Natural Capital of the Elephant Hill Wildfire Area

Valuation of the ecosystem services affected by the 2017 Elephant Hill fire

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EARTH ECONOMICS

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SECWEPEMCÚL'ECW RESTORATION AND STEWARDSHIP SOCIETY

Contents

TABLES

FIGURES

PHOTOS

Photos were taken on Secwépemc territory, in and around the burn area. We are grateful to the organizations and people who generously shared their photographs.

Some photos have been reproduced, with permission of the photographers and authors, from:

Dickson-Hoyle, S. & John, C. (2021) Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery. Secwepemcúl'ecw Restoration and Stewardship Society.

Ignace, M.B., Turner, N.J. & Peacock, S. L., Editors. (2016) Secwépemc People and Plants: Research Papers in Shuswap Ethnobotany

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Summary

This report was prepared for the Secwepemcúl'ecw Restoration and Stewardship Society (SRSS) to evaluate the natural capital impact of the 2017 Elephant Hill fire in economic terms.

SRSS is an organization of eight First Nation communities whose traditional territories were impacted by the fire.

Solstice Sustainability Works Inc., in association with Earth Economics and Michelle Molnar Consulting, used well established ecological economics approaches to valuing ecosystem services. Natural capital valuation has its limitations, but it is a useful tool for ensuring that nature's services do not get undervalued in decision-making. Nature has infinite value, but in practice it is often not given economic weight and effectively valued at zero. Natural capital valuation makes its worth more visible.

SRSS supported us to identify the ecosystem services of particular significance to community members – cultural and well-being services, the existence of a richly biodiverse territory, and food harvesting, as well as services that could have a broader set of beneficiaries in the region – water, air and climate regulation, plus natural hazard mitigation. We were also tasked with determining specific losses related to ranching and timber benefits. Our methods represent an agreed upon "medium" level of effort. Throughout the report we also provide suggestions for how SRSS could develop more robust estimates.

We have taken a conservative approach to the valuation throughout, and some ecosystem benefits fell outside our scope or were not capable of measurement. For that reason, even the high end of the estimate likely understates the true value of nature's services in the study area.

All values are in 2021 Canadian dollars (CAD) unless otherwise stated.

ANNUAL ECOSYSTEM SERVICE VALUES

Culture and well-being

We were inspired by recent research in the area of Indigenous cultural ecosystem services to take a well-being approach to culture. Secwépemc culture is deeply rooted in the land and in the sharing of knowledge about how to look after it. Culture includes practices such as tending and gathering plants with medicinal, ceremonial and other uses. Well-being suffers when people don't have access to the land where their ancestors walked to practice their culture. We estimated the value of culture and well-being services based on the replacement cost of community organized cultural workshops and events. The value of substitute activities ranged from $2.6 million to $26.7 million per year, depending on the required frequency of activities.

Biodiversity existence

Elephant Hill is a richly biodiverse area. While Secwépemc people have benefited materially from the diversity of ecosystems and species, Secwépemc teaching sees humans as part of that biodiversity rather than separate from it. Biodiversity is a reality that connects past to present and future generations. To reflect this understanding, we looked at the residual existence value of biodiversity that is not already captured in other services such as culture and well-being, food providing and the regulating services. We used a benefit transfer approach that distinguished Indigenous views to determine a low value of $286,131 per year and high value of $425,819. It is a low number because much of the benefit of biodiversity is accounted for in other services and because the calculation is based on a small number of households.

Material contributions

Harvesting wild food (meat, fish and plants) has tangible nutrition benefits, in addition to the non-material benefits associated with the activity of harvesting it. We limited our valuation to the most commonly consumed foods (deer, salmon and berries), using local replacement costs, for an annual estimate of $1.2 million representing our low estimate. The high estimate, utilizing benefit transfer, is $39.9 million and includes all material provisioning services, not just food. These could include medicine, firewood, and materials for crafts or ceremonial objects. With this higher valuation, there is some risk of double counting with cultural and well-being services.

Water regulation

Elephant Hill, with its landscape of forests, grasslands, lakes and myriad streams is the source for both surface and ground water for ecosystem functions and community drinking water. Healthy ecosystems also serve to purify the water, removing excess phosphorus and nitrogen. We valued the water regulating services of quantity and quality with reference to Canadian and U.S. research. The estimate of drinking water supply ranged from $128,395 per year to $24.3 million per year. For water purification our research did not produce a range, but a point estimate of $433.5 million per year.

Flood and landslide mitigation

The Elephant Hill fire unleashed both floods and landslides in the area, so it was not hard to imagine that pre-fire flood and landslide mitigation would be important services, especially as communities adapt to a changing climate. We transferred benefits from forest and wetland studies for flood mitigation and two Alpine studies on mountain forests for landslide mitigation. Our estimate of flood and landslide mitigation value ranged from $58.4 million to $101.5 million per year.

Air quality

The vegetation of healthy ecosystems plays an important role in cleaning the air. We used two studies from rural Washington State that model the human health benefits of air pollutant removal by vegetation. We estimate that the pre-fire vegetation of Elephant Hill provided $905,145 annually in air quality services.

Carbon sequestration

With climate change an increasing concern, ecosystems are highly valued for their ability to remove excess carbon from the air. We applied the social cost of carbon to our land cover analysis for this study. Our estimate of the annual carbon sequestration benefit from Elephant Hill ecosystems pre-fire ranges from $15.2 million to $366.1 million.

ONE-TIME LOSSES

Carbon storage

Unlike carbon sequestration, carbon storage is not an annual figure. It represents the total carbon locked up in biomass (vegetation and soils) at a point in time. By burning trees and soils, the Elephant Hill fire released vast amounts of carbon and turned the area into a source of carbon to the atmosphere, as opposed to a reservoir for it. We used field data from the Elephant Hill fire area and the social cost of carbon to calculate the change in value of carbon stored before and after the fire. We estimate this difference, representing carbon released, at between $1.57 billion to $1.58 billion.

Productive ranch land

We focused on one Secwépemc ranch within the Elephant Hill area. Bonaparte First Nation was unable to use their grazing tenure for a three year period from the fire. We calculated the lost economic benefit based on average beef prices for the number of cows and calves the tenure would support. We estimate a loss of between $317,952 and $426,222.

Timber benefits

SRSS communities receive a share of economic benefits from timber harvesting under Forest Consultation and Revenue Sharing Agreements (FCRSA) or Interim Forestry Agreements (IFA). We calculated the First Nations share as a percentage of the value of the total timber lost in the Elephant Hill fire, on the assumption that the timber burned in timber supply areas would have been eligible for harvest at some point. We took into consideration the varying burn severity across the area. Our low estimate of lost revenue is $83.1 million, and the high estimate is $137 million.

The ranching and timber benefits differ from the others in that they represent actual lost revenues, rather than an economic interpretation of ecosystem service values.

Table 1 provides a summary of all estimated values, in 2021 Canadian dollars.

Table 1: Summary of natural capital values

Ecosystem service	Low estimate	High estimate
	Annual values	
Culture and well-being	$2,568,325	$26,710,580
Biodiversity*	$286,131	$425,819
Material contributions	$1,256,346	$39,900,630
Water supply	$128,395	$24,339,558
Water purification	$433,498,473	$433,498,473
Flood and landslide mitigation	$58,396,592	$101,480,687
Carbon sequestration	$15,246,743	$366,139,012
Air quality	$905,145	$905,145
Total annual value	**$512,286,150**	**$993,399,904**
	One time values	
Carbon storage loss	$1,568,000,000	$1,584,000,000
Ranching loss**	$317,952	$426,222
Timber benefit loss**	$83,146,031	$136,993,780
Total one time value	**$1,651,463,983**	**$1,721,420,002**

* represents residual existence value not already included in other services

** represents lost revenue to First Nations

CHAPTER 1

Introduction to the Project and Study Area

CONTEXT FOR THIS PROJECT

This project was born from the ashes of the Elephant Hill fire that charred almost 192,000 hectares of Secwepemcúl'ecw, the traditional territory of the Secwépemc people, in the summer of 2017.

The fire burned for 75 days and was one of the worst fires in an historically bad wildfire season (SRSS, n.d.). The burn area, in the interior of British Columbia was directly north of Cache Creek and fewer than 80 kilometres west of Kamloops. Important water features were severely affected, including Loon Lake, Hihium Lake, the Bonaparte River on the west side of the fire area and Deadman Creek on the east side, as well as many smaller streams. Some stream channels were destroyed, and others changed course.

The fire was so intense that it in places it burned the soil away, exposing bare rock and scorching buried seeds. The combined effects have made natural regeneration difficult (SRSS, n.d.). As of the writing of this report, the Elephant Hill fire area remains an altered landscape.

The fire directly affected the traditional territories of eight communities within the Secwépemc Nation. These communities came together in the aftermath of the fire to partner with the BC provincial government through the Elephant Hill Wildfire Recovery Joint Leadership Council and Joint Technical Committee. The SRSS was later founded to coordinate and carry forward this work of recovering and restoring Secwepemcúl'ecw through Secwépemc stewardship.

Figure 1: Satellite image of burn area

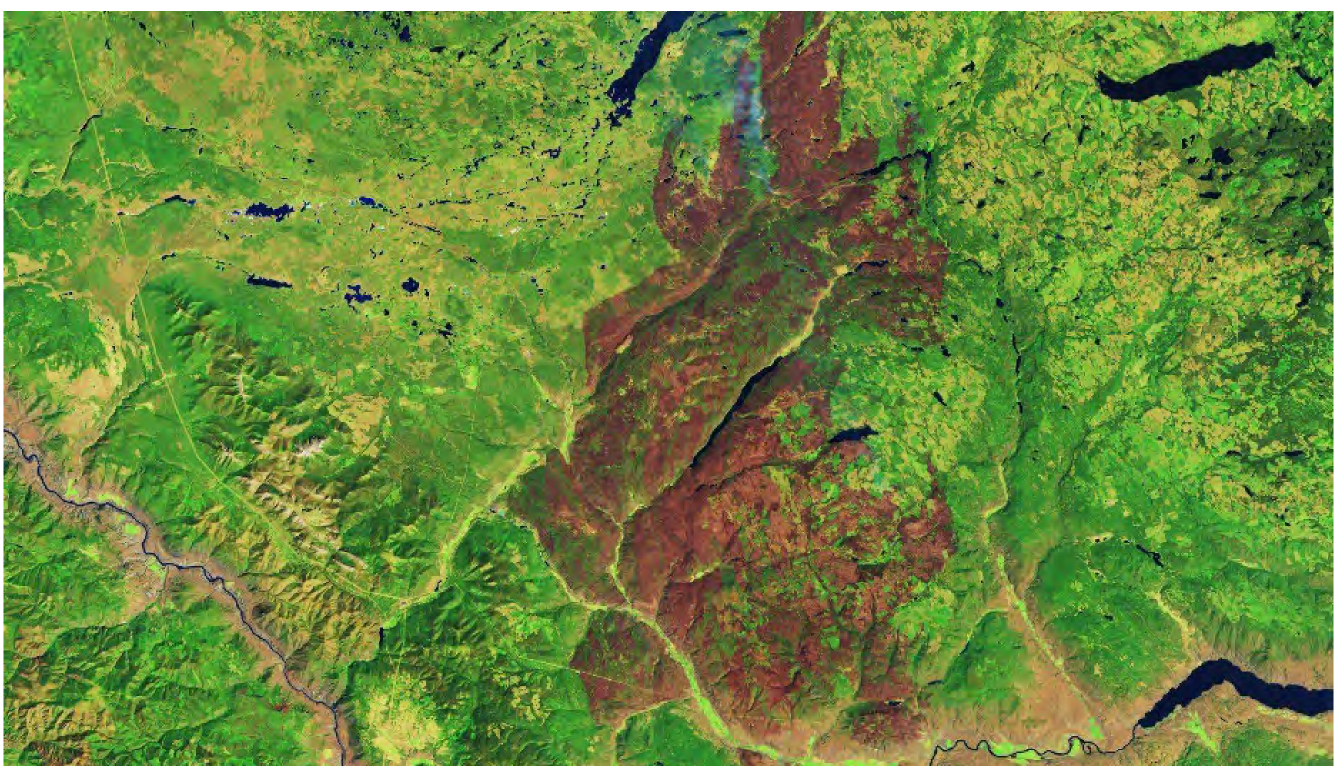


Image credit: Skeetchestn Natural Resources Corp.

High severity burn near Hihium Lake. Photo credit: Sarah Dickson-Hoyle.

SRSS also wished to take stock of the fire's impact on the ecosystem services the communities rely upon. They commissioned this natural capital valuation as a way of estimating, in an economic sense, the value of what nature provided before the fire. Natural capital valuations can only approximate the full value of the complex array of services nature provides, especially when these services have been mediated over generations by the people living in those lands. As such, this should be considered a partial valuation and a starting point for discussion. Its purpose is to educate and communicate about the importance of the area's ecosystem services, with a view to informing future decisions affecting Secwepemcúl'ecw.

OVERVIEW OF THE PROJECT

We conducted this study in phases over two years beginning in January 2020. We started with a scoping study to identify sources for economic, geographic and ecological data. We also devoted time to developing a literature base and understanding the area, its people and the impact of the fire. We used the information to prepare a plan and budget for a valuation of the area with three options for level of effort. These ranged from lowest effort being entirely done through benefit transfer (see *Natural Capital Valuation*), medium effort where strategically chosen local information could be used to refine results from benefit transfer, and highest effort being primary research. SRSS chose to pursue a medium level of effort, and we have added options for additional research where relevant. We presented the proposed study plan to the Joint Leadership Council of SRSS in February 2021, where it was accepted. SRSS embarked on fundraising, and we began work on Phase 2 in July 2021. Throughout the project, the consulting team was actively assisted by SRSS staff and natural resources staff of various SRSS communities. Planned trips to the study area were derailed by waves of the COVID-19 pandemic and wildfire.

Figure 2: Location of study area

Sources: Esri, GeoBC, BC Wildfire Service

ETHICS

Our primary ethical considerations for this work relate to ownership of community information and the appropriateness of quantifying and monetizing cultural services, especially in an Indigenous context.

We did this study with direction and support from SRSS. Through the scoping phase we determined that we would not be conducting any primary research that required personal interviews of elders or other community members. We did interview staff of SRSS and other Secwépemc communities and organizations in their professional capacity to gather information and relevant context, and this engagement took place either through introductions from SRSS or through SRSS directly. SRSS reviewed this report and gave permission for the inclusion of maps and other information that originated with community organizations. For further information about community natural assets, inquiries should be directed to SRSS and/or each community's natural resource staff.

With respect to cultural services, our approach is detailed in that chapter together with its limitations. Considering the importance of the Elephant Hill area to the culture of the affected communities, we determined that our estimation, with all its inherent weaknesses, was better than implicitly valuing cultural services at zero. Even so, we acknowledge that there are many ways of knowing and being in the world for Secwépemc people that this study cannot and will not represent.

SECWÉPEMC LAND AND PEOPLE

Secwepemcúl'ecw is a vast area of interior British Columbia that includes parts of major watersheds – the Fraser, North and South Thompson, and Columbia rivers. Its roughly 180,000 square kilometres comprise a diverse landscape of mountains, forests, grasslands, and river valleys, where most of the Secwépemc people live (Ignace & Ignace, 2017).

The Secwépemc Nation consists of 17 communities (First Nations or "bands"), some of which are represented by the Shuswap Nation Tribal Council or the Northern Shuswap Tribal Council. The people speak three dialects of a common language, Secwepemctsín, an Interior Salish language[1]. They are united by this language, a rich history and common culture. Eight of these communities were particularly

1 An exception is Llenlleney'ten (High Bar First Nation) which no longer has any members who speak the language.

affected by the Elephant Hill wildfire, due to proximity of their reserve lands and its impact on traditional territories. For convenience only, we refer to them collectively in this report as the SRSS communities.

We have listed the peoples with their Secwépemc community names and formal First Nation or band names, as used on community websites. We have used the formal names in this report.

- St'uxwtéws (Bonaparte First Nation)
- Llenlleney'ten (High Bar First Nation)
- Skítsesten (Skeetchestn Indian Band)
- Pellt'iq't (Whispering Pines/Clinton Indian Band)
- Stswecem'c Xget'tem (Stswecem'c Xget'tem First Nation)
- Tk'emlúps (Tk'emlúps te Secwépemc)
- Ts'kw'aylaxw (Ts'kw'aylaxw First Nation)
- Tsq'escen' (Canim Lake Indian Band)

Table 2: Population of SRSS communities 2021

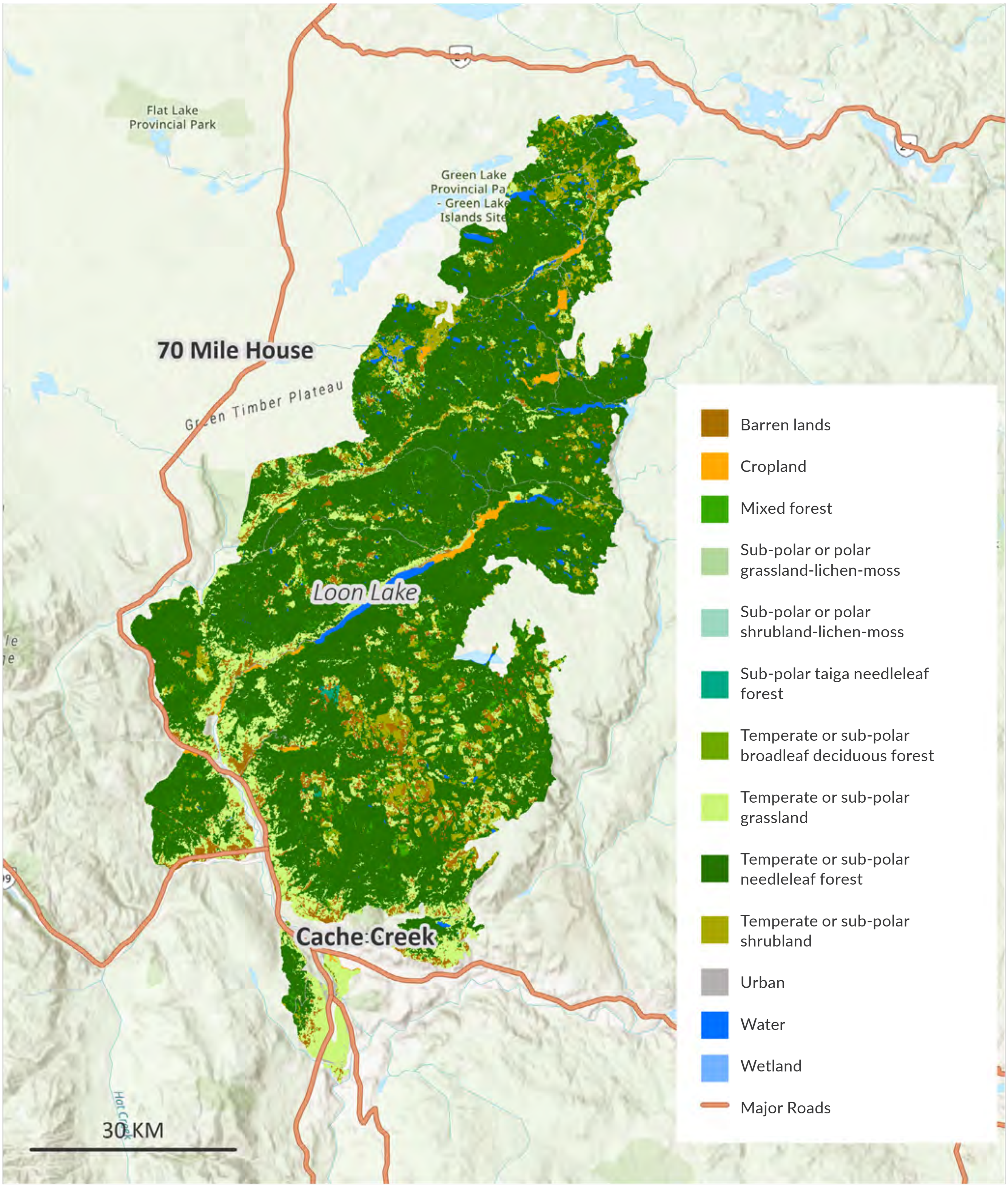
	Total status members on own reserve	Total status members on another reserve	Total status members off-reserve	Crown Land	Total on and off-reserve	Estimate of total adults (81%)[i]	Estimate of households[ii]
Bonaparte	152	47	798	1	**998**		
Canim Lake	403	21	183		**607**		
Tk'emlúps te Secwépemc	561	103	778	1	**1443**		
Skeetchestn	220	32	309		**561**		
Stswecem'c Xget'tem	242	50	502	3	**797**		
Ts'kw'aylaxw	186	78	316		**580**		
Whispering Pines/Clinton	41	6	153		**200**		
High Bar	1	2	218		**221**		
Total	**1806**	**339**	**3257**	**5**	**5407**	**4380**	**2253**
% Total	**33.4%**	**6.3%**	**60.2%**	**0.1%**	**100.0%**		

Source: INAC profile December 2021 except for Bonaparte (profile site was unavailable) where we used 2016 census data from Statistics Canada. The census data comes with caveats about accuracy. We used 2021 data after confirming with SRSS that community populations had not changed dramatically since the fire. https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations/first-nations-negotiations/first-nations-a-z-listing

i We used census data for the number of youth in each household.

ii We used Statistics Canada norm of 2.4 people per household and applied it to total population. This may overstate the number of households if housing is in short supply.

