	Spent most of his time in the LDL cutblock. The signal came from the cliffs above, in natural habitat.
	Sadie	Dutch	Sept 7, 2021	Unknown	Likely too early to be hibernation. Not recovered. Needs confirming.
	Sadie	Quill	Sept 7, 2021	Unknown	Likely too early to be hibernation. Not recovered. Needs confirming.
Strathcona	Washington	Buckbean	July 7, 2021	Predation	Selective consumption indicates cougar. Not in typical marmot habitat.

		Cap	July 28, 2021	Predation	Selective consumption indicates cougar. Not in typical marmot habitat.
		Dora	Aug 5, 2021	Predation	Selective consumption indicates cougar. Not in typical marmot habitat.
		Gigi	Aug 23, 2021	Predation	Selective consumption, caching indicates cougar.
		Sorrel	Aug 23, 2021	Unknown	Not recovered.
		Bruce Banner	Aug 25, 2021	Predation	Selective consumption, caching indicates cougar.
		Reginald	Aug 31, 2021	Predation	Selective consumption indicates cougar.
		Ernest2	Sept 2, 2021	Predation	Selective consumption indicates cougar.
		Macallan	Sept 4, 2021	Predation	Selective consumption indicates cougar.
		Rasa	Sept 7, 2021	Predation	Selective consumption indicates cougar.
		Joseph	Sept 11, 2021	Predation	Selective consumption indicates cougar.
		Manzanita	Sept 11, 2021	Unknown	Not recovered.
		Violet2	Sept 14, 2021	Predation	Selective consumption indicates cougar.
		Debbie	Sept 24, 2021	Predation	Selective consumption indicates cougar.
	Tibetan area	Pilot	Aug 10, 2021	Unknown	Not recovered.
	Morrison col	Unknown marmot	Aug 11, 2021	Unknown	Small mummified remains found below burrow.
TOTAL		33 mortalities			17 recovered

4.4. Reproduction

The Foundation counted at least 24 litters and 74 weaned pups in 2021. In the Nanaimo Lakes area, eight colonies produced at least 14 litters and 44 pups, and in the Strathcona region, six colonies produced at least 10 litters and 30 pups. Colonies that produced multiple litters included Big Ugly, Mt. McQuillan, Landale, and Mt. Arrowsmith in the Nanaimo Lakes region, and Becher, Marble Meadows, and Mt. Washington in the Strathcona region.

Pup counts were higher than expected for 2021, since there had been strong reproduction (>70 weaned pups) in 2019 and 2020, and most of those breeding females were expected to skip a year before producing another litter. Although Mt. Washington did produce several litters, it should be noted that it is possible many of these pups were predated in the same time frame as other mortalities at the site.

Table 4. Weaned pups counted in 2021.

Region	Colony	# Litters	# Pups (low)	# Pups (high)	Suspected dam (suspected sire)	Notes
Nanaimo Lakes	Arrowsmith	4	10	11	unknown (unknown)	
	Big Ugly	2	5	5	unknown (Loki3, unknown)	
	Butler	1	4	4	unknown (unknown)	
	Douglas	1	2	2	Temple (unknown)	Temple was tagged but untelemetered and was trapped by the CZ team.
	Gemini	1	4	4	unknown (Diego2)	Diego2 was captive-bred, released 2020.
	Landale	2-3	7	10	unknown (unknown)	
	McQuillan	2	7	7	unknown (unknown)	
	Moriarty	1	5	5	Kel (Anik)	Kel was predated Aug 5.
Strathcona	Albert Edward	1	1	1	unknown (unknown)	Observed during a camera maintenance flight.
	Becher	2	4	4	unknown (unknown)	
	Castlecrag	1	3	3	unknown (unknown)	Hiker reports, photos.
	Marble Mdws	2	7	8	Unknown (unknown)	
	Sunrise	1	2	2	unknown (unknown)	
	Washington	3-4	13	13	Willow (Gord), Jordan (Ernest2 or Macallan), Hollis and Debbie (Ernest2 or Macallan).	Jordan was a captive-bred 2yoF released 2020 and was not expected to breed.
TOTAL		24-26	74	79		

4.5. Snowpack and Hibernation Survival

The 2020-2021 winter season saw higher snow levels than has been seen in the previous two years. This snow pack may have provided meadows with moisture during the summer heat dome, potentially mitigating the impact of the unusually high temperatures on the marmot's food source.

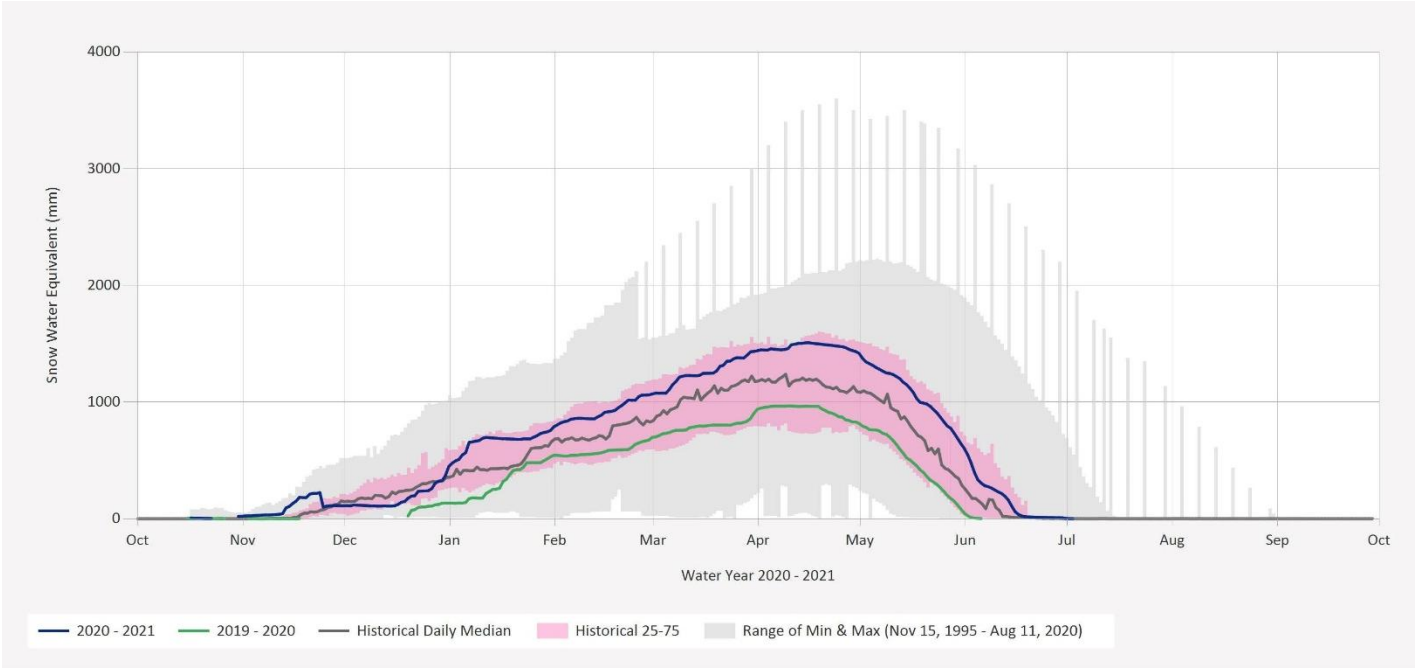

Figure 4. Snow water accumulation at the Jump Creek water station in the Nanaimo Lakes region (2020-21; FLNRORD 2021).

