NWT Cumulative Impact Monitoring Program
2017/18 Final Report Form

1 Project Information

NWT CIMP #	**20170501161201529**
Project Title	Using Traditional Knowledge of JMRFN Elders to better understand changes in the boreal caribou habitat.
Project length (years of CIMP funding)	1 year
Date Submitted	Final version submitted on May 17th, 2018
Author(s) & their Organizations:	Margaret Ireland – Jean Marie River Fist Nation - project lead
Contact Information Include mailing address, email, telephone and website	Jean Marie River First Nation General Delivery Jean Marie River, NT X0E 0N0 Phone (main line): (867) 809-2000 http://jmrfn.com/
Author(s) & their Organizations:	Cyrielle Laurent Yukon Research Centre (Yukon College) – Coordinator and GIS specialist
Contact Information Include mailing address, email, telephone and website	Yukon College 500 College Drive, PO Box 2799 Whitehorse, Yukon Y1A 5K4 Canada t. 867.668.8849 f. 867.456.8672 www.yukoncollege.yk.ca
Author(s) & their Organizations:	Alison Perrin Yukon Research Centre (Yukon College) – Social Scientist
Contact Information Include mailing address, email, telephone and website	Yukon College 500 College Drive, PO Box 2799 Whitehorse, Yukon Y1A 5K4 Canada

	t. 867.668.8849 f. 867.456.8672 www.yukoncollege.yk.ca
Type of Research	☐ Science ☒ TK
Valued Component Check all that apply. If 'other' please specify.	☒ Caribou ☐ Fish ☐ Water ☐ Other
Geographic Area/Region	☐ North/South Slave ☒ Dehcho ☐ Sahtu ☐ Gwich'in ☐ ISR ☐ Wek'èezhii
Project Keywords (at least 4)	**Caribou, Traditional Knowledge, Climate Change, Habitat**
Location In **decimal degrees (dd.mmm)** provide coordinates for the general study location; or if regional, provide 4 coordinates for the bounding box.	North point 61.886°N West point 121.678°W East point 119.708°W South point 60.945°N

Consent I acknowledge that the completed report will be posted for public access on the NWT Discovery Portal.	☒ I agree

2 Abstract

Jean Marie River First Nation (JMRFN) has been working on climate change related projects since 2012. Climate change is greatly impacting our land and our way of life, including our food security, and it is important for us to better understand the evolution of our environment and the impacts it has on our community.

Our project aims to demonstrate the cumulative impact of permafrost degradation and forest fire on boreal caribou habitat and how caribou habitat degradation affects our community. To do this we used a holistic approach integrating Traditional and scientific Knowledge with a larger emphasis on Traditional Knowledge (TK). We collected Traditional Knowledge in one-on-one interviews and scientific knowledge from existing datasets. We analysed the content of the interviews and conducted a spatial analysis that

allowed us to identify areas where the quality of boreal caribou habitat has changed. Our results show that the quality of boreal caribou habitat has decreased in 35% of the areas, remained stable in 64% of the areas and increased in 1% in the areas. Our evaluation of the impact of forest fire and permafrost degradation showed that the latter has a particularly high impact on boreal caribou habitat with 88% of boreal caribou areas affected. Forest fire still has a significant impact with 29% of boreal caribou areas affected. The cumulative impact of these two factors reveals that the boreal caribou habitat in the Jean Marie River (JMR) area is in a medium state of health and is degrading. This means that boreal caribou could move away from our traditional territory and that the herds traveling through it are becoming smaller. For our community, it translates as increasing difficulty to access caribou meat, which impacts our diet and wellness, and also reduces our opportunities to practice traditional activities.

3 Introduction

This community driven project responds to the need of our people to adapt to a changing environment and to better understand the cumulative impacts affecting our land.

Elders, land users and researchers in Jean Marie River First Nation (JMRFN) have identified changes in the landscape and the behavior of certain animals, including changes in boreal caribou habitat. As permafrost thaws, areas used by boreal caribou every year are turning into wet areas (comprising marsh, grass land, and mossy areas), which doesn't constitute suitable habitat for boreal caribou. Additionally, forest fires around Jean Marie River (JMR) are becoming more virulent year after year which also impacts boreal caribou habitat. In JMR we rely partially on boreal caribou to feed our people; and the degradation of caribou habitat could greatly affect our diet. Boreal caribou is currently identified as a threatened species by the Species at Risk Act; consequently, we are limiting our hunting activities for this species. This project has the overarching goal of better understanding cumulative environmental impacts on boreal caribou and bringing our Elders into decision-making processes on a regional scale by using our TK and sharing our results with stakeholder groups.

Results from our previous research projects led to the development of several new research questions, and those have formed the objectives for this project. Our main objective is to demonstrate the impact that boreal caribou habitat degradation has on our community. Our three specific objectives are:

- Identify areas where the quality of boreal caribou habitat has changed;
- Estimate the potential level of degradation of boreal caribou habitat caused by the cumulative impact of permafrost thaw and forest fire;
- Identify indicators associated with boreal caribou habitat to provide baseline information on current conditions.

In our methodology, we used an approach focused on the use and collection of Traditional Knowledge in which we integrated scientific knowledge through the collection of existing datasets. Our analyses used both types of knowledge, which produces comprehensive results. This is a very innovative approach that allows our community to have a powerful sense of ownership over the project and also promotes active collaboration with researchers.

4 Methods

In our research projects, we aim to use both Traditional and scientific Knowledge. Collectively, the two types of knowledge have been demonstrated to be extremely instrumental in informing our understanding around various environmental topics. Indigenous TK provides for region-specific information and comparison points on a larger temporal scale (Ellis, 2005), whereas western scientific knowledge offers broader contextual generalizations of concepts and points for reference across a spatial scale. In addition, TK often provides a rich source of information on the relationship between people and the land (Ellis, 2005). In the context of our project, scientific data offers an understanding on how climate change factors interact with one another and with boreal caribou in other regions. Complementarily, JMRFN TK helps us understand how our traditional territory, the regional boreal caribou herds and habitat, and the community's experiences have changed over time. This combination gives us a holistic and more accurate understanding of the cumulative impact of climate change factors on boreal caribou habitat in the JMR area.

4.1 Study area

As shown on Figure 1, we have used two study areas for this project. The study area for TK data collection (Study Area 1) is centered in JMRFN traditional territory at a scale of 1:250,000, which includes Fort Simpson at the far North-West corner, Cormack Lake at the far South-West corner and the winter road junction to Trout Lake in the South-East corner. We have performed the impact analysis of forest fire on Study Area 1 and then focused the permafrost and cumulative impact analysis on Study Area 2, which corresponds to the boundaries of our permafrost map. This map represents an area of approximately 1000 km² around the community.

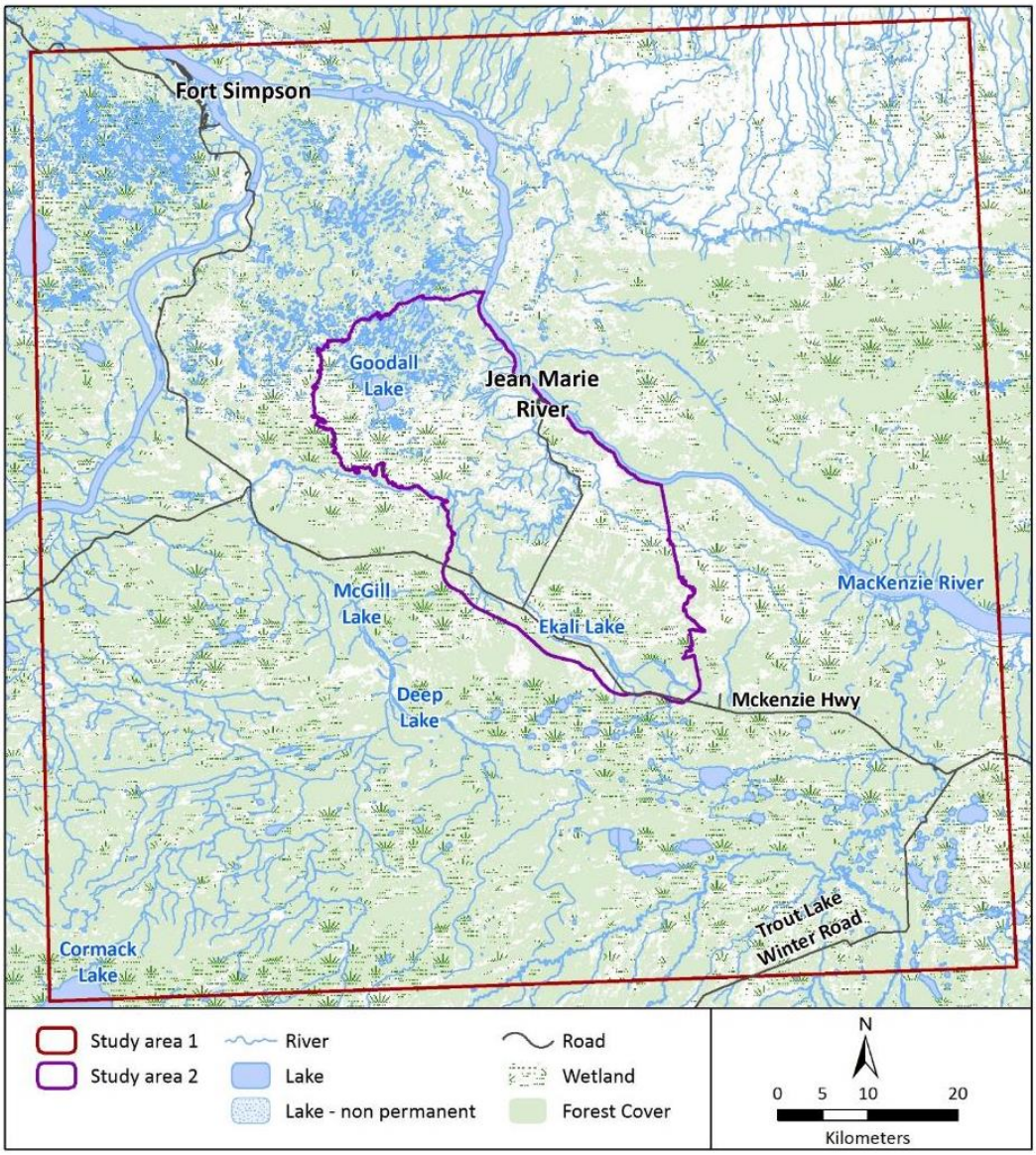

Figure 1: Project study areas

4.2 Ethical considerations

Doing research in smaller communities magnifies the risk of any negative impacts from a study (i.e. the participant to researcher ratio is much smaller), and therefore, it is imperative that extra precaution is taken when approaching research in a small Indigenous community. Some Indigenous communities have had negative research experiences, which are attributed to marginalization through colonialism and negligence of Traditional Knowledge systems (Genuis et al., 2015). Linda Tuhiwai Smith writes, "'research' is probably one of the dirtiest words in the indigenous world's vocabulary" (2012, p.1). Accordingly, researchers and communities have engaged in participatory, or collaborative approaches to research, where the community members are co-researchers, and are consulted at all stages of the research process (Holkup et al., 2004). Collaboration places control of the research in the hands of the community, holds the researcher accountable, and reduces the researcher-participant power inequalities that have occurred in the past with Indigenous communities (Wesche et al., 2011). This project was proposed and led by JMRFN, specifically Margaret Ireland. Community members were involved at all stages of the research process, including participating in the study, co-conducting interviews, collecting data (i.e. mapping of TK), and producing the final report. Collaborators from the Yukon Research Centre have established relationships with the community and co-developed the project with JMRFN. The band office provided the necessary support to make sure the interview process conformed with the TK collection protocol in place at JMRFN (as per the revised 2011 TK protocol). The appropriate research permit was obtained from the Aurora Research Institute, and the Yukon College Research Ethics Board (REB) approved our project.