Figure 3: Land cover in study area



Sources: Esri, USGS, North American Land Change Monitoring System

ECOSYSTEMS OF ELEPHANT HILL

For area based valuations we need to know the area of each type of land cover in the fire area. We identified ecosystems from the main land cover types present in the Elephant Hill study area before the fire. Land cover classification was based on the North American Land Change Monitoring System (2015)[2]. The classification corresponded well to the Normalized Difference Vegetation Index (NDVI) obtained from satellite monitoring in 2016 and was better at distinguishing grassland from exposed rock. However, it does not have a fine enough resolution to show all the streams and smaller water bodies (see *Water Regulation* for finer resolution map). For some sections of the report (*Climate and Air Regulation* and *Timber Benefits*) we also used the Provincial forest inventory data from the Vegetation Resource Inventory (VRI).

Table 3: Land cover area pre-fire

Land cover	Hectares
Forest, deciduous	595
Forest, evergreen	135,374
Forest, mixed	3,785
Subtotal forest	139,754
Grassland	25,374
Shrubland	12,437
Water	3,068
Wetland	6
Barren lands	8,276
Cropland	1,424
Total	**190,339**

Elephant Hill land cover before the fire was dominated by forests of various type and seral stage, and also included grassland and water sources, which includes wetlands, lakes, rivers, streams and their riparian areas. Wetlands are extremely productive ecosystems with typically high ecosystem service values, but since they are a very small proportion of the area, we have combined them with water where relevant. Shrubland, in our context, is similar to grassland and is combined with it for some services. The total area within the fire boundary was closer to 192,000 hectares, but we excluded built up land for our analysis.

A LANDSCAPE SHAPED BY FIRE

We prepared this evaluation at a point in time – just before the Elephant Hill fire. However, the landscape that provides the ecological services is dynamic and influenced by human interaction.

Human induced climate change has already affected ecosystem services and will continue to do so (Molnar et al., 2021). Within our scope we could not describe all the ways climate change will affect future ecosystem services in the study area, but we acknowledge that it will have significant implications. One way climate change is leading to losses in ecosystem services is by driving changes in wildfire patterns, with large destructive wildfires becoming more common (Lee et al., 2015).

Wildfire is not always destructive. Indigenous people in Western North America have long lived with and managed fire as stewards of their natural resources (Christianson, 2014; Knight et al., 2022; Lake & Christianson 2019). Historically, Secwépemc people used fire on a regular basis to maintain a landscape that nurtured a diversity of plants and animal life that sustained the people (Dickson-Hoyle et al., 2021; Ignace & Ignace, 2017; Turner, 1999). Indigenous fire management maintained the grasslands with small, controlled fires that kept the forest from encroaching and encouraged seed germination. This practice has the co-benefit of burning away excess fuel, preventing catastrophic fires that could threaten communities and cultural sites. The importance of

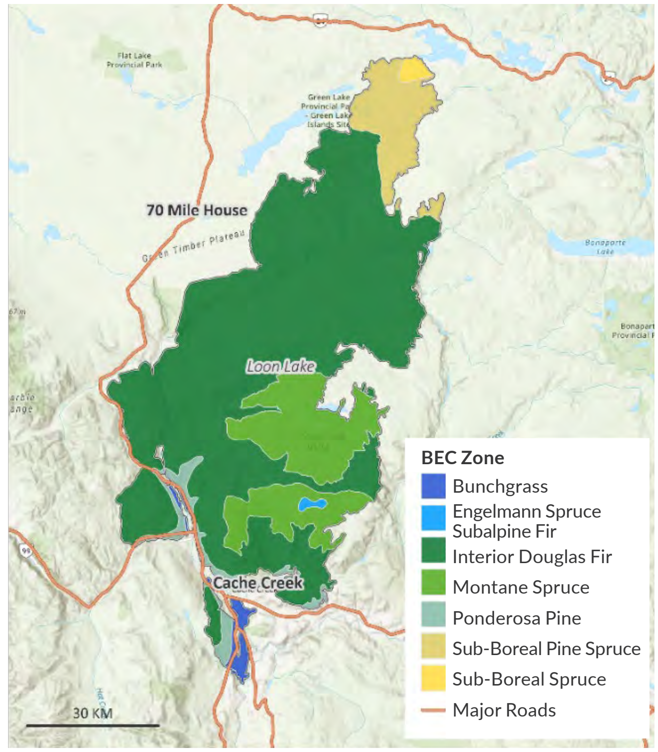
2 https://www.mrlc.gov/data/north-american-land-change-monitoring-system

fire in the Indigenous relationship with the land led Pausus and Keeley (2019) to position wildfire as an ecosystem service that drives other regulating, provisioning and cultural services.

In the period of professional forestry, forests have been managed differently – fire that could damage valuable timber has been actively suppressed (Lake & Christianson, 2019) and forest composition has shifted towards softwood species that are favoured for timber harvesting. We can see from the maps of biogeoclimatic (BEC) zones (Figure 4) and the vegetation resource inventory (VRI) (Figure 5), that the forest in the Elephant Hill area is dominated by softwoods, while the deciduous species which can act as a natural firebreak are less prominent in the landscape (Anderson, M. interview February 29, 2020). Fire suppression was also practised in the Elephant Hill areas (SRSS, 2021). There is growing recognition that managing forests exclusively for timber has actually increased the risk of devasting fires such as the one that affected the Elephant Hill area (Hessburg et al., 2019). The focus on a limited set of economic benefits may be undermining the broader range of ecosystem service values. This has led to renewed interest in Indigenous-led restoration and stewardship (Dickson-Hoyle et al., 2021).

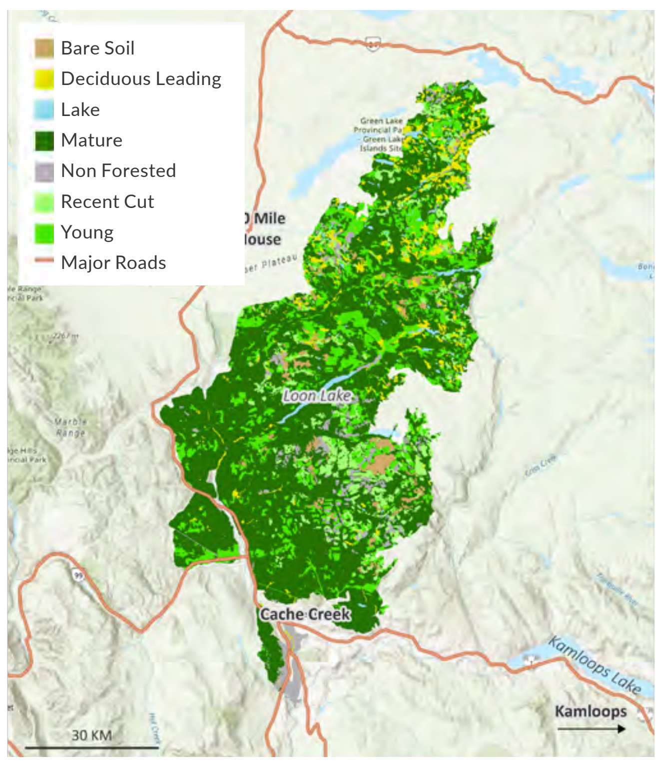
Indigenous people and forest management professionals alike are increasingly looking to traditional Indigenous knowledge, especially about fire management, to increase forest resilience to climate change and other disturbances (Copes-Gerbitz et al., 2021; Dickson-Hoyle et al., 2021; Hessburg et al., 2019; Lake & Christianson, 2019; Lake et al., 2017).

Figure 4: BEC Zones



Sources: Esri, USGS, GeoBC, BC Forest Analysis and Inventory

Figure 5: Land cover classification (VRI)



Sources: Esri, GeoBC, BC Forest Analysis and Inventory

Former Kukpi7 Ron Ignace tends a cultural burn.
Photo credit: Marianne Ignace.

FIRE ADAPTED ECOSYSTEMS

The Elephant Hill area is a good example of the dry forest ecosystems of interior British Columbia and the U.S. Inland Northwest that are naturally shaped by regular low-to mixed-severity wildfires. Plant species in such fire adapted ecosystems have evolved to tolerate or take advantage of fires. For example, ponderosa pine (Pinus ponderosa) has developed protective bark, deep root systems, open crowns and scales on the buds to withstand some fire events (Fitzgerald, 2005). Forests in low-to mixed-severity fire adapted ecosystems tend to be more open, allowing room and light for a wide range of understory plants such as shrubs, grasses, and flowering plants (Hagmann et al., 2013; Harvey et al., 2017; Hessburg et al., 2005). If regular, smaller fires are suppressed, trees eventually invade grasslands, producing denser forests which provide the fuel and close spacing that permit more severe wildfires (Harvey et al., 2017; Hessburg et al., 2019).

INDIGENOUS FIRE MANAGEMENT

Nikolakis and Roberts (2020), Lake and Christianson (2019), and Lake et al. (2017) explain how Indigenous Peoples in Western Canada have long used low intensity burning for cultural purposes, to reduce risks and to promote crop growing, harvesting, and hunting. A "cultural burn" refers to a fire whose primary purpose is to fortify and renew the landscape by encouraging the growth of forage and medicinal plants for the benefit of all species (Boutsalis, 2020).

As supported by the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and other international and national agreements, several First Nations have been revitalizing their cultural burning practices and supporting local fire management efforts.[3] The revival of Indigenous fire management practices alongside provincial forest management and fire governance is integral to protecting communities from wildfire (Lewis et al., 2018).

Based on a study conducted with The Confederated Tribes of the Colville Reservation, Wynecoop et al. (2019) find that integrating Indigenous knowledge in mainstream fire management – particularly with respect to thinning and prescribed burning – helps vegetation respond to future fires. As these studies show, Indigenous fire management promotes healthy, fire-resilient forests that provide multiple benefits to Indigenous communities and beyond.

3 For example, the Western Klamath Restoration Partnership (see Lake et al., 2018) and efforts by the Xwisten Nation, Shackan Indian Band, and the Yunesit'in governments. It should be noted, however, that while "prescribed burns" conducted by fire service professionals also reduce fuel loads, they do not necessarily incorporate all the values of a cultural burn.

ECONOMIC ACTIVITY

The historic economy of Secwépemc people is well documented in Ignace and Ignace (2017). The important point for our purpose is that the land has consistently been at the heart of the Secwépemc economy. Until colonization in the nineteenth century, Secwépemc people relied on the land to harvest materials for their own food, shelter, medicine, and cultural practices and to trade with others. Family and community territories were maintained through law and custom, and their resources carefully stewarded.

With settlement and colonial laws, the economic activity of the Secwépemc people changed radically. By the first half of the twentieth century Secwépemc people carried out a mixed economy that involved waged work – often as ranch and farm labor – together with hunting and fishing. They also continued to gather wild plants, but hunting and plant gathering were constrained by no-trespassing rules, and the expansion of the settler economy which included ranching, logging, and mining. The Indian Act and the residential school system sought to separate Secwépemc people from their land and further bind them to the wage and market economy.

In the twenty-first century Secwépemc people are again asserting ownership and stewardship of their lands and resources. Some members are still employed in ranching but some of these operations are Secwépemc owned (https://issuu.com/secwepemcnews)(see *Productive Ranching Land*) and First Nations have negotiated agreements to share benefits from timber harvesting (see *Timber Benefits*).

First Nations communities in the area have demonstrated an ability to proactively address challenges. For example, following the Elephant Hill fire, when an influx of mushroom pickers from outside the community threatened further destruction, SRSS asserted its law and put in place a permit system to control the morel harvest (Dickson-Hoyle & John, 2021). When a mining proposal threatened a sacred site, the Tk'emlúps te Secwépemc and Skeetchestn Indian Band, formed a joint organization known as Stk'emlupsemc te Secwépemc Nation (SSN) to bring forward community knowledge of how it would damage the land, fish and community (SSN, 2017), resulting in the rejection of the project.

SRSS communities are also addressing longer term challenges such as climate change and the impacts of industrial forestry. They have created natural resource stewardship functions with responsibility for monitoring and restoring the health of forests and streams and conducting archaeological surveys in advance of harvesting. Some SRSS communities also participate in the Secwépemc Fisheries Council which monitors salmon population and harvest numbers.

This valuation project continues in that vein – integrating knowledge and practice to understand and care for Secwépemc territories.

REFERENCES

Boutsalis, K. (2020). The art of fire: Reviving the Indigenous craft of cultural burning. *The Narwhal*. Retrieved January 19, 2022, from https://thenarwhal.ca/Indigenous-cultural-burning/

Christianson, A. (2014). Social science research on Indigenous wildfire management in the 21st century and future research needs. *International Journal of Wildland Fire, 24*, 190–200. https://doi.org/10.1071/WF13048

Copes-Gerbitz, K.M., Hagerman, S. & Daniels, L. (2021). Situating Indigenous knowledge for resilience in fire-dependent social-ecological systems. *Ecology and Society, 26*(4):25. https://doi.org/10.5751/ES-12757-260425

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery*. Secwepemcúl'ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm

Dickson-Hoyle, S., Ignace, R.E., Ignace, M.B., Hagerman, S.M, Daniels, L.D., & Copes-Gerbitz, K. (2021). Walking on two legs: a pathway of Indigenous restoration and reconciliation in fire-adapted landscapes. *Restoration Ecology, Strategic Issues Article*. https://doi.org/10.1111/rec.13566

Fitzgerald, S. (2005) Fire Ecology of Ponderosa Pine and the Rebuilding of Fire-Resilient Ponderosa Pine Ecosystems In: Ritchie, M.W., Maguire, D. A. & Youngblood, A., tech. coordinators. *Proceedings of the Symposium on Ponderosa Pine: Issues, Trends, and Management, 2004 October 18-21, Klamath Falls, OR*. Pacific Southwest Research Station, U.S. Forest Service, 197-225. https://www.fs.usda.gov/treesearch/pubs/27269

Hagmann, R.K., Franklin, J.F. & Johnson, K.N. (2013). Historical structure and composition of ponderosa pine and mixed-conifer forests in south-central Oregon. *Forest Ecology and Management, 304*, 492–504. http://dx.doi.org/10.1016/j.foreco.2013.04.005

Harvey, J., Smith, D., & Veblen, T. (2017) Mixed-severity fire history at a forest-grassland ecotone in west central British Columbia, Canada. *Ecological Applications, 27*(6), 1746–1760

Hessburg, P.F., Agee, J.K. & Franklin, J.F. (2005). Dry forests and wildland fires of the inland Northwest USA: Contrasting the landscape ecology of the pre-settlement and modern eras. *Forest Ecology and Management, 211*, 117–139. doi:10.1016/j.foreco.2005.02.016

Hessburg, P.F., Miller, C., Parks, S., Povak, N., Taylor, A., Higuera, P., Prichard, S., North, M., Collins, B., Hurteau, M., Larson, A., Allen, C., Stephens, S., Rivera-Huerta, H., Stevens-Rumann, C., Daniels, L., Gedalof, Z., Gray, R., Kane, V.,...Salter, R.B. (2019). Climate, Environment, and Disturbance History Govern Resilience of Western North American Forests. *Frontiers in Ecology and Evolution, 7*, Article 239. doi: 10.3389/fevo.2019.00239

Ignace, M., & Ignace, R.E. (2017). *Secwépemc people, land, and laws*. McGill-Queen's University Press. doi: 10.14237/ebl.9.2.2018.1380.

Knight, C., Anderson, L. Bunting, M.J., Champagne, M., Clayburn, R.M., Crawford, J.N., Klimaszewski-Patterson, A., Knapp, E. E., Lake, F.K., Mensing, S.A, Wahl, D., Wanket, J., Watts-Tobin, A., Potts, M.D. & Battles, J.J (2022) Land management explains major trends in forest structure and composition over the last millennium in California's Klamath Mountains. *The Proceedings of the National Academy of Sciences (PNAS)*119 (12) e2116264119 https://doi.org/10.1073/pnas.2116264119

Lake, F. K., Wright, V., Morgan, P., McFadzen, M., McWethy, D., & Stevens-Rumann, C. (2017). Returning fire to the land: celebrating traditional knowledge and fire. *Journal of Forestry, 115*(5), 343-353.

Lewis, M., Christianson, A. & Spinks, M. (2018). Return to Flame: Reasons for Burning in Lytton First Nation, British Columbia, *Journal of Forestry, 116*(2),143–150, https://doi.org/10.1093/jofore/fvx007

Lake, F. K., & Christianson, A. C. (2019). Indigenous Fire Stewardship. *Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires*, 714-722. https://doi.org/10.1007/978-3-319-51727-8_225-1

Lee, C., Schlemme, C., Murray, J. & Unsworth, R. (2015). The cost of climate change: Ecosystem services and wildland fires. *Ecological Economics, 116*, 261-269. https://doi.org/10.1016/j.ecolecon.2015.04.020

Molnar, M., Olmstead, P., Mitchell, M., Raudsepp-Hearne, C. & Anielski, M. (2021). Ecosystem Services, Chapter 5. In F.J. Warren and N. Lulham (eds.) *Canada in a Changing Climate: National Issues Report*. Government of Canada. https://www.nrcan.gc.ca/sites/nrcan/files/pdf/National_Issues_Report_Final_EN.pdf

Nikolakis, W. & Roberts, E. (2020). Indigenous fire management: a conceptual model from literature. *Ecology and Society, 25*(4).

Pausas, J.G. & Keeley, J.E. (2019) Wildfires as an ecosystem service. *Frontiers in Ecology and the Environment, 17*(5): 289–295. doi:10.1002/fee.2044

Secwepemcúl'ecw Restoration and Stewardship Society (n.d.). Elephant Hill Fire [Webpage]. Retrieved November 9, 2021, from https://www.srssociety.com/elephant-hill-fire.htm

Secwepemcúl'ecw Restoration and Stewardship Society. (2021). February Newsletter. Retrieved January 19, 2022, from https://www.srssociety.com/blog/february-newsletter-2021.htm

Stk'emlúpsemc te Secwépemc Nation. (2017) Honouring Our Sacred Connection to Pípsell: Stk'emlúpsemc te Secwépemc Says Yes to Healthy People and Environment [Webpage]. Retrieved from https://stkemlups.ca/wp-content/uploads/2013/11/2017-03-ssnajaxdecisionsummary_0.pdf, July 21, 2020

Turner, N. (1999). Time to burn. In R. Boyd (ed.) *Indians, Fire, and the Land in the Pacific Northwest*. Oregon State University Press.

