Feasibility Study on the Reintroduction of Beavers at Inspiration Ridge Preserve: Mitigating Climate Change Impacts to Peatlands on the Southern Kenai Peninsula

Center for Alaskan Coastal Studies

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Executive Summary

The Center for Alaska Coastal Studies (CACS) tasked us with assessing if the current site conditions in the Inspiration Ridge Preserve (IRP), within the Fritz Creek watershed, are suitable as beaver habitat. With the disappearance of beavers from the Fritz Creek watershed and decreasing water availability on the Kenai peninsula over the past twenty years, peatlands and wetlands downstream of the site have dried significantly, putting stress on those systems and on the natural flora and fauna. Since beaver reintroductions have been successful in other systems to improve peatlands and wetlands undergoing significant desiccation (Simmons, 2015), CACS is suggesting the use of beavers as a restoration tool for the Fritz Creek watershed. CACS also expects that this project will jumpstart an initiative to reintroduce beavers to several historic sites within the Homer area. The main objectives of this report are i) to provide a recommendation to CACS regarding the feasibility of reintroducing the North American beaver (*Castor canadensis)* to the Fritz Creek watershed and ii) to recommend reintroduction methods and a monitoring plan to address the water quality concerns and carbon storage effectiveness of the peatlands in this location.

To assess the feasibility of beaver reintroduction in the area, we conducted field surveys for a total of 21 observations along three reaches of the Fritz Creek stream to evaluate specific environmental parameters associated with suitable beaver habitat. We applied the Methow Beaver Project (MBP) Suitability Scorecard (2020 version) to estimate metrics of beaver habitat suitability and calculate a final suitability score for each observation and an average for each reach. The suitability scores range from 43 to 85, where a score above 45 indicates suitable habitat. Additionally, we assess the beaver dam capacity of the full stream length in the IRP using the Beaver Restoration Assessment Tool Capacity Inference System (BRAT-cIS) Form.

The three reaches along the Fritz Creek we evaluated for release all received overall suitability scores above 45, indicating that they are suitable habitat for beaver reintroduction. The area is easily accessible and contains plenty of herbaceous food as well as woody food and trees that are appropriately sized dam building materials. The low streamflow and stream depth at our site poses one of the only major threats to beaver populations due to its inability to provide necessary cover and protection from predators.

Our recommendation to CACS is to proceed with the plan to reintroduce beavers in the Fritz Creek watershed contingent on some modifications to improve the stream habitat. We strongly recommend the installation of at least three Beaver Dam Analogues (BDAs) in the stream to raise the water levels. Based on our research of beaver relocations and BDAs, we believe this will greatly increase the chances of successfully establishing a beaver population in the watershed and providing them with the means they will need to survive year round. Throughout

this report, we provide additional strong recommendations, a monitoring plan, and resources to ensure a high chance of success in beaver reintroduction as a restoration strategy. Beyond the scope of this report is the assessment of extensive flooding and potential beaver migration to other locations, thorough habitat surveying and adjacent land ownership should also be considered when deciding the reintroduction.

Acknowledgements

We would like to thank the Center for Alaskan Coastal Studies and the staff at Inspiration Ridge Preserve, especially Beth Trowbridge and Nina Faust, for providing us with this opportunity to conduct this study and learn more about reintroduction efforts and beaver ecology. We would like to thank them for providing us with housing and transportation for both parts of our team during our stay, for supplying us with any materials we needed to conduct our research, and for always being eager and willing to answer our questions and giving us guidance during the different phases of this project. We would also like to thank Jason Herreman from the Alaska Department of Fish and Game for his help and consultation regarding what would be needed for beaver reintroduction and helping us to formulate starting points for that. We would like to thank Ed Berg for providing his expertise on what factors we should consider before moving forward with the reintroduction and Bretwood Higman for providing soil, geomorphology, and GIS data for the IRP and our study site. We would like to thank Kim McNett for allowing us to share our research with the Peatland Camp, helping us to jumpstart our educational outreach. We would also like to thank the members of KBNERR that assisted us with our project, including John Morton, Rohith Moolakatt, and Jacob Argueta, especially Jacob for coming to the IRP with us and helping us take more accurate flow measurements. We would like to thank Sue Mauger at Cook Inletkeeper for letting us use their flow meters and Henry Reiske of CACS for teaching us how to use the drone. We also thank Joel Cooper and Dan Marsden of the Kachemak Heritage Land Trust, Dan for providing a tour of the Hogback property and Joel for his work on getting approval for a BDA and his responsiveness to our questions regarding that. We'd also like to thank Julie Nelson of the Methow Beaver Project for meeting with our team and her key assistance in constructing our final suitability index. Finally, we'd like to thank the faculty and staff of SEAS responsible for providing us with this opportunity, and our advisor Ines Ibanez for guiding us throughout the entire process of this project.

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Introduction

Center for Alaskan Coastal Studies

The Center for Alaskan Coastal Studies (CACS) is a non-profit environmental conservation organization located in Homer, a coastal city in the Anchor River/Fritz Creek watersheds on the southern terminal of the Kenai Peninsula in Alaska, which is surrounded by Cook Inlet on the west and Kachemak Bay on the east (Figure 1). CACS has been dedicated to environmental stewardship, ecological conservation, science popularization and education for 41 years since its founding in 1982. Today, it stewards several land properties for conservation, research, and education purposes. The three primary land properties are the Wynn Nature Center (Wynn), the Peterson Bay Field Station (PBFS), and the Inspiration Ridge Preserve (IRP). The Wynn is on top of a cliff facing the Kachemak Bay and overlooking the city of Homer, while the PBFS is a summer-accessible ecological research and education station located across Kachemak Bay from Homer. The IRP also lies on top of the cliff and is about 4.8 km (3 mi) northeast from the Wynn. It contains 19 parcels with a total area of 2.8 km^2 (693 acres) and is filled with forest, bogs, meadows, ponds, and creeks. The parcel in the upper right northernmost portion of the IRP is called Hogback (Figure 1).

Figure 1. A map showing locations of three land properties of CACS, including the Inspiration Ridge Preserve, Wynn Nature Center and Peterson Bay Field Station.

History of Inspiration Ridge Preserve (IRP)

The land that now comprises the IRP was stewarded by the Indigenous people of the region - the Dena'ina and Sugpiaq communities. The Dena'ina and Sugpiaq people inhabited much of the Southcentral Alaska land before being moved out by settlers (Freeman, 2021). The stewardship of the land from these indigenous peoples has allowed for continuous use and benefit of the ecological community by residents and researchers.

The IRP was established by Nina Faust and Edgar Bailey, a couple who shared a vision of stewardship and preservation and were dedicated to conserving the land around them and creating essential wildlife corridors (Faust, 2020). In 1986, E. Bailey and N. Faust purchased the first 0.13 km^2 (32 acres), and through decades of hard work, passion, and helping hands from volunteers, plot by plot, the IRP accumulated to 2.8 km^2 (693 acres) of conserved land (Faust, 2020). The IRP was completed in December 2019 and then proceeded to be donated to CACS to serve educational and conservation purposes ("Inspiration Ridge Preserve," n.d.). To maintain the vision of preservation, human activities are limited within the preserve, under CACS management. This protects habitats, migratory pathways, and biodiversity.

Environmental Context

Located on the southern portion of the Kenai Peninsula, the Anchor River watershed has a total area of 583 km^2 (225 mi^2), including 185 km (115 mi) of streams that are classified as anadromous fish spawning habitat by Alaska Department of Fish and Game (Hagan, 2017). In close proximity to the Anchor River watershed, the Fritz Creek watershed is located at the southern edge of the Kenai Peninsula, covering an area 10 by 32 km (6 by 20 mi) on the northeast of Homer. Within the IRP, the Fritz Creek flows northwards from the top of the cliff, then turns east to flow downhill into the Kachemak Bay on the south, as shown in Figure 3. The headwater section of Fritz Creek that flows through the western parcel of the IRP (will be referred to as the Main Stream thereafter) is about 0.55 km (0.34 mi) long and has historically contained abundant peatlands.

The IRP is also in close proximity to the Anchor River/Fritz Creek Critical Habitat Area (ARFCCHA) and the adjoining parcel north of the IRP boundary is in the ARFCCHA (Figure 2). This 76.9 km^2 (19,000 acre) area was established in 1985 by the Alaska Legislature to protect natural habitat critical to perpetuation of fish and wildlife, especially moose (Alaska Department of Fish and Game, 1989). The Anchor River/Fritz Creek Critical Habitat Area Management Plan, created in 1989, includes many goals for protecting wildlife and habitat, however it specifically states that two goals of this plan are protecting important furbearer habitat and minimizing harmful disturbances to furbearers. The Fritz Creek connects the IRP and ARFCCHA, allowing beaver populations to replenish and restore natural habitat between these drainages and waterways. Thus, beaver reintroduction in the IRP may benefit the ARFCCHA and contribute to the goals and objectives of the management plan.

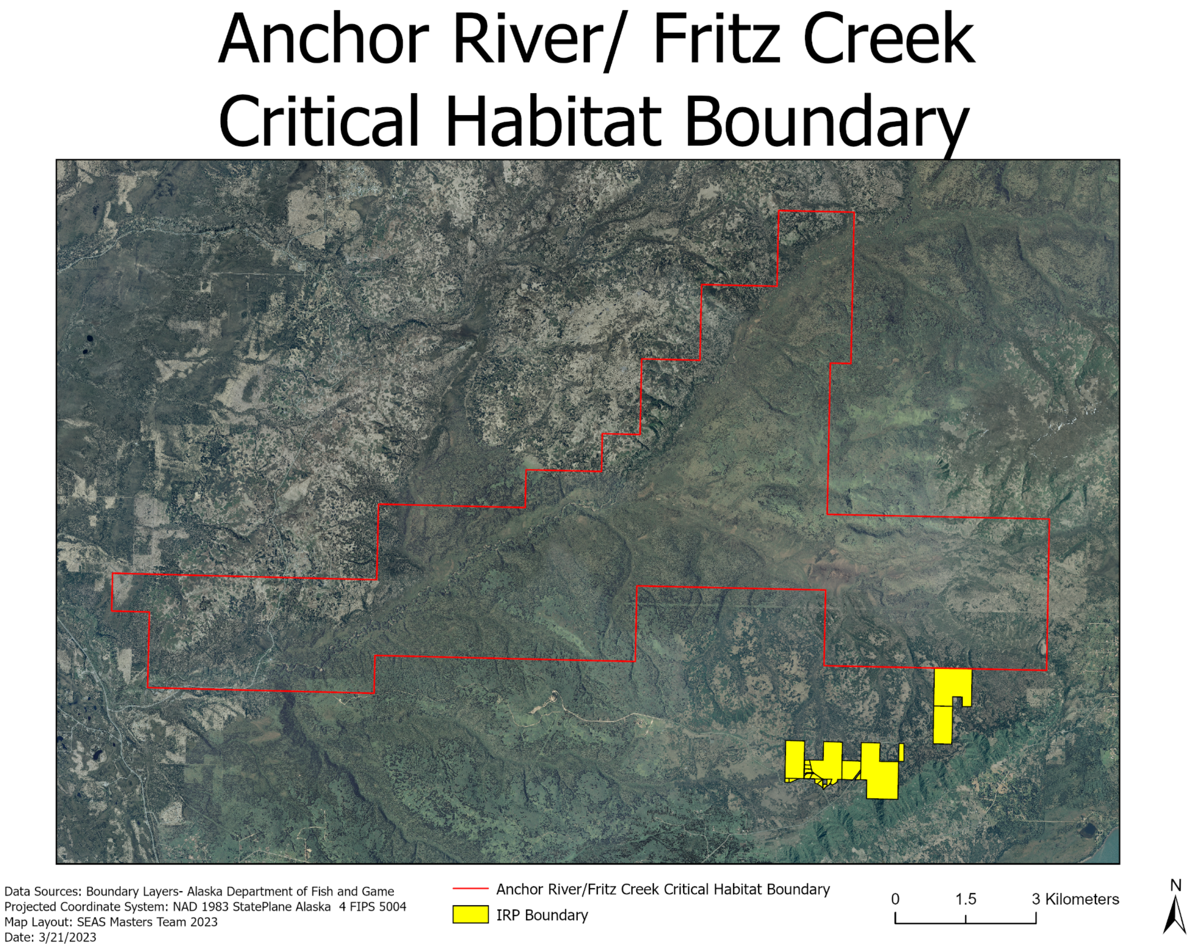


Figure 2. Anchor River/Fritz Creek Critical Habitat boundary.

Peatland ecosystems are terrestrial environments where net primary production (NPP) exceeds organic matter decomposition over a long term. These ecosystems contain substantial accumulation of incompletely decomposed organic matter, thus they act as places of carbon storage (Vitt, 2006). With the decrease in precipitation and increase in drying throughout the Kenai Peninsula, substantial decomposition in peatlands has been ongoing for years, emitting the once stored carbon as carbon dioxide (Ives et al., 2013). Gracz et al. (2008) note that many areas on the Kenai Peninsula categorized as fibric soil series (undecomposed) in the early 1970s are now being mapped as hemic soil series (partially decomposed).

There are records of increased temperature and decreased precipitation in the Kenai Lowlands over the past 50 years. Climate records from the city of Kenai show that the mean May–August temperature within the Kenai Peninsula was 9.9°C during 1944–1968 and 10.5°C during 1969–2002. Kenai weather records show nearly a 40% decrease in the mean annual water balance (precipitation - potential evapotranspiration), dropping from a mean of 13.7 cm (5.4 in) between 1944 and 1968 to a mean of 8.3 cm (3.3 in) between 1969 and 2002 (Klein et al., 2005).

Many studies have described the impact of warming and drying over Alaska, e.g., doubled large wildfires (Kahn, 2015), larval maturation and overwinter survival of forest pests (Berg et al., 2009). There is also anecdotal evidence for climate change particularly in the Kenai Peninsula, such as rising tree lines in the Kenai Mountains and drying of muskegs, kettle ponds, and closed basin lakes (Klein et al., 2005).

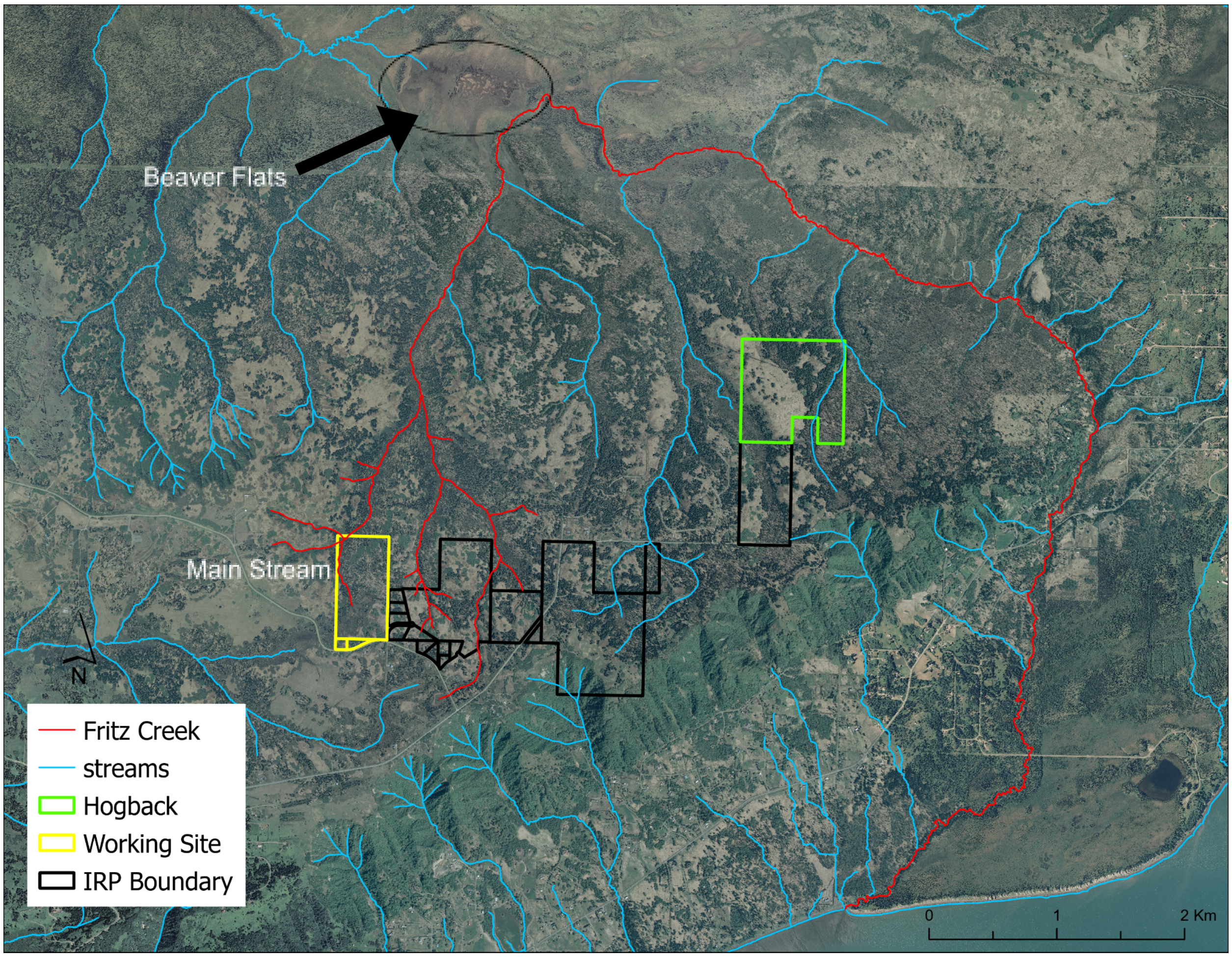


Figure 3. Map showing Fritz Creek and its tributaries as well as its drainage pathway to Kachemak Bay. Additionally highlighted is the Beaver Flats, IRP Boundary, Hogback Property, and Working Site (Main Stream) for Suitability Assessment.

Study Area Overview

The area specific to our study spans 0.344 km^2 (85 acres) and is located at the westernmost part of the IRP (Figure 3). It is also known as the Bailey Wong Property. It supports a significant diversity of wildlife and vegetation where moose, bear, coyotes, and sandhill cranes roam freely, and historically beavers as well. The main woody plants found in this area include willow (*Salix* *spp.*), alder (*Alnus spp.*), spruce (*Picea spp.*), and cottonwood (*Populus spp.*), in addition to grasses and sedges.

The stream in our study area originates from a flood plain and flows through a valley dominated by willow shrub thickets (Figure 5). The volume of flow in this part of the stream is low and most of the stream channels in the study area are covered by dense willow branches. In addition, the channel is deeply incised and eroding laterally into the bank soil (Figure 4), forming overhangs which could reach as long as 0.9 m (3 ft) wide. The incision width of the stream at the Main Stream is typically 0.9 to 1.5 m (3 to 5 ft) wide, and the depth of the stream is approximately 0.3 to 0.9 m (1 to 3 ft). The narrowest section could allow only one person standing in the channel.

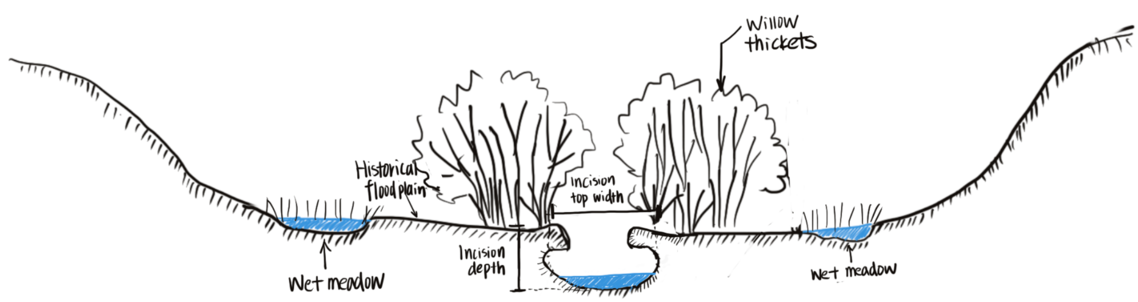


Figure 4. Illustration showing cross-section of the Main Stream valley (dimensions are not to scale)

Throughout many regions of the world, channel incision is a widespread environmental problem that has caused extensive ecosystem degradation (Montgomery, 2007). The defining characteristics of an incised alluvial stream are a lowered streambed and disconnection from the floodplain (Darby & Simon, 1999). Research has proven that the stream incision problem can be tackled by beaver dams via promoting sediment deposition (Pollock et al., 2014). Given such a status quo in our study area as mentioned above, we expect the dam building activities of reintroduced beavers could raise the water level in the stream channel so that the overhanging soil could be eroded and sediments could deposit. Subsequently, the channel structure could be reshaped and a flood plain could form.

