Inventory of Fisher Populations and Reproductive Dens in the Bridge River Watershed BCRP Project # 12W BRG 01

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EXECUTIVE SUMMARY

The final year of this project focused calculating a population estimate for fisher (*Pekania pennanti*), proposing five Wildlife Habitat Areas, producing an article on the project for the BC Trappers Magazine, and developing a brochure on fisher habitat needs for private landowners. This information will provide resource managers with data to set sustainable harvest levels for fisher; focal areas for the application of strategies to retain and augment fisher reproductive habitat; and may help sustain fisher habitat values on locations outside of direct government control, such as private lands.

We used DNA-based capture-mark-recapture methods to estimate the number of fishers in 38-20.3 km² cells at the southwest edge of the species' range in the Bridge River watershed of British Columbia. Genetic samples of fishers were collected at 16 hair-snag sites and we used 7 microsatellite markers and sex-specific markers to identify 8 individual fishers (5 male, 3 female) in our 771.4 km² study area. We used the two-innate rates model of program CAPWIRE to estimate the local population size to be 14 individuals (95% CI: 8 – 26 animals), giving us an estimated density of 18.1 fishers/1000 km². This density is higher than reported elsewhere in British Columbia in part because our estimate included all age classes and not just adult resident animals. In addition, other studies in British Columbia based density on the number of animals known alive at the end of the study, whereas we did not account for animals that may have died or dispersed. Despite these differences, the cost-effectiveness and expediency of non-invasive sampling techniques used with the program CAPWIRE hold promise for estimating the population size of low-density species such as fishers.

In addition to the population estimate generated in this year, work completed in past years of this project has provided data on the abundance of potential den trees for fisher and the locations of another blue-listed species, the wolverine (Gulo gulo), in the Bridge Watershed. The fisher density estimate will be used to refine the provincial population estimate. A manuscript has also been prepared for publication to disseminate information on fisher density in the Bridge Watershed and population analysis techniques to the scientific community. Location data from this project has been used to delineate the proposed Wildlife Habitat Areas for fisher and will also be used to focus habitat treatments, such as providing artificial den boxes, in areas where fisher are located. Information on the supply of reproductive den trees will be incorporated into management recommendations by the BC Fisher Working Group (fisher.forrex.org) for the forest industry to help protect this habitat element. Finally, data detailing the observations of wolverines has been provided to the Ministry of Environment to aid in the conservation of that species.

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1.0 INTRODUCTION

Fishers (*Pekania pennanti*) are forest-dependent carnivores of the weasel family that are an important component of healthy ecosystems. Several aspects of the ecology of fishers, including their use of rare structural elements found primarily in late-successional forests, make them susceptible to changes to the forested landbase resulting from hydro-electric development, forest-harvest activities, and oil and gas development. As such, fishers are considered a species at risk under the Identified Wildlife Management Strategy and are blue-listed (S2S3) in British Columbia. Fishers are a high priority for conservation efforts, as they are considered Rank 2 under Goal 3 of the provincial Conservation Framework: Maintain the diversity of native species and ecosystems.

The fisher population in British Columbia is estimated at between 2236 and 3715 (Lofroth 2004) based on 243,542 km^2 of moderate – very high capability habitat mapped in the province. This estimate is based on studies in the Williston area (average 8.8 fishers/1000 km^2, Weir and Corbould 2006) and northeastern region (average 16.3 fishers/1000 km^2, Weir et al. 2011) of British Columbia. These estimates are between 4 – 33% of those reported in eastern North America and California (Weir et al. 2011). The reasons for the much lower densities in British Columbia are not known, but may stem from lower prey densities and deeper snow conditions found at higher latitudes affecting fisher locomotion (Raine 1983).

The sustainable management of fisher populations requires information on population size. In British Columbia, fisher population density varies among regions likely in response to habitat quality, but more inventories are required in a variety of habitats to provide better estimates of local and regional densities (B.C. Conservation Data Centre 2013). Density estimates are also required to help address and potentially mitigate impacts by recent large-scale insect infestations, hydroelectric reservoirs, and forest harvesting. Fishers are secretive and difficult to inventory (Powell and Zielinski 1994) and a variety of methods (e.g. MNA, mark-resight, territorial mapping) have been used to estimate fisher densities.

Information from this project will provide BC Hydro and the St'át'imc Nation with better data upon which to evaluate impacts of hydroelectric and other resource developments on fishers in the Bridge River drainage and identify mitigation options, where necessary and feasible, to retain and recover reproductive habitat for this species. This project provides a unique opportunity to apply the knowledge gained from research funded by other Wildlife Compensation Programs of BC Hydro (e.g., Weir and Corbould 2008) and build upon our base of understanding of fisher ecology.

1.1 Objectives

The multi-year objectives of this project are to conduct inventories of fishers in the assessment area to ascertain the status of the population and to complete a habitat inventory that will

document the distribution and abundance of potential den trees for fishers in areas outside of the footprint to determine if these features are limiting. In this third year of the study, our objectives were to:

1. Conduct a DNA based mark-recapture study to estimate fisher densities in the Bridge River watershed.
2. Produce a manuscript on fisher densities in the Bridge River watershed for publication.
3. Propose 5 candidate Wildlife Habitat Areas and submit the data to the Ministry of Environment.
4. Submit an article on the project to the BC Trappers Magazine.
5. Develop an information brochure for private landowners on preserving fisher reproductive habitat.

