FISHER (*Pekania pennanti*) ARTIFICIAL REPRODUCTIVE DEN BOX STUDY

CAT18-3-345 / COA-F18-W-2394

31 March 2018

Prepared for:

Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders,

Habitat Conservation Trust Foundation,

and the Forest Enhancement Society of British Columbia

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Executive Summary

Fishers (*Pekania pennanti*) are a threatened species (S2S3) in British Columbia and are a high priority for conservation efforts. Fishers are the largest obligate tree-cavity user in North America and this study seeks to determine if the species will use artificial den boxes for reproduction. Trees with characteristics of natural fisher dens are rare in forested landscape and changes to the forest landbase resulting from hydro-electric development, insect infestations, forest-harvest activities, and large-scale fires are likely to have decreased the supply of these elements. This fifth year of the study continues the monitoring efforts on the 53 remaining den boxes.

Similar to 2017, monitoring during the reproductive season (April – June) identified four den boxes that were used for reproduction and three of the structures used were in the Bridge Watershed. The fourth den box is located in the Chilcotin near Puntzi Lake. Two den boxes that had not previously been used for reproduction were used in 2017, bringing the total number of den boxes used to 8 and reproductive uses to 10 over 4 denning seasons. Over the 4 years, an average of 1.7 kits were observed at the den boxes.

A male fisher was also observed chewing the entrance of one den box open sufficiently to allow his entry and he subsequently killed both kits. This is the only documented case of infanticide by fishers, although it has long been theorized that females choose dens with entrance sizes that exclude the larger male fishers for this reason. This incident helped identify a design flaw in the structures that we have now addressed. Squirrel chewing damage on plywood at the entrance of den boxes has enlarged the entrances of approximately 20% of structures and likely facilitated the male's entry into this den box. We have designed a replaceable solid wood door jamb and molding that will deter squirrel chewing and decrease the potential for male fishers gaining entry to the den boxes.

We also assessed 17 fisher den trees identified during other research projects for structural integrity. The den trees included 11 cottonwoods (*Populus balsamifera ssp. trichocarpa*), 4 lodgepole pines (*Pinus contorta*), 1 trembling aspen (*Populus tremuloides*), and 1 Douglas-fir (*Pseudotsuga menziesii*). Approximately 50% were still functional as den trees, and the trees had lasted at least 14 years since being first discovered. The longevity of the den trees likely varies by species and when cottonwood trees were analyzed separately, 6/11 were still alive and functional. Cottonwoods lasted for at least 16 years since being found yielding a longevity estimate of at least 32 years. Increasing the number of trees assessed and conducting periodic assessments of the remaining trees is recommended to allow for a more rigorous examination of den tree longevity.

The project videos continue to provoke interest and enquiries about the project. Den boxes have been constructed and installed by the Toronto and Region Conservation Authority and Alberta Environment and Parks after viewing the videos and soliciting

project information. Other extension efforts included a presentation to the BC Naturalist AGM in Lillooet BC, and making reports and plans available on the BCFisherhabitat.ca website. All extension products include information on our funding partners.

The results of this project help the Bridge-Coastal Restoration Program achieve several of their specific objectives for the Bridge River watershed. The primary Action/Watershed Plan that this project aligns with is the ***Species Based Action Plan***. Fisher is listed as a high priority for FWCP investment and the results of this project are helping meet Objective 1: maintain or improve the status of species or ecosystems of concern. Fisher have low reproductive output and populations in the area are benefiting from the addition of reproductive habitat. Work that helps maintain viable populations of fishers will also help meet Objective 2 – maintain or improve opportunities for sustainable use. Increasing the amount of reproductive habitat will help promote sustainable populations of fishers in the watershed for the trapping and tourism industries. The project also provides a specific opportunity to enhance riparian areas that are degraded or sub-optimal (***Riparian and Wetlands Action Plan***) by providing a proven mitigation strategy that will supply fisher reproductive habitat for the short to mid-term until longer term measures, such as fungal inoculation, can increase the availability of cavity-bearing trees.

Finally, I recommend that the Fish and Wildlife Compensation Program provide the updated den box design to BC Hydro to facilitate any habitat mitigation planning using den boxes at the Site C Hydroelectric Dam. The changes to the design will help ensure that fisher kits inside the structures will not be harmed by male fishers or other predators. This mitigation strategy for reproductive habitat lost in the foot print of the project should be seen as a short to mid-term treatment that provides denning habitat until sufficient natural dens develop in the landscape.

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Introduction

Fishers (*Pekania pennanti*) are forest-dependent carnivores in 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. Fishers are also the largest obligate tree-cavity user in North America, requiring trees that have cavities >30 cm inside diameter as reproductive dens during the rearing period (Weir and Corbould 2008). In British Columbia, reproductive dens are found in large-diameter black cottonwood, balsam poplar, trembling aspen, lodgepole pine, and Douglas-fir trees (Weir and Corbould 2008, Weir 2009, Davis 2009), which are most common in late-successional ecosystems. The development of trees that support suitable cavities for fishers is uncommon and these critical habitat elements are rare in sub-boreal landscapes (Davis and Calabrese 2010, Davis 2012).

This project provides a unique opportunity to apply the knowledge gained from research funded by the Fish and Wildlife Compensation Program and the Habitat Conservation Trust Foundation (e.g., Davis 2012, Davis and Weir 2011, Weir 2000, Weir and Corbould 2008) to build recovery tools for fishers in areas where their habitat has been impacted. At a broad scale, the Bridge River watershed and Cariboo-Chilcotin are rated as having medium to high capability for fishers (Lofroth 2004). Habitat impacts from hydro-electric development, mountain pine beetle, large-scale fires, and salvage harvesting in these areas likely removed many of the large, cavity-bearing trees that fishers require for reproductive dens. A decrease in the supply of critical denning structures may impact on the ability of the landscape to support sustainable populations of fishers.

Previous work on fishers in these areas (Davis 2012, Davis and Calabrese 2010) has estimated that there are approximately 0.5 trees/ha with external features of reproductive dens in the remaining high value habitats. High value habitats are older stands that are becoming increasingly rare in the landscape. Further, even where present, not all den trees with external features characteristic of reproductive dens will contain a cavity large enough for fisher to use. The loss of denning opportunities may be affecting recruitment rates within the population and therefore the ability of the population to sustain itself. To potentially mitigate the impacts of development on fishers and their reproductive habitat, an increase in the supply of reproductive dens is needed. Work in the United Kingdom has found that artificial denboxes are used by pine marten (*Martes martes*) in that country (Messenger *et al.* 2006). This project demonstrates that a similar structure provides a suitable site that fisher will use for reproductive denning.

Goals and Objectives

The objectives of this multi-year project are four-fold. Firstly, we developed a denbox design that accommodated fisher reproductive needs. Secondly, we are assessing the use of the den boxes by fisher. Thirdly, attributes affecting the successful use of den boxes by fisher will be analyzed. Lastly, we will collect and analyze information on natural den tree longevity to predict the supply of natural den sites. Information from this project will provide land managers with better data upon which to evaluate mitigation options to augment reproductive habitat for this species.