Before the interviews began, participants read and signed an informed consent form that included a confidentiality statement to preserve their privacy (approved by the Yukon College REB). The confidentiality and privacy of participants was furthermore guaranteed by using PIN numbers. No names appear in the report, maps, or any other documents that could directly link a participant to the information they provided unless permitted by participants. The project and the use of results were clearly explained prior to beginning the interview and participation was completely voluntary.

4.3 Research methodology

For the collection of TK data our team prepared an interview guide customized to the objectives of our project. We started with general questions about traditional activities on the land followed by more specific questions about boreal caribou, hunting areas, boreal caribou habitat, and changes on the land. The interview guide (see Appendix A) was developed with the assistance of our technical team (Alison Perrin, Cyrielle Laurent, and Holly Bull, YRC) and with guidance from Don Russell, biologist, who ensured the accuracy and relevance of the questions related to boreal caribou habitat. We wanted to collect information on observed changes of boreal caribou habitat and related impacts. As we already had access to datasets for changes and impacts due to forest fire and permafrost, we chose to direct our interview questions on other changes like water and ground moisture, precipitation, and vegetation (other than burns) to avoid the overrepresentation of forest fire and permafrost impacts.

Two large format base maps displaying the area around JMR were used for mapping as much information as possible during the interview; one map at 1:120,000 and one at 1:250,000. The two scales proved useful by providing the option to record detailed information on one and knowledge about a larger area on the other. Both maps show basic layers such as rivers, lakes, forested areas, wetlands, roads, communities, and indigenous place names. We used the land use-and-occupancy research method, also called the map biography, as developed by Terry Tobias (Tobias, 2009). This is a very robust and rigorous method that ensures consistency in the collection and leaves little room for error. The researchers linked features drawn on the maps to written comments by attributing codes. The codes were recorded on the map and in the interview notes, allowing the two to be connected during data analysis. Youth from JMRFN were trained leading up to the interviews and helped with various tasks as needed, including taking pictures and operating the microphone.

Due to the lack of time and scheduling issues, we were not able to conduct a focus group as was outlined in our activity plan. Instead, this activity was grouped with the data validation meeting conducted in November. Our research team compiled the collected data and presented preliminary results with maps. This preliminary analysis allowed us to review our objectives and identify gaps in the collected data. The data validation meeting was the perfect opportunity to fill in these gaps and further discuss the impacts that boreal caribou habitat degradation has on our community (as originally planned for the focus group) in addition to validating the data.

We collected existing data sets for forest fire data and GPS collar data from different departments at GNWT. We used the forest fire data in our analysis, however we decided to not use the GPS collar data at this stage and keep the caribou data limited to Traditional Knowledge data. We are interested in using scientific knowledge in the future to further study boreal caribou habitat, and the caribou GPS dataset can be of better use at that time. All collected data were stored in a GIS database.

Our community was involved in this project from conception to end and we kept regular communication with our research team. We held several meetings throughout the project involving Margaret Ireland, as the project lead, community members providing Traditional Knowledge, input and feedback, and our research team from Yukon Research Centre for scientific knowledge and technical expertise. July 18th, 2017 was our introductory meeting where we presented the objectives and project activities. In the following 10 days, we conducted the one on one interviews with Elders and land users. On November 14th, 2017, we held our data validation meeting; our research team had digitized all collected data and done a first round of analyses. We reviewed the project data and filled in the gaps. Our last meeting was held on February 28th, 2018, where we presented the results and asked for final community input.

4.4 GIS analysis method

Maps from the interviews were digitized using the Roll Up III mat connected to a computer and directly linked into ArcGIS version 10.5. All digitized data from the interview maps are password protected and encrypted at all times. We used a very rigorous process of data validation and verification during the digitization and database organization.

To answer our first objective, *identify areas where the quality of boreal caribou habitat has changed*, we produced two maps: one showing hunting areas and boreal caribou habitat location, and one showing and quantifying the changes observed in these areas. We compared current and past hunting areas and used interview data to identify which important boreal caribou areas had changed and how. There were areas where boreal caribou habitat had gained in quality, lost quality or not changed.

For our second objective, *estimate the potential level of degradation of boreal caribou habitat caused by the cumulative impact of permafrost thaw and forest fire*, we first produced three maps. We started with the map from Objective 1 showing boreal caribou habitat change and then overlapped it with:

i. forest fire data;
ii. permafrost data; and
iii. both forest fire and permafrost data.

At this stage, we calculated the amount of overlap with areas of gain, loss and no change identified on the map of boreal caribou habitat change (Objective 1).

Finally, we created a model and produced one final map. Figure 2 shows the criteria based on TK and scientific knowledge that we used in the model. Interview participants provided the forest fire criteria, estimating that the land recovers enough after 40 years to be considered suitable habitat for boreal caribou and that after 10 years caribou start using these areas again but not extensively. Scientific knowledge provided the permafrost criteria, as explained below. In this model:

- an impact value of -1 was attributed to:
    - gain in quality on boreal caribou areas
- an impact value of 0 was attributed to:
    - no change in quality on boreal caribou areas
    - forest fire areas burned over 40 years
    - areas non-vulnerable to permafrost thaw
- an impact value of +0.5 was attributed to:
    - forest fire areas burned between 10 and 40 years
    - areas moderately vulnerable to permafrost
- an impact value of +1 was attributed to:
    - loss in quality on boreal caribou areas
    - forest fire areas burned in the past 10 years
    - areas highly vulnerable to permafrost

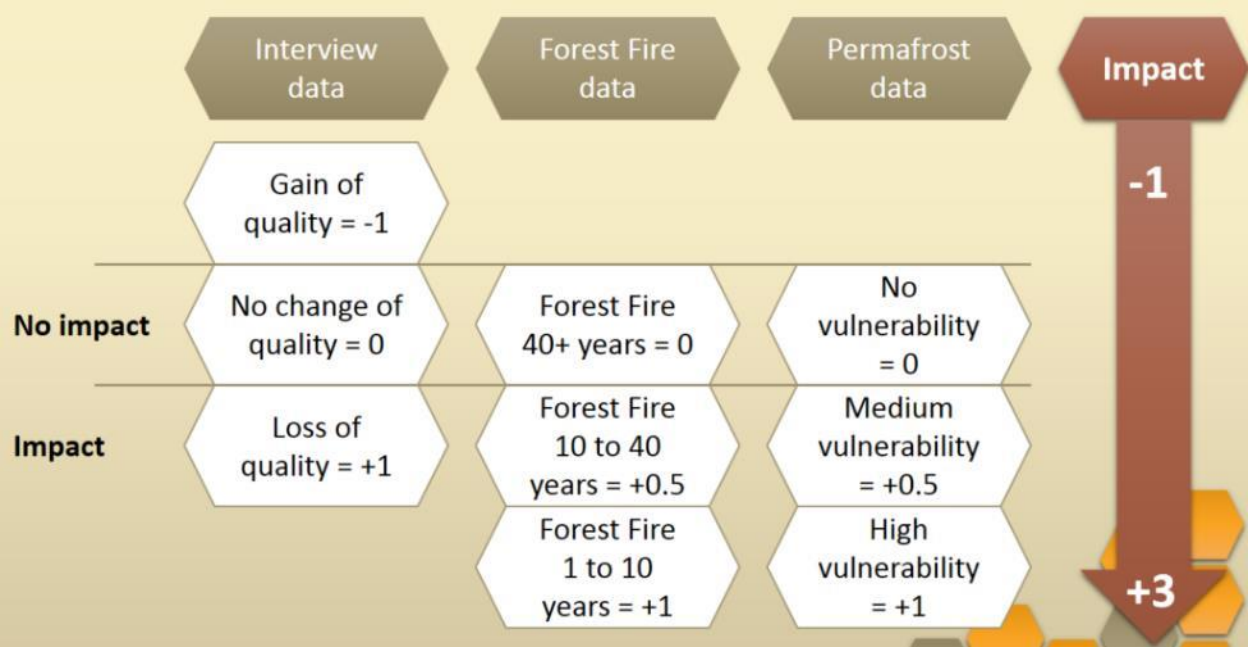

Figure 2: GIS model used to create the final map

After running the model, we were able to produce the final map and estimate the current condition of boreal caribou habitat which fits well with our third objective to *provide baseline information on current conditions of caribou habitat*. On this map values between -1 and 0 were classified as "no impact", values of 0.5 and 1 are "lowest impact", between 1 and 2 "medium impact", and 2.5 and 3 are "highest impact".

4.5 Thematic analysis method

In response to our third objective*, identify indicators associated with boreal caribou habitat to provide baseline information on current conditions*, we turned to the interview transcripts. We transcribed the interviews and conducted a thematic analysis by coding the interview data using NVivo, a qualitative analysis software. We used both a deductive and inductive approach; searching for pre-identified themes based on our objectives while also allowing new themes to emerge from the data. There were nine main thematic topics emerging from the interviews that could inform indicators for boreal caribou habitat: boreal caribou population sizes and movement, hunting practice for caribou, cultural significance of caribou, threats to boreal caribou habitat, landscape changes caused by forest fire, landscape changes caused by permafrost thaw, changes in water, changes to precipitation, and predators. We had designed the interview guide around the topics of caribou hunting practices and locations, boreal caribou condition

and habitat, and landscape changes. Based on our questions we were analyzing the interview transcripts looking for information related to those themes. The themes that emerged through the interviews were changes in water and changes to precipitation. While those two themes directly related to landscape change, we had not identified them from the start and they do not correlate to specific questions. All of the themes were identified because they re-appeared multiple times throughout the interviews. The results of the thematic analysis are discussed in the results and discussion, see section 6 and 7.

5 Resource management implications

- Our results demonstrate that our approach of using both TK and scientific knowledge is effective and can be applied by other northern communities and indigenous organizations.
- Caribou protection and country food are issues that affect almost all communities in northern Canada. Our results can be extrapolated to neighbouring communities that live in similar environments and face similar challenges.
- Environmental regulators can use our results in the development of Łue Túé Sųlái candidate protected area. It can also be used to prioritize the protection of the most vulnerable areas for caribou and assist in the development of a range management plan.
- Our results show that there may be negative interactions between boreal caribou and landscape that has been changed by forest fire or permafrost degradation. This can inform community adaptation planning in other northern communities.