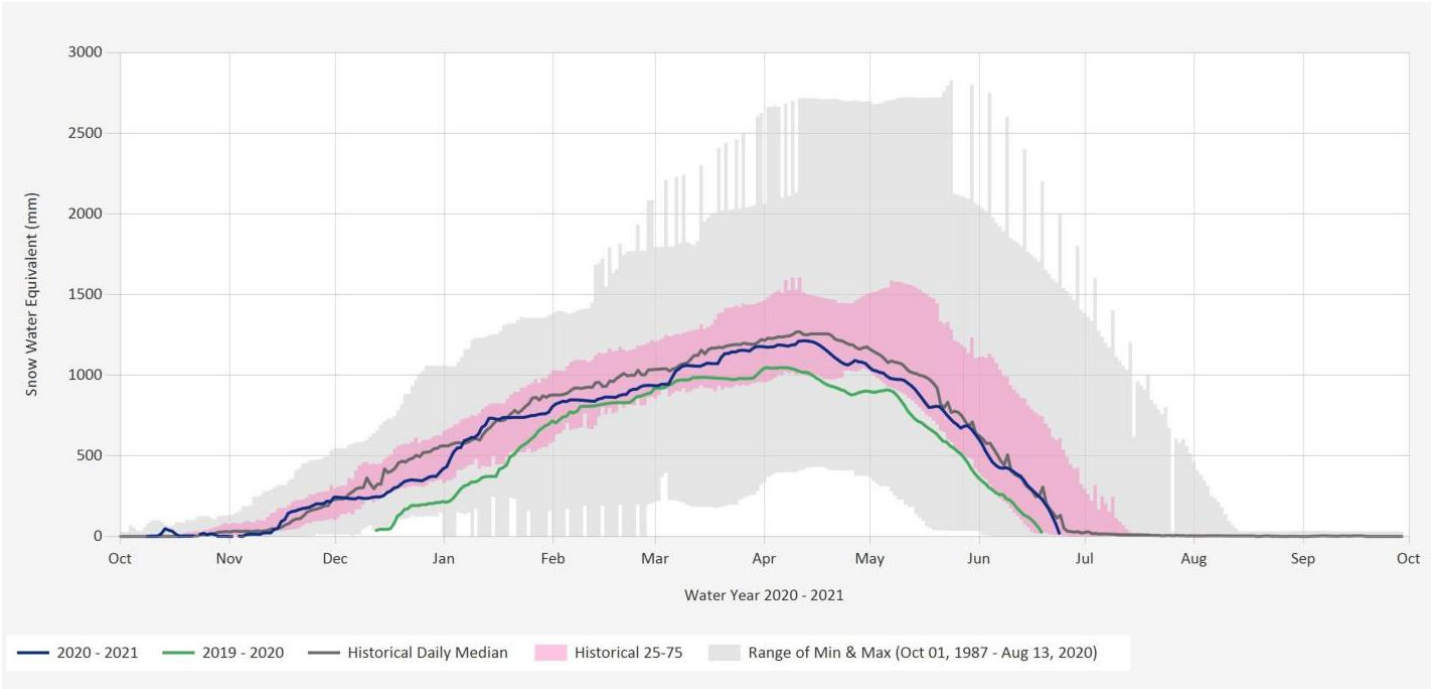

Figure 5. Snow water accumulation at the Wolf River Upper water station in the Strathcona region (2020-21; FLNRORD 2021).

The larger snowpack did not appear to translate to poor overwinter survival in the wild. The Marmot Recovery Foundation defines a marmot as having survived hibernation when it was detected on active telemetry signal, or not active but tracked to a burrow, on or after September 15, 2020, and on active signal again by mid-June 2021. By this definition, 100% of monitored marmots in the wild survived hibernation (18 of 18).

Table 5. Overwinter survival and mortality in 2021.

Population	**Suspected Overwinter Mortalities**	**Overwinter Survival for Monitored Population (x of y)**
Nanaimo Lakes	None	100% (5 of 5)
Strathcona (Mount Washington and Castlecrag)	None	100% (13 of 13)
Extralimital Sites	Unknown	Unknown
TOTAL		**100% (18 of 18)**

4.6. Summer, Fall Weather

Drought was a large concern within the summer of 2021. The Foundation saw several field conditions that suggested marmot forage senesced early in response to drought. Marmots began to re-enter hibernation in September, with the first detection of a marmot in torpor at Haley Lake Ecological Reserve on September 22nd.

Despite a particularly hot and dry summer, there were very few wildfires on Vancouver Island. However, an extreme heatwave event occurred between June 25th to July 7th. While the direct impact this heat wave had on marmots has not been investigated, some colonies appeared to be negatively impacted by this event. Colonies such as Mount Arrowsmith's South Meadow saw very few marmots during the Calgary Zoo Research Team's survey days, as well as field conditions that suggest marmot forage had senesced considerably following the event. While the direct cause has not been investigated, there is potential for future heat waves to negatively impact marmot forage availability if such events return annually.

4.7. Observations of Marmot Habitat

Field teams continued to note that tree ingress is a problem at several 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 would conduct habitat improvement activities before predation or vegetation succession becomes a significant problem for a colony. This could mean that the colony remains stable without needing augmentation support. 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 2021.

Region	Site	Sublocation	Notes
Strathcona	Castlecrag Mountain	West Shelf, Main Meadow	Recommended focal site for future habitat improvement efforts. 2021 field observations saw dense forests below well-used hibernacula in both sublocations. Tree ingression 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. 2021 field observations saw dramatic infilling of subalpine forests. While there are no known, well-used hibernacula in direct vicinity of the canopy closure hotspot, it is recommended restoring sightlines from marmot habitat features into this subalpine forest where terrestrial predators could potentially be sourced.
	Flower Ridge	Price Pass	Recommended focal site for future habitat improvement efforts. 2021 field observations saw heavy, dense tree cover within the main drainage system occupied by marmots at this sublocation. Future actions should prioritize addressing tree ingression within this area, particularly upslope where denser forests are.
		Cream Lake	Recommended focal site for future habitat improvement efforts. 2021 field observations saw dramatic tree ingression 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. 2021 field observations saw heavy tree ingression 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 ingression hot spots (i.e. towards the present-day treeline).
	Douglas	Main Meadow	2021 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. Two distinct stands of dense trees formed within the Main Meadow, dividing this sublocation into three micro meadows. This blocked sightlines from well-used burrows towards the southwest ridgeline where there is known predator traffic.
		Aster's Bowl	2021 focal site for habitat improvement – tree ingress report available. Main concern was dense tree growth along the perimeter of the sublocation, blocking sightlines from well-used marmot habitat features towards areas with confirmed mortalities and predator scat - suggesting high predator traffic. This area is the southwest ridgeline extending from Mount Gemini towards the main meadow.
	Green	North Green	Recommended focal site for future habitat improvement efforts. 2021 field observations saw 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	Recommended focal site for future habitat improvement efforts. 2021 field observations saw considerably heavy tree ingression, with very minimal talus field habitat available. Based on these observations, it is recommended to address tree ingression at the periphery of remaining talus field habitat.
		Summit West	Recommended focal site for future habitat improvement efforts. 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. 2021 field observations saw 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. 2021 field observations saw 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	Recommended focal site for future habitat improvement efforts. 2021 field observations saw heavy tree ingression at lower elevations. Priority areas for a restoration project at this sublocation should be tree ingression around marmot habitat features at lower elevations. Additional observations from the 2021 field season revealed heavy ungulate use of lower elevation meadows, suggesting the potential for heavy predator traffic through these areas.
	Hooper	Main Meadow	Recommended focal site for future habitat improvement efforts. 2021 field observations saw heavy tree ingression 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 ingression at the periphery of the sublocation. Where resources are available, addressing tree ingression 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. Concerns in this area focused on a stand of trees bordering the south side of three well-used hibernacula. This was particularly urgent to address due to a mortality that had occurred right at the entrance of one of the hibernacula during the 2021 field season, confirmed with remote camera footage. Previous habitat improvement efforts were made here in 2017 – wherein trees on the north side of the 3 hibernacula were treated.

	McQuillan	Main meadow	2021 focal site for habitat improvement – tree ingress report available. Areas requiring improvement was a stand of trees in the centre of the meadow, blocking sightlines directly adjacent to well-used marmot burrows. As well, a stand of trees growing at the eastern edge of the meadow had potential to grow and close in on a well-used marmot travel corridor, connecting with another well-used area. Future restoration efforts should focus 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. Addressing tree ingression along the periphery of these stands can help travelling marmots access additional habitat easier.
		West Talus	Recommended focal site for future habitat improvement efforts. 2021 field observations saw considerable tree ingression 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 ingression within talus fields. Additional observations from the 2021 field season saw marmots using the upper ridgeline as travel corridors between the West Talus and Main Meadow sublocations, where dense forest was also observed. Marmots were also observed using talus fields at lower elevations, where tree ingression was observed as heavy.
		NW Meadow	Assessed as potential focal site for habitat improvement in 2022. This site hosts heavy tree ingression on the northwest end of the meadow, in which extensive young growth is enclosing often-used marmot burrows. Suitable for treatment with a large crew with chainsaws.