The results of this project will also help address specific objectives for the Bridge-Coastal Restoration Program. The primary Action/Watershed Plan that this project aligns with is the ***Species Based Action Plan***. Fisher is listed as a high priority for FWCP investment and the results of this project are helping meet Objective 1: maintain or improve the status of species or ecosystems of concern. Work that helps maintain viable populations of fishers will also help meet Objective 2 – maintain or improve opportunities for sustainable use. Finally, the project also provides a specific opportunity to enhance riparian areas that are degraded or sub-optimal (***Riparian and Wetlands Action Plan***) by providing a mitigation strategy that will supply fisher reproductive habitat for the short to mid-term until longer term measures can increase the availability of cavity-bearing trees.

Study Areas

This project is composed of several study areas in the central interior of BC. The 990-km² Bridge study area lies within the Gun, Tyaughton, and Yalakom drainages to the northwest of Lillooet, BC (Appendix 1). The Cariboo-Chilcotin study area has a much wider distribution occurring between 100 Mile House and Quesnel on a north – south axis and between Horsefly and Anahim Lake on an east – west axis (Appendix 2).

Project Background

Den boxes were designed, constructed, and installed between fall 2013 and fall 2014 (Davis 2014, Davis and Horley 2015). Two den box prototypes were tested for thermal properties prior to being installed in the field. The two designs were a solid wood design with sides constructed of 38 mm thick spruce (laminated 2 x 6" lumber) and a layered plywood design (sides composed of two 19 mm thick pieces of plywood and a 19 mm rigid foam core). The inside dimensions were 28.5 cm by 28.5 cm with a box height of 95 cm. Both the lids and bottom were constructed of the same materials as the sides. A circular 10 cm diameter opening was created near the top of each box and 15 cm of wood shavings were placed in the bottom. Temperatures inside the solid wood and insulated plywood designs were compared over a 2-week period in early April when fisher typically use natal dens. A 7.5 W bulb was used in each design to provide a heat source that would represent the heat generated by fisher kits. The insulated design had greater buffering capacity than the solid design with cooler daytime and slightly warmer nightly temperatures. The solid design more closely tracked ambient temperatures outside the boxes and sometimes had warmer daytime temperatures than ambient temperatures, which could potentially result in heat stress for young kits. Based on these results, the insulated plywood design was chosen to proceed with the project.

Female fishers are selective for the entrance dimensions to reproductive dens, presumably to exclude larger predators, including male fishers. The den box design uses a rectangular opening (7 x 12 cm) to mimic the size of entrance holes at natural fisher dens observed in the field (Davis 2009, Weir and Corbould 2008, Weir et al. 2012). The outsides of the boxes are treated with a water-based stain to provide protection from precipitation, and 15 cm of wood shavings are placed in the box to improve its insulating properties (Davis 2014).

Twenty-five insulated den boxes were installed on trees in the Bridge River Watershed in the fall of 2013. The boxes were hung using plastic coated wire and clamps at approximately 3 m from the ground. In December 2013, lure was hung at the box locations to increase the probability of fisher visiting the site. Each box had a hair snagger at the entrance and 10 trail cameras were rotated between the boxes for monitoring on a monthly basis. Over the winter of 2013-14, nine additional den boxes were installed on trees in the Cariboo-Chilcotin using funds donated by Davis Environmental Ltd, West Fraser Mills Ltd, and Tolko Industries Ltd in anticipation of the project being funded by HCTF in 2014-15. In 2014 HCTF became a funding partner and an additional 20 den boxes were installed. Thus far, this project has monitored the den boxes for 4 reproductive denning seasons.

In 2014 – 15, we also compared the thermal properties of den boxes in the field with nearby known fisher den cavities. We placed paired temperature probes inside and outside of 2 known fisher den trees and 2 nearby den boxes. We compared the daily low temperatures over 18 days at den boxes and den trees with ambient temperatures and compared daily low temperatures inside den boxes and den trees. Both the fisher den trees and artificial den boxes had significantly warmer temperatures inside the tree/structure than ambient temperature. The sample size was small; however, den trees and den boxes had similar differences in temperature between inside and outside the structures (approximately 2° C). Mixed results were seen when comparing inside temperatures of the den trees and den boxes. One den box was significantly warmer inside than the closest den tree, while another den tree was significantly warmer than the closest den box (Davis and Horley 2015).

Methods

We used a combination of motion detection cameras, a hair snagger, and observations of wildlife sign at the den boxes locations to monitor for fisher use. Twenty-five cameras were deployed at the structures with the cameras moved between den boxes on each visit. A wildlife permit was obtained to allow the collection of hair samples (VI13-91889). Sticky pads that were fastened to the top of the box entrance allow us to verify use at den boxes where no camera is present. Pads with hair were sent to a commercial genetics laboratory (Wildlife

Genetics International for analysis of species, sex, and individual identity. The combination of video and DNA evidence allows us to tally the number of visits to each structure. During April – June, we also examined the interior of each den box for signs of reproductive use using a GoPro camera to capture any evidence. Den boxes that were being used for reproduction had a trail cam installed to document fisher use.

At each location, data associated with a medium-sized territorial carnivore detection station has been collected (BC Ministry of Environment Lands and Parks 1998). This information was analyzed with the data on fisher use of the structures to identify factors influencing fisher use of the den boxes. We also visited known fisher den trees in the Chilcotin and Williston areas. Each tree was assessed to determine if it was still functional for fisher reproductive use. A Wildlife Tree Assessment form was completed for each tree still standing (BC Ministry of Environment Lands and Parks 1998).

Results and Outcomes

The analysis of hair samples from the previous winter and 2017 reproductive denning season identified 26 fisher samples out of the 39 samples submitted from 53 den boxes. Table 1 shows the sampling effort and results for all species detected over the 4 reproductive seasons thus far. Fisher detection rates varied from 0.01 – 0.11 detections per sample session over this period. Of the fisher samples in 2017, we had 10 different individuals leave DNA at the den boxes showing a slight decrease in numbers over the 4 years. Similar to the last three years, the den boxes are selective for females. Out of the 10 fishers in 2017, 7 are individuals not previously identified. The total number of fisher identified to individual identity using DNA over 4 seasons is 28 (23 female and 5 male).

Monitoring during the winter of 2017-18 continued our trend of reducing the number of visits to den boxes prior to the denning season. While in 2016-17 we did not bait den boxes where reproduction had occurred, in this season no bait was used at any den box. The decrease in visits and baiting was to reduce the disturbance created during monitoring visits and increase the probability of use during the reproductive season. We made one visit to set up cameras and add hair snaggers to each den box in January and then checked each structure in March. We collected 6 hair samples from the 52 den boxes remaining in the study. One of the den boxes burned in a 2015 wildfire near Puntzi Lake, a second burned during the 2017 wildfires near Quesnel, BC.

The total number of den boxes with a visit verified by DNA or camera is 34 out of the 54 den boxes to the end of March 2018 (Appendix 1 and 2). The Cariboo portion of the study area (east of the Fraser River) had the least number of detections, with only 2 out of 12 den boxes (17%) having confirmed fisher detections. West of the Fraser River, the Chilcotin area had 12 of 17 den boxes (71%) with fisher detections. The Bridge Watershed had the greatest proportion of den boxes with fisher detections at 18 out of 25 den boxes (72%). The Bridge Watershed den boxes have been deployed for 5 years, while 9 of the Cariboo-Chilcotin den boxes have

Table 1. Species detected at fisher den boxes using DNA between 2014 – 2017 (Sample session = # den boxes x # sampling occasions). Results include the previous winter monitoring and subsequent reproductive denning season. Only fishers were analyzed for individual identity and sex (Females = F, Males = M).