2.0 STUDY AREA

The 771.4-km² study area lies within the Gun, Tyaughton, and Yalakom drainages to the northwest of Lillooet, BC and occurs within the Southern Chilcotin Range and Central Chilcotin Range ecosections. The area is dominated by the Interior Douglas-fir (IDF, 356.0 km², 46% of study area), Montane Spruce (MS, 175.6 km², 23%), and Engelmann Spruce - Subalpine-fir (ESSF, 233.1 km², 30%) biogeoclimatic zones with a small amount (6.7 km²; 1%) of high-elevation Interior Mountain-Heather Alpine zone (Meidinger and Pojar 1991). The study area encompasses portions of 3 registered traplines, occurs within the traditional territory of the St'át'imc First Nation, and is located at the southeastern edge of the distribution of fishers within the province (Figure 1).

At a broad scale, the Gun, Tyaughton, and Yalakom drainages of the Bridge River Watershed are rated as having moderate to high capability for supporting fishers (Lofroth 2004). However, flooding of the Bridge River Valley by the Carpenter and Downton hydroelectric reservoirs and recent large wildfires in the assessment area may have reduced the habitat quality of this area for fishers. Much of the area is also part of the harvesting landbase with clear-cut logging being the dominant harvesting system.

The study area is dominated by broad lower valleys with steep-sided slopes and elevations ranging from 650 m near the Carpenter reservoir to approximately 3000 m in the rugged peaks at the headwaters of the watershed. Weather is primarily affected by continental and modified maritime weather that produces deep snowpacks during winter and occasional short duration rainfall between June – July. Summer to early fall is generally warm and dry (Fish and Wildlife Compensation Program 2011).

Valley bottoms support mixed deciduous forests, with coniferous forests dominating elevations above these areas. Black cottonwood (*Populus balsamifera* var *trichocarpa*), trembling aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*) are the leading broadleaf trees. Coniferous species are dominated by ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii* var *glauca*) at low- to mid-elevations. Lodgepole pine (*Pinus contorta*) is found in seral stands throughout the area. Hybrid spruce (*Picea engelmannii* x *glauca*) becomes more common with increasing elevation and is found at all elevations in moist habitats. Small areas of western red cedar (*Thuja plicata*) are found in wetter isolated sites, whereas sub-alpine fir (*Abies lasiocarpa*) is found at higher elevations and on north aspects.

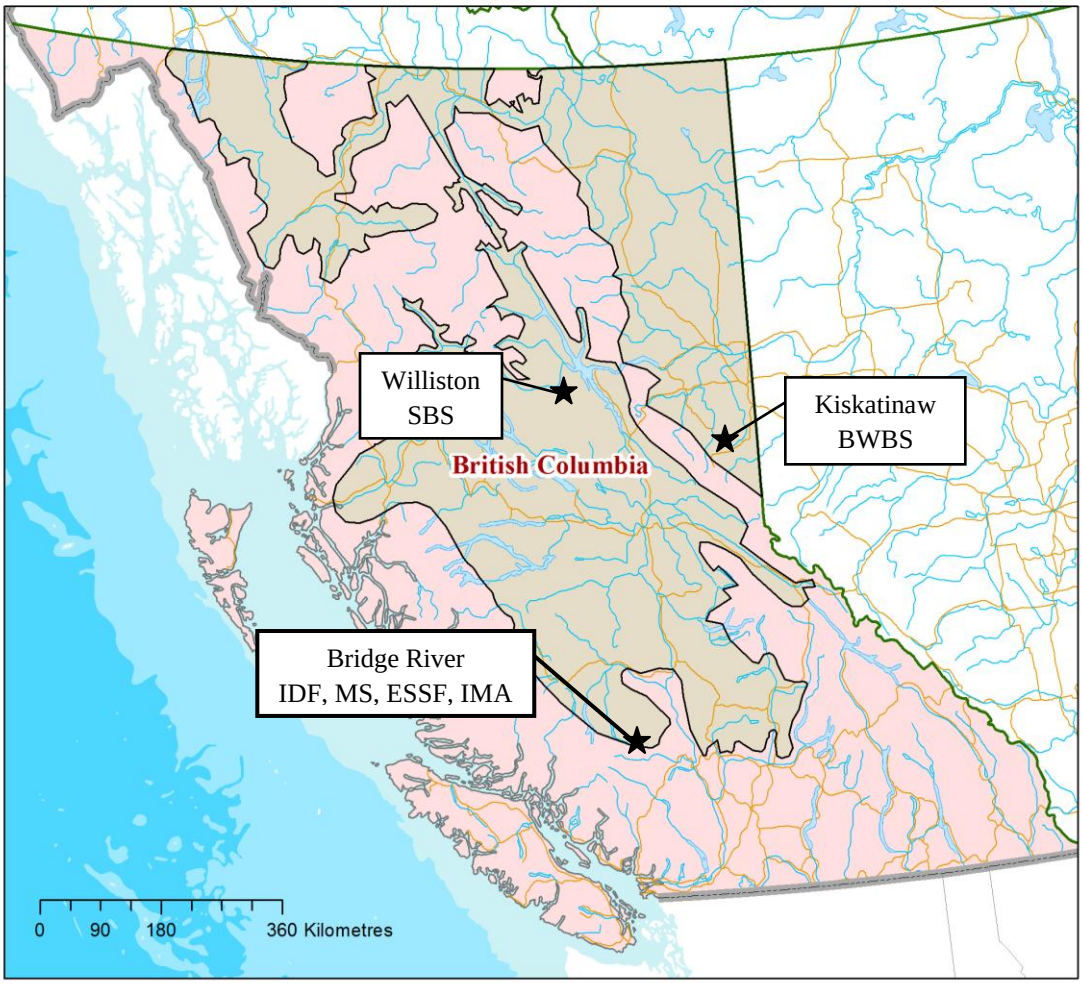

Figure 1. Location of Bridge River study area within the distribution of fishers (beige area) in British Columbia (black boundary; adapted from Weir 2003). Study areas from 2 other density estimates in the province are also shown (Williston, Weir and Corbould 2006; Kiskatinaw, Weir et al. 2011).