Wynecoop, M.D., Morgan, P., Strand, E.K. & Sanchez Trigueros, F. (2019). Getting back to fire *sumés*: exploring a multi-disciplinary approach to incorporating traditional knowledge into fuels treatments. *Fire Ecology, 15*(17). https://doi.org/10.1186/s42408-019-0030-3

CHAPTER 2

Natural Capital Valuation

THE IMPORTANCE OF MEASURING NATURAL CAPITAL

Natural capital studies illuminate the connections between people and ecosystems.

All the things we need to survive, such as food, clean air, drinkable water, and shelter come from natural resources. Natural systems also provide things that are essential for any economy, such as fuel and resources, and nature is where communities find their roots and sense of place. In fact, a recent study estimates that total global ecosystem services provided $160 trillion CAD in 2011, which is more than 1.5 times the size of global GDP (Costanza et al., 2014). However, many of the goods and services provided by nature are economically invisible, and when coupled with the growing disconnect of people from nature, this often leads to the over-use and under-valuing of nature.

When nature's goods and services are lost, we are confronted with quantifiable costs and a decline in our quality of life. The loss of streams for instance, can increase flood risk as water is no longer being stored, retained, and released slowly back into the surrounding environment. To some extent these natural services can be replaced with pipes and culverts, which have a finite lifespan. In some cases, however, no expenditures can replace lost ecosystem goods and services. For instance, the wildlife that depended on the lost stream may not relocate to another stream so easily or individuals who depended on time in nature to ground themselves may not have accessible alternatives.

A growing number of economists, researchers, and scientists are working to bring attention to the many things important to human well-being beyond manufactured products. Things like leisure time, equality, healthy relationships, and time in nature are far more important to happiness than consumption. While many know this intuitively, a great deal of research is helping to build the case. Natural systems are beginning to be recognized as economic assets, providing a flow of benefits over time. Those pursuing this path, are recognizing that our communities, environment, and economy are intricately intertwined, and this knowledge is starting to factor into decision-making with illuminating results.

OVERVIEW OF NATURAL CAPITAL VALUATION AND BENEFIT TRANSFER METHOD

Work to systematically link functioning ecosystems with human well-being arose in academic circles in the latter half of the 20th century. Since then, there has been considerable progress, with the approach entering general awareness in the last two decades, propelling it to become a mainstream practice[4]. Studies such as the Millennium Ecosystem Assessment (Reid et al., 2005), the Economics of Ecosystems and Biodiversity (Sukhdev et al., 2010), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Rice et al., 2018), and the Dasgupta Review (2021), have marked key advancements in the development of a conceptual framework for valuing natural capital and its related goods and services.

4 See, for example, Daly, H. E., & Farley, J. C. (2004). *Ecological economics: Principles and applications.*

Natural capital frameworks translate the complexity of ecological structures and processes into a number of ecosystem functions that provide goods and services of value to people. While these are most certainly a simplification of reality and will continue to be refined, they have gained broad recognition and acceptance. Here we use the latest, and most authoritative classification from the IPBES, with its three categories: 1) regulating contributions, 2) material contributions, and 3) non-material contributions (Table 4). We have made some adjustments to this system – for example we have approached biodiversity from a non-material perspective of existence value, similar to the maintenance of options service. Services covered in this study are shown in bold below.

Through our scoping work, and in collaboration with SRSS, we identified the most significant ecosystem services for the study area. For non-material contributions, we have combined learning, physical and mental wellness, supporting identities, and maintenance of options (crossing generations) under the heading of Culture and Well-being services.

Table 4: IPBES Classification System Used in this Study

Classification	Ecosystem service
Regulating Contributions	**Regulation of climate**
	Regulation of freshwater and coastal water **quality**
	Regulation of air quality
	Regulation of ocean acidification
	Regulation of freshwater quantity, location, and timing
	Formation, protection and decontamination of soils and sediments
	Pollination and dispersal of seeds and other propagules
	Habitat creation and maintenance
	Regulation of natural hazards and extreme events
	Regulation of organisms detrimental to humans
Material Contributions	Energy
	Food and feed
	Materials and assistance
	Medicinal, biochemical, and genetic resources
Non-material Contributions	**Learning and inspiration**
	Physical and psychological experiences
	Supporting identities
	Maintenance of options

Source: IPBES, 2018

Hillside of flowering balsamroot (Balsamorhiza saggitata) near McLean's Lake. Photo credit: Sarah Dickson-Hoyle.

OUR APPROACH AND METHODS

Our study had two distinct approaches. We conducted a natural capital valuation of the ecosystem services that were present before the fire and could have been expected to continue had the fire not damaged the Elephant Hill area. Since burn severity varied across the area and ecosystems respond in differing ways to fire, we cannot conclude that *all* the ecosystem services value was destroyed. This would require field work to evaluate recovery of ecosystem function at relevant points in time after the fire.

At the request of SRSS we also made estimates of specific losses (timber and ranching) that resulted from the fire. As the methods are different, the values should not be added together.

All monetary units are 2021 Canadian dollars (2021 CAD) unless otherwise indicated.

Methods for valuing ecosystem services before the fire

Economists have worked with ecologists and other disciplines to develop techniques (Table 5) to assign dollar values to non-market goods and services provided by ecosystems. As these methodologies require primary research, which can be time consuming and costly, many studies use an approach of "transferring" the monetary values from primary studies to others that are sufficiently similar. This method is called benefit transfer and was used in this study. To improve the accuracy of estimates we sometimes transferred the logic of the calculation from previous studies, but used local data inputs. In transferring values, the project team gave preference to primary studies that fit the following criteria:

- Similar geography
- Similar socio-economic context
- Peer-reviewed
- With respect to material and non-material contributions, we also prioritized studies that had been done with First Nations or other Indigenous Peoples.

Valuation techniques for primary studies fall into three broad categories: 1) direct market valuation approaches, where related market data is used to estimate value; 2) revealed preference approaches, where the market price of associated goods and services indicate minimum values; and 3) stated preference approaches, where people are surveyed to determine how they value the target service. The estimates we transferred were derived from studies that used all three of these approaches. Table 5 provides examples of valuation techniques and how each was used for the purposes of this study. In most cases, our use of these methods was indirect as we relied mainly on a benefit transfer methodology.

Table 5: Non-market valuation approaches and methods

Valuation method	Description	How it was used in this study
DIRECT MARKET VALUATION APPROACHES		
Replacement cost	Estimates value of service according to cost to replace it with human-made systems; for example, waste treatment provided by wetlands can be replaced with costly built treatment systems.	Used to assess value of water filtration
Avoided damage cost	Estimates value, based on cost of treating the damages arising from loss of the service, such as health effects.	Avoided healthcare costs associated with pollution were used to value air quality services
Production approaches	Production approaches assume that an environmental good or service essentially serves as a factor input into the production of a marketed good that yields utility; for example, forests are an essential input to timber production.	Used to value lost timber harvesting and ranching benefits
REVEALED PREFERENCE APPROACHES		
Opportunity cost	Value based on the cost of the next best alternative use of resources.	Used to assess some cultural values (e.g., cost of cultural workshops and other activities)
Travel cost	Value based on travel costs that can reflect the implied value of the service; for example, recreation areas can be valued by what visitors are willing to pay to travel to them.	Not used because we focused on benefits for residents of the area rather than visitors
Hedonic pricing	Value based upon prices people will pay for associated goods; for example, housing prices near greenspace tend to exceed the prices of homes located at a distance from natural areas.	Did not use this method. More applicable in urban centres
STATED PREFERENCE APPROACHES		
Contingent valuation	Value estimated by asking how much people are willing-to-pay for an ecosystem service or how much people are willing-to-accept for being deprived of the ecosystem service. Surveys, structured games, and ranking methods are used to arrive at estimates.	Used selectively when socio-economic conditions were similar (e.g., existence value of biodiversity)
Choice modeling	Value is estimated by posing hypothetical scenarios that involve some valuation of alternatives. Similar methods to contingent valuation are used.	Used in salmon study featured in Biodiversity

Source: Adapted from Molnar et al., 2012

CANADIAN AND GLOBAL NATURAL CAPITAL INITIATIVES

The underlying premise of natural capital accounting is that since nature is important to society and the economy, it should be recognized as an asset that must be maintained and managed, with its contributions (services) measured and considered in decision-making. Today we are witnessing changes in both the public and the private sectors, internationally and nationally.

At the international level, the System of Environmental Economic Accounting (SEEA) (https://seea.un.org/) has been recently adopted as the official international framework for natural capital accounting. Used primarily by the public sector, its use by national governments has grown from 0 in 2013 to over 40 countries, including Canada, by the end of 2019. In the private sphere, the United Kingdom recently developed natural capital accounting standards for private sector organizations (British Standards Institute [BSI], 2021). The Taskforce on Nature Related Financial Disclosures (TNFD) (https://tnfd.global) is working to develop a framework for nature-related risks and aims to shift global financial flows from nature-negative outcomes and toward outcomes that support nature.

Within Canada, considerable work is occurring at the local scale. Groups like the Municipal Natural Assets Initiative (MNAI) (https://mnai.ca) have worked with approximately 100 communities to help them understand, measure, and value the services provided by natural assets. The Insurance Bureau of Canada has partnered with Swiss Reinsurance Company on a pilot project to develop insurance products that are structured around the resilience value of nature (http://www.ibc.ca/pe/disaster/nature-based-solutions).

Valuation of selected economic losses related to ecosystem services

As ranching and forestry are natural resource based industries with economic benefits to SRSS communities, we supplemented our natural capital valuation with estimates of the losses to the natural capital sustaining these industries. For these areas our approach was different because ranching and timber production have known market values.

LIMITATIONS AND CAVEATS

Limitations of natural capital valuations are noted here but should not deter from the over-arching finding that natural systems provide significant value to people, communities, and local economies. These limitations can be grouped into challenges associated with static analysis, unique ecosystems, human-centric analysis, tendency of under-estimation, and conflation of value with price[5].

- Static analysis: This analysis provides estimates of ecosystem service values at a point in time, specifically prior to the Elephant Hill fire of 2017. It ignores ecological interdependencies and dynamics, not because they aren't important, but because this is outside the scope of a benefit transfer approach. Primary studies are best suited to take these considerations into account.
- Unique ecosystems: Every ecosystem is unique, and it can be argued that values cannot be transferred from one study location to another. While it is true that no two ecosystems are exactly alike, ecosystem types share similar functions. For instance, intact forests provide food for sustenance, and riparian wetlands filter water.
- Human-centric analysis: Natural capital frameworks adopt an explicit focus on the value of functioning ecosystems to *people*. In addition to value to people, nature has intrinsic value which should be factored into decision-making.

5 Discussion of limitations has been adapted from Molnar, M., Kocian, M. & Batker, D. 2012)

- Under-estimation: We were not able to locate transferable studies for all services we wished to assess, for example economic value of the medicinal services of wild plants in the area. As such the reported values are an under-estimation of the value of Elephant Hill area ecosystems. Furthermore, it is highly likely society is ignorant of the full range of values provided by natural systems, which implies such studies will always be low estimates and should be interpreted as such.
- Confusing value with price: The terms 'value' and 'price' are often used interchangeably, leading us to think that the price of something signals how much it is worth. Value encompasses price in addition to other factors. The study does not support the monetization of nature, but it does support the appreciation of nature's value, which are two very different things.

There are also some limitations specific to the Indigenous context of this study.

- One-way relationship: Natural capital frameworks tend to treat the flow of benefits as one way from nature to humans. Indigenous worldviews tend to see people as part of nature and with a duty of care towards nature so that there is a two-way relationship (Sangha et al. 2015). We took guidance from Sangha et al.'s Indigenous framework for natural capital valuation by incorporating capability for stewardship in our interpretation of Culture and Well-being services.
- Inseparability of services: Bélisle et al. (2021) investigated the use of an ecosystem services framework in Indigenous contexts. Some of the limitations they found in conventional frameworks have been addressed. In addition, they found that well-being benefits were contextual and could be linked to practices on the land, making it difficult to tease out individual ecosystem services or distinguish provisioning from cultural services. We have addressed this by bundling cultural and well-being services to some extent.

REFERENCES

Bélisle, A. C., Wapachee, A., & Asselin, H. (2021). From landscape practices to ecosystem services: Landscape valuation in Indigenous contexts. *Ecological Economics*, *179*, 106858, https://doi.org/10.1016/j.ecolecon.2020.106858

British Standards Institute. (2021). *First Standard for Natural Capital Accounting*. Retrieved from https://www.bsigroup.com/en-GB/about-bsi/media-centre/press-releases/2021/june/first-standard-for-natural-capital-accounting/

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S., & Turner, R.K. (2014). Changes in the global value of ecosystem services. *Global Environmental Change*, *26*, 152-158. https://doi.org/10.1016/j.gloenvcha.2014.04.002.

Dasgupta, P. (2021). *The Economics of biodiversity: The Dasgupta review*. HM Treasury. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf

Molnar, M., Kocian, M. & Batker, D. (2012). *Nearshore natural capital valuation: Valuing the aquatic benefits of British Columbia's Lower Mainland*. David Suzuki Foundation and Earth Economics. Retrieved from https://davidsuzuki.org/wp-content/uploads/2012/11/nearshore-natural-capital-valuation-aquatic-benefits-british-columbia-lower-mainland.pdf.

Reid, W.V., Mooney, H.A., Cropper, A., Capistrano, D., Carpenter, S.R., Chopra, K., Dasgupta, P., Dietz, T., Duraiappah, A.K., Hassan, R., Kasperson, R., Leemans, R., May, R.M., McMichael, T.A.J., Pingali, P., Samper, C., Scholes, R., Watson, R.T., Zakri, A.H., Shidong, Z., Ash, N.J., Bennett, E., Kumar, P., Lee, M.J., Raudsepp-Hearne, C., Simons, H., Thonell, J., & Zurek, M.B. (2005). *Ecosystems and human well-being: Synthesis*. Millennium Ecosystem Assessment. Island Press. Retrieved from https://www.millenniumassessment.org/documents/document.356.aspx.pdf

Rice, J., Seixas, C.S., Zaccagnini, M.E., Bedoya-Gaitán, M., and Valderrama, N. (2018). *The IPBES regional assessment report on biodiversity and ecosystem services for the Americas*. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://doi.org/10.5281/zenodo.3236252

Sukhdev, P., Wittmer, H., Schröter-Schlaack, C., Nesshöver, C., Bishop, J., ten Brink, P., Gundimeda, H., Kumar, P., & Simmons, B. (2010). *The economics of ecosystems and biodiversity: Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB*. Retrieved from http://teebweb.org/publications/teeb-for/synthesis/

CHAPTER 3

Culture and Well-being

DESCRIPTION OF CULTURAL AND WELL-BEING SERVICES

In this report we interpret well-being to include physical, mental, emotional and spiritual dimensions.

There is increasing recognition of the intangible ways nature enhances human well-being across cultures (Hatala et al., 2020). This has come into sharper focus through the global COVID-19 pandemic as Canadians turned to nature to combat the strain on their mental health (Haggert, 2021). For Indigenous peoples, the relationship with their land is especially important to well-being, including for those living off-reserve in urban areas (Hatala et al., 2020; Wilson & Peters, 2005). Some have described the Indigenous relationship with land as "health sustaining" (Tobias & Richmond, 2014) or a "determinant of health" (Richmond & Ross, 2009).

Nature's cultural services include its source of inspiration and knowledge for art, language and technology. For Secwépemc and other Indigenous peoples, culture is lived, learned and transmitted through the connection to the land. Land is the source of continuity, connecting people to their ancestors, and to future generations (Bélisle et al., 2021; Ignace and Ignace, 2017; Wilson, 2003). Nature's benefit goes beyond direct use of the land for gathering the essentials of life (see *Material Contributions*), to be the foundation of identity and belief system (Wilson, 2003).

Researchers have also linked well-being to the opportunity to express capabilities such as developing and passing on knowledge of how to care for the land (Sangha et al., 2018). Improvements in self-esteem and cultural pride, belonging, and overall health, have been documented among those with a connection to their traditional land.

For this report we are interested in what happens when the connection to the land or the land's cultural services are lost or damaged. Research on displacement or dispossession suggests that loss of the land's cultural services is experienced as a direct impact on well-being (Tobias & Richmond, 2014; Wilson & Peters, 2005). Commentators on the hugely destructive Australian bushfires of 2020, noted the unique anguish experienced by Aboriginal peoples in Australia as they saw their ancestral lands consumed, and suffered again the "perpetual grief" of dispossession (Williamson, Markham & Weir, 2020; Williamson, Weir & Cavanagh, 2020).

In Canada, colonialism, racism, industrialization and environmental damage have contributed to dispossession, which is sometimes experienced by Indigenous peoples as a rupture in how the community lives in respectful balance with the land, exacerbating health inequalities (Richmond & Ross, 2009; Tobias & Richmond 2014). Wildfires in Canada frequently displace First Nations people who are in the path of the fire and these displacements can be enduring, resulting in isolation and psychological distress, as documented in a guide for displaced First Nations people and host communities (Pearce et al., 2017).

In their report on the Elephant Hill fire experience, response, aftermath and lessons learned, Dickson-Hoyle and John (2021) connected the impacts to the land with impacts to the wellness of the communities through interviews with people directly affected. Interviewees spoke of their grief for the lands walked by their ancestors and for their "brothers and sisters" — other species who had lost habitat.

Former Kukpi7 Ron Ignace and son Joe Ignace harvesting corms of spring beauty (Claytonia lanceolata). Photo credit: Sarah Dickson-Hoyle

CULTURAL AND WELL-BEING SERVICES OF THE ELEPHANT HILL AREA

While we have included culture and well-being in our analysis and relied on information from the SRSS communities, we do so as researchers only. We do not attempt to speak for or interpret Secwépemc culture, heritage, knowledge or values.

We observed through our research that Secwépemc culture emphasizes the wholeness of nature. The Elephant Hill fire area covers seven biogeoclimatic (BEC) zones with the integrated whole contributing to culture. We therefore determined that culture and well-being services were delivered across the whole study area before the fire. This is supported by work done by Skeetchestn Natural Resources Corp. (SNR) and Skeetchestn elders to create an inventory of culturally significant plants (unpublished). The inventory was compiled by conducting plot surveys in areas planned for timber harvesting. The cultural plant inventory includes 158 plants that are significant for various, and sometimes multiple, reasons, including food, medicine, structures, traditional technologies, spiritual practice or other cultural use. As the inventory associates each plant with the BEC zones in which it grows, we observed that every BEC zone that appears within the Elephant Hill fire boundary is important for many culturally significant plants. Gathering plants and passing on knowledge of how to use them is an important Secwépemc cultural practice (Ignace et al., 2016).

Secwépemc culture attaches value to specific places. Significant cultural sites that were damaged or made inaccessible also include archaeological sites, hunting grounds, and the communal fishing camps at Hihium Lake and Loon Lake (Dickson-Hoyle & John, 2021). Fishing together and sharing the catch is an important indigenous cultural value (Earth Economics, 2021).

The traditional territories of the SRSS communities extend beyond the Elephant Hill fire area. Skeetchestn Natural Resources GIS staff provided a rough estimate of the portion of each community's territory within the fire area. It averaged 12% but ranged as high as 27%. Since Secwépemc culture is so place-based, we cannot expect that the cultural services associated with any particular places within the fire area could be easily replaced elsewhere on a community's territory.