Year	# Sample sessions/ samples submitted	Species	Number detections	Individuals identified / Sex
2014	175 / 5	Fisher (Pekania pennant)	2	2 / 2 F
		Woodrat (Neotoma cinereal)	1	
2015	378 / 75	Fisher	43	14 / 12 F, 2 M
		Marten (Martes Americana)	9	
		Flying squirrel (Glaucomys sabrinus)	9	
		Red squirrel (Tamiasciurus hudsonicus)	4	
		Black bear (Ursus americana)	1	
2016	318 / 66	Fisher	28	12 / 9 F, 3M
		Marten	8	
		Flying squirrel	3	
		Red squirrel	21	
		Black bear	1	
2017	265 / 39	Fisher	26	10 / 8F, 2M
		Marten	4	
		Red squirrel	8	
		Black bear	1	

Table 2. Verified reproduction at den boxes over 4 denning seasons (2014 – 2017). Den boxes with a "CB" are in the Cariboo-Chilcotin and those with a "DB" are in the Bridge Watershed.

Den box	Years used	Comments
CB7	2015	Female returned to box twice and 2 kits observed on each visit.
DB23	2015, 2017	Females with 1 kit in 2015 and 2 kits in 2017. Different females in both years with the same female from DB24 in 2016 using DB23 in 2017.
CB289	2016	Female with 3 kits.
DB20	2016	Female with 1 kit.
DB10	2016, 2017	Female with 1 kit. The same female that used DB20 in 2016 and in 2017 had 1kit in DB10.
DB24	2016	Female with 2 kits.
DB4	2017	Female with 2 kits.
CB5	2017	Female with 1 kit

Figure 1. Fisher leaving den box 10 with her single kit. This is the second year the same female has used this structure.

Figure 2. Fisher and her kits leaving den box 23. This den box has been used by 2 different females in different years.

been deployed for 5 years and 20 have been deployed for 4 years.

Over the 4 reproductive denning seasons (April – June) that we have monitored, 0/25 den boxes were used in 2014, 2/54 where used in 2015, and 4/53 were used in 2016 (Table 2). Similar to 2016, monitoring during the 2017 denning season identified four den boxes that were being used by female fisher as reproductive dens (Figures 1-2). Some females have used the structures in multiple consecutive years. A female that previously had a litter at DB24 in 2016 moved to an adjacent den box (DB23) in 2017. A second female has reproduced for two consecutive years (2016 and 2017) at DB10. In 2017, video monitoring identified 1 kit at 2 denboxes and 2 each at 2 denboxes during 2017. Over the 4 denning seasons, fishers have had an average of 1.7 kits observed at the structures.

A cannibalism event was also recorded on video at den box “DB4” in the Bridge Watershed. A female with two kits had left to forage for several hours when a male fisher arrived at the structure. The male chewed at the opening to the den box and, over approximately 0.5 hours, enlarged it sufficiently to enter the structure. The male was then observed to remove one kit at a time. One was eaten on top of the den box and the second was carried away (Figure 3). The female returned to the den box that day and was observed at the structure several other times over the next week. Many of the den boxes have had the entrances enlarged by squirrel chewing over the course of the project, and I suspect that this prior chewing damage may have aided the male fisher in entering the den box (Figure 4).

At the outset of this project, feedback from trappers was to avoid constructing the den box out of plywood since squirrels are prone to chewing the material, presumably because squirrels are attracted to the resins used to laminate the layers. Despite this feedback, the logistics of building 55 insulated structures out of solid wood were prohibitive. To gauge the impact of squirrel damage on the den boxes, we have assessed all the structures using a 5-point scale where a score of 1 reflects the box being virtually untouched by squirrels and a 5 indicates that the structure has been made unusable for a reproductive den. This survey indicated that much of the damage has occurred at the ends of individual pieces of plywood, including the entrance. Despite this, approximately half of the den boxes had no damage from squirrel chewing as of June 2017 (Table 2). However, some degree of enlarging of the entrance was seen in 21% of den boxes. To address this problem, we installed solid wood 2cm thick by 4cm wide door molding on the outside of every den box in June 2017 (Figure 5). In the 9 months since this addition, we have not observed any chewing damage on the door moldings. Given this, we have prepared a design change to the den boxes construction plans that includes a solid wood door jamb and molding (Appendix 3). The door jamb and molding cover the exposed plywood end grain at the entrance which is a focus of squirrel chewing on the structures and can also be easily changed if significant chewing damage occurs.

Table 3. Survey results of squirrel chewing damage on den boxes in June 2017.

Score	Number of den boxes	Proportion of den boxes
1. No chewing damage	28	0.53
2. Minor damage, entrance size not impacted	14	0.26
3. Moderate damage, entrance enlarged slightly	8	0.15
4. Extensive damage, entrance enlarged significantly	3	0.06
5. Extensive damage, box no longer functional	0	0.00
	53	

Figure 3. Male fisher leaving with second kit after chewing the opening wide enough to gain entry and consuming a kit.

Figure 4. Red squirrel (*Tamiasciurus hudsonicus*) and chewing damage at entrance to a den box.

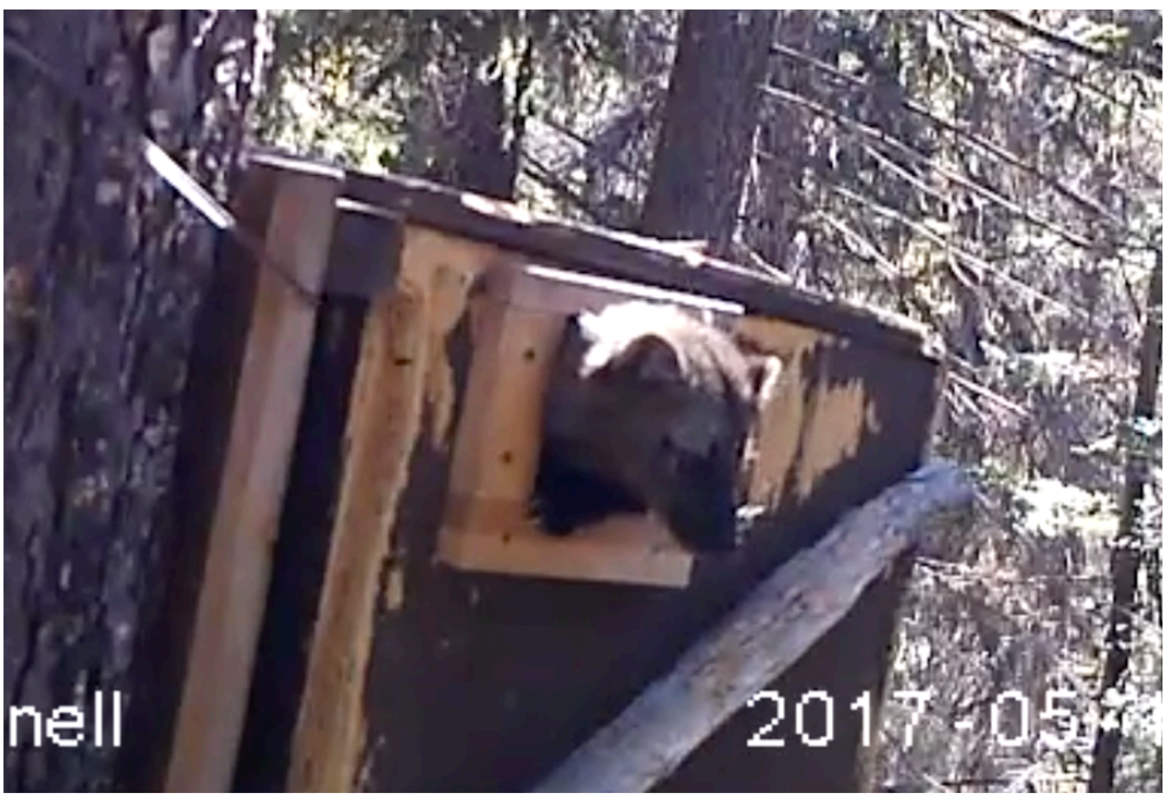

Figure 5. Door molding added to existing den boxes in the field to prevent squirrel chewing damage to the entrance.