3.0 METHODS

3.1 DNA-based Inventory

We conducted a capture-mark-recapture (CMR) survey using genetic sampling to estimate the abundance of fishers within the project area, following RISC standards (Resources Information Standards Committee 1999) and using the field methodology outlined by Mowat and Paetkau (2001). The study area was originally divided into 45-20.3 km^2 cells, each of which approximated the smallest expected size of a female home range in this area (i.e., lower quartile of documented sizes; Weir et al. 2009). We accessed each cell by foot, truck, snow machine, and helicopter for sampling; however, 7 cells could not be accessed safely by any method and were not surveyed, resulting a total of 38 cells being sampled. All sampling occurred under Wildlife Act permit KA11-75934 and conformed to welfare standards of the Canada Council on Animal Care.

We passively collected hair and follicle samples containing genetic material from individual fishers attracted to a baited hair trap within each cell using non-invasive sampling techniques (e.g., Foran et. al. 1997). We situated sampling sites in the best available habitat (Davis 2009, Weir 2003) based on the field crew's discretion; typically these were productive stands with trees >15m tall and connected to other like stands. We recorded habitat information at each sampling site including: location, elevation, aspect, slope, crown closure, mesoslope position, structural stage, broad ecosystem unit, surface topography, and the 3 most abundant tree species (British Columbia Ministry of Environment, Lands, and Parks and British Columbia Ministry of Forests 1998).

We deployed hair traps fashioned after the design of Foran et al. (1997), with two pieces of board (2 x 19 x 60cm) screwed together along the long edge to form a triangle. Hair traps had four pieces (approximately 2 x 7 cm) of adhesive-based mouse trap boards attached inside to collect hair from fishers that tried to access the bait within the hair trap. We baited hair traps with chicken with commercial beaver castor and commercial fisher lure used as attractants. Traps were attached vertically to a tree with a small board attached as a roof above to protect hair samples from precipitation. Researchers used battery powered drivers to screw the traps to a tree and applied attractants to jute string hung on branches adjacent to the traps.

We deployed hair traps at each site for approximately 18 days, then moved the unit to a new location within the cell for a subsequent 18 days. Trap sites were first established in mid-January, then moved to a new location within each cell twice in February, once in March, and finally retrieved in early April, for a total of four 18-day sampling sessions. On consecutive sampling sessions, we moved the traps $\geq$ 1 km from the previous site to reduce the likelihood of habituation, and consequent re-sampling, of resident animals.

At the end of each sampling session, we checked each glue pad to assess if an animal left hair and follicle samples in each glue pad of the trap. We removed each glue pad that had collected a sample and covered it with plastic ribbon, then stored it in a paper envelope with the date,

session, and trap number recorded on it. The field crews also recorded information on the putative species of the sample and tracks of species observed near the sample site. We stored sample envelopes in dry conditions until ready to be submitted for genetic analysis.

Genetic Analysis

We sent samples to a commercial genetics lab (Wildlife Genetics International, Nelson, B.C.) for sorting to species and genetic fingerprinting. Samples with no guard hair roots and < 5 underfur hairs were identified as inadequate due to unacceptably low success rates in previous studies[1]. DNA was extracted using QIAGEN DNeasy Tissue kits following the manufacturer's instructions[2]. The lab then used clipped roots of 10 guard hairs where available, or an entire clump of under-furs (with the number of hairs estimated) used instead of clipping roots for DNA extraction. Where extraction required removal from the glue pad, a commercial solvent was used.

The lab conducted a mitochondrial prescreen using a sequence-based analysis of a segment of the mitochondrial 16S rRNA gene to identify those samples that came from fishers. Sequence profiles were compared to reference data from 125 species of mammals to identify species. For samples identified as fisher, individual identity was characterized using 7 microsatellite markers used in an earlier study on fishers elsewhere in BC (MP0055, MP082, MP0144, MP0114, MP0175, Mvis072, LUT604; Weir et al. 2013) and the ZFX/ZFY/SRY gender system developed by the lab for mustelids[1] for a total of 8 markers. A 3-phase approach was used to identify individuals beginning with a first pass of 8 markers on the samples. A clean-up phase reanalyzed data points that were weak or difficult to read, producing a set of samples with complete 8-locus genotypes.

Data Analysis

We estimated the local population size using the genetic tagging data in a single session capture-mark-recapture (CMR) model using the program CAPWIRE (Miller et al. 2005). The program uses likelihood functions to describe an urn model in which individuals are drawn with replacement from a population that is continuously mixing. Miller et al. 2005) found that CAPWIRE is also robust for species that occupy semi-discrete areas, such as fishers, especially where DNA deposition rates are heterogeneous. We accounted for differential capture probabilities within the survey population using two models: equal captureability model (ECM), and two innate rates model (TIRM). CAPWIRE implements a likelihood-ratio test to choose the most appropriate capture model in the estimation of population size. CAPWIRE estimated confidence intervals for the size estimate using a parametric bootstrap procedure (Miller et al. 2005).

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[1] 2012 Unpublished communication with Wildlife Genetics International.