6 Results

6.1 Changes in boreal caribou habitat

Boreal caribou are an ecotype of the woodland caribou, and inhabit boreal forest regions in small herds across Canada, including peatland, fens and black spruce bogs (Bradshaw et al., 1995). Boreal caribou rely most commonly on peatland complexes, avoiding upland areas of the boreal forest (i.e. areas with mature forests, such as aspen stands, white spruce, or poplar), which provide habitat for predators, such as wolves or black bears (Ministry of Environment, 2010). Boreal caribou primarily consume terrestrial and arboreal

lichens and supplement with winter-green plants for added sources of protein and phosphorous (Goddard, 2009). Peatlands and smaller bogs provide necessary nutritive qualities while simultaneously offering a refuge from predators. However, tree stands are often sought out in seasons of increased snowfall as a means to conserve energy during travel and to improve access to terrestrial lichens (Ministry of Environment, 2010).

In Jean Marie River, our community members continue to use their land for traditional activities, such as gathering plants, berries, and other materials, hunting, trapping, and fishing. When out on the land, they have observed both seasonal and long-term changes. While they have witnessed changes during their lifetime with their own eyes, using the knowledge of their ancestors they can understand change over several generations. We asked interview participants to show us where they go hunting, where they have seen caribou, and places they would consider boreal caribou habitat. Figure 3 shows areas that were identified as boreal caribou habitat and boreal caribou hunting; when participants mentioned they had seen boreal caribou it was always in one of those two types of areas. The total size for boreal caribou habitat is 736 km² and the larger habitat areas are located on the north side of the Mackenzie River. Boreal caribou hunting areas cover 1068km² and are spread across the study areas quite evenly.

For each of these areas we asked participants to indicate a time frame of use, either when they used the area for hunting or when they saw boreal caribou use the area.

- Areas that were used more than 10 years ago, and not used in the past 10 years were classified with a loss in habitat quality.
- Areas that have been used in the past 10 years, and not used more than 10 years ago were classified with a gain in habitat quality.
- Areas that have been used in both time periods were classified as having no change in habitat quality.

These areas are shown on Figure 4. According to our classification, 64% of all areas have had no change in quality, mainly located in the northern half of the study area. 35% of all areas have had a loss in quality and are generally located in the southern half of the study area. Only 1% of all areas seem to have gained in quality. The paragraphs below describe the changes represented in Figure 4 and were themes identified through the interviews. They include:

- hunting practices which had to be adapted to the boreal caribou population size,
- threats to boreal caribou habitat,

- changes to water on the land, some of which can be linked to permafrost,
- changes to precipitation, and
- impacts of predators.

Participants talked quite a bit about hunting practices for caribou. The interviews were focused on boreal caribou, but people often mentioned hunting barren-ground caribou more on the horn plateau, compared to boreal in other areas. Generally, these days people only hunt boreal caribou when they happen to be spotted and they aren't necessarily out looking specifically for boreal caribou, "as for [boreal], I think in the olden days they may have hunt them, but now if you see them and you have an opportunity to shoot them, then you do it. But other than that, nowadays, people don't really go out and hunt them" (Interview Participant). The shift from dogsled to skidoos and vehicles corresponds to more sightings of boreal caribou on the roads and cut lines, but overall people go out on the land less. Overall the number of boreal caribou hunted yearly has gone down, from about 5-10 per year for an individual hunt and about 30 as a community to 1-4 per year for an individual hunt. Hunting for boreal caribou is seasonal in many Dehcho communities (Dehcho First Nations, 2011). In JMR, the boreal caribou herd resides in a region south of the community, but shift north, west, and east in a seasonal pattern (Dehcho First Nations, 2011).

Participants noted a number of different threats to boreal caribou habitat including sweet clover competing with lichen, which is a prime food source for caribou. It was also mentioned that bison compete with boreal caribou for habitat. Lichen was brought up as a key source of food for caribou, and a number of concerns were mentioned around lichen including the length of time it takes for it to grow, and the impact of fire on lichen, "because the fires, the areas where they usually get their food - the lichens - have been destroyed and so they may be looking for different locations where they could get their food" (Interview Participant).

Another landscape change that emerged from the interview data was changes in water, but it was not consistently mentioned in the same way. Some areas were identified as becoming wetter and other areas drier. Some rivers are breaking up early in spring, and then are drier in the fall. In some lakes, the banks are higher (i.e. water is lower) and in others the opposite is happening and the water is higher.
There was general agreement that caribou do not like wet areas, but also some muskeg areas have become too dry and there is less lichen than before which also is not good for caribou. As one participant noted, "wherever there's lakes, the water level has seemed to have gone down quite a bit. Cause all the

lakes that I had visit seemed to have higher banks, and aside from the frost heaves that are melting around that area, that is noticeable it's a little bit more wet where they melted, and other than that, there was some places that seemed to be drier. But then again, there are some places that seem to be wetter."

Another theme that emerged from the data was changes in precipitation, which was also sometimes tied to changes in water. Changes in precipitation feed into some areas getting wetter, but they also have other impacts on caribou. Based on the interviews, issues surrounding precipitation seem to be related to timing. First, there is often more rainfall in the fall, which can freeze and create an ice base over the tundra. This can result in less access to food for caribou, as happened in the fall of 2016. Second, there can be increased snowfall in the winter which makes it harder for caribou to access food, "Some years there's too much snow, some years there's less snow. Hard for the caribou to get the lichen when there's too much snow. It's hard for them to hooved it out" (Interview Participant). The increase in snow fall may also push caribou into upper forested areas, thus exposing them to a higher risk of predation (Ministry of Environment, 2010). Third, if there is not enough precipitation in the summer the areas can become dry affecting plants that caribou feed on, "I think due to the foods that they eat I think it's becoming scarce due to, you know summer time- you don't get enough rain. So, some of the plants that they eat are becoming scarce too and it's all drying up" (Interview Participant).

Finally, the last theme was around the impact of predators on caribou. Participants noted that there is an increased wolf population and that wolves can have a detrimental effect on the caribou population, although it was also noted by one participant that the population of wolves is usually proportional to caribou. More wolves have been seen on cut lines in recent years, although with more motorized travel people are also likely using cut lines more. One participant mentioned that caribou also avoid bison and bears, "they avoid buffalos too, and bears, and especially wolves. Yeah, one time we've seen buffalos kicking at a caribou and the caribou was just running around. It escaped and didn't come back". Other predators that were mentioned as having an impact on caribou include ticks, magpies, and coyotes. One participant noted that the cumulative impacts of forest fire and an increase in predators could be affecting the population, "the wolf population have been kind of increasing, and so there's these two- the forest fire and the wolf- are two that have a lot to do with the population decrease on the woodland caribou".

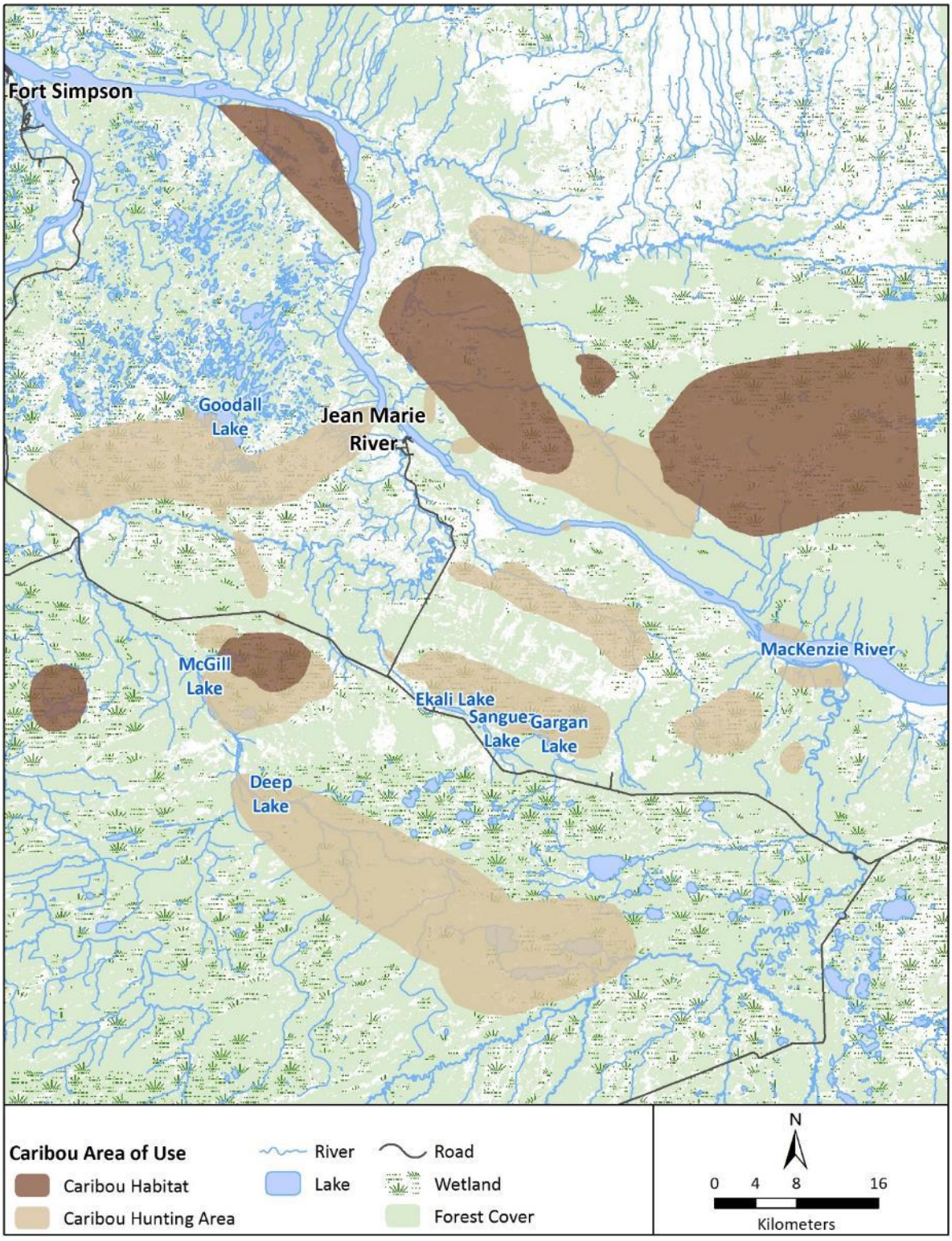

Figure 3: Areas identified by interview participants as boreal caribou habitat and boreal caribou hunting