Figure 6 Tree growth in marmot habitat on Mount Gemini - Main Meadow. Photo by Kevin Gourlay.

Figure 7 Tree growth in marmot habitat on Mount Gemini – Aster's Bowl. Photo by Chelsea Brager.

Figure 8 Tree growth in marmot habitat on Mount Moriarty – LDL Meadow. Photo by Chelsea Brager

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

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

Figure 11 Tree growth in marmot habitat on P Mtn– NW Meadow. Photo by Chelsea Brager.

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, the Recovery Team, and the Marmot Recovery Foundation. The Foundation's efforts for the 2021 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. 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 2021, 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, a total of 15 captive-bred marmots were released to support 7 key colonies in the Nanaimo Lakes region, as well as 2 captive-bred marmots released into Steamboat Mountain, an extralimital site (Table 7). The other eight captive-bred marmots were released on Mount Washington to become future resident breeders. Unfortunately, many of these releases were predated in the late summer. It has been hoped that their litters would provide translocation candidates to augment colonies in Strathcona Provincial Park (see 5.2 for more discussion on translocations).

Table 7. Captive-bred marmots released in 2021.

Region	Release Site	Birth Facility	# Released	# Females	# Males	Names & Ages (d=deceased)
Strathcona	Washington	CZ, TZ, TBMWMRC	8	3	5	Cap (1yoM, d), Bruce2 (1yoM, d), Manzanita (1yoF, d), Buckbean (1yoM, d), Sorrel (1yoM, d), Rasa (1yoM, d), Bonnie2 (1yoF, r), Esmerelda (1yoF, r).
Nanaimo Lakes	Haley	TZ, TBMWMRC	4	2	2	Jasper2 (1yoM, d), Oliver2 (1yoM, d), Natasha2 (1yoF), Pepper (1yoF).
	Butler	CZ, TBMWMRC	2	1	1	Vetch (1yoM), Leila (1yoF, d)
	Gemini	CZ	3	1	2	Camas (1yoM), Phlox (1yoM, d), Buttercup2 (1yoF).
	Douglas	CZ	2	1	1	Salal (1yoM, d), Ginger3 (1yoF)
	Heather	CZ, TBMWMRC	2	1	1	Seigfried (1yoM), Honey (1yoF, d)

	Hooper	CZ	1	1	0	Aster2 (1yoF)
	Sadie	CZ	1	0	1	Groundsel (1yoM)
Clayoquot Plateau	Steamboat	CZ	2	1	1	Burnet (1yoM), Arnica2 (1yoF)
Total	9 colonies		25	11	14	25

Table 8. Numbers of captive-bred marmots released 2003-2021.

Captive-bred Marmots Released 2003-2021				
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
TOTAL	**199**	**313**	**42**	**554**

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 very rare cases, 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 were either wild-born or had been released, and so had already gained experience living in the wild. Translocation counts also include marmots re-released to their original location after a captive hibernation.

Since 2012, Strathcona Park colonies have been augmented through the translocation of marmots from the wild colony on Mt. Washington. 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 2021, four yearlings (two males and one female/one male pair) were translocated to Marble Meadows and Greig Ridge respectively. In total, Strathcona Provincial Park received four translocated wild-born marmots this season. Additionally, 2021 translocation candidates were also sent to two sites in the Nanaimo Lakes area. One adult male was translocated from a cutblock colony onto Mount Hooper in July 2021. An additional adult male who was initially released onto Mt. Washington in 2020 was translocated to Mt. Sadie in July 2021 after continually returning to the captive-breeding centre to interact with other marmots.

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

Table 9. Marmots translocated in 2021.

	Release Site	**Source**	**# Released**	**Names (d=deceased)**	**Notes**
Strathcona	Washington	Washington	2	Quill (2yoM, captive-bred, r), Sandi (2yoF, Washington, r).	Quill was recaptured again days after re-release and translocated elsewhere (see below).
	Marble Meadows	Cutblock - LDL trailhead/K-block	2	Rex2 (1yoM, wild-born), Peabody (1yoM, wild-born)	Rex2 was from the LDL cut-block. Peabody was from K-block.
	Greig Ridge	Cutblock – LDL trailhead/K-block	2	Ralph (1yoM, wild-born), Diana (1yoF, wild-born)	Ralph was from the LDL cut-block. Diana was from K-block.
Nanaimo Lakes	Hooper	Cutblock – K-Block	1	Yabber (2yoM, wild-born, d)	Born in K-block.
	Sadie		(1)	Quill (2yoM, captive-bred, d)	Initially released on Washington in June 2020 and June 2021, then recaptured and translocated to Sadie.
Total	**5 colonies**		**7**		

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 2021, all transmitters were implanted by the Foundation's project 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 twelve implant sessions over the field season, including four sessions in cutblock colonies, three sessions at other Nanaimo Lakes colonies, and five sessions at Mt. Washington in the Strathcona region. In total, 12 marmots were captured and implanted, of which eleven were first-time captures. Dr. McAdie also implanted each of the twelve captive-bred marmots prior to their release into the wild.

Table 10. Transmitter implants of wild-living marmots in 2021.

Region	Site	Implanted marmots	New implants	Replaced transmitters	Total	Notes
Nanaimo Lakes	Cutblock – LDL trailhead	Rex2, Ralph	2	0	2	All captured for translocation.
	Cutblock – K block	Diana, Peabody	2	0	0	All captured for translocation.
	Haley	Maddie, Hershey2, Zenya	3	0	3	All re-released.
Strathcona	Mt. Washington	Reginald, Gigi, Joseph, Violet, Autumn, Flossie	5	1	6	All re-released.
Total			12	1	11	

Photo 1 "Ernest" by Eden Rowe

5.4. Managing Marmots in Unsuitable Habitat

The response by the Foundation to marmots living in unsuitable habitat depends upon the reasons and projected timeframe for the habitat issues. In 2021, three situations arose (see Table 11).

In the first situation, a captive-bred adult male was released onto Mt. Washington in 2020 but had been seen returning to the captive-breeding centre to interact with other marmots. This individual was re-released to Mt. Washington in June 2021, but again returned to the captive-breeding centre shortly after. As a result, this individual was re-captured just days after and translocated to Mt. Sadie in the Nanaimo Lakes region.

In the second situation, the Foundation visited two cutblocks that had been occupied in 2020, and discovered a total of four yearlings and three adult females. Although these cutblocks are not natural habitat and do not have intermediate- or long-term potential for supporting Vancouver Island Marmots, neither do they present a critical threat to the individuals currently living there. The Foundation implanted all four yearlings (see Table 10) and captured them for quarantine at the breeding centre. In August 2021, the yearlings were translocated to Marble Meadows and Greig Ridge in Strathcona Provincial Park. At the end of 2021, there were still three telemetered adult females remaining in the cutblocks.

In the third situation, two wild-born pups and one wild-born adult female on Mt. Washington were captured towards the end of September 2021 due to cougar predation risk. The east side of Mt. Washington received an unprecedented number of fall cougar predations during the month of September. The Foundation found it necessary to capture the wild-born adult female as she was the last breeding-age female left within this area of Mt. Washington who had yet to begin hibernation. While field crew had not been able to confirm which litter the two pups belonged to, it was suspected that these were the sole surviving pups of two separate marmot families. As a result, the risk of cougar predation was too high and immediate capture was required. Both the resident adult female and the two pups were moved to the breeding centre for captive hibernation with the intent to re-release in 2022.

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 2021, 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 2021.

Region	Location	Marmot	Age	Reason for capture	Notes
Strathcona	Mount Washington	Quill	2	Translocation into Nanaimo Lakes region.	Initially released on Mt. Washington in 2020 but returned to interact with marmots at the Centre. Re-released in 2021 with same result.
	Mount Washington	Joey, Walnut	0	Cougar predation risk.	Possibly from different litters. Captured without parents or siblings nearby, and in area where most cougar predations occurred. Will likely re-release on Mt. Washington in 2022.
	Mount Washington	Sandi	2	Cougar predation risk	Captured in the area where most cougar predations occurred. Will likely re-release on Mt. Washington in 2022.
Nanaimo Lakes	Cutblock – LDL trailhead	Rex, Ralph	1	Translocation into Strathcona	Translocated. Marmots still onsite may include one telemetered adult female (Blossom2).
	Cutblock – K-block	Diana, Peabody	1	Translocation into Strathcona	Translocated. Marmots still onsite include two telemetered adult females (Patricia2 and Marmalade) and a telemetered adult male (Piccolo).
TOTAL:		**8**			

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 initiated a pilot study to test potential methodology for a study on supplemental feeding and its benefits to marmot reproduction. In 2019, the Calgary Zoo expanded the study, funding two research teams to conduct a four-month study at six locations: three control sites (Big Ugly, Douglas and Moriarty) and three feeding sites (Arrowsmith, Haley, and P Mtn). 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 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 four times during the month of August.