METHODS

Ecological economists tend to be wary of quantifying cultural service values, especially in an Indigenous context (Mucioki et al., 2021). Some have described cultural services as being of "infinite value" to an area's Indigenous people due to their intimate connection with the landscape (Voora & Barg, 2008). We share the view that cultural values are priceless and irreplaceable and that monetizing cultural service values may be inappropriate in some situations. However, we were struck by conversations with SRSS personnel suggesting that cultural services may be the most important of all ecosystem services provided by nature in the Elephant Hill area. If so, leaving them out would greatly understate what was lost in the fire. We have therefore attempted a conservative valuation of the services.

The previously mentioned guide for First Nations displaced by wildfire recommends spiritual and healing events and culturally relevant wellness services for those suffering displacement. The guide does not deal with the longer term grief for lost forests, waters and meadows that may take generations to heal. However, we consider it reasonable that similar forms of healing services may be needed to replace the well-being and cultural benefits that are lost through wildfires, such as the Elephant Hill fire.

Previous research has proposed the value of traditional healing as a proxy for spiritual services (Sangha & Russell-Smith, 2017; Voora & Barg, 2008). The culturally important capability of being able to pass on knowledge, has been estimated by Sangha and Russell-Smith (2017) based on the cost of a research position. We applied the same approach as previous researchers, substituting local costs.

The Llenlleney'ten people (High Bar First Nation members), have been dispossessed from their reserve lands since the reserve was deemed uninhabitable in the 1980s and access is quite limited. Since that time, Llenlleney'ten people have experienced the loss of not being able to gather together on their land, and not being able to have a seasonal fish harvest and communal fish fry, among other traditions. High Bar First Nation's Service Coordinator explained that access to another First Nation's land does not provide the same benefit as being able to walk on one's own land – "where they walked is their culture." (Hawkins, T. interview December 9, 2021)

This First Nation's response to dispossession provides a useful model for how organized cultural services can substitute, in some small measure, for the loss of nature's cultural services brought about by the Elephant Hill fire and subsequent closures. The replacement of organized activities for traditional land-based activities has also been accepted as a substitute by the Secwépemc Health Council during the COVID-19 pandemic (Manuel, 2020).

The Canadian Red Cross provided High Bar First Nation and other communities affected by the 2017 BC wildfires with funding for mental wellness. An information sheet about the funding obtained from the First Nation[6] indicates that the funding covers any community opportunity for holistic healing, and provides as examples: harvesting, preserving and storage of traditional food/medicines, sweat lodge ceremonies, brushing off ceremonies, water ceremonies, hunting, fishing, regalia making, traditional crafts, healing the land ceremonies, and many more. A strong connection to nature, as materials for, or location of, activities is evident in many of the suggested activities.

6 Canadian Red Cross information sheet and cost estimates provided by High Bar First Nation Service Coordinator Trina Hawkins March 1, 2022.

We interviewed High Bar First Nation's Service Coordinator to understand the cultural importance of the area, the substitute activities organized by High Bar First Nation and the costs of those activities on a per person basis. We estimated the minimum replacement cost for nature's cultural services based on the average cost of activities for which per person costs were available (Table 6). The average cost per person is a very conservative estimate as it includes only fees or honoraria for instructors or elders and does not include transportation, accommodation or food for instructor or participants. Some costs were a flat rate and cost per person was based on the number of participants which ranged from 17 to 30 people.

While these activities were organized by High Bar First Nation, we learned that such activities are often open to members of neighbouring communities. We applied this average annual cost to the whole population of the eight communities directly affected by the Elephant Hill fire.

Different activities are appropriate for each season. We therefore assumed that one activity per person per season would be the minimum necessary to sustain culture in the absence of access to traditional territory. As Voora and Barg (2008) assumed weekly visits from a traditional healer, the higher end of our range is calculated based on weekly activities. This would be consistent with religious practices that are observed weekly.

WHAT SHOULD WE CALL THESE SERVICES?

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2018) recognizes four categories of non-material ecosystem services:

- Learning and inspiration
- Physical and psychological services
- Supporting identities
- Maintenance of options

However, recent work to conceptualize Indigenous cultural ecosystem services has challenged the non-material labelling, noting that while the flows of services may be non-material, they make "tangible contributions to human well-being that are observed in identities, experiences and capabilities" (Mucioki et al., 2021). Mucioki et al. and other researchers have contributed to an understanding of Indigenous cultural ecosystem services (ICES) that recognizes benefits are:

- interconnected and not easily distinguishable;
- created through connection to nature that enables people to develop capabilities that contribute to well-being; and
- mutual, with nature also benefiting from Indigenous stewardship (Belisle et al., 2021; Sangha et al., 2015)

As these findings fit with what we have been learning from SRSS communities, we have used the phrase cultural and well-being services as an inclusive label for the bundle of benefits community members experience and create through their connection with the land.

Table 6: Estimated value of culture and well-being services

Cultural activity	Cost per person	Replacement value low estimate (seasonal[ii])	Replacement value high estimate (weekly)
Pine needle baskets	$50		
Fishing spear	$150		
Copper etching	$75		
Flint napping	$75		
Secwépemc museum tour	$15		
Medicinal herb teas	$40		
Moccasin Trail 1½ day tour	$247		
Average	$95	$95	$95
Annual cost per person		$475	$4,940
Total population[i]		5,407	5,407
Estimate of annual replacement cost		**$ 2,568,325**	**$ 26,710,580**

i Population includes all status members of the eight SRSS communities whether on or off-reserve.
ii As Ignace and Ignace (2017) explain that there are five seasons in the Secwépemc year, we used this in our calculations.

Bark baskets. Secwépemc knowledge includes how to remove bark without damaging birch trees. Photo credit: Nancy Turner.

Balsamroot/tséts'elq. Secwépemc people have developed specialized cooking processes to make the tap roots digestible. Photo credit: Sandra Peacock.

RESULTS

We conservatively estimate the annual replacement cost for cultural services to be between $475 and $4,940 per person or $2.6 million and $26.7 million for the SRSS population, depending on the frequency of replacement activities.

For comparison, Canadian Red Cross mental wellness funding of $87,000 over three years for High Bar First Nation amounts to $131 per person per year, using population data from Table 2. If all SRSS communities received a similar funding amount, this would represent a mental health cost of the wildfires of at least $700,000, but as our results show, the cost of replacing nature's cultural and wellness services with organized activities is much higher, even with our conservative estimates.

DISCUSSION AND OPPORTUNITIES FOR FURTHER RESEARCH

As well-being and culture are so intimately connected to the land, Secwépemc people are putting considerable effort into restoration and stewardship. Healing the land strengthens the people.

Mucioki et al. (2021) have documented negative impacts on Indigenous Cultural Ecosystem Services from climate change, including declining plant and animal health, and changes in seasonal cycles that can affect the timing of cultural practices such as hunting, gathering, and burning. Climate change could threaten the benefits estimated in this work and also make replacement services more valuable.

We were not able to establish a basis for a valuation on an areas basis (per hectare of land). While some previous studies have arrived at an estimate per hectare, the calculations originate with values per person or per household, leading to very different results if benefits are transferred to areas with different population density.

Skeetchestn's inventory of culturally significant plants may provide a basis for a more detailed valuation on an area basis that was not within the scope of this study. With help from B. Amundsen of Skeetchestn Natural Resources Corp., we obtained a test calculation of the abundance of one plant, common juniper (*Juniperus communis*), that has multiple cultural uses. The presence of common juniper in sampled blocks was compared to the total number of blocks, by BEC zone and the ratio extrapolated over the area of Elephant Hill fire area for each BEC zone to estimate the presence of common juniper in the fire area (Table 7).

Table 7: Sample calculation of area for a significant plant

BEC Zone	Area of blocks where Juniper found (Ha)	Area of all blocks (Ha)	Ratio	Fire area BEC Zone Totals (Ha)	Estimated area with Juniper (Ha)
Interior Douglas-fir	1258.6	2114.8	0.60	137,954.1	82,104.3
Montane Spruce	804.8	1331.2	0.60	31,176.7	18,848.0
Sub-Boreal Pine – Spruce	440.1	483.6	0.91	13,306.3	12,110.8
Engelmann Spruce – Subalpine Fir	0.0	21.5	0.00	479.1	0.0
Bunchgrass*	–	–	–	2,549.1	–
Ponderosa Pine*	–	–	–	5,307.1	–
Sub-Boreal Spruce*	–	–	–	1,165.1	–
Total	**2503.5**	**3929.6**	**0.64**	**191,937.4**	**122,284.4**

Source: Skeetchestn Natural Resources Corp.

* No surveys were done in these BEC zones

It may be feasible to develop a valuation for a hectare that produces juniper, and each of the other culturally significant plants, using replacement cost or contingent valuation methods. We did not pursue this approach for several reasons:

- We address the food value of wild plants in the next section and wanted to avoid double counting.
- Ecological economic methods for valuing wild plants (known as non-timber forest products) tend to be based on willingness to pay by recreational harvesters as opposed to ability to pay by local First Nations.
- Cultural valuations are not well documented in the literature beyond the replacement cost method already used above.
- The effort of a species by species approach was beyond the scope of this study.

REFERENCES

Bélisle, A. C., Wapachee, A., & Asselin, H. (2021). From landscape practices to ecosystem services: Landscape valuation in Indigenous contexts. *Ecological Economics, 179, 106858*, https://doi.org/10.1016/j.ecolecon.2020.106858

Chan, K. M., Satterfield, T., & Goldstein, J. (2012). Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics, 74, 8-18*. https://doi.org/10.1016/j.ecolecon.2011.11.011

Earth Economics. *The Sociocultural Significance of Pacific Salmon to Tribes and First Nations. 2021*. https://static1.squarespace.com/static/561dcdc6e4b039470e9afc00/t/60c257dd24393c6a6c1bee54/1623349236375/The-Sociocultural-Significance-of-Salmon-to-Tribes-and-First-Nations.pdf

Haggert, A. (2021). Access to nature critical to coping with COVID-19 pandemic. *Canadian Geographic*. Retrieved from https://www.canadiangeographic.ca/article/access-nature-critical-coping-covid-19-pandemic

Hatala, A.R., Njeze, C., Morton, D., Pearl, T., & Bird-Naytowhow, K. (2020). Land and nature as sources of health and resilience among Indigenous youth in an urban Canadian context: a photovoice exploration. *BMC Public Health*, *20*(1). https://doi.org/10.1186/s12889-020-08647-z

Ignace, M., & Ignace, R.E. (2017). *Secwépemc people, land, and laws*. McGill-Queen's University Press. doi: 10.14237/ebl.9.2.2018.1380.

Ignace, M., N. Turner & S. Peacock (eds.) (2016). Secwépemc people and plants: Research papers in Shuswap ethnobotany. Society of Ethnobiology Contributions series. https://ethnobiology.org/sites/default/files/publications/contributions/Secwépemc-web-07-2017.pdf

Manuel, V. (2020). Secwépemc Traditional Wellness Inspiration – In Time of COVID 19 Ancestors Teachings – Cultural Practices and Traditional Idea's. Secwépemc Health Caucus. Retrieved from http://www.skeetchestn.ca/files/secwepemc-traditonal-wellness-plan-p1.pdf

Mucioki, M., Sowerwine, J., Sarna-Wojcicki, D., Lake, F. & Bourque, S. (2021). Conceptualizing Indigenous Cultural Ecosystem Services (ICES) and Benefits under Changing Climate Conditions in the Klamath River Basin and Their Implications for Land Management and Governance. *Journal of Ethnobiology, 41(3), 313-330*. https://doi.org/10.2993/0278-0771-41.3.313

Pearce, L., Murphy, B., & Chrétien, A. (2017). From displacement to hope: A guide for displaced Indigenous communities and host communities. *Contemporary Studies, 10*. Retrieved from https://scholars.wlu.ca/brantford_ct/10

Richmond, C.A.M., & Ross, N.A. (2009). The determinants of First Nation and Inuit health: a critical population health approach. *Health and Place*, *15*(2), 403-411. https://doi.org/10.1016/j.healthplace.2008.07.004

Sangha, K.K., Le Brocque, A., Costanza, R., & Cadet-James, Y. (2015). Ecosystems and Indigenous well-being: An integrated framework. *Global Ecology and Conservation*, *4*(July)Pages 197-206. https://doi.org/10.1016/j.gecco.2015.06.008

Sangha, K. K., Preece, L., Villarreal-Rosas, J., Kegamba, J. J., Paudyal, K., Warmenhoven, T., & Ramakrishnan, P. (2018). An ecosystem services framework to evaluate Indigenous and local peoples' connections with nature. *Ecosystem Services*, *31*, 111-125. https://doi.org/10.1016/j.ecoser.2018.03.017

Sangha, K.K. & Russell-Smith, J. (2017). Towards an Indigenous Ecosystem Services Valuation Framework: A North Australian Example. *Conservation and Society*, *15*(3), 255-269. Retrieved from http://www.jstor.org/stable/26393294

Tobias, J.K., & Richmond, C.A.M. (2014). "That land means everything to us as Anishinaabe....": Environmental dispossession and resilience on the North Shore of Lake Superior. *Health and Place*, *29*, 26-33. https://doi.org/10.1016/j.healthplace.2014.05.008

Voora, V., and Barg, S. (2008). *Pimachiowin Aki World Heritage Project Area ecosystem services valuation assessment*. International Institute for Sustainable Development. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.564.3008andrep=rep1andtype=pdf

Williamson, B., Weir, J., & Cavanagh, V. (2020). Strength from perpetual grief: how Aboriginal people experience the bushfire crisis. The Conversation. Retrieved from https://theconversation.com/strength-from-perpetual-grief-how-aboriginal-people-experience-the-bushfire-crisis-129448

Williamson, B., Markham, F. & Weir, J.K. (2020). Aboriginal Peoples and the response to the 2019–2020 bushfires. Centre for Aboriginal Economic Policy Research, Working Paper No. 134. https://www.aidr.org.au/media/7718/aboriginal-people-and-the-response-to-the-2019-20-bushfires.pdf

Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: an exploration of culture, health and place. *Health and Place*, *9*(2), 83-93. https://doi.org/10.1016/S1353-8292(02)00016-3

Wilson, K., & Peters, E. J. (2005). "You Can Make a Place for it": Remapping Urban First Nations Spaces of Identity. *Environment and Planning D: Society and Space*, *23*(3), 395–413. https://doi.org/10.1068/d390

CHAPTER 4

Biodiversity

DESCRIPTION OF BIODIVERSITY SERVICES

Biodiversity, at its simplest, means the variety of life in the area.

The value of biological diversity as an ecosystem service has received widespread attention (Costanza et al., 1997; Ehrenfeld 1988; Nunes & Van den Bergh, 2000; OECD, 2001; Randall 1988).

Biodiversity plays multiple roles in ecosystem processes and services. Biodiversity is a regulator of ecosystem processes, such as in soil nutrient cycles via decomposition and nutrient uptake. Biodiversity can be a final ecosystem service that contributes directly to various goods, such as crops, livestock, and wild medicines. Biodiversity can also be a benefit in itself, as something people value due to its aesthetic appeal or simply by virtue of existing. In this case, biodiversity's value is independent of potential usefulness to people.

Some object to placing a monetary value on biodiversity, arguing that it has an intrinsic value that is incalculable. Others see valuation as relevant for making explicit the range of services biodiversity supports which, although imperfect, can be considered as a democratic approach to decide about public issues, including biodiversity ones.

BIODIVERSITY IN THE ELEPHANT HILL AREA

Secwepemcúl'ecw spans seven diverse biogeoclimatic zones that have historically supported a high level of biodiversity. Within the low-elevation river valleys, arid plateaus, deserts, interior and subalpine forests, grasslands, and snow-capped mountains, lie a rich diversity of plants and animals. Species such as bald eagles (*Haliaeetus leucocephalus*), black bears (*Ursus americanus*), cougars (*Puma concolor*), mule deer (*Odocoileus hemionus*), bighorn sheep (*Ovis canadensis*), sockeye salmon (*Oncorhynchus nerka*), and rainbow trout (*Oncorhynchus mykiss*), have relied on these local ecosystems for thousands of years. Today, many are under threat of extinction due to human activities, such as destruction and the pollution of habitat. Species at risk include the Great Basin spadefoot toad (*Spea intermontana*) which relies on small wetland areas and the Black Swift (*Cypseloides niger*) which is known to nest behind waterfalls on the Deadman River (Freeman, 2021). Boreal woodland caribou (*Rangifer tarandus*) have disappeared from the area and moose (*Alces alces*) are less abundant, compared to the time before industrial forestry moved into the upper elevations of the Elephant Hill area (Anderson, M. interview January 29, 2020). The loss of any single species represents a lost thread in the web of life.

For this report we are considering the biodiversity value for SRSS community members specifically, but the Elephant Hill fire area also has conservation value for British Columbians in general. Three large provincial parks with ecological significance – Arrowstone, Chasm and Elephant Hill – are contained to some extent within the fire boundary (Figure 6).[7]

7 Information on the natural and cultural significance of each park, from a BC Government perspective, can be found at https://bcparks.ca/explore/parks/

Dry grasslands of the British Columbia interior are a threatened ecosystem due to climate change and development pressures. Photo credit: Sandra Peacock.

Figure 6: Provincial parks within the Elephant Hill fire area

Sources: Esri, GeoBC, BC Parks, BC Wildfire Service

The Secwépemc Peoples' Laws and Governance reflect the interconnected nature of all living beings and a relational worldview. They see themselves as deeply connected with everything and everyone around them and promote humility, stewardship, and responsibility for living things over rights and ownership. This worldview is evident in their harvesting techniques (e.g., the use of weirs that allow the release of fish), rituals (e.g., burning of tobacco as an offering), practices (e.g., sweat-bath construction), and knowledge of the natural systems (e.g., recognition of keystone species) (Christian & Laubman, 2021; Ignace & Ignace, 2017).

Secwépemc people have also influenced biodiversity through their cultivation and stewardship of culturally valuable plants and the use of fire. For hundreds of thousands of years, Indigenous people managed fire to shape their lands, until the practice was restricted by settler governments. These restrictions were ultimately counter-productive. Recent studies have linked Indigenous fire management with an increase in biodiversity across almost all of Earth's terrestrial biomes (Hoffman et al., 2021) (see *Indigenous Fire Management* in *Introduction to the Project and the Study Area*).

The black swift nests on steep cliffs and has been located behind waterfalls on the Deadman river. Photo credit: Skeetchestn Natural Resources Corp..

THE LINK BETWEEN BIODIVERSITY AND ECOSYSTEM SERVICES

Biological diversity (or Biodiversity) refers to the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems (Secretariat of the Convention on Biological Diversity, 2006). While ecosystem services and biodiversity are related, they are distinct concepts. For ecosystems of all types, biodiversity is a precondition of the flow of ecosystem services because ecosystems, with their full native complement of species, tend to be more productive and more resilient to change or external shocks. Simply put, reduce biodiversity, and the health of ecosystems suffer.

Impact of the Elephant Hill fire

Biodiversity is affected by wildfires through two key processes. First, the historic instance of fire influences the species that have been able to persist at the site. Second, the fire regime (including the severity, size, occurrences, cycle) will negatively impact some species while favouring others, across the landscape. High severity fires, such as much of the Elephant Hill fire, tend to favour species that are shade intolerant (Gedalof, n.d.). However, the response of plant communities to different fire severities is variable and there is limited research in B.C. (Dickson-Hoyle, S. personal communication February 9, 2022). In addition, habitat conversions may reduce overall biodiversity and contribute to increased susceptibility of fire (Lee et al., 2015).

As of the time of writing this report, there is not a formal assessment of the impacts of the Elephant Hill Wildfire on biodiversity. Considering habitat loss is the most significant impact on biodiversity from large-scale fire, recent habitat studies (including an equivalent clear-cut analysis and stream temperature monitoring) suggest impacts to biodiversity have occurred. The Equivalent Clear-cut Analysis of the 2017 Elephant Hill Wildfire report assessed lost habitat within the major drainages of the land, breaking the analysis into 140 individual assessment units (Lewis, 2018). Of these, 24 assessment units were more than half burned. For these 24 assessment units, the area of moderate-high severity burn ranged from 15-71%. In addition to the loss of species and ecosystems, there can be cascading impacts such as changes in stream temperature (when riparian shading vegetation is lost) that impacts the ability of cold-water fish, such as salmon, to survive. Preliminary results of watershed monitoring have, in fact, shown that stream temperatures in 2020 have stayed higher for longer, across most monitoring sites, throughout the year (Lewis, 2018). Although the report authors note it is difficult to attribute the change in temperature to the Elephant Hill fire without long-term stream temperature monitoring, they do make note of it as a potential contributing factor.