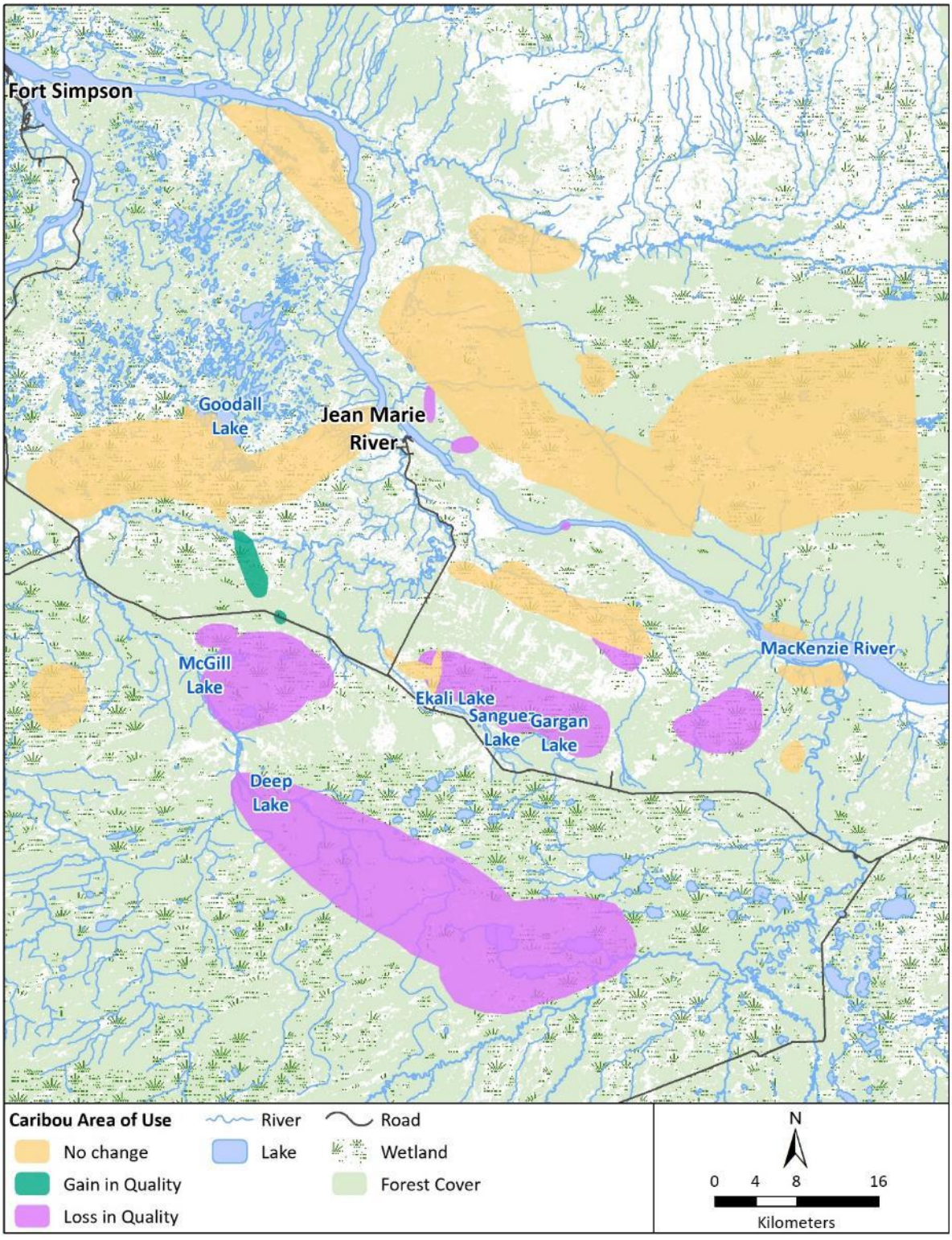

Figure 4: Boreal caribou habitat change in quality from analysis of interview data

6.2 Cumulative Impact of permafrost thaw and forest fire on boreal caribou habitat

JMR is located along the discontinuous permafrost zone, which has been noted to be one of the most sensitive regions to climate change in the world (Yoshikawa et al., 2003). Many areas within this zone have ground temperatures approaching 0 °C (JMRFN et al, 2014). As permafrost is defined as earth materials that remain at or below 0 °C for more than two year, the discontinuous zone is extremely susceptible to permafrost thaw (Vitt, Halsey, & Zoltai, 2000). Correspondingly, there is abundant overlap between boreal forest regions, and therefore boreal caribou habitat, and the discontinuous permafrost zone (Yoshikawa et al., 2003).

Wildfires are the primary ecological cause of succession in boreal forests. Boreal caribou herds have reportedly adapted to many wildfires in previous years through migration to other ranges (Chapin, et al., 2004). However, with current climatic changes, the prevalence and severity of forest fires are on the rise (Flannigan, 2008). With projected increases in wildfire prevalence and severity, there are major concerns for the resiliency of the boreal caribou herd and habitat, as well as the sustainability of hunting in the JMR region.

Both community members (Elders and land users) and scientists have found evidence that climate change is impacting the land by causing permafrost to thaw, and contributing to larger, more frequent and more intense forest fires (Flannigan, 2008). Permafrost thaw can cause significant environmental changes on the land depending on the kind of soil and vegetation present. In the Jean Marie River area, permafrost covers approximately 50% of Study Area 2, see Figure 5; and (JMRFN et al. 2014); and more than 1400 km² were burned in the past 10 years (GNWT 2016). According to our analysis, for Study Area 1 (see Figure 6):

- 1846km² have been burned in the past 10 years
- 833km² have been burned between 10 and 40 years ago
- 58km² have been burned more than 40 years ago

Interview results tell us that the land does recover from forest fire but at different rates depending on the type of environment. Participants indicated that the recovery time for willow is about 3 years, for lichen

is about 30 to 50 years, and that caribou start coming back in the area 5 to 6 years after a fire but don't use it extensively and don't spend a lot of time there. Lichen is an important resource for caribou and participants therefore estimated that it takes 40 years on average for the land to be suitable boreal caribou habitat again. Although wildfires are considered beneficial for lichen growth in the long term (i.e. century time scale), the increasing rate of forest fires may not allow the necessary time for full rehabilitation of caribou habitat (Klein, 1982; Collins et al., 2011). In 2014, and 2015 alone forest fires in southern NWT caused an estimated 3% reduction in the territory's boreal caribou herd habitat (Conference of Management Authorities, 2017).

Forest fires can change how both people and animals get around on the land. They have an impact on hunting routes; sometimes making them less accessible and less safe. They can also change caribou migration patterns and destroy boreal caribou habitat, driving caribou to use other areas. As a participant noted, "they [caribou] are moving away from here. Too much forest fires; nothing for them to eat after everything's burnt".

Permafrost thaw on the other hand seems to have more permanent effects. Indeed, when permafrost thaws the land changes from one type of environment to another; as an example, provided in the interviews, a forest composed mainly of small black spruce turned into a wetland type area (muskeg or pond). The impact of forest fire is much more sudden than permafrost thaw, however the land recovers from it, whereas an area affected by permafrost thaw does not go back to its original state. Although herds disproportionately favour low lands in boreal habitat, they avoid open bog areas (Dehcho First Nations, 2011). Flooded regions are better suited for moose, and a rising moose population may also attract predators (e.g. wolves and bears) to the area (Ministry of Environment, 2010). Therefore, as permafrost thaws, there may not only be a reduced cooling effect in grasslands, but also an increased likelihood for boreal caribou habitat to transform into unfavourable bogs, with increasing predation in the area.

Our analysis tells us that in Study Area 1 boreal caribou areas (habitat or hunting) overlap at 29% with burned area, see Figure 7. In Study Area 2 boreal caribou areas (habitat or hunting) overlap at 66% with areas highly vulnerable to permafrost thaw and at 22% with areas moderately vulnerable to permafrost thaw, see Figure 8. This is significant, it means that 88% of the area used by boreal caribou is underlain by permafrost and susceptible to some degree of change.

In the interviews, participants reported that permafrost thaw can change the landscape and impact how people get around. Palsas, frozen mounds that are several feet tall, are a common feature of the landscape, and when the permafrost thaws the mounds disappear and the landscape becomes flat or shows depressions and often gets wet. Another change that participants connected to permafrost thaw was trees falling on specific embankments, forcing the community to change how and/or where they travel, “when we cut along the cutline for our traps - this way and that way. And sometimes we go up here and set a line for rabbit snares. Next year we go back over there - everything has fallen and we need to work hard to clear our land again.” (Interview Participant).

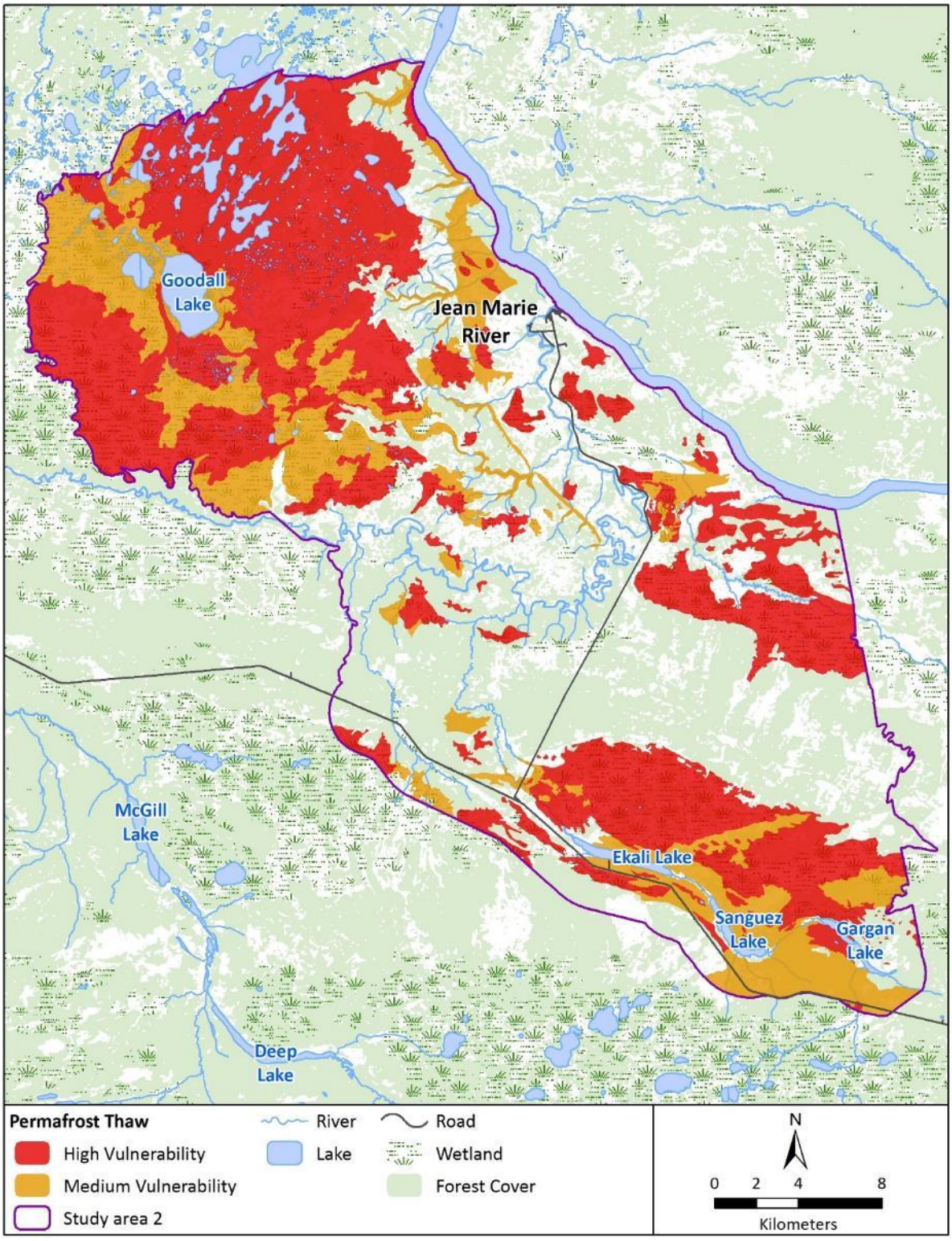

Figure 5: Permafrost vulnerability map in Study Area 2.