Figure 5. Photo showing the meadow within the IRP with thousands of willow stems as well as spruce trees lining the drainage valley.

Ecological Significance of Beavers

Beavers are widely known as ecosystem engineers (Morgan, 1868). They can make a landscape their own with the right materials (Glenk & Martin-Ortega, 2018). Beavers build dams that will provide shelter and protection as they create a pond and lodge (Clements, 1991). With the creation of the pond comes many benefits to the ecosystem. Ponds rehydrate the groundwater and increase the water table, which is essential for the hydrating of peatlands in our study area and increasing water storage (Runyon, 2018). Vegetation productivity and biodiversity throughout the floodplain is increased due to seasonal wetting, resulting from the watershed restoration provided by beaver dams (Jordan & Fairfax, 2022). As a result, beavers can have an important role when it comes to mitigating climate change since these peatlands are important places of carbon storage (IUCN, 2021). In addition to increased carbon storage, reintroducing beavers could restore the incised streambank and reduce hydrology concerns through aggrading entrenched channels, slowing head cut migration, and reducing conifer encroachment (Pollock et al., 2014).

Further ways beavers help with addressing climate change is by cooling the stream, which is preferred by the local fish population. Water temperatures that are too high will influence foraging responses and thermal deaths of Dolly Varden trout (*Salvelinus malma)*, which is the dominant fish population in Fritz Creek, altering their behaviors and lessening their chance of survival (Takami et al., 1997). Swimming ability for fish is also affected by water temperature. Dolly Varden trout often dominate in cold streams with temperature of 6–8°C, the swimming endurance time (SET), which is the time at which the fish could no longer swim despite prodding from the downstream end, decreased sharply for temperature of 12°C comparing to 6°C (Yamada et al., 2020). Deep pools can be formed even when dams are built in shallow water. It is preferred by the juvenile population as it increases the potential area for fish to hide and find food without having to travel long distances.

Past Beaver Activity and Historic Ecosystem

Beavers are a popular game species in Alaska and have been historically trapped for their fur and their glands, called castor sacs. Using these sacs, beavers excrete Castor, a strong vanilla-scented substance used to mark their territory, and considered highly valuable. Historically, the Anchor River/Fritz Creek Critical Management Plan from 1989 (Alaska Department of Fish and Game, 1989) states that the beaver was common along the entire length of the South Fork of the Anchor River and its tributaries as well as along the headwaters of Fritz Creek. Harvesting data from years 1984-1987 in this report shows that beavers were plentiful at this time.

According to personal communication with Homer residents, it was agreed that beavers were plentiful in the Beaver Flats area until about 2005, when they were trapped out (Fig. 3). When speaking to Dave Lyon, an IRP neighbor and longtime resident in Homer, he explained that beavers were present in upper Fritz Creek adjoining Inspiration Ridge until about 25 years ago (1998-99). The beavers formed a good sized pond with perhaps 4 lodges and a solid dam (Lyon, 2022). However, he noted it was particularly cold that winter, and the beaver ponds froze close to solid. This made beavers an easy source of prey, and wolves nearly eliminated them. There was a pair of beavers that moved up the drainage around 1.6 km (1 mi) from the bluff at that time, however that area also froze. There is no evidence of current beaver populations within the IRP or within a close proximity (i.e. Homer and Kachemak Bay). The ARFCCHA Management Plan also identifies that periodic winter flooding and subsequent refreezing may be a major source of mortality of beavers in this region (Alaska Department of Fish and Game, 1989).

Experimental Relocation of Beavers

Relocation of beavers has become a popular restoration tool in the United States, particularly in arid climates where degradation of ecosystems due to warmer temperatures and less precipitation has been most noticeable. Many projects have been successful, such as the Methow River project in Washington, where beavers were established and benefits from their presence were noticeable almost instantly. They have often provided boosted ecosystem services to the habitats they have been reintroduced in. However, there has also been controversy and some concerns regarding beaver relocation. An inventory of relocation projects across the Western US found that while relocating beavers has become a common practice, there is a lack of peer-reviewed research regarding the after effects of relocation and there is a lack of regulation for the matter (Pilliod et al., 2018). In many relocation efforts, beavers are relocated without following a strict set of guidelines to account for things like predation, disease, genetics, to name a few. Since beavers are considered a nuisance animal for the general public, emigration to privately owned land is a big concern.

In Washington, as part of the Methow Beaver Project, three beaver pairs were released at three separate sites within Woody Creek in the lower Methow River watershed in the fall of 2014. The following spring, it was discovered that all beavers had survived the winter and had created two dams. Throughout that summer and into the fall, more than seven dams were built at each of the three sites (Simmons, 2015). Beavers have had continued success of survival in this watershed and their dams have increased vegetation protection against wildfires.

Starting in 2014 and continuing over three years, 69 beavers were relocated from lowland areas of the study location into various headwaters within the Skykomish River watershed in another location within Washington. This relocation occurred in an effort to measure what impact beavers have on water temperature and storage within the area. Results showed that beavers had a positive effect on both the temperature and water storage within the first year of reintroduction, decreasing the stream temperature by an average of 2.3°C and raising water levels by 0.33 m (1.1 ft) through the assistance of dams. Another important finding from this study included that relocation to areas with large complexes that have been abandoned or habitats that are vacant result in greater water storage (Dittbrenner et al., 2022).

A study conducted in Oregon experimented with relocating nuisance beavers in an attempt to restore critical salmon habitats (Petro et al., 2015). Instead of using solely expert opinion like similar previous projects, this study utilized habitat selection models to identify the most ideal habitat for beaver reintroduction and relocation. As the beavers were monitored long-term, it was discovered that they tended to emigrate from the release sites as far as 29 km (18 mi), and there was a high rate of mortality due to predators and illness. In some of these cases, the beavers moved out of the target area and instead established themselves on private landowner property or close enough to private properties that their activities made them a nuisance again.

An extensive relocation effort in Wyoming moved around 200 beavers over a span of 5 years (McKinstry & Anderson, 2002). Ultimately, beaver populations were reestablished at thirteen out of the fourteen release sites. Factors like habitat suitability and current predator populations were not taken into much consideration, so high mortality and emigration rates were also observed in this effort. The importance of adequate water levels and hiding places for beavers to escape from predators was emphasized, as beaver populations remained stable in habitats where they had deep water. It took releasing an average of 17 beavers per site for the beavers to begin constructing natural dams and lodges and remaining in the release site. In the streams where they were successfully reestablished, the wetland and riparian habitats did improve due to beaver activity.

In summary, beaver relocation can have great success when it is done properly and critical factors are accounted for. In order to have a successful reintroduction and avoid causing additional conflicts, there are proper steps to take to maximize success and minimize conflict. Factors to be considered:

1) Genetic testing and disease testing prior to reintroduction can ensure the population will be healthy when it is most vulnerable and avoid transmitting disease to any native populations.
2) Age of introduced individuals. The study (McKinstry & Anderson, 2002) did find that beavers between 2.5 to 3 years age seemed to have the lowest mortality rates, so age may be an important consideration as well.
3) Thorough habitat surveys. The site should be adequately assessed for essential factors in a suitable beaver habitat. Several relocation efforts have failed or lost most of their population to predation because the site was not assessed for adequate water levels and escape means from predators. Surveying the site and quantifying the necessary habitat factors as much as possible can determine if its current environment would sustain a population of beavers effectively.
4) The surrounding land and its ownership should be considered due to the potential that reintroduced animals might emigrate from their release sites to other locations. Extensive flooding could also affect land outside IRP.

In this report, we focused on assessing suitable habitat (point 3 above), but recommended all other points to be addressed before the reintroduction.

Habitat Suitability Assessment

Methow Beaver Project (MBP) Suitability Scorecard

To assess the feasibility of successful reintroduction of beavers in this area, we used the Methow Beaver Project (MBP) Suitability Scorecard to evaluate habitat suitability (see Appendix A and B). The Methow Beaver Project (MBP) Suitability Scorecard (2020 version) (Appendix B, referred to as Scorecard hereafter) includes field evaluation of thirteen variables that are considered key parameters to a successful beaver reintroduction. These key parameters consist of stream gradient, stream flow, flow depth, habitat unit size, woody food, herbaceous food, floodplain width, dominant stream substrate, historical beaver use, building materials, browsing impacts, ease of access, and existing aquatic escape cover. The Scorecard produces a final cumulative score that determines habitat suitability for reintroduction. Descriptions of each factor considered in the Scorecard are included below.

After conducting the field surveys, the scores of each variable are added into overall scores with respect to sample points and reaches. Each variable is weighted based on each factor's importance to habitat suitability in the Scorecard. Although we primarily follow the scoring regime from MBP Scorecard (2020 version), we adapted the weights of some factors that are more tailored to our site after consulting with Julie Nelson from the Methow Beaver Project. A total score ranging from 0 to 44 points indicates unfavorable release sites, while a total score ranging from 45 to 90 points indicates favorable release sites (Methow Assessment, 2020).

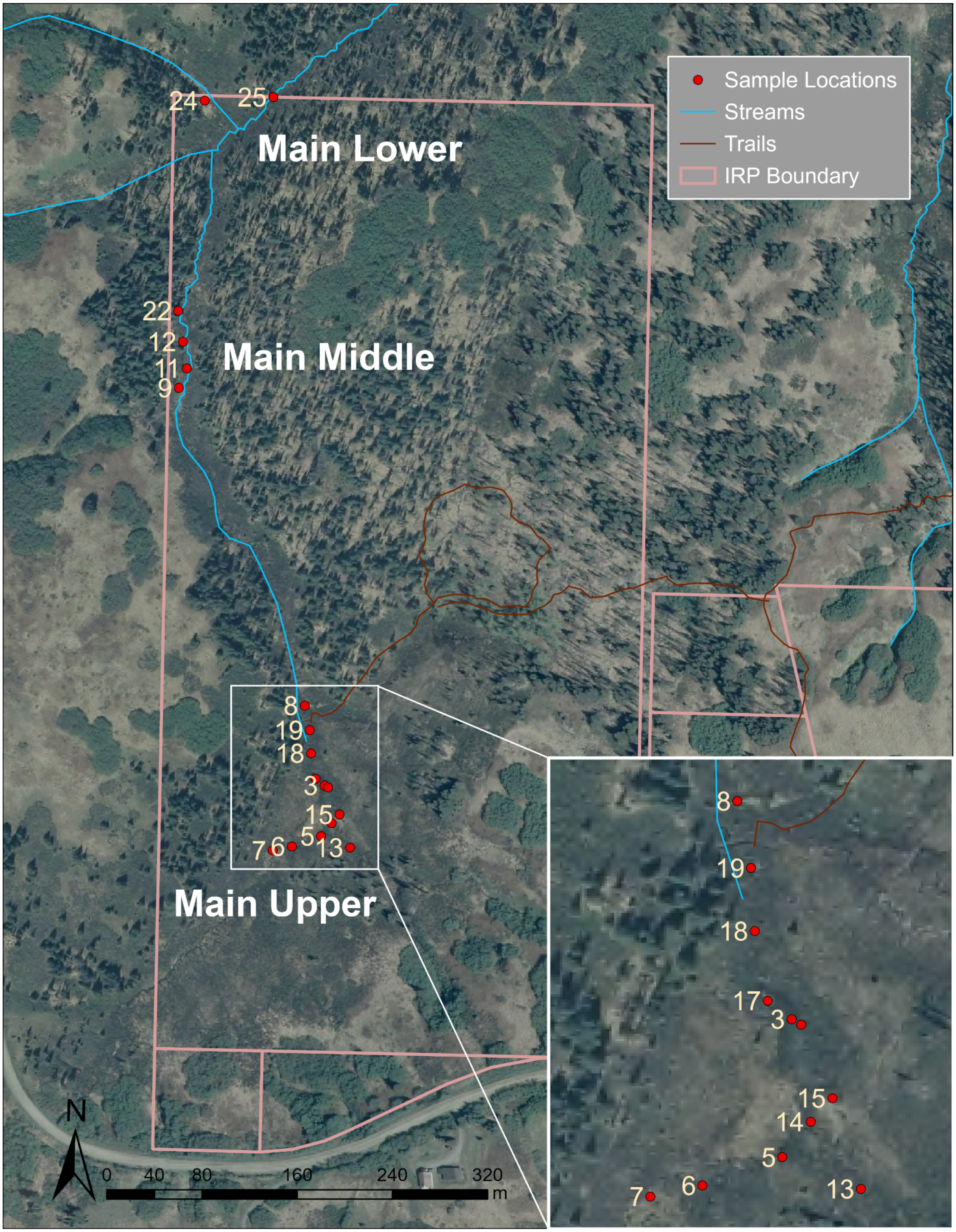


Figure 6. Map showing the sample points in the IRP summarized by three reaches: Main Upper, Main Middle, and Main Lower in this study using The Methow Beaver Project (MBP) Suitability Scorecard (2020 version). Points 1,2,4,10 were omitted as test points

Assessment sites:

Field data was collected along the Fritz Creek within the IRP boundary over 6 weeks in the summer of 2022. We surveyed all stream sections accessible within the IRP boundary. We qualitatively assessed or quantitatively measured the MBP factors at three reaches with a total of 18 sample points along the length of the stream and assigned a score for each point, according to the Scorecard. Each sample point was selected for being a potential release site, which are generally spaced in the same intervals within the same reach. The average distance between adjacent sample points was 2.5 m (8.2 ft). Some portions of the creek were not accessible due to dense thickets of willows and difficult terrain, hence the sample points were clustered into three reaches along the western portion of the creek: Main Upper, Main Middle, and Main Lower (Figure 6) and an average suitability score was calculated for each.

We designated three reaches as being defined as having similar hydraulic conditions of the stream section, and reflected collectively by multiple sample points (Table 1). The Main Upper reach is located at a headwater basin, where groundwater seepage comes out of the ground forming small pools and wet meadows on each side of the stream. The Main Upper reach is characterized by a deeply incised cross-section. The distinction between Main Upper and Main Middle is approximately where the valley narrows. Main Middle reach generally had a wider active channel and more stream flow during our field visits. Main Lower reach has the ideal amount of flow and active channel, but is the closest to the IRP boundary. Due to poor accessibility and a steep gradient, we are not assessing the suitability of the Hogback reach.

Table 1. Basic characteristics of the three reaches of the Main Stream.

Reach	Characteristics
Main Upper	- 12 sample points - 161.5 m (530 ft) long including two tributaries - Located at a headwater basin where groundwater seepage feeds into the stream. - Various hydraulic conditions including deep pools and deeply incised steam.
Main Middle	- 4 sample points - 76.2 m (250 ft) long - Narrower valley than Main Upper
Main Lower	- 2 sample points - 100.6 m (330 ft) long - Ideal average flow and active channel - Closest to IRP boundary

Assessment factors:

1) **Gradient (%)**
River morphology is a primary consideration in habitat suitability assessment for beavers. High stream gradients result in faster flowing water, which affects beavers' ability to build dams. Beavers prefer small to medium sized streams with low channel gradient (slope <6%) and generally populate the lowest gradient (slope <1-2%) sites first (Pollock et al., 2017). According to Maringer & Slotta-Bachmayr (2006), the ideal channel gradient for beavers is less than 3%.

To measure the stream gradient, we marked two PVC pipes with ticks of 2.54 cm (1 inch) intervals and used them as yardsticks. They were placed into the streambed with a fishing line tied between them at a tick with the same number, and the fishing line was kept under tension. We then used Inclinometer, a mobile app, to measure the angle α (Figure 7 left), and took the tangent of the angle α as the mean stream gradient.

Scores were assigned as follows:

Score	0	+3	+5
Gradient	>7%	4-6%	≤3%

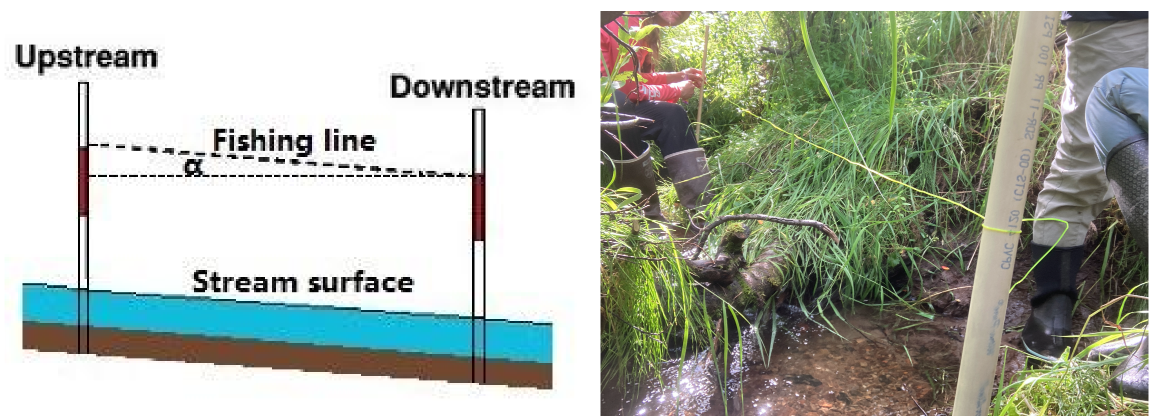


Figure 7. The geometry of stream gradient measurements (left). An example of how the stream gradient was measured, showing the two PVC pipes in the streambed with the fishing wire stretched between them (right).

2) **Average Stream Flow**
Stream flow is calculated as the volume of water discharged per unit time, which is estimated from the cross section area of the water and the flowing velocity (Figure 8). At each stream site, we fixed a meter tape to one side of the stream and stretched it perpendicularly to the flow to the other side of the stream (Figure 7 right). Water depth

and velocity were recorded along the direction of the meter tape at 7.62 cm (3 inch) intervals. The total stream discharge Q was then calculated as the sum of the discharges through all the subsections, described by the following equation:

$$Q = \sum_i d_i \cdot w_i \cdot v_i$$

where d_i represents depth of the subsection, w_i represents width of the subsection, v_i represents the velocity of the water flowing through the subsection.

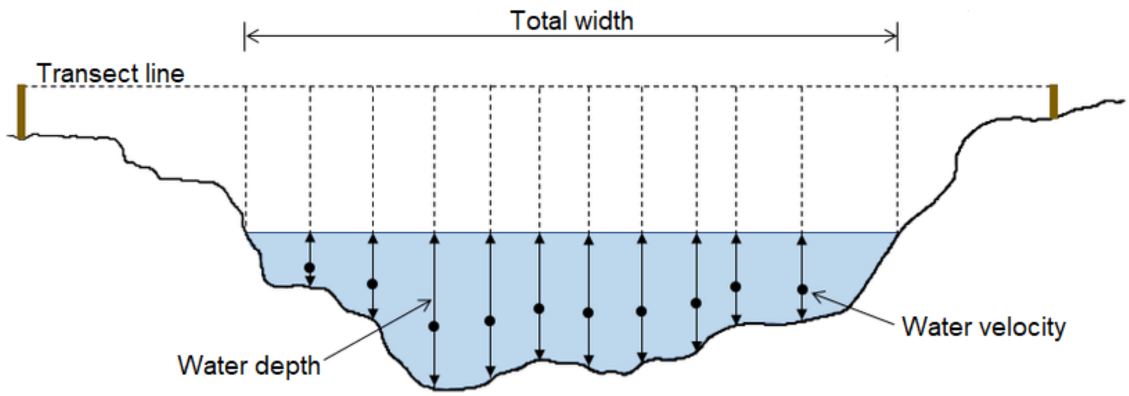


Figure 8. An illustration of stream channel cross section and how it is divided into numerous subsections (Franklin et al., 2018).

The water depth was measured by a yardstick, and velocity was measured by a Turbo-Prop flow meter, as shown in Figure 9. We used the method from Beardsley et al. (2015) to assign quantitative cubic meter per second (m^3/s) or cubic feet per second (cfs) equivalents to the Scorecard qualitative descriptors of stream flow.

Scores were assigned as follows:

Score	0	+3	+5
Stream Flow	Unwadeable (too fast) > 0.014m^3/s (0.5 cfs)	Garden Hose (slow flow) < 0.003 m^3/s (0.1 cfs)	Fire Hose (fast flow) ≤ 0.014 m^3/s (0.5 cfs)

Figure 9. The Turbo-Prop flow meter (left) utilized to measure water velocity (right).