[2] QIAGEN DNeasy Tissue kits. http://www.qiagen.com/

3.2 Delineation of Wildlife Habitat Areas

Previous research in the Bridge Watershed (Weir and Davis 2011; Davis 2012) and the results of the DNA-based inventory has identified high value habitats for fisher in the Bridge watershed. We delineated high value habitats on 1:20,000 scale forest cover maps and overlaid fisher occurrence data to provide areas of interest for Wildlife Habitat Areas (WHA). Field reconnaissance of these areas was conducted to identify 1- 3 ha patches of mature – old forest that contained an abundance of large diameter, decaying, cottonwood, Douglas-fir, and aspen. Candidate WHAs were marked with an identification tag (WHA ID and L. Davis phone number) flagged with orange "Wildlife" ribbon, blazed, and painted with orange bars. Each WHA was mapped using GIS and the data submitted to the Ministry of Environment in Kamloops.

3.3 Outreach

The results of this project have been prepared as a manuscript for publication, summarized as an article for the BC Trappers Magazine, and used to develop an information brochure for private landowners to help preserve fisher reproductive habitat.

4.0 RESULTS

4.1 DNA-based Inventory

Between January and April 2012, we had hair traps active for 2592 trap-nights (i.e., 1 hair-trap active for a 24-hour period) at 152 sample sites within the 38 surveyed cells in the Bridge River watershed. Hair samples were collected from 61 (40%) of the sample sites. Genetic analysis identified species in 60 of the samples, with a total of 16 captures of fishers recorded (Table 1). Other species captured include American marten, red squirrel, northern flying squirrel, and wolverine (See map in Appendix 4 for the distribution of species captures). Fishers were detected within cells by the second session, on average. The fisher samples yielded an average of 7.0 guard hair roots per sample and, from this, we achieved 100% genotyping success. Of the 16 fisher samples, 8 individuals were identified, including 3 females and 5 males. The most similar genotypes differed at 3 of the 8 loci used in the analysis, with the mean observed heterozygosity being 0.66 for the 7-microsatellite markers. Within our sample, 2 males were detected at 4 different sampling sites, 1 female was detected at 3 different sampling sites, and the remaining 5 individuals were only detected at a single sampling site.

We primarily detected fishers in the IDF (13 detections; 81%) with only 3 locations in the MS (19%) and none in higher elevation biogeoclimatic zones (i.e., ESSF and IMA; Table 2). On average, fishers were detected at 1141 m elevation (SE = 41.2, n = 16), whereas American martens were found at an average of 1309 m elevation (SE = 68.0, n = 23). Detections of

Table 1. Detections of fishers and other species between January and April 2012 in the Bridge River watershed, British Columbia. We calculated capture rate as the percentage of sampling sessions in which a capture occurred. Latency was estimated as the average number of sessions that needed to pass in a cell before a capture occurred, not including traps without captures for that species.

Species	Captures	Capture rate (%)	Latency
Fisher	16	11.1	2.1
American marten (*Martes americana*)	23	16.0	2.1
Red squirrel (*Tamiascurus hudsonicus*)	11	7.6	2.6
Northern flying squirrel (*Glaucomys sabrinus*)	9	6.3	1.8
Wolverine (*Gulo gulo*)	1	0.01	4
All species	60	41.7	1.9

Table 2. Elevations and biogeoclimatic zones (BEC) at species detections in the Bridge River watershed, British Columbia.

Species	Mean Elevation (range) (m)	BEC		
		IDF	MS	ESSF/ IMA
Fisher	1141 (861 – 1423)	13	3	0
American marten	1309 (822 – 1978)	11	4	8
Red squirrel	1180 (937 – 1439)	9	1	1
Northern flying squirrel	1057 (733 – 1424)	8	1	0
Wolverine	1898	0	0	1

American martens appeared to be more evenly spread among biogeoclimatic zones than either fishers or squirrels.

Using the automatic model selection option within program CAPWIRE, we identified TIRM as the model best fitting the data that we collected. We estimated the population for our study area to be 14 fishers (95% CI: 8-26). The model estimated that the 'easy' to catch fishers (i.e., those fishers with >1 capture, Type A; Miller et al. 2005), were 5.9 times as likely to be captured as the 'hard' to capture fishers (i.e., type B). We estimated the density of fishers to be 18.1 fishers/1000 km² (95% CI: 10.4-33.7 fishers/1000 km²) through our entire sampled area.

4.2 Wildlife Habitat Areas

Five candidate WHAs have been located in the field, mapped, and submitted to the BC Ministry of Natural Resource Operations (John Surgenor, Wildlife Biologist, Thompson Okanagon Region). The areas are distributed across the study area with one in the Yalakom valley, two near Marshall Lake, and two near Gunn Lake (see maps in Appendix 5).

4.3 Outreach

An article on the project has been sent to the BC Trappers Association for inclusion in their magazine and a brochure for landowners and fisher reproductive habitat has been prepared (see Appendix 6). In addition, a manuscript on the density estimate is in the process of peer review and will be submitted to a journal (Appendix 7).

5.0 DISCUSSION

Our study used non-invasive genetic CMR methods to estimate the size of the local population of fishers in the Bridge River watershed, British Columbia. The density of fishers that we observed was high relative to other areas in the province, which may be the result of a number of reasons, including relative productivity of ecosystems among the different regions, methodological differences among studies, population differences, and other spatial and temporal factors.

The biological and environmental conditions found in the biogeoclimatic zones in which we conducted our survey likely affected the density that we observed. Unlike other studies in British Columbia in which fisher density was estimated for a single biogeoclimatic zone (i.e., Sub-Boreal Spruce, Weir and Corbould 2006; Boreal White and Black Spruce, Weir et al. 2011), our study area encompassed 4 different biogeoclimatic zones, each likely with a different capability

to support fishers. These zones were previously predicted by Lofroth (2004) to have high (IDF zone), moderate (MS zone), low (ESSF), or no (IMA) capability to support fishers based on the climate, vegetation, and prey communities found in each. Our detections broadly supported these predictions; 13 of 16 detections of fishers occurred in the IDF zone, 3 detections were in the MS zone, and no fishers were detected in either the ESSF or IMA zones.