The Foundation typically 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 2021, the Foundation installed spring supplemental feeders at five colonies in the Strathcona region, four colonies in the Nanaimo Lakes region, and one extralimital colony (Steamboat Mountain). Most colonies received just one or two feeders, and those feeders were not refilled. The exception was Mt. Washington, where eight feeders were maintained and refilled over the month of May. The Foundation used remote cameras to document activity by marmots and other species of interest at the feeders.

Photo 2 "Check-up on releases" by Adam Taylor

Table 12. Supplemental Feeding Sites in 2021.

Region	Site	Team	Time frame	Feeders	Fills per feeder	Minimum number of marmots
Nanaimo Lakes	Gemini	MRF	May 20 – Sept 21	1	1	2
	Heather	MRF	May 20 –	1	1	3
	Hooper	MRF	May 20 – Aug 23	1	1	1
	Sadie	MRF	May 20 – Aug 6	1	1	5
	Arrowsmith	CZ	July 12 – Sept 21	3	4	0
	Haley	CZ	July 8 – Sept 20	3	4	6
	P Mtn	CZ	July 15 – Sept 21	3	4	1
Strathcona	Albert Edward	MRF	May 20 – Sept 31	2	1	5
	Castlecrag	MRF	May 20 – Oct 7	2	1	5
	Greig Ridge	MRF	May 20 – July 6	1	1	5
	Marble Meadows	MRF	May 20 – Sept 31	2	1	8
	Sunrise	MRF	May 20 – Sept 31	1	1	6
	Washington	MRF	May 8-26	8	31	20
Clayoquot Plateau	Steamboat	MRF	May 21 – July 19	1	1	4
TOTAL	14 colonies			30	53	71

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 that provide stalking cover to terrestrial predators. By regaining long, continuous lines of sight, marmots have a better opportunity to detect and evade predators.

In the fall of 2021, the Foundation was granted funding for habitat improvement projects during the months of October – November. 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. The Foundation also received funding within December 2021 to quantify historic levels of change through a photo analysis report at two colonies within the Strathcona region and seven colonies within the Nanaimo Lakes region. This photo analysis project aims to provide direction and priority areas for future habitat improvement projects. 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.

Table 13. Habitat Improvement in 2021. All work was conducted in the Nanaimo Lakes region.

Colony	Hectares improved	Description of Work
Gemini	2	Work conducted within two sublocations: the main meadow and Aster's Bowl. Both sublocations experienced expansive tree growth, blocking sightlines into areas with heavy predator traffic. Within the main meadow, the crew focused on thinning two large stands that bisected the sublocation into 3 micro meadows. At Aster's Bowl, the crew focused on young trees encroaching the talus field along the perimeter, blocking sightlines to where the Foundation believes there to be heavy predator traffic.
Douglas	1	Work conducted within China Bowl, in which the crew focused on four areas: upper meadow, north stand, lower south avalanche chute, and runout rocks. Work in the upper meadow consisted of removing very small, young saplings that had potential to reduce the amount of meadow habitat available. Within the north stand, lower south avalanche chute, and runout rocks work consisted of removing the dense sapling layer and thinning lower branches on larger trees, hoping to restore sightlines into areas where predators could be stalking (i.e. below China Bowl, to the north within mature forest, etc.).
P Mtn	1	Work was completed within the Main Meadow sublocation, in which there was only one medium-sized stand that was treated, due to time constraints. This stand was prioritized as it was the only patch of trees in the meadow that was directly impacting sightlines. A dense sapling layer was removed, and all large trees thinned of large, lower limbs. An assessment of work needed within the NW meadow was completed at the end of the day for future restoration efforts.

Mount McQuillan	1	Work completed on Mount McQuillan was within the main meadow, in which there were two stands of high priority for treatment. Work in the mid meadow stand consisted of removing young trees and limbing larger trees. Treatment of this stand was important as it was the only treed area within the main meadow itself that reduced sightlines from the burrows that are directly adjacent. The lower north stand consisted of very large trees, and thus most of the work in this stand involved de-limbing. This was an important stand to address as it had potential to grow and decrease the size of the well-used travel corridor between an additional well-used talus field.
Mount Moriarty	1	Work completed was focused on one band of trees on the south end of Moriarty's LDL meadow. This stand of trees consisted of primarily large trees with wide swooping lower limbs that closed in the lower canopy. There were several well-used hibernacula that had experienced on-site predator mortality. As a result, work focused primarily on removing lower limbs from these large trees, and removing smaller trees where size allowed.

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 2021, the Foundation received two reports of *M. flaviventris*, with verified sightings near Vancouver Island University in Nanaimo (n=2). The Foundation shared these reports with wildlife rehabilitation organizations (WildArc, North Island Wildlife Rehabilitation Centre). Foundation staff attempted to capture these two individuals but was successful with only one *M. flaviventris*. The captured individual was transported to the North Island Wildlife Rehabilitation Centre for care. The remaining individual is still at large, suspected to still be in Nanaimo. The Foundation will continue to monitor reports into 2022 to determine the location of this individual.

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. 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 sent out a pulse that changed 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, they counted the number of pulses in a minute to discover whether the marmot was alive (≥30ppm), possibly alive (29ppm) or dead/hibernating (≤28ppm). 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 2018 and especially in 2019, the Foundation greatly benefitted from the regular presence of the Calgary Zoo's research team at several marmot colonies. The tangential benefits to this partnership, beyond the value of the research itself, included more rapid detection and recovery of mortalities, stronger estimates of colony size and composition at their study sites, and the ability for the Foundation to spend additional survey and trapping time at less accessible sites. In 2021, the Calgary Zoo research team returned with a similar level of effort to 2019, with two research teams of two working from May – September. During this time, they assisted the Foundation's monitoring efforts by conducting telemetry and visual surveys. They also deployed remote cameras at their six study sites, facilitating the collection of thousands of images of marmots and other species that spent time in marmot habitat.

Towards the end of the 2021 field season, aerial telemetry was conducted for several colonies within Strathcona Provincial Park. While effort surmounted to only one day 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 19 colonies: ten natural and two cutblock colonies in the Nanaimo Lakes region, six colonies in the Strathcona region, and one extralimital colony (Steamboat Mountain). In total, over 100 marmots were monitored by cameras during the 2021 field season. The camera installed on Flower Ridge fell over, and recorded corrupted data in 2021, and thus the Foundation was unable to confirm additional counts from this colony. Camera data from the Calgary Zoo Research Team is still under review for footage of other species. 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 Heather Mountain, Mt. Gemini, Albert Edward, Castlecrag, Greig Ridge, Marble Meadows, and Sunrise Lake. Ermine, a smaller mustelid species, were also recorded at Greig Ridge 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 one colony, Heather Mountain, in 2021.

Table 14. Footage captured by select remote cameras in 2021.