The site characteristics of den boxes used for reproduction are shown in Table 4. Six out of 8 of these den boxes were in the Interior Douglas-fir biogeoclimatic zone, and two boxes are located in the Sub Boreal Pine Spruce zone. In general, den boxes used for reproduction are on gentle slopes (<15%), at lower mesoslope positions, and all are in structural stage 6 and 7 stands. Analysis of variance (ANOVA) on tree cover found that reproductive den boxes had greater cover than those not used for reproduction (Table 5, $\alpha=0.10$). Comparisons of other site characteristics at reproductive den boxes versus boxes not used for reproduction did not find any significant predictive variables ($\alpha=0.10$) (Tables 6 – 10).

We assessed the status of 17 known natural fisher den trees from previous fisher studies in BC (Davis 2009, Weir 2000) (Table 11). The majority of trees we examined are cottonwood (11) (*Populus balsamifera ssp. trichocarpa*), followed by lodgepole pine (4) (*Pinus contorta*), trembling aspen (1) (*Populus tremuloides*), and Douglas-fir (1) (*Pseudotsuga menziesii*). Of the 17, only 9 appear to be in a state still usable by fishers for reproduction. Eight of the 9 remaining trees that appear to be functional as reproductive dens, are alive except for the 1 Douglas-fir. Den trees lasted an average of >14 years (n = 17, SE = 1.5) since being first discovered. When cottonwoods are analyzed separately, the den trees lasted an average of >16 years (n = 11, SE = 2.2). Of the trees no longer usable for reproductive dens, 4 cottonwoods had fallen, 2 trees had structural defects (1 cottonwood and 1 lodgepole pine) and 2 lodgepole pine had burned.

Table 4. Site characteristics and number of years used for eight den box sites in the central interior of British Columbia used by fishers for reproduction up to 2016. Site descriptions based on Describing Ecosystems in the Field (Province of BC 1998).

Denbox	# Years used	Elevation (m)	Aspect	% Slope	Biogeoclimatic zone	Mesoslope	Structural Stage	% Tree cover	% Shrub Cover	Dominant tree species
CB7	1	986	E	12	IDFdk4	Mid	7	30	20	Douglas-fir, lodgepole pine
CB5	1	1137	N	3	SBPSxc	Toe	6	60	30	White spruce, lodgepole pine
CB289	1	1138	W	5	SBPSxc	Toe	6	25	30	Salix spp., Betugla glandulosa
DB23	2	996	SE	10	IDFdc	Toe	6	60	50	Douglas-fir, paper birch
DB10	2	1145	Flat	0	IDFdc	Toe	7	40	40	Shepherdia canadensis, Salix spp.
DB4	1	857	Flat	0	IDFdc	Depression	6	60	60	Trembling aspen, paper birch
DB20	1	1149	SW	4	IDFdc	Lower	6	50	20	Shepherdia canadensis, Rosa spp.
DB24	2	1052	E	15	IDFdc	Lower	7	60	50	Acer glabrum, Cornus stolonifera

Table 5. Comparison of continuous site variables at fisher den boxes used for reproduction.

	Reproductive dens			Other dens		
	Mean	**Count**	**SE**	**Mean**	**Count**	**SE**
Shrub cover (%)	38.8	8	5.8	31.0	45	2.8
Tree cover (%)*	46.9	8	4.9	36.7	45	2.1
Slope (%)	6.1	8	2.0	8.8	45	1.3
Elevation (m)	1014	8	46.9	1077	45	20.5

*Significant ANOVA at α=0.10

Table 6. Reproductive use of fisher den boxes in different aspect classes (Flat: <5% slope; North: 134 - 271°; Southwest: 135 - 270°).

	Reproductive	Others	Total
Flat	4	20	24
North	2	8	10
South-west	2	17	19
Total	**8**	**45**	**53**

Table 7. Reproductive use of fisher den boxes in different biogeoclimatic zones (IDF: Interior Douglas-fir; MS: Montane Spruce; SBPS: Sub Boreal Pine Spruce).

	Reproductive	Other	Total
SBS	0	6	6
IDF	6	23	29
MS	0	4	4
SBPS	2	12	14
Total	8	45	53

Table 8. Reproductive use of fisher den boxes at different mesoslope positions (Low: depression, flat, and toe; Mid: lower slope; Upper: mid, upper, and crest).

	Reproductive	Other	Total
Low	4	20	24
Mid	2	10	12
Up	2	15	17
Total	8	45	53

Table 9. Reproductive use of fisher den boxes in different structural stages (4: pole/sapling; 5: young forest; 6: mature; 7: old).

Seral stage	Reproductive	Other	Total
4 + 5	0	5	5
6 + 7	8	40	48
Total	**8**	**45**	**53**

Table 10. Reproductive use of fisher den boxes in different stand types (Coniferous: <20% deciduous; Mixed: ≥20% deciduous component).

	Reproductive	Other	Total
Coniferous	4	29	33
Mixed	4	16	20
Total	6	47	53

Table 11. Longevity of known fisher den trees in BC by species.

Year used	Species	Year assessed	Den usable	Longevity
1997	Act	2017	No	20
1997	Act	2017	Yes	20
1997	Act	2017	No	20
1997	Act	2017	Yes	20
1998	Act	2017	Yes	19
1998	Act	2017	Yes	19
1998	Act	2017	Yes	19
1999	Act	2017	No	18
1999	Act	2017	Yes	18
1997	Act	1999	No - 1999	2
1998	Act	2000	No - 2000	2
2006	At	2018	Yes	12
2007	Pl	2018	No	11
2006	Pl	2015	No - 2015	9
2006	Pl	2015	No - 2015	9
2006	Pl	2018	Yes	12
2006	Fd	2018	Yes	12

Discussion

This project has been successful in attracting fishers to den boxes and showing that the structures can provide reproductive habitat. Detection rates are very similar for the last 3 years at approximately 10% of sampling sessions and 63% of the structures have had fisher use documented via DNA or video evidence over the life of the project. Fisher reproductive use has increased from 0% in 2014 to 7.5% of den boxes in the past two years. Several den boxes have been used repeatedly both within denning seasons and between years despite the intrusiveness of our monitoring protocols. The monitoring protocols have changed over the 4 years with no bait being used in the first year (2013-2014), bait being added to every box in 2014-15, and decreasing numbers of boxes having bait attached inside the structures since 2015. The effects of the decrease in baiting frequency is likely reflected in the slight reduction in detection rates over the last 3 years; however, the successful reproductive use in the past 3 years and number of new individuals identified in 2017 indicates that baiting may only be required during the first several years of den box deployment.