It is unclear as to the effect on our density estimate of conducting a survey with sample cells that included considerable amounts of poor-capability biogeoclimatic zones. Approximately one-third of the surveyed area included high-elevation zones that had considerable snow depth and few denning opportunities for fishers (i.e., no cavity-bearing trees; Lofroth et al. 2010). In addition to virtually no deciduous trees present, the ESSF zone has much deeper snow than lower elevation zones with a mean annual snowfall of 782 cm (Boss Mountain) compared to 145 cm in the IDF (150 Mile House) and 398 cm in the MS (Brenda Mines) (Meidinger and Pojar 1991). Fisher locomotion is restricted by soft, deep, snow, which increases energetic costs (Raine 1983). These results also suggest that lower elevation areas (i.e., IDF zone) impacted by hydroelectric reservoirs would have contained valuable fisher habitat. Valley bottom habitats along rivers generally have the lowest annual snowfalls and usually contain the richest sources of prey and highest numbers of cavity-bearing trees needed for reproduction. Given that less than half of the study area was rated as high-capability, it is possible that the density would have been higher if our study area only included the IDF biogeoclimatic zone.

When compared to other studies in British Columbia, the Bridge River watershed has the highest documented fisher density in the province despite our study area being rated moderate – high capability (Lofroth 2004). Weir et al. (2011) estimated fisher densities in northern British Columbia between 11.4 – 20.8 fishers/1000 km² over 3 years in the Boreal White and Black Spruce biogeoclimatic zone, and 8.8 fishers/1000 km² in the Sub Boreal Spruce zone (Weir and Corbould 2006). Both estimates were calculated for late winter and used minimum known alive (MNA) methods to estimate the number of fishers in the study area. This approach is subject to negative bias caused by variable capture probabilities (Nichols and Pollock 1983; Nichols 1986), heterogeneity in trapability (Jolly and Dickson 1982), and tapering bias (Pocock et al. 2004). However, fishers are a low-density species in British Columbia and sample sizes are often too small for more rigorous estimators. We found that program CAPWIRE, which has been used for other low-density populations such as Bengal tiger (*Panthera tigris*; Borthakur et al. 2010), Arabian leopards (*Panthera pardus nimr*; Perez et al. 2006), and capercaillie (*Tetrao urogallus*; Jacob et al. 2010), showed great promise for estimating abundance for populations with less than 100 individuals, such as fishers.

The density calculation used by Weir and Corbould (2006) and Weir et al. (2011) was also slightly different than we used, which may have accounted somewhat for the difference in density that we observed. In those studies, density was estimated as the number of individuals known to be alive at the end of March, so it excluded any animals that died or dispersed. Our estimate of density, however, was based upon samples collected over the course of winter and

may not have accounted this occurrence. Furthermore, density was estimated elsewhere in the province for resident adult fishers only, with the rationale that non-resident individuals (i.e., juvenile and transient animals) do not make substantial contributions to the functioning of the population. Conversely, our estimate of population size likely included juvenile and transient fishers resulting in a higher population estimate than would have been obtained using the methods employed elsewhere in British Columbia.

Our survey and resultant estimate provide only a single snapshot in time of the fisher population in the Bridge River watershed. Both Weir and Corbould (2006) and Weir et al. (2011) observed that their density estimates fluctuated 30% and 82% among years, respectively. Our observed density of 18.1 fishers/1000 km² lies within 3 years of variation in density observed in purported high-capability habitat in northeastern British Columbia (i.e., 11.4 – 20.8 fishers/1000 km²; Weir et al. 2011), but was higher than any of the 4 yearly estimates from the moderate-to-high capability Sub-Boreal Spruce zone in northcentral British Columbia (i.e., 7.9 – 10.3 fishers/1000 km²; Weir and Corbould 2006). Continued monitoring of our study population would be helpful for confirming or updating this single-year population estimate.

Our use of non-invasive CMR sampling methods provided an economical method by which to estimate population density in a quick, efficient manner. Unlike the intensive, multi-year live-capture and radiotelemetry approach used by Weir and Corbould (2006) and Weir et al. (2011) to estimate fisher density, non-invasive CMR methods likely reduced stress, capture bias, and the sampling period needed to estimate population size. The program CAPWIRE was developed specifically for small populations, such as fishers, and can incorporate multiple sampling within a sampling session (Miller et al. 2005) like is common with non-invasive CMR programs. Genotyping error is a concern with non-invasive CMR studies due to inflation of the number of individuals in the data set that can have a large inflationary effect on population parameters (Mills et al. 2000; Waits and Leberg 2000; Creel et al. 2003). In this study, the most similar genetic fingerprint differed by at least 3 markers, which makes it highly unlikely that the number of individuals were inflated through undetected genotyping error (Kendall et al. 2009). Despite this success, we recommend that caution should be exercised when interpreting results where there are low numbers of unique individuals and low recapture rates as was found in this study.

The few number of recaptures that we achieved likely contributed to the relatively low precision of our estimate. Our number of captures was lower than the average of 2.5 captures per individual recommended by Miller et al. (2005) to reach a 15% mean relative error (MRE) for the true population size. Our average of 2 captures per fisher yielded a MRE within 25-30% of the estimated population size. Increasing the number of sampling sessions may have increased the capture rate, and concentrating sampling in zones more likely to contain fishers, such as lower elevation biogeoclimatic zones, may also have resulted in an improved capture rate.