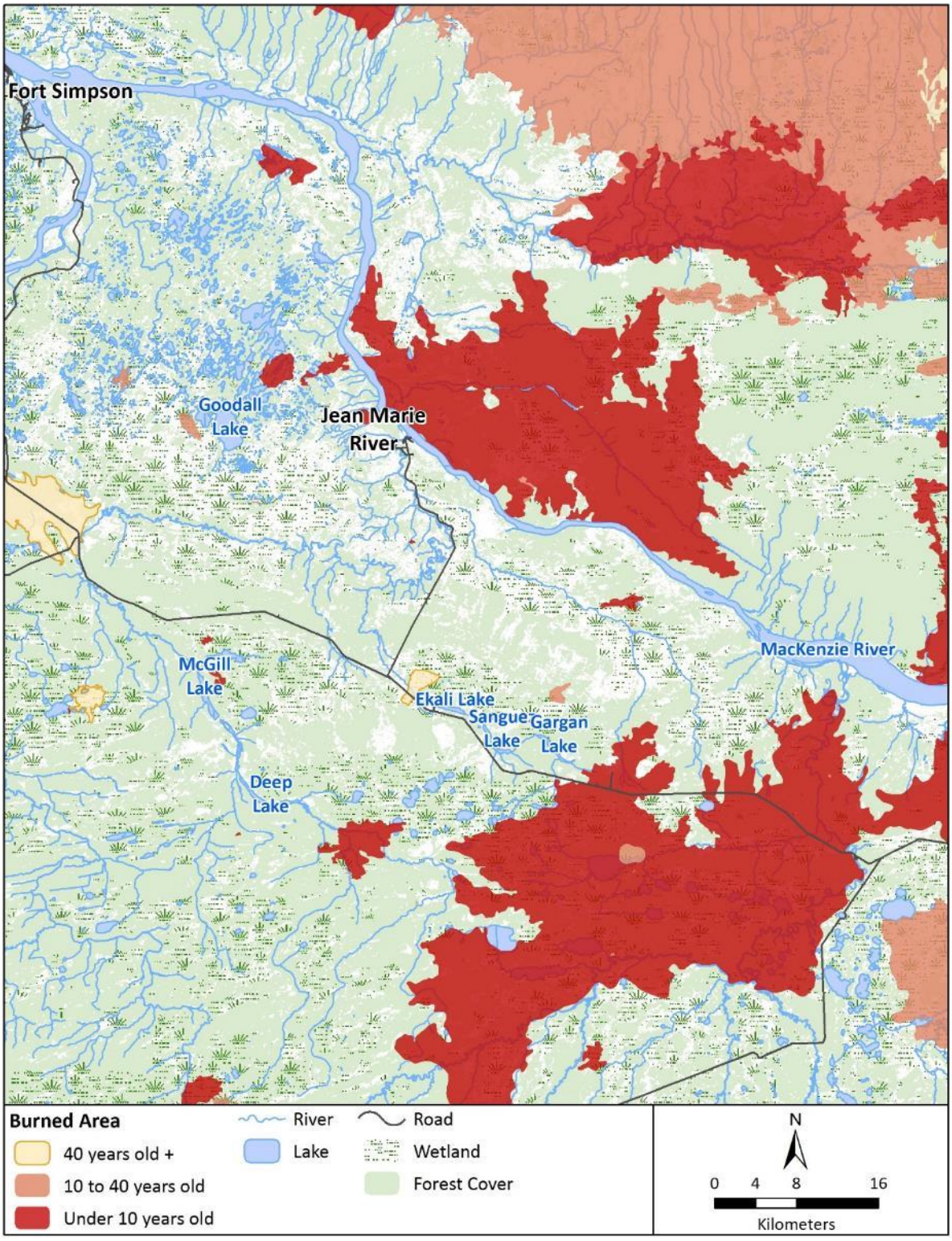

Figure 6: Forest fires of different age in Study Area 1

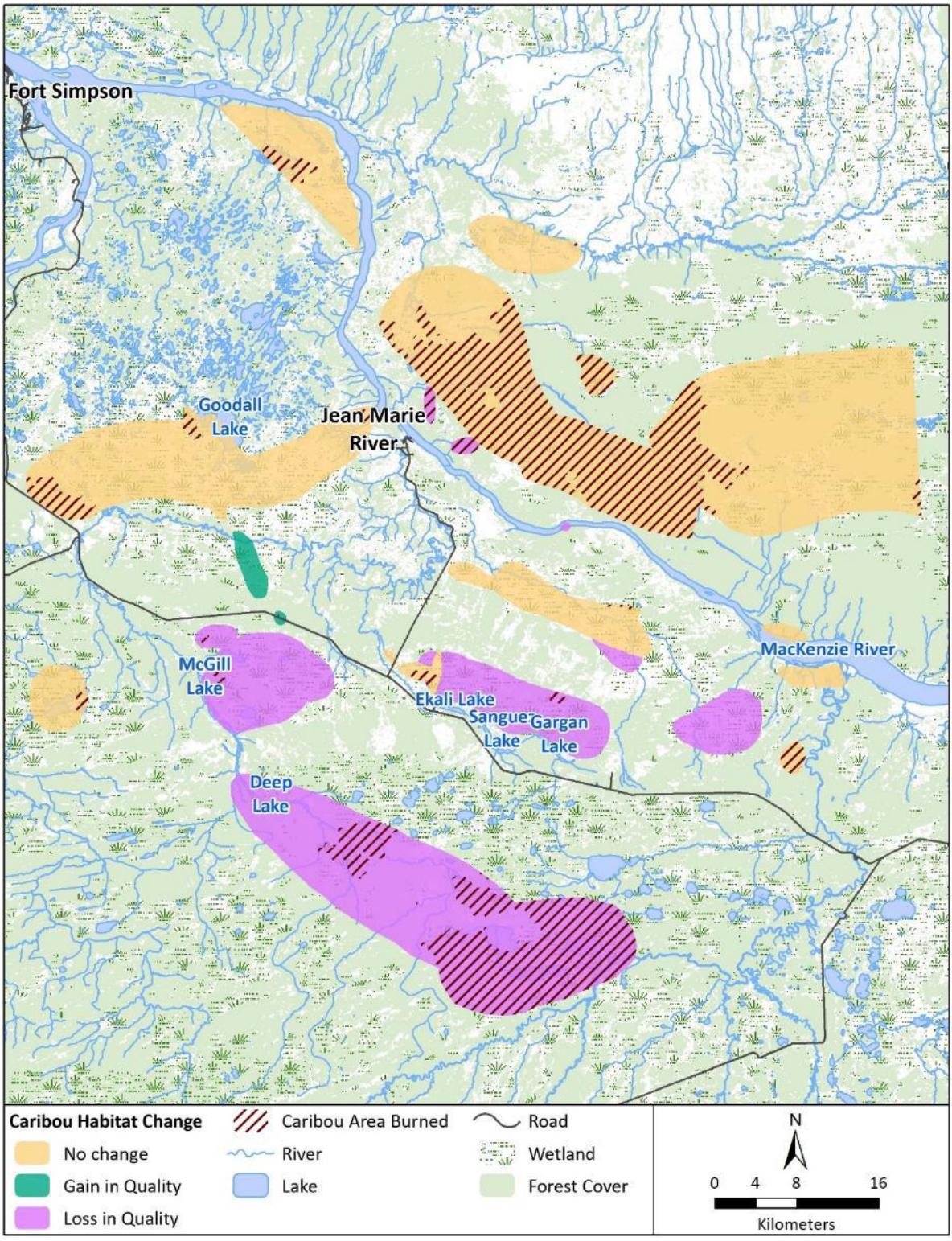

Figure 7: Overlap of forest fire and boreal caribou areas

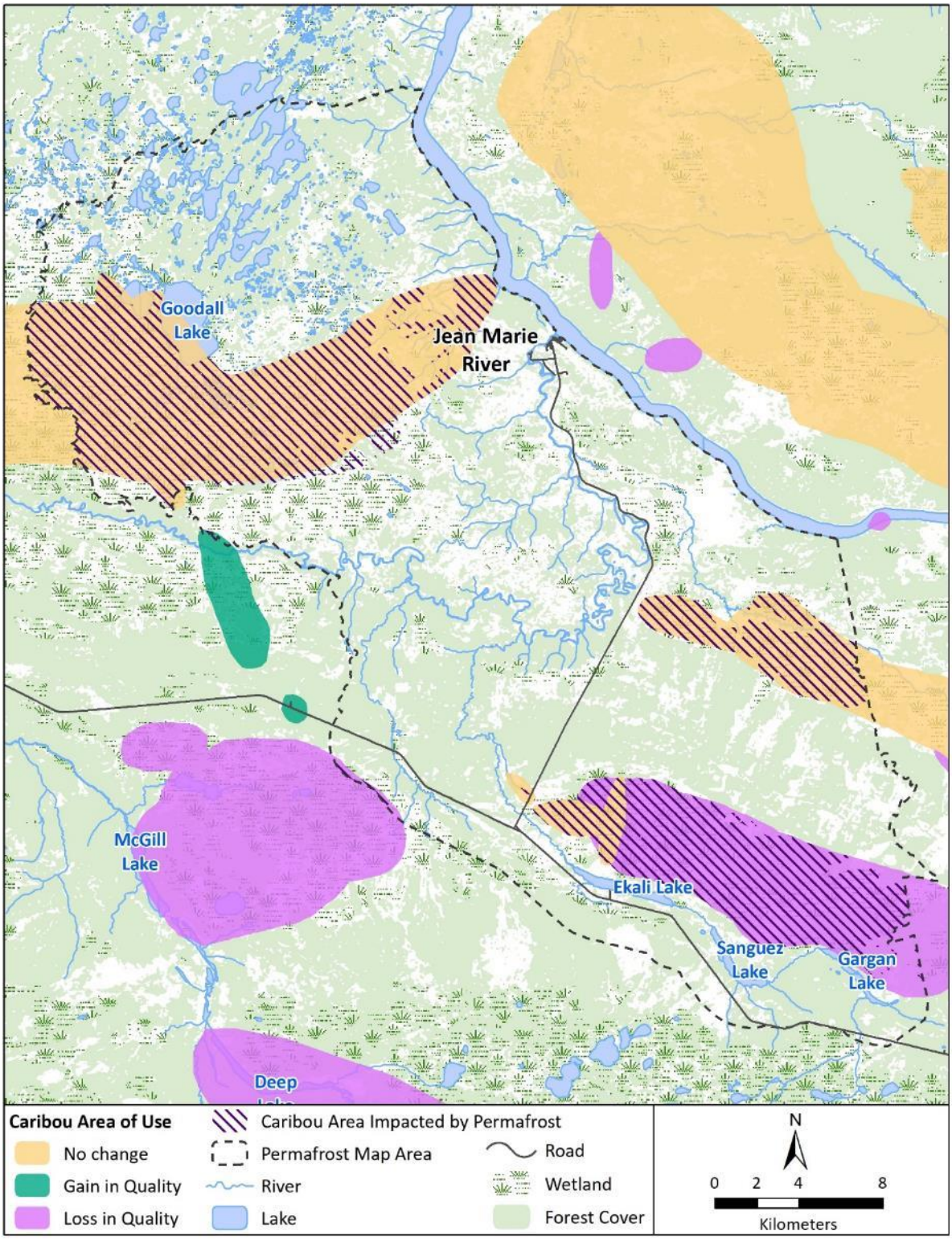

Figure 8: Overlap of permafrost vulnerable areas and boreal caribou areas

6.3 Current condition of boreal caribou habitat

Generally, interview participants qualified the current state of boreal caribou habitat as medium quality. They have observed lots of different changes affecting the habitat over the years and the general impression is that these changes are intensifying or accelerating.

