

Vancouver Island Marmot - Buttle Lake Supplementation Project
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(Photo by C. Jackson)

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EXECUTIVE SUMMARY

The endangered Vancouver Island marmot (*Marmota vancouverensis*, Swarth 1911) is one of only five endemic land mammals in Canada (Nagorsen 2004). The National Recovery Plan for the Vancouver Island marmot (1994, 2000) recommended captive breeding and reintroduction as the best hope for recovering the species. The Recovery Strategies describe an ultimate goal of two to three geographically distinct metapopulations, each comprised of 150-200 marmots (Janz et al. 1994, 2000; Vancouver Island Marmot Recovery Team 2008). Since 2003, the captive-breeding program has produced 431 marmots for release to the wild. Initial releases focused on the southern core and achieved some success at re-establishing a metapopulation in the Nanaimo Lakes area. To expand the distribution into more of the marmot's historic range, we introduced several fledgling colonies to the east and west sides of Buttle Lake; however, re-establishment of metapopulations outside the southern core were more challenging because of a lack of extant colonies. An evaluation of reintroduction success for captive-bred Vancouver Island marmots determined that overwinter survival was the most limiting factor in marmots surviving their first post-release year, but that marmots that survived the first winter had nearly perfect survival in subsequent years (Jackson 2012). In 2011, the Recovery Team approved testing of new release techniques in hopes of improving overwinter survival of released marmots. This project addressed that problem through use of multiple strategies aimed at accelerating species' recovery. Project trials included (1) the introduction of spring supplemental feeding as a possible stimulant for successful breeding, (2) evaluation of wild-born marmots as a superior source of marmots for translocation to the Buttle Lakes area, and (3) evaluation of efficiency gained by pre-conditioning captive-bred marmots in a wild hibernation at Mt. Washington. Feeder trials were initiated in 2011, and translocation trials began in 2012. In 2013, we installed 12 feeders on Mt. Washington and translocated 11 pre-conditioned and 16 wild-born marmots to the Buttle Lake area. We counted 12 pups born on Mt. Washington, and documented the first known litter on Castlecrag Mountain.

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1. INTRODUCTION

The Vancouver Island marmot (*Marmota vancouverensis*) is a large ground squirrel endemic to Vancouver Island, in British Columbia, Canada. In 1979, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Vancouver Island marmot as a nationally endangered species, a designation confirmed by the BC Wildlife Act in 1980 (Munro et al. 1985), the International Union for the Conservation of Nature in 1982 (Thornback and Jenkins, 1982), and the United States Endangered Species Act in 1984 (Vancouver Island Marmot Recovery Team, 2008). In 1994, the National Recovery Strategy (Janz et al. 1994) called for increased inventory and research on the species. By 1997, the southern population of Vancouver Island marmots was still in decline and the Buttle Lake metapopulations were represented by a single, isolated colony on Mount Washington (Bryant 1997).

Paleoecological evidence suggests that a shift in historic habitat from open heather and meadow to forest may have reduced availability of suitable habitat (Hebda et al. 2004), and increased predator success (Milko 1984). Recent population declines have been attributed primarily to predation (Aaltonen et al. 2009; Bryant and Page 2005, Bryant 2000). The reasons for population decline in Strathcona Provincial Park remain unclear, but it was probably related to a combination of pressures from predation, weather, disease, landscape-level change, and colony isolation (Janz et al. 1994). The impoundment of Buttle Lake is hypothesized to have impeded marmot dispersal between colonies because of a lack of landscape connectivity (Janz et al. 2000). Prior to 2007, the last marmots reported in Strathcona Park were solitary individuals seen on Mount Albert Edward in 1992, and at the Westmin mine site in 1995 (A. Bryant, unpublished data).

Following the recommendations laid out in the National Recovery Strategies for the Vancouver Island Marmot (1994, 2000, 2008), a captive-breeding program was established in 1997. The Recovery Strategies describe an ultimate goal of two to three geographically distinct metapopulations, each comprised of 150-200 marmots (Janz et al. 1994, 2000; Vancouver Island Marmot Recovery Team 2008). Releases have been carried out since 2003 to increase the wild population and expand the geographic distribution of extant colonies. Initial reintroduction efforts focused on the southern core of historic habitat in the Nanaimo Lakes area, north of Lake Cowichan and south of Port Alberni. After several years of releases and shepherding efforts by field crew, a metapopulation of 150-200 marmots has been re-established in the Nanaimo Lakes area. We are presently evaluating its viability.

Multiple metapopulations are necessary to protect the Vancouver Island marmot against stochastic demography and catastrophic events (VI Marmot Recovery Team 2008); therefore, in 2007, the recovery project began releasing captive-bred marmots in historic habitat to the east and west sides of Buttle Lake. Reintroductions have proven more challenging in the Buttle Lake area than in the south, which had extant colonies to provide additional support to metapopulation recovery. An evaluation of reintroduction success for captive-bred Vancouver Island marmots determined that overwinter survival was the most limiting factor for marmots surviving their first post-release year. Once captive-bred marmots had survived their first wild hibernation, their predicted overwinter survival rate was equivalent to that of wild-born marmots (Jackson 2012). In 2012, with Recovery Team approval, we adapted our reintroduction strategy to introduce and evaluate several new techniques aimed at increasing overwinter survival by marmots released to the Buttle Lake area. These techniques included (1) the introduction of spring supplemental feeding as a possible stimulant for successful breeding, (2) evaluation of wild-born marmots as a superior source of marmots for translocation to the Buttle Lakes area, and (3) evaluation of efficiency gained by pre-conditioning captive-bred marmots in a wild hibernation at Mt. Washington. This report describes our methods and results for 2013, year two of a three-year project.

2. OBJECTIVES

- Continue feeder trials initiated in 2011. Install feeders at all emergence holes on Mt. Washington and at select sites in the Buttle Lake area.
- Continue translocation trials initiated in 2012. Translocate marmots to support fledgling colonies on Greig Ridge, Tibetan Plateau, Henshaw, Castlecrag and Sunrise Lake, and to sites near Morrison Spire and at the upper Drinkwater drainage.
- Improve detection rate for marmots released to the Buttle Lake area.
- Assess overwinter survival of marmots moved in 2012 translocation trials. Monitor active season for marmots released in the Buttle Lake area in 2012 and 2013.
- Monitor movements of marmots. When possible, locate hibernacula to aid in verification of emergence from hibernation in subsequent years.
- Verify reproduction and survival of previously released or translocated breeding age females and their offspring.
- Capture and implant pups born in the previous year and replace expired transmitters from past releases.
- Ongoing collection of field data to monitor marmot population numbers and answer research questions

3. STUDY AREA

All of the sites selected (Figure 1) reflect typical Vancouver Island marmot habitat consisting of wet sedge meadows in combination with talus boulder complexes in the alpine tundra (ATc) and subalpine zones (MHmm2) between 900 metres and 1400 metres in elevation (Bryant 1998). They are located within the historically occupied range of the Vancouver Island marmot (see Recovery Strategy 1994, 2000, 2008).

(i) Castlecrag (UTM: 10U 327898 E 5509715 N) is located at the south end of Forbidden Plateau, near the headwaters of the Cruickshank River. Its relatively close proximity to Sunrise Lake means that it may serve as a midpoint for marmots dispersing from Mt. Washington, Sunrise Lake, or Henshaw. It is characterized by a large expanse of lush meadows and rock slides on the southern face of the mountain, which makes it ideal habitat. We released captive-bred marmots to Castlecrag in 2010 and 2011 and translocated marmots here in 2013. We installed a spring feeder near a successful hibernaculum in 2011, 2012 and 2013.

(ii) Drinkwater (UTM: 10U 316487 E 5483468 N) basin is located at the south end of Buttle Lake and the north end of Della Falls, southwest of Flower Ridge. Drinkwater features slide habitat, meadows, boulder complexes and a surrounding area that should support dispersing marmots. We rated Drinkwater highly on our initial 2005 surveys of suitable marmot habitat. We released captive-bred marmots to the Drinkwater in 2009, 2010, and translocated a group of marmots in 2012 and 2013.

(iii) Flower Ridge (UTM: 10U 319832 E 5485480 N) is at the south end of Buttle Lake near the headwaters of Price Creek. It is located between Drinkwater and Henshaw. The south end of Flower Ridge was chosen because it has highly suitable habitat. We released captive-bred marmots to Flower Ridge in 2009, and translocated a group of marmots in 2013.

(iv) Greig Ridge (UTM: 10U 305628 E 5502021 N) is located approximately 10.5 kilometers west of Buttle Lake, within the Phillips Creek drainage which flows into the west side of Buttle Lake. Tibetan and Morrison Spire release sites are to the northeast of Greig Ridge. Greig Ridge includes over six kilometres of alpine/subalpine habitat and features the largest subalpine complex with high marmot habitat suitability

in the Buttle Lake area. This site was initially chosen for reintroductions because of existing burrows (c1980). We have released marmots at Greig Ridge every year since 2007, including translocating mixed groups of marmots to the hill in 2012 and 2013.

(v) Henshaw (UTM: 10U 320795 E 5491691 N) is located at the south east end of Buttle Lake near the headwaters of Henshaw Creek. Henshaw is north of Flower Ridge and southwest of Castlecrag release sites. A broad band of lush alpine meadows and talus boulder slides spans across the mountain. Surveys completed in 2009 showed large amounts of suitable marmot habitat at this site. We released marmots at Henshaw in 2010 and 2011 and translocated a group of marmots here in 2013. We installed a spring feeder at Henshaw in 2012.

(vi) Morrison Spire (UTM: 10U 307683 E 5507015 N) is located near the headwaters of Greig Creek and the Marble Meadows/Limestone Cap area. Morrison Spire sits northeast of the Tibetan release site, and is typically one of the first sites in spring to become free of snow. We released marmots to Morrison Spire in 2010 and 2011 and translocated marmots here in 2013.

(vii) Sunrise Lake (UTM: 10U 315875 E 5483088 N) is part of Forbidden Plateau. It is located on the north side of Jutland Mountain near the headwaters of Oyster River and Piggott Creek. Sunrise Lake sits northwest of Castlecrag and southwest of Mount Washington. Initially, we chose Sunrise because of its historical relevance; it was one of the last known locations in the park where a marmot was sighted (1981, A. Gibson, pers. comm.). Last year, a male from Mount Washington dispersed eight kilometres to this location, the first dispersal recorded by a marmot outside the southern metapopulation. We released marmots at Sunrise in 2010, 2011 and translocated marmots here in 2013. We installed a supplemental feeder at Sunrise Lake in 2012 and 2013.

(viii) Tibetan (UTM: 10U 306568 E 5503614 N) is the first peak on the connecting ridgeline from Greig Ridge to Marble Meadows and Morrison Spire. This site contains a mixed boulder and talus slope, with many options for refuge. This site was chosen for its proximity to Greig Ridge and its potential to act as a stepping stone to Morrison Spire. We released marmots to Tibetan in 2009, 2010, and translocated two marmots here in 2012. We did not release or translocate marmots to this site in 2013, but we did install a spring supplemental feeder in both 2012 and 2013.

4. METHODS

4.1 New reintroduction strategies

4.1.1. Feeder trials

Literature on reintroduction of species strongly recommends the use of wild-born animals when possible (Fischer and Lindenmayer 2000; Wolf et al. 1996; Griffith et al. 1989; Beck et al. 1994). However, until very recently, there were no wild Vancouver Island marmot colonies that were large enough to provide 'surplus' marmots for translocation into the Buttle Lake area without risking adverse demographic effects at local and metapopulation levels (D. Doyle, pers. comm.). Supplemental feeding has been demonstrated to increase adult body condition, percentage lactating, percentage weaning litters, and litter size in Columbian ground squirrels (Karels et al. 2001). Therefore, we conducted feeder trials at Mt. Washington in the springs of 2011-2013, with the hope that providing early, high-quality supplemental food would promote pup production on the hill and that this would make available wild-born candidates for translocation to the Buttle Lake watershed. Feeders were constructed from PVC pipe, and were filled with Mazuri® leaf-eater biscuits. The feeders at Mt. Washington were re-filled twice a week from the date of installation (May) until the snow had melted enough to reveal natural food sources (mid-to-late June). We also installed feeders at emergence burrows for captive-bred marmots that were completing their first wild hibernation at Mt. Washington as part of a pre-conditioning experiment (see 4.1.2). We installed secondary feeders at select sites around Buttle Lake to see if it would increase the likelihood of

reproduction at fledgling colonies (Table 1). Feeders at these sites were accessible only by helicopter, and so were not typically refilled after initial installation.

We designed feeder trials as a multi-year project aimed at answering the following research questions:

1. Are wild-born and previously released marmots more likely to wean **larger than average litter sizes** when provided with supplemental food at their spring emergence hole?
2. Are wild-born and previously released marmots more likely to produce **more frequent than average litters** when provided with supplemental food at their spring emergence hole?
3. Are wild-born and previously released marmots more likely to produce **litters at an earlier age** when provided with supplemental food at their spring emergence hole?
4. Are captive-bred marmots released to Mt. Washington in pre-conditioning experiments more likely to achieve **greater overwinter survival rates** when provided with supplemental food at their spring emergence hole?