Although the fisher density estimate is high for British Columbia populations, our density estimate was low compared to eastern North America (50 – 385 fishers/1000 km²: Powell and

Zielinski 1994; Fuller et al. 2001) and California (58 – 199 fishers/1000 km²: State of California Dept. Fish and Game 2010). Weir et al. (2011) theorized that these differences in abundance may be explained by differing snow conditions and prey abundance in the eastern and southern portions of the fishers range. These factors along with reproductive den tree abundance vary widely between British Columbia and other areas of the species range, which may help further explain some of the differences in fisher densities across the species range.

This study will provide resource managers and trappers with information on fisher densities at the southern edge of the species range in British Columbia, and local information is likely to better estimate sustainable harvest levels for this species. This density estimate will also help refine the estimate of the provincial population of fishers, as previous estimates did not have empirically based data for the Interior Douglas-fir biogeoclimatic zone, which accounts for some of the highest suitability fisher habitat in the province (Lofroth 2004). Although our study area was subject to several relatively large-scale habitat impacts, care must be taken in interpreting the results. The estimate is based on only one year of data that suffered from low precision. Further, impacts such as mountain pine beetle infestation and large-scale fires are relatively recent and habitat-related effects from these disturbances may still be occurring on the population. Further, non-invasive methods also do not provide information on population demographics that are required to estimate sustainable harvest levels.

6.0 CONCLUSIONS

The inventory has supplied valuable information on the density and distribution of fishers in the Bridge Watershed. The data can be used by resource managers to help set sustainable harvest levels, but may also provide spatial information for targeted habitat management. For instance, large-scale habitat impacts can affect the supply of important habitat elements, such as reproductive den trees, which can have profound long-term demographic effects for which mitigation may be required to ensure sustainable populations. The establishment of Wildlife Habitat Areas in the Bridge Watershed will aid in preserving patches of habitat with higher potential for denning; however, fisher often use multiple dens when rearing kits and other options for providing this habitat are required. This project has also supplied important data on the supply of reproductive den trees in the Bridge Watershed (Davis 2012) that will be integrated with recommendations for forestry operations prepared by the BC Fisher Working Group (fisher.forrex.org). The adoption of these recommendations by forest companies will help sustain fisher habitat values. Likewise, it is hoped that the information brochure for private land will result in the retention of large trees that can benefit a range of wildlife including fisher. Despite these actions, some areas may be lacking in reproductive denning structures that can take many years to develop (Lofroth et al. 2010). Developing conservation strategies for increasing the supply of denning structures in those areas will be important in maintaining fisher populations across the species range.

7.0 RECOMMENDATIONS

Conservation strategies for maintaining and augmenting fisher habitat are required for areas that are being impacted by development. Focusing forest retention on stand types more likely to have den trees has been recommended by the BC Fisher Working Group (fisher.forrex.org) as a strategy for forest harvesting operations. Alternatively, increasing the supply of reproductive denning structures has been identified as an important strategy for landscapes where the supply of den trees may be limited by large-scale impacts, such as mountain pine beetle. Artificial den boxes may provide reproductive habitat for the short to mid term (5 – 50 years) and research is required to determine the best size/configuration for fisher as well as other factors that may influence use. Female fisher are very selective for the size of entrance hole to cavities and mechanical alteration of trees with existing heartrot but lacking an appropriate sized entrance hole could also be employed to increase the supply of suitable trees. Finally, fungal inoculation holds promise in producing heart rot to enhance the mid to long-term supply of wildlife trees and efforts to promote heart rot in all tree species used by fishers should be explored. Weir et al. (2012) recommended focused research on how the duration and intensity of infection in wounds of different types affects cavity development. Identifying the morphological and developmental patterns of tree growth that facilitate tree infection, cavity development, and the creation of access holes is also key to maintaining the supply of reproductive structures (Weir et al. 2012).

Table 3. Strategies for increasing the supply of large cavity trees for fisher and other cavity dependent wildlife.

Strategy	Description
Forest retention	Retention of individual trees, patches, and stands containing large old trees will provide immediate benefits to wildlife. This elements, patches, and stands can be retained during forest harvesting and through the creation of Wildlife Habitat Areas. Current guidance is available through the BC Fisher Working Group (http://fisher.forrex.org/) on stands and trees that provide reproductive habitat.
Mechanical alteration	Creating appropriate sized holes in trees with extensive heart rot may increase the supply of suitable den trees. Applied research is needed to identify the trees most likely to benefit from this treatment and assess use by wildlife.
Artificial den boxes	Den boxes may provide reproductive habitat in areas where most large old trees have been lost. Applied research is required to determine the size/configuration of the den boxes and other factors that contribute to use by fisher.
Fungal inoculation	Research is needed to identify fungal species that cause heart rot in trees used by fisher, how the duration and intensity of infection affects cavity development, and identifying the morphological and developmental patterns of tree growth affect infection and decay processes.

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APPENDIX 1. FINANCIAL STATEMENT

	Budget		Actual	
Income	BCRP	Other	BCRP	Other
Income by source	$19,550	$21,200	$11,730.00	$21,174.90
Total income	$40,750		$32,904.90	
Expenses				
Project personnel				
Senior Biologist (employee)	$9,000.00	$9,000.00	$17,545.50	$13,500.00
St'át'imc Technicians	$1,250.00	$1,250.00	0	$975.00
St'át'imc Coordinator	$0.00	$800.00	$0.00	$800.00
Government Biologist	$0.00	$400.00	$0.00	$400.00
Materials & Equipment				
Field Accommodation	$375.00	$375.00	$0.00	$260.00
Meals	$105.00	$105.00	$201.60	$0.00
Mileage	$550.00	$550.00	1319.57	$0.00
Genetic analysis	$7,825.00	$7,825.00	0	$2,764.95
Field supplies	Not specified	Not specified	$0.00	$79.95
Mapping	Not specified	Not specified	$43.31	$1,945.00
Administration				
Laptop, software, printer	$0.00	$450.00	$0.00	$450.00
Project poster	$95.00	$95.00	$0.00	$0.00
Extension delivery products	$350.00	$350.00	$411.74	$0.00
Total expenses	$40,750.00		$40,696.62	
Balance (total income - total expenses	$0.00		($7,791.72)	

APPENDIX 2. PERFORMANCE MEASURES

Because this project did not involve habitat manipulations, there were no standard reportable "performance measures" as outlined in the report guidelines.