3) Stream Depth

1. According to Slough & Sadleir (1977), beavers require a permanent supply of water and prefer a seasonably stable water level. Water levels lower than 50 cm prevent beaver colonization (Stocker, 1985). The ideal water depth is between 1.5 m to 3 m as this depth is known to provide beavers with enough water to escape from danger and allows light to reach the river bottom for the growth of aquatic vegetation, creating a necessary food supply (Pachinger & Hulik, 1999)
We adjusted the criteria for the depth assessment to make it implementable in our study sites based on the Scorecard (2020 version). This factor was measured when measuring the stream flow. We took the average of multiple measurements along the stream cross section as the final depth. The marked PVC pipe was used as a measuring tool.

Scores were assigned as follows:

0	+1	+5
Over waist or lower than sneakers; < 10 cm (3.9 in)	Over sneaker; 10-38 cm (3.9-14.9 in)	Over knee-high boots; > 38 cm (14.9 in)

4) Habitat Unit Size

This variable indicates a linear extent of unoccupied habitat suitable for beavers under current conditions. Linear channel length of the stream has been used in previous studies (Pollock et al., 2017) to define the habitat unit size for beavers. At each sample location, we estimated habitat unit size by measuring the channel length both upstream and downstream using the distance measuring tool in ArcGIS. Ideally, this factor represents the stream length measured in both directions (Methow, 2020). Given the high possibility of relocated beavers moving downstream due to limited upstream length, we account for the downstream length only. The stream length located downstream beyond the IRP boundary was also considered as a potentially habitable stream section. For our site, we referred to the study conducted by Lundquist & Dolman (2019) to use quantitative descriptors in substitution for the qualitative criteria found in the Scorecard (2020 version).

Scores were assigned as follows:

0	+1	+2	+3	+4	+5
0-199m (0-650 ft)	200-549m (650-1800 ft)	550-899m (1800-3000 ft)	900-1249m (3000-4100 ft)	1250-1609m (4100-5290 ft)	>1610m (>5290 ft)

5) **Woody Food**

At each reach, we estimate the presence and abundance of favored hardwood food species. For woody food, beavers prefer species from the genera *Populus* and *Salix* (i.e. aspen, cottonwood, and willows). The points for this factor are calculated by considering distance from the stream and the abundance of stems with the corresponding numerical values.

Scores were assigned as follows:

Hardwood food (aspen, willow, alder, etc.)			
________ Woody food score = $a \times b$			
Score	+5	+3	+1
a. distance	Within 9.1m (30 ft)	Within 30.5m (100 ft)	Within 91.4m (300 ft)
b. abundance	Large amount (thousands of stems)	Some (hundreds of stems)	Few (dozens of stems)

6) **Herbaceous Food**

At each reach, we estimated the presence and abundance of favored herbaceous food species, including hydric grasses, forbs and sedges (Henker, 2009). Beavers consume woody food year round, but during the spring, summer, and fall months they tend to consume more herbaceous foods (Holland, 2016). They feed particularly on the leaves and roots of herbaceous plants.

Scores were assigned as follows:

+0	+5
No grass or forbs present	Aquatic and terrestrial grasses and forbs abundant

7) Floodplain Width

We walked the length of the channel to qualitatively assess floodplain width. GIS layers (elevation from DEMs) were used to aid this assessment. Floodplains typically lie at, or somewhat above, bankfull stage (Dunne & Leopold, 1978). Bankfull stage is the gauge height beyond which a rise in water surface will cause the stream to overflow. Indicators of bankfull include vegetation, bank shape, and undercuts (Harrelson et al., 1994). In the areas where the stream has undercuts, we estimated the bankfull widths as the upper extent of the undercuts. Zones of frequent inundation are defined by an elevation above the channel equivalent to two bankfull depths (Rosgen, 1996; Simon et al., 2016). We visually estimated the floodplain width at two bankfull depths. If the floodplain width is two times wider than the stream bottom, it is considered a wide-bottomed stream. On the other hand, if the floodplain width is less than two times the bankfull width, it is considered a narrow “V” channel.

Scores were assigned as follows:

+0	+5
Narrow “V” channel	Wide stream bottom with a floodplain at least twice the width of the stream

8) Dominant Stream Substrate

Beavers do not build bank burrows in areas where the substrate limits their construction, including areas with very rocky soils or those categorized as permafrost (Pollock et al., 2017). McComb et al. (1990) found that beaver dams occurred exclusively at sites with dirt rather than bedrock or cobble-dominated banks. The substrate of the stream was assessed using these categories: Silt/clay/mud as very fine dirt particles, sand as particles measuring less than 2 mm (0.08 in), gravel as particles measuring less than 50 mm (1.97 in), cobble as particles measuring less than 250 mm (9.84 in), boulders as anything measuring greater than 250 mm (9.84 in), and flat bedrock. Physical examination of the stream substrate through visualization and touch was done to determine if it was mainly sand, clay, or mud. Web Soil Survey (Appendix J) was also utilized to assess soil substrate in GIS analyses.

Scores were assigned as follows:

+0	+1	+2	+5
Cobble	Gravel	Sand	Silt/Clay/Mud

9) Historic Beaver Use

Easily recognizable physical evidence of historic beaver use, such as chewed trees, remnant dams and lodges, was recorded when surveying the creek and its surrounding meadow. We distinguished between old structures and relics present and no indication of previous occupancy. Overall, beavers reestablish themselves better when there are previous structures available. It also is an indicator of suitable habitat if historical beaver presence is observed (Pollock et al., 2017).

Scores were assigned as follows:

0	+10
No indication of previous occupancy	Old structures present

10) Building Material

The most common building materials found in beaver dams consist of tree trunks, branches, twigs, bark, leaves, soil, mud, and occasionally stones (Gurnell, 1998). We estimated the presence and abundance of 2.5-15.2 cm (1-6 in) diameter woody vegetation at each reach and determined whether that size class of preferred building material is abundant or not. The diameter of woody vegetation was measured using DBH (diameter at breast height) tape to determine if it was within the diameter range on the Scorecard.

Scores were assigned as follows:

0	+5
No building material present	Abundant 2.5-15.2 cm (1-6 in) diameter woody vegetation available

11) Browsing Stress

Willows along the riparian edge of the stream were visually assessed for signs of heavy browsing by moose in the area, as moose are the only known cervids to occupy the IRP (Turner et al., 2017). Moose and beavers are both herbivores drawn to riparian areas and prefer foraging on willow (Hood & Bayley, 2009). As these two mammals have similar browsing patterns, it is important to consider the competition they may have when it comes to foraging, especially along the riparian edge (Kay, 1994). At each sample point, the tops of the trees were evaluated for visual damage caused by branches being ripped off by cervid teeth. If more than 75% of the trees in the area had heavy damage, browsing stress was considered high. If less than 75% had heavy damage, browsing stress was considered low to none. Additionally, animal tracks and their density along the trail were monitored to determine presence of browsers and grazers.

Scores were assigned as follows:

0	+5
Heavy browsing/ grazing	No impact or obvious presence of browsers/grazers

12) Access

Accessibility to the reintroduction site is determined by the travel time from the parking location to the translocation site along the stream. It is important to consider distance when it comes to accessibility as monitoring will occur on a regular basis for an extended period of time. There is a designated parking location at the IRP that also serves as the trailhead where an established path leads to the translocation spot.

Scores were assigned as follows:

0	+5
Long hike	Easy travel to deliver beavers and monitor

13) Aquatic Escape

Deep pools provide covers for beavers to escape from predators since the entrance of their lodges are built underwater (Pollock et al., 2017). The presence of deep pools are a critical part for beavers' survival. A marked PVC pipe, the same one referenced in the Gradient section, was utilized to determine depth of pools at each reach.

Scores were assigned as follows:

0	+5
No deep pools	Multiple deep pools greater than 0.9 m (3 ft) deep present

Beaver Restoration Assessment Tool (BRAT)

The Beaver Restoration Assessment Tool (BRAT: http://brat.riverscapes.xyz) is a model developed by Utah State University and is commonly used by researchers and restoration managers to predict potential locations for beaver dam construction, and to what extent they could exist in the restoration area by estimating the upper limit of dam density (number of dams per km) (Macfarlane et al., 2017). The model uses GIS layers that include slope, vegetation, and hydrology data to create an output layer estimating dam capacity per km of the stream. In the model, it is possible to include other optional data for context as well such as land ownership, roads, canals, and more. The full BRAT model is designed to manage large-scale planning and assess the potential for beaver as a stream conservation and restoration agent over large regions and watersheds. It is a widely used tool in any research involving watershed restoration by beavers and is recommended for prioritization in decision-making and planning. For a more detailed recommendation for using the full BRAT model to consider dam capacity along the Main Stream in IRP, refer to Appendix F.

Since the stream we are assessing is less than 1 km (0.62 mi) long, it is not recommended to apply the BRAT to our data. Instead, our team utilized the Beaver Restoration Assessment Tool Capacity Inference System (BRAT cIS) Form that the BRAT model is based on to assess the stream's potential for beaver dam activity (Bennett et al., 2019, p. 3). When the BRAT model is run with GIS data, a fuzzy inference system deals with categorical ambiguity and uncertainty in the input data. However, the inference systems are nothing more than rule tables, and BRAT suggests that if the user is comfortable committing to specific categorical calls for the inputs that drive the capacity model, one can ‘run’ the model very simply (Macfarlane et al., 2017). The BRAT cIS Form involves these associated rule tables for a field-based assessment of beaver dam capacity (See Appendix E). The Form includes two suitability evaluations to assess beaver dam density capacity:

1. Evaluation of the vegetation capacity to support dam building activity
2. Evaluation of the combined dam density capacity after considering other potential limiting factors such as stream flow, slope, and current or historic dam/beaver activity.

Assessment Outcomes

Habitat Suitability - MBP Suitability Scorecard

At individual sample points within a given reach, scores from each of the factors were totaled. We then later estimated the mean and standard deviation of the scores within the three main reaches, referred to as Main Upper, Main Middle, Main Lower. A summary of the results from each sample point is provided in Table 2, and the results for each reach are summarized in Table 3.

Three aspects of the site that would result in automatic unsuitability include:

1. If there is current beaver activity at the site or there is an active colony within 1.6 km (1 mi).
2. If neighboring landowners have low acceptance for introduction, potentially resulting in negative wildlife interactions.
3. If damage to roads, culverts, and structures is likely due to flooding or blocking.

These circumstances are presented at the beginning of the Scorecard (Appendix B) and should be considered before moving forward with an assessment. Before beginning fieldwork, the suitability of the IRP was addressed when it came to these three aspects. Once the IRP was deemed suitable, we were able to proceed with assessing suitability when it came to specific factors.

Table 2. Methow Beaver Project Scorecard Survey Results, by sample locations.

Reach ID	Sample Pt.	Gradient(%) (+5,+3,0)	Stream flow (+5,+3,0)	Flow Depth (+5,+1,0)	Habitat Unit Size (+5,0)	Herb. food (+5~0)	Fldpln Width (+5,0)	Dominant substrate (+5~0)	Old structure (+10,0)	Bldng material (+5,0)	Browsing Stress (+5,0)	Access (+5,+3, 0)	Woody food (+25~0)	Aquatic Escape (+5,0)	SUM (+90~0)
Main Upper	3	5	5	1	5	5	5	1	0	5	5	5	25	0	67
	5	5	5	0	5	5	5	5	0	5	5	5	25	0	70
	6	5	5	0	5	5	5	5	0	5	5	0	25	5	70
	7	5	3	1	5	5	5	5	0	5	5	0	25	5	69
	8	5	3	0	5	5	5	2	10	5	5	5	25	0	75
	13	3	3	0	5	5	0	5	10	5	5	5	25	0	71
	14	0	3	1	5	5	0	5	10	5	5	5	25	0	69
	15	0	5	0	5	5	5	5	10	5	5	5	25	0	75
	16	5	5	0	5	5	5	5	10	5	5	5	25	0	80
	17	5	5	0	5	5	5	2	10	5	5	5	25	0	77
	18	5	5	0	5	5	5	5	10	5	5	5	25	0	80
	19	5	3	5	5	5	0	5	10	5	5	5	25	0	78
Main Middle	9	5	5	0	5	5	5	2	10	5	5	5	25	0	77
	11	3	5	1	5	5	5	2	10	5	5	5	25	0	76
	12	5	5	0	5	5	5	2	10	5	5	5	25	0	77
	22	5	5	0	5	5	5	1	10	5	5	5	25	0	76
Main Lower	24	0	3	0	5	5	0	1	10	5	5	3	25	0	62
	25	0	5	0	5	5	5	2	0	5	5	3	25	0	60
	26	0	3	1	4	5	0	1	0	5	5	0	25	0	49
	27	0	3	0	4	5	0	5	0	5	5	0	25	0	52
	28	0	5	1	4	5	0	2	0	5	5	0	25	0	52

Table 3. Methow Beaver Project Scorecard Survey Results summarized, by reaches.

Reach ID	Sample Pt.	Gradient(%) (+5,+3,0)	Stream flow (+5,+3,0)	Flow Depth (+5,+1,0)	Habitat Unit Size (+5,0)	Herb. food (+5~0)	Fldpln Width (+5,0)	Dominant substrate (+5~0)	Old structure (+10,0)	Bldng material (+5,0)	Browsing Stress (+5,0)	Access (+5,+3, 0)	Woody food (+25~0)	Aquatic Escape (+5,0)	SUM (+90~0)
Main Upper	AVE	4.00	4.17	0.67	5.00	5.00	3.75	4.17	6.67	5.00	5.00	4.17	25.00	0.83	73.42
	SDEV	1.95	1.03	1.44	0.00	0.00	2.26	1.53	4.92	0.00	0.00	1.95	0.00	1.95	17.02
Main Middle	AVE	4.50	5.00	0.25	5.00	5.00	5.00	1.75	10.00	5.00	5.00	5.00	25.00	0.00	76.50
	SDEV	1.00	0.00	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Main Lower	AVE	0.00	4.00	0.00	5.00	5.00	2.50	1.50	5.00	5.00	5.00	3.00	25.00	0.00	61.00
	SDEV	0.00	1.41	0.00	0.00	0.00	3.54	0.71	7.07	0.00	0.00	0.00	0.00	0.00	12.73

Main Upper

The Main Upper reach received an overall score of 73.42±17.02 (mean±SD), out of a maximum of 90, which falls above the 45 threshold of suitability for reintroduction to this site. At this reach, factors that received higher scores are gradient %, stream flow, habitat size, herbaceous food, building material, access, and woody food. Whereas flow depth, floodplain width, presence of old structures, and aquatic escape were given lower scores.

With most of the sample points in Main Upper reach having less than 3% slope, the reach received an average score 4±1.95 (maximum 5.0) for the gradient factor. The result indicates a favorable gradient for establishing dams at Main Upper.

At Main Upper reach, we recorded stream flow ranging from non-detectable flow to 0.00138 m^3/s (0.49 cfs) which is equivalent to that of a fire hose. The stream flow factor received an average score of 4.17 (maximum 5.0) for this reach, indicating adequate flow at the time of our field surveys (August 2022). However, we could not find ideal stream depth greater than 37.8 cm (14.9 inches; about the length of knee-high boots) at most sampling locations where flow depth highly varies from 2.28 to 40.64 cm (0.9 to 16 inches), hence an average score of 0.67 (maximum 5.0) was calculated for this factor. There are also highly varied scores for the Main Upper reach since there are very few deep pools present (deeper than 0.91 m (3 ft)), resulting in an average score of 0.83 (maximum 5.0) for the aquatic escape factor. Stream depth is essential for beaver survival since deeper water serves as cover to escape from predators, especially during winter.

The Main Upper reach received an average score of 5.0 (maximum 5.0) for habitat unit size, indicating there is more than 1610 m (5282 ft) of available space for beavers once released at this reach. As for herbaceous and woody food, this reach provides abundant willow and grasses, which are preferred foods of beavers. All sample locations within the reach received scores of 5.0 for abundant herbaceous foods and 25.0 for availability of hundreds of woody stems. In summary, Main Upper reach received full scores for habitat size (5.0), herbaceous food availability (5.0), and woody food abundance (25.0).

Sample points within Main Upper reach were categorized in variation for the floodplain factor, with partial locations categorized as wide floodplain since the reach is primarily located in the headwater fen basin. As a result, an average score of 3.75 ± 2.26 (maximum 5.0) was given to the floodplain width factor. For the Substrate factor, most of the points along the Main Upper received scores of 5 and 2, indicating silt/clay/mud and sand respectively, with an average score of 4.17 ± 1.53 (maximum 5.0) for the reach. Willow species are abundant on site, and are both an important source of food and structure for beavers. Its heavy presence throughout the Main Upper reach earned an average score of 5.0 (maximum 5.0) for the Building Material category.

At 8 out of 13 sample locations, we found evidence of old structure relics, resulting in an average score of 6.67 (maximum 10.0) for the Old Structure factor at Main Upper reach. Currently, there is no beaver activity observed or documented in this area. There was no evidence of browsing stress found through site observations. As for the access to the Main Upper reach, it has a slightly lower score since it is a longer hike from the parking location, about 35 minutes one way. However, it is still relatively close to the maintained trail. The Main Upper reach received an average score of 4.17 (maximum 5.0) for access.

Main Middle

The Main Middle reach of the stream scored exceptionally high in regards to stream flow, habitat size, herbaceous food, woody food, floodplain width, building material, old structure, browsing stress, and access. Scores on the high end were given for gradient % and lower scores were given to stream depth, aquatic escape, substrate, and current beaver activity. The Main Middle received an overall score of 76.5 ± 2.0, out of a maximum of 90, which falls above the 45 point threshold of suitability for reintroduction to this site.

Stream flow received an average score of 5.0 (maximum 5.0). The average flow rate was 0.0142 m^3/s (0.5 cfs), relative to the flow you would see from a fire hose. Habitat size received an average score of 5.0 (maximum 5.0), indicating a stream length greater than 1610 m (5282 ft), allowing for adequate space for beavers to roam until they find ideal locations to build dams and lodges. Herbaceous food received an average score of 5.0 (maximum 5.0) due to the availability of grasses and forbs for beaver consumption. Woody food received an average score of 25.0 (maximum 25.0) as the sources of woody food, namely willow and aspen, are in great abundance within the IRP. Woody food is located in large amounts close to the stream, giving beavers increased accessibility to food. Floodplain width received an average score of 5.0 (maximum 5.0) because the stream bottom was wide with an even wider floodplain. Building material received an average score of 5.0 (maximum 5.0) as the material used for woody food is also what beavers can use for building material. Due to the abundance of willow, the Main Middle is a strong area for building material availability. Old structure presence received an average score of 10.0 (maximum 10.0) because old structures from previous beaver use are present at several points within the Main Middle. Browsing stress received an average score of 5.0 (maximum 5.0) as there was no obvious visibility of predator browsing stress along areas of the Main Middle. Access to the Main Middle received an average score of 5.0 (maximum 5.0) as the trail to the stream is an easy terrain for reintroduction of the beaver and continuous monitoring.

The gradient percentage for Main Middle received an average score of 4.50 (maximum 5.0). This score was earned because the average stream gradient measured was near a 3% slope or lesser. This is a good score because beavers prefer a low gradient, ideally less than 3% (Maringer & Slotta-Bachmayr, 2006).

Stream depth received an average score of 0.25 (maximum 5.0), which indicates that the stream depth in the Main Middle is between 9.9-37.8 cm (3.9-14.9 in). This score is on the low end and would ideally need to be higher than 37.8 cm (14.9 in) deep to provide adequate coverage for beavers to build dams and lodges and avoid predation. Aquatic escape received an average score of 0 (maximum 5.0) because there are no deep pools present in the Main Middle. As with the stream depth, having pools deeper than 1 m (3.3 ft) are essential for beaver building their homes and for survival from predators. Substrate type received an average score of 1.75 (maximum 5.0) as the common substrate accounted for in Main Middle was sand and gravel. Beavers prefer less rocky substrate, so the presence of gravel at multiple points gave the Main Middle a lower score for substrate. Current beaver activity received an average score of 0 as there is no current beaver activity in the area.

Main Lower

The Main Lower reach of the stream scored exceptionally high in regards to habitat size, herbaceous food, woody food, building material, and browsing stress. High scores were given for stream flow, old structure, and access. while lower scores were given for gradient %, stream depth, aquatic escape, floodplain width, substrate, and current beaver activity. The Main Lower received an overall score of 61.00±12.73, out of a maximum of 90, which falls above the 45 point threshold of suitability for reintroduction to this site.