METHODS

In this study we've chosen not to assess the *use* values of biodiversity because biodiversity is a supporting component of intact ecosystems. As ecosystems support a range of services, valuing biodiversity invites the risk of double counting. For instance, the value of plants and animals for the provision of food and medicine[8] is discussed in *Material Contributions* and the value of biodiversity for cultural services is addressed in *Culture and Well-being*. The value of biodiversity for supporting market-based natural resource economic activity is assumed in the timber and ranching sections.

We have included an estimate of the *non-use* value of biodiversity. Many people report valuing biodiversity simply for its existence, even if they never see or use all species. Similarly, many want to ensure the availability of biodiversity to future generations.

Our estimate is based on two studies: one for wilderness protection and the other specifically for salmon (see *The Value of Salmon to Secwépemc People*).

The first is a study by Kulshreshtha and Loewan (1997) completed in Saskatchewan. In this study, the authors asked residents their willingness-to-pay for wilderness protection and provided their findings for non-Indigenous and Indigenous populations, noting that Indigenous respondents were willing to pay approximately 30 % more than their non-Indigenous counterparts. Here we used the per household values calculated earlier in this report (see *Introduction to the Project and the Study Area*) and converted to 2021 CAD for an estimate of $127 per household.

We estimated the value of salmon based on the Lewis et al. (2019) study that surveyed residents along the Oregon Coast on their willingness-to-pay for conservation actions aimed at recovering Coho salmon and effectively removing it from the US Endangered Species Act. We converted the value per household to 2021 CAD and applied it to an estimate of the number of SRRS households, producing an estimate of $189 per household.

8 The biodiversity of medicinal plants is another important provisioning value, but it was beyond the scope of this study to quantify it.

Skeetchestn Indian Band doing communal fishery. Photo credit: Secwépemc Fisheries Commission.

THE VALUE OF SALMON TO SECWÉPEMC PEOPLES

Pacific salmon are a vital part of Secwépemc identity. As a cultural and ecological keystone species, salmon are central in rituals, such as the Secwépemc First Salmon Ritual; practices, such as the use of weirs to ensure too much salmon was not taken from their waterways; and stories, such as the Story of Coyote and Salmon (Ignace & Ignace, 2017).

Four species of Pacific salmon are present in the Secwépemc study area: Sockeye (Oncorhynchus nerka), Chinook (Oncorhynchus tshawytscha), Coho (Oncorhynchus kisutch), and Pink salmon (Oncorhynchus gorbuscha), in addition to other salmonids such as Steelhead (Oncorhynchus mykiss). Sustenance fishing is practiced, although there have been years where communities have chosen not to fish due to concerns related to declining populations (Gillespie, A. interview, January 6, 2022).

It is difficult to determine the impact the Elephant Hill wildfire had on salmon populations. Pacific salmon population numbers have been declining for decades but attempts at identifying the causes of decline have been unsuccessful. The 2009 Cohen Commission spent ~$35 million to investigate the decline of sockeye salmon in the Fraser River. The Commissioner Bruce Cohen heard from 179 witnesses, 2,145 exhibits and 892 public submissions and ultimately concluded much is still unknown about individual stressors as well as cumulative and delayed effects.

RESULTS

Table 8: The existence value of biodiversity

Number of SRSS community households	Value per household/year		Total value per year	
	Low estimate	High estimate	Low estimate	High estimate
2253	$127	$189	$286,131	$425,819

The resulting estimates for biodiversity appear very low, but this is because so much of the value of biodiversity is already embedded in other services as described above. We can think of this as the residual biodiversity existence value that cannot be attributed to any other service. The finding that salmon alone has a higher existence value than biodiversity generally cannot be probed fully within our scope. A possible explanation comes from the dates of the studies, with the newer study producing a higher value. As biodiversity becomes more threatened and scarce globally, its perceived value may rise.

DISCUSSION AND FURTHER OPPORTUNITIES

Biodiversity is notoriously over-used and under-valued. Scientists recommend protecting a minimum of 30% of the land and marine base to stem biodiversity loss, ecological degradation, and climate change. At a global scale, 30% protection would require 0.16% of global GDP and less than a third of government subsidies that are currently supporting activities that damage nature (Dasgupta, 2021; Waldron et al., 2020). Canada is one of more than 74 world leaders to join the High Ambition Coalition, which aims to meet the 30% protection target.[9] As of 2019, Canada has protected 11.4% of land and inland waters.

As federal and provincial governments embark on reconciliation with Indigenous people, biodiversity improvement may be a co-benefit. Healing for Indigenous people implies recognizing that people, culture, and their lands are inseparable, and there is reason to believe this can benefit biodiversity. In fact, there is evidence that Indigenous-managed lands in Canada have greater levels of vertebrate biodiversity than protected areas, while also supporting a greater number of threatened vertebrate species (Schuster et al., 2019).

Indigenous people are increasingly becoming involved in conserving and maintaining ecosystems, to protect or restore lands, to exercise Indigenous rights and governance, and to provide place for cultural expression and healing (Molnar et al., 2021).[10]

SRSS is already engaged in important restoration and stewardship initiatives that will likely support biodiversity. For instance, the water management planning project is identifying improved water management practices using salmonid instream flow needs as a key indicator of success. This effectively gives salmonids a voice at the water planning table. In addition, extensive efforts to improve water resources are underway, including governing at a watershed scale, source water protection, and source-to-tap multi-barrier initiatives (Secwépemc Knowledge Relationships webinar, 2021).

7 https://www.campaignfornature.org/high-ambition-coalition
10 See for example the proposed Dasiqox Tribal Park of the Tsilhqot'in people https://dasiqox.org/about-us/map/

REFERENCES

Christian, W. & Laubman, R. November 2021. Secwépmec Knowledge Relationships Webinar. https://youtu.be/x2lY4guku0U.

Cohen, B. (2012). *The uncertain future of Fraser River sockeye: Volume 1*. Minister of Public Works and Government Services Canada. https://publications.gc.ca/site/eng/9.696128/publication.html.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., & van den Belt, M. (1997). The Value of the World's Ecosystem Services and Natural Capital. *Nature*, *387* (15), 253-260. doi: 10.1016/S0921-8009(98)00020-2.

Dasgupta, P. (2021). *The economics of biodiversity: The Dasgupta review*. Abridged version. London: HM Treasury. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/957292/Dasgupta_Review_-_Abridged_Version.pdf.

Ehrenfeld, D. (1988) Why put a value on biodiversity? In *Biodiversity*, ed. E. O. Wilson, pp. 212-216. National Academy Press, Washington, D.C.

Freeman, Shaun. Meeting transcript from SRSS Technical Committee meeting December 2, 2021.

Gedalof, Z. no date. Fire and biodiversity in British Columbia. (2020). In Klinkenberg, B. (ed.). *Biodiversity of British Columbia* [www.biodiversity.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia. https://ibis.geog.ubc.ca/biodiversity/FireandBiodiversityinBritishColumbia.html.

Hoffman, K.M., Davis, E.L., Wickham, S.B., Schang, K. Johnson, A., Larking, T., Lauriault, P.N., Le, N.Q., Swerdfager, E., & Trant. A.J. (2021). Conservation of Earth's biodiversity is embedded in Indigenous fire stewardship. *Proceedings of the National Academy of Sciences*, *118* (32) e2105073118. doi: 10.1073/pnas.2105073118.

Ignace, M., & Ignace, R.E. (2017). *Secwépemc people, land, and laws*. McGill-Queen's University Press. doi: 10.14237/ebl.9.2.2018.1380.

Kulshreshtha, S.N., & Loewen, K.G. (1997). Value of wilderness protection in Saskatchewan: A case study of existence values. *Journal of Sustainable Forestry 5*(1-2), 207-216. doi 10.1300/J091v05n01_02.

Lee, C., Schlemmem C., Murray, J., & Unswoth, R. 2015. The cost of climate change: Ecosystem services and wildland. *Ecological Economics 116*, 261-269. doi 10.1016/j.ecolecon.2015.04.020.

Lewis, D.J, Dundas, S.J., Kling, D.M., Lew, D.K., & Hacker, S.D. (2019). The non-market benefits of early and partial gains in managing threatened salmon. *PLoS One*, *14*(8), 15pp. doi 10.1371/journal.pome/02200260.

Lewis, D. (2018) Equivalent clearcut analysis of the 2017 Elephant Hill wildfire. Prepared for the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Molnar, M., Olmstead, P., Mitchell, M., Raudsepp-Hearne, C. & Anielski, M. (2021). Ecosystem Services, Chapter 5. In F.J. Warren and N. Lulham (eds.) *Canada in a Changing Climate: National Issues Report*. Government of Canada. https://www.nrcan.gc.ca/sites/nrcan/files/pdf/National_Issues_Report_Final_EN.pdf

Nunes, P., & van den Bergh, J. (2000). Economic valuation of biodiversity: sense or nonsense? *Ecological Economics*, *39*, 203-222. https://www.oecd-ilibrary.org/environment/valuation-of-biodiversity-benefits_9789264195844-en.

OECD (2001), *Valuation of Biodiversity Benefits: Selected Studies*, OECD Publishing.

Randall, A. (1988). What mainstream economists have to say about the value of biodiversity. In E.O.

Wilson (ed.). *Biodiversity*, 217-223. National Academies Press.

Schuster, R., Germain, R.R., Bennett, J.R., Reo, N.J. & Arcese, P. (2019). Vertebrate biodiversity on Indigenous-managed lands in Australia, Brazil, and Canada equals that in protected areas. *Environmental Science and Policy*, *101*, 1–6. Retrieved March 2021, from https://doi.org/10.1016/j.envsci.2019.07.002

Secretariat of the Convention on Biological Diversity. (2006). Global Biodiversity Outlook 2. https://www.cbd.int/doc/gbo/gbo2/cbd-gbo2-en.pdf.

Secwépemc Knowledge Relationships: Kukpi7 Wayne Christian and Robin Laubman. (November 2021). Living Lakes Canada. https://www.youtube.com/watch?v=x2lY4guku0U

Waldron, A., Adams, V., Allan, J., Arnell, A., Asner, G., Atkinson, S., Baccini, A., Baillie, J., Balmford, A., Beau, J.A., Brander, L., Brondizio, E., Bruner, A., Burgess, N., Burkart, K., Butchart, S., Button, R., Carrasco, R., Cheung, W.,...Zhang, Y.P. (2020), *Protecting 30% of the planet for nature: Costs, benefits and economic implications*. Available at: https://www.conservation.cam.ac.uk/files/waldron_report_30_by_30_publish.pdf.

CHAPTER 5

Material Contributions

DESCRIPTION OF MATERIAL CONTRIBUTIONS

Material contributions include all the materials nature provides that have direct benefits for humans – food, water, medicine, and ornamental and raw materials to fashion clothing, shelter, technology, and cultural artifacts.

In this section we focus on food[11], specifically wild or "traditional" food that is obtained through hunting, fishing or cultivating and gathering wild plants[12]. Hunting, fishing and gathering are common activities for First Nations living both on-and off-reserve (Chan et al., 2011; Kumar et al., 2019). The primary reasons for harvesting wild food are personal or family use, followed by pleasure or leisure. Commercial sale is a relatively minor use.

Recent research on Indigenous ecosystem services has questioned whether the provision of food and other materials can be seen as distinct from cultural ecosystem practices and benefits (Belisle et al., 2021; Mucioki et al., 2021). In this view, gathering plants, hunting and fishing are as much an expression of culture as a means to acquire sustenance, and our work on culture and well-being supports this. Secwépemc research also emphasizes the cultural dimension of these activities (Ignace & Ignace, 2017).

Research documents food security and nutrition issues among Indigenous peoples in British Columbia (Batal et al., 2021; Chan et al., 2011). The low cost of wild food has been cited as a benefit of traditional food (Chan et al., 2011), suggesting that the ecosystem service of food provisioning may have economic value. We set out to determine if there is a substantial ecosystem service of food provisioning, distinct from cultural ecosystem services.

FOOD PROVISIONING SERVICES IN THE ELEPHANT HILL AREA

Thanks to years of ethnobotany and ethnoecology work by researchers in collaboration with Secwépemc elders, there is a good understanding of how Secwépemc people have managed the landscape for, and made use of, culturally significant plants (Ignace & Ignace, 2017; Turner, 2014). As noted in the *Culture and Well-being* section, and based on SNR's inventory of culturally significant plants, (SNR, unpublished) every biogeoclimatic (BEC) zone that appears within the fire boundary is important for many culturally significant plants that may be harvested for food, medicine, or materials.

Hunting is practised in the Elephant Hill area for local food needs, with mule deer (*Odocoileus hemionus*) the preferred game species. Local hunters have observed a decline in deer populations in the area since the fire as they have moved to better foraging locations (Freeman, S. interview, January 10, 2022). Moose, a preferred species for many Secwépemc members, have not been abundant in the Elephant Hill area for many years and local people attribute this to intensive forestry that has made the forest denser (Anderson, M. interview, January 29, 2020). The area has seen a recent influx of recreational hunters from elsewhere in BC. Recreational hunters tend to be equipped with more sophisticated and costly gear. With the decline in deer and the greater number of hunters, there are concerns about potential scarcity of wild meat for community members (Freeman, S. interview, January 10, 2022).

11 Turner (2014) and Ignace and Ignace (2017) have documented the medicinal use of wild plants. As market based pharmaceuticals can be costly, there is reason to believe that traditional plant based medicines would have significant replacement values, but we did not include this in our scope due to the lack of literature to establish amounts consumed or replacement costs.

12 Planting a garden is considered traditional food gathering in Chan et al. (2011) and in Tobias and Kay (1993). We focused on wild food.

Skeetchestn Indian Band drying harvested Sockeye. Photo credit: Secwépemc Fisheries Commission.

Salmon is culturally significant, as previously described, but both salmon and trout are also very important sources of protein and other nutrients, historically and currently (Chan et al., 2011; Ignace & Ignace, 2017; Marushka et al., 2019). Sockeye, Chinook, Coho, Pink, and Steelhead salmonids are present in Elephant Hill waterways. Rainbow trout are found in Hihium Lake, Loon Lake and others within the Elephant Hill area. Fishing is culturally a communal activity. Communities come together to fish the dominant runs and share fish with others that do not have fish running in their waters.

SRSS and Skeetchestn Natural Resources Corp. personnel confirmed that since each family has their own gathering, fishing and hunting places, damage to one family's land cannot be easily substituted by another area of land. Our communications with SRSS established that the Elephant Hill fire and the closures that resulted from it have increased barriers to traditional food access.

BENEFITS OF TRADITIONAL FOOD

Benefits of traditional food for Indigenous peoples globally have been well established (Chan et al., 2011; McCartan et al., 2020). For First Nations and other Indigenous peoples, traditional food provides high levels of essential nutrients, reduces reliance on overly processed alternatives, and reduces food insecurity (Batal et al., 2017; Batal et al., 2021; Marushka et al., 2019; Phillips, 2014). Among First Nations people living on-reserve, 41% reported moderate or severe food insecurity (Chan et al., 2011). Harvesting wild food may also be a more efficient use of time for some people than participating in the market economy to earn income to purchase food (Delang, 2006).

Tubers of spring beauty/skwenkwinem, also knows as mountain potatoes, are an important food source. Photo credit: Nancy Turner.

METHODS

The literature on provisioning services is weighted heavily towards recreational values for hunting, fishing and gathering based on a travel costs methodology. For Secwépemc people, traditional food gathering is more than recreation – it is an essential source of nutrients and a cultural practice that also includes sharing food, sharing knowledge of the land, keeping heritage alive and reinforcing identity (Ignace & Ignace, 2017). We therefore determined that travel costs would not be a suitable method and instead looked to harvest replacement cost studies for benefit transfer, such as Tobias and Kay (1994) and Wolfe (2020). We first established a range based on a much cited replacement cost study by Haenar and Adamowizc (2000).

Haenar and Adamowizc applied earlier harvest studies to 6.8 million hectares of Alberta mixed boreal forest. The study included all non-market services related to traditional uses of "wood harvesting, hunting, fishing, trapping, food gathering, and use of forest materials in making crafts or traditional medicine." They valued this basket of provisioning services between $8,050 to $17,710 per household per year in 2021 CAD. For our estimate of 2,253 SRSS households that use the Elephant Hill area, the transferred benefit would range from $18,136,650 to $39,900,630 annually. This estimate is for all materials, not just food, and provides the upper end of our estimate.

Table 9: BC First Nations traditional food harvesting participation rates

Food harvesting practice	Ecozone 3 participation rate* on-reserve (%)	Average BC participation rate* on-reserve (%)	BC participation rate**, off-reserve (%)
Collected wild plant food	54	33	30
Planted a garden	35	25	Not available
Fished	37	35	28
Hunted or set snares	31	20	28

Source: FNFNES. Fig. 11a and 11b.

* Participation rate is the percent of people 19 years of age or older, in the past four seasons. Source: FNFNES, 2011

** Participation rate is the percent of people 15 years of age or older, in the last 12 months. Source: Kumar et al., 2019

We sought to refine this estimate by using current and local replacement costs for commonly harvested foods and substituting data on First Nation food consumption for the absence of detailed harvest data. We relied on the comprehensive First Nations Food, Nutrition and Environment Study (FNFNES) for British Columbia by Chan et al. (2011) for understanding the extent of food harvesting and the foods primarily consumed by adult members on-reserve.

We considered the FNFNES BC study to be an especially relevant source because one of the First Nations included in the study was Splatsin, a Secwépemc community. We used results for Ecozone 3 (Montane-Cordillera, Plateau) which is the closest fit for ecology and culture in the study. The study participants in this zone had a higher participation rate of traditional food gathering than the BC average, either on-or off-reserve (Table 9). We also obtained off-reserve data from Kumar et al. (2019). While living off-reserve may impose additional barriers to access and convenience, participation is still significant. Further discussion with SRSS staff and others confirmed that we should not treat off-reserve members differently from on-reserve members in terms of valuing opportunities to harvest wild food.

Dwarf blueberry/sesép (Vaccinium caespitosum) in a small patch of unburned forest within the Elephant Hill fire area. Photo credit: Sarah Dickson-Hoyle.

The traditional of sharing food and providing for family, elders and others means that the proportion of people consuming traditional foods can be higher than the portion who participate in harvesting. Through discussion with SRSS Technical Committee we identified deer, salmon, trout and wild berries as significant traditional foods for the communities.

As shown in Table 10, we used supplementary FNFNES data tables for Ecozone 3 to identify the top ten foods consumed, excluding moose,[13] and the percentage of the adult population consuming each. We multiplied this factor by the adult population of the SRSS communities. We obtained the mean intake of each food from a supplementary FNFNES report for a larger population of interior BC First Nations (see footnote iv in Table 10). We multiplied mean intake by the number of adult consumers and converted intake to annual kilograms consumed. With help from SRSS and SNR staff we obtained the replacement cost per kilogram to arrive at an annual replacement cost for community consumers of traditional foods.