We completed the following in the 2012-2013 fiscal year:

- Located, mapped, and submitted five candidate Wildlife Habitat Areas
- Identified the species for 60 hair snag samples/individual identity and sex for 16 fisher samples.
- Produced a density estimate for fisher in the Bridge Watershed based on the hair snag results.
- Recommended the development of 4 strategies/research priorities for retaining and augmenting the supply of fisher reproductive habitat.
- Produce an article for the BC Trappers Magazine
- Developed a pamphlet on preserving fisher reproductive habitat for private landowners.
- Produced a manuscript on fisher abundance in the Bridge Watershed that will be submitted to a journal.

APPENDIX 3. BCRP RECOGNITION

Over the course of fieldwork in the study area we stopped and discussed the project with people living and working in the area. Several phone calls were fielded from residents that found the Wildlife Habitat Areas near their property. In all cases, we identified FWCP as the funding agency for the work and discussed fisher habitat needs. All discussions of the project were positive with people generally very interested in the work and asking where they could find our reports. Other examples of recognition are outlined below.

Community Outreach

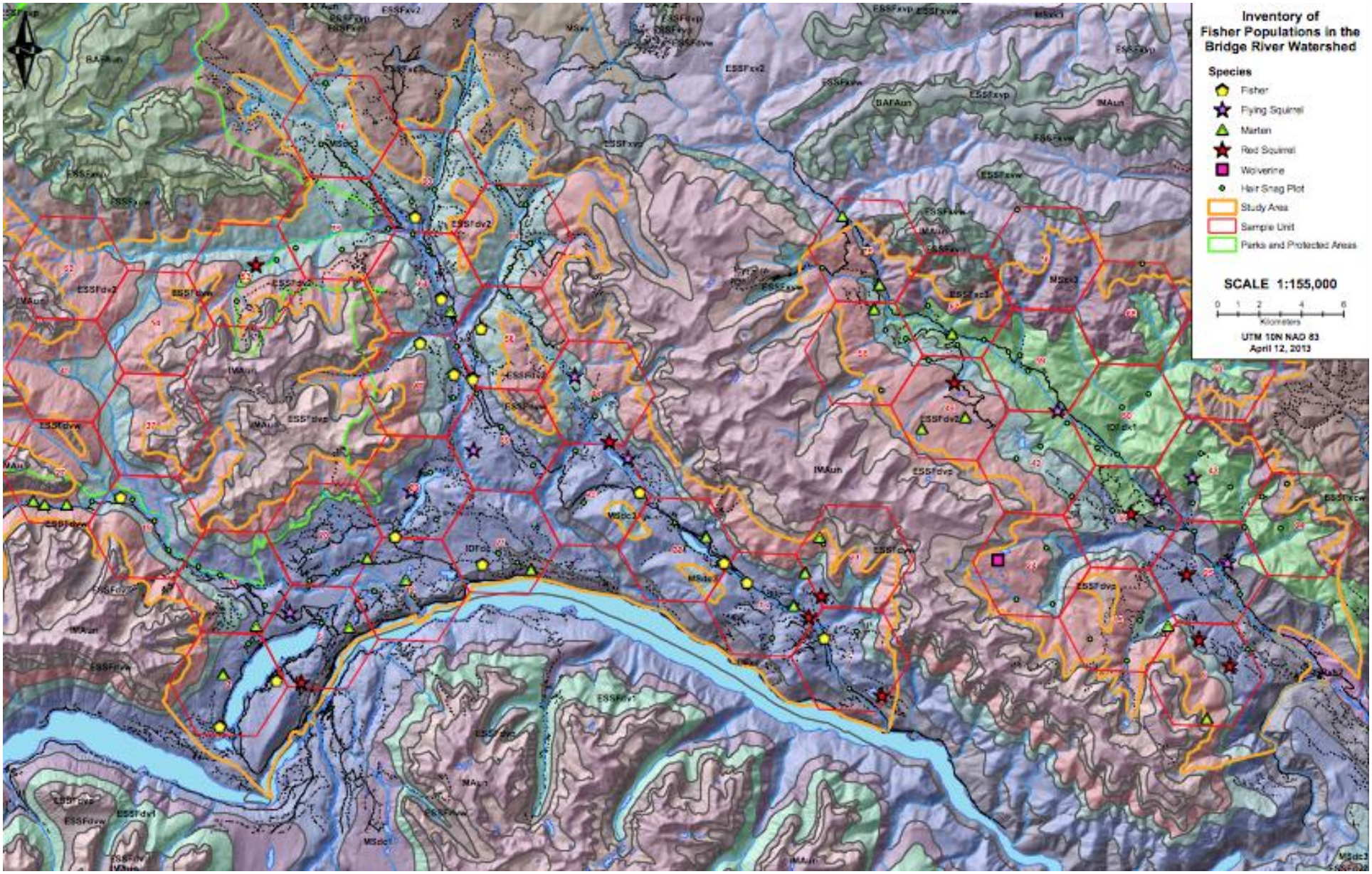
- A brochure has been developed for private landowners that outlines fisher habitat needs and promotes the retention of large cavity bearing trees. This pamphalet will be made available for download at fisher.forrex.org and will be made available at all public presentations on fishers. The FWCP logo is displayed on the brochure.