Habitat size received an average score of 5.0 (maximum 5.0) as the stream is greater than 1610 m (5282 ft) in length, providing beavers with adequate space to locate an ideal location for building a dam and lodge. The Main Lower reach of the stream is closest to the boundary of the IRP. This is a potential concern due to the roaming distances beavers are capable of. Once a beaver is outside of the IRP boundary, it no longer falls under the protection of the preserve. This puts the beaver in danger of potentially being trapped by those who own the land the beavers wander on. Herbaceous food received an average score of 5.0 (maximum 5.0) as grasses and forbs are readily available for beaver consumption. Woody food received an average score of

25.0 (maximum 25.0) as there is a high quantity of woody food, in the form of willow, available near the stream for beaver usage. Building material received an average score of 5.0 (maximum 5.0) as the presence of woody building material is in high amounts along the Main Lower part of the stream. Browsing stress received an average score of 5.0 (maximum 5.0) as there was no indication of browsing from any browsers or grazers.

Stream flow in the Main Lower received an average score of 4.0 (maximum 5.0) as the stream flow was higher at some points and lower at other points, averaging about 0.0085 m^3/s (0.3 cfs) which falls between the flow of a garden hose and a fire hose. Old structure presence received an average score of 5.0 (maximum 10.0) as there is indication of old structures in some points along the Main Lower, but not all points. Access to the site received an average score of 3.0 (maximum 5.0) as the trail to the Main Lower is a longer hike along the IRP boundary, where trails are not as well maintained as other areas, though still accessible for reintroduction and monitoring of beavers.

Gradient percentage received an average score of 0 (maximum 5.0) as the gradient slope is greater than 7% and considered unfavorably high for beaver accessibility and usage. Stream depth received an average score of 0 (maximum 5.0), indicating that the average measured depth was less than 10 cm (3.9 in). To ensure safe escape and protection from predators, the depth would ideally be a minimum of 37.8 cm (14.9 in) for beavers. Aquatic escape received an average score of 0 (maximum 5.0) because there are no deep pools present in the Main Lower. Deep pools, along with a higher stream depth, are important for beaver survival, so lower scores in this factor for the Main Lower should be kept in mind when considering suitability. Floodplain width received an average score of 2.50 (maximum 5.0) as some points in the Main Lower are adequate in their width and some are quite narrow. Substrate type received an average score of 1.50 (maximum 5.0) as common substrate in the Main Lower is gravel and sand, while beavers prefer a more mud-like substrate. Current beaver activity received an average score of 0 as there is currently no beaver presence in the area.

Hogback

There is currently no trail access to the stream and the gradient of the stream is over 9%. Due to this, the Hogback stream is unlikely to be suitable for a beaver reintroduction, and we will not be taking this reach into consideration for relocation. If there is improved trail access to this site in the future, it would be easier to conduct more thorough surveys to determine if this area contains any suitable habitat or not.

Feasibility Summary

Main Upper, Main Middle, and Main Lower received average scores of 73.42, 76.50, and 61.00 respectively. All three reaches of the Main Stream received overall scores above 45, making them suitable locations to release beavers. Coherent outcomes among three reaches include adequate herbaceous foods, adequate woody food and building materials, good access, and little to no browsing stress observed. On the other hand, the three sites received low scores on hydraulic characteristics including non-ideal flow depth, no existing deep pools, and non-ideal larger substrates. Old beaver structures appear more frequently at the Main Middle reach compared to the other two reaches, where the old structures were more infrequent.

BRAT cIS

Using the BRAT cIS Form seen in Figure 10 and 11 below, we were able to roughly estimate the potential capacity of the Main Stream within the IRP property. Figure 10 shows the assessment of dam density capacity based on suitability of vegetation only and Figure 11 evaluates the combined dam density capacity after considering other factors such as stream flow, slope, and current or historic dam/beaver activity. As a result of both assessments, it was determined that the dam density capacity of the Main Stream is considered "Pervasive."

The "Pervasive" ranking estimates the dam density capacity range to be 15-40 dams/km. The length of the Main Stream in the working boundary is ~0.55 km (~0.34 mi), therefore it is assumed the stream is capable of hosting roughly 7-20 dams. We know that historically, the stream did support several beaver dams although the landscape has changed since their absence. It should be noted that the BRAT cIS Form is not a detailed assessment of the dam density capacity for the Main Stream. There are environmental factors that are not being accounted for in the inference system that may affect true dam capacity outcomes; however, the results give good insight on the high suitability of the habitat to support beaver.

VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

SUITABILITY OF STREAMSIDE VEGETATION

- ○ Unsuitable
- ○ Barely Suitable
- ○ Moderately Suitable
- ○ Suitable
- ✓ Preferred

Vegetation within 30 m of water's edge

What vegetation types are abundant?

- ✓ Desirable woody (e.g. Aspen, Willow, Cottonwood)
- □ Other woody (e.g. conifers, sagebrush)
- ✓ Grasses □ Crops □ Ornamentals □ Developed

SUITABILITY OF RIPARIAN/UPLAND VEGETATION

- ○ Unsuitable
- ○ Barely Suitable
- ○ Moderately Suitable
- ✓ Suitable
- ○ Preferred

Vegetation within 100 m of water's edge

What vegetation types are abundant?

- ✓ Desirable woody (e.g. Aspen, Willow, Cottonwood)
- ✓ Other woody (e.g. conifers, sagebrush)
- ✓ □ Grasses □ Crops □ Ornamentals □ Developed

DAM DENSITY CAPACITY ASSESSMENT BASED ON SUITABILITY OF VEGETATION ONLY (USE TABLE 1)

- ○ None (no dams)
- ○ Rare (0-1 dams/km)
- ○ Occasional (1-4 dams/km)
- ○ Frequent (5-15 dams/km)
- ✓ Pervasive (15-40 dams/km)

Figure 10. Beaver Restoration Assessment Capacity Inference System (BRAT cIS) Form for assessing dam density capacity based on suitability of vegetation only.

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?

- ○ Probably can build dam
- ○ Can build dam
- ○ Can build dam (saw evidence of recent dams)
- ✓ Could build dam at one time (saw evidence of relic dams)
- ○ Cannot build dam (stream power really high)

IF BEAVERS BUILD A DAM, CONSIDER WHAT HAPPENS TO THE DAM(S) IN A TYPICAL FLOOD (E.G. MEAN ANNUAL FLOOD)?

- ○ Blowout
- ○ Occasional Blowout
- ✓ Occasional Breach
- ○ Dam Persists

HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?

- ○ Too steep they cannot build a dam (e.g. > 20% slope)
- ○ Probably can build dam
- ○ Can build dam (inferred)
- ✓ Can build dam (evidence or current or past dams)
- ○ Really flat (can build dam, but might not need as many as one dam might back up water > 0.5 km)

COMBINED DAM DENSITY CAPACITY ASSESSMENT BASED ON ALL (USE TABLE 2)

- ○ None (no dams)
- ○ Rare (0-1 dams/km)
- ○ Occasional (1-4 dams/km)
- ○ Frequent (5-15 dams/km)
- ✓ Pervasive (15-40 dams/km)

Maximum Dam Density (dams/km)

0 - None | 0 - 1 Rare | 1 - 4 Occasional | 5 - 15 Frequent | 16 - 40 Pervasive

Figure 11. Beaver Restoration Assessment Capacity Inference System (BRAT cIS) Form for assessing combined dam density capacity including other potential limiting factors to hydrology.

Major Considerations for Reintroduction

Beaver Dam Analogs (BDAs)

For successful beaver reintroduction and continued habitation, the stream depth and flow need to increase and remain at an adequate level, as reflected in the scores from the Scorecard. To avoid potential loss of beavers through predation or migration from reintroducing them to a location that is not yet entirely suitable, installing a series of Beaver Dam Analogs (BDAs) in the Main Stream prior to beaver reintroduction is our recommendation.

BDAs are temporary structures that are intended to raise water tables, trap sediment and help to force water onto the floodplain to recharge the groundwater and carbon storage (Goldfarb, 2018). BDAs are the fastest growing stream restoration practice in the Western United States (Goldfarb, 2018). BDAs are low-cost, stream-spanning structures that mimic natural beaver dams and are installed to confer the ecological and hydrologic benefits of beaver dams in streams that are no longer suitable for beavers to inhabit (Davis et al., 2021). Private agencies, public agencies, and people on a personal level have taken to BDAs as a way to heal eroded streams and successfully re-establish the beaver population. In the absence of beaver populations, a BDA is a man-made approach to increase the water table and overall water flow and sediment capture which are important for stream health and productivity (Bouwes, 2017). It has been reported that changes within streams and floodplains have occurred within 1 to 3 years of the BDA implementation (Goldfarb, 2018).

There are two types of BDAs: postless and post-assisted. Low-Tech Process Based Restoration, a restoration consortium as part of Utah State University, offers Recipes which are resources that include instructions and visuals on how to construct postless and post-assisted BDAs (Wheaton, 2021). Post-assisted BDAs are formed with untreated lumber that is pounded into the streambed for support. Branches and grasses are then woven among the posts to create a strong, yet porous wall to slow the flow of water (Edwards & Northwest Climate Hub, 2021). Postless BDAs utilize stumps and roots in addition to woody debris to build up a dam-like structure and are strategically placed within the stream (Grover, 2022). These types of BDAs are recommended as they are most representative of a natural beaver dam, since beavers do not drive posts into the ground when building dams on their own. Figure 12 represents the most common BDA which can be built quickly and works better than previously designed dams (Wheaton et al., 2022).

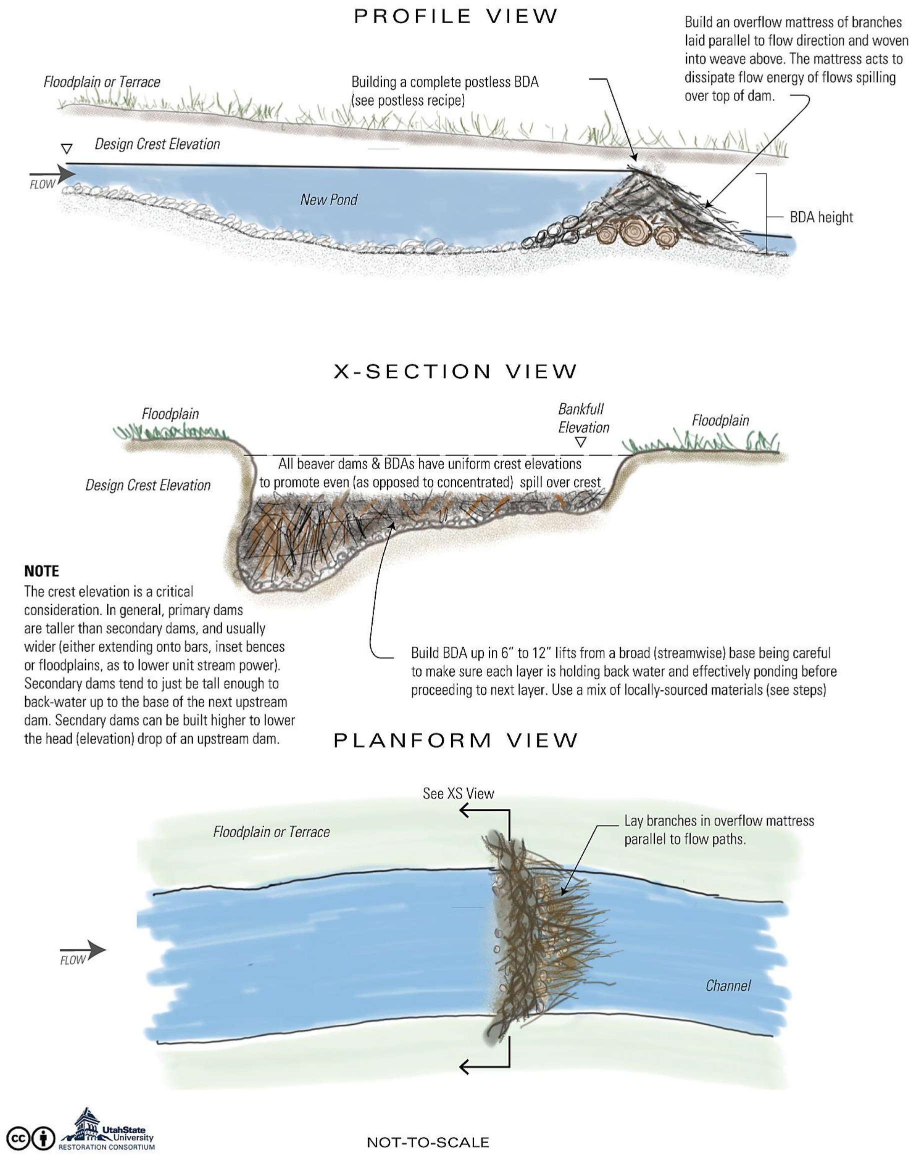


Figure 12. Most common BDA recipe from Low-Tech Process Based Restoration.

The BDAs should be maintained until the site is determined to be suitable enough with adequate food and building materials to sustain reintroduced beavers (Simmons & Vanderwal, 2018) and the streambed has reached the elevation of the former floodplain (Pollock et al., 2014). Maintenance can look like replacing portions of the system that are damaged, extending the length of the structure if it is no longer damming water, and increasing the height, often through building a BDA on top of the built up sediment (Pollock et al., 2017). As these structures, in the case of our recommendation, are made with all natural materials already existing throughout the location, it is not a requirement to remove them once beavers have moved in and started building their own dams. In fact, as it will be disruptive to beavers and their production, there should be as little human interference as possible once they have been reintroduced, other than observation.

An important aspect of BDA implementation is choosing the location. The success of restoring the waterway is based more on where within the stream the structures are placed rather than the construction of the BDA (Pollock et al., 2017). A more critical aspect of the implementation is the quantity of BDAs installed. Multiple placements increase system resilience and effectiveness. Additionally, when one dam fails, whether beaver-made or man-made, it can lead to more heterogeneity within the habitat (Pollock et al., 2014).

Channels that are incised, as is the case for the portion of Fritz Creek that we are looking at for reintroduction, tend to be shallow and narrow, resulting in less time for stream levels to increase and making restoration more feasible. BDAs can assist in accelerating the recovery process of these channels (Pollock et al., 2014). As Fritz Creek is not a wide stream and has a low stream depth, postless BDAs will be sufficient for the purpose of getting started. Places that beavers have historically been, but no longer are, is usually due to there being a less suitable habitat. Improvements to the aquatic habitat and riparian edge can increase suitability and both those areas of improvement can be done so through successful BDAs usage (Grover, 2022).

For the IRP, we recommend building a BDA where the largest historic beaver dam was found at coordinates 59.70268N, 151.44228W (See Appendix G). Specifically, the BDA should be built on the upstream side at the base of the historic dam.

Beaver Selection and Translocation

There are many general considerations for selecting and transplanting beavers. It is easily plausible in Alaska to trap and relocate a beaver, however the overall logistics of transporting the beaver from the holding site to the relocation site should be well planned and should consider the general comfort of the animal. Scattered throughout the United States, you can find programs and organizations specialized in safe beaver translocation processes. In addition to offering professional services, some of these programs will also offer training opportunities or other beaver restoration outreach events. The Beaver Institute, Inc (https://www.beaverinstitute.org/) was created to offer resources for restoration projects and resolving beaver conflicts. This organization developed the BeaverCorps Training Program (*Problems and Solutions*, 2021), allowing anyone to become a certified Beaver Wetland Professional Graduate. People are able to find the nearest Beaver Wetland Professionals Graduate in the area to hire in the relocation process. The Alaska professional is Skip Lisle, owner of Beaver Deceivers International (https://beaverdeceivers.com/), a company that works across all of North America using non-lethal methods to solve beaver conflicts.

The MBP offers their expertise in these processes to restoration professionals and watershed agencies for watershed restoration purposes, as well as developing solutions for landowners who feel that beavers are a nuisance to their property. For the latter, they first attempt to find ways for the landowner and beaver to coexist. This may include a beaver crew bringing tools and strategies to your site to help mitigate the conflict such as installing flow devices to control beaver damming, a BDA for restoration purposes, or applying tree protection from beaver chewing. However, when cohabitation is not possible, the MBP team offers translocation services to live trap and relocate beavers.

The MBP provides great resources to engage with throughout the entire duration of this reintroduction process for watershed restoration purposes such as:

- project design consultation - how beaver may respond to new in-stream infrastructure
- beaver potential evaluation - where are beaver most likely to enable project goals
- beaver habitat optimization - creating conditions for beaver to succeed
- beaver translocation - when possible, translocating beaver into a target restoration site
- beaver management - when beavers are challenging your restoration priorities

We consulted with Julie Nelson (julie.mbp@methowsalmon.org) from the MBP to discuss and evaluate the project design and methods we used. Overall, it was suggested that during the relocation process to our site, we should consider the importance of food sources from the holding site to the IRP release site. From J. Nelson's experience, beavers from sister watersheds will not always prefer the same food sources. A beaver may become well adapted to the food sources from their initial site, even if they are not the preferred food source for beaver. When reintroduced elsewhere, the beavers may become "picky," causing them to move somewhere else and away from the release site. Therefore, it is important to identify the main similarities and differences of the food sources between the two sites. Additionally when identifying food sources at each site, consider who else may be relying on the food source or woody material, such as moose and bears. For successful reintroduction, it is crucial that enough woody material remains for beavers to build, store for winter, supply for food, without compromising the survival of other species in the IRP.

During our field experience, we were fortunate to also meet and discuss our project with Dr. Ed Berg, a long time local and a retired ecologist from the US Fish & Wildlife Service, Kenai National Wildlife Refuge, Alaska. Dr. Berg was concerned about the low density of aspen and cottonwood at our site, and emphasized the importance of diverse hardwoods for beavers to eat and build with, mentioning that beavers can recognize the genetic diversity in the cottonwood species. He suggested that transplanting some additional hardwood species, specifically aspen and cottonwood, to our site would be beneficial. Currently, cottonwood species are existing at the site but there is a lack of aspen. Dr. Berg also emphasized the importance of considering additional species that may also rely on these hardwood species, especially predators. A transplantation plan would have to be approved by the Kachemak Heritage Land Trust and a general recommendation for this process includes increasing the amount of cottonwood and aspen density within a 30 m (98.4 ft) buffer from the streambed where beavers prefer to forage.

Potential Conflicts

People Beaver Interactions

Beaver populations have decreased significantly, with a loss of nearly 98% of what the population was before the 16th century, leaving around 9-12 million beavers in North America today (Scamardo et al., 2022). The significant decline of beaver populations is linked to trapping for their pelts which were used for luxurious accessories, such as hats (Ruxton & Kephart, 1922).

In the present day, beavers are often seen as a nuisance by humans. Their damming behaviors have a tendency to flood areas, affecting agriculture and private lands (Willis, 2013). Roads can become flooded when located close to a waterway that beavers actively dam in (Pollock et al., 2017). As beavers utilize woody plants for food and building materials, they are seen as the culprit of many fallen trees.

Another concern for the beavers is that they can move about the area until they find ideal spots to build their dams. The downside to the site is that only part of the stream proposed for reintroduction is protected by IRP boundaries. While the beavers would be introduced with the intent of occupying land that is in the IRP, they may wander from the reintroduction point. If they cross outside of the boundaries, they are no longer under the protection of the IRP. While this is important to keep in mind, one advantage to our site is that most of the adjoining properties to the valley where the creek is contained do not have residential developments, and some of the closest neighbors of this part of the IRP have had favorable dispositions towards beaver presence in the past. The land downstream of our three reaches are mostly state-owned and maintained land with no private landowner property.

By accessing parcel ownership data (Figure 13) from the Kenai Peninsula Borough GeoHub (KPB GeoHub), we found that most of the Main Stream outside the IRP flows on vacant land owned by either federal, state or private entities. A nearby commercially-used parcel is an aviation facility (registered as VOR-DME HOM 114.6) that one of the upstream tributaries flows through has no obvious structures close to the stream, confirmed via aerial photo. In addition, there are no roads or culverts intersecting with the Main Stream. As a result, there are currently no obvious concerns that relocating beavers would cause damages to other properties and structures in proximity. Vacant state and federal lands provide an extended area for beavers to roam beyond the IRP boundary without becoming a nuisance to private landowners.

According to the Scorecard, a certain level of social tolerance from neighbors regarding beaver populations is fundamental in achieving suitability. If landowners express hesitancy to reintroduction or give indications of potential negative interactions with the beavers, the site is automatically deemed unsuitable. Education of the local population is essential when it comes to this coexistence. Providing information on the benefits beavers bring to the Fritz Creek

Watershed and the surrounding ecosystems as well as the resulting benefits for the fish populations in the area are important tactics to show the community the positives of a beaver reintroduction and change appreciation for them. These educational opportunities can take form as bulletins posted in stores and restaurants throughout the area, an article in the newspaper for residents, education in classrooms through curriculum or special guest presentation, and speaking at local board meetings. CACS can continue their mission to "educate, connect, and protect" through these avenues.