Table 10: Replacement value of commonly consumed traditional foods

Traditional food[i]	% Adults consuming each food[ii]	Adult population[iii]	# of Adult consumers	Mean intake grams/day/person[iv]	Total consumption (kg/yr)	Replacement cost ($/kg)[v]	Annual replacement cost total
Deer meat	86	4380	3767	22.7	31,210	$18.05	$563,212
Sockeye salmon	78	4380	3416	14.0	17,458	$19.82	$346,014
Chinook salmon	55	4380	2409	8.04	7,069	$19.82	$140,117
Rainbow trout	36	4380	1577	4.63	2,665	$22.02	$58,677
Blue huckleberries	56	4380	2453	3.31	2,963	$11.65	$34,523
Soapberries	52	4380	2278	3.88	3,226	$11.65	$37,578
Wild strawberry	72	4380	3154	1.78	2,049	$11.65	$23,870
Raspberries	40	4380	1752	1.73	1,106	$11.65	$12,888
Saskatoon berries	58	4380	2540	2.18	2,021	$11.65	$23,549
Blueberries	33	4380	1445	2.59	1,366	$11.65	$15,919
							$1,256,346

i Includes those foods or categories with the highest consumption for Ecozone 3 in the FNFNES BC report. Moose was consumed by 70% of study respondents but was excluded from calculation. While moose was traditionally an important food source, it had ceased to be abundant in the study area by the time of the fire.

ii FNFNES BC report Table 6 Percent of on-reserve BC FN consuming traditional foods in the past year, by ecozone/culture area.

iii SRSS Adult population from Table 1. FNFNES BC data was for adults aged 19 and over.

iv Since the original BC FNFNES did not show intake per consumer for the foods of interest, we relied on the FNFNES Technical supplement, Table S1.3 for Montane Cordillera zone. The data in this supplement were drawn from six First Nations that included the two in the FNFNES BC report plus four from montane ecozones further north. The difference in populations for the studies could affect our calculation.

v Replacement costs were obtained from online grocery websites in the Kamloops area in January 2022. To better approximate the nutritional value of wild food, we selected organic or non-medicated options, and since food is often shared, we chose whole or large format sizes.

13 While moose was traditionally an important food source, it had ceased to be abundant in the study area by the time of the fire.

Table 11: Reasonableness check on deer and salmon consumption

Type of traditional food	Calculated annual consumption (kg)	Equivalent animals	Benchmark harvest range
Deer meat	31,210	1040	332 to 520
Sockeye salmon	17,458	4364	14 to 7346
Chinook salmon	7,069	505	206 to 1332

We performed reasonable checks on the foods for which we have harvest information – deer and salmon (Table 11). In each case we calculated equivalent animals and compared to a benchmark range of sustainable harvests.

For our check on the amount of sockeye and chinook salmon consumption we calculated, we used harvest data from the Secwépemc Fisheries Council's annual Secwépemc Community Catch Surveying reports for 2016–2019 (Celesta & Gillespie, 2017; Celesta, 2018; Celesta & Sterling, 2019; Celesta, 2020). We assumed a weight of 4 kg per sockeye and 14 kg per chinook. The calculated harvest falls within the range of sockeye and chinook harvests by the four SRSS communities that are part of the Secwépemc Fisheries Commission.[14] These harvests took place mainly on the Bonaparte and Thompson Rivers and to a lesser extent in Kamloops Lake. The Bonaparte River and its tributaries lie partially within the Elephant Hill fire area and the Bonaparte feeds the Thompson River. Kamloops Lake is part of the Thompson River system and is upriver from the Bonaparte-Thompson confluence. The Elephant Hill area provides headwaters for the Thompson River system (see *Water Regulation*).

As a reasonableness check for meat, we received support from Skeetchestn Natural Resources to convert the calculated kg of meat consumed to equivalent numbers of mule deer and to compare to recent harvest figures for Wildlife Management Unit (WMU) 3–29, which corresponds most closely to the Elephant Hill fire area. The best deer habitat is found in the designated Ungulate Winter Range (UWR). The Elephant Hill area provides significant UWR areas and corridors (Figure 5). Since one deer provides approximately 30 kg of meat, our calculated consumption of deer (31,210 kg) corresponds to 1,040 animals. The sustainable harvest from 2016 to 2019 for WMU 3–29 ranged from 332 to 520 animals (Freeman, S. interview, January 10, 2022). This may suggest that community members are obtaining some of their deer meat from other parts of their territory outside the Elephant Hill area. We were not able to resolve this question within our scope. We have chosen to let the calculation stand because it represents the lower end of the range and has been conservatively calculated in other respects.

14 These communities are Skeetchestn, Bonaparte, Whispering Pines/Clinton and Tk'emlups Te Secwépemc.

Figure 7: Ungulate winter range

Sources: Esri, BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development

RESULTS

The low end of our estimate is $1.2 million as calculated above. This represents the cost to replace the annual consumption of the most commonly consumed traditional foods, and excludes a wide range of plant foods which may be highly valued, but hard to replace in a store. This also represents solely the food value, and not the activity involved in harvesting or gathering food, which we have treated as cultural activity.

The high end of the range, $39.9 million comes from Haenar and Adamowizc (2000), based on all provisioning services for SRSS households.

DISCUSSION AND OPPORTUNITIES FOR FURTHER RESEARCH

Other provisioning studies have added harvesting costs to capture the economic value of the cultural opportunity involved in harvesting (Voora & Barg, 2008). Adding harvesting costs reflects an approach to provisioning that could address the earlier concern that harvesting should not be conceptualized as solely a sustenance activity. There is value in the gathering, hunting or fishing activity that goes beyond the food on the table. These values have been estimated in CAD 2021 as $100 and $70 per day for hunting and fishing respectively (Federal, Provincial, and Territorial Governments of Canada, 2014) and $49 per day for recreational berry or mushroom harvesting (Starbuck et al., 2004). As discussed above, the harvesting activity does indeed have value for Secwépemc people, but this value goes far beyond recreational value. We have therefore decided not to add any value for harvest experience to what has already been calculated in *Culture and Well-being*, to avoid double counting. This is however an opportunity for further research.

To refine our estimate SRSS could conduct primary research of traditional food intake by community members. This is intensive research requiring community members to complete logs or recall their consumption. As it would reproduce aspects of the FNFNES BC study, the greater precision of the estimate would have to be weighed against the costs and impact on community members.

REFERENCES

Batal, M., Johnson-Down, L., Moubarac, J-C., Ing, A., Fediuk, K., Sadik, T., Tikhonov, C., Chan, L., & Willows, N. (2017). Quantifying associations of the dietary share of ultra-processed foods with overall diet quality in First Nations peoples in the Canadian provinces of British Columbia, Alberta, Manitoba and Ontario. *Public Health Nutrition*, *21*(1), 103-113. https://doi.org/10.1017/S1368980017001677

Batal, M., Chan, H. M., Fediuk, K., Ing, A., Berti, P. R., Mercille, G., Sadik, T., & Johnson-Down, L. (2021). First Nations households living on-reserve experience food insecurity: prevalence and predictors among ninety-two First Nations communities across Canada. *Canadian Journal of Public Health*, *112*(1), 52–63. https://doi.org/10.17269/s41997-021-00491-x

Bélisle, A. C., Wapachee, A., & Asselin, H. (2021). From landscape practices to ecosystem services: Landscape valuation in Indigenous contexts. *Ecological Economics*, *179*, 106858, https://doi.org/10.1016/j.ecolecon.2020.106858

Celesta, A. & Gillespie, A. (2017). Secwépemc community catch surveying 2016. Secwépemc Fisheries Commission.

Celesta, A. (2018). Secwépemc community catch surveying 2017. Secwépemc Fisheries Commission.

Celesta, A. & Sterling, J. (2019) Secwépemc community catch surveying 2018. Secwépemc Fisheries Commission.

Celesta, A. (2020). Secwépemc community catch surveying 2019. Secwépemc Fisheries Commission.

Chan, L., Receveur, O., Sharp, D., Schwartz, H., Ing, A., & Tikhonov, C. (2011). *First Nations Food, Nutrition and Environment Study (FNFNES): Results from British Columbia (2008/2009)*. University of Northern British Columbia.

Chan, L., Batal, M., Sadik, T., Tikhonov, C., Schwartz, H., Fediuk, K., Ing, A., Marushka, L., Lindhorst, K., Barwin, L., Odele, V., Berti, P., Singh, K., & Receveur, O. (2021). FNFNES Final Report for Eight Assembly of First Nations Regions: Comprehensive Technical Report – Supplemental Data. Assembly of First Nations, University of Ottawa, Université de Montréal. http://www.fnfnes.ca/docs/Comprehensive_Technical_Report-_Supplemental_Data_2021-06-05.pdf

Delang, C. (2006). Not just minor forest products: The economic rationale for the consumption of wild food plants by subsistence farmers. *Ecological Economics*, *59*(1), 64-73. https://doi.org/10.1016/j.ecolecon.2005.10.006

Federal, Provincial, and Territorial Governments of Canada. (2014). *2012 Canadian Nature Survey: Awareness, participation, and expenditures in nature-based recreation, conservation, and subsistence activities*. Canadian Councils of Resource Ministers.

Haener, M.K., & Adamowicz, W.L. (2000). Regional forest resource accounting: A northern Alberta case study. *Canadian Journal of Forest Research*, *30*(2), 264-273. https://doi.org/10.1139/x99-213

Ignace, M., & Ignace, R.E. (2017). *Secwépemc people, land, and laws*. McGill-Queen's University Press. doi: 10.14237/ebl.9.2.2018.1380.

Kumar, M.B., Furgal, C., Hutchinson, P., Roseborough, W., Kootoo-Chiarello, S. (2019). Harvesting activities among First Nations people living off-reserve, Metis and Inuit: Time trends, barriers and associated factors. Retrieved from https://www150.statcan.gc.ca/n1/pub/89-653-x/89-653-x2019001-eng.htm

Marushka, L., Kenny, T-A., Batal, M., Cheung, W.W.L., Fediuk, K., Golden, C.D., Salomon, A.K., Sadik, T., Weatherdon, L.V., & Chan, H.M. (2019). Potential impacts of climate-related decline of seafood harvest on nutritional status of coastal First Nations in British Columbia, Canada. *PLoS ONE 14*(2). https://doi.org/10.1371/journal.pone.0211473

McCartan, J., Van Burgel, E., McArthur, I., Testa, S., Thurn, E., Funston, S., Kho, A., McMahon, E., & Brimblecombe, J. (2020). Traditional Food Energy Intake among Indigenous Populations in Select High-Income Settler-Colonized Countries: A Systematic Literature Review. *Current Developments in Nutrition*, 4(11). https://doi.org/10.1093/cdn/nzaa163

Mucioki, M., Sowerwine, J., Sarna-Wojcicki, D., Lake, F. & Bourque, S. (2021). Conceptualizing Indigenous Cultural Ecosystem Services (ICES) and Benefits under Changing Climate Conditions in the Klamath River Basin & Their Implications for Land Management and Governance. *Journal of Ethnobiology*, *41*(3), 313-330. https://doi.org/10.2993/0278-0771-41.3.313

Phillips, K.M., Pehrsson, P.R., Agnew, W.W., Scheett, A.J., Follett, J.R., Lukaski, H.C., & Patterson, K.Y. (2014).Nutrient composition of selected traditional United States Northern Plains Native American plant foods. *Journal of Food Composition and Analysis*, *34*(2), 136-152. https://doi.org/10.1016/j.jfca.2014.02.010

Skeetchestn Natural Resources Corp. Unpublished. Inventory of culturally significant plants [database].

Starbuck, C.M., Alexander, S.J., Berrens, R.P., & Bohara, A.K. (2004). Valuing special forest products harvesting: a two-step travel cost recreation demand analysis. *Journal of Forest Economics*, *10*(1), 37-53. https://doi.org/10.1016/j.jfe.2004.03.004

Tobias, T. N., & Kay, J. J. (1994). The Bush Harvest in Pinehouse, Saskatchewan, Canada. *Arctic*, *47*(3). https://doi.org/10.14430/arctic1291

Turner, N.J. (2014). *Ancient pathways, ancestral knowledge: ethnobotany and ecological wisdom of Indigenous peoples of northwestern North America*. McGill-Queen's University Press.

Voora, V., & Barg, S. (2008). Pimachiowin Aki World Heritage Project Area ecosystem services valuation assessment. International Institute for Sustainable Development. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.564.3008andrep=rep1andtype=pdf

Wolfe, R. (2000). Subsistence in Alaska: A Year 2000 Update. Division of Subsistence, Alaska Department of Fish and Game. Retrieved from http://www.adfg.alaska.gov/download/download/subupd00.pdf

CHAPTER 6

Water Regulation

DESCRIPTION OF WATER REGULATING SERVICES

The regulating services of freshwater quantity and quality are interrelated, as each service is ultimately dependent upon the functioning of others and takes place across all land classes of a watershed, as well as the atmosphere.

Ecosystems regulate water storage through interactions with the hydrological cycle and microclimates that affect temperature, humidity, and precipitation (Reid, 2005).

Water supply refers to the quantity of water available through surface and ground sources for a wide range of human and ecosystem needs, including drinking water, agriculture and industry, fisheries, biodiversity and cultural practices. To avoid double counting, we focus in this section on provision of drinking water[15].

The ecosystem service of water purification refers to removal, filtration, and breaking down of pollutants and wastes from water by microorganisms, algae, and plants. This process results in water suitable for drinking, industry, and wildlife habitat. In this section we focus on the contribution of forests, wetlands, and riparian areas to clean drinking water.

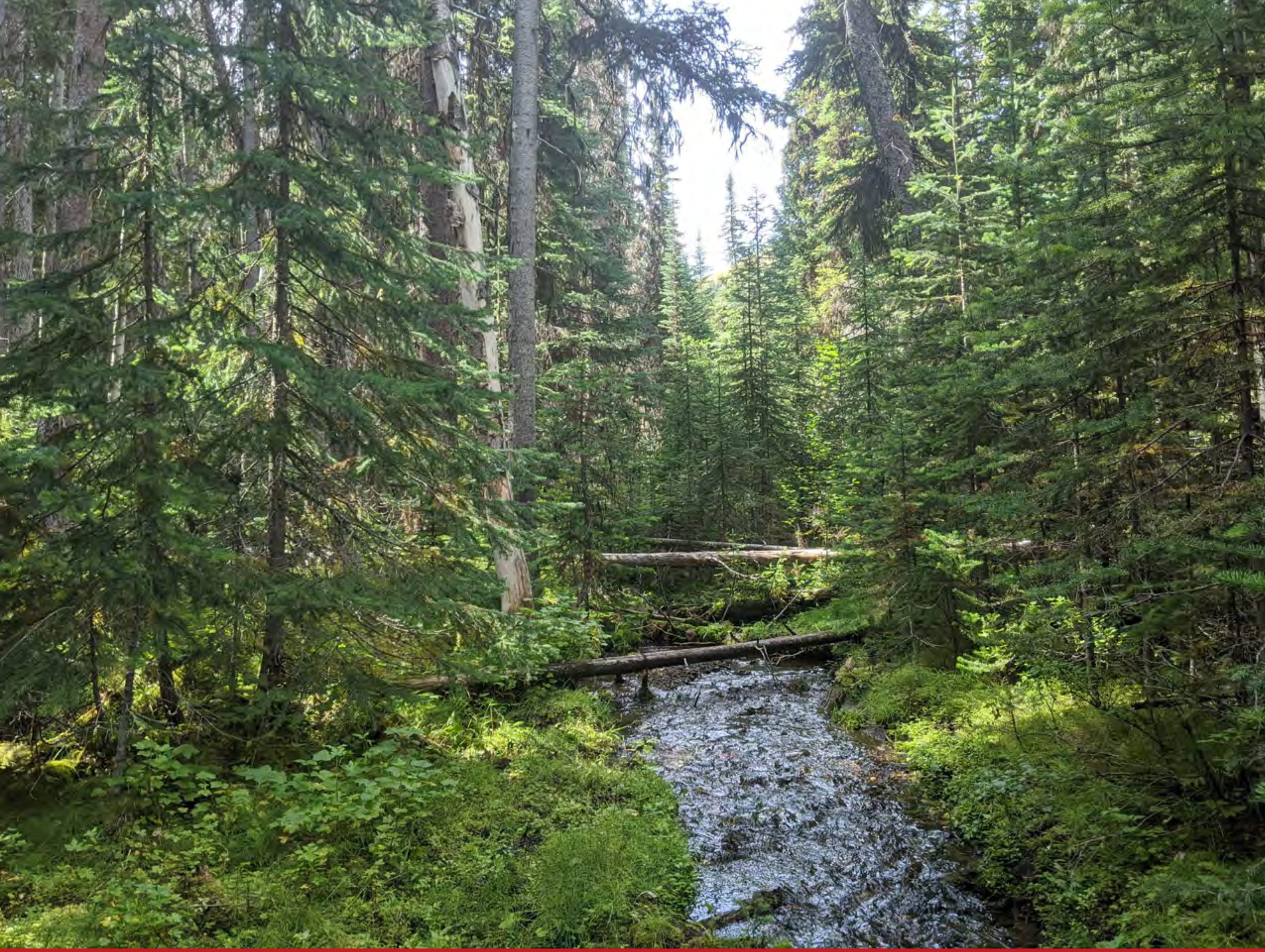
WATER REGULATION IN THE ELEPHANT HILL AREA

Within the Elephant Hill study area, drinking water is drawn from both surface and groundwater sources and used by the Bonaparte and Skeetchestn First Nations[16]. The Bonaparte watershed was experiencing low flow issues prior to the fire. Over-licensing of streams and a lack of groundwater legislation were identified in the 2010 Water Management Report as historical issues, which the impacts from the Elephant Hill fire and climate change may be exacerbating (Bonaparte Watershed Water Management Project, 2010).

Since the fire, an Equivalent Clearcut Analysis (Lewis, 2018), and an evaluation of geomorphic change in the Lower Bonaparte River and Tributaries (Reid, 2021) point to changes in stream flow. The Equivalent Clearcut Analysis found that approximately 17% of assessment units had 50 or more per cent of the total area burned by wildfire. The Geomorphic Analysis showed an increase in the 1-in-10 year peak flows but does not speak to the specific causes of change. Project partners also noted changes to stream hydrographs, which confirms changes to water volume and flow rates.

15 We excluded from scope the use of water for hydropower generation and industry as these were not present in the Elephant Hill area. Water is used for irrigation in the Bonaparte and Deadman watersheds, but mainly for ranching, which is addressed in a separate section. Water for recreation generally refers to boating, swimming or fishing. We have addressed fishing in other sections and recreational use was not considered significant.

16 Personal communications with Angie Kane, SRSS.



Anderson Creek, on the western side of Hat Creek valley. Photo credit: Sarah Dickson-Hoyle.