The results of the model built for the cumulative impact analysis agree with the interview results. As shown on Figure 9, 45.5% of boreal caribou areas has a low impact and 14% a medium impact, with only 0.5% of high impact and 40% of no impact. We know these results to be biased by the fact that we had to use two study areas, one being much smaller than the other. Based on traditional and scientific observations, we believe that if we were able to expand our permafrost map to the Study Area 1 the cumulative impact would be much higher. For example, look at the area west of Goodall Lake and how the limit between the "no impact" and "low impact" matches with the boundary of Study Area 2. Indeed, if we expanded the permafrost map to the west it is very likely that this area would be classified as "low impact" instead of "no Impact". Other areas currently classified in low or medium impact could be medium or high impact, if we had used Study Area 1 for all analyses. In general, very few forest fires have affected Study Area 2 which very much limits the overlap of the two layers on the map. From field observations, it is likely that the areas around McGill and Deep lakes contain quite a lot of permafrost.

The areas with medium and high level of impact are mostly peatlands and these areas are the ones that are the most valuable to boreal caribou. The area north of Ekali, Sanguez and Gargan lakes is extensively used by boreal caribou and even as calving ground for some females. As the quality of these types of areas degrade boreal caribou will use them less often and possibly even stop using them, which will force our land users to travel further to find caribou.

Based on the interviews, there are several environmental trends that we can identify. Quantity of soil moisture and water on the land are changing. It is increasing in some areas and decreasing in others but rarely does it remain stable. Water is the source of life and affects all elements of the land. The increase of water and soil moisture can be, at least partially attributed to permafrost thaw. Permafrost usually contains a large portion of ice, in small or large lenses, and releases lots of water when it thaws. This water can either accumulate on the ground surface or flow underground into lakes and rivers. Therefore, it affects both the soil moisture and the water level in waterbodies. Areas subject to this phenomenon are

problematic for caribou as they tend to avoid wet areas during calving season and at several other times during the year (Government of Canada, 2011).

Another trend identified through the thematic analysis of the interviews is the change in boreal caribou population sizes and movements. Participants have noted that both populations and group sizes are decreasing. Caribou are constantly moving, and their migration patterns are easily disrupted by industry and human behaviour. As one participant remarked, "you can't see them [caribou] on this side [of the river] anymore. I haven't hardly seen them, just one or two, all the time. You hardly see them." In the Northwest Territories, northern herds have shown to be relatively stable, whereas the southern herds, such as those native to the JMR region, are far less self-sustaining and are diminishing in numbers (GNWT, 2016; Environment Canada, 2008). There has been a notable decline in population, with group sizes diminishing to 2 or 3 caribou, as opposed to larger groups of around 15 caribou as was frequently seen in the past (Dehcho First Nations, 2011). Researchers have attributed the declining trend in southern regions to an increased impact from industry and forest fires (Joly, Duffy, & Rupp, 2012). However, there has been minimal industrial influence in the JMR region since the closing of resource exploration in the 1970's, and therefore other factors need to be considered as primary determinants of caribou herd resiliency (Dehcho First Nations, 2011) such as increasing prevalence of wildfires, and permafrost thaw as demonstrated in our analyses.

6.4 Cultural significance of caribou

Finally, another theme arising from the interviews was the cultural significance of caribou. Changes to caribou availability or accessibility for harvesting will have cultural impacts on JMRFN. From the interviews, the primary significance of caribou in the community is for art, medicine (e.g. bone marrow), practical use in clothing or tools (e.g. sinew for snowshoes), and as a traditional source of food, although currently caribou is used less for food than in the past because of the quota. Participants described different uses of caribou including one particularly detailed description, "they use the brains for tanning their caribou hide, they boil the bones and then they take all the bones out and they strain all into something else. And then they put the hide in there, they soak it. That's what they do, I see them, I watch them do that. And then, for the caribou head, they just cook it, and hang it, and let it go round and round roasting- and they eat the- they go for the tongue mostly, and the marrow too. The marrow, they take the bones apart and they freeze them too in the winter time. They just get all the marrows out and use

them as lard. And they make dried meat out of it. For the sinew on the moose and caribou, they make sinew threads. The backstrap has a lot of sinew on it. And I see them do, and those little hooves- moose and caribou hooves- I seen one old man mix the stuff out of the hooves into spruces gum. Because he said its more stronger glue if you mix those two together." Caribou are also a part of how JMRFN experience the land through different senses, as one participant described, "caribou, I need the hide. Yes um, it would be great to see more caribou coming back down this way. I like to listen to their antlers touching each other. It's like click click click click click click- it's like music."

Figure 10 shows how community wellness is directly linked to caribou habitat and indirectly impacted by what affects caribou habitat. Predators, permafrost, water variation and precipitation, forest fire and other threats all impact the caribou population size and its movements. This shows the many factors considered in our project that have a cumulative impact on caribou habitat and community wellness. Less caribou in the JMRFN traditional territory means changing our hunting practices to go hunt further away or start hunting other species less significant to our culture.

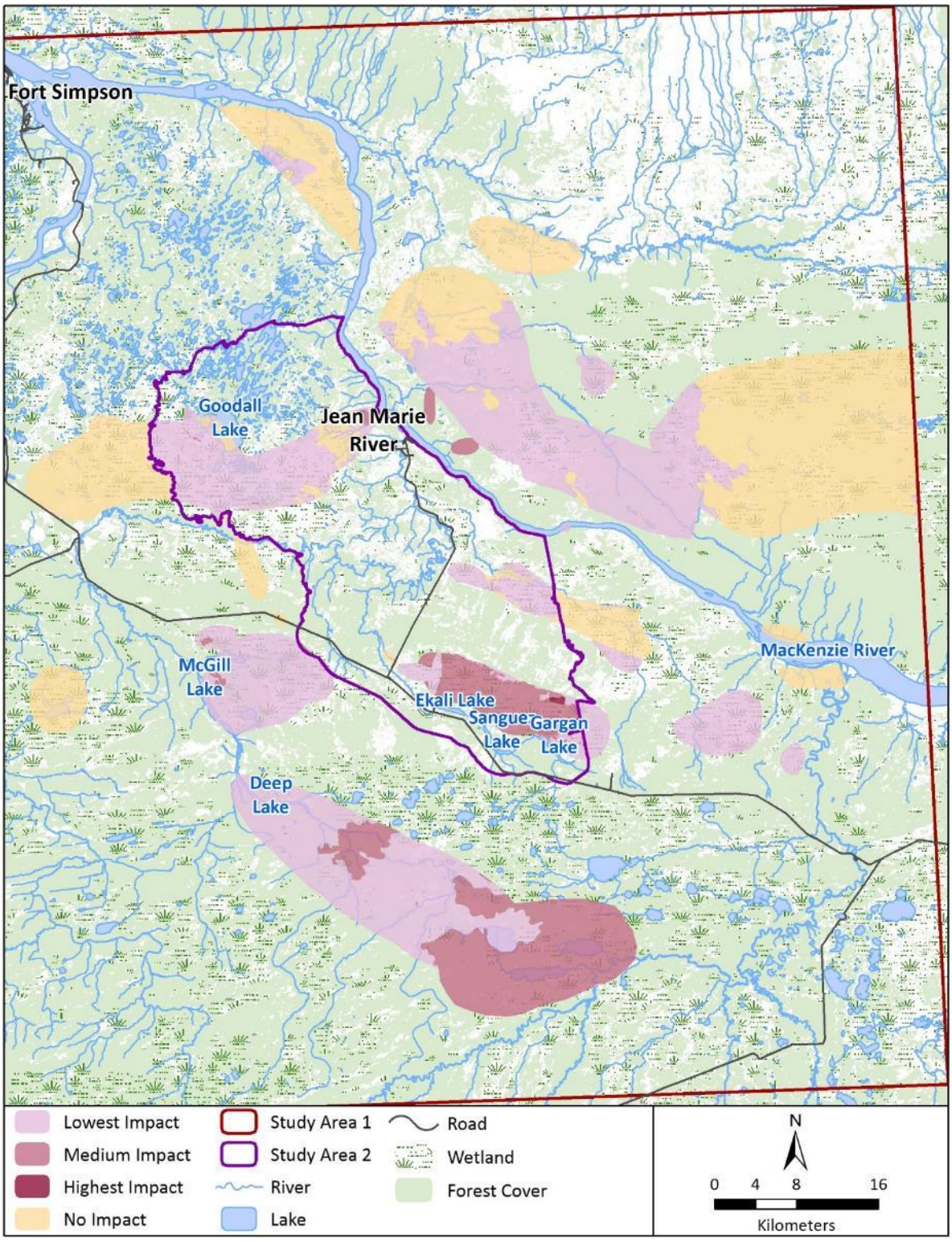

Figure 9: Cumulative impact of forest fire and permafrost thaw on boreal caribou habitat.