Region	Colony	Timing	# Adults	# 1yo	# Pups	Other species	Notes
Nanaimo Lakes	Sadie	May 20 – Aug 6	3	0	0		
	Hooper	May 20 – Aug 24	4	0	0	Bear	Data corrupted July 24 – Aug 24.
	Heather	May 20 - Aug 25	2	2	0	Bear, cougar, marten, elk	
	Gemini	May 20 – Sept 21	3	1	0	Bear, deer, marten	
	Cutblock – Area K	June 19 – Aug 23	1	1	0	Bear	
	Cutblock – Terminus	July 13 – Aug 23	2	1	0	Sooty grouse	
	Moriarty	June 14 – Sept 23	3	0	5		Calgary Zoo cameras. Still under review.
	P Mtn	June 28 – Sept 21	2	2	0		Calgary Zoo cameras. Still under review.
	Arrowsmith	May 26 – Sept 21	2	1	1		Calgary Zoo cameras. Still under review.
	Big Ugly	May 31 – Sept 23	3	6	5		Calgary Zoo cameras. Still under review.
	Haley Lake	May 25 – Sept 20	1	7	0		Calgary Zoo cameras. Still under review.
	Douglas	June 25 – Sept 20	2	2	2		Calgary Zoo cameras. Still under review.
Strathcona	Albert Edward	May 20 – Oct 1	4	0	1	Bear, marten	
	Flower Ridge	May - Oct 1	0	0	0	None	Suboptimal placement, only triggered by vegetation. Camera fell shortly after deployment.
	Castlecrag	May 20 – Oct 7	2	2	1	Bear, deer, marten	

Region	Colony	Timing	# Adults	# 1yo	# Pups	Other species	Notes
	Greig Ridge	May 20 – Oct 1	2	3	0	Bear, deer, ermine, marten	
	Marble Meadows	May 20 – Oct 1	5	2	7	Marten	
	Sunrise	May 20 – Oct 1	4	2	2	Bear, ermine, marten	
Clayoquot Plateau	Steamboat	May 21 – July 19	3	0	0	Bear	
TOTAL	**19 colonies**		**48**	**32**	**24**		

5.8.3. Summary of monitoring effort by location

The global COVID-19 pandemic continued to impact the Foundation's ability to monitor marmots in the 2021 field season, but with fewer restrictions that enabled the Foundation to maintain a broader coverage of marmot colonies. With the implementation of provincial vaccine programs and a better understanding of disease transmission, the Foundation was able to return to normal operations with added modifications and protocols. Additional biosecurity protocols limited the ability for field teams and the marmot care team to share vehicles and equipment, work closely in the same spaces, or for volunteers to assist the Foundation during field visits.

The Calgary Zoo research team was able to return for a full field season with four field staff in 2021. This allowed the Foundation to focus efforts on colonies that were not surveyed in 2020 and seek out additional priorities in 2021. This included confirming the occupation of three new colonies in the Nanaimo Lakes and Strathcona regions (one new colony and two new colonies, respectively).

The colony that received the greatest amount of effort (Table 15) was Mt. Washington. In 2021, Dr. Gorrell and Vancouver Island University had a team of two monitoring all telemetered marmots daily. The next six colonies receiving the most intensive efforts were all six Calgary Zoo research sites, with the assistance of two Calgary Zoo research teams from May to September. The collective grouping of cut block colonies also received a lot of effort relative to many of the natural sites. These colonies were prioritized in order to facilitate the capture and translocation of wild-born yearlings into Strathcona Provincial Park. The field team also spent time at colonies in Strathcona Provincial Park; five individuals spent time surveying colonies such as Mount Becher, Castlecrag Mountain, Marble Meadows, Marble Peak, Morrison Spire, Flower Ridge, and Tibetan.

Table 15. A comparison of monitoring effort in 2021 and 2020, in decreasing order of 2021 effort.

Region	Site	2021 Effort (Person Days)	2020 Effort (Person Days)	% of 2020 effort	Notes
Strathcona	Washington	190	92	206%	Vancouver Island University research team
Nanaimo Lakes	Haley	62	14	443%	Calgary Zoo study site.
Nanaimo Lakes	Moriarty	47	10	470%	Calgary Zoo study site.
Nanaimo Lakes	Douglas	46	18	255%	Calgary Zoo study site.
Nanaimo Lakes	Big Ugly	46	20	230%	Calgary Zoo study site.
Nanaimo Lakes	Arrowsmith	44	33	133%	Calgary Zoo study site.
Nanaimo Lakes	P Mtn	32	26	123%	Calgary Zoo study site.
Nanaimo Lakes	Cut blocks	26	32	81%	Includes K-Block, Terminus, and LDL trailhead
Nanaimo Lakes	Gemini	22	6	367%	
Strathcona	Castlecrag	16	0	N/A	Site not monitored in 2020.
Nanaimo Lakes	Butler	15	7	214%	
Strathcona	Becher	14	0	N/A	Site first monitored in 2021.
Nanaimo Lakes	Heather	11	10	110%	
Nanaimo Lakes	Landale	10	0	N/A	Site first monitored in 2021.
Nanaimo Lakes	McQuillan	9	10	90%	
Strathcona	Sunrise	6	2	300%	
Strathcona	Flower Ridge	6	0	N/A	Site not monitored in 2020.

Nanaimo Lakes	Green	4	4	100%	
Strathcona	Marble Peak	4	8	50%	
Strathcona	Marble Meadows	4	0	N/A	Site not monitored in 2020.
Strathcona	Morrison Spire	4	0	N/A	Site not monitored in 2020.
Strathcona	Tibetan	1	12	8%	
Strathcona	Limestone	0	3	0%	
Strathcona	Greig Ridge	0	8	0%	
Nanaimo Lakes	Sadie Peak	0	11	0%	
Nanaimo Lakes	Hooper	0	0	N/A	
Strathcona	Albert Edward	0	0	N/A	Site not monitored in 2020 or 2021.
Strathcona	Frink	0	0	N/A	Site not monitored in 2020 or 2021.
Extralimital	Steamboat	1	0	N/A	Site not monitored in 2020.
TOTAL	29 locations	620	326	190%	

Photo 3 "Ernest2 and Debbie" by Eden Rowe

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 2021, the Foundation received a number of significant observations.

Table 16. Significant reports from the public in 2021.

Region	Location	Nature of Report(s)	Significance
Nanaimo Lakes	Mt. Arrowsmith	Hiker report	Increased Foundation understanding of habitat use at this location.
	Mt. Landale	Hiker reports, photographs, location data	Assisted field crew in finding two occupied sublocations, resulting in strong counts over multi-day visit.
Strathcona	Albert Edward	Hiker report, photographs, location data	Increased Foundation understanding of habitat use at this location.
	Becher	Hiker report, photographs	Increased Foundation understanding of habitat use at this location.
	Castlecrag	Hiker reports, photographs, location data	Documented an additional pup litter not observed by Foundation staff. Additional info about hibernation immergence dates.
	Marble Meadows area	Hiker report, photographs, location data	Expanded habitat use in the area, likely by dispersers from the main colony.
	Wheaton Lake	Hiker reports, photographs, location data	Documented movements into new habitat by a resident adult male.
	Mt. Washington	Hiker report, photographs with visible ear tag.	Documented movements into new habitat by a resident adult male.
Clayoquot Plateau	Steamboat Mtn	Hiker report, photographs	Confirmed site occupancy, remote camera data.

6. TONY BARRETT MOUNT WASHINGTON MARMOT RECOVERY CENTRE

6.1 Background

The TBMWMRC received its first marmots on October 15, 2001, so the facility celebrated its 20th year of operation in 2021. From 2002 to 2012 TBMWMRC functioned as a quarantine and breeding center. The captive program was intentionally downsized in 2012, and from 2013 to 2017 TBMWMRC served as a seasonal quarantine (i.e. VIM coming from the other captive facilities in the spring for release) and staging facility (temporary holding of VIM for translocation, primarily from the wild Mount Washington colony to sites in Strathcona). TBMWMRC was recommitted to overwintering release marmots during the winter of 2017 / 18 and returned to being a year-round facility (which included maintenance of breeding pairs and future breeders) in 2019.
Year-round operation of the TBMWMRC has significantly increased the overall program's capacity for captive breeding and releases, and it has also given MRF staff much better 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 TBMWMRC (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 played a critical role in snow management.

6.2 Operations in 2021

In September 2020 five marmots were moved to Calgary from TBMWMRC and two were moved to Toronto. A total of 19 marmots were received from Calgary and seven from Toronto (total = 33 moves). In the spring of 2021, there were 64 marmots at TBMWMRC. This included 10 pairs where both the male and female were two years of age or older. In 2021, only two females successfully reproduced (an 11-year-old female and unexpectedly a yearling female - yearling females have produced litters on three previous occasions). On average, over 50% of the breeding pairs maintained at TBMWMRC have produced litters (overall program average = 41%) and 2021 had the lowest success rate when compared to any of the previous breeding years at the centre. This result is not too surprising, as many of the pairs in 2021 were young and newly established, and most of the older females had reproduced in one or two of the previous breeding seasons.

There were 27 captive marmots (15 males, 12 females) at TBMWMRC for potential release in 2021. Of the 27, 25 were eventually released during the summer. One yearling female was retained due to a chronic left eye problem resulting in an area of corneal fibrosis that significantly impaired her vision. The seriousness of this injury may preclude her release in 2022. One yearling male was retained due to a broken incisor identified on his pre-release exam. He will probably be released in 2022. In addition, 3 two-year-old marmots that were being temporarily held for release in 2021 were all released. Two yearlings from the Labor Day Lake cut-block and two yearlings from Northwest Bay cut-block were temporarily held at the centre before translocation into Strathcona Park in early August.