However the information is portrayed, it is important to include the ecological significance beavers provide when it comes to the land and water, local terrestrial and aquatic species, what beaver actions do for climate change, and practical tips on how humans and beavers can live among each other. Some of those tips can come in the form of solutions to frequent concerns residents have, especially in regard to fallen trees or flooded property. For example, educating landowners to put fencing around trees they do not want taken down by beaver activity or collaborate with residents who have concerns of flooding on how to install culvert barriers (Taylor et al., 2017). Having a support line available to call for those residents who are experiencing beaver troubles can be utilized to humanely remove beavers from unwanted properties.

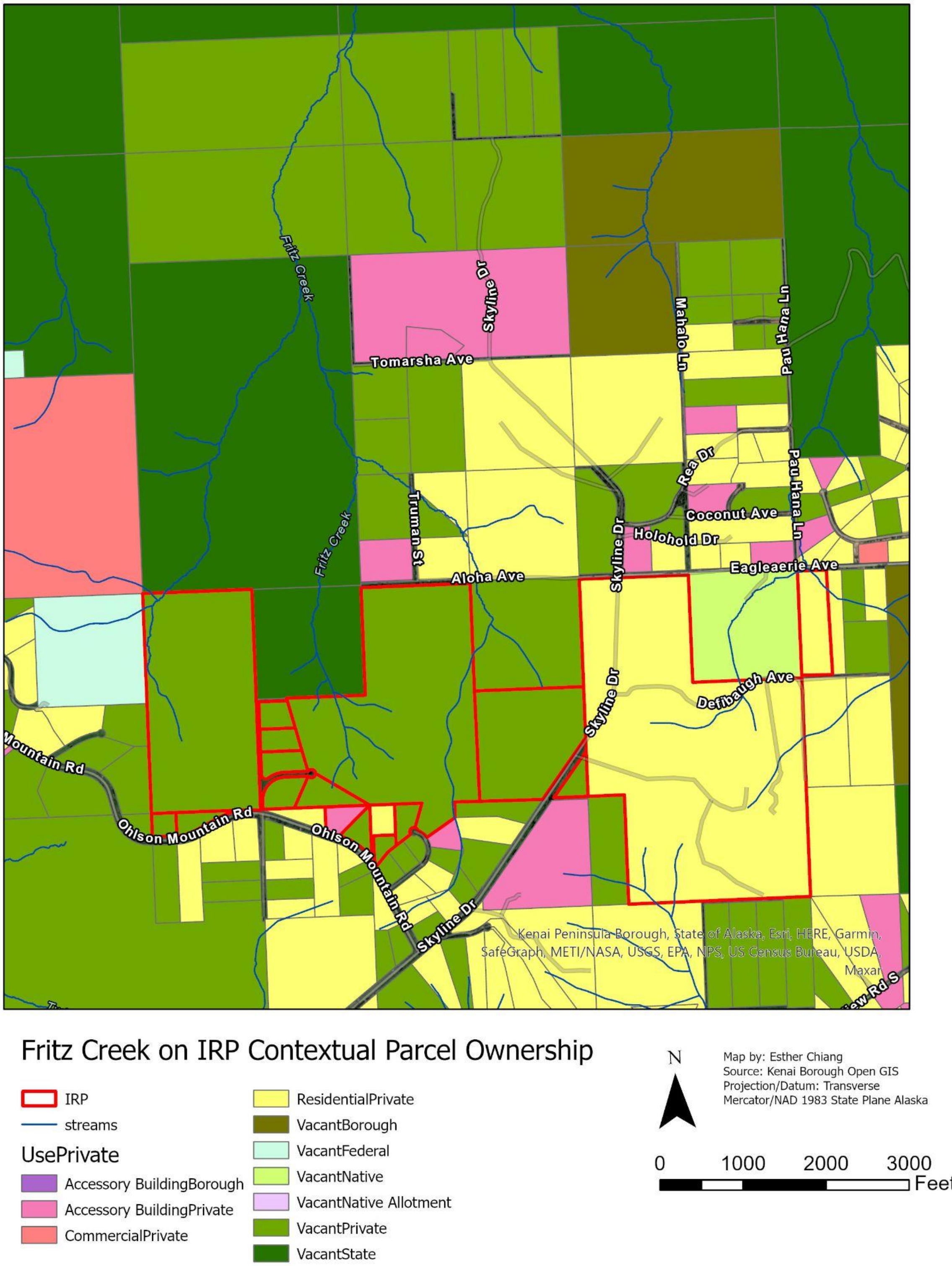


Figure 13. Main Stream contextual parcel ownership

Legal Issues

The Alaska Department of Fish and Game divides the state of Alaska into Game Management Units (GMUs) to apply hunting and trapping regulations throughout the state. The IRP is located in Unit 15, specifically Unit 15C (Figure 14) in very close proximity to the Anchor River/Fritz Creek Critical Habitat Area. Current regulations for the 2022-2023 season for all Kenai Peninsula State Restricted Areas can be found in Appendix H.

Trapping is the major reason for the decrease in beaver population in Homer area and this is evident in the proposals that were submitted to the Board of Game meeting for Southeastern Alaska which took place on March 17-22, 2023 (Full Proposals in Appendix I.) During this meeting, the Alaska Board of Fish and Game reviewed and voted on several proposals aiming to restore beaver populations through trapping regulations:

- Proposal 155 suggests closing Unit 15C to beaver trapping entirely
- Proposal 156 suggests closing the beaver hunting season for up to six years in Kenai Peninsula Area, specifically in Anchor River and Deep Creek Drainages within Unit 15C.
- Proposal 160 suggests limiting beaver trapping to one set per lodge and one beaver may be removed per lodge within Kenai Peninsula area while requiring lodges that have been or are being trapped in the current season to be marked with a pole set vertically in the ice.

The Alaska Board of Fish and Game voted no on Proposals 155 and 160, and voted yes on an amended Proposal 156 to keep the beaver hunting season open, but shorten it from Oct 10-Apr 30 to Nov 10-Apr 30. Without the trapping regulations, the reintroduction of a beaver population to the IRP could result in another elimination of the species from the area. The proposals resulted in some discussion regarding the hunting and trapping season, but even the proposed duration of the closed season would not have been sufficient enough for the reintroduction process to achieve its purpose. The passed proposal amendment that shortens the beaver hunting/trapping season will be somewhat helpful to native beaver populations, but still does not provide an adequate amount of time that would be beneficial in restoring beaver populations like an extended closing of the season. Proposal 155 by resident Sue Christiansen mentions that the goal for closing beaver trapping season is to give beaver populations time to recover so they can be trapped again in the future, representing the overall perspective of beavers as just game animals or a means for profit through their pelts rather than necessary components of wetland ecosystems. Without changing people's perspective on beaver trapping, temporarily closing the trapping season will not change the status quo of beavers, and the population will continue to be at risk after the closed season ends.

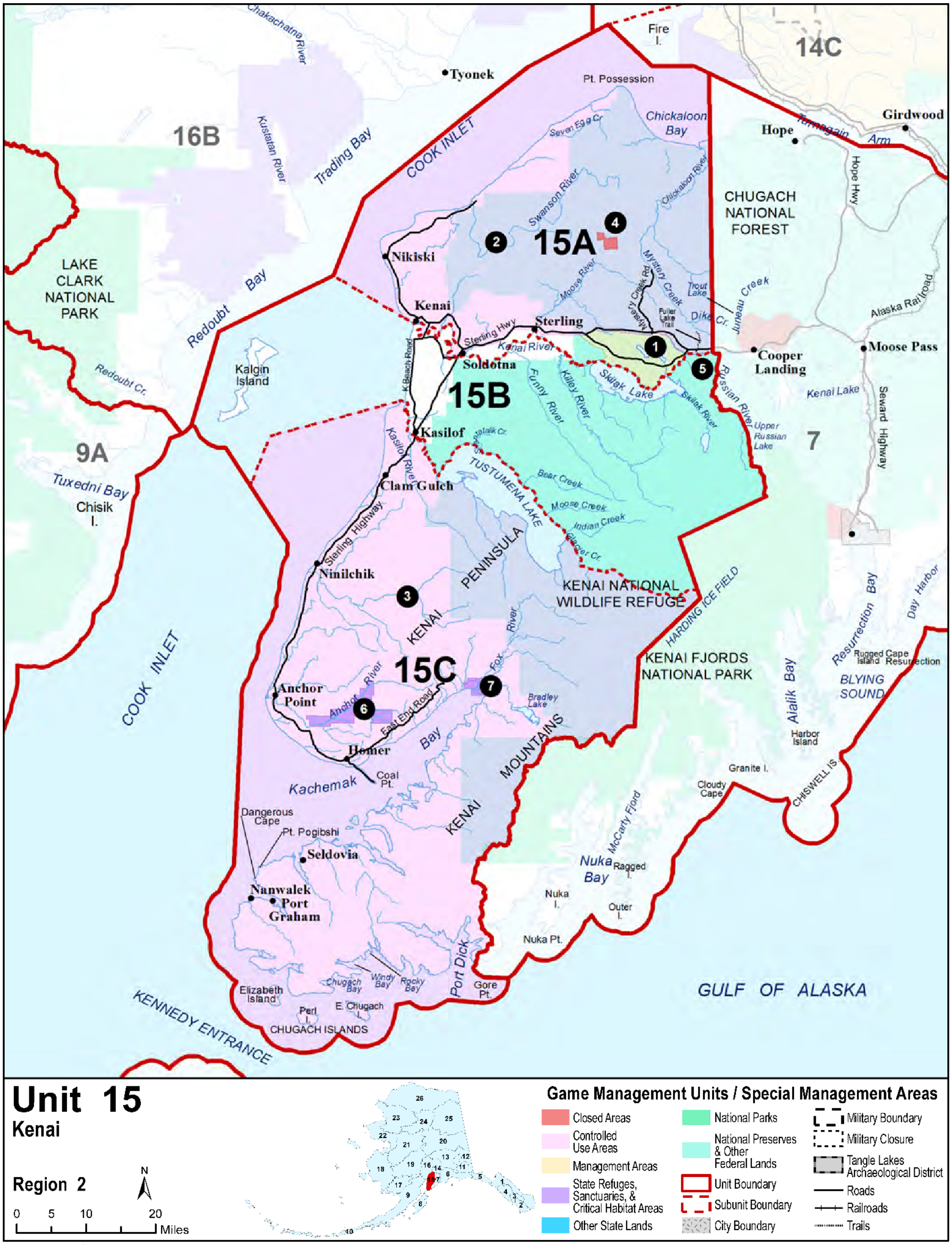


Figure 14. Map of Game Management Units for the Kenai Peninsula showing Homer and the IRP located in GMU 15C. Smaller numbers refer to Special Management areas with certain regulations and can be found in depth in Appendix G. (https://www.adfg.alaska.gov/index.cfm?adfg=huntingmaps.gmuinfo&gmu=15)

Predator/Prey Interactions and Competition

For reintroduction to be successful, the other animal species in the proposed site and how they may interact with beavers should be considered. Based on a previous inventory of wildlife in IRP, moose, black and brown bears, coyotes, and lynx have all been recorded on the preserve (Blongewicz et al., 2019). Wolves have been sighted in the IRP, and there is an established presence on the Kenai Peninsula (Neyman, 2014). Wolves, bears, coyotes, and lynx are all potential predators (Shepherd, 2008) while moose may be resource competitors (Hood & Bayley, 2008). In both cases of predation or competition, reintroducing beavers will alter the established ecosystem dynamics and may affect existing animal populations.

A heavy predator presence in the proposed site could pose a threat to any reintroduction attempts. In past relocations, predation is often a main reason that relocation has failed and is likely a contributing factor to the disappearance of beavers from the IRP originally (McKinstry & Anderson, 2002). Even if there is not currently a large presence of potential predators, the introduction of a prey species like beavers could attract predators to the area. This risk makes the efforts to increase escape options even more important, further showing the need for BDA installations. Since the Main Stream is incised, there is some cover provided by the large amount of space under the banks. If the reintroduction is successfully conducted, part of the long-term monitoring plan should include looking for increases in predator populations.

The dominant tree species in the watershed is willow. Willows are preferred by beavers for dam construction and winter food, and with willow being the dominant species in the area, the beavers will likely consume large amounts of it (Nolet et al., 1994). Willows are also a key winter food source for moose on the Kenai Peninsula, presenting a potential conflict for competition between the two species that could impact the beaver population’s survival (Oldemeyer et al., 1977).

While we were collecting data, we did not notice evidence of heavy grazing on the willows along the stream. However, our data is only representative of the summer months, when there is abundant nutrient-rich food available in better sources such as aquatic grasses and forbs. Moose will feed on these sources in the summer and will switch in the winter months to trees that are accessible in the snow, such as the willow (Bevins et al., 1990). It may be helpful to monitor the willows along the stream and moose in the IRP to get a better idea of how much grazing on those willows is actually taking place. If these willows are heavily grazed on by moose in the winter, competition could present a problem in the winter months and pressure from moose graze could impact beaver populations.

Monitoring and Future Research Opportunities

Stream Temperature

Many studies have shown that beaver dams can reduce water temperature (Dittbrenner et al., 2022), providing a more suitable environment for temperature-sensitive species, like salmon and trout. Considering that there are no historical records of stream temperature at this dam site, a data logger was installed to collect temperature data in the Main Stream. While the timing for the release of beavers in the IRP is still uncertain, this will set a baseline that can be used in the future to compare with stream temperature data after reintroduction (should the effort go forward) and monitor the impact of beaver activity on stream temperature.

Based on the habitat assessment conducted in the IRP during our fieldwork in Homer, the abandoned structure of the largest beaver dam (at sample point #8, 59.702683° N, 151.442283° W, there is a spruce standing on top which N. Faust pointed out to us) might be suitable for future reintroduction. Currently, there are no ponds formed upstream of the dam due to the absence of beaver activity, but it is still a potentially suitable habitat according to the model. Therefore, we chose this beaver dam site to conduct the stream temperature monitoring.

Data Logger Installation and Settings

We attached a temperature data logger to a wooden block and mounted it in the stream water at the dam site (sample point #8) downstream part, as shown in Figure 15 and Figure 16 here. The data logger was screwed onto one side of the wooden block, which was then pressed by a heavy dead branch to prevent the block from floating. The dead branch was covered by mud to hold it in place. A green indicator flag was also stuck in the mud at the stream bed, next to the data logger.

Figure 15. The data logger was screwed onto a wooden block.

Figure 16. An illustration of the data logger and how the wooden block is stabilized by a heavy branch and the mud.

The data logger was set to collect temperature data on an hourly basis, resulting in 24 records per day. We have set it to start collecting on August 8, 2022 and stop on August 8, 2023, considering that the battery is estimated to last for 1 year according to the manual. While monitoring the data logger long-term, it is important to ensure the log and data logger are not displaced and that the data logger is completely submerged.

Data Transfer and Download

We appreciate that CACS staff visited the site on September 26, 2022 upon our installation to check the status of the data logger and downloaded the existing data. Considering that the memory will not get full within the whole year, we suggest downloading the data three times during the summer season - May, July, September - to ensure data is not lost due to potential damage to the device.

To offload the data from the logger to a cell phone, an application called ‘HOBOconnect’ is needed and the data is transferred through Bluetooth. Press the circular button on the center of the logger to wake it up and you will see an LED light blinking. You might need to press it hard to wake it up. Also, during data transfer, it could be done without touching the wooden block at all. It is fairly easy and quick to transfer based on our experience.

Note that the Bluetooth signal might be unstable since the logger is fixed underwater. To get a stable connection, you might need to place your phone fairly close to the logger, potentially as close as the water surface. Otherwise, it may fail to search for the signal or lose the connection.
The ‘HOBOconnect’ application supports exporting csv files and sharing, which is recommended.

Recommendation for Future Temperature Monitoring Protocols

It is recommended to deploy the temperature monitoring data logger in the stream at least three months before the construction of BDA to acquire adequate baseline data. Each potential BDA construction site should be instrumented with a temperature data logger at the upstream and downstream of the site. The upstream data logger should be located sufficiently far upstream to avoid impacts of anticipated dam and pond creation. To eliminate the effects of other environmental factors, the net water warming/cooling (ΔT) within the BDA site is calculated by subtracting the mean daily stream temperature at the upstream data logger location from that at the downstream location. Thus negative values indicate that the stream is cooling when flowing through this section, and positive values indicate warming. These values derived in the preceding period of the BDA construction can be considered as a baseline scenario (ΔT_{before}), while the ones after the BDA construction can be considered as the BDA scenario (ΔT_{BDA}), and the ones long after the beavers' settlement and modification on the BDA can be considered as the settlement scenario (ΔT_{settle}). As such, the effect of BDA building and pond formation on stream temperature can be evaluated by $\Delta T_{BDA} - \Delta T_{before}$, the effect of the overall beaver engineering activities on stream temperature can be evaluated by $\Delta T_{settle} - \Delta T_{before}$.

As mentioned above, during the beaver team Group 2's field work in Homer, one temperature data logger was only deployed at the downstream part of the dam site (at sample point #8) within the reach of Main Upper. Considering that this historical dam site is evaluated to be a potential BDA construction site, it is necessary for CACS to fix the other temperature data logger in the stream water at a suitable upstream location.

Stream Depth, Flow, Width

A measurement spot at sample point #8 (Figure 6) should be set up to measure the overall change in water characteristics caused by the BDA and beaver activity. Other spots near the BDA should be randomly selected to measure stream depth before the reintroduction and after placement of a BDA to determine if the BDA is increasing water levels. Water depth of the ponds created by the BDA and the stream characteristics (e.g. stream depth and flow rate) should also be recorded to evaluate how the BDA will alter water systems in the IRP region. After beavers relocate to other locations and build dams, stream characteristics for both the new location and previous dam should be measured to study both how beavers affect water systems and whether removing beavers would impact surrounding water systems.

Beaver Population, Lodges, Dams

If of interest to CACS, staff within the IRP could be in charge of monitoring beaver activity on a monthly basis. There are wildlife cameras set up by previous projects that can be used as monitoring equipment for beavers. New cameras would have to be set up near BDA, beaver dams and lodges. Number of beaver lodges and beaver dams should be identified and recorded. Movement of beavers should be monitored and identified for future research.

Drone monitoring

Recent research in spatial ecology has been highlighting the use of unmanned/uninhabited aerial vehicles (UAVs or drones) to realize a cost and time-efficient surveying option, especially in impenetrable wetlands (Puttock et al., 2015). By utilizing the existing asset of CACS, drone imagery is an effective way to visualize and monitor the impact relocation of beavers and BDAs overtime. During the 2022 field work collection, we created a 5*10 grid with an interval of 100 m (328 ft) covering the westernmost IRP parcel (Bailey Wong Property) and captured 50 drone images at the 50 grid points to establish a baseline for future aerial imagery monitoring techniques. The grid is shown in Appendix K, and the drone images will be uploaded to Basecamp of CACS.

The 50 drone images have all been georeferenced and georectified with geoinformation. With the presence of the geoinformation files (file extension is .JGwx), the images can be easily opened with ArcGIS Pro and displayed at the correct spatial location.

Ground-based location photograph monitoring

Photography is a technique included in most beaver restoration projects. It is essential to establish a series of permanently marked ground-level photo points. At each point, specified dates, times, and weather conditions should be recorded. Photographs should be taken at least once in each season for the establishing years. Special attention should be paid to capture before and after the establishment of BDAs.

Conclusion

The Fritz Creek watershed in the IRP has suffered a degradation of the stream and its ecosystem services due to the disappearance of beavers from the area and the continuing trends of warmer, drier weather on the Kenai Peninsula. This degradation may also be affecting important wetland and peatland systems downstream from the IRP. Based on the suitability index provided by MBP, the watershed meets the scoring requirements to be considered a suitable beaver habitat. However, we have some concerns regarding the specific criteria that determine suitability. The greatest of these concerns is the lack of water that is present year-round in the stream and its depth. With the levels currently being so low, any reintroduced beavers are at high risk of predation since there is not adequate water for them to utilize for hiding and escape. This concern has led us to recommend the site for reintroduction following a 1-2 year installation of multiple BDAs to increase stream depth and water levels and produce deeper ponds in the area. We believe this step is critical to ensuring the survival of any reintroduced populations. We also recommend that other factors such as genetics, disease testing, current predators in the IRP, and moose populations in the IRP be evaluated and monitored throughout the process to best protect the health of the incoming population and the native populations of other animals in the IRP.