While we detected fishers at 63% of den boxes overall, some areas showed much greater success in both the number of detections and reproductive events. Differences in detection rates and reproductive use among different areas may be partially a result of the use of knowledge gained from past research in these areas. The Bridge Watershed and West Chilcotin have had much higher numbers of fisher detections and reproductive events. In the Bridge Watershed, 75% of den boxes have been visited by fishers and there have been 7 reproductive events over 4 years. The West Chilcotin (areas around Puntzi and Anahim Lakes) has had 83% of den boxes visited by fishers and 3 reproductive events over the 3 years the project has been conducted at those locations. The den box placement in the field for both the Bridge Watershed and West Chilcotin has likely benefited from previous inventories and research on fishers in the past (Davis 2004, Davis 2009, Davis 2012).

The placement of den boxes near Quesnel and 100 Mile House depended on discussions with the areas trappers, and those near Beaver Valley were based on discussions with a fisher researcher[1] who had transplanted fishers there in the early 1990s. These locations may have had greater success detecting fishers if a recent fisher inventory had been conducted in the area, or if the trappers and previous researchers for the area had actively participated in the den box placement. Conversely, fisher densities in these areas may be naturally low, have decreased due to habitat impacts, are kept at low density by active trapping, or some combination of these effects. Forest harvesting has been extensive in these areas after recent bark beetle epidemics and may have resulted in decreased habitat quality for fishers. Recent transplants of fishers to Washington State have also been conducted in the area and these losses would be additive to fishers being caught as by-catch by trappers targeting other species.

On an individual den box site basis, only percent canopy cover had a significant relationship with reproductive use of a den box. In the Chilcotin, tree cover at fisher den trees was also

[1] Rich Weir, Carnivore Conservation Specialist, Ecosystem Branch, BC Ministry of Environment.

significant at $\alpha = 0.1$ when compared to random locations in a fisher's home range (Davis 2009). However, other variables such as older forest, greater numbers of larger trees/ha, and location on warm aspects had a greater influence on den tree presence (Davis 2009). The lack of significance for most variables in predicting reproductive use of den boxes likely stems from the deliberate placement of den boxes in locations more likely to be used by fisher. Further, den box placement was also constrained by the requirement of gentle terrain for installing den boxes due to safety concerns and avoidance of areas likely to be logged. Thus, most den boxes have been placed in riparian forests with gentle terrain and where there are legislated requirements for forested reserves. Fishers have an affinity for riparian stands making these locations good candidates for den box deployment, and, as stated previously, placing the structures in locations where recent inventories or local knowledge may have had the greatest influence on reproductive use.

The cannibalism event in the Bridge Watershed helped identify a shortcoming in the den box design. Squirrel chewing damage to the structures has been documented over the course of the project. All den boxes have received some use by squirrels as evidenced by cones and feces present in the structures but approximately 20% of the structures have received extensive chewing damage that is directed at ends of the plywood pieces, including at the entrance. Female fishers appear to select natural cavities in trees with entrances that are just large enough for them to squeeze into, which has been theorized as helping to prevent infanticide by the larger male fishers (Powell 1993, Paragi et al. 1996). The den box where the infanticide occurred had some squirrel damage at the entrance and there is some small variation in the size of entrance holes we cut in the den boxes. Combined, this may have facilitated the male's entry into the structure. The door jamb and molding upgrade to the box design facilitates being more precise with the entrance size construction, increases the thickness of wood at the entrance, and incorporates the use of solid wood that should be less attractive to squirrels. Given the preliminary results of the solid wood door molding we attached to the den boxes already deployed, the door jamb and molding change to the design should decrease the potential for squirrel chewing and successful attempts by male fishers to gain entry to the structures.

It is worth noting that this is the first study to document infanticide by a male fisher on kits. Infanticide has been reported in numerous species of mammals including primates, lions, bears, and rodents. Infanticide committed by males is generally thought to support a *sexual selection* hypothesis (Agrell et al. 1998). Under this hypothesis, the killing of an offspring results in the female stopping lactation and coming into estrus sooner than if she continued to nurse the young. However, this hypothesis is generally only thought to work in species that breeds aseasonally, have long breeding seasons, or very short breeding cycles (Agrell et al. 1998). Fishers breed within 7 – 10 days of giving birth followed by delayed implantation, where the blastocyst does not implant in the uterus and development of the embryo is delayed to the following February. Given this, killing of the young would not induce the female to come into estrus any sooner than dictated by the natural cycle.

Infanticide that includes cannibalism, as seen here, is also seen in other species such as bears (Davis and Harestad 1996) and the *exploitation* hypothesis would attribute the behavior to the male gaining nutritional benefits from eating the kit. In this case, the male fisher killed the kits in early spring and prey at this time year may be more difficult to find, making the kits an attractive resource. A third hypothesis for infanticide is the *resource competition* hypothesis where unrelated young are killed to increase resources available for the perpetrator or their offspring (Agrell et al. 1998). Fishers are intersexually territorial with males usually overlapping the territories of several females. In this case, the male fisher could have been from an adjacent territory and killing these kits decreases potential competition for future territories of his kits. Another scenario could involve the dominant male for the area being removed (e.g. killed or trapped) and a new male moving into the territory. Infanticide in either of these scenarios could increase the perpetrator's relative genetic contribution to the areas fisher population (Agrell et al. 1998). Finally, neither of these hypotheses are mutually exclusive, and it is possible that both the *resource competition* and *exploitation* hypotheses could help explain infanticidal behavior by male fishers.

Approximately half the den trees we examined have become no longer usable by fishers for reproductive dens and den trees lasted an average of 14 years since they were first discovered. If we apply the following simplifying assumptions: that den trees are suitable only for a specific period of time (i.e. when there is a standing tree with a large intact internal cavity and a suitable sized entrance hole), and that, on average, these den trees were discovered at a point half way through their usable life, then this data indicates that fisher den trees should be available for at least 28 years using all tree species we examined(i.e. 14 years x 2). However, it is likely that different species of trees will have different decay characteristics which would influence longevity. When only cottonwood trees are examined, the same assumptions yield cottonwood den trees being available for at least 32 years. At this time, a simplified approach is warranted given the paucity of data for individual tree species and time constraints; however, there are more rigorous analysis methods that can be employed.

Edworthy et al. (2013) used Kaplan-Meier survival estimates to quantify median survival rates and patterns of cavity longevity for cavity nesting bird gilds near Williams Lake, BC. Cavity survival in aspen was 65% at 5 years and 59% at 10 years, while lodgepole pine cavity survival was 65% at 5 years and unchanged at 10 years, with 90% of cavities lost due to blowdown or stem splitting (Edworthy et al. 2012). Cavities in live aspen had a median predicted survival rate of >15 years (i.e. predicted survival rate after 15 years = 0.56) with trees in more advanced decay classes having loss indicators of up to 3.56 times greater. Edworthy et al. (2013) did not estimate lodgepole pine and Douglas-fir longevity due to the small sample sizes, but these results indicate that longevity estimates will vary for different tree species. A comparison of age-decay relationships for aspen and balsam poplar illustrate this with aspen having a much more rapid decay relationship with age than balsam poplar (Hiratsuka and Loman 1984). Given the sparseness of our data, obtaining more data on each tree species would aid in conducting a more rigorous analysis. Further, assessing fisher den trees on a regular basis (e.g. 5 years) would help provide a more complete data set for analysis given that at least half the trees are still standing.