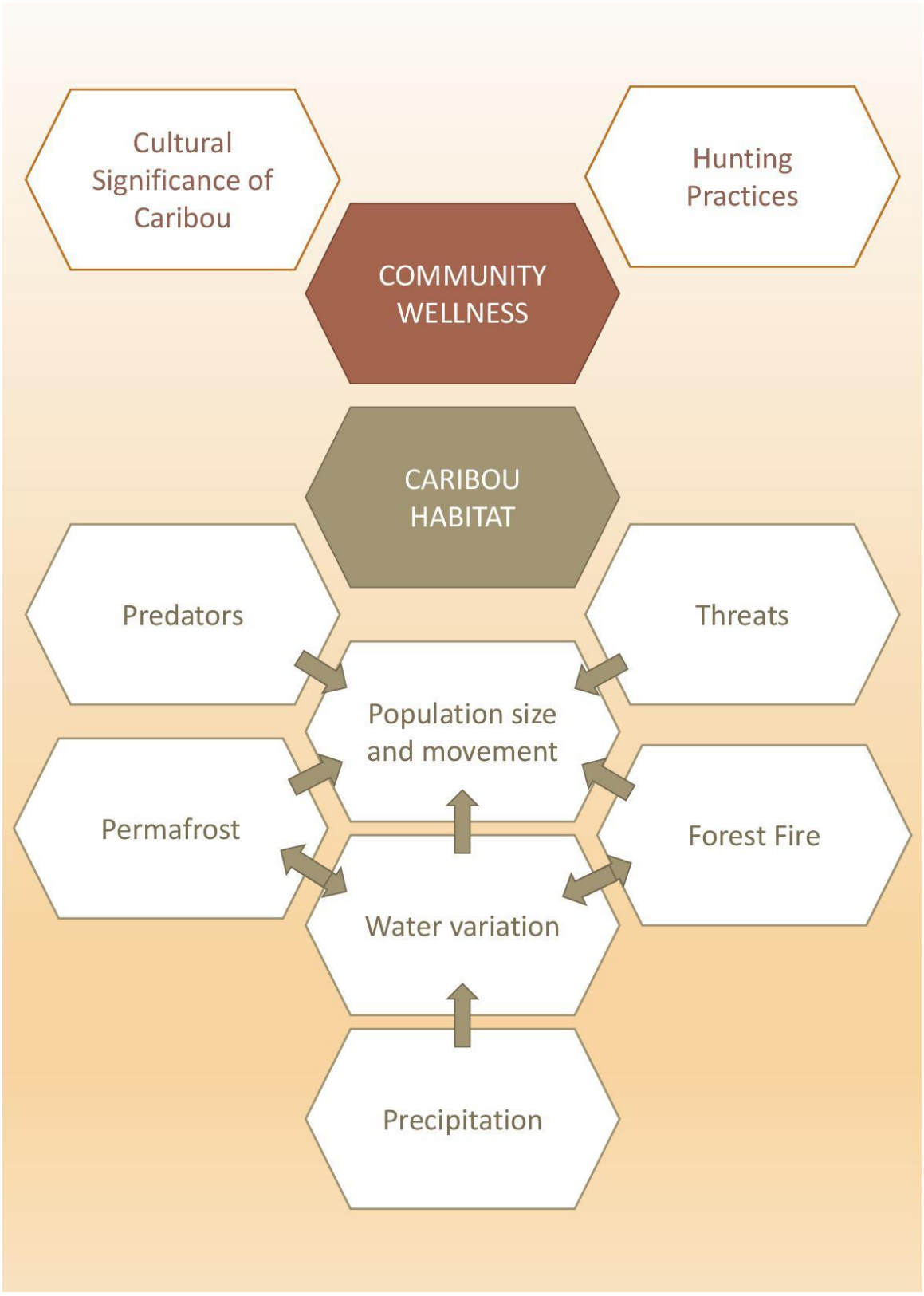

Figure 10: Factors impacting caribou habitat and community wellness and their relationships.

7 Discussion

With this project, we analysed mainly the cumulative impact of permafrost degradation and forest fire on boreal caribou habitat but we also discovered that many other factors impact that same habitat, like other species competing for habitat, predator, vegetation changes, water variation in the soil, and the amount of precipitation. We have kept a focus and put more emphasis on permafrost and forest fire, however our final map reflects the cumulative impact of all these factors. It is significant for us to see that approximately one third of our territory is impacted by forest fire alone and that permafrost can impact more than three quarters of our land. Our final analysis also shows that boreal caribou habitat is currently in a medium state of health and seems to be deteriorating.

Landscape changes can have far-reaching consequences. The increase in wetness in some areas has led to trees dying and falling down. This makes traveling difficult for both humans and caribou, pushing both to find new access routes. It also adds fuel for forest fires. In other areas where it appears that it is getting drier, there are more favourable conditions for forest fire ignition which can contribute to the rapid propagation of fires. There is a direct connection between permafrost thaw and forest fire and both of these factors have an impact on the other, see Figure 10. In areas with better water drainage, thawing permafrost increases the risk for wildfires, which have shown to have a detrimental and long-lasting impact on caribou habitat (Flannigan et al., 2008). Permafrost thaw often disrupts the active layer and causes a shift in the direction of forest growth, causing a “drunken forest” effect and increased tree death (Kokelj, & Burn, 2003). This increase in dead organic matter, therefore, may also increase the incidence of forest fires in an area (JMRFN et al, 2014). Consequently, regardless of the result of permafrost degradation (i.e. flooding in low drainage areas, or increased forest fire risk in high drainage areas) there are consequences for boreal caribou habitat in the region. The impact of permafrost thaw on boreal caribou herds and habitat, therefore, likely includes the eradication of habitat, the formation of more unfavourable landscapes, an increased risk of competition and predation from more moose in the area, as well as a rising incidence of forest fire. However, little is known about the extent of these possible repercussions, resulting impacts on the community, and reactionary adaptions within the boreal caribou habitat in the JMR region. Wildfires also increase the rate of permafrost degradation in an area. When the top organic layer is burned by a forest fire, surface albedo decreases, leading to more heat absorption (Yoshikawa et al., 2003). This results in more permafrost thaw and thickens the active layer. In addition,

climate change has caused an overall lowering of the water table, which has been predicted to increase the likelihood of peatland burns (Flannigan et al., 2008). Peatlands are not only preferential for caribou habitat, but are also associated with permafrost regions (due to the peat's thermal insulation qualities) (Zoltai & Tarnocai, 1975). Therefore, with the increased risk of wildfires in boreal regions, caribou habitat may be particularly vulnerable to both peatland fires and permafrost thaw.

Since forest fire occurrences and permafrost conditions and characteristics are influenced by climate, our project also links to climate change. Increases in temperature and dryness in the environment favour forest fires; in the past few years JMRFN has been seriously affected by forest fire and the community has been partially evacuated on several occasions. Permafrost conditions can be greatly affected by temperature increase and changes in land cover (like forest fire) which can trigger thaw and degradation. We have been feeling the impact of climate change on our health and wellness for years now and it is critical to measure these impacts in order to take appropriate actions and prepare our youth for what is to come. Every aspect we discussed and analysed during this project always ties back to accessibility and availability of country food. In 2014 we had established that our traditional activities were possibly impacted at 33% by permafrost degradation (JMRFN et al., 2014) and today we determine that boreal caribou habitat is in a medium state of health and probably deteriorating. For our community, it means that country food will be more and more difficult to access as the boreal caribou moves away from our traditional territory and the herds traveling through it become smaller. In addition, the areas identified by participants as boreal caribou areas are also heavily used for many traditional activities such as hunting (in general, not just caribou), trapping, and gathering; meaning that if the conditions on the land are deteriorating, that will also impact all of our other traditional activities and our entire diet.

There are many other communities facing the same challenges and we believe that we need to work together and develop food security strategies with concrete actions that can be implemented at the community level by community members with the help of decision-making bodies and governments.

8 Project linkages

This project is community driven, therefore JMRFN was actively engaged in this project from development through results validation. The Jean Marie River Council is particularly interested in the results and how they may impact caribou management practices. We would like the results to inform and influence forest fire management policies and industrial development decisions as well as support the establishment of conservation zones.

This project was discussed in two northern events. Margaret Ireland participated in an Elders gathering on climate change in London, Ontario, where she shared the objectives and advancement of our project. She also traveled to Iqaluit with Cyrielle Laurent to a Pan-territorial workshop on hazards mapping. They were able to present this project as one of the many possible uses of the permafrost map we produced in 2014. Presenting our project in these meetings was a wonderful opportunity to connect with other communities and researchers and show how communities can be deeply involved in research projects.

In developing this project, we were in contact with employees from the GNWT Department of Environment and Natural Resources (ENR) working in the Wildlife Branch. They were interested in how the results from our project could be applied to their work in developing range management plans for which they need as much community input as possible. We will send them the results of our study and also engage with them in discussions around opportunities and limitations to scaling up the methodology. JMRFN can set up a data sharing agreement to share some GIS datasets. GNWT ENR is also interested in knowing if the methodology, particularly modeling permafrost vulnerability, could be applied at a larger scale. This is also something we can explore together and possibly develop future research in this area.

We have also been in contact with Dr. Jennifer Balzer of Wilfried Laurier University about connecting our study with her project on understanding forest and permafrost dynamics following a severe fire year. Her work relates to our study as her project helps to understand the recovery of caribou habitat following fire. We have had conversations with Dr. Balzer and will be following up with her upon completion. Two students are currently working with our research partner at YRC; one of them is producing a boreal caribou habitat quality index (HQI) and comparing changes in vegetation over time in JMR traditional territory. The other student is starting her Master's degree and will be researching the relationship between

permafrost thaw and vegetation composition in JMR traditional territory. All these projects are related to one another and it is important for us as a community to encourage collaborations between projects conducted in our traditional territory. We will try this summer to bring Dr. Baltzer and our YCR research team together in JMR for a meeting to discuss the opportunity of linking our projects and developing collaborations.

9 Contribution to understanding

Part 1		
Monitoring and research conducted *during the project life* led to:		
New or enhanced knowledge in the field of study	☐	
New or enhanced knowledge of cumulative effects	☒	
Directly impacted a current decision-making process (1)	☐	
Could contribute to a future decision-making process	☒	
Development of a standardized monitoring protocol(s)	☐	
Adoption of standardized monitoring protocol(s) by decision-maker	☐	
Responded to a community concern	☒	
New or enhanced community capacity (2)	☒	
New or enhanced analytical tool	☐	
New or enhanced modeling capacity	☐	
Other (please specify, insert rows as required)	☒	**New research approach**
Part 2 - Must provide evidence that the project results have been directly used in a NWT environmental decision-making process between April 1, 2017 and March 31, 2018.		

Our project does contribute to enhancing knowledge of cumulative effects of forest fire and permafrost by measuring how it impacts boreal caribou habitat and what the consequences are on the people in JMR. Our results show that boreal caribou habitat in the JMRFN area is at a medium state of health and shows that peatlands are particularly sensitive to the cumulative impacts.

This community driven project responds to the need of our people to adapt to a changing environment and to better understand the cumulative impacts affecting our land. With the results of this project we are now in a better position to develop informed food security strategies.

Chief and Council in JMRFN, as a decision-making body, is taking steps to use the results of this project in their climate change adaptation strategy planning. They are working to the development of Łue Túé Sųlái candidate protected area and intend to use our results in this process as well. Jean Marie River First Nation is a member of the Dehcho First Nations, the Mackenzie Valley Environmental Impact Review Board and the Mackenzie Valley Land and Water Board. Now that this project is completed, the next step is to bring the results to these boards and organisations, so that we can inform and influence forest fire management policies and industrial development decisions as well as support the establishment of conservation zones.

Our choice of using TK and scientific knowledge is a new research approach that very few people use. It is vital for communities to use this approach in collaboration with researchers on various research topics to demonstrate how effective and reliable it is for all kinds of projects. This approach promotes community involvement, capacity building, and collaborations which are important elements that make northern research successful.

During our project we contributed to community capacity by providing training for youth in skills related to conducting interviews. We coached the youth through the training program for the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS 2) where they were awarded a certificate of completion. The TCPS 2 and the hands-on training prepared the youth for future work with researchers who are conducting interviews or focus groups.

10Recommendations

Because our project uses a holistic approach and integrates Traditional and scientific Knowledge our results can serve both the scientific public and northern communities. We would like to see communities working together to face our common challenges including the development of food security strategies on a regional scale. Projects like ours provide tangible information on the impacts that we are facing and therefore help us develop appropriate actions. We would like to hear more about other community research projects conducted in the Dehcho region or even NWT-at-large that are related directly or indirectly to country foods.

- We recommend holding a gathering for that purpose. This is something our community would be interested in organising but have never had the funding resources to do so.

We also believe that our project demonstrates how significant the impacts of permafrost thaw and forest fire are.