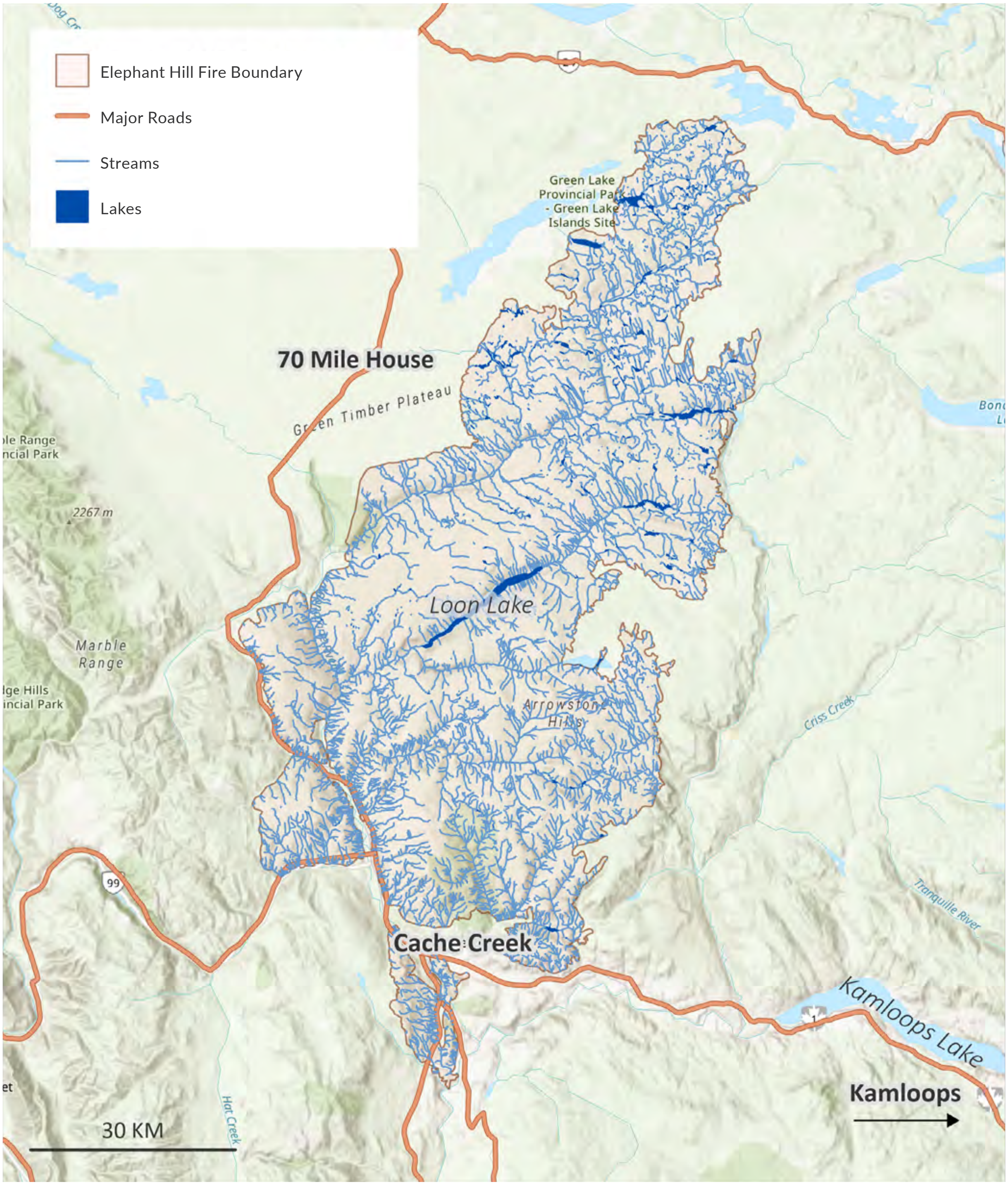
FOUR KEY ENVIRONMENTAL DRIVERS OF AQUATIC ECOSYSTEM HEALTH

The quantity and quality of water available to communities for multiple uses is dictated by the properties of local watersheds, which include geology, topography, climate, land cover, and human uses. These properties interact with environmental drivers of aquatic ecosystem health, to dictate the extent of water-based ecosystem services.

Flow Regime	Thermal and light inputs	Sediment flux	Chemicals, nutrients, and Pathogens
Relates to the quantity, rate, timing, and pathways of water through the watershed, and is characterized by base flows, seasonal timing of flows, annual variation, and floods.	Relates to how thermal inputs are dispersed, vegetation in riparian zones and is characterized by stream temperatures and volumes of water.	Relates to volumes and types of sediment and organic matter. Important for rebuilding wetlands and providing soil for vegetation	Relates to removal of pollutants by vegetation

Source: Binder et al., 2017

Figure 8: Surface water in the Elephant Hill Area, pre-fire



Sources: Esri, GeoBC, USGS, Freshwater Atlas, BC Wildfire Service

Speaking of water flows as "services" is consistent with the economic perspective used in this study, and we recognize the limitations of this view that could lead to an underestimation of values (See Limitations in *Natural Capital Valuation*). All forms of water are central to Secwépmec spirituality and worldview, which demands that water is understood as having rights, and people as having responsibilities for the care of the water within their lands. These responsibilities are embedded in Secwépmec laws and governance and revealed through storytelling and traditional practices. The importance of understanding interconnectedness and reciprocal accountability was discussed by Kukpi7 Wayne Christian during the Secwépemc Knowledge Relationships webinar[17] held in November 2021.

These principles are captured in three priorities for "Sellkwe" that Kukpi7 Wayne reviewed, which include:

- Approach our relationship with water from a holistic and interconnected perspective
- Respect water and rights of water
- Work together to secure healthy water for future generations

It was not possible in this study to fully represent the rights of water or the interconnectedness of water with the whole ecosystem.

17 https://www.youtube.com/watch?v=x2lY4guku0U

IMPACT OF WILDFIRE ON DRINKING WATER SUPPLY AND QUALITY

The quantity and quality of water stored in and flowing from forests are vulnerable to natural and human-made disturbances. However, while the effects of some disturbances (e.g., urbanization, agriculture, forestry) are well-studied, impacts from forest fires are less understood (Bladon et al., 2014). Overall, it is assumed that the greater the disturbed area, the greater the potential for hydrological change. Here we review the impacts of large forest fires on drinking water supply.

Large wildfires, such as the Elephant Hill wildfire, can impact the hydrological processes of interception, infiltration, and evapotranspiration, which influences the timing and volume of stream flows (Bladon et al., 2014; Lewis, 2017). The loss of forest reduces evaporation since vegetation can no longer intercept precipitation. This results in increased amounts of rain and snow reaching the ground, and increased rates of runoff and volume of stream flows. Large fires can also damage soils and the protective layer of vegetation and litter. "Postfire," a water-repellent layer may develop at or near the soil layer. This can significantly reduce, or in extreme cases, entirely prevent water from infiltrating soils during rain events or snowmelt, which results in rapid overland runoff and an increased potential of flooding (Bladon et al., 2014). Studies have shown that the combination of high severity burns and short-intense rain events can generate peak flows that are 5 to 870 times larger than peak flows in unburned catchments (Moody & Martin, 2009b).

Wildfires can result in increased erosion rates, changes to runoff volumes, and more pollutant sources, and ultimately increase sediment loads, nutrients, and other water quality constituents that contaminate water supplies (Smith et al., 2011). These impacts can travel downstream and choke streams, rivers, reservoirs, and lakes when fine sediments settle. When subsequent rain events and high flow periods occur, sediments are remobilized and transported further downstream, contaminating additional water supplies (Bladon et al., 2014).

Increased erosion rates are generally short-lived – in the range of 3 to 8 years. However, the legacy downstream can be long-lasting, persisting from 10 to 100 years (Moody & Martin, 2009a; Moody & Martin, 2009b). Furthermore, the impacts of wildfire on water quality can extend to downstream communities far from the site of the fire.

METHODS

We used benefit transfer methods for estimating the value of drinking water supply (quantity) and purification (quality). Underlying studies used replacement cost of water supply infrastructure, ecological production functions combined with commodity costs, and replacement cost of water treatment.

Drinking water supply

We used two studies for estimating drinking water supply, one for ground water and one for surface water. Wilson et al. (2020) assessed the value of groundwater for drinking water supply in a New Brunswick, Canada village as part of a Municipal Natural Assets Initiative (MNAI) study, and Hill et al. (2014) assessed the value of surface water for drinking water supply.

Groundwater

The MNAI groundwater supply study (Wilson et al., 2020) used results from a hydrological model that assessed runoff volumes over approximately 20 years to quantify the capacity of an intact watershed to store and supply drinking water. Based on modeling results, a replacement cost estimate was determined by assessing the cost to replace the modeled capacity of the watershed with groundwater wells. The study assessed the cost of well drilling, including the costs of research, design, and implementation of a new well, at $400,000 per well (2020 CAD). We used this study because it:

- employed hydrological modeling to capture a variety of hydrological parameters (e.g., runoff, evaporation, snowmelt);
- represents the value of a rural watershed for drinking water supply for a small community (population ~350); and
- is a recent study. It should be noted that the watershed is significantly smaller (~203 ha) however.

To arrive at a value for the Elephant Hill area, we converted the 2020 cost of constructing a well to 2021 CAD ($412,946) and applied the cost to an estimate of 8 groundwater wells[18] within the study area for a total value of $3,303,568. Since the wells are a one-time cost, we needed to annualize the result with the Equivalent Annual Cost equation below. We assumed that the average lifespan of wells is 50 years[19] and used a 3% rate of return[20].

$$EAC = (AP * R)/[(1-(1+R)^{-n})], \text{ where}$$

AP = asset price

R = rate

n = number of years

The resulting value of $128,395 (Table 12) was allocated to forests, grasslands, shrublands, water and wetlands of the watershed, as multiple land classes contribute to water supply.

Surface water

The surface water study (Hill et al., 2014) estimated the potential economic value of drinking water supply services provided by headwater catchments as the product of ecological production functions and published commodity prices. Similar to the MNAI study, the value was based on a modeled analysis that considered multiple variables that predict water supply (e.g., annual precipitation, runoff rates, peak flow rates) and used the results of the model to arrive at economic estimates. We chose this study due to:

- the strong methodology;
- the fact that it is a meta-analysis, which improves the precision of the results;
- the study being relatively recent; and the ability to isolate results from the Western Mountain Region of the United States.

18 The estimate was based on an informal survey of SRSS communities conducted by SRSS staff.
19 Groundwater well lifespan is variable and can last anywhere from 25 to 100 years. We used a conservative estimate of 50 years
20 The rate of 3% is a central value typically used for this kind of analysis and represents the rate recommended by Canada's Treasury Board Secretariat Analysis Guide, https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

To arrive at a value for the Elephant Hill area, we converted data in 2014 US dollars (USD) to 2021 CAD. We then applied the per hectare value ($433.21) to 40% of the forest area[21]. We believe this provides a conservative estimate of the head water area (55,902 ha), considering the watershed contains headwaters for both the Columbia and Fraser Rivers.

Purification of drinking water

The value of clean drinking water was estimated for forests, streams and rivers, and riparian areas. Values for forests and stream and rivers were based on the same Hill et al. (2014) study used for surface water supply. In this case, pollutant removal was estimated from a regression model that indicated the level of water treatment required. Based on the model results, the costs of water treatment for phosphorus and nitrogen removal (forests) and denitrification (streams) were assessed.

To arrive at a value for the Elephant Hill area, we converted data in 2014 USD to 2021 CAD. We then applied the per hectare values for phosphorus removal[22] to forests and the per hectare denitrification for water land classes (which was used as a surrogate for streams and rivers).

Values for riparian areas were based on the cost of riparian restoration in the study area ($2,500/km) through conversations with SRSS (Kane, A. interview October 19, 2021). To arrive at a per hectare value, we worked with the GIS technician for Skeetchestn Natural Resources Corp. to identify the total kilometers of riparian zone within the fire area (3,873km). Using the targeted width of restoration work (15m on either side) we arrived at a total of 11,619 hectares of riparian area. The amount of restoration work done varies from year to year. To arrive at an annual value, we multiplied the riparian area (11,619 ha) by the per hectare restoration cost ($7,500). We than annualized the total value ($87,142,500), by applying the same Equivalent Annual Cost equation as above.

As elsewhere in the report, we assumed a 3% rate of return. We annualized the cost over 150 years based on correspondence with SRSS's registered professional forester who indicated the restoration could take up to 150 years to reach full maturity (Verkaik, T. email March 9, 2022). Completing the equation resulted in an annual value of $2,645,677, or $228 per hectare per year (Table 13).

RESULTS

Water supply results

Table 12 shows the value of various land cover classes and forest headwaters in particular.

The groundwater results represent the replacement cost of nature's groundwater storage and recharge services. The annualized value of $128,395, was allocated among the relevant land cover classes based on their share of total area and an average annual value per hectare of $0.71. This small size of this estimate reflects a limited number of groundwater wells across a large landscape.

We estimate the role of headwater forests in the supply of fresh surface water at $24.2 million annually based on our calculation of $433.21 per hectare per year (Table 12). The surface water values reflect the need for extensive infrastructure to transport surface water from its source to end users.

We estimate the total value of water supply at $24.3 million.

21 Headwater forest streams can account for anywhere from 40 - 80% of a catchment (see for example, MacDonald, L.H. & Coe, D. 2007. Influence of Headwater Streams on Downstream Reaches in Forested Areas. Forest Science, 53(2). https://doi.org/10.1093/forestscience/53.2.148

22 We chose to focus on the costs of phosphorus removal over nitrogen removal as it is likely the greater source of nutrient pollution in this watershed.

Table 12: Drinking water supply

Drinking water source	Land cover type	Hectares	$/Hectare/Year	$/Year
Groundwater	Forests	139,754		$99,335
	Grassland	25,374		$18,035
	Shrubland	12,437		$8,840
	Water	3,068		$2,180
	Wetland	6		$4
	TOTAL	**180,639**	**$0.71**	**$128,395**
Surface water	Headwater forests	55,902	$433.21	$24,217,305
Total				**$24,339,558**

Table 13: Drinking water purification

Land cover type	Hectares	$/Hectare/Year	$/Year
Forests	128,135	$3,296	$422,332,960
Water (streams and rivers)	3,068	$2,777	$8,519,836
Riparian	11,619	$228	$2,645,677
Total			**$433,498,473**

Water purification results

Table 13 reflects the contribution of forests, streams and rivers, and riparian vegetation to water purification. The forest and streams and rivers values of $422 million and $8.5 million respectively, reflect the high cost of artificially purifying water – something these ecosystems have evolved to manage over millions of years. The riparian value of $2.6 million is the annualized value of the total costs involved in riparian restoration activities when these land classes are degraded due to human or natural impacts.

Loon Lake from Bonaparte First Nation's reserve. Photo credit: Sarah Dickson-Hoyle.

DISCUSSION AND OPPORTUNITIES FOR FURTHER RESEARCH

Options for refining estimates are provided below. These are offered in the event refined estimates are required to support on-going efforts to improve ecosystem health. We recognize on-going efforts to improve water resources, which were reviewed during the November Secwépemc Knowledge Relationships webinar. These initiatives bring together all jurisdictions with an interest in water to protect at a broader scale and explicitly recognize the requirement for action over a long-time frame and the development of relationships with water users of every type. Specific objectives include:

- Source-to-tap multi-barrier approach to water security
- Source water protection plans
- Govern at a watershed scale
- Working with multiple water authorities
- Working within the community

Young Lake. Photo credit: Angie Kane.

Water supply

If SRSS wishes to refine these values, we suggest options for low, medium, and high-level of effort. At the lower end of effort, mapping should be updated to improve the resolution of water land classes, which would also allow for an accurate quantification of headwater streams. It was acknowledged that several streams and tributaries do not appear within the maps we relied on for calculating the area of streams and tributaries. This will result in higher confidence values.

A medium to medium-high level of effort to improve drinking water supply estimates include groundwater mapping. The identification of recharge zones based on local expert knowledge could likely be completed with a medium level effort, whereas ground water mapping would require a medium-high level of effort.

At the higher end of effort, SRSS could consider completing hydrological modeling to obtain a place-based understanding of how water moves throughout the watershed. The level of effort to complete modeling is dependent upon the extent of monitoring data. For a model to reliably simulate how stormwater moves across a landscape, many different landscape characteristics and hydrologic processes must be represented. Required inputs to stormwater models commonly include meteorological (i.e., precipitation, temperature, solar radiation), topographic (i.e., digital elevation models), and land cover data (i.e., soils, land use).

Water purification

Options for refining values at the lower end of effort include updated mapping of water features to improve the estimate of the contribution of streams and rivers to water purification.

At the medium level of effort, extending water quality monitoring to downstream communities will provide an understanding of the role the Elephant Hill watersheds have in improving water quality to downstream users. It is highly likely that the beneficiaries of water purification extend far beyond the study area, which may be used as rationale for further funding for restoration efforts.

At the higher end of effort, SRSS could consider completing hydrological modeling to obtain a place-based understanding of how water moves throughout the watershed (see water supply above for discussion of hydrological modeling).

REFERENCES

Binder, S., Haight, R.G., Polasky, S., Warziniack, T., & Mockrin, M.H. (May 2017) Assessment and Valuation of Forest Ecosystem Services: State of the Science Review. U.S. Forest Service. General Technical Report NRS-170. Available at: https://www.fs.usda.gov/treesearch/pubs/54252.

Bladon, K.D., Emelko, M.B., Silins, U., & Stone, M. (2014). Wildfire and the Future of Water Supply. *Environmental Science and Technology, 48* (16) 8936-8943. https://pubs.acs.org/doi/10.1021/es500130g

Bonaparte Watershed Water Management Project: Opportunities for Improved Water Management in the Bonaparte River Watershed, 2010. Available at: https://psf.ca/wp-content/uploads/2021/10/Download-PDF91-1.pdf.

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery.* Secwepemcúl̓ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm

Hill, B.H., Kolka, R.K., McCormick, F.H., Starry, M.A. (2014). A synoptic survey of ecosystem services from headwater catchments in the United States. *Ecosystem Services, 7,* 106-115. doi 10.1016/j.ecoser.2013.12.004.

Lewis, D. (2018) *Equivalent clearcut analysis of the 2017 Elephant Hill wildfire*. Prepared for the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Moody, J.A., & Martin, D.A. (2009a). Synthesis of sediment yields after wildland fire in different rainfall regimes in the Western United States. *International Journal of Wildland Fire, 18* (1), 96-115. doi 10.1071/WF07162.

Moody, J.A., & Martin, D.A. (2009b). Forest fire effects on geomorphic processes. In A. Cerda & P. Robichaud (eds.) *Fire Effects on Soils and Restoration Strategies*, 41-79. Science Publishers. Available at: https://www.fs.fed.us/psw/publications/4403/nonfs/mcdonald.2009.FireEffectsonSoilsandRestorationStrategies.EffectsForestFires.pdf.

Reid, D.A. (August 2021). Elevation of Historical and Ongoing Geomorphic Change along the Lower Bonaparte River and Tributaries. Department of Geography, UBC. Prepared for M. Simpson, Fraser Basin Council, & A. Gillespie, Secwépemc Fisheries Commission. Available at: https://www.researchgate.net/publication/355208575_Evaluation_of_historical_and_ongoing_geomorphic_change_along_the_lower_Bonaparte_River_and_tributaries.

Reid, W.V., Mooney, H.A., Cropper, A., Capistrano, D., Carpenter, S.R., Chopra, K., Dasgupta, P., Dietz, T., Duraiappah, A.K., Hassan, R., Kasperson, R., Leemans, R., May, R.M., McMichael, T.A.J., Pingali, P., Samper, C., Scholes, R., Watson, R.T., Zakri, A.H., Shidong, Z., Ash, N.J., Bennett, E., Kumar, P., Lee, M.J., Raudsepp-Hearne, C., Simons, H., Thonell, J., & Zurek, M.B. (2005). *Ecosystems and human well-being: Synthesis*. Millennium Ecosystem Assessment. Island Press. Retrieved from https://www.millenniumassessment.org/documents/document.356.aspx.pdf

Smith, H.G., Sheridan, G.J., Lane, P.N.J., Nyman, P. & Haydon, S. (2011). Wildfire effects on water quality in forest catchments: A review with implications for water supply. *Journal of Hydrology, 396* (1), 170-192. doi:

Wilson, J., Molnar, M., Thiessen, J., Taylor, A., Bornemann, J., Long, M-A. & Brawn, C. (2020). Municipal Natural Assets Initiative: Cohort 2 National Project, Village of Riverside-Albert, New Brunswick (Final Technical Report). Available at: https://mnai.ca/village-of-riverside-albert/.

CHAPTER 7

Regulation of Natural Hazards

DESCRIPTION OF NATURAL HAZARD REGULATING SERVICE

Damaging events such as flooding and landslides can have serious effects on the environment and local populations whose life, health, livelihoods, and well-being depend on a given environment.

Environmental impacts may include direct damage to natural resources and ecosystem functions and indirect damages resulting from recovery actions that fail to take ecosystems into account. In addition, new vulnerabilities and risk may emerge if cumulative impacts result. For example, timber salvaging after a wildfire can bring additional damage if harvesting occurs in live stands that experienced low burn severity. The *Elephant Hill Wildfire Recovery Joint Leadership Council Principles for Timber Salvage* provides an ecosystem-based approach to timber salvage to minimize further damage (Dickson-Hoyle & John, 2021).