- An article has been prepared for the BC Trappers Magazine that outlines the results of the project. The FWCP is recognized in the article as a funding source for the project

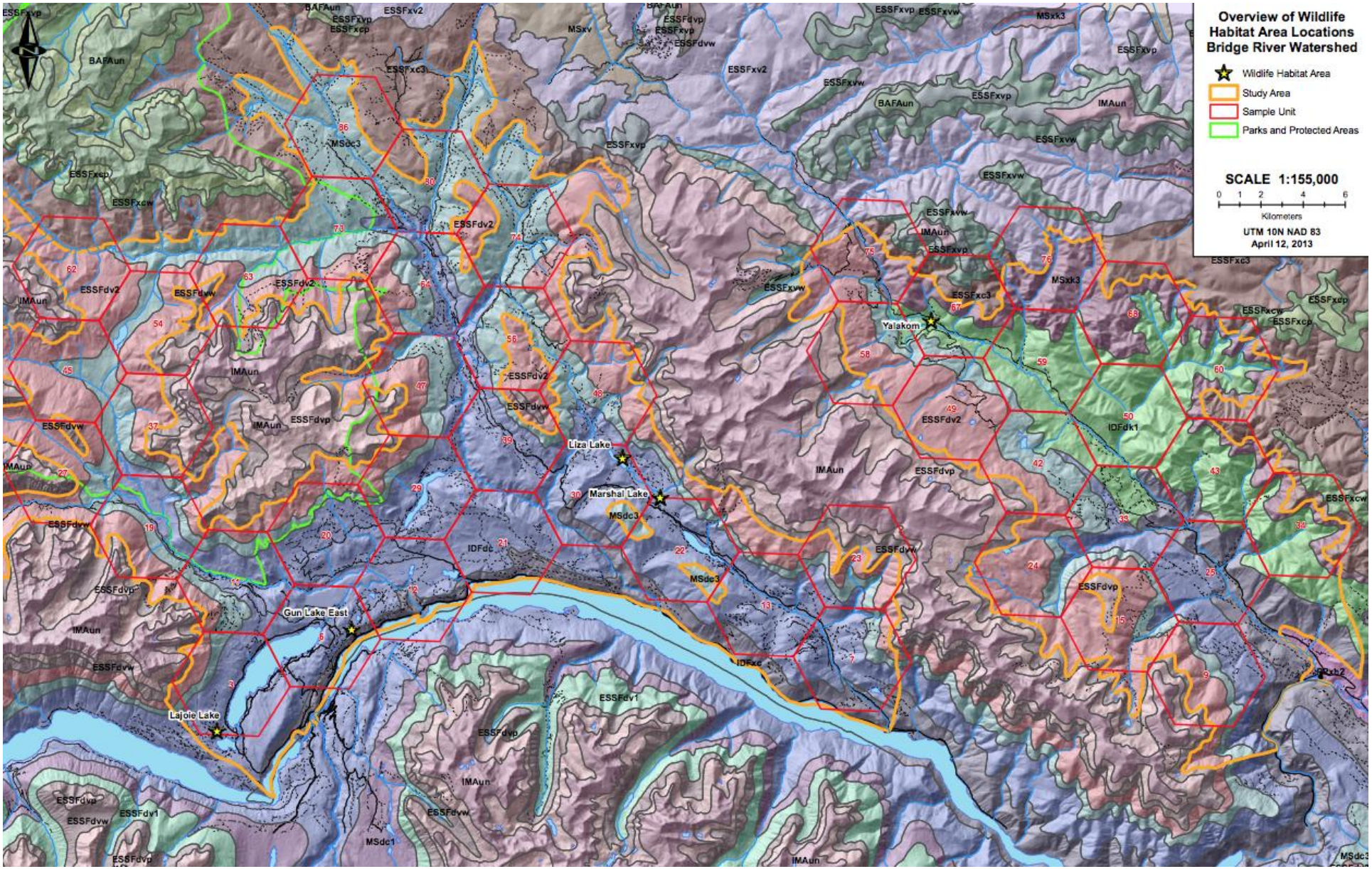
Communication of Results to Government, Industry, and Academia

- The density information has been provided to the BC Government to promote the sustainable management of fishers.
- Results of this project have been made available to the BC Fisher Working Group who will incorporate the information into the management recommendations for forest companies to promote habitat management strategies for fishers.
- A manuscript on fisher density in the Bridge Watershed has been prepared and peer reviewed that will be submitted to a journal for publication.

APPENDIX 4. MAP OF SPECIES CAPTURES DURING DNA-BASED SAMPLING IN THE BRIDGE WATERSHED OF BRITISH COLUMBIA


Inventory of
Fisher Populations in the
Bridge River Watershed
Species
Fisher
Flying Squirrel
Marten
Red Squirrel
Wolverine
Hair Snag Plot
Study Area
Sample Unit
Parks and Protected Areas
SCALE 1:155,000
0 1 2 4 6
Kilometers
UTM 10N NAD 83
April 12, 2013

APPENDIX 5. MAPS OF WILDLIFE HABITAT AREAS PROPOSED IN THE BRIDGE WATERSHED



See attached files for individual WHA maps.

APPENDIX 6. OUTREACH

See attached files.

APPENDIX 7. FISHER DENSITY MANUSCRIPT

See attached file.