4.1.2 Translocation trials

An evaluation of reintroduction success for captive-bred Vancouver Island marmots released 2003-2010 identified a “release effect” of poor overwinter survival in the first post-release hibernation (Jackson 2012). Captive-bred marmots were found to average only 58.3% survival, whereas wild-born and previously released marmots achieved near-perfect survival each winter (Jackson 2012). A common assumption across reintroduction projects is that wild-born animals are superior to captive-bred animals in their survival and reproductive abilities at new locations. To evaluate whether or not this may be true for the Vancouver Island marmot, we initiated translocation trials that released mixed groups of wild-born and captive-bred marmots to the Buttle Lake area. In 2012, we structured Buttle Lake release groups to include marmots with three levels of hibernation experience: (a) “wild-born” marmots from Mt. Washington with at least one wild hibernation, (b) “pre-conditioned” captive-bred marmots that had been released to the wild colony at Mt. Washington and survived for one or more winters, and (c) “direct-released” captive-bred marmots moved from captivity directly into the wild without any prior wild experience. In 2013, release groups included only wild-born and pre-conditioned marmots (Table 2).

Many sites used in the translocation trials received both released and translocated marmots. For the sake of simplicity, we will call all sites “release sites” and describe all marmots as being “released” regardless of the method of reintroduction. When describing marmots moved into the Buttle Lake area, by definition, “wild-born” marmots were all necessarily translocated, “pre-conditioned” marmots were all captive-bred, released once at Mt. Washington, and then translocated, and “direct-released” marmots were all released from captivity for the first time to a mountain in the Buttle Lake area.

Translocation trials required an intensive effort on Mt. Washington, as there were several stages in preparing groups of animals for release, and preparation must begin one year prior (see Appendix IV for approximate timelines). Briefly, in July 2012, we surgically implanted and released 15 captive-bred marmots to be pre-conditioned in the wild colony on Mt. Washington. They hibernated overwinter in true hibernacula, were provided with supplemental food at emergence, and the 11 survivors that could be located were re-trapped in 2013 for translocation. In June 2013, we trapped and implanted 19 wild-born marmots with radiotelemetry transmitters, and in July, we re-trapped 16 wild-born marmots for translocation. In 2013, we did not direct-release any captive-bred animals to the Buttle Lake area. Translocations were carried out in July, as described in the release protocols section below. We also released 16 captive-bred marmots at Mt. Washington for a pre-conditioning hibernation in anticipation of translocating them to the Buttle Lake area in 2014.

The translocation experiments were designed to help us answer the following *a priori* research questions:

1. In the first summer after translocation, are wild-born and/or pre-conditioned captive-bred marmots more likely to achieve *active season survival* than direct-released captive-bred marmots?
2. In the first hibernation after translocation, are wild-born and/or pre-conditioned captive-bred marmots more likely to achieve *overwinter survival* than direct-released captive-bred marmots?
3. In the first spring following translocation, are wild-born marmots and/or pre-conditioned captive-bred marmots more likely to *successfully breed* than direct-released captive-bred marmots?

4.2 Release Preparation

Release sites were selected once overwinter survival of marmots in 2012-13 had been confirmed, so that marmots could be released to or near colonies that most needed support. In June and July, we conducted helicopter-based surveys of release sites to verify that snow had sufficiently melted and forage plants would be available for translocated marmots. All release sites had been used in previous years, and so ground searches for appropriate release burrows were unnecessary.

4.3 Field Camp Preparation

We set up a reduced base camp on Greig Ridge in the same location as in previous years. We took care to minimize the ecological impact of all activities while working onsite, and we paid particular attention to avoid damaging alpine heathers (*Calluna spp.*). Because we anticipated less intensive camping at Greig Ridge in future years (shorter and/or less frequent trips), we dismantled the base camp at the end of the 2013 active season and hired a helicopter to fly out the tent platforms and BC Parks tank toilet. We did not set up field camps at Castlecrag, Sunrise, Morrison Spire, Henshaw, Flower Ridge and Drinkwater, although we intend to camp at many of these sites next year for inventory and implant purposes.

4.4 Release Protocols

Captive-born marmots were bred at three facilities across Canada: the Calgary Zoo (CZ), the Toronto Zoo (TZ), and the Mountain View Breeding and Conservation Center (MVF) in Langley, BC. We used the Tony Barrett Mount Washington Marmot Recovery Center (TBMWMRC) on Mt. Washington as a temporary holding facility for wild-born and pre-conditioned marmots that were re-trapped prior to their translocation to the Buttle Lake area.

The Project Veterinarian examined, ear tagged (National Band and Tag Co. Newport, KY USA) and implanted wild-born marmots with VHF radio transmitters (Telonics Inc. Mesa, AZ. USA; Holohil Systems Ltd. Ontario, Canada; or ATS, Inc. Isanti, Minnesota). Because they had never been in captivity and the stress of a captive environment could have hindered their recovery, we released wild-born marmots back to their burrows after field surgery. Implanted marmots were given a minimum of two weeks convalescence to allow for adequate healing from the implants before we re-trapped them in preparation for translocation. In the days immediately prior to translocation, wild-born and preconditioned marmots were kept in captivity for a short period of time. This was necessary because all 27 marmots translocated to the Buttle Lake area in 2013 first needed to be re-trapped in the wild, examined by the veterinarian and then partitioned into release groups balanced by sex and age.

With the goal of maximizing breeding potential, it is a principle of the Recovery Team to leave no breeding-age females unpaired (Janz et al. 2000). Castlecrag, Sunrise, and Morrison Spire each had only one marmot (a female) with a working transmitter in the spring of 2013. The first translocation groups were released at these sites, which made up roughly half of the translocation sites for 2013.

4.5 Monitoring

4.5.1 Radiotelemetry

We tracked each marmot by radio telemetry throughout the field season. Telemetry receivers include the HR2000 Osprey® (Habit Research Ltd. BC, CA), TR-4® (Telonics Inc. AZ, USA), R1000 (Communications Specialist, Inc. CA, USA) Lotek SRX 400® and SRX 1000® (Lotek Wireless Inc. ONT. CA.). Antennas include the Telonics RA-14® “Rubber Ducky” antenna (Telonics Inc. AZ, USA) and 3-element Yagi from Wildlife Materials (Wildlife Materials Inc. IL, USA).

Implanted transmitters were designed to emit different pulse rates based on the transmitter temperature and ultimately determined by the body temperature of the marmot itself. A marmot was considered to be on “active” pulse if the pulse rate averaged ≥ 28 beats per minute. Marmots with an active pulse were considered to be alive. Because bare transmitters exposed to the sun have been known to heat to an active pulse rate when they should really indicate mortality, we conducted ground- and helicopter-based telemetry in the morning before temperatures became warm enough to create this effect.

A marmot was considered to be on “mortality” pulse when there was an average pulse rate of < 28 beats per minute. A marmot with a mortality pulse rate was evaluated as either dead or hibernating depending on the time of year, although marmots on mortality pulse between late September and early June could have been either dead or hibernating. Whenever possible, we attempted to recover transmitters of marmots detected on mortality pulse to infer the cause of death. Mortalities were classified as hibernation-related when the marmot was known to have survived to the previous fall and did not emerge the following spring, or when it died shortly after emergence. Mortalities were classified as predation events when a bare transmitter was recovered within a few months of the animal being detected alive. At many kill sites, predators left clues as to which species was responsible for the mortality, and we swabbed recovered transmitters to verify species by DNA.

It is critical for us to collect data on the success of marmots released in translocation trials in order to infer the best direction for our future reintroduction efforts. However, much of our inventory in the Buttle Lake area required helicopter-based telemetry that is costly and time-consuming, particularly when searching for marmots that left their release sites. We attempted to increase the end-of-season detectability of marmots translocated in 2013 by modifying our flight strategy so that we could detect marmots over a greater distance. Marmots have been known to travel > 25 km in a single active season (J. MacDermott, pers. comm.), and so we started at each release site and flew in increasing spirals to a maximum distance of 20 km before moving back to the next release site and starting a new search. We also flew at a much higher altitude than in typical flights. This sacrificed our ability to precisely locate each marmot but increased the distance at which we could detect them and confirm their survival status.

4.5.2 Measures of Success

In a study comparing reproduction by wild and captive marmots, Bryant (2005) found that the mean age of first breeding for wild females was 3.6 years. He estimated that the average number of pups in wild litters was 3.4 (SD=1.1, n=58), and determined that females usually produced pups either biennially (39.3%, n=11) or with a two-year interval (14.3%, n=4). Although females could wean pups in consecutive years (46.4%, n=13), Bryant estimated that the average interval between litters was 1.9 years (SE=0.7, n=17).

We defined feeder trial success as a lower average age of first breeding, smaller average interval between litters, or a higher average litter size than that noted in the wild litters studied by Bryant (2005). We also monitored overwinter survival of captive-bred marmots released at Mt. Washington for a pre-conditioning winter prior to translocation to the Buttle Lake area. From 2003-2009, the average rate of first-year overwinter survival by captive-bred marmots on Mt. Washington was 64.3%. Therefore, we consider a

greater estimated overwinter survival rate for as an additional measure of success for feeder trials, although we acknowledge the confounding influence of year.

We identified two short-term and one long-term measure of success for our translocation trials:

We defined *active season survival* as the survival of a marmot from its date of release or translocation to mid-September. Ideally, we would have waited until each marmot was on mortality signal and tracked them to a plugged burrow to confirm that they were underground and hibernating. As a proxy, because not all marmots can be tracked to their hibernaculum in the fall, Jackson (2012) assumed that a marmot survived to hibernation if it was detected alive in October and if its bare transmitter was not found above ground the following spring. We chose to define the end of the active season as September because inclement weather in October typically prevents helicopter surveys in the Buttle Lake area, and because the challenging terrain precludes ground searches for transmitters in spring.

We defined *overwinter survival* as the survival of a marmot that was presumed to have survived to enter hibernation the previous fall to a spring survey in early June of the following year.

A female marmot achieved *successful breeding* by raising a litter of pups to weaning so that at least one pup was seen or recorded by remote camera above ground on or after the first week of July. Because Vancouver Island marmots stay at their natal site until at least two years of age (Bryant 2005), pup litters could also have been confirmed retroactively by documenting yearlings at a site.

4.6 Statistical Analyses

For biologists conducting observational studies, information theory has become increasingly popular as a means to draw robust inferences about the processes underlying their data. Information theory was designed as an extension of likelihood theory that estimates the information lost by applying one probability distribution to approximate another (Burnham and Anderson 2002). In an information theoretic approach, biologists identify *a priori* questions, design models to represent biologically tractable hypotheses, and select one or more models to use in estimating parameters. Models are evaluated based on their predictive performance, and variables can be evaluated according to the precision of their estimates and, in the case of multi-model inference, their relative importance within the model set (Burnham and Anderson 2002).

We intend to create several models to predict our measures of success. Measures of success for the feeder trials on Mt. Washington include litter frequency, litter size, and age of first breeding by marmots that are provisioned with spring supplemental food. An additional measure of success for the feeder trials is first-year overwinter survival by newly released captive-bred marmots, which have poor survival in their first wild hibernation relative to wild-born and previously released marmots (Jackson 2012). The translocation trials also have several measures of success, including active season and overwinter survival and, with time, reproduction.

We expect to use mixed effects models to analyze the data because they also permit the inclusion of random effects such as year and mountain. Fixed effects will vary for each measure of success, but will include class variables such as ‘experience treatment’ (e.g. wild-born, pre-conditioned captive-bred, or direct-released captive-bred), binary variables such as supplemental feeding (e.g. yes or no), and variables identified in literature as being important to our measures of success. To avoid over-parameterization, we will aim for a ratio of $n/10$ for parameters estimated in each model (Burnham and Anderson 2002), although events-per-variable ratios as low as 5-9 can sometimes provide robust parameter estimates (Vittinghoff and McCulloch 2007). We expect an imbalance in the number of successes and failures; therefore, we plan to evaluate discriminatory performance of models using the True Skill Statistic (TSS), which is not influenced by prevalence (Allouche et al. 2006).

5. RESULTS

5.1 Feeder Trials

(i) Mt. Washington - We identified 12 emergence holes and installed 12 feeders and remote cameras nearby. Of the 13 captive-bred marmots released to Mt. Washington in 2012 that survived to hibernate, 11 were detected in spring, and eight of the 11 (72.7%) had achieved overwinter survival (Figure 2). Field crew observed five litters born to females aged seven (Nicola), five (Patricia, Roselie), and two (Hollis, Buffy), and comprised of 12 pups. Given a 47% underestimation for pups counted in 2012 and standard litter sizes of 3-4 pups, we assume there were probably 15-20 pups born in 2013 (Figure 3). Two of the litters were born to females that also successfully weaned litters in 2011 and 2012 (Nicola and Roselie). The wild-born 2yo females Hollis and Buffy had been candidates for translocation, but we did not move them when we discovered that they had bred.

(ii) Sunrise – We located one emergence hole, and a single feeder was installed. Time constraints prevented crew from conducting ground surveys to check for pup litters.

(iii) Castlecrag – We did not find a spring emergence hole, but we did see fresh tracks and so we installed a single feeder nearby. Remote camera footage showed use by a single tagged marmot, but field crew noted a single pup at the hibernaculum during an inventory trip in September, which proves that there had been >1 adult at the site in spring. There was probably >1 pup in the litter, but time constraints precluded more intensive surveys.