References

Alaska Department of Fish and Game. (1989). *Anchor River/Fritz Creek Critical Habitat Area Management Plan*. https://www.adfg.alaska.gov/static/lands/protectedareas/_management_plans/anchor_river.pdf

Beardsley, M., Doran, J., & Meyer, K. (2015). *Beaver Restoration on Thirtynine Mile Mountain*. http://cusp.ws/wp-content/uploads/2014/05/2015-Thirtynine-Mile-Beaver-Wetland-Report.pdf

Bennett, S., Wheaton, J., Bouwes, N., Macfarlane, W., & Portugal, E. (2019). *Chapter 3—Planning for Low-Tech Process-Based Restoration* (S. Shahverdian, Ed.; Utah State University Restoration Consortium, Logan, Utah). https://doi.org/10.13140/RG.2.2.15815.75680

Berg, E. E., Hillman, K. M., Dial, R., & DeRuwe, A. (2009). Recent woody invasion of wetlands on the Kenai Peninsula Lowlands, south-central Alaska: A major regime shift after 18 000 years of wet Sphagnum–sedge peat recruitment. *Canadian Journal of Forest Research*, *39*(11), 2033–2046. https://doi.org/10.1139/X09-121

Bevins, J. S., Schwartz, C. C., & Franzmann, A. W. (1990). Seasonal activity patterns of moose on the Kenai Peninsula, Alaska. *ALCES VOL.*, *26*, 14–23.

Blongewicz, K., Cortes, L., Finch, E., Joyal, L., Leisman, D., & McLaughlin, E. (2019). *Inspiration Ridge Preserve Protocols for Ecological Inventories and Management* [Master's Project Report, University of Michigan]. http://deepblue.lib.umich.edu/handle/2027.42/148816

Bouwes, N. (2017, July 27). *BDA Stream Restoration | Beaver Institute, Inc.* https://www.beaverinstitute.org/management/stream-restoration/

Clements, C. (1991). Beavers and Riparian Ecosystems. *Rangelands*, *13*(6), 277–279.

Darby, S., & Simon, A. (1999). *Incised River Channels: Processes, Forms, Engineering and Management*. John Wiley & Sons. https://www.wiley.com/en-us/Incised+River+Channels%3A+Processes%2C+Forms%2C+Engineering%2C+and+Management-p-9780471984467

Davis, J., Lautz, L., Kelleher, C., Vidon, P., Russoniello, C., & Pearce, C. (2021). Evaluating the geomorphic channel response to beaver dam analog installation using unoccupied aerial vehicles. *Earth Surface Processes and Landforms*, *46*(12), 2349–2364. https://doi.org/10.1002/esp.5180

Dittbrenner, B. J., Schilling, J. W., Torgersen, C. E., & Lawler, J. J. (2022). Relocated beaver can increase water storage and decrease stream temperature in headwater streams. *Ecosphere*, *13*(7), e4168. https://doi.org/10.1002/ecs2.4168

Dunne, T., & Leopold, L. B. (1978). *Water in Environmental Planning*. Macmillan. https://www.google.com/books/edition/Water_in_Environmental_Planning/d7WEkcTNk6EC?q=dunne+and+leopold+1978&kptab=overview#f=false

Edwards P. & Northwest Climate Hub. (2021, March 12). *Going with the Flow*. ArcGIS StoryMaps. https://storymaps.arcgis.com/stories/a3aba834f59e4a628166ae00500e95a1

Faust, N. (Director). (2020, February 11). *The Making of Inspiration Ridge Preserve*. https://www.youtube.com/watch?v=Mok6P0jK8L0

Franklin, P., Gee, E., Baker, C., & Bowie, S. (2018). *New Zealand Fish Passage Guidelines: For structures up to 4 metres* (Vol. P52).

Freeman, A. (2021, March 31). *Point of View: Land acknowledgment works toward racial justice*. Homer News. https://www.homernews.com/opinion/point-of-view-land-acknowledgment-works-toward-racial-justice/

Glenk, K., & Martin-Ortega, J. (2018). The economics of peatland restoration. *Journal of Environmental Economics and Policy*, *7*(4), 345–362. https://doi.org/10.1080/21606544.2018.1434562

Goldfarb, B. (2018). Beavers, rebooted. *Science*, *360*(6393), 1058–1061. https://doi.org/10.1126/science.360.6393.1058

Gracz, M., Noyes, K., North, P., & Tande, G. (2008). Wetland mapping and classification of the Kenai Lowland, Alaska. *Kenai Watershed Forum, Fritz Creek, Alaska.(Availablefrom: Http://Www. Kenaiwetlands. Net)*.

Grover, H. (2022, September 12). *Beaver dam analogs bring ecosystem benefits in areas where habitat won't support beavers*. NM Political Report. https://nmpoliticalreport.com/2022/09/12/beaver-dam-analogs-bring-ecosystem-benefits-in-areas-where-habitat-wont-support-beavers/

Gurnell, A. M. (1998). The hydrogeomorphological effects of beaver dam-building activity. *Progress in Physical Geography: Earth and Environment*, *22*(2), 167–189. https://doi.org/10.1177/030913339802200202

Hagan, J. A. (2017). *Assessing the Accuracy of Landsat-Derived Stream Temperature for Use in Juvenile Salmonid Habitat Assessments on the Anchor River, Alaska* [M.S.E.S.]. https://www.proquest.com/docview/1896531137/abstract/8E18B8908834457APQ/1

Harrelson, C. C., Rawlins, C. L., & Potyondy, J. P. (1994). *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. https://www.google.com/books/edition/Stream_Channel_Reference_Sites/u6CGyePFTkMC?q=harrelson+et+al+1994&kptab=overview#f=false

Henker, K. (2009). *What Do Beaver Eat? A literature review prepared for the Grand Canyon Trust*. Green Mountain College. https://www.grandcanyontrust.org/sites/default/files/ut_beaverDietReview.pdf

Holland, M. (2016, August 31). Beavers Consuming Herbaceous Plants. *Naturally Curious with Mary Holland*. https://naturallycuriouswithmaryholland.wordpress.com/2016/08/31/beavers-consuming-herbaceous-plants/

Hood, G. A., & Bayley, S. E. (2008). The effects of high ungulate densities on foraging choices by beaver (Castor canadensis) in the mixed-wood boreal forest. *Canadian Journal of Zoology*, *86*(6), 484–496. https://doi.org/10.1139/Z08-029

Hood, G. A., & Bayley, S. E. (2009). A comparison of riparian plant community response to herbivory by beavers (Castor canadensis) and ungulates in Canada's boreal mixed-wood forest. *Forest Ecology* *and Management*, *258*(9), 1979–1989. https://doi.org/10.1016/j.foreco.2009.07.052

Inspiration Ridge Preserve. (n.d.). *Center for Alaskan Coastal Studies*. https://www.akcoastalstudies.org/guided-tours/inspiration-ridge-preserve.html

IUCN. (2021). *Peatlands and climate change* (Issues Brief). International Union for Conservation of Nature. https://www.iucn.org/resources/issues-brief/peatlands-and-climate-change

Ives, S. L., Sullivan, P. F., Dial, R., Berg, E. E., & Welker, J. M. (2013). CO2 exchange along a hydrologic gradient in the Kenai Lowlands, AK: feedback implications of wetland drying and vegetation succession. *Ecohydrology*, *6*(1), 38–50. https://doi.org/10.1002/eco.274

Jordan, C. E., & Fairfax, E. (2022). Beaver: The North American freshwater climate action plan. *WIREs Water*, *9*(4), e1592. https://doi.org/10.1002/wat2.1592

Kahn, B. (2015). *Drying Soils in Alaska Could Add to Wildlfire Concerns*. Scientific American. https://www.scientificamerican.com/article/drying-soils-in-alaska-could-add-to-wildlfire-concerns/

Kay, C. E. (1994). The impact of native ungulates and beaver on riparian communities in the intermountain west. *Natural Resources and Environmental Issues*, *1*, 6.

Klein, E., Berg, E. E., & Dial, R. (2005). Wetland drying and succession across the Kenai Peninsula Lowlands, south-central Alaska. *Canadian Journal of Forest Research*, *35*(8), 1931–1941. https://doi.org/10.1139/x05-129

Lundquist, K., & Dolman, B. (2019). *Beaver Restoration Feasibility Assessment for the North Fork Kern River Drainage* (p. 26). Occidental Arts & Ecology Center.

Macfarlane, W. W., Wheaton, J. M., Bouwes, N., Jensen, M. L., Gilbert, J. T., Hough-Snee, N., & Shivik, J. A. (2017). Modeling the capacity of riverscapes to support beaver dams. *Geomorphology*, *277*, 72–99. https://doi.org/10.1016/j.geomorph.2015.11.019

Maringer, A., & Slotta-Bachmayr, L. (2006). A GIS-based habitat-suitability model as a tool for the management of beaversCastor fiber. *Acta Theriologica*, *51*(4), 373–382. https://doi.org/10.1007/BF03195184

McComb, W. C., Sedell, J. R., & Buchholz, T. D. (1990). Dam-Site Selection by Beavers in an Eastern Oregon Basin. *The Great Basin Naturalist*, *50*(3), 273–281.

McKinstry, M., & Anderson, S. H. (2002). Survival, fates, and success of transplanted beavers, Castor canadensis, in Wyoming. *Canadian Field-Naturalist*, *116*, 60–68.

Montgomery, D. R. (2007). *Dirt: The Erosion of Civilizations* (1st ed.). University of California Press; JSTOR. http://www.jstor.org/stable/10.1525/j.ctt1pnm6p

Morgan, L. H. (1868). *The American beaver and his works*. Philadelphia, J.B. Lippincott & Co. http://archive.org/details/americanbeaverhi68morg

Neyman, J. (2014, April 20). *Kenai Peninsula wolves prove resilient in face of harsh history*. Anchorage Daily News. https://www.adn.com/wildlife/article/kenai-peninsula-wolves-prove-resilient-face-harsh-history/2014/04/21/

Nolet, B. A., Hoekstra, A., & Ottenheim, M. M. (1994). Selective foraging on woody species by the beaver Castor fiber, and its impact on a riparian willow forest. *Biological Conservation*, *70*(2), 117–128. https://doi.org/10.1016/0006-3207(94)90279-8

Oldemeyer, J. L., Franzmann, A. W., Brundage, A. L., Arneson, P. D., & Flynn, A. (1977). Browse Quality and the Kenai Moose Population. *The Journal of Wildlife Management*, *41*(3), 533–542. https://doi.org/10.2307/3800528

Pachinger, K., & Hulik, T. (1999). Beavers in an Urban Landscape. In P. E. Busher & R. M. Dzięciołowski (Eds.), *Beaver Protection, Management, and Utilization in Europe and North America* (pp. 53–60). Springer US. https://doi.org/10.1007/978-1-4615-4781-5_9

Petro, V. M., Taylor, J. D., & Sanchez, D. M. (2015). Evaluating landowner-based beaver relocation as a tool to restore salmon habitat. *Global Ecology and Conservation*, *3*, 477–486. https://doi.org/10.1016/j.gecco.2015.01.001

Pilliod, D. S., Rohde, A. T., Charnley, S., Davee, R. R., Dunham, J. B., Gosnell, H., Grant, G. E., Hausner, M. B., Huntington, J. L., & Nash, C. (2018). Survey of Beaver-related Restoration

Practices in Rangeland Streams of the Western USA. *Environmental Management*, *61*(1), 58–68. https://doi.org/10.1007/s00267-017-0957-6

Pollock, M. M., Beechie, T. J., Wheaton, J. M., Jordan, C. E., Bouwes, N., Weber, N., & Volk, C. (2014). Using Beaver Dams to Restore Incised Stream Ecosystems. *BioScience*, *64*(4), 279–290. https://doi.org/10.1093/biosci/biu036

Pollock, M. M., Lewallen, G. M., Woodruff, K., & Jordan, C. E. (2017). *The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.0.* (J. M. Castro, Ed.; 2.0). https://www.fws.gov/oregonfwo/promo.cfm?id=177175812

Problems and Solutions. (2021, February 3). Beaver Institute. https://www.beaverinstitute.org/problems-solutions/overview/

Puttock, A. K., Cunliffe, A. M., Anderson, K., & Brazier, R. E. (2015). Aerial photography collected with a multirotor drone reveals impact of Eurasian beaver reintroduction on ecosystem structure. *Journal of Unmanned Vehicle Systems*, *3*(3), 123–130. https://doi.org/10.1139/juvs-2015-0005

Rosgen, D. L. (1996). *Applied river morphology*. Pagosa Springs, Colo. : Wildland Hydrology. http://archive.org/details/appliedrivermorp0000rosg

Runyon, L. (2018, June 24). The Bountiful Benefits Of Bringing Back The Beavers. *NPR*. https://www.npr.org/2018/06/24/620402681/the-bountiful-benefits-of-bringing-back-the-beavers

Ruxton, G. F. A., & Kephart, H. (1922). *Wild life in the Rocky Mountains: A true tale of rough adventure in the days of the Mexican War*. New York : Macmillan. http://archive.org/details/wildlifeinrockym00ruxtuoft

Scamardo, J. E., Marshall, S., & Wohl, E. (2022). Estimating widespread beaver dam loss: Habitat decline and surface storage loss at a regional scale. *Ecosphere*, *13*(3), e3962. https://doi.org/10.1002/ecs2.3962

Shepherd, P. (2008). *Beaver—Wildlife Notebook Series* (Alaska Department of Fish and Game). https://www.adfg.alaska.gov/index.cfm?adfg=beaver.resources

Simmons, H. (2015, December 2). *Beaver reintroduction a watershed success*.

https://ecology.wa.gov/Blog/Posts/December-2015/Beaver-reintroduction-a-watershed-success

Simmons, H., & Vanderwal, J. (2018, January 8). *Triple Creek Project: Human-built "beaver dams" restore streams*. https://ecology.wa.gov/Blog/Posts/January-2018/Triple-Creek-Project-Human-built-beaver-dams-resto

Simon, A., Castro, J., & Rinaldi, M. (2016). Channel form and adjustment: Characterization, measurement, interpretation and analysis. In *Tools in Fluvial Geomorphology* (pp. 235–259). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118648551.ch11

Slough, B. G., & Sadleir, R. M. F. S. (1977). A land capability classification system for beaver (Castor canadensis Kuhl). *Canadian Journal of Zoology*, *55*(8), 1324–1335. https://doi.org/10.1139/z77-172

Stocker, G. (1985). [The beaver (Castor fiber L.) in Switzerland. Biological and ecological problems of re-establishment]. *Berichte. Rapports. Rapporti, Reports (Switzerland)*. https://scholar.google.com/scholar_lookup?title=%5BThe+beaver+%28Castor+fiber+L.%29+in+Switzerland.+Biological+and+ecological+problems+of+re-establishment%5D&author=Stocker%2C+G.&publication_year=1985

Takami, T., Kitano, F., & Nakano, S. (1997). High Water Temperature Influences on Foraging Responses and Thermal Deaths of Dolly Varden (Salvelinus malma) and White-spotted Charr (S. leucomaenis) in a Laboratory. *Fisheries Science*, *63*(1), 6–8. https://doi.org/10.2331/fishsci.63.6

Taylor, J. D., Yarrow, G. K., & Miller, J. E. (2017). *Wildlife Damage Management Technical Series: Beavers*. U.S. Department of Agriculture, Animal & Plant Health Inspection Service. https://www.aphis.usda.gov/wildlife_damage/reports/Wildlife%20Damage%20Management%20Technical%20Series/Beaver-WDM-Technical-Series.pdf

Turner, S., Clayton, A., He, Y. "Flora," Flickinger, J., & Carlson, C. (2017). *Ecological Baseline and Management Plan for the Center for Alaskan Coastal Studies* [Master's Project Report, University of Michigan, Ann Arbor]. http://deepblue.lib.umich.edu/handle/2027.42/136566

Vitt, D. H. (2006). Functional Characteristics and Indicators of Boreal Peatlands. In R. K. Wieder & D. H. Vitt (Eds.), *Boreal Peatland Ecosystems* (pp. 9–24). Springer. https://doi.org/10.1007/978-3-540-31913-9_2

Wheaton, J. (2021, April 18). *LTPBR Manual—Chapter 4—Appendix E - Typical Schematics of BDAs* [Figure]. Figshare; figshare. https://doi.org/10.6084/m9.figshare.14445567.v1

Wheaton, J., Wheaton, A., Shore, D., Bouwes, N., Bailey, P., Clawson, M., & Reimer, M. (2022). *Riverscapes/PBR: 1.0.0. In Low Tech Process Based Restoration of Riverscapes Design Manual* (1.0.0). BookBaby. https://doi.org/10.5281/zenodo.7233916

Willis, K. (2013, March 6). *Leave It To The Beavers: Tips for a Peaceful Coexistence with Beavers*. Haw River Assembly. https://hawriver.org/peaceful-coexistence-with-beavers/

Yamada, T., Koizumi, I., Urabe, H., & Nakamura, F. (2020). Temperature-Dependent Swimming Performance Differs by Species: Implications for Condition-Specific Competition between Stream Salmonids. *Zoological Science*, *37*(5), 429–433. https://doi.org/10.2108/zs190149

Appendix A. Methow project Release Site Suitability Assessment, 2015 update w/2017 Water Inst. revisions

Methow Beaver Project Release Site Score Card (2015 update w/2017 WATER Inst. revisions) Date________________

Site ID____________________________ Observer______________

GPS Coordinates_UTM (NAD 83)________________________ Subwatershed__________________________

Lat x Long___________________________ Location Description ____________________________________

_______ **Gradient of the assessed stream habitat unit** **10.** ≤3% **0.** 4-6% **-10.** 7-9% **-30.** ≥9%

_______ Stream Flow

Max (spring) \ Min (fall)	**garden hose**	**fire hose**	**10″culvert**	**30″ culvert**
Fire hose	**1**			
10″ culvert	**3**	**4**		
30″culvert	**4**	**5**	**10**	
un-wadeable	**1**	**3**	**2**	**1**

NOTE – Stream flow above or below these parameters limits beaver dam viability

_______ **Habitat Unit Size** (linear stream measure) **5.** Extensive stretch of the stream (≥1610 meters) 4. (1,250-1609m) 3. (900-1,249m) 2. (550-899m) **1.** Small isolated pocket (200-549mm) 0. (0-199m)

Woody Food (select the highest number possible in each line – then multiply lines**)**

a. **3.** Aspen, willow **2.** Alder **1.** Other hardwoods
b. **3.** Within 10 meters **2.** Within 30 meters **1.** Within 100 meters
c. **2.** Large amount (hundreds of stems) **1.** Some (dozens of stems)

_______ **Woody food score = multiply a x b x c**

_______ **Herbaceous Food** **10**. Grasses and forbs (aquatic and terr.) abundant **5.** No Grass/Forbs Present

_______ **Floodplain Width** **5.** Wide stream bottom (at least 2X as wide as stream) **0.** Narrow 'V' Channel

_______ **Dominant Stream Substrate**

5. Silt/Clay/Mud **2.** Sand **1.** Gravel **0.** Cobble **-1.** Boulders **-3.** Bedrock

_______ **Historical Beaver use**

15. Old structures present **0.** No indication of previous occupancy

_______ **Lodge and dam building materials**

5. abundant 1-6″ diameter woody vegetation available **-20.** no building material present

_______ **Browsing / Grazing impacts**

5. No Impact or obvious presence of browsers / grazers **-10.** Heavy browsing / grazing

_______ **Ease of access** **2.** Easy travel to deliver beavers and monitor. **-5** Long hike

_______ **Existing aquatic escape cover** **10**. Multiple deep pools (>1 meter deep) present. **-10.** No pools

_______ **Total Score** (100 points maximum)

Release site viability requires securing adjacent landowner support and careful mitigation of human infrastructure conflicts in the vicinity.
Narrative description of site and notes/ Photo ID #s / sketch on back

Excerpted with permission from: Pollock, M.M., G. Lewallen, K. Woodruff, C.E. Jordan and J.M. Castro (Editors) 2018. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.01. United States Fish and Wildlife Service, Portland, Oregon. 228 pp. Online at: http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp

Excerpted from (Lundquist & Dolman, 2019)

Appendix B. Methow project Release Site Suitability Assessment, 2020

Used with permission

BEAVER RELOCATION PILOT | Report 2020

Release Site Suitability Assessment

Permit ID (Individual or Group):		Permittee Name:	
Site ID:		Assessment Date:	
County:		Watershed:	
Latitude (decimal degrees)		Longitude (decimal degrees)	
Location Description:			

1. Survey 2000 feet upstream and 2000 feet downstream for current beaver activity.

	Enter count					*Mark if present*			
	Observed individuals	Active dam	Active den	Active lodge	Forage cache	Tracks	Fresh chewings / cuttings	Scent mounds / droppings	Other (specify)
2000 ft upstream									
2000 ft downstream									

If site is active or less than one stream mile from a known active colony, this site is unsuitable for beaver relocation.