- We strongly recommend to systematically include these factors in land use planning, range management planning, and protected area development (e.g. parks, heritage areas, etc.). More specifically in wildfire management, we would like to see the more sensitive boreal caribou habitat areas considered in the wildfire suppression planning in our region.

This proposed one-year project is our baseline project for studying boreal caribou habitat. In the future, in addition to using TK and involving our Elders, we want integrate TK with additional scientific knowledge. In future projects, we plan on using remote sensing, environmental models, and field surveys to evaluate and monitor the loss and rate of degradation of boreal caribou habitat, as well as locate sustainable boreal caribou habitat around our community. TK and scientific data will be analyzed together and results will form a very comprehensive report. As mentioned in the project linkage section (section 8), a student at Sherbrook University, supervised by Dr. Jerome Théau, is currently finalising an essay on boreal caribou habitat quality index (HQI). We would like to do a comparison study to see how these results match our results and analyze the differences. We are also in discussion with Dr. Théau to develop our next project and progress our research on boreal caribou habitat.

11Key messages

Provide (in bullet form) the key messages and/or results of this project. Maximum of 5 bullets. These are high level summary points.

- Boreal caribou habitat is currently in a medium state of health and seems to be deteriorating.
- The deterioration of boreal caribou habitat means that country food will be more and more difficult to access as caribou move away from our traditional territory and the herds traveling through it become smaller.
- Forest fire and permafrost thaw act together to amplify each other's impact. The dead trees resulting from changes induced by permafrost thaw provide fuel for forest fires, which in turn increase the rate of permafrost degradation.
- While community members have adapted to change and now consume less caribou, boreal caribou is still an important species for the Jean Marie River First Nation.

12Anticipated Publications

- YRC will produce their own report on this project using similar title as the present report.
    - Using Traditional Knowledge of JMRFN Elders to better understand changes in the boreal caribou habitat (subject to change)
    - Report publication published on https://www.yukoncollege.yk.ca/
    - Date of completion; summer 2018
- We are also considering submitting a scientific paper for peer-review publication. Date of completion unknown.

13Acknowledgements

The JMRFN would like to thank all the participating community members, Elders, land users, and youth, for their enthusiasm and commitment at the different stages of the project. Some of them have been involved in a number of our research projects and we appreciate their continued support and input without which we could not complete our goals.

We would also like to thank our research team at YRC, composed of Cyrielle Laurent and Alison Perrin, and their research assistant Holly Bull for the skills and expertise they generously share with us. We value strong and reliable partnerships such as this one and wish to continue this fruitful relationship.

14Literature Cited

Bradshaw, C., Hebert, D., Rippin, A., & Boutin, A. (1995). Winter peatland habitat selection by woodland caribou in northeastern alberta. *Canadian Journal of Zoology, 73*, 1567-1574.

Chapin, F., Peterson, G., Berkes, F., Callaghan, T., Angelstam, P., Apps, M., . . . Whiteman, G. (2004). Resilience and vulnerability of northern regions to social and environmental change. *Ambio, 33*(6), 344-349.

Collins, W., Dale, B., Adams, L., Mcelwain, D., & Joly, K. (2011). Fire, grazing history, lichen abundance, and winter distribution of caribou in Alaska's taiga. *The Journal of Wildlife Management, 75*(2), 369-377.

Conference of Management Authorities. (2017). Recovery strategy for the boreal caribou in the northwest territories: species at risk (NWT) management plan and recovery strategy series. Yellowknife: Environment and Natural Resources, Government of Northwest Territories.

Dehcho First Nations. (2011*). Northwest Territories aboriginal traditional knowledge summary reports: Dehcho report.* Fort Simpson: Dehcho First Nations.

Ellis, S. (2005). Meaningful consideration? a review of traditional knowledge in environmental decision making. *Arctic, 58*(1), 66-77.

Environment Canada. (2008). Scientific review for the indentification of critical habitat for woodland caribou, boreal population, in canada. Ottawa: Environment Canada.

Flannigan, M., Stocks, B., Turetsky, M., & Wotton, M. (2008). Impacts of climate change on fire activity and fire management in the circumboreal forest. *Global Change Biology, 14*, 1-12.

Genuis, S., Willows, N., Alexander First Nation, & Jardine, C. (2015). Partnering with indigenous student coresearchers: improving research processes and outcomes. *International Journal of Circumpolar Health,* 74(1).

Government of Canada (2011). Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada. Species at Risk Public Registry. Accessed April 4th, 2018. http://www.registrelep-sararegistry.gc.ca/document/doc2253pa2/appf2_e.cfm#_001

GNWT (2016). Caribou blueprint for boreal caribou in NWT.

Holkup, P., Tripp-Reimer, T., Salois, E., & Clarann, W. (2004). Community-based participator research. Advances in Nursing Science, 27(3), 162-175.

Jean Marie River First Nation, Calmels, F., & Laurent, C. (2014). Food security vulnerability assessment related to permafrost degradation the jean marie river first nation. Jean Marie River First Nation; Yukon College; Watertight Solutions.

Joly, K., Duffy, P., & Rupp, T. (2012). Simulating the effects of climate change on fire regimes in arctic biomes: implication fo caribou and moose habitat. *Ecosphere, 5*(36).

Klein, D. (1982). Fire, lichens, and caribou. *Journal of Range Management, 35*(3), 390- 395.

Kokelj S.V.. Burn C.R. (2003). 'Drunken forest' and near-surface ground ice in Mackenzie Delta, Northwest Territories, Canada. *Permafrost, Phillips, Springman & Arenson,* 567-571.

Ministry of Environment. (2010). *Science update for the boreal caribou in british columbia.* Victoria: Government of British Columbia.

Tobias, T. (2009). Living Proof: The Essential Data-Collection Guide for Indegenous Use-and-Occupancy Map Surveys. *Ecotrust Canada*

Vitt, D., Halsey, L., & Zoltai, S. (2000). The changing landscape of canada's western boreal forest: the current dynamics of permafrost. *Canadian Journal of Forest Research, 30*, pp. 283-287.

Wesche, S., Schuster, R., Tobin, P., Dickson, C., Matthiessen, D., Graupe, S., Williams, M., & Chan, H. (2011). Community-based health research led by the Vuntut Gwitchin First Nation. *International Journal of Circumpolar Health,* 70:4, 396-406.

Yoshikawa, K., Bolton, W., Romanovsky, V., Fukuda, M., & Hinzman, L. (2003). Impacts of wildfire on the permafrost in the broeal forests of interior alaska. *Journal of Geophysical Research, 107*(8148).

Zoltai, S., & Tarnocai, C. (1975). Perennially frozen peatlands in the western arctic and subarctic of canada. *Canadian Journal of Earth Science, 12*, 28-43.

15Appendices

Appendix A: INTERVIEW GUIDE

Using the Traditional Knowledge of Jean Marie River First Nation Elders to better understand changes in the boreal caribou habitat

Introduction

Turn the recorder on and read the following section:

Today's date is _____. The researchers here are Margaret Ireland, Cyrielle Laurent, Alison Perrin, Holly Bull, _____ and _____ (two JMR youth). _____ will be taking notes during the interview and we will be recording the interview with a digital voice recorder. _____ will be taking pictures during or after the interview. The knowledge holder has read and signed the consent form and we have assigned Interview ID # ____.

We are documenting Traditional Knowledge on boreal caribou with the Jean Marie River First Nation to better understand cumulative impacts on caribou habitat and how fire and permafrost impact their habitat. This information will help the caribou management decisions of the Jean Marie River First Nation, DehCho First Nations and Government of the Northwest Territories.

The interview will take about an hour and you can take a break or decide to stop whenever you would like. We will be asking questions about your knowledge and use of caribou, how caribou use the land, and how the land has changed over time. If there's anything that we don't ask about that you think is important, please let us know.

Background Information Questions

What year were you born? (*optional – gives a sense of the time scale in relation to their answers*)

Have you always lived in Jean Marie River?

What types of activities do you do on the land?

- What types of activities did you do on the land when you were younger?
- Where do you spend time on the land? (Mapping question)
- What seasons are you there?

Caribou Knowledge

Are boreal caribou important to you and your community?

- What role do caribou fill in your community?
- Has this changed over time?

What is the name for boreal caribou in your language?

- Are there other special words that are specific to caribou?

Caribou Hunting

Do you hunt caribou (or your family)?

- Have hunting practices changed over time? Why?

- Are caribou easier or harder to hunt now?
- How many do you usually harvest a year? Has that changed over time?
- Where did you go hunt caribou when you were younger? (Mapping question)
- Where do you go hunting now? (Mapping question)
- Have your hunting areas changed in size over time? Why do you think is changed? (Mapping question)
- Are there changes to how you access your hunting areas? Can you use the usual trails and routes?
- What are the barriers to hunting (i.e. getting enough or getting more)?
- What time of year are you hunting?

Caribou Condition and Habitat

When/how/what time of year do you usually see caribou?

Have the number of caribou changed over time? Compared with what your parents/grandparents said, are there more or less now? If yes: why do you think this is?

Where are you seeing caribou? (Mapping questions)

- What type of landscape do you find caribou in?
- What areas around here are important to caribou? (areas)
- Can you locate caribou calving grounds on the map? (sites)
- Can you locate caribou feeding grounds on the map? (sites)
- Why are those places important to caribou? What are they looking for?
- How does this change at different times of year? (winter/summer)
- Have you noticed changes in the timing of when they are there? If yes: Why do you think this is?

What do caribou eat? (Mapping questions)

- What type of plants are important to them? Has this changed?
- Where do these grow? Are you seeing changes in where or how they're growing? (Mapping question)
- What things (animals, landforms, plants, etc.) do they stay away from? Or are they attracted to?

What does a healthy herd look like to you (i.e. number of bulls/cows/calves)?

- Have you noticed any changes in the survival of calves? If yes: Why do you think this is?

Have you noticed changes in the health or quality of caribou? (e.g. body condition, size, behaviour, parasites, diseases, mortality) If yes: Why do you think this is?

Do you know any traditional stories or oral histories about caribou?

- Any about where they are or at what time of year?/changes in behaviour?

Changes on the land

Have you noticed changes in weather? (snow, rain, seasons?)

What changes have you seen that may have changed the way caribou use the land? (Mapping questions)

- Where have you noticed landscape change? (vegetation, soil condition)
- Where have you seen permafrost thaw? Describe the changes.
- Where have you seen forest fires? How bad were they?
- How quickly does vegetation grow back after fires?

- Do forest fires change the way caribou use the land? Will they return to burned areas and how long does it take for them to come back?

Are you seeing more or less of other animals in the area? (predators?) Why do you think this is?

What do you think are the biggest stressors to caribou in this area?

- Does the way people travel impact caribou? (skidoos, ATVs, etc.?)

What are JMR's (or DehCho's) cultural management practices for caribou?

- Are there other (GNWT) management practices that impact caribou?

Mapping codes

BR	berries gathering
CB	cabin
CR	caribou presence
EG	eggs gathering
WG	wood gathering
FH	fishing
PL	plants
MP	medicinal plant
TN	tent
HA	hunting area
TR	travel route
CH	caribou habitat
CG	calving ground
FG	feeding ground
LC	landscape change
PT	permafrost thaw
FF	forest fire