(v) Tibetan – We observed one emergence hole in spring, and a single feeder was installed on-site. Remote camera footage showed three adults, only two of which had ear tags (Figure 4). We suspect the third adult was one of two pups born in 2009 because only one pup was trapped, implanted and tagged during the 2010 trapping trip.

5.2 Translocation trials

5.2.1 – Detectability

As in previous years, site surveys were limited by time, weather, rugged terrain, and the large number of marmots for which to search. Fall 2012 surveys detected 66.7% of marmots translocated in 2012, and spring 2013 flights detected 47.8% of translocated marmots that may have survived to hibernate in 2012-13. The new flight strategy we applied in the fall, in combination with ground surveys on Greig Ridge and Tibetan Plateau in early September, enabled us to detect 92.6% of marmots translocated in 2013, a significant improvement on the previous year. We also detected 66.7% (14 of 21) of marmots translocated in 2012 that had not previously been confirmed as mortalities, including locating six marmots that had been missing in previous surveys.

5.2.2 – Pre-conditioning at Mt. Washington

Marmots released in 2011, 2012 that survived to emergence the following springs had access to supplemental feeders upon emergence. In the 2011-12 hibernation, captive-bred marmots being pre-conditioned at Mt. Washington achieved 62.5% overwinter survival (10 of 16 animals). In the 2012-13 hibernation, captive-bred marmots achieved 72.7% survival (8 of 11 animals). The 2013 spring was particularly mild when compared to previous years, with low snow levels and rapid melt (Figure 5).

5.2.3 – 2012 translocations

At the end of the 2012 active season, we detected 20 of 30 marmots translocated in 2012 (see Appendix V for summary). Thirteen marmots had survived the active season, seven marmots had died prior to hibernation, and 10 were missing. In the spring of 2013, we located 11 of 23 animals (47.8%), and confirmed overwinter survival for 10 of them (90.9%). By the end of the 2013 active season, we had re-located six missing marmots, and confirmed survival for 10 of 14 detected marmots. One of the marmots

detected on mortality signal was missing from her date of translocation to late September, and so there is a chance that she was already hibernating when detected; because we could not confirm her survival status, we counted her as “missing”. We estimate that 83.3% of wild-born marmots survived a full year after translocation (5 of 6 detected), compared to 25.0% of pre-conditioned marmots (1 of 4 detected) and 36.4% of direct-released marmots (4 of 11 detected; Figure 6). One possible mortality and three new mortalities were confirmed in 2013, and 8 marmots were missing in our last ground and helicopter-based surveys. Known survivors include 5 wild-born marmots, 1 pre-conditioned marmot, and 4 captive-bred direct-released marmots.

5.2.4 – 2013 translocations

In September 2013, we detected 25 of 27 (92.6%) marmots translocated in 2013 (see Appendix VI for summary). We found that 23 of 25 marmots (92%) had survived the first active season, including 12 of 16 wild-born marmots and all 11 pre-conditioned marmots (Figure 7). We detected 2 mortalities of wild-born marmots. Two wild-born marmots were not detected during ground surveys or helicopter flights.

5.3. Statistical analyses

We are still in the process of collecting the data we need to model our measures of success.

5.4. Population dynamics in the Buttle Lake area

There were nine mortalities in the Buttle Lake area in 2013, including one mortality during hibernation and eight mortalities of unknown cause. It has been our experience with the Nanaimo Lakes metapopulation, whose release sites are more accessible and transmitters more regularly recovered, that active season mortalities between early June and late September are almost always the result of predation (D. Doyle, pers. comm.). We recovered transmitters for 100 mortalities of tagged marmots in the Nanaimo Lakes metapopulation (1994-2013), and determined that 89% of active-season mortalities were predation-related and 1% was caused by accident or injury. The remaining 10% of mortalities were caused by factors that could not be inferred. Based on the timing of mortalities detected in 2013, therefore, we attributed one mortality to hibernation, and five mortalities to suspected predation. We assigned three mortalities to unknown causes; those marmots were not detected within a small enough time frame to infer the cause of mortality.

To date, there have been a total of 103 marmot mortalities in Strathcona Provincial Park since releases began in 2007. We attributed 35% of mortalities to predation (9% confirmed, 26% suspected), 23% to hibernation, and 42% to unknown causes (Figure 8). Of the nine predated marmots whose transmitters we recovered, we determined that six mortalities were caused by eagles, one by a wolf and one by a cougar. For one mortality, we could not identify the type of predator. There were an additional eight mortalities on Mt. Washington, including five mortalities related to hibernation, two caused by predation, one by infection, and one in an accident.

In 2013, there were no known dispersals from Mt. Washington to colonies on the east side of Buttle Lake, although one marmot released to Mt. Washington in 2013 for pre-conditioning left the mountain and was found on mortality signal near Mt. Albert Edward. There were nine marmots missing from Mt. Washington at the end of the field season that could have dispersed from the ski hill. At Castlecrag, hikers photographed an untagged marmot near the summit. We do not know where this marmot came from, but Mt. Washington has a large population and is located only ~10km away, so it is the most likely source. South of Buttle Lake, there were several marmots moving through the landscape, although flight priorities prevented us from pinpointing their location to determine if they had settled with other marmots. On the west side of Buttle Lake, one marmot dispersed from Morrison Spire to Tibetan Plateau.

In 2013, there was successful breeding at Mt. Washington and at Castlecrag (Figure 9). Field crew observed no new litters at Greig Ridge or Tibetan, although ground surveys focused primarily on detecting transmitter signals and less on visually observing the marmots at each site.

We estimate that there are 45-84 marmots with previous hibernation experience in the Buttle Lake area. This includes 30-70 adults, with another 17-24 adults in the colony on Mt. Washington (Table 3).

For greater detail on the status of colonies at each release site, please see Appendix VII.

6. DISCUSSION

6.1. Pre-conditioning

By pre-conditioning captive-bred marmots at Mt. Washington, we hoped to increase post-translocation overwinter survival by first exposing captive-bred marmots to a true wild hibernation. We also attempted to boost overwinter survival of captive-bred marmots at Mt. Washington by providing them with supplemental food in the spring. Captive-bred marmots released at Mt. Washington in 2004-2008 achieved an estimated 64.3% overwinter survival in their first wild hibernation without access to feeders. For marmots pre-conditioned at Mt. Washington with spring feeder access, estimates of overwinter survival were similar in 2011-12 (63%) and higher in 2012-13 (73%). Snow cover and spring melt vary from year to year, and so it could be that conditions in 2012-13 were more conducive to survival than in previous years.

Of the eight marmots that did not survive hibernation (six in 2011-12, three in 2012-13), six died prior to spring or were unable to successfully emerge in spring, and so supplemental food was never truly accessible to them. The other marmots did emerge successfully above ground, but “due to prolonged inanition associated with hibernation they may have lacked the capacity to effectively digest and assimilate the food” (M. McAdie, pers. comm., November 28, 2013). One of the marmots in that latter category was barely alive when reported by staff at Mt. Washington and taken back into captivity by our project veterinarian, who was able to save her. She was re-released at Mt. Washington later that summer, and hibernated successfully in 2012-13. She was translocated to the Buttle Lake area in 2013. When counting overwinter survival of pre-conditioning marmots, we classify her as a mortality because without veterinary intervention there is no question that she would have died. However, it is one of the benefits of conducting pre-conditioning trials at Mt. Washington that marmots needing veterinary assistance may still be recovered early enough to be saved.

Although data do not yet suggest that spring supplemental feeding helps to increase the overwinter survival of pre-conditioning marmots, the feeders could provide benefits that are not immediately apparent. Reproductive success in marmots can be a function of female body condition (*M. marmota*, King and Allainé 2002, Hackländer and Arnold 1999), food resources in the spring (*M. flaviventris*, Andersen et al. 1976; but see Woods and Armitage 2003), food resources the previous year (*M. caudata aurea*, Blumstein and Foggin 1997), and the length of the previous growing season (*M. flaviventris*, Van Vuren and Armitage 1991). Supplemental feeding of Columbian ground squirrels (*Spermophilus columbianus*) was found to increase spring body weight and decrease the age at which females achieved reproductive maturity (Dobson and Kjelgaard 1985). Captive-bred Vancouver Island marmots released to the wild rarely produce offspring until they have survived at least two hibernation periods. Therefore, if spring feeders artificially extend the growing season and contribute to females more quickly recovering their body condition from their first wild hibernation, they might also stimulate more rapid reproduction following translocation to the Buttle Lake area.

6.2. Active season survival

Many captive-bred species show “release effects” during their first year in the wild. These can manifest in a number of ways, such as poor survival or excessive ranging (e.g. *Dama dama mesopotamica*, Bar-David et al. 2005; *Gyps fulvus fulvus*, Sarrazin et al. 1994; *Ovis canadensis*, Ostermann et al. 2001). Although Jackson (2012) found that active season survival for newly released captive-bred marmots was not particularly low (84.4%), evidence suggested that captive-bred Vancouver Island marmots also experience release effects in the form of poor overwinter survival in the first post-release year. And while 2/3 ‘experience’ treatment groups translocated to the Buttle Lake area in 2012 and both treatment groups translocated in 2013 had previous experience living in the wild, we did anticipate the potential for release effects in all groups because they were moved to foreign environments and released in new social groups in some state of stress.

In our first year of translocations, we detected moderate active season survival for translocated marmots, based on flights and ground surveys in September 2012. We detected 20 of 30 marmots, and confirmed survival for 65% (13 of 20). Initially and contrary to our expectations, we estimated the highest survival rate for direct-released captive-bred marmots (69%, 9 of 13), which had no experience in the wild prior to their translocation. We were surprised to detect only 50% survival of wild-born marmots, although we recognized that number could be misleading because only two wild-born marmots were detected that fall. In September 2013 we modified our flight strategy, and increased our detection rate for marmots translocated in 2012 and in 2013. As Figure 6 illustrates, our most recent findings suggest that of marmots translocated in 2012, wild-born marmots actually fared the best, with 83.3% of wild-born marmots surviving two active seasons (2012, 2013) and one hibernation (2012-13), compared to only 36.4% of direct-released marmots and 25.0% of pre-conditioned marmots. This is only a small sample size based on one year of experiments. However, the change in inference with greater success in collecting data speaks to the importance of achieving high detection rates when estimating measures of success.

In 2013, newly translocated marmots were successful at achieving much higher levels of active season survival than was detected in the previous year. In flights and ground surveys conducted in September 2013, we detected 23 of 25 marmots that had been translocated in July. Of those detected, we confirmed survival for 92%, including all 11 pre-conditioned captive-bred marmots, and 12 of 14 wild-born marmots. Because of our high September detection rates, we feel confident in our findings that both wild-born and pre-conditioned marmots translocated in 2013 achieved high success at active season survival in their first post-translocation summer.

6.3. Overwinter survival

Prior to translocation trials, the largest releases to the Buttle Lake area took place in 2009 and 2010, with 22 and 77 captive-bred marmots released to Strathcona Provincial Park, respectively. Unfortunately, those releases were followed by winters with high levels of snow deposition and long, cool springs that contributed to overwinter mortality of >75% (White et al. 2012). By pre-conditioning captive-bred marmots at Mt. Washington prior to translocation and including wild-born marmots in release groups, we hoped to increase the rates of overwinter survival for marmots newly introduced to the Buttle Lake area. Our translocation trials of 2012 included marmots that were wild-born, pre-conditioned marmots, and direct-released. We were encouraged to record only a single overwinter mortality by marmots released in 2012, including direct-released marmots, although we acknowledge that many marmots were missing that could have suffered overwinter mortality, and that survival was likely helped by a gentle spring in 2013. It will be interesting to discover the rates of overwinter survival of marmots translocated in 2013, particularly if the winter and spring conditions prove similar to previous years associated with high mortality.

6.4. Predation

The immediate focus of our translocation trials was to increase overwinter survival so that released marmots survived for more than a scant few months at their release sites. And yet, captive-bred marmots that survive their first hibernation in the Buttle Lake area are not necessarily given a chance to contribute to population growth because many are predated upon before they can breed. In the southern core area, harvesting of cougars and wolves by local hunters and trappers has provided some limits to predator numbers, and yet predation was still responsible for 89% of mortalities in which transmitters were recovered. In the Buttle Lake area, we confirmed predation as the cause of death in 9% of mortalities and suspected predation in an additional 26% of mortalities, but we believe that predation caused well over 35% of mortalities to date. This is particularly true because all release sites have been located in Strathcona Provincial Park, a large protected area where predator harvesting does not take place and there are no controls on predator populations.

Perhaps the best defense against predation events would be to establish larger colonies at release sites such as those found on Mt. Washington or in the south metapopulation, in conjunction with a denser clustering of colonies. Bryant (2005) reported several examples of missed breeding opportunities by mature females because males were not present. Large colonies are generally less sensitive to predation events because there are multiple animals that could potentially breed to help the colony recover, and nearby colonies may help struggling colonies by providing dispersing marmots. However, low first-year site fidelity by released animals has been problematic at all regions of Vancouver Island (67.1% from 2003-2010; Jackson 2012), and so we cannot increase colony size simply by increasing release group size. The most likely way for colony sizes to increase is for natural reproduction at colonies to produce and recruit their own marmots. Since predators often take animals before they can breed, predation continues to play a significant role in constraining population recovery in the Buttle Lake area.