Dissemination of project information has taken place using several formats in 2017-18. A new video on the den box project has been released in January 2018 on Youtube and links were provided from Facebooks "Phat Weasels" page, as well as the FWCP and HCTF websites. The video is part of a series on this project that explicitly recognize the support of all project sponsors and currently have a combined 2162 views. The project was also presented at the BC Naturalist Convention in Lillooet on May 6th 2017. Information on the project was also provided to meetings with the Tsilhqot'in First Nations in March 2018. Links to project reports and den box plans are also available on the BCFisherhabitat.ca website, further helping disseminating the project results.

The project continues to gain interest from parties wishing to implement fisher habitat enhancement. Den box designs are being used to offset habitat losses at the Site C hydro-electric project and will be installed this fall. The Toronto and Region Conservation Authority continues to monitor 3 den boxes installed at that location and has a series of videos on Youtube showing fishers investigating their den boxes[2]. A biologist from Alberta Environment and Parks has also installed 3 denboxes in the Red Deer area[3] that received use by 3 fishers during July 2017. I have requested that anyone using this information reference the work on den boxes completed in BC in any extension they produce.

The results of this project help the Bridge-Coastal Restoration Program achieve several of their specific objectives for the Bridge River watershed. The primary Action/Watershed Plan that this project aligns with is the ***Species Based Action Plan***. Fisher is listed as a high priority for FWCP investment and the results of this project are helping meet Objective 1: maintain or improve the status of species or ecosystems of concern. Fisher have low reproductive output and populations in the area are benefiting from the addition of reproductive habitat. This habitat will be especially important over time as timber harvesting is ongoing in the area and natural dens are likely to be impacted. Work that helps maintain viable populations of fishers will also help meet Objective 2 – maintain or improve opportunities for sustainable use. Increasing the amount of reproductive habitat will help promote sustainable populations of fishers in the watershed for the trapping and tourism industries. The project provides a specific opportunity to enhance riparian areas that are degraded or sub-optimal (***Riparian and Wetlands Action Plan***) by providing a proven mitigation strategy that will supply fisher reproductive habitat for the short to mid-term until longer term measures, such as fungal inoculation, can increase the availability of cavity-bearing trees.

Recommendations

This project has shown that artificial den boxes provide a method of augmenting reproductive habitat with the use of 8 den boxes for 10 reproductive events over 4 denning seasons. Although the Fish and Wildlife Compensation Program is no longer funding this project, we are hopeful that continued monitoring using funds contributed by the Habitat Conservation Trust Foundation and the Forest Enhancement Society of BC will yield additional useful information on den box use by fishers in the 5th reproductive denning season. Specifically, our goal in 2018 is

[2] Adam Weir, Restoration and Infrastructure, Toronto and Region Conservation Authority.
[3] Dave Prescott, Senior Species at Risk Biologist, Alberta Environment and Parks.

to determine if the entrance molding added to the existing den boxes in 2017 helps decrease the potential for infanticide by male fishers. I also recommend that the Fish and Wildlife Compensation Program provide the updated den box design to BC Hydro for implementation of any den boxes installed as part of habitat mitigation at the Site C Hydroelectric Dam.

Finally, while we have exceeded our goal of assessing 10 fisher den trees for structural integrity, adding additional data on the longevity of den trees from across BC would be helpful in assessing longevity and supply of this critical habitat element. We will seek this information from locations in the Cariboo-Chilcotin where trees have not been recently assessed and other fisher researchers for analysis in 2018-19. Lastly, the majority of den trees we examined are still standing. Conducting an assessment of den tree integrity for the remaining trees every 5 years would provide for a more complete analysis to aid in predicting the supply of fisher den trees.

Acknowledgements

I would like to acknowledge the contributions of Tolko Industries Ltd and West Fraser Mills Ltd in supplying labor and material for the construction of den boxes. Matt Manual, Ed Serr, Howard Shields, Travis Peters, and Curtis Narcisse of the St'át'imc Nation provided support for work in the Bridge Watershed. The advice and support of Rich Weir, BC Ministry of Environment, was also invaluable. This Project is funded by the Habitat Conservation Trust Foundation, the BC Forest Enhancement Society, and the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and the public, who work together to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams.