One wild-caught, elderly female (12) with chronic health problems was euthanized on 27-June-21.
In late July 2021 a TBMWMRC inspection report was commissioned by MRF to determine the physical status of the facility and identify building infrastructure which may break, fail, or require updating or replacement. Many of the report recommendations were addressed during this fall and winter

(including electrical and plumbing repairs and diesel tank replacement). Additional recommendations will be dealt with in 2022 depending upon their functional (versus esthetic) importance. Additional expertise will be brought in to evaluate the embankment immediately to the north of the facility (erosion and steepness were identified as possible concerns). Overall, the facility has aged well given the repeated influences of extreme weather and large snow burdens.

6.3 Outlook for 2022

In September 2021, two marmots were moved to Calgary from TBMWMRC and two were moved to Toronto. These moves were made to establish breeding pairs based upon recommendations by the Studbook Keeper (John Carnio). A total of 15 marmots were received from Calgary and eight from Toronto (total = 27 moves). There are currently 65 marmots hibernating at the TBMWMRC. This includes:

- 31 marmots (15 pairs) in the captive breeding program
- 4 younger marmots (less than 2 years of age) retained in the captive program for future breeding
- 4 unpaired, adult males* in the captive program
- 21-22 captive marmots for release in 2022
- 5 marmots captured / recaptured to safeguard them from cougar predation:
    - 2 x yearling, captive-release females* recaptured from Mt Washington (release in 2022)
    - 1 x two-year-old female* recaptured from Mt Washington (release in 2022)
    - 2 x pups captured from Mt Washington (release in 2022)

Note: In the spring of 2022 the 3 recaptured females* will be paired with the unpaired captive males*, so their release in 2022 will depend upon their reproductive status.

Photo 4 "Emergence" by Ryan Tidman

6.4 Summary of Research Colloborations with Marmot Recovery Centre

All three Captive Breeding facilities collaborate on research initiatives with the goal of improving outcomes for released marmots and the wild population. These collaborations may involve providing samples (e.g. fur, tissues, blood, or feces), taking measurements, and assisting with analysis. At MRC in 2020, the Foundation collaborated with partners on the research projects noted below.

- Predator Recognition (Wilder Institute / Calgary Zoo Centre for Conservation Research)
- Food Supplementation (Wilder Institute / Calgary Zoo Centre for Conservation Research)
- Habitat assessment in the Beaufort Range (Alison Macpherson)
- Endoparasites of captive and wild marmots (Kevin Gourlay and Jamie Gorrell, Vancouver Island University)
- Genetics (Kimberley Barrett 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)
- Genome Mapping (Steve Jones, Co-Director & Head, Bioinformatics at the Genome Sciences Centre, BC Cancer Research Centre)
- Marmot nutrition (Sarra Gourlie, CMG nutrition advisors at TZ)
- Morbidity and mortality (Malcolm McAdie)

7. SUMMARY OF CAPTIVE BREEDING PROGRAM

7.1 Background

The captive program began with the first wild captures in 1997 and 2021 represents the 24th year of the captive program. The Toronto Zoo has been involved with the program for 24 years (1997 – present) and the Calgary Zoo for 23 years (1998 – present). The Mountain View Conservation and Breeding Centre in Langley, BC participated from 2000 to 2014. The Tony Barrett Mount Washington Marmot Recovery Centre (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.

Beginning 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 (there were no wild captures in 2020). Although the Recovery Team has endorsed the capture of individuals from select sites (for genetic enhancement of the captive population), in 2021 MRF staff did not catch any additional marmots for the captive program. This activity will continue in 2022, if opportunities present themselves.

To date, a total of 86 wild marmots have been captured for the captive program.

Photo 5 "Nest Box" Automated Camera

7.2 Reproduction

2021 represented the 24th potential breeding season and the 22nd consecutive year of successful breeding in captivity (2000 – 2021). The program has produced 699 weaned pups (386 males, 308 females and 5 unknown) or 8.1 pups for every wild marmot captured for the program.

2019 CAPTIVE REPRODUCTION

- 16 breeding pairs
- Toronto Zoo produced 4 litters and 13 pups (from 7 pairs)
- Calgary Zoo produced 2 litters and 5 pups (from 5 pairs)
- The Marmot Recovery Centre produced 1 litter and 3 pups (from 4 pairs)
- For a total of 7 litters (or 38.9% success of breeding pairs) and 21 pups

2020 CAPTIVE REPRODUCTION

- 20 breeding pairs
- Toronto Zoo produced 2 litters and 8 pups (from 6 pairs)
- Calgary Zoo produced 3 weaned litters and 17 pups (from 7 pairs)
- MRC produced 4 litters and 12 pups (from 7 pairs)
- For a total of 9 litters (or 45% success of breeding pairs) and 37 pups

2021 CAPTIVE REPRODUCTION

- There were 27 breeding pairs in the spring of 2021
- Toronto Zoo produced 2 litters and 6 pups (from 7 pairs)
- Calgary Zoo produced 5 litters and 13 pups (from 9 pairs)
- The Marmot Recovery Centre produced 2 litters and 7 pups (from 10 pairs)
- For a total of 9 litters (or 33% success of breeding pairs) and 26 pups

7.3 Hibernation

From the winter of 1997/98 to the winter of 2020/21 there were a total of 1,979 individual marmot hibernations in captivity with 29 mortalities. Therefore, 1,950 or 98.5% of the captive hibernations were successful over 24 winters.

During these 24 winters there has been one pup hibernation mortality and no yearling mortalities. During the current ongoing hibernation (2021/22) there have been two mortalities, both involving older marmots.

7.4 Mortalities

There have been 130 mortalities in captivity since 1997: 37 cardiovascular, 29 infectious / inflammation, 25 neoplasia, 17 iatrogenic (4 quarantine), 7 cardiovascular / neoplasia, 6 congenital / early onset, 2 intervertebral disc degeneration, 3 unknown, 1 mesenteric torsion, 1 with one osteoarthritis, 2 post-mortems pending.

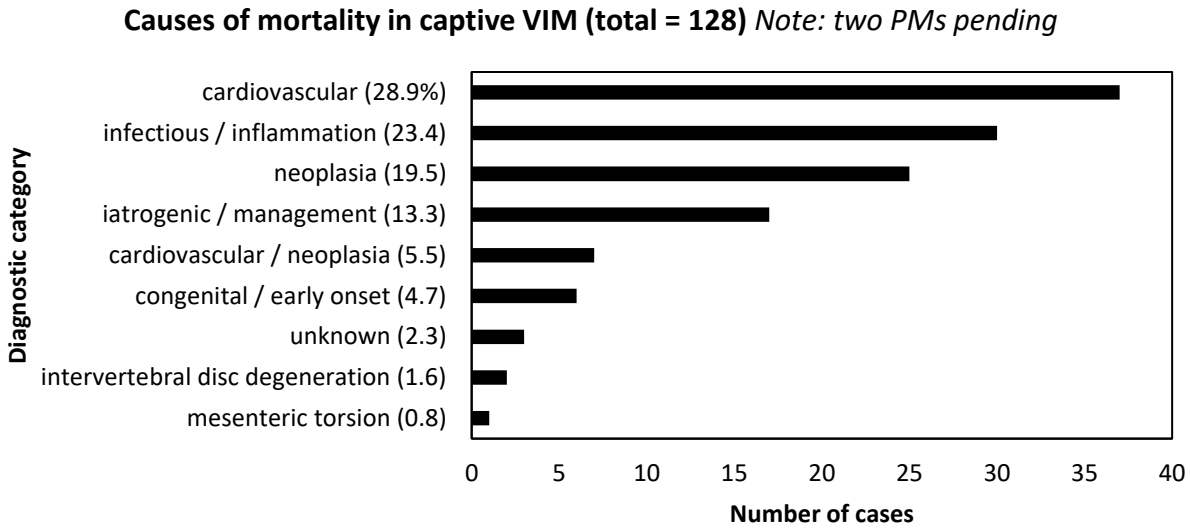

Figure 12. Causes of captive marmot mortality (total = 128, two post-mortems pending)

7.5 Releases

Releases began in 2003 and from 2003 to 2021 (19 seasons) a total of 565 captive marmots have been released to the wild (11 wild-born and 554 captive-born marmots). This represents 6.5 captive-born pups for every wild capture. 80.1% of captive-born pups have been released to the wild. There has been an average of 30 releases per year (range 4 to 85).