6.5. Reproduction

There has been strong reproduction at Mt. Washington over the past three years. This is likely a result of several females reaching reproductive maturity at approximately the same time, since the average age of first breeding is 3.6 years (Bryant 2005). However, there is also some evidence that that suggests that spring feeders could also be contributing to fecundity on the hill. Two wild-born females that were candidates for translocation in 2013 produced their first litters at age two and therefore could not be moved. There were three females that in 2013 bred for their third consecutive year at Mt. Washington since feeders were installed. Vancouver Island marmots have a lifespan of approximately ten years, and a 9yo marmot weaned her first successful litter the year we provided a feeder at her hibernaculum. These are just observations that may lend some support to spring feeding, but we will continue to gather data to better evaluate whether there are any true trends.

Outside of Mt. Washington, there has been minimal reproduction in the Buttle Lake area. Perhaps as a consequence of the initial wild hibernations being so physiologically demanding, breeding-aged captive-bred marmots rarely reproduce before they have been in the wild for two years. It was our hope that we may facilitate a shorter time lag between release and reproduction for marmots in the Buttle Lake area by pre-conditioning captive-bred marmots at Mt. Washington and including wild-born marmots in the release groups. We will not know whether or not this has been successful for another year or two.

Pup litters were recorded at Greig Ridge and Tibetan in 2009 and 2011, with a single litter seen at Castlecrag in 2013. However, because of other priorities related to trapping and translocating marmots and the expense of accessing many of our release sites, we spent limited time at most hills in the Buttle Lake area in 2013. Consequently, there could have been litters or untagged individuals present at sites that were not observed. With 30-70 adults in the Buttle Lake area and the potential for resident breeding-age pairs to emerge at Sunrise, Castlecrag, and Tibetan, we are hopeful that there will be successful

reproduction at multiple sites in the Buttle Lake area in 2014. Trapping and translocating marmots will continue to be a time-consuming priority, and so we hope to identify sites where reproduction is likely and to install remote cameras these sites in order to better inventory site inhabitants. As you can see in Figure 4(b), remote camera imagery confirmed the existence and age of a third adult at Tibetan based on ear tags, size, and adult moult patterns. Figure 4(d) also illustrates how, in the Nanaimo Lakes area in 2013, video footage enabled us to identify the first pup litter at that site in over a decade based on a pup's size relative to an untagged adult marmot seen in different videos. So we feel confident that remote cameras will be a significant aid in conducting inventory at sites that we are not able to survey thoroughly or frequently.

6.6. Site fidelity

Our ability to detect marmot transmitters seemed to improve when we flew at a higher altitude and planned longer, more expansive searches of the area around each release site. Such expansive searches will become increasingly necessary next year, as the marmots translocated in 2012 and 2013 that did not remain at their release sites will have had 12-24 respective months to travel through the landscape. Although these intensive searches helped us detect a greater number of marmots to confirm active season survival, they provided less information about the location of each animal. To confirm that a marmot is alive once it has been detected requires just 30-60 seconds of listening to a consistent transmitter pulse, whereas following a nearby transmitter signal to its source can take 5-10 minutes. But transmitter pulses can travel for tens of kilometres, and so hearing marmots from such a large distance made it more difficult to gather data on location because there were fewer audio cues to where the marmot was truly located.

We select release locations for our translocation trials with the aim of increasing colony sizes, expanding the distribution of colonies and creating a greater density of colonies in the Buttle Lake area. Therefore, it is important for us to know where marmots hibernate and which marmots survive hibernation, to help direct our translocations to optimize the potential for colony establishment and future reproduction. In September, 2013, we made the decision to sacrifice collecting location data in order to focus on collecting data on active season survival that would help us to answer our research questions. We also forfeited intensive searches for marmots released to the Buttle Lake area prior to 2012. However, this means that in 2014, we will need to spend additional time locating survivors to better inform our translocation decisions for later in the summer.

7. RECOMMENDATIONS

We will continue to use a strategic approach to design experiments and gather data to help us answer our research questions. At the end of the 2013 active season, we conducted the standard multi-day ground- and aerial-based radiotelemetry surveys; however, in an attempt to increase our ability to detect translocated marmots by helicopter, we expanded the survey perimeter around each mountain and searched from a higher altitude. As a consequence, we determined the active season fate of 93% of translocated marmots, a considerable increase on the 67% detection rate in the fall of 2012. We will use this same flight strategy in the spring of 2014 to collect data on the overwinter survival of translocated marmots, and in the fall of 2014 to collect data on active season survival at release sites.

In the spring of 2014, we will continue feeder trials at Mt. Washington and at select sites in the Buttle Lake area. We have identified three sites (Sunrise, Castlecrag, and Tibetan) at which mature marmot pairs could potentially breed; if spring snow conditions permit, we will install feeders at those sites in an attempt to stimulate breeding. We will monitor reproduction at Mt. Washington and all release sites using a combination of ground surveys and remote cameras.

Release and translocation plans for 2014 will be guided by survival, dispersal, and reproduction by the marmots presently living in the Buttle Lake area. Similarly, the number of wild-born and pre-conditioned marmots available for translocation will rely upon individuals surviving overwinter hibernation on Mt. Washington. We expect to implant and translocate 10-20 wild-born marmots from Mt. Washington to the Buttle Lake area. Three captive-bred marmots released to Mt. Washington in 2013 died prior to hibernation, leaving a maximum of 13 pre-conditioned marmots to be re-trapped and translocated next year. There are 29 captive-bred release candidates for 2014. We intend to release a subset to Mt. Washington to be “pre-conditioned” and a subset directly to the Buttle Lake area to continue our comparative evaluation of the survival of pre-conditioned versus direct-released captive-bred marmots.

The 2013 First Nations Internship was highly successful (see the report prepared by intern Art Van Volsen, Appendix VIII). In 2014, we hope to again incorporate a First Nations training component, but across all phases of the program. First Nations would participate in spring emergence surveys, feeder and remote camera installation and releases and translocations, and would receive training in monitoring marmot populations by observational survey and using radio telemetry equipment (both ground- and aerial-based).

Disclaimer

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REFERENCES

- Aaltonen K, Bryant AA, Hostetler JA, Oli MK. 2009. Reintroducing endangered Vancouver Island marmots: survival and cause-specific mortality rates of captive-born versus wild-born individuals. *Biological Conservation*. 142(10): 2181-2190.
- Allouche O, Tsoar A, Kadmon R. 2006. Assessing the accuracy of species distribution models: prevalence, kappa and the true skill statistic (TSS). *Journal of Applied Ecology*. 43(6): 1223-1232.
- Andersen DC, Armitage KB, Hoffmann RS. 1976. Socioecology of marmots: female reproductive strategies. *Ecology*. 552-560.
- Beck BB, Rapaport LG, Price MRS, Wilson AC. 1994. Reintroduction of captive-born animals, in: Olney PJS, Mace GM, Feistner ATC, (Eds). *Creative conservation: interactive management of wild and captive animals*. Chapman and Hall: London UK. pp. 265-286.
- Blumstein DT, Foggin JM. 1997. Effects of vegetative variation on weaning success, overwinter survival, and social group density in golden marmots (*Marmota caudata aurea*). *Journal of Zoology*. 243(1): 57-69.
- Bryant AA. 1997. Updated status of the Vancouver Island marmot (*Marmota vancouverensis*) in Canada. Committee on the Status of Endangered Species in Canada, Ottawa, ON. pp. 1-21.
- Bryant AA. 1998. Metapopulation ecology of Vancouver Island marmots (*Marmota vancouverensis*). PhD thesis. University of Victoria. pp. 1-96.
- Bryant AA. 2000. Relative importance of episodic versus chronic mortality in the decline of Vancouver Island marmots (*Marmota vancouverensis*) in: Darling L. (Ed.), *Proceedings of a conference on the biology and management of species and habitats at risk*. Queen's Printer. Victoria. pp. 189-195.
- Bryant AA. 2005. Reproductive rates of wild and captive Vancouver Island marmots (*Marmota vancouverensis*). *Canadian Journal of Zoology*. 83(5): 664-673.
- Bryant AA, Page RE. 2005. Timing and causes of mortality in the endangered Vancouver Island marmot (*Marmota vancouverensis*). *Canadian Journal of Zoology*. 83(5): 674-682.
- Burnham KP, Anderson DR. 2002. *Model selection and multimodel inference: a practical information-theoretic approach*. Second ed. Springer-Verlag. New York, NY.
- COSEWIC. 1979. Status of the Vancouver Island marmot in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. pp. 1-12.
- Dobson FS, Kjelgaard JD. 1985. The influence of food resources on life history in Columbian ground squirrels. *Canadian Journal of Zoology*. 63: 2105-2019.
- Fischer J, Lindenmayer DB. 2000. An assessment of the published results of animal relocations. *Biological Conservation*. 96(1): 1-11.
- Griffith B, Scott JM, Carpenter JW, Reed C. 1989. Translocation as a species conservation tool: status and strategy. *Science (Washington)*. 245(4917): 477-480.
- Hackländer K, Arnold W. Male-caused failure of female reproduction and its adaptive value in alpine marmots (*Marmota marmota*). *Behavioral Ecology*. 10(5): 592-597.
- Hebda RJ, McDadi O, Mazzucchi D. 2004. Habitat history and the decline of the Vancouver Island marmot (*Marmota vancouverensis*) in: Hooper TD. (Ed). *Proceedings of the Species at Risk 2004 Pathways to Recovery Conference*. BC Species at Risk 2004 Pathways to Recovery Conference Organizing Committee. Victoria, BC. pp. 1-11.

- Jackson CL. 2012. First year site fidelity and survival in reintroduced captive-bred Vancouver Island marmots (*Marmota vancouverensis*). MSc thesis. University of British Columbia. pp. 1-72.
- Janz D, Blumensaat C, Dawe NK, Harper B, Leigh-Spencer S, Munro WT, Nagorsen D. 1994. National Recovery Plan for the Vancouver Island Marmot. Report No. 10. Recovery of Nationally Endangered Wildlife Committee. Ottawa, ON.
- Janz DW, Bryant AA, Dawe NK, Schwantje H, Harper B, Nagorsen D, Doyle D, deLaronde M, Fraser D, Lindsay D, Leigh-Spencer S, McLaughlin R, Simmons R. 2000. National Recovery Plan for the Vancouver Island Marmot (2000 Update). Report No. 19. Recovery of Nationally Endangered Wildlife. Ottawa, ON.
- Karels TJ, Byrom AE, Boonstra R, Krebs CJ. 2000. The interactive effects of food and predators on reproduction and overwinter survival of arctic ground squirrels. *Journal of Animal Ecology*. 69: 235–247.
- King WJ, Allainé D. 2002. Social, maternal, and environmental influences on reproductive success in female Alpine marmots (*Marmota marmota*). *Canadian Journal of Zoology*. 80: 2137-2143.
- Milko RJ. 1984. Vegetation and foraging ecology of the Vancouver Island marmot (*Marmota vancouverensis*). M.Sc. thesis. University of Victoria. Victoria, B.C.
- Munro WT, Janz DW, Heinsalu V, Smith GW. 1985. The Vancouver Island marmot: status and management plan. BC Ministry of Environment. Wildlife Branch. Wildlife Bulletin No. B-39. Victoria, BC.
- Nagorsen DW. 2004. Canada's endemic mammals at risk: recent taxonomic advances and priorities for conservation. In *Proceedings of the "Species at Risk: Pathways to Recovery"* Conference.
- Thornback J, Jenkins M. 1982. The IUCN Mammal Red Data Book: Threatened mammalian taxa of the Americas and the Australasian zoogeographic region (excluding Cetacea). IUCN. Gland. Switzerland. pp. 225-227.
- Swarth HA. 1911. Two new species of marmots from British Columbia. University of California Publications in Zoology. 7(6): 201-204.
- Van Vuren D, Armitage KB. 1991. Duration of snow cover and its influence on life-history variation in yellow-bellied marmots. *Canadian Journal of Zoology*. 69(7): 1755-1758.
- Vancouver Island Marmot Recovery Team. 2008. Recovery strategy for the Vancouver Island marmot (*Marmota vancouverensis*) in British Columbia. Prepared for the B.C. Ministry of Environment. Victoria, BC.
- White C, Reid C, Doyle D. 2012. Vancouver Island Marmot Buttle Lake Supplementation Project. Prepared for BC Hydro Bridge Coastal Fish and Wildlife Restoration Program. pp. 1-40.
- Vittinghoff E, McCulloch CE. 2007. Relaxing the rule of ten events per variable in logistic and Cox regression. *American Journal of Epidemiology*. 165(6): 710-718.
- Wolf CM, Griffith B, Reed C, Temple SA. 1996. Avian and Mammalian Translocations: Update and Reanalysis of 1987 Survey Data. *Conservation Biology*. 10: 1142–1154.
- Woods BC, Armitage KB. 2003. Effects of food addition on life history of Yellow-Bellied Marmots. *Oecologia Montana*. 12: 29-36.