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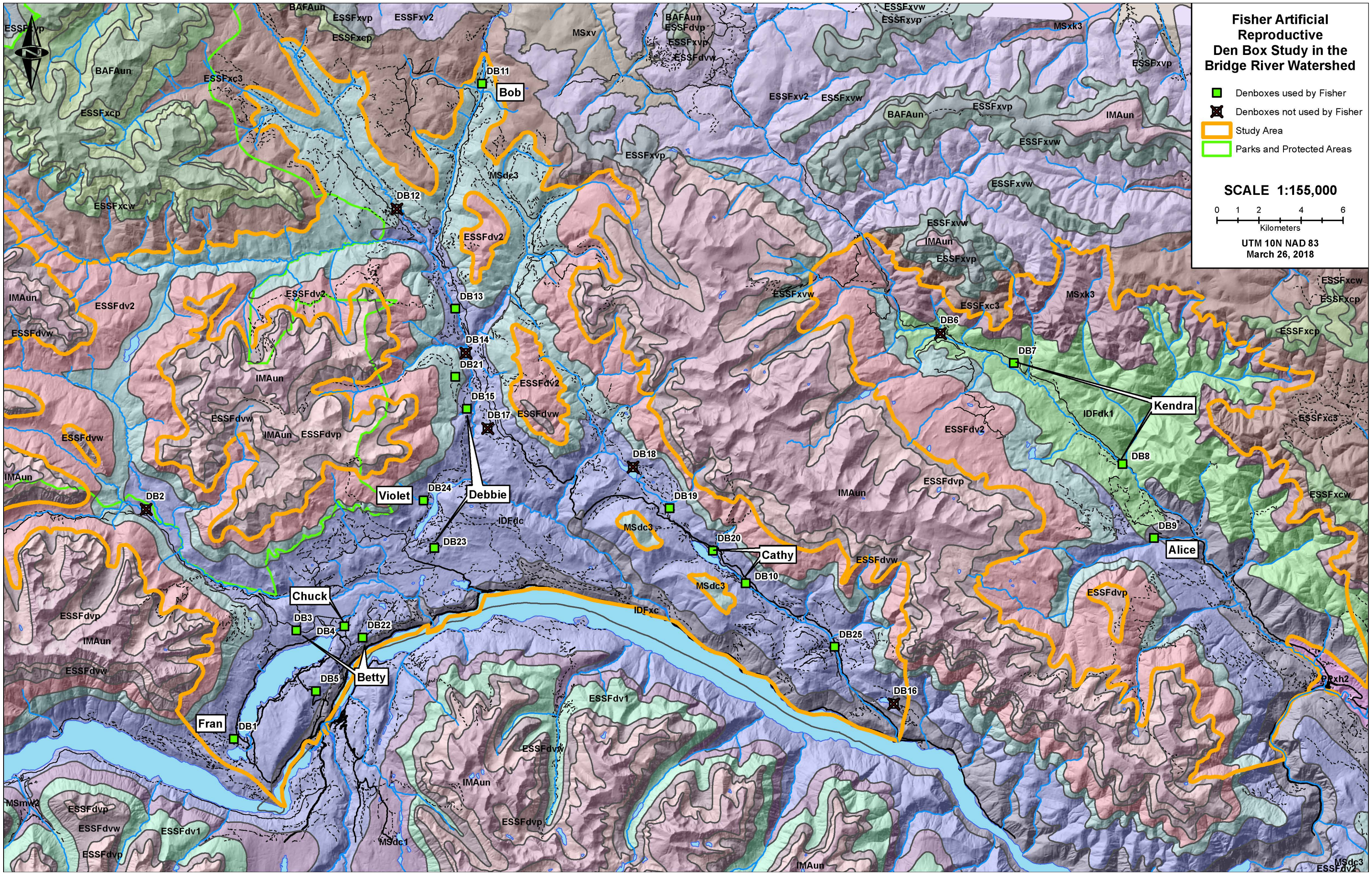
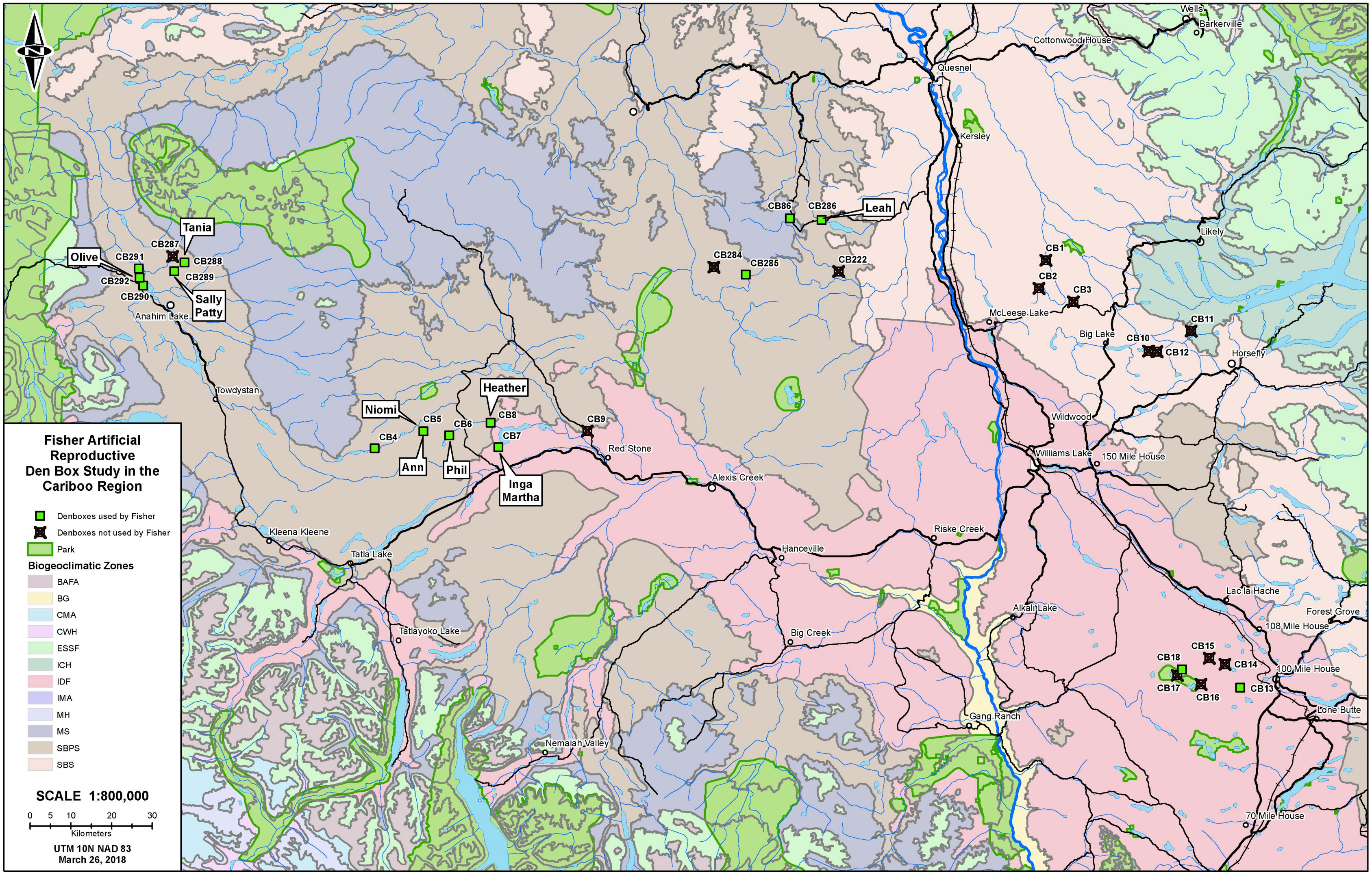
Appendix 1. 2017-18 Fisher den box locations and use in the Bridge River Watershed.



Appendix 2. 2016-17 Fisher den boxes and use in the Cariboo–Chilcotin Region



Appendix 3. Addendum 1 to the Fisher Denbox Drawings

Addendum 1 to FISHER DENBOX DRAWINGS 31 March 2018

Background: squirrel damage has enlarged the entrances of some den boxes. Female fishers are very selective for the entrance dimensions to reproductive dens, presumably to exclude larger predators, including male fishers. In 2017, we had one instance of infanticide where a male fisher was able to chew open the entrance sufficiently to gain entry and kill the two kits inside. We believe that squirrel chewing damage on the plywood at the entrance facilitated the male's entry (see photograph A) . Approximately 21% of den boxes showed significant chewing damage at the entrance after 4 years of deployment. To address this, we have designed a solid wood door jamb and molding that fits into the entrance and can be changed easily if it is damaged (Photograph B).

Photograph A: example of squirrel chewing damage.

Photograph B: replaceable door jamb and molding.