Suitable ☐ Unsuitable ☐

2. Briefly describe the level of social tolerance for beaver by potentially affected neighboring landowners.

If a negative wildlife interaction with neighboring landowners is likely, this site is unsuitable for beaver relocation.

Suitable ☐ Unsuitable ☐

3. Is there potential for damage to roads, culverts, or structures (i.e., flooding or blocking)?

If damage is likely, this site is unsuitable for beaver relocation.

Suitable ☐ Unsuitable ☐

If the site is suitable based on all three responses above then continue site assessment by circling answers below (choosing only one from each row) then filling in the points on the line to the left.

4. Average stream gradient

_______ **5**. ≤3% **3**. 4-6% **0.** ≥7%

5. Average stream flow

_______ **5**. Fire hose (fast flow) **3**. Garden hose (slow flow) **0.** Unwadeable (too fast)

6. Average stream depth

_______ **5**. Over knee-high boots **1**. Over sneaker **0**. Over waist

7. Are there multiple pools or a large body of water (pond/lake) greater than 3 feet in depth present?

_______ **5.** Yes. **0.** No

8. Dominant stream substrate

_______ **5.** Silt/Clay/Mud **2.**Sand **1.** Gravel **0**. Cobble/ boulders

9. Habitat unit size

_______ **5.** large pond or lake **5.** ≥2000 ft of stream length in each direction **0.** 0

10. Hardwood food (aspen, willow, alder, etc.)

a. **5**. Within 30 feet **3**. Within 100 feet **1**. Within 300 feet

b. **5**. Large amount (thousands of stems) **3.** Some (hundreds of stems) **1.** Few (dozens of stems)

_______ **Woody food score = multiply a x b**

11. Herbaceous food (aquatic vegetation, grass, forbs, and/or shrubs)

_______ **5**. Abundant herbaceous food **0.** Minimal herbaceous food

12. Floodplain Width

_______ **5.** Adjacent floodplain **0.** Narrow V channel

13. Lodge and dam-building materials

_______ **5**. Variety of 1-6" diameter woody vegetation available **0.** Insufficient building material present

14. Bonus: (5 points each)

a. Historic beaver use.
b. Large woody debris or channel-spanning logs present.
c. No impact or obvious presence of browsers/grazers.

____

_______ **Total Score** **'Good' Release Site: 45-90pts** **'Poor' Release Site: 0-44pts**

Other notes (best place to access, added advantages/disadvantages, land ownership/access/permission):

Final determination: ACCEPTABLE ☐ UNACCEPTABLE ☐

Appendix C. Methow Beaver Project Scorecard Survey Summary, by sample location

Reach ID	Sample Pt.	Gradient(%)	Stream flow	Flow depth(in)	Habitat Unit Size	Herb. food	Flpln. Width	Dominant substrate	Old structure	Bldg. material	Browsing Stress	Acess	Woody food	Woody Veg Notes	Aquatic Escape
Main Upper	3	<= 3%	FH	4.3	>1610m	Abd	Wide	Gravel	No	Abd	No	Easy	Abd	Aspn/Wlw	No
	5	<= 3%	FH	2.0	>1610m	Abd	Wide	S/C/M	No	Abd	No	Easy	Abd	Aspn/Wlw	No
	6	<= 3%	FH	3.0	>1610m	Abd	Wide	S/C/M	No	Abd	No	Dfc	Abd	Aspn/Wlw	Yes
	7	<= 3%	GH	5.7	>1610m	Abd	Wide	S/C/M	No	Abd	No	Dfc	Abd	Aspn/Wlw	Yes
	8	<= 3%	GH	2.5	>1610m	Abd	Wide	Sand	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	13	4-6%	GH	2.0	>1610m	Abd	Narrow V	S/C/M	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	14	>=9%	GH	3.0	>1610m	Abd	Narrow V	S/C/M	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	15	7-9%	FH	3.0	>1610m	Abd	Wide	S/C/M	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	16	<= 3%	FH	16.0	>1610m	Abd	Wide	S/C/M	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	17	<= 3%	FH	2.0	>1610m	Abd	Wide	Sand	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	18	<= 3%	FH	7.0	>1610m	Abd	Wide	S/C/M	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	19	<= 3%	GH	2.0	>1610m	Abd	Narrow V	S/C/M	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
Main Middle	9	<= 3%	FH	1.7	>1610m	Abd	Wide	Sand	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	11	4-6%	FH	4.5	>1610m	Abd	Wide	Sand	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	12	<= 3%	FH	3.0	>1610m	Abd	Wide	Sand	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	22	<= 3%	FH	2.5	>1610m	Abd	Wide	Gravel	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
Main Lower	24	>=9%	GH	0.9	>1610m	Abd	Narrow V	Gravel	Yes	Abd	No	Easy	Abd	Aspn/Wlw	No
	25	7-9%	FH	3.0	>1610m	Abd	Wide	Sand	No	Abd	No	Easy	Abd	Aspn/Wlw	No

Appendix D. Instruction of the temperature data logger APP 'HOBOconnect'

Quick Start for the HOBO® Pendant® MX Temp (MX2201) and Temp/Light (MX2202) Logger

HOBO
Data Loggers

1 Download on the App Store | GET IT ON Google Play — Download HOBOconnect™ to your phone or tablet.

2 Open the app. Enable Bluetooth® in your device settings if prompted.

3 Firmly press the circular button near the center of the logger to wake it up. Both LEDs on the logger will blink once when it wakes up. Tap Devices in the app. Tap the logger in the app to connect to it. If the logger does not appear, make sure it is within range of your mobile device.

4 Tap [icon] to set up the logger. Choose your logger settings and then tap [icon] to save the settings to the logger. The logger will begin logging data based on the settings you selected in the app. Press the circular button in the center of the logger for 3 seconds if you set it up to start logging with a button push (logger LEDs will blink 4 times).

5 Deploy the logger to the location where you will be monitoring the conditions. Mount the logger to a flat surface or in a way that prevents the logger housing from bowing, or use the optional mounting boot. Follow the deployment and mounting guidelines in the full product manual (see link below).

6 To offload data from the logger to your device, tap Devices and press the circular button near the center of the logger to wake it up (if necessary). Connect to the logger and tap [icon]. To view, export, and share the data, tap HOBO Files, tap [icon], and then tap [icon].

For detailed information about the logger, scan the code at left or go to www.onsetcomp.com/support/manuals/21536-mx2201-mx2202-manual.

WARNING: Do not cut open, incinerate, heat above 85°C (185°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

ONSET 1-800-LOGGERS (564-4377) • 508-759-9500
www.onsetcomp.com/support/contact

This product has been manufactured by Onset Computer Corporation and in compliance with Onset's ISO 9001:2015 Quality Management System.

Patent #: 8,860,569

21538-I MAN-MX2201-MX2202-QSG

[HOBO® Pendant® MX Temp (MX2201) and Temp/Light (MX2202) Logger Manual (onsetcomp.com)]

Appendix E. BRAT-cIS–Beaver Dam Capacity Assessment Form

The Beaver Dam Capacity Assessment Form is developed by Utah State University and is a resource of the

BRAT-cIS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC

OBSERVATION INFO

Observer Name: ________________________

Reach ID: ________________________

Observation Date: ________________________

Stream Name: ________________________

LOCATION OF ASSESSMENT REACH

GPS UTM Easting: _______________ GPS UTM Northing: _______________

LENGTH OF REACH

Length __________ meters OR ______ x bankfull widths

VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

SUITABILITY OF STREAMSIDE VEGETATION

○ Unsuitable
○ Barely Suitable
○ Moderately Suitable
○ Suitable
○ Preferred

Vegetation within 30 m of water's edge

What vegetation types are abundant?
□ Desirable woody (e.g. Aspen, Willow, Cottonwood)
□ Other woody (e.g. conifers, sagebrush)
□ Grasses □ Crops □ Ornamentals □ Developed

SUITABILITY OF RIPARIAN/UPLAND VEGETATION

○ Unsuitable
○ Barely Suitable
○ Moderately Suitable
○ Suitable
○ Preferred

Vegetation within 100 m of water's edge

What vegetation types are abundant?
□ Desirable woody (e.g. Aspen, Willow, Cottonwood)
□ Other woody (e.g. conifers, sagebrush)
□ □ Grasses □ Crops □ Ornamentals □ Developed

DAM DENSITY CAPACITY ASSESSMENT BASED ON SUITABILITY OF VEGETATION ONLY (USE TABLE 1)

○ None (no dams)
○ Rare (0-1 dams/km)
○ Occasional (1-4 dams/km)
○ Frequent (5-15 dams/km)
○ Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?

○ Probably can build dam
○ Can build dam
○ Can build dam (saw evidence of recent dams)

○ Could build dam at one time (saw evidence of relic dams)
○ Cannot build dam (stream power really high)

IF BEAVERS BUILD A DAM, CONSIDER WHAT HAPPENS TO THE DAM(S) IN A TYPICAL FLOOD (E.G. MEAN ANNUA L FLOO D)?

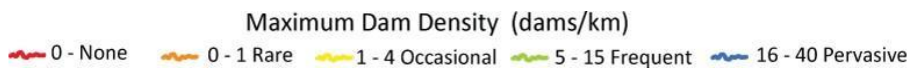
○ Blowout
○ Occasional Blowout
○ Occasional Breach
○ Dam Persists

HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?

○ Too steep they cannot build a dam (e.g. > 20% slope)
○ Probably can build dam
○ Can build dam (inferred)
○ Can build dam (evidence or current or past dams)
○ Really flat (can build dam, but might not need as many as one dam might back up water > 0.5 km)

COMBINED DAM DENSITY CAPACITY ASSESSMENT BASED ON ALL (USE TABLE 2)

○ None (no dams)
○ Rare (0-1 dams/km)
○ Occasional (1-4 dams/km)
○ Frequent (5-15 dams/km)
○ Pervasive (15-40 dams/km)



INFERENCE SYSTEM OF CAPACITY BASED ON VEGETATION ONLY:

Table 1. Rule table for two input inference system that models the capacity of the reach to support dam building activity (in dam density) using the suitability of streamside vegetation and suitability of riparian/upland vegetation as inputs.

		Inputs				Output
Rules		**Suitability of streamside vegetation**	*&*	**Suitability of riparian/upland vegetation**		**Dam density capacity**
1	*If*	Unsuitable	*&*	Unsuitable	*, then*	None
2	*If*	Unsuitable	*&*	Barely suitable	*, then*	Rare
3	*If*	Unsuitable	*&*	Moderately suitable	*, then*	Rare
4	*If*	Unsuitable	*&*	Suitable	*, then*	Occasional
5	*If*	Unsuitable	*&*	Preferred	*, then*	Occasional
6	*If*	Barely suitable	*&*	Unsuitable	*, then*	Rare
7	*If*	Barely suitable	*&*	Barely suitable	*, then*	Rare
8	*If*	Barely suitable	*&*	Moderately suitable	*, then*	Occasional
9	*If*	Barely suitable	*&*	Suitable	*, then*	Occasional
10	*If*	Barely suitable	*&*	Preferred	*, then*	Occasional
11	*If*	Moderately suitable	*&*	Unsuitable	*, then*	Rare
12	*If*	Moderately suitable	*&*	Barely suitable	*, then*	Occasional
13	*If*	Moderately suitable	*&*	Moderately suitable	*, then*	Occasional
14	*If*	Moderately suitable	*&*	Suitable	*, then*	Frequent
15	*If*	Moderately suitable	*&*	Preferred	*, then*	Frequent
16	*If*	Suitable	*&*	Unsuitable	*, then*	Occasional
17	*If*	Suitable	*&*	Barely suitable	*, then*	Occasional
18	*If*	Suitable	*&*	Moderately suitable	*, then*	Frequent
19	*If*	Suitable	*&*	Suitable	*, then*	Frequent
20	*If*	Suitable	*&*	Preferred	*, then*	Pervasive
21	*If*	Preferred	*&*	Unsuitable	*, then*	Occasional
22	*If*	Preferred	*&*	Barely suitable	*, then*	Frequent
23	*If*	Preferred	*&*	Moderately suitable	*, then*	Pervasive
24	*If*	Preferred	*&*	Suitable	*, then*	Pervasive
25	*If*	Preferred	*&*	Preferred	*, then*	Pervasive

COMBINED INFERENCE SYSTEM:

Table 2. Rule table for four input inference system that models the capaicty of the reach to support dam building activity (in dam density) uisng the vegetation dam density capacity (output of Table 1 model), the two-year flood stream power, baseflow stream power and reach slope.

		Inputs								Output
Rules		**Vegetation dam density capacity**	&	**2-year flood stream power**	&	**Baseflow stream power**	&	**Reach slope**		**Dam density capacity**
1	*If*	None	&	-	&	-	&	-	*, then*	None
2	*If*	-	&	-	&	Cannot build dam	&	-	*, then*	None
3	*If*	-	&	-	&	-	&	Cannot build dam	*, then*	None
4	*If*	Rare	&	Dam persists	&	Can build dam	&	NOT Cannot build dam	*, then*	Rare
5	*If*	Rare	&	Dam persists	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Rare
6	*If*	Rare	&	Occasional breach	&	Can build dam	&	NOT Cannot build dam	*, then*	Rare
7	*If*	Rare	&	Occasional breach	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Rare
8	*If*	Rare	&	Occasional blowout	&	Can build dam	&	NOT Cannot build dam	*, then*	Rare
9	*If*	Rare	&	Occasional blowout	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Rare
10	*If*	Rare	&	Blowout	&	Can build dam	&	NOT Cannot build dam	*, then*	None
11	*If*	Rare	&	Blowout	&	Probably can build dam	&	NOT Cannot build dam	*, then*	None
12	*If*	Occasional	&	Dam persists	&	Can build dam	&	NOT Cannot build dam	*, then*	Occasional
13	*If*	Occasional	&	Dam persists	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Occasional
14	*If*	Occasional	&	Occasional breach	&	Can build dam	&	NOT Cannot build dam	*, then*	Occasional
15	*If*	Occasional	&	Occasional breach	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Occasional
16	*If*	Occasional	&	Occasional blowout	&	Can build dam	&	NOT Cannot build dam	*, then*	Occasional
17	*If*	Occasional	&	Occasional blowout	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Occasional
18	*If*	Occasional	&	Blowout	&	Can build dam	&	NOT Cannot build dam	*, then*	Rare
19	*If*	Occasional	&	Blowout	&	Probably can build dam	&	NOT Cannot build dam	*, then*	Rare
20	*If*	Frequent	&	Dam persists	&	Can build dam	&	Really flat	*, then*	Occasional
21	*If*	Frequent	&	Dam persists	&	Can build dam	&	Can build dam	*, then*	Frequent
22	*If*	Frequent	&	Dam persists	&	Can build dam	&	Probably can build dam	*, then*	Occasional
23	*If*	Frequent	&	Dam persists	&	Probably can build dam	&	Really flat	*, then*	Occasional
24	*If*	Frequent	&	Dam persists	&	Probably can build dam	&	Can build dam	*, then*	Frequent
25	*If*	Frequent	&	Dam persists	&	Probably can build dam	&	Probably can build dam	*, then*	Occasional
26	*If*	Frequent	&	Occasional breach	&	Can build dam	&	Really flat	*, then*	Occasional
27	*If*	Frequent	&	Occasional breach	&	Can build dam	&	Can build dam	*, then*	Frequent
28	*If*	Frequent	&	Occasional breach	&	Can build dam	&	Probably can build dam	*, then*	Occasional
29	*If*	Frequent	&	Occasional breach	&	Probably can build dam	&	Really flat	*, then*	Occasional
30	*If*	Frequent	&	Occasional breach	&	Probably can build dam	&	Can build dam	*, then*	Frequent
31	*If*	Frequent	&	Occasional breach	&	Probably can build dam	&	Probably can build dam	*, then*	Occasional
32	*If*	Frequent	&	Occasional blowout	&	Can build dam	&	Really flat	*, then*	Occasional
33	*If*	Frequent	&	Occasional blowout	&	Can build dam	&	Can build dam	*, then*	Frequent
34	*If*	Frequent	&	Occasional blowout	&	Can build dam	&	Probably can build dam	*, then*	Occasional
35	*If*	Frequent	&	Occasional blowout	&	Probably can build dam	&	Really flat	*, then*	Rare
36	*If*	Frequent	&	Occasional blowout	&	Probably can build dam	&	Can build dam	*, then*	Occasional
37	*If*	Frequent	&	Occasional blowout	&	Probably can build dam	&	Probably can build dam	*, then*	Rare
38	*If*	Frequent	&	Blowout	&	Can build dam	&	Really flat	*, then*	Rare
39	*If*	Frequent	&	Blowout	&	Can build dam	&	Can build dam	*, then*	Rare
40	*If*	Frequent	&	Blowout	&	Can build dam	&	Probably can build dam	*, then*	Rare
41	*If*	Frequent	&	Blowout	&	Probably can build dam	&	Really flat	*, then*	Rare
42	*If*	Frequent	&	Blowout	&	Probably can build dam	&	Can build dam	*, then*	Rare
43	*If*	Frequent	&	Blowout	&	Probably can build dam	&	Probably can build dam	*, then*	Rare
44	*If*	Pervasive	&	Dam persists	&	Can build dam	&	Really flat	*, then*	Frequent
45	*If*	Pervasive	&	Dam persists	&	Can build dam	&	Can build dam	*, then*	Pervasive
46	*If*	Pervasive	&	Dam persists	&	Can build dam	&	Probably can build dam	*, then*	Frequent
47	*If*	Pervasive	&	Dam persists	&	Probably can build dam	&	Really flat	*, then*	Frequent
48	*If*	Pervasive	&	Dam persists	&	Probably can build dam	&	Can build dam	*, then*	Pervasive
49	*If*	Pervasive	&	Dam persists	&	Probably can build dam	&	Probably can build dam	*, then*	Frequent
50	*If*	Pervasive	&	Occasional breach	&	Can build dam	&	Really flat	*, then*	Frequent
51	*If*	Pervasive	&	Occasional breach	&	Can build dam	&	Can build dam	*, then*	Pervasive
52	*If*	Pervasive	&	Occasional breach	&	Can build dam	&	Probably can build dam	*, then*	Frequent
53	*If*	Pervasive	&	Occasional breach	&	Probably can build dam	&	Really flat	*, then*	Frequent
54	*If*	Pervasive	&	Occasional breach	&	Probably can build dam	&	Can build dam	*, then*	Pervasive
55	*If*	Pervasive	&	Occasional breach	&	Probably can build dam	&	Probably can build dam	*, then*	Frequent
56	*If*	Pervasive	&	Occasional blowout	&	Can build dam	&	Really flat	*, then*	Frequent
57	*If*	Pervasive	&	Occasional blowout	&	Can build dam	&	Can build dam	*, then*	Pervasive
58	*If*	Pervasive	&	Occasional blowout	&	Can build dam	&	Probably can build dam	*, then*	Frequent
59	*If*	Pervasive	&	Occasional blowout	&	Probably can build dam	&	Really flat	*, then*	Occasional
60	*If*	Pervasive	&	Occasional blowout	&	Probably can build dam	&	Can build dam	*, then*	Frequent
61	*If*	Pervasive	&	Occasional blowout	&	Probably can build dam	&	Probably can build dam	*, then*	Occasional
62	*If*	Pervasive	&	Blowout	&	Can build dam	&	Really flat	*, then*	Occasional
63	*If*	Pervasive	&	Blowout	&	Can build dam	&	Can build dam	*, then*	Occasional
64	*If*	Pervasive	&	Blowout	&	Can build dam	&	Probably can build dam	*, then*	Rare
65	*If*	Pervasive	&	Blowout	&	Probably can build dam	&	Really flat	*, then*	Occasional
66	*If*	Pervasive	&	Blowout	&	Probably can build dam	&	Can build dam	*, then*	Occasional
67	*If*	Pervasive	&	Blowout	&	Probably can build dam	&	Probably can build dam	*, then*	Rare

Appendix F. Beaver Restoration Assessment Tool (BRAT) Model Parameters:

The Beaver Restoration Assessment Tool (BRAT) model is developed by Utah State University and is commonly used by researchers and restoration managers to predict potential locations for beaver dams construction, and to what extent in the restoration area by estimating the upper limit of dam density(number of dams per km). It may be used to filter out unsuitable sites within the IRP region and to demonstrate selected sites are suitable beaver habitat. Four main parameters are used to construct the BRAT model; drainage network layer and associated hydrography, vegetation type raster data, digital Elevation Model (DEM) and drainage streamflow information. Below are general recommendations for running the BRAT model using IRP data. A more detailed tutorial can be found on the BRAT website.