FIGURES

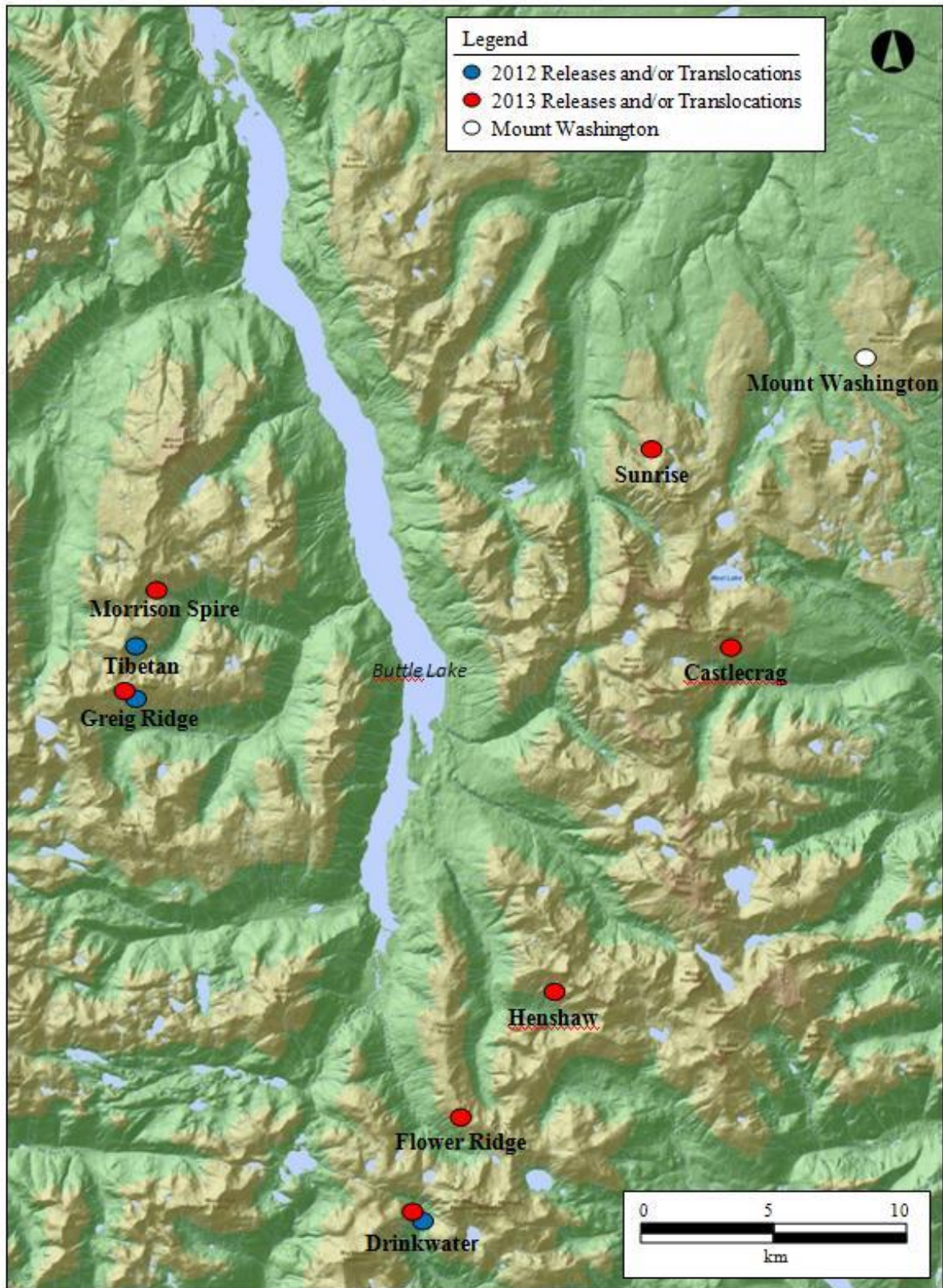


Figure 1. Study area for VI marmot feeder and translocation trials in 2012, 2013.

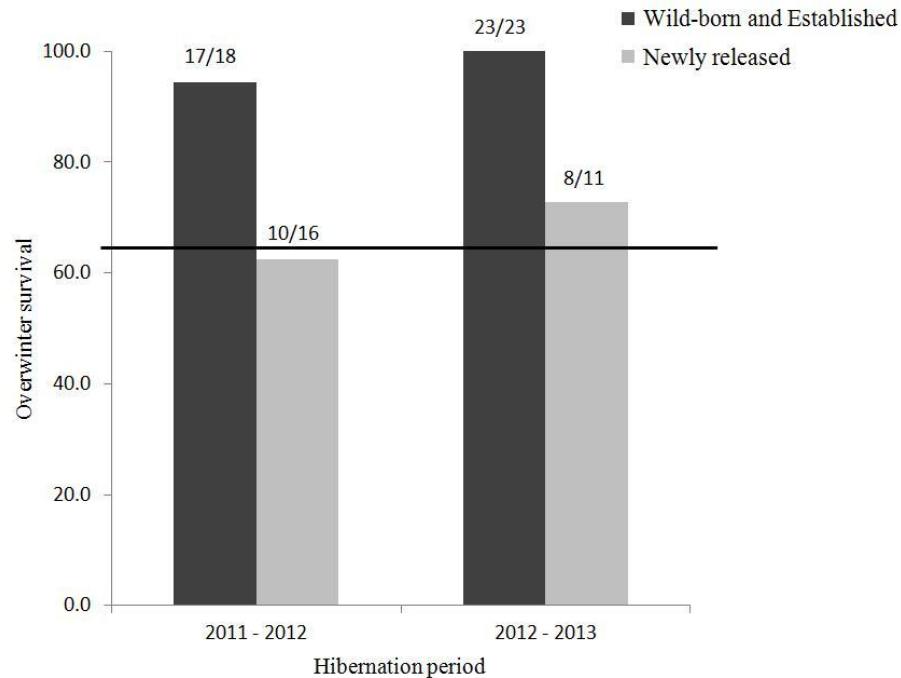


Figure 2. Prior to feeder trials, overwinter survival for captive-bred marmots released at Mount Washington averaged 64.3% (2003-2010, black line). We estimated 62.5% and 72.7% overwinter survival by marmots being pre-conditioned in 2011-12 and 2012-13, respectively. The higher survival rate in 2012-13 could have been influenced by mild winter conditions with low snow levels and a rapid spring melt (see Figure 5).

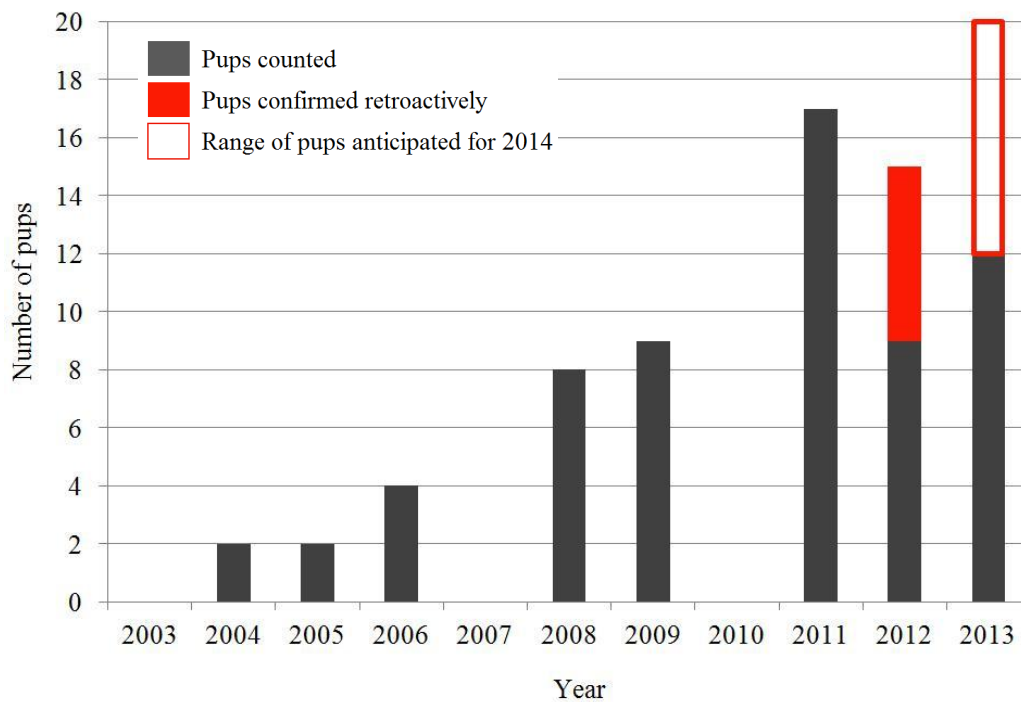


Figure 3. Pup production by year at the wild colony on Mt. Washington. In 2012, field crew counted 9 pups but in 2013 we trapped 15 yearlings, increasing the retroactive pup count by 6 (solid red). In 2013, field crew counted 12 pups in 5 litters. We assume there were actually 15-20 pups, and expect to find 12-20 yearlings at Mt. Washington in 2014 (red outline).



Figure 4. Remote cameras were helpful for collecting inventory data at remote sites. (a) A camera at Mt. Washington revealed a tagged animal with adult moult patterns, and two untagged yearlings at a feeder. These yearlings were later captured, implanted, and translocated to the Buttle Lake area. (b) A camera at Tibetan near Greig Ridge documented two tagged adults and an untagged adult using the feeder. We believe the untagged adult is the sibling of the female tagged marmots, both born at the site in 2009. Without this image we would not have been able to confirm its survival. The fact that it remains at this site despite an adult male being present suggests that it may be female and another potential breeder. (c) An adult marmot lounges on a rock at Arrowsmith, a mountain used by the southern metapopulation. We determined that it is a mature marmot by its moult pattern, and video footage revealed that it did not have ear tags. (d) A pup lounges on that same rock. Prior to viewing these remote camera images, we had not known there was a litter at this site. The image stills, showing marmots sitting at the same place on the same rock, enabled us to compare sizes and confirm the first successful breeding on this mountain in over a decade.

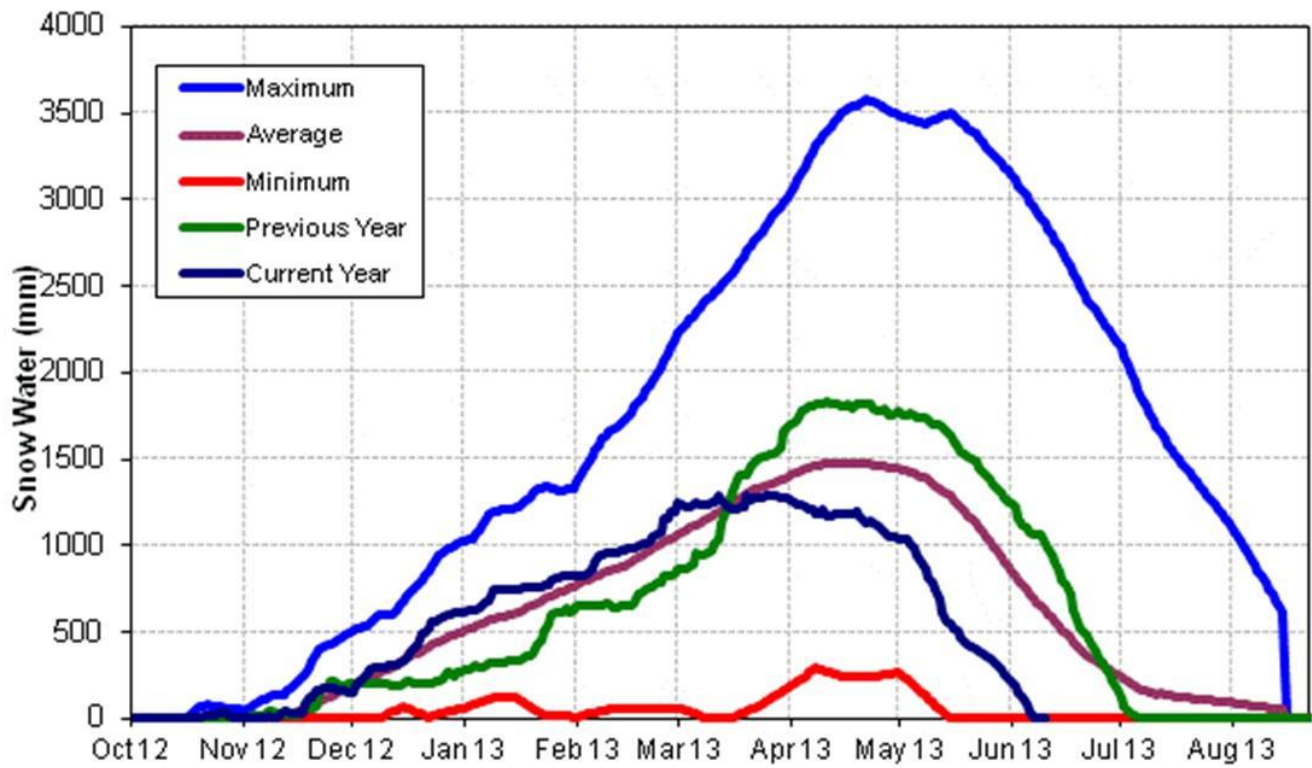


Figure 5. Snow water accumulation at the Wolf River snow station in Strathcona Provincial Park, on Vancouver Island, BC. The winter of 2012-13 (dark blue) was characterized by lower than average snow levels, an early peak in snow accumulation, and rapid spring melt.