Of the 554 captive-born pups that have been released, 134 were born in Toronto, 146 were born in Calgary, 98 at Mountain View, and 176 at TBMWMRC.

Of the 565 releases (up to 2021), 205 went to Nanaimo Lakes (36.3%), 131 to Mount Washington (23.2%), 22 to Mount Cain / Mount Schoen (3.9%), 20 to Clayoquot (3.5%), and 187 to Strathcona (33.1%).

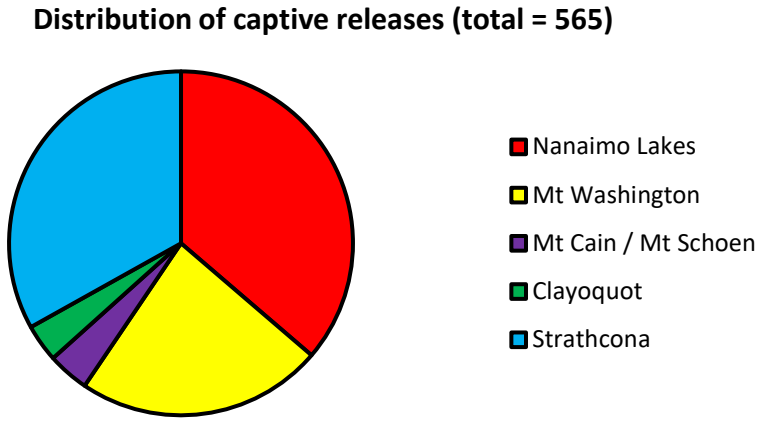

Figure 13 Distribution of Captive Releases

In 2022 we will potentially release the following individuals from captivity:

- two-year-old wild-born female* – recaptured from Mount Washington due to late season cougar predation risk
- 2 x captive-release, two-year-old females* – recaptured from Mount Washington due to late season cougar predation risk
- 2 x wild-born yearlings (one male, one female) – captured from Mount Washington due to death of mother and predation risk
- captive-born 2-year-old male
- captive-born 2-year-old female* – doubtful release candidate due to chronic eye injury, will be paired up in spring 2022
- captive-born 2-year-old male – probable release candidate (held back due to broken incisor, but tooth issue has resolved)
- 21 to 22 captive yearlings (12 males, 10 females)

Note: The release of females indicated by * will be contingent upon their reproductive status in 2022

7.6 Current numbers

Currently, the Studbook lists 92 marmots (30 breeding pairs in the Studbook) in the captive program. This includes:

- 60 marmots at the Marmot Recovery Centre (14+ breeding pairs) – there are also an additional 5 marmots captured / recaptured from Mount Washington late in the 2021 season due to predation risk.
- 14 marmots at Toronto Zoo (7 breeding pairs)
- 18 marmots at Calgary Zoo (9 breeding pairs)

OVERALL CAPTIVE POPULATION NUMBERS (1997 to 2021)

86 wild captures + 699 pups - 565 releases - 130 mortalities + 2 recaptures = 92

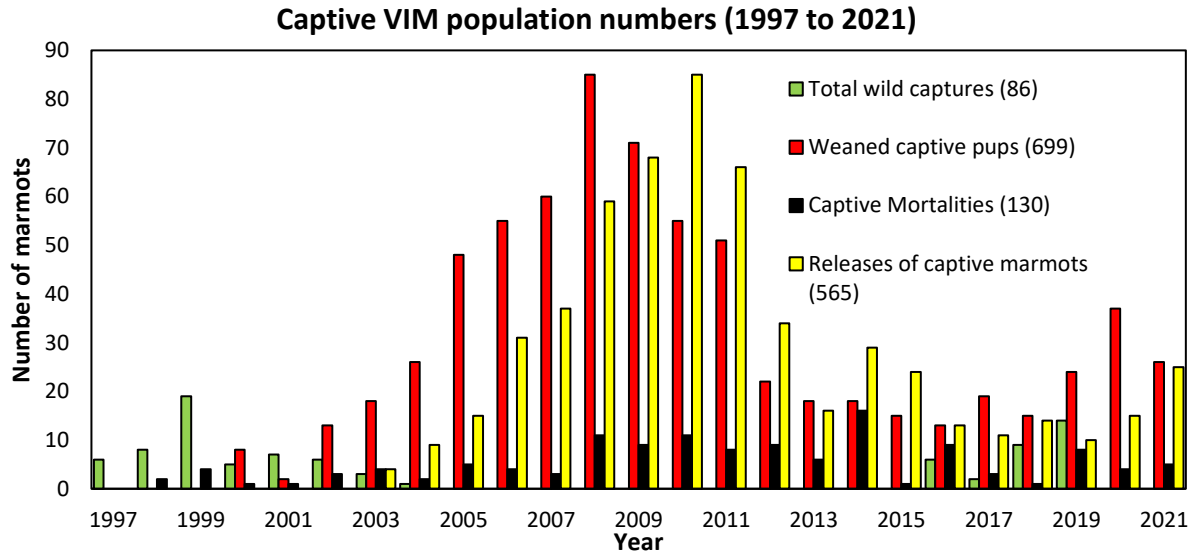

Figure 14. Captive marmot population numbers from July 1997 to March 2021.