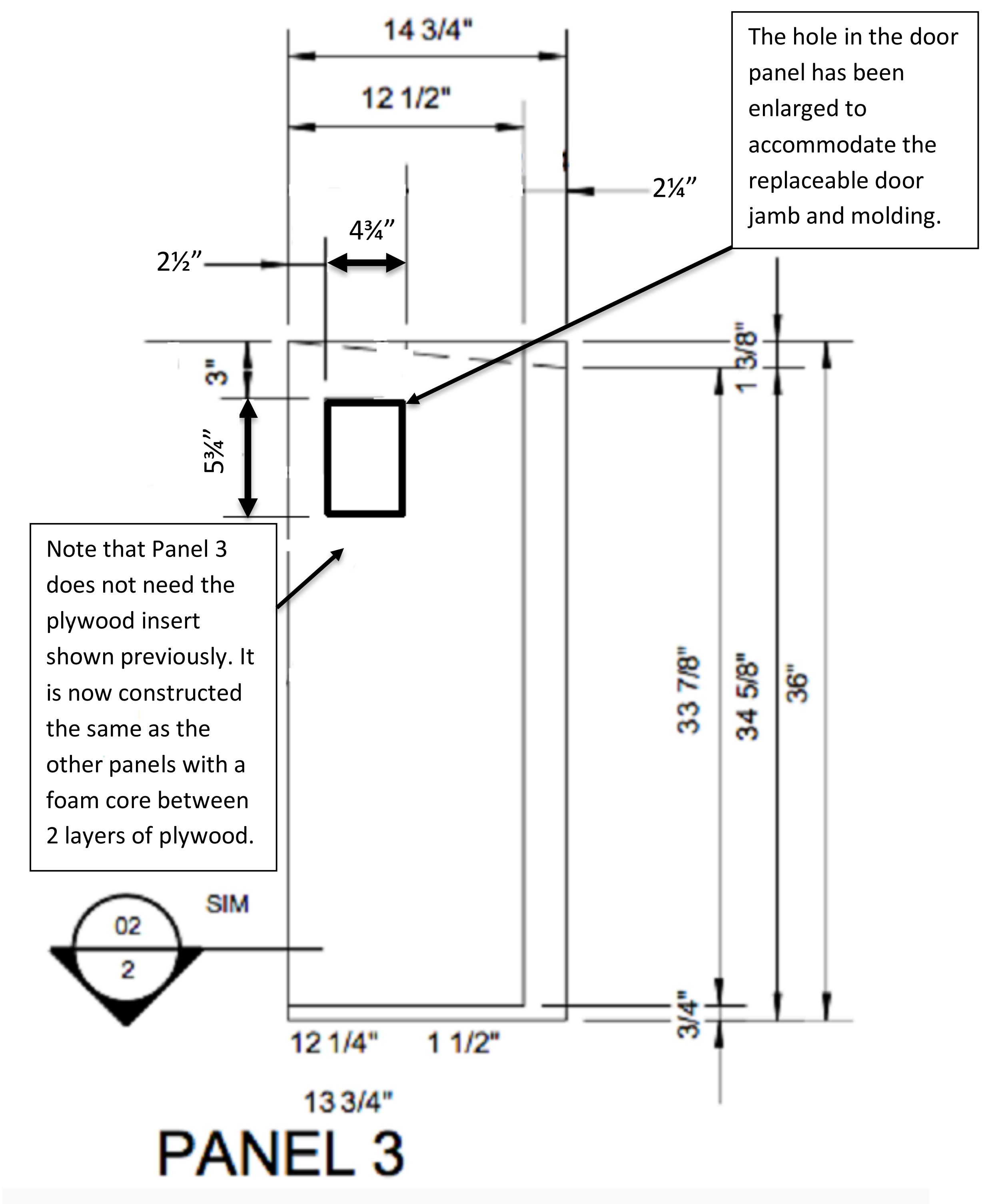
Project funding provided by:

FWCP Fish & Wildlife Compensation Program

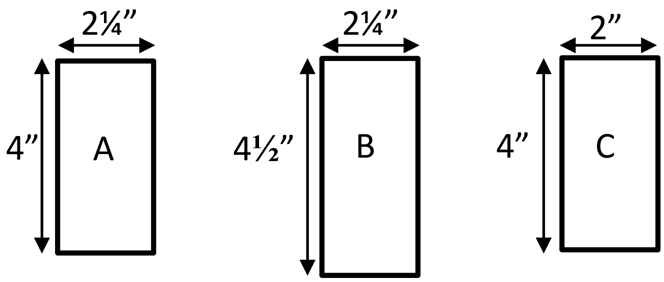
Habitat Conservation Trust Foundation

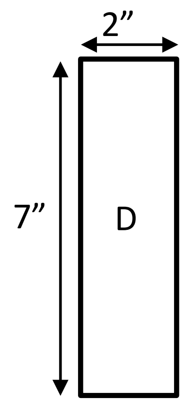
FESBC Forest Enhancement Society of British Columbia

Addendum 1 to Fisher Denbox Drawings 31 March 2018

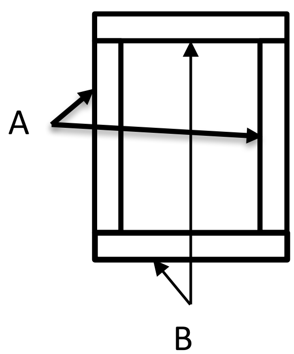


Addendum 1 to Fisher Denbox Drawings 31 March 2018

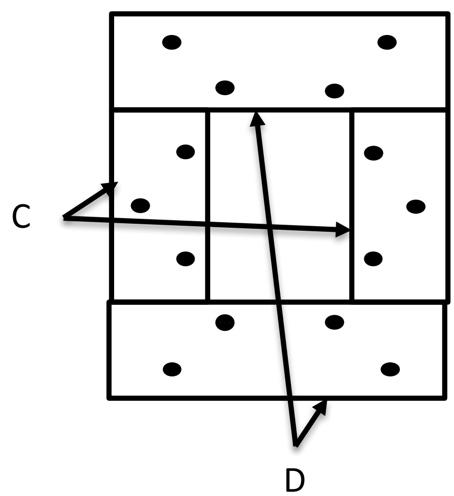




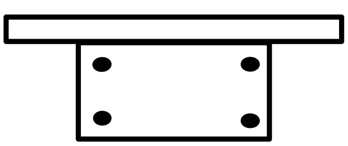
Door Jamb and Molding: 2 pieces each of A and B form the door jamb. 2 pieces each of C and D are the door molding. All pieces are ¾” thick solid wood. Pieces can be cut from 1 x 4” wood.



Jamb End View



Molding Face View with screw locations ●



Jamb and door molding End View with screw locations ●

Assembly instructions

- Pre-drill all holes with ⅛” bit and counter sink with 5/16” bit.
- Assemble jamb using 8 – 2” construction grade screws.
- Add door moulding using 2” screws. Inner 8 holes are for attaching moulding.
- Outer 6 holes are for attaching jamb and moulding to the den box.

Appendix 4. Confirmation of FWCP Recognition

Over the course of fieldwork in the study area we often stop and discussed the project with people living and working in the area. There is local concern regarding the effects of forest harvesting that is ongoing in the area. We have also had enquiries on the availability of construction plans for denboxes. All discussions of the project were positive with people generally very interested in the work. Other examples of recognition are outlined below.

In all cases, our project funding partners are explicitly recognized in presentations and literature that I disseminate.

Community Outreach

- A presentation on the project was given to the BC Naturalists at their annual convention during May 2017 in Lillooet BC.
- Information on the project was provided at a meeting with the Tsilhqot'in First Nations in March 2018.
- Video on the den box project was released on Youtube and links were provided from Facebooks "Phat Weasels" page, as well as the FWCP and HCTF websites in January 2018.

Communication of Results to Government, Industry, and Academia

- Information on this project was presented in March 2018 to the private sector at a meeting in Williams Lake, B.C.
- Reports and den box plans were also requested by and sent to:
  - Michael Joyce, PhD candidate, University of Minnesota, who has applied for grants to start a similar project in Minnesota.
- Reports and den box plans have been made available for download from the BCFisherhabitat.ca website.

• Appendix 4. Performance measures

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
Maintain or Restore Habitat forming process													
Artificial gravel recruitment	Area of stream habitat improved by gravel placement												
Artificial wood debris recruitment	Area of stream habitat improved by LWD placement												
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing												
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved												
Habitat Development													
New habitat created	Functional area created												
Other													
New habitat elements created	52 Den Boxes installed	Fishers (*Pekania pennanti*)				X			X	X			