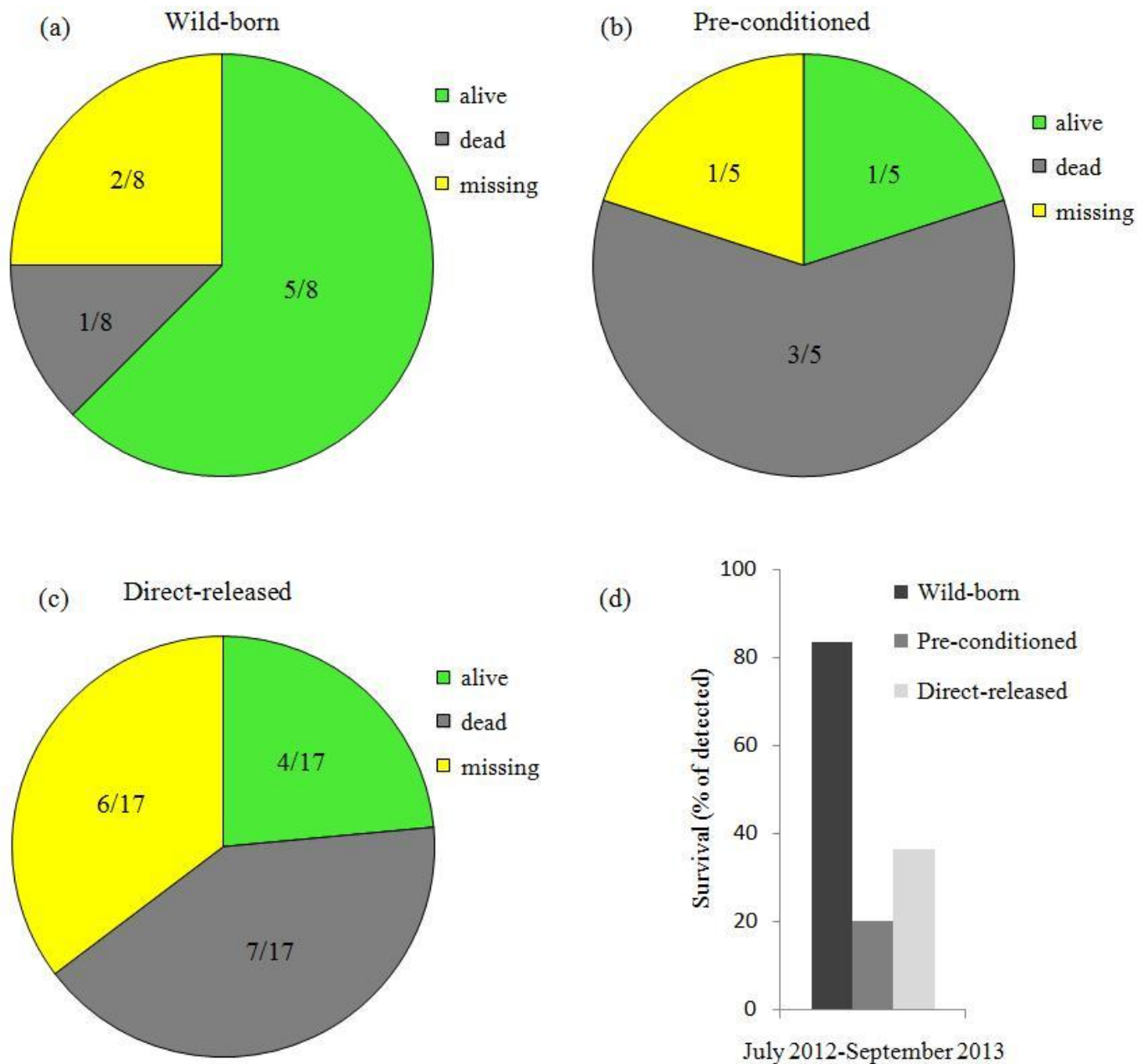


Figure 6. Survival status of marmots that were released to the Buttle Lake area in 2012. (a) Wild-born marmots were born in the wild colony at Mt. Washington. (b) Pre-conditioned marmots were captive-bred and released to the wild colony at Mt. Washington at least one summer prior to their translocation; therefore, they survived ≥ 1 hibernation in the wild before being released in the Buttle Lake area. (c) Direct-released marmots were captive-bred and released directly to the Buttle Lake area without any previous wild experience. A greater proportion of wild-born marmots than pre-conditioned or direct-released marmots were confirmed to have survived to September 2013. However, a large proportion of direct-released marmots and some wild-born and pre-conditioned marmots were still missing, and their survival status could change the perception of which experience treatment achieved the greatest rate of short-term success.

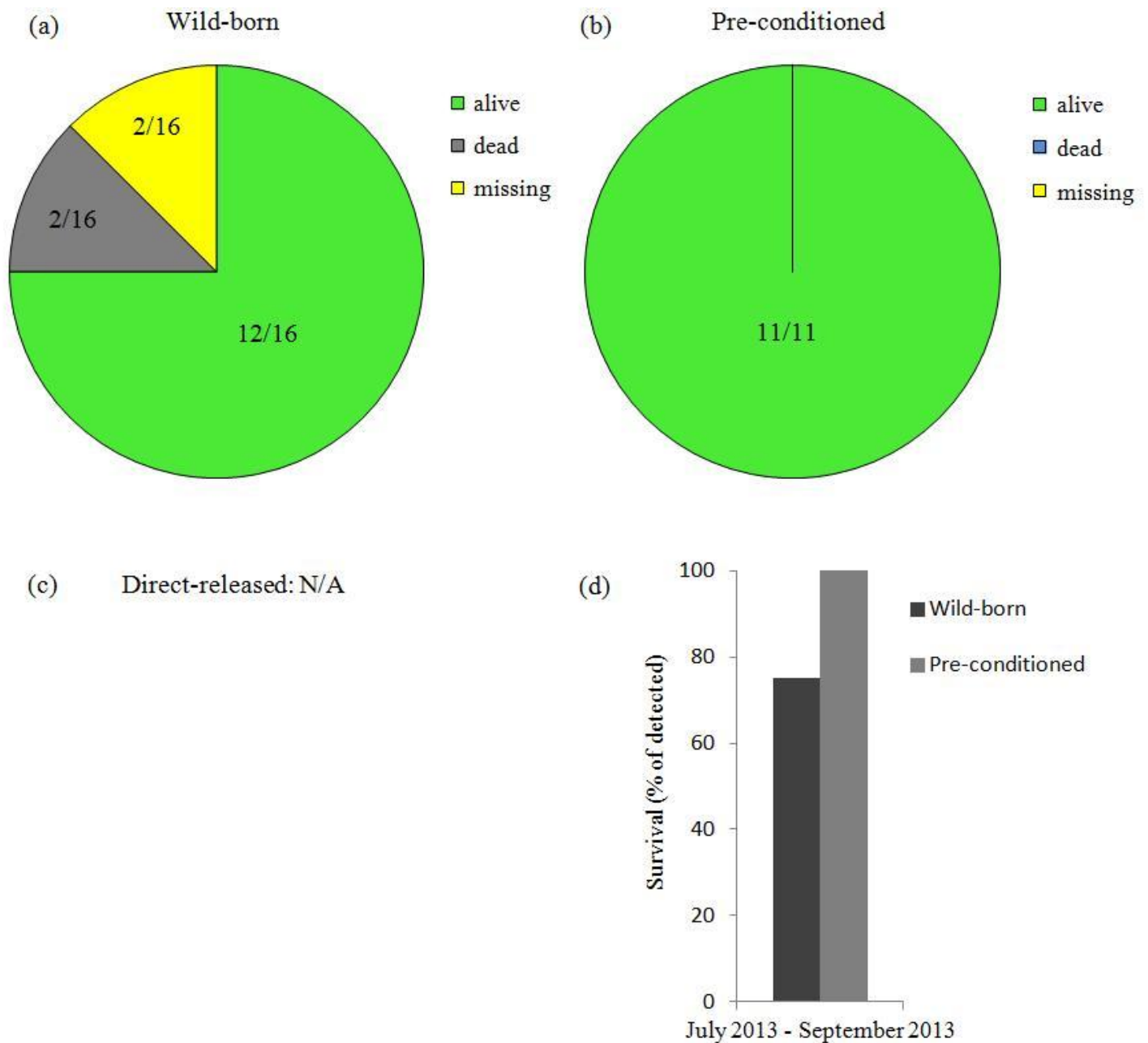


Figure 7. Active season survival of marmots that were released to the Buttle Lake area in 2013. (a) Wild-born marmots were born in the wild colony at Mt. Washington. (b) Pre-conditioned marmots were captive-bred and released to the wild colony at Mt. Washington at least one summer prior to their translocation; therefore, they survived ≥ 1 hibernation in the wild before being released in the Buttle Lake area. (c) There were no captive-bred marmots that were direct-released to the Buttle Lake area in 2013. The detection rate was much higher for marmots in the 2013 translocation trials than for those released in 2012. This gave us greater confidence in our interpretation of active season survival, that both groups of marmots performed well in achieving this measure of success.

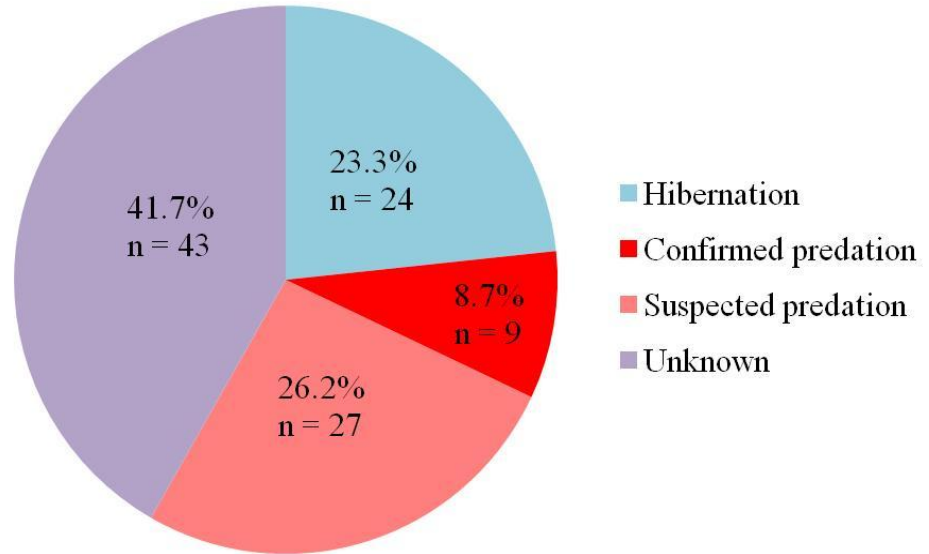


Figure 8. The causes of mortality in the Buttle Lake area remain largely unknown. This is mostly a result of time lags between detections and the inability to recover transmitters in areas of challenging terrain. We estimate that 23% of mortalities occurred during hibernation. We attributed nearly nine percent of mortalities to predation, and we strongly suspect predation in an additional 26% of mortalities to date. Analysis of mortality patterns in the south metapopulation suggests that most mortalities should be attributed to predation or hibernation, rather than disease or accident.

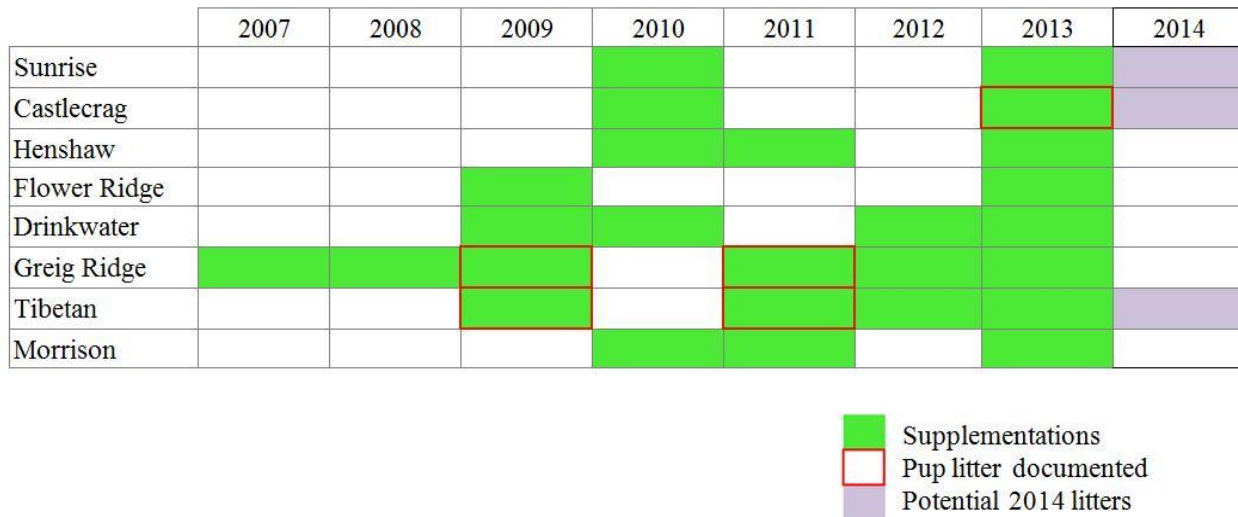


Figure 9. Reproduction in the Buttle Lake area has been less frequent than in the southern metapopulation. This is likely a consequence of interrupted pairing at fledgling colonies, where pairs were established but one or both marmots died before the pair could produce and wean a litter. In 2014, there should be three colonies with a breeding-age pair that could potentially produce litters.