A drainage network layer and associated hydrography

- Drainage network and associated hydrography data from USGS and the National Hydrography Dataset (NHD or NHDPlus) is suggested to be used in the model. Stream flowline, waterbody and area feature classes are required for the BRAT model.

Vegetation type raster data

- Existing vegetation raster: In the field, we used a DJI Mavic Pro Drone to capture photos of the IRP area and georectified the images with coordinates using ArcGIS Pro. Vegetation cover types may be identified based on the image we captured or using another aerial photograph, and a vegetation map can be created. Additionally, there are existing vegetation layers on the Kenai Peninsula Borough GeoHub.
- Historic vegetation raster: At this time, we are unable to locate a historical vegetation data layer for Homer. This data layer may need to be extracted and classified from historical aerial imagery if no historical vegetation raster can be located.

The vegetation factor would be rated from a scale of 0 - 4 based on the criteria shown in the following image (Fig. F1).

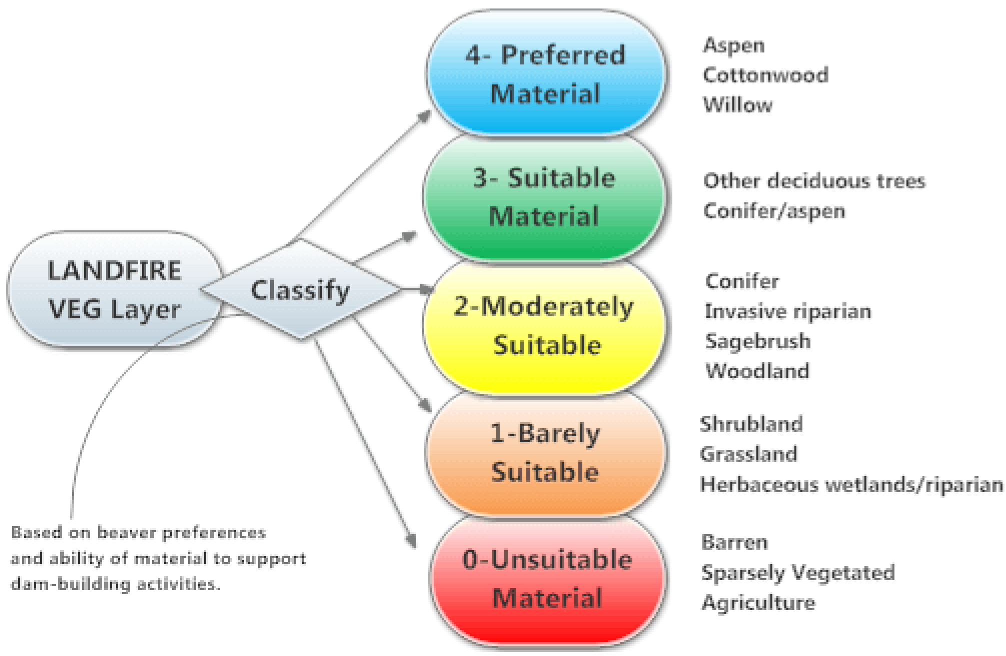


Figure F1. Criteria of scoring vegetation types in BRAT model (https://brat.riverscapes.net/Documentation/Tutorials/2-Preprocessing)

Digital Elevation Model (DEM):

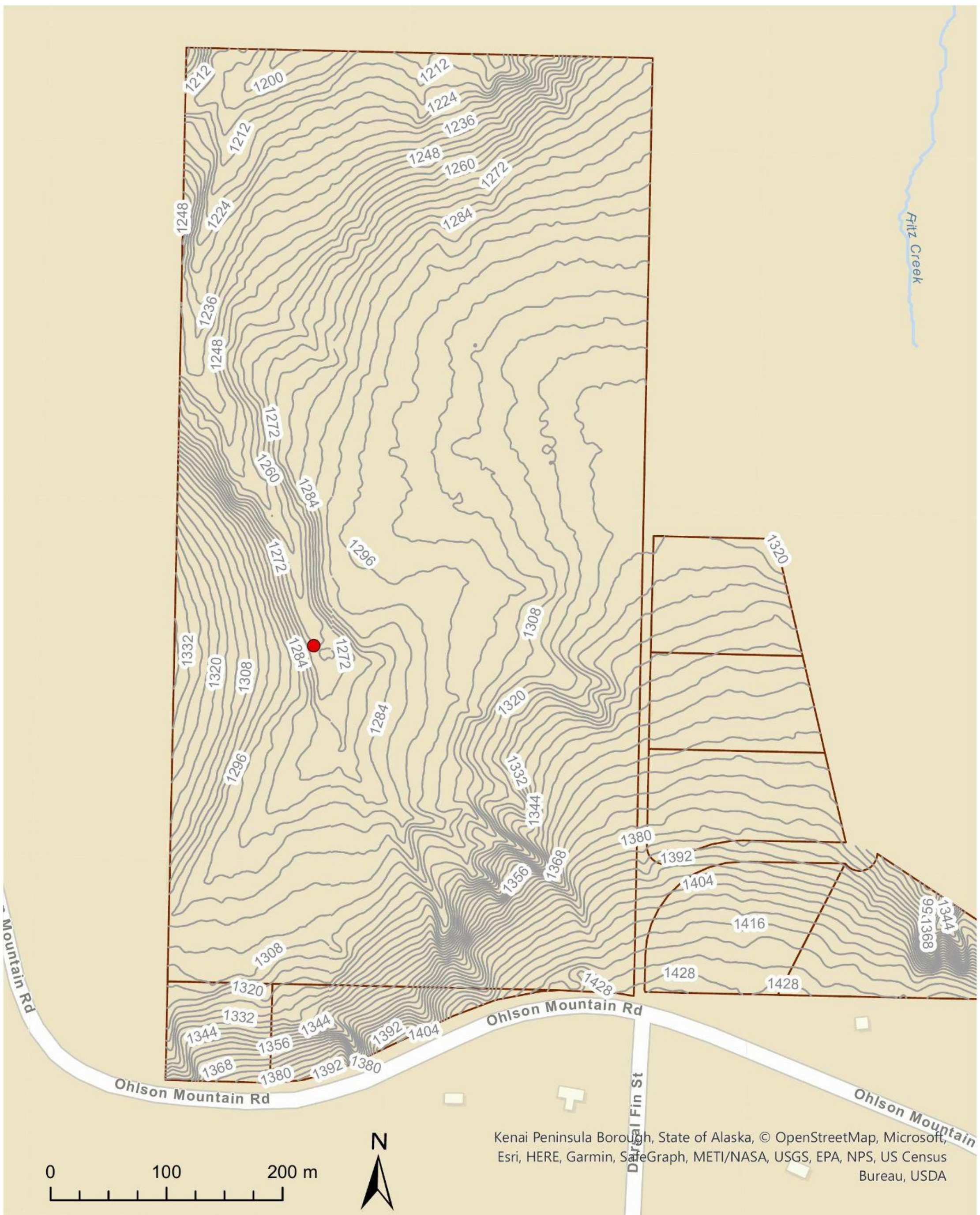
- Elevation data from the USGS National Elevation Dataset (NED) (Elevation Products 3DEP) for Homer, AK can be applied to the BRAT assessment. For Alaska, we recommend downloading a DEM layer with the highest possible resolution such as 5-meter or ⅓ arc-second (10-meter).

Streamflow (baseflow and peak flow) information throughout drainage network:

- Streamflow data from the NHD or USGS can be used in the BRAT model. If you need base and high flow estimations for your stream network, regional regression equations can be found at USGS StreamStats or USGS National Streamflow Statistics.
  - Baseflow regional regression equations (e.g. PQ80 for month with lowest flows)
  - Highflow regional regression equations (e.g. Q2 - 2 year recurrence interval peak flow)

Appendix G. Beaver Dam Analogue Proposed Site

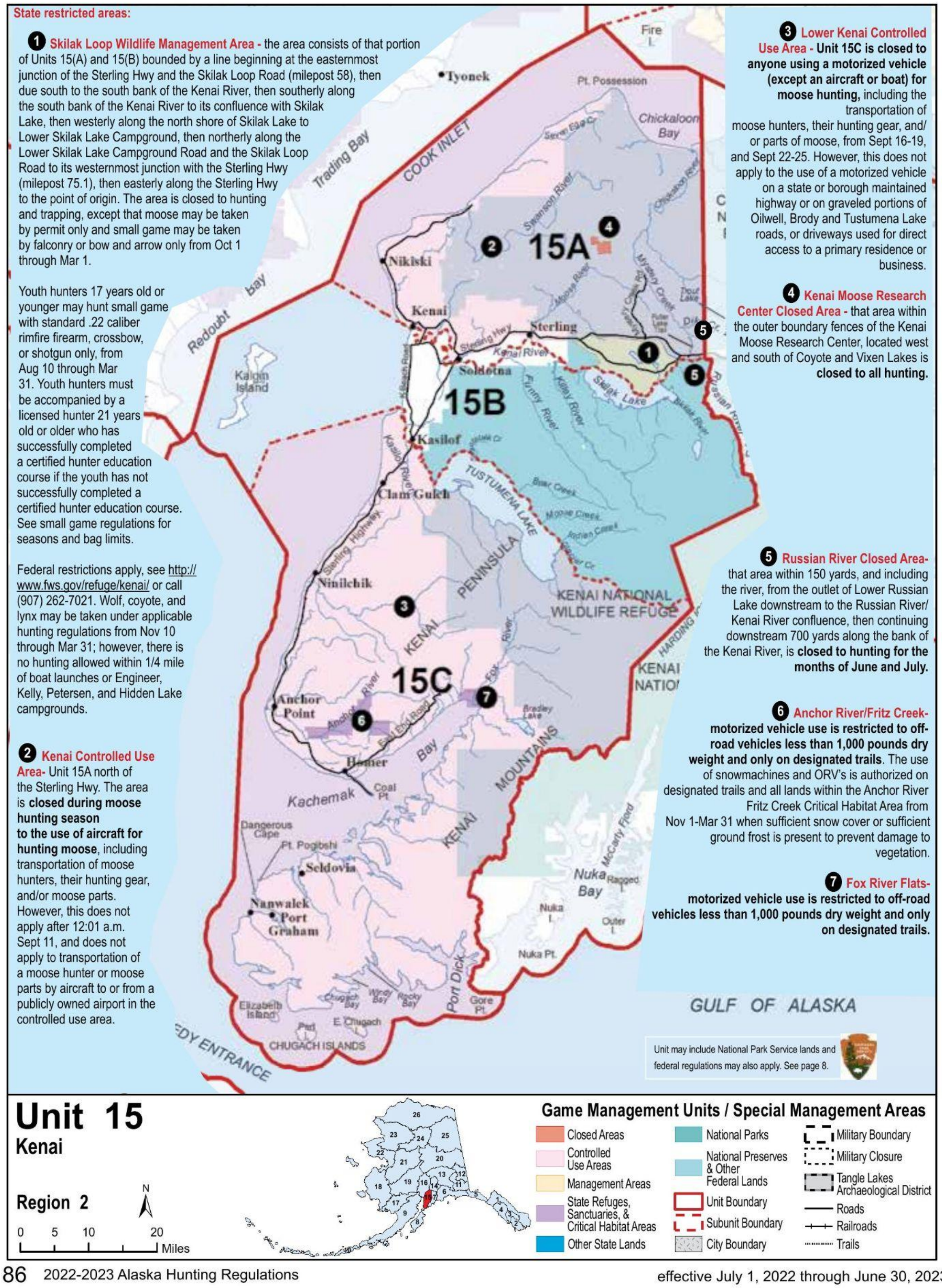
Proposed BDA Location within Bailey Wong Property



Proposed BDA (59.70268N, 151.44228W)
Bailey Wong Property Bounday

Source: Kachemak Heritage Land Trust, Alaska
Projected Coordinate System/datum: NAD 1983
StatePlane Alaska 4 FIPS 5004 (US Feet)
Map Layout: SEAS Masters team 2023
Date: 3/11/2023

Appendix H. Kenai Peninsula Wildlife Regulations for State Restricted Areas



(https://www.adfg.alaska.gov/index.cfm?adfg=wildliferegulations.hunting)

Appendix I. Alaska Department of Board and Game Proposals

Proposal 155

PROPOSAL 155

5 AAC 92.550 Areas closed to trapping.

Close Unit 15C to beaver trapping as follows:

5 AAC 92.550 Southcentral Trapping Regulations

The following areas are closed to trapping as indicated: ....Unit 15 - Kenai Peninsula Area

• Skilak Loop Wildlife Management Area, consisting of that portion of Unit 15A bounded by a line beginning at the easternmost junction of the Sterling Highway and the Skilak Loop Road (milepost 58.0), then due south to the south bank of the Kenai River, then southerly along the south bank of the Kenai River to its confluence with Skilak Lake, then westerly along the north shore of Skilak Lake to Lower Skilak Lake Campground, then northerly along the Lower Skilak Lake Campground Road and the Skilak Loop Road to its westernmost junction with the Sterling Highway, then easterly along the Sterling Highway to the point of beginning;

• Kenai Moose Research Center Closed Area in Unit 15A, which consists of the area within the outer boundary fences of the Kenai Moose Research Center, located west and south of Coyote and Vixen Lakes.

***Unit 15C closed.**

What is the issue you would like the board to address and why? Close beaver trapping in Unit 15C.

There are very few beaver around these days on the Kenai Peninsula. Please give beavers some time to replenish themselves down here...just a few years, get the population back up. Give trappers some beaver to catch.

This is an issue bigger then beaver trapping. Beavers are engineers in rewetting and recharging ground water, essential for our diminishing salmon. They also have a huge ability to restore drying peatlands, vital for carbon sequestration and climate change mitigation. We need them.

PROPOSED BY: Sue Christiansen (EG-F22-132)

****

Proposal 156

PROPOSAL 156

5 AAC 84.270. Furbearer trapping.

Close beaver trapping in the Anchor River and Deep Creek Drainages in Unit 15C for six years as follows:

Close all beaver trapping in the Anchor River and Deep Creek drainages in Unit 15C for two board cycles with a required sunset review.

What is the issue you would like the board to address and why? In recent years beavers have been nearly completely extra paid from the Anchor River and Deep Creek drainages. Given historic numbers and an abundance of suitable habitat it seems likely that with protection they may recall and ice these drainages and again offer trapping opportunities.

PROPOSED BY: Homer Fish and Game Advisory Committee (EG-F22-067)

Proposal 160

PROPOSAL 160

5 AAC 92.095. Unlawful methods of taking furbearers; exceptions.

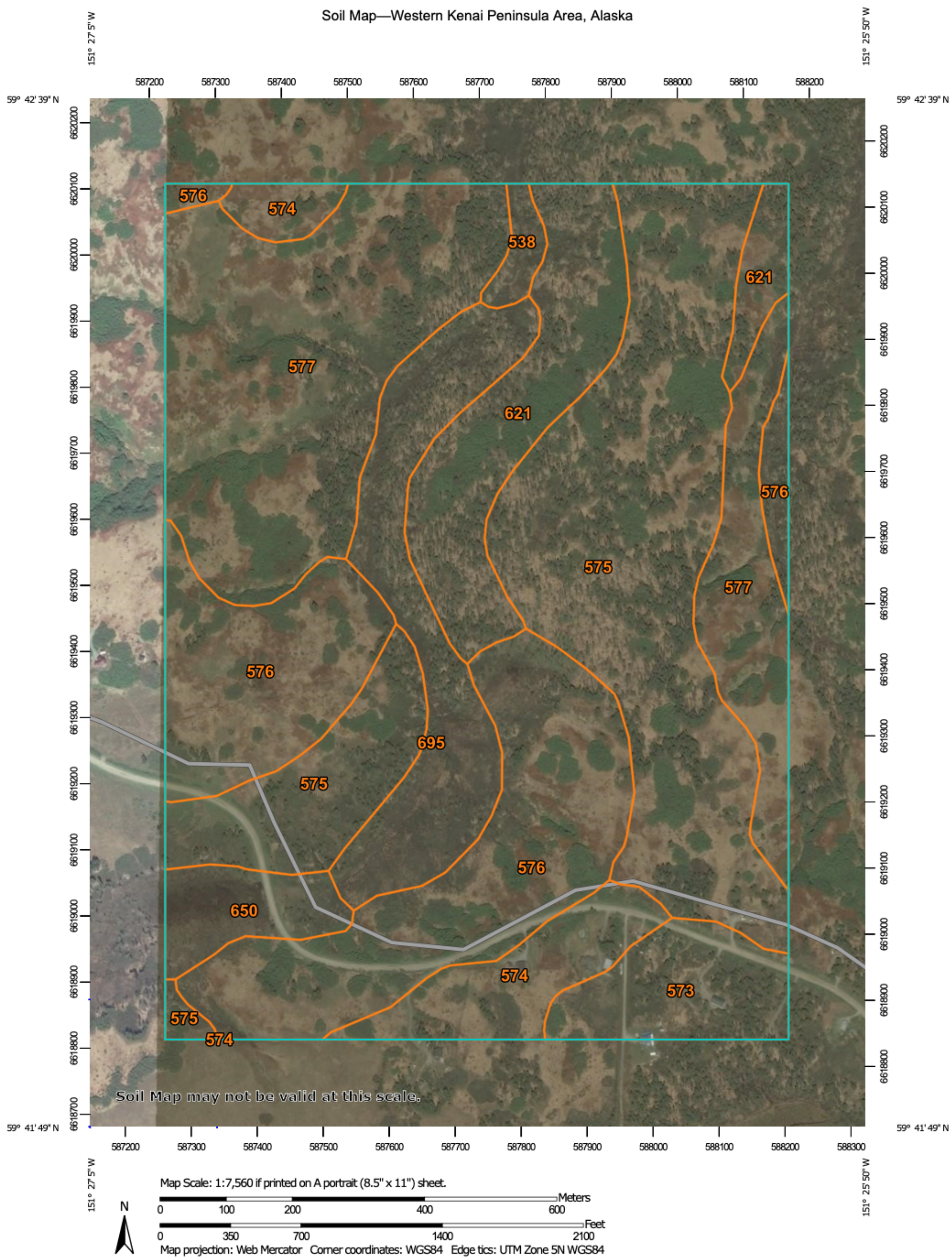
Limit beaver trapping to one set per lodge for Units 7 and 15, and require visual markers as follows:

Limit beaver trapping to one set per lodge and only one beaver may be removed per lodge in Units 7 and 15. All lodges that have been or are being trapped in the current season must be visually marked with a pole set vertically in the ice. This regulation has been successful in the Kenai National Wildlife Refuge.

What is the issue you would like the board to address and why? Trapping appears to be a major factor in the extirpation of beavers in many areas of the Kenai Peninsula. Multiple trappers in one area can contribute to overharvest of beaver lodges.

PROPOSED BY: Homer Fish and Game Advisory Committee (EG-F22-068)

Appendix J. Soil Map for IRP from Web Soil Survey



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Western Kenai Peninsula Area, Alaska
Survey Area Data: Version 21, Aug 31, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Map—Western Kenai Peninsula Area, Alaska

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
538	Coal Creek silt loam, 8 to 15 percent slopes	2.4	0.8%
573	Kachemak silt loam, 4 to 8 percent slopes	12.6	4.2%
574	Kachemak silt loam, 8 to 15 percent slopes	15.2	5.0%
575	Kachemak silt loam, 15 to 25 percent slopes	80.5	26.5%
576	Kachemak silt loam, 25 to 35 percent slopes	63.2	20.8%
577	Kachemak silt loam, 35 to 45 percent slopes	68.8	22.7%
621	Mutnala silt loam, 25 to 45 percent slopes	27.4	9.0%
650	Salamatof and Doroshin peats, 0 to 2 percent slopes	7.8	2.6%
695	Truuli muck, 0 to 4 percent slopes	25.7	8.5%
Totals for Area of Interest		**303.6**	**100.0%**

https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Appendix K. Aerial Imagery Grid Points for Bailey Wong Property