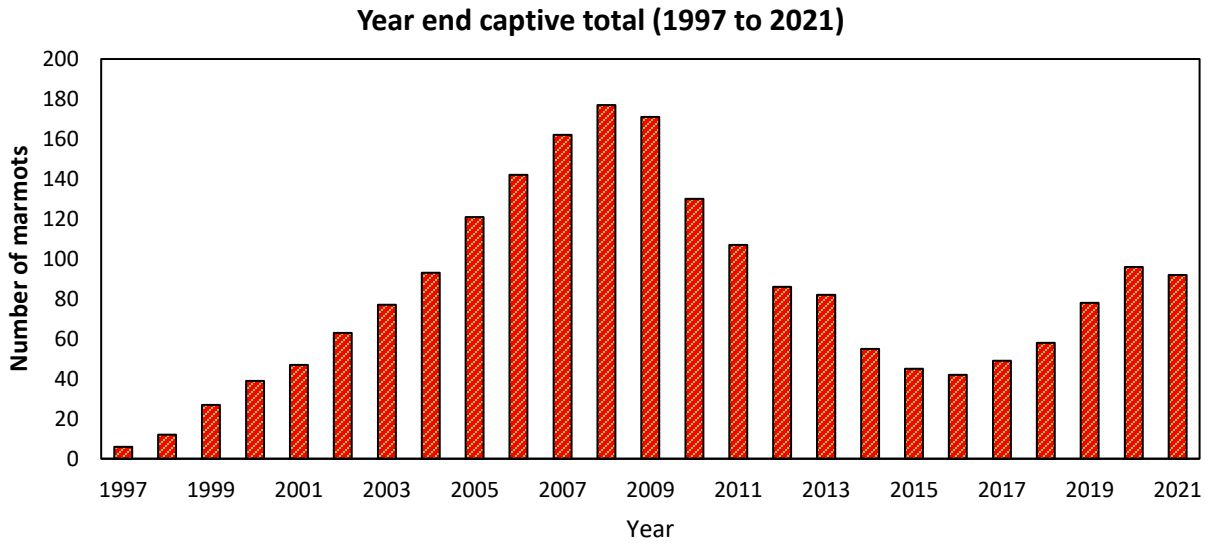

Figure 15 Year-end Captive Total to 2021

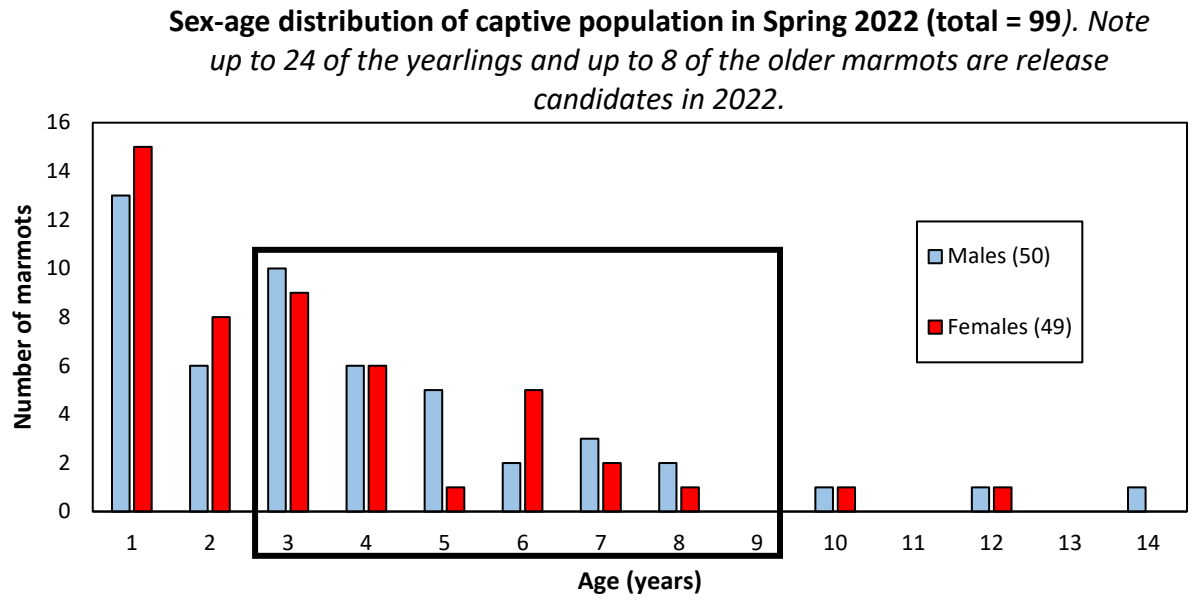

Figure 16 Sex-Age distribution of captive population in spring 2022

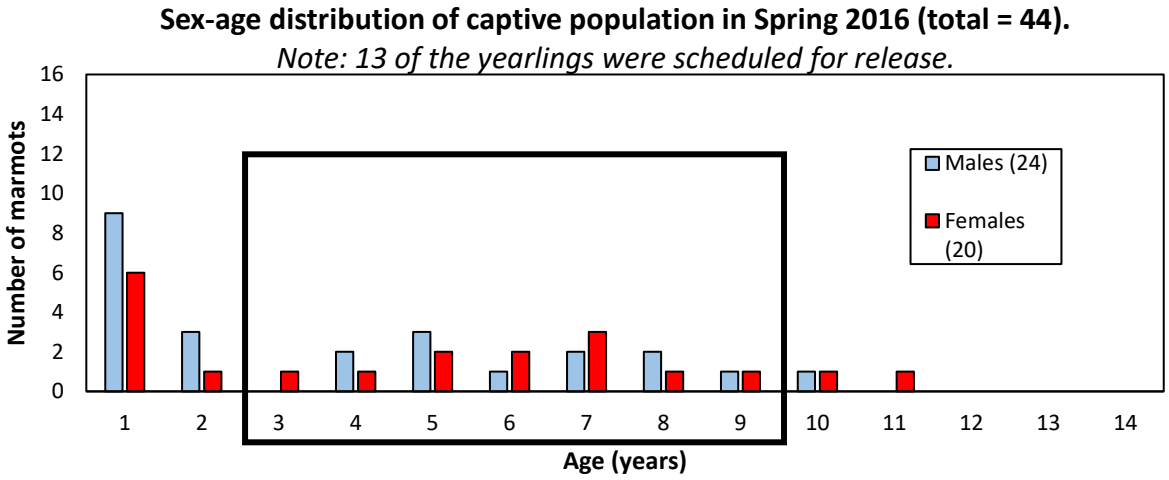

Figure 17 Sex-age distribution of captive population in spring 2016

Table 13 Sources of wild captures (1997 to 2019) – in 2020 and 2021 no individuals were specifically captured for the captive program

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	0	2	11	18
KNIGHT LAKE	LOGGED	0	0	0	2	2
NW BAY	LOGGED	1	0	0	5	6
WHISKEY CK	EXTRALIMITAL	0	1	0	0	1
TOTAL - OTHER		16	4	6	31	57
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	86

Table 14 Annual Summary of captive releases (2003 to 2021 – 19 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
TOTAL	565		89	85	356	35	2

Table 15 Annual summary of releases and translocations (1997 to 2021). Red = captive-releases, yellow = translocations, and blue = translocations

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
TOTAL	**205**	**13**	**5**	**131**	**22**	**1**	**187**	**80**	**34**	**20**	**1**	**565**	**94**	**40**
Number of years	14	5	2	15	4	1	9	10	7	5	1	19	12	9
19	**223**			**131**	**23**		**301**			**21**		**699**		

8. FIELD SAFETY SUMMARY

There were no serious safety incidents in 2021. Field teams continued to take a proactive approach to hazard identification and mitigation, and were quick to report new hazards as they emerged. Near-misses were discussed as a team and have now been incorporated into the Foundation's job safety documents for next season.

8.1 Minor Incidents

- Resource road communication:
  One field team was traveling in separate vehicles near the start of the season. Because they didn't have a truck radio for each vehicle, they traveled in convoy, with the first truck calling kilometers for the three vehicles. New crew in a leading vehicle misunderstood the proximity of a forestry vehicle that had just turned onto their mainline from another mainline, causing the entire group of vehicles to proceed when they should have pulled over. The second vehicle also had a radio and an experienced crew member who recognized the mistake but didn't speak up because they didn't want to appear to be chatting on a busy channel. It worked out fine because the vehicles passed in an area with a wide road. This wasn't a near-miss, but a scary incident that could have been a near-miss. The group reviewed the road names for the area to help everyone become better acquainted with which roads intersect where. They also discussed how communications should have gone in that situation. The crew leader encouraged everyone to prioritize safety and speak up if there was ever risk, even if that meant interrupting on the hauling channel.

8.2 Near-misses

- No near misses to report.

Photo 6 "Field Team 2021" Michael Lester

9. RECOMMENDED APPROACH FOR 2022

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 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 two primary recommendations for 2022:

- 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.

The net result of the above actions is that even with 29 to 30 marmots available for release, there will likely be few marmots available to augment the small colonies in Strathcona Provincial Park in 2021.

9.1. Proposed Supports for the Wild Population

(i) *Captive-breeding releases*

There are 29 to 30 marmots currently at the Tony Barrett Mount Washington Marmot Recovery Centre identified as potential release candidates for 2022. 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 a number 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 retain the majority of potential translocation candidates in the wild colony on Mt. Washington. Exceptions may be made for young marmots that already have sufficient genetic representation in this colony, marmots that are not socially integrating with other members of the colony, or marmots that are spending time in unsuitable habitat or appear likely to naturally disperse from Mt. Washington if not first translocated. The Foundation expects to re-release onto Mt. Washington five marmots captured or recaptured there in 2021 due to predation risk. This plan will change if these marmots are reproductively active, or develop health or welfare concerns that might prevent them from contributing to a colony upon their re-release.

The Foundation will also attempt to trap, implant, and translocate young (1-2yo) marmots from cutblock colonies and other unsuitable habitat in 2022. This activity will be critical for

providing some support to colonies in Strathcona Provincial Park, since the Foundation does not anticipate other sources of augmentation candidates for that region.

(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 8-16 spring feeders on Mt. Washington and at select sites in Strathcona Provincial Park and 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 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 3 to 6 locations.

(viii) Predator deterrence

The Foundation will trial and report on using predator-deterring lights at one location on private land.

9.2. 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 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 will use wildlife cameras at colonies that are not easily accessible for ground-based surveys. The Foundation will attempt aerial telemetry via helicopter using a new antenna setup.

(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 the use of acoustic recorders and telemetry base-stations to improve monitoring efficiency and effectiveness. Both 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.

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

9.3. 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 2022, 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).

9.4. COVID-19 Safety Measures

The Foundation believes that safety measures will continue to be needed to mitigate potential risk to the marmots, our staff, and the general public. The Foundation will continue to implement COVID-19 safety plans prepared in 2020, and will continuously review and update those plans in response to guidance from Provincial Authorities. Should public requirements be removed, the Foundation will develop and implement protocols to mitigate risk to marmots specifically.

10. 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-deterring 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.
- 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.
- Exploration of drone-based radio telemetry technology.

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

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MARMOT

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