TABLES

Table 1. Locations of spring supplemental feeders in the 2011, 2012, and 2013 feeder trials.

Site	2011	2012	2013
Castlecrag	0	1	1
Greig	0	1	0
Henshaw	0	1	0
Sunrise	0	1	1
Tibetan	0	1	1
Washington	7	12	12

Table 2. Release group composition and age classification of marmots released in the Buttle Lake area in 2013.

	Age	Castlecrag		Drinkwater		Flower Ridge		Greig Ridge		Henshaw		Morrison		Sunrise	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F
Wild-born	1yo	1	2	1	1	2	-	-	1	-	2	-	-	1	1
	2yo	-	-	-	-	-	1	1	-	1	-	-	-	-	-
	3yo	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Pre-conditioned	2yo	-	-	-	-	1	-	1	1	2	-	2	1	1	-
	3yo	1	-	-	-	-	-	-	-	-	1	-	-	-	-

Table 3. Population estimates for the Buttle Lake area at the end of the 2013 active season.

	Known Tagged Adults		Known Tagged Yearlings		Known Tagged Pups		Observed Untagged Adults		Untagged Yearlings		Untagged Pups		Age unknown		Total Marmots	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Mountain	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Allan Brooks	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Castlecrag	2	9	3	3	0	0	1	2	0	0	1	1	0	0	7	15
Sunrise	2	7	2	2	0	0	0	0	0	0	0	0	0	0	4	9
Drinkwater	3	11	2	2	0	0	0	0	0	0	0	0	0	0	5	13
Flower Ridge	2	2	2	2	0	0	0	0	0	0	0	0	0	0	4	4
Greig Ridge	11	20	0	0	0	0	0	0	0	0	0	0	0	0	11	20
Henshaw	3	6	2	2	0	0	0	0	0	0	0	0	0	0	5	8
Morrison Spire	4	6	0	0	0	0	0	0	0	0	0	0	0	0	4	6
Tibetan	3	3	0	0	0	0	2	2	0	0	0	0	0	0	5	5
BUTTLE LAKE AREA	30 - 68		11 - 11		0 - 0		3 - 4		0 - 0		1 - 1		0 - 0		45 - 84	
MOUNT WASHINGTON	17 - 24		15 - 15		0 - 0		0 - 0		1 - 5		12 - 12		1 - 1		46 - 57	

APPENDICES

Appendix I. Financial Statement



Financial Statement Form

Project # 13.W.CBR.01

	BUDGET		ACTUAL	
	FWCP	Other	FWCP	Other
INCOME				
	\$72,600.00	\$145,750.00	\$58,080.00	\$145,750.00
<i>Total Income by Source</i>				
Grand Total Income (FWCP Other)	\$218,350.00		\$203,830.00	
EXPENSES				
<i>Project Personnel</i>				
Coordinator MRF		\$12,250.00		\$12,250.00
Field Technicians	\$15,000.00	\$45,000.00	\$15,000.00	\$45,000.00
Field Biologist		\$17,500.00		\$17,500.00
First Nations training	\$5,000.00		\$5,000.00	
Vetrinary Support		\$12,500.00		\$12,500.00
<i>Materials & Equipment</i>				
Helicopter fuel and rental	\$36,000.00		\$36,000.00	
Transmitters	\$10,000.00	\$10,000.00	\$10,000.00	\$10,000.00
Food allowance		\$5,500.00		\$5,500.00
Field camps		\$2,000.00		\$2,000.00
Toilet (back country TAJ)		\$6,000.00		\$6,000.00
Safety equipment		\$2,000.00		\$2,000.00
Telemetry receivers		\$8,000.00		\$8,000.00
Vehicle rental		\$20,000.00		\$20,000.00
Vehicle fuel		\$5,000.00		\$5,000.00
<i>Administration</i>				
MRF 10% Admin Costs	\$6,600.00		\$6,600.00	
Total Expenses	\$72,600.00	\$145,750.00	\$72,600.00	\$145,750.00
Grand Total Expenses (FWCP & other)	\$218,350.00		\$218,350.00	
BALANCE (Grand Total Income - Grand Total Expenses)	\$0.00		-\$14,520.00	

Appendix II. Performance Measures – Actual Outcomes

Performance Measures

Using the performance measures applicable to your project, please indicate the amount of habitat anticipated to be restored/enhanced for each of the specified areas (e.g. riparian, tributary, mainstream). The same table will be used in the final report to summarize project results.

Performance Measures – Target Outcomes													
Project Type	Primary habitat benefit targeted of project (sq.m.)	Primary Target Species	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland	Other
Impact Mitigation													
Fish passage technologies	Area of habitat made available to target species		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Drawdown zone revegetation/ stabilization	Area turned into productive habitat		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Wildlife migration improvement	Area of habitat made available to target species	Vancouver Island marmot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Improved ecosystem function and quality of marmot habitat in ~2,400ha.
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Habitat Conservation													
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and management		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Habitat conserved - general	Functional habitat conserved by other measures (e.g. riprapping)		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Designated rare/special habitat (subset)	Rare/special habitat protected		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Performance Measures – Target Outcomes - Continued													
Project Type	Primary habitat benefit targeted of project (sq.m.)	Primary Target Species	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir-Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland	Other
Maintain or Restore Habitat forming process													
Artificial gravel recruitment	Area of stream habitat improved by gravel placement		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Artificial wood debris recruitment	Area of stream habitat improved by LWD placement		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing	Vancouver Island marmot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Improved ecosystem function and quality of marmot habitat in ~2,400ha.
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved	Vancouver Island marmot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Improved ecosystem function and quality of marmot habitat in ~2,400ha.
Habitat Development													
New habitat created	Functional area created		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Other													
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Appendix III. Confirmation of FWCP Recognition

Our research, with recognition of the substantial support from BC Hydro Bridge Coastal Fish and Wildlife Restoration Program, has been presented to the:

- Vancouver Island Marmot Recovery Team at the biannual full day meetings at the Ministry of Forests, Lands and Natural Resources Operations office in Nanaimo (2080 Labieux Road)
- Vancouver Island Marmot Captive Management Group multiday meetings
- Vancouver Island University third-year Resource Management students
- Hupacasath First Nation, at a full day tour of Mt. Washington (see Appendix IX for photos)
- Denman Island Naturalists

Weekly reports were electronically mailed to the Vancouver Island Marmot Recovery Board during the field season. The public was made aware through news articles and newsletters.

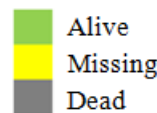
Appendix IV. Timeline of activities at Mt. Washington.

	Active Season					
	May	June	July	August	September	October
1. Feeder trials						
Feeders and remote cameras	Emergence holes located; feeders installed and maintained; camera footage analyzed.	Emergence holes located; feeders installed and maintained; camera footage analyzed.	N/A	N/A	N/A	N/A
2. Translocation trials						
(a) Wild-born marmots	N/A	Marmots trapped and implanted with radiotelemetry transmitters.	Re-trapped marmots; veterinary examination; translocated to Buttle Lake area.	Active season survival monitored.	Aerial surveys to verify active season survival.	Ground surveys (when possible) to monitor hibernation status.
(b) Pre-conditioned captive-bred marmots	Emergence holes located; feeders installed and maintained; camera footage analyzed.	Emergence holes located; feeders installed and maintained; camera footage analyzed; overwinter survival confirmed.	Re-trapped marmots; veterinary examination; translocated to Buttle Lake area.	Active season survival monitored.	Aerial surveys to verify active season survival.	Ground surveys (when possible) to monitor hibernation status.
(c) Direct-released captive-bred marmots	Marmots moved from captive-breeding facilities to TBMWMBC.	Marmots implanted with radiotelemetry transmitters.	0 marmots direct-released to Buttle Lake area).	Ground surveys (when possible) to monitor active season survival.	Aerial surveys to verify active season survival.	Ground surveys (when possible) to monitor hibernation status.
3. Pre-conditioning captive-bred marmots						
Preparation for 2014	Marmots moved from captive-breeding facilities to TBMWMBC.	Marmots implanted with radiotelemetry transmitters.	Captive-bred marmots released to wild colony on Mt. Washington.	Active season survival monitored.	Ground surveys at Mt. Washington to verify active season survival.	Ground surveys to monitor hibernation status.

Appendix V. Detection rate and survival status of marmots released to the Buttle Lake area in 2012. Status is tabulated through the 2012 active season, overwinter hibernation of 2012-13, and 2013 active season. Marmots are grouped by “experience” treatment, which includes (a) wild-born marmots from the Mt. Washington colony, (b) captive-bred marmots that were released to Mt. Washington at least one summer prior to their translocation, and (c) captive-bred marmots released directly to the wild with no experience. A green colour indicates an active transmitter signal, yellow indicates the marmot was missing, and grey indicates the marmot was on mortality signal and not hibernating.

(a) Wild-born marmots

Name	Active season 2012	Overwinter 2012-13	Active season 2013
Atticus	Missing	Alive	Alive
Carol	Missing	Missing	Missing
Cricket2	Alive	Alive	Alive
Elise	Missing	Missing	Missing
Erica	Missing	Missing	Alive
Finn	Dead	Missing	Missing
Isis	Missing	Alive	Alive
Kelly	Missing	Missing	Alive
alive	1	3	5
dead	1	0	0
detected	2	3	5
released/available	8	7	7
alive (% of detected)	0.50	1.00	1.00
dead (% of detected)	0.50	0.00	0.00
detected (%)	0.25	0.43	0.71



(c) Direct-released captive-bred marmots

Name	Active season 2012	Overwinter 2012-13	Active season 2013
Corey	Missing	Missing	Missing
Dawn2	Dead	Missing	Missing
Francesca	Missing	Missing	Missing
Hati	Missing	Missing	Missing
James	Alive	Alive	Alive
JT	Alive	Missing	Dead
Kasia	Alive	Alive	Dead
Lanigan	Alive	Missing	Alive
Margaret	Alive	Alive	Alive
Nigel	Dead	Missing	Missing
Ota	Alive	Alive	Alive
Pan	Alive	Missing	Missing
Pandora	Alive	Missing	Missing
Ringo	Alive	Alive	Dead
Velvet	Missing	Missing	Missing
Waffles	Dead	Missing	Missing
Ymir	Dead	Missing	Missing
alive	9	5	4
dead	4	0	3
detected	13	5	7
released/available	17	13	13
alive (% of detected)	0.69	1.00	0.57
dead (% of detected)	0.31	0.00	0.43
detected (%)	0.76	0.38	0.54

(b) Pre-conditioned captive-bred marmots

Name	Active season 2012	Overwinter 2012-13	Active season 2013
Horizon	Alive	Alive	Alive
Tobe	Dead	Missing	Missing
Roberta	Alive	Alive	Missing
Harry2	Dead	Missing	Missing
Nic	Alive	Dead	Missing
alive	3	2	1
dead	2	1	0
detected	5	3	1
released/available	5	3	2
alive (% of detected)	0.60	0.67	1.00
dead (% of detected)	0.40	0.33	0.00
detected (%)	1.00	1.00	0.50

Appendix VI. Detection rate and survival status of marmots released to the Buttle Lake area in 2013. Status is shown through the 2013 active season only. Marmots are grouped by “experience” treatment, which includes (a) wild-born marmots from the Mt. Washington colony, and (b) captive-bred marmots that were released to Mt. Washington at least one summer prior to their translocation. We did not release captive-bred marmots directly to the wild in 2013. A green colour indicates an active transmitter signal, yellow indicates the marmot was missing, and grey indicates the marmot was on mortality signal and not hibernating.

(a) Wild-born marmots

Name	Active season 2012
Allira	2
Delta	0
Emma	2
Flash	2
Ian	2
Jonah	1
Kerry	2
Kim	2
Malty	2
McGinty	2
McKean	2
Merrick	0
Ora	2
Rosco	2
Tuffy	2
Wheatley	1
alive	12
dead	2
detected	14
released/available	16
alive (% of detected)	85.71
dead (% of detected)	14.29
detected (%)	87.50



(b) Pre-conditioned captive-bred marmots

Name	Active season 2012
Andrea	1
Arthur	1
Cadmium	1
Dawn3	1
Gideon	1
Hawking	1
Horatio	1
Lester2	1
Mosaic	1
Smokey	1
Wascana*	1
alive	3
dead	2
detected	5
released/available	5
alive (% of detected)	0.60
dead (% of detected)	0.40
detected (%)	1.00

* Wascana was released at Mt. Washington in 2011. She was in extremely poor condition when rescued by our project veterinarian in May, 2012, but she recovered and was re-released on Mt. Washington in July 2012. She survived the 2012-13 hibernation without further veterinary intervention, and was therefore translocated to the Buttle Lake area as part of a release group in 2013.

Appendix VII. Marmot summaries for release sites used in 2012 and 2013 translocation trials.

Sunrise

In the spring of 2013, we detected a single 5yo female, Marigold, at the Sunrise Lake colony. Remote camera footage was consistent with telemetry and showed feeder use by a single adult marmot with ear tags. On July 2, 2013, we translocated a 2yo male (Horatio) to the site, and on July 25, we translocated two wild-born yearlings (a male, Flash, and female, Ora) from Mount Washington to a nearby talus cluster on Sunrise. All four marmots were confirmed alive and in their pairings at the site in the fall.

Castlecrag

In the spring of 2013, we detected a single 5yo female, Mia, at this location. Remote camera footage showed use by a single adult marmot with ear tags, so field crew translocated a 3yo male named Mosaic to the site in early July. Mosaic had been released on Mt. Washington in 2011 for pre-conditioning, but had dispersed from the ski hill and was recovered from the community of Merville in June 2013. An additional three wild-born yearlings (two females, Kim and Tuffy and a male, Rosco) were translocated to Castlecrag on July 25. Over the course of the summer, two groups of hikers reported sightings of marmots on Castlecrag. One group submitted photographs of a tagged yearling, and the other group submitted photos of an untagged adult. In an inventory visit in September, field crew observed Tuffy near the release site, and confirmed all known marmots were alive. They also reported seeing a single pup and untagged adult at the hibernaculum site with Mia. This was the first litter recorded on Castlecrag, the third site within the Buttle Lake area to produce pups, and the fifth litter born within Strathcona Provincial Park since releases began in 2007.

Henshaw

Marmots were initially released to this site in 2010 and 2011. Several marmots died during the 2010-11 hibernation period, but at least one marmot was confirmed at the site in the late summer of 2012. In the spring of 2013, we could not detect any sign of marmots at Henshaw, and so in July 2013, we translocated six marmots to this site. The release group included two wild-born yearling females (Emma, Malty), and two pre-conditioned 2yo males (Smokey, Lester2), and one wild-born 2yo male (Ian). Wascana, a 3yo female, was originally pre-conditioned at Mt. Washington in the 2011-12 winter, but was taken back into captivity when found in severe distress that spring. She was re-released to Mt. Washington later in the summer of 2012, survived the 2012-13 hibernation in the wild, and was included in the Henshaw translocation group. All six marmots were confirmed alive at the end of the active season.

Flower Ridge

We first released marmots to Flower Ridge in 2009, but most marmots abandoned the release site. One female dispersed ~5km towards Buttle Lake. No marmots were found alive in 2010, although a hiker found the complete remains of a male on top of Flower Ridge in the late summer. In 2013, we translocated two wild-born yearling males (McGinty, Jonah), one pre-conditioned 2yo male (Hawking), and one wild-born 2yo female (Allira) to the site. At the end of the 2013 active season, we confirmed that the female and two of the males were alive and near the release site. We did not detect the other male, Jonah, on the flight.

Greig Ridge

In the spring of 2013, we confirmed survival of seven of the marmots that had been translocated to Greig Ridge in 2012. One 3yo male, Nic, was suspected to have died during hibernation. This was the only suspected hibernation death this year in the park, and a stark contrast to previous years which were characterized by large snow accumulations and extended cold weather into the spring and summer months (White, Reid and Doyle, 2012).

One of the five marmots found alive on Greig Ridge in the spring died over the summer (Kasia), as did two wild-born marmots translocated in 2013 (Delta and Merrick) and Ringo, a captive-born marmot direct-released to Tibetan in 2012 who dispersed to Greig Ridge later that summer. Two marmots that were missing in the spring were later heard on mortality signal (JT and Francesca). Francesca was detected in late September while flying near the Westmin mine site, approximately half-way between Greig Ridge and Drinkwater release sites, but the timing of her detection means that she could theoretically be hibernating. Two other marmots in the area were detected on mortality signal on that same date (Reto on Tibetan and Andrea on Greig Ridge), after being confirmed alive just two weeks prior.

At the end of the 2013 active season, we estimated 10-20 adults with prior wild hibernation experience on Greig Ridge.

Tibetan

Field crew spent one day surveying Tibetan in September, 2013. They observed one untagged adult, one untagged 2yo, and tagged 4yo adults Cherry and Skipper. Cherry was born in 2010 to a captive-bred female (Penny) who had been released at Greig Ridge in 2007. We believe the untagged adult is her 4yo sibling from the same litter. Skipper was captive-bred and released on Greig Ridge in 2011, and dispersed to Tibetan in 2012. Before we became aware of Skipper's dispersal, we translocated two males to Tibetan in 2012 to provide potential mates for Cherry. Harry2, a 5yo pre-conditioned marmot, died in the 2012 active season. Ringo, who was direct-released to Tibetan in 2012, dispersed to Greig Ridge as a 2yo and died in the 2013 active season. Telemetry flights in September 2013 also revealed that Reto, a 4yo captive-bred male released at Morrison Spire in 2010, had dispersed to the western side of Tibetan. However, his signal was on mortality mode and the timing of the flight meant that he could have been either hibernating or dead when detected.

Morrison Spire

Prior to 2013, there was a single 4yo male, Reto, who had shown site fidelity to Morrison Spire since his release there in 2010. In the spring of 2013, he was not detected at Morrison Spire, but a 2yo captive-bred female direct-released in 2012 (Margaret) had dispersed there from her release site on Greig Ridge. We translocated three pre-conditioned 2yo marmots to Morrison Spire from Mount Washington in 2013 (Arthur, Dawn3, and Gideon). All three marmots translocated in 2013 were confirmed to have survived the active season, although only a single male sounded close to the release site. In September, Margaret was also detected alive and in terrain between Morrison Spire and Mount McBride.

Appendix VIII. First Nations Internship – Final Report

13.W.CBR.01

BC Hydro FWCP, Coastal Region

VI Marmot – Buttle Lake Supplementation Project

First Nations Internship

Final Report

The Marmot Recovery Foundation is a not-for-profit organization whose purpose is to save the Vancouver Island marmot from extinction. In cooperation with forestry companies, provincial government and various other public interests, the foundation has successfully established one "metapopulation". A metapopulation is a cluster of populations whose members intermingle with each



Phil on Mt Washington.

other. The recovery goal is to have three metapopulations. A captive breeding program was developed and a breeding facility was built on Mt. Washington. Captured wild marmots are brought to the facility and bred as well as being implanted with a small transmitter. The transmitter emits a frequency (specific to each marmot) that can be tracked by use of radio telemetry gear. A "yagi" is an antenna that can pick up the signal from the marmots and used to "pin down" their exact location.

My name is Art Van Volsen and I am a member of the Hupacasath First Nation in Port Alberni.



Art on Mt Washington looking for Phil.

I came to this internship after a conversation with band CFO Rick Hewson. We were discussing different employment opportunities with the band and he brought up the BC Hydro FWCP internship opportunity with the Marmot Recovery Foundation. It was a position for a student interested in outdoor activities, but he pointed out that the position had not been filled for several months. Being on the far side of my 40's, I was apprehensive to say the least. Was I fit, could I work out of town, was I up for some long days and hard work?

I received a call from Cheyney Jackson at the end of September. I had many questions which were promptly answered. Yes, long days and hard work were the order of the day. We organized a meeting with MRF crew leader Chris White to get me properly equipped for the job. Good

hiking boots, rain gear, and quality hiking clothes were purchased and we spent some time going over the contents of a properly prepared back pack. Chris was very knowledgeable.

My first outing was to Mt. Washington to do some "pup counting". It was a great chance to try out my telemetry skills as we also needed to retrieve the transmitter from a deceased marmot. Mt. Washington ski hill has many roads and hiking was not a big issue on the first day. By day's end, the transmitter was recovered and I had good sense of what telemetry was all about.

The second outing (and most days from here on in) involved considerably more effort in the hiking needed to get to the marmots. As the days wore on, it was apparent that most marmot locations were accessed only by hiking UP. Great for the thirty something crowd by my tired old body had to do some waking up to keep pace with the crew.

The internship has offered up many opportunities to gain new skills. Among them were:

Telemetry - The proper use of radio telemetry gear is essential to field work done by MRF crew. Using the gain feature on the hand held receiver, I was able to locate hibernating or burrowed marmots as well as deceased marmots.



Using telemetry in typical west coast weather.

GPS - I was issued a hand held GPS unit navigating and collection of Universal Transverse Mercator's. UTM's are collected for trail heads, hibernaculems, transmitter recoveries and various other outdoor navigating purposes.

Spot Unit - MRF crew use both "SPOT" units and sat phones to stay in contact with office staff. I was show how to and given the chance to use both devices in real situations.

Bear safety - Predatory animals can be a concern when in the back country. I was instructed on the proper use of bear spray as well as "bear bangers".



Lifting off for an inventory trip.

Helicopter Safety - Helicopters are commonly used to access the more remote marmot habitats. Helicopter safety is essential. MRF crew have a strong relationship with several of the local pilots. Before entry into the helicopter I was given a thorough briefing by the pilot on the safety procedures involved with entry, flight, and exit. |

Field inventory methods - Using binoculars, spotting scope and telemetry to observe, document and locate marmots. By close observation with binoculars or spotting scope, it can be determined if the marmot is a pup, yearling or adult. Also to be noted is if the marmot has been "counted" already. Teamwork and communication go a long way towards assessing the marmot populations.

VHF Radio - Traveling on the many mountainous logging roads is necessary to get to the marmot habitats. Safe road travel depends on the use of VHF radio and the "call out" system where by travelers call out the km, road name, and direction to other VHF radios. The point being that everyone traveling on the roads is aware of each other. You do not want to meet a loaded logging truck on a tight corner or small bridge. VHF radio is also a great way for crew members to communicate important information to each other in the field.

It has been 8 weeks of internship and it seems hard to imagine getting up and not going outside and climbing the biggest mountains around. It is a lifestyle choice for sure but one that I personally would choose again without hesitation.

Appendix IX. Photos from the 2013 field season.



A feeder installed at the Sunrise Lake colony in the spring, 2013. The remote camera sits in a bracket at the top of the feeder (C. White).



Remote camera footage shows a wild-born adult marmot investigating a feeder on Mt. Washington, May 2013.



BUSHNELL 6.08.2013 16:14:46

Remote camera footage shows two captive-bred marmots that were released at Mt. Washington for pre-conditioning in 2012. Having survived their first wild hibernation, they were translocated to the Buttle Lake area later in the summer.



BUSHNELL 6.13.2013 4:56:15

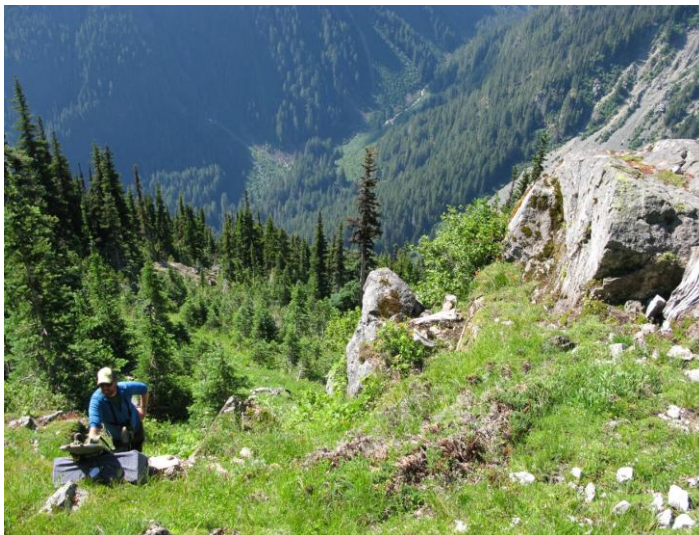
Remote cameras can also collect images in the dark. This marmot was apparently hungry for an early morning snack at the nearby feeder.



Crew member Chris White prepares a marmot for release (Henshaw, July 2013).



A marmot peeks out from its release burrow (Henshaw, July 2013).



Release time at Morrison Spire, July 2013.



Releasing marmots at Greig Ridge (July 2013).



We use baited Havahart traps to secure marmots for implant surgery.



Crew member Cystal Reid sets a trap for a marmot.



Crew member Sig Johnson carries a trapped marmot to the field surgery site.



Project veterinarian, Dr. Malcolm McAdie, checks on a marmot as it recovers from implant surgery.



A group from the Hupacasath First Nation visited us on Mt. Washington for a marmot tour (July 2013).



Taking photos of Buffy, one of the 2yo females that bred unexpectedly this year.



We gathered on one of the ski runs to count pups.



Children from the Hupacasath First Nation practice their telemetry skills while searching for a hidden elk collar.



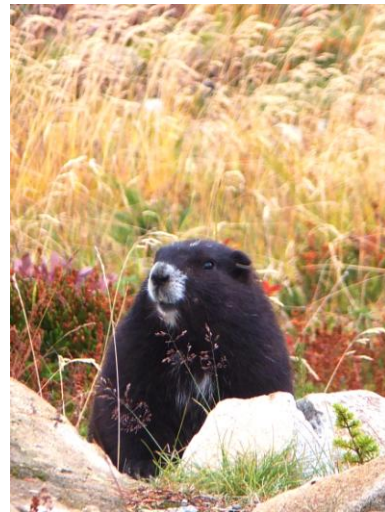
There were marmots everywhere we looked!



An inventory flight to check on active season survival of the marmots released in 2012, 2013 translocation trials (C. White).



Wodewick, a captive-bred marmot, poses for a photo. He was released at Mt. Washington in 2013 to be pre-conditioned in preparation for translocation to the Buttle Lake area in 2014 (C. White).



Iza was also released at Mt. Washington in 2013 to be pre-conditioned for translocation next year (C. White).



Art Van Volsen conducts fall telemetry in the blueberries at Mt. Washington, October 2013 (C. Reid).



A plugged hibernaculum signals the end of the active season (October 2013; C. Reid).