A growing body of evidence is pointing to the important role of intact ecosystems in reducing the hazards that give rise to extreme events or mitigating their effects (e.g., United Nations Office for Disaster Risk Reduction (UNDRR), 2020). Ecosystems help to mitigate the effects of natural hazards, such as floods, storm surges, droughts, and landslides by acting as natural buffers to mitigate hazard impacts. Here, we consider the values of ecosystems for mitigating landslides and flooding, which are common post-fire hazards.

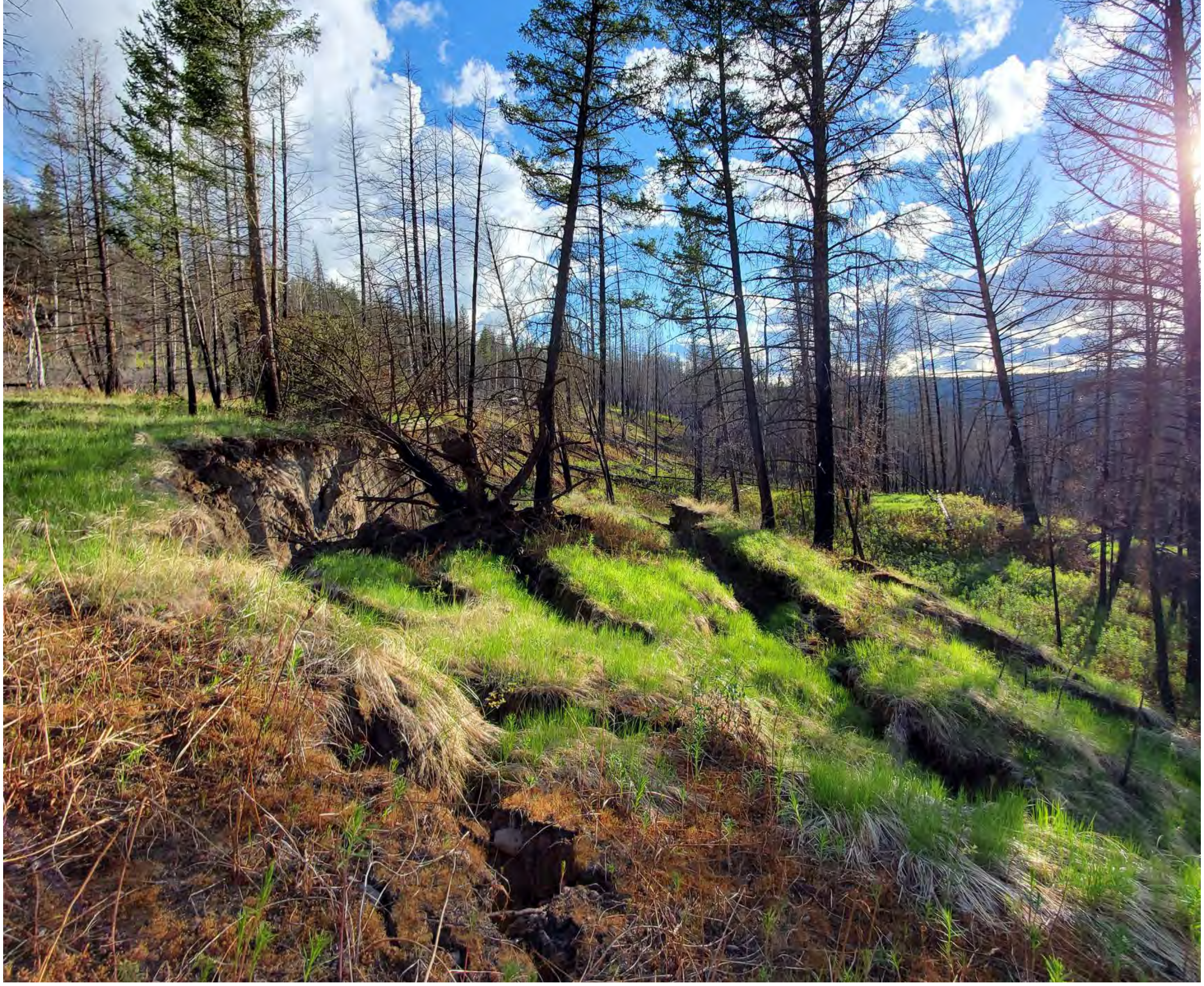
REGULATION OF NATURAL HAZARDS IN THE ELEPHANT HILL AREA

Since the Elephant Hill study area is largely forested, we focus on the role forests play in natural hazard regulation. Forest vegetation regulates the amount of precipitation reaching the forest floor and root systems stabilize soils. Disturbances (which can include fire, pest outbreaks and timber harvesting) remove or damage vegetation that provides these vital services (Berretti et al., 2007).

The Elephant Hill wildfire severely damaged vegetation, which created a condition called hydrophobic soils that contributed to increased risk of runoff, erosion, and debris. Forests were already under stress prior to the fire from the mountain pine beetle epidemic, logging, and climate change impacts (Dhar et al., 2016; Zhang & Wei, 2012). In combination, they have negatively impacted ecosystem resilience.

Intense rainfalls after the Elephant Hill fire caused loss of life, damage, flooding, and drainage issues. Mudslides in the Cache Creek, Clinton and Lillooet areas in 2018 have been attributed to the fire, and resulted in cut off highways, property damage, and the evacuation of 24 people from the Bonaparte Indian Band (Dickson-Hoyle & John, 2021; Tannant, 2021). Recent geomorphic studies in the lower Bonaparte River and tributaries conducted by the University of British Columbia, indicate that recent disturbances have elevated the 1-in-10 year peak flow by 10 to 15%, and contributed to some channel instability near tributary confluences (Reid, 2021).

Restoration efforts are underway but estimates of recovery time are sobering. It is estimated to take decades for the vegetation to recover, anywhere from 50 to 100 years for the forests to return, and considerably longer for soils, which lost organic matter that took thousands of years to develop (Reid, 2021; Wood, 2021).



Severe erosion following the Elephant Hill wildfire at Horse Camp Ranch. Photo credit: Nicola von Rosen.

METHODS

We used benefit transfer methods to estimate the value of flood mitigation and landslide mitigation. The underlying studies used replacement costs methods.

Flood mitigation

We used two studies, one for forests and one for wetlands. These include a MNAI study by Molnar et al. (2020), which assessed the contribution of forests to managing flood and stormwater flows and the Anielski & Wilson (2009) study of Canada's Boreal ecosystem natural capital, which included the value of wetlands for flood control.

Forests

The MNAI study we used to estimate forest values was completed in two steps. The first step assessed peak flow rates using a modeling approach (i.e., the USSCS TR-20 Method) to complete a hydrologic evaluation of flood control provided by forests. The second step used the replacement cost method to estimate the cost of replacing the forests with engineered alternative(s) capable of providing the same level of service. The cost of replacing the forest area with stormwater management ponds to provide an equivalent detention function for stormwater was based on the required storage volume and an assumed cost of $175 per cubic meter (which captures the design and construction costs for a stormwater detention pond with landscaping and environmental components and excludes land purchases).

To arrive at a value for the Elephant Hill area, we converted per hectare values from 2020 to 2021 CAD and applied the resulting per hectare value ($19,441) to forests (for a total of $2,716,957,514). To arrive at an annual amount, we completed an Equivalent Annual Cost calculation, using the same formula as in *Water Regulation*:

EAC = (AP * R)/[(1-(1+R)^-n), where

AP = asset price

R = rate

n = number of years

As elsewhere in the report, we assumed a 3% rate of return. We assumed stormwater management ponds have a 55-year life[23]. Completing this equation resulted in a total annual value of $101,475,839 or $726 per hectare per year for our high forest estimate (Table 14).

Wetlands

The Anielski & Wilson (2009) study used to estimate wetland values extrapolated average wetland values by wetland function from a meta-analysis of 89 wetland valuation studies. Given the extensive review taken by the meta-analysis, it is considered comprehensive. In addition, the average values provide estimates for the cost of replacing wetland functions globally. To arrive at a value for the Elephant Hill area, we converted the average value of flood control services, $571 in 2002 CAD to 2021 CAD and applied the per hectare value to the small area of wetlands identified in the Elephant Hill fire area. The project team identified this study because it is a Canadian study and used a meta-analysis of existing research, which provides a high level of confidence in the average values.

Landslide mitigation

One study was chosen to estimate the value of forest soils for landslide risk reduction. Although it is a European study, it considers the role of mountain forests at a local scale, using cost-based methodologies. We preferred this method because it builds economic values from ecological data, and effectively avoids reliance on public

Notaro and Paletto (2008) developed a methodology for developing reliable costing to advise in the planning and management of forests. The methodology was tested in the Italian Alps, which has some broad similarities to the Elephant Hill study area with comparable altitudes (the Italian Alps site altitudes range from 620m – 1,350m) and temperatures (the Italian Alps site temperatures range from 1 – 22 degrees Celsius), but lower annual rainfall (the Italian Alps site has annual precipitation of 90 – 105mm). Notaro and Paletto considered stand variables (e.g., forest canopy cover, vegetation composition, dominant species root system, incline of land, soil organic matter, soil depth). Based upon these variables they divided the region into four classes:

1. land requiring a low level of protection, requiring the establishment of grasses;
2. land requiring a medium level of protection, requiring hydro-seeding;
3. land requiring a medium-high level of protection, requiring terraces to be cut; and
4. land requiring a high level of protection, where it is necessary to substitute the forest with a single or double palisade (i.e., a fence or defensive wall).

For each class, Notaro and Paletto worked out the total costs of carrying out and maintaining the different natural engineering. The total costs of carrying out and maintaining each natural engineering option was calculated for each class and combined to arrive at a yearly cost per hectare for the forest as a whole.

23 We used Statistics Canada's Average expected useful life of new publicly owned stormwater assets table for stormwater management ponds in British Columbia: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3410021601.

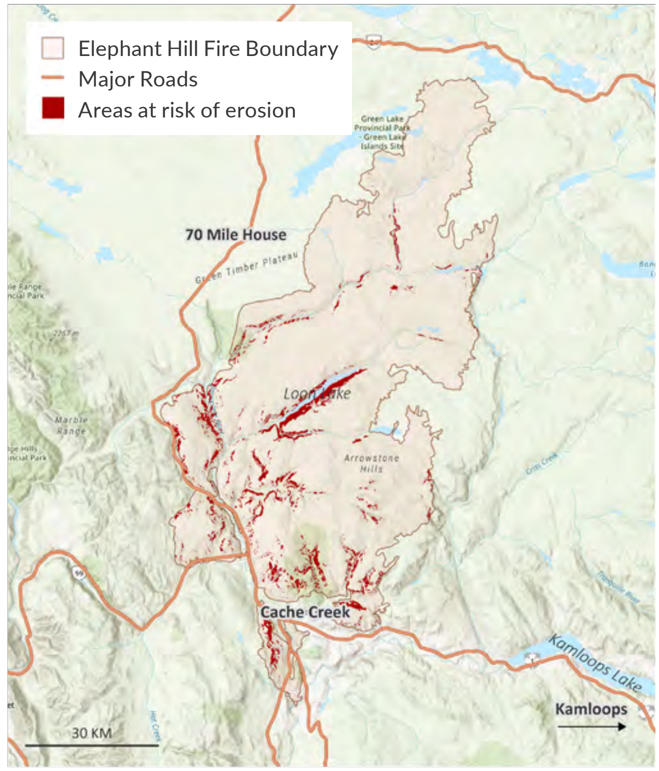
To transfer the results of this analysis to the study area, our project team used GIS techniques to identify lands with high risk of erosion risk. We defined these as lands with 1) slopes that places them at risk for landslides[24] and 2) burn severities of severe and moderate. The resulting high risk areas, representing 7% of forest lands, are shown in Figure 9: Areas at risk of erosion. We treated these hectares as class 4 lands (in the Notaro and Paletto classification), requiring the most intensive management actions.[25] We divided the remaining forest lands amongst the remaining three classes, and conservatively allocated 65% of forests to the lowest risk class 1, 17% of forests to class 2, and 11% to class 3. We converted the per hectare costs for each class of action into 2021 CAD and averaged costs across the four classes to determine an average per hectare value of $418 per year for the low end of forest values (Table 14).

RESULTS

The values for both flood mitigation and landslide mitigation are presented in Table 14. The forest category includes values for both hazards. The low values relate to landslides, whereas flood mitigation values represent the high end estimates. Wetland values were assessed for flood mitigation only. Only 6 hectares were classified as wetland for this study, producing a small annual value. It is possible that with finer resolution, some of the area categorized as forest would reveal small ponds are other wetlands, which would be valued higher on a per hectare basis.

Our estimate is that the Elephant Hill area, prior to the fire, was providing flood and landslide mitigation services of between $58 million and $101 million. As described above, these services were severely impaired by the fire.

Figure 9: Areas at risk of erosion



Sources: Esri, GeoBC, USGS, BC Forest Analysis and Inventory, BC Wildfire Service

24 We referred to Brändli & Herold (2001) to identify this range as slope angles between 16 to 37 degrees.

25 The slope range was that provided in the primary study as the range at which increased landslide risk is present. We layered the top two classes of burn severity to the criteria, as this indicates significant tree loss has occurred and increased landslide risk.

Burned hillsides above Cache Creek in 2018. Photo credit: UBC Tree-ring lab.

Table 14: Flood and landslide mitigation

Land cover type	Hectares	$/Hectare/Year		$/Year	
		Low estimate	High estimate	Low estimate	High estimate
Forest	139,754	$418	$726	$58,391,744	$101,475,839
Wetlands	6	$808	$808	$4,848	$4,848
Total				**$58,396,592**	**$101,480,687**

OPPORTUNITIES FOR FURTHER RESEARCH

Our estimate could be refined with further research, with options that are similar to the options provided for refining the freshwater quantity and quality estimates.

Lower end of effort

Improved mapping of water features would improve the estimate of the contribution of wetlands to flood mitigation.

Medium level of effort

Water-level monitoring (e.g., water level loggers) could be utilized to identify areas where forests and wetlands are reducing flood risk. Values could subsequently be targeted to such areas.

Higher end of effort

SRSS could consider completing hydrological modeling to obtain a place-based understanding of how water moves throughout the watershed. (See Water Supply in *Water Regulation* for discussion of hydrological modeling.)

With respect to future geomorphic improvements, authors of the 2021 UBC study (Reid, 2021) recommend:

- Ongoing monitoring of installed reference sites in Cache Creek, Hat Creek, and Scottie Creek
- Updating analysis with new imagery as it is obtained and released
- Completing a second Lidar flight
- Detailed modeling of channel change to inform channel restoration works.

REFERENCES

Anielski, M. & Wilson, S. (2009). *Counting Canada's natural capital: Assessing the real value of Canada's boreal ecosystems*. Pembina Institute. Available at: https://www.pembina.org/pub/counting-canadas-natural-capital.

Berretti, R., Caffo, L., Camerino, P., De Ferrari, F., Domaine, A., Dotta, A., Gottero, F., Haudemand, J.C., Letey, C., Meloni, F., Motta, R., & Terzuolo, P.G., (2007). Selvicoltura nelle foreste di protezione. Sherwood 134, 11-38. Available at: http://www.regione.piemonte.it/foreste/images/files/pubblicazioni/selvicoltura_foreste_protez.pdf.

Brändli, U.B., Herold, A., 2001. Protection against Natural Hazards. In: Brassel, P. & Lischke, H. (eds.), *Swiss National Forest Inventory: Methods and Models of the Second Assessment*, 231-253. Swiss Federal Research Institute WSL.

Dhar, A., Parrott, L., & Heckbert, S. (2016). Consequences of mountain pine beetle outbreak on forest ecosystem services in western Canada. *Canadian Journal of Forest Research*, *46*, 987-999. doi 10.1139/CJFR-2016-0137.

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery*. Secwepemcúl̓ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm

Molnar, M., Wilson, J., Thiessen, J., Taylor, A., & Mitchell, S. (2020). Municipal Natural Assets Initiative: Cohort 2 National Project, Town of Florenceville-Bristol, New Brunswick (Final Technical Report). Available at: https://mnai.ca/town-of-florenceville-bristol/.

Notaro, S. & Paletto, A. (2008). Natural disturbance and natural hazards in mountain forests: a framework for the economic valuation. Department of Economics, University of Trento, Italy. Available at: https://www.researchgate.net/publication/24136580_Natural_disturbances_and_natural_hazards_in_mountain_forests_a_framework_for_the_economic_valuation.

Reid, D.A. (2021). Elevation of historical and ongoing geomorphic change along the lower Bonaparte River and tributaries. Department of Geography, UBC. Prepared for M. Simpson, Fraser Basin Council, and A. Gillespie, Secwépemc Fisheries Commission. Available at: https://www.researchgate.net/publication/355208575_Evaluation_of_historical_and_ongoing_geomorphic_change_along_the_lower_Bonaparte_River_and_tributaries.

Tannant, D., as quoted (August 23, 2021). Landslides an urgent threat after wildfires burn, UBC engineering professor says. CBC News. Accessed online: https://www.cbc.ca/news/canada/british-columbia/landslides-growing-threat-afte r-wildfires-burn-1.6150932

UNDRR (2020), Ecosystem-Based Disaster Risk Reduction: Implementing Nature-based Solutions for Resilience, United Nations Office for Disaster Risk Reduction – Regional Office for Asia and the Pacific, Bangkok, Thailand. Available at: https://www.undrr.org/media/48333/download.

Wood, S. (January 2021). After the fire: the long road to recovery. *The Narwhale*. Available at: https://thenarwhal.ca/bc-forest-fires-restoration-secwepemc/.

Zhang, M. & Wei, X. (2012). The effects of cumulative forest disturbance on streamflow in a large watershed in the central interior of British Columbia, Canada. *Hydrology and Earth System Sciences*, *16(7)*, 2021-2034. doi 10.5194/hess-16-2021-2012.

CHAPTER 8

Climate and Air Regulation

CLIMATE AND AIR REGULATION IN THE ELEPHANT HILL AREA

Ecosystems in the Elephant Hill area provide clean, breathable air to the region.

These ecosystems also store and sequester carbon dioxide to support a stable climate at global and local levels, helping to mitigate the effects of climate change. Initial data presented in the report "Biomass and Soil Carbon Field Sampling in the Battle Creek Region of the Elephant Hill Wildfire" (Whitworth & Freeman, 2021) show that the fire significantly impaired climate regulating services. In control sites, which are non-burnt, the authors found the average carbon stored was 154.33 tCO_2e/ha compared to 68.00 tCO_2e/ha from burn plots. Compared to the non-burnt sites which are actively sequestering carbon, burned areas—covered in dead timber—instead release carbon to the atmosphere. The report expects that the lack of moisture and lack of shade conditions in the burned area are leading to slow forest regeneration. It is reasonable to assume that in a similar vein, little to no air quality services are also being provided after the burn, due to the loss of vegetation and slow forest regeneration.

Investments in restoring forest health and resilience will help to reclaim the lost climate and air regulating services provided by the land.

METHODS

Carbon sequestration and carbon storage

Carbon sequestration is an annual value that ecosystems provide by removing excess carbon from the atmosphere. In comparison, carbon storage represents the value of carbon captured in biomass and soils that is retained year-over-year. Carbon storage, unlike sequestration, is not an annual value, and is typically measured at one point in time. Although valued in a similar way, these two benefits are distinct from one another and should not be added together.

Carbon sequestration is estimated based on the land cover that existed before the fire as outlined in the North American Land Change Monitoring System (2015); it is assumed that the same area provides little to no carbon sequestration benefit after the burn.

Carbon storage values for different land cover types were derived from the studies listed in the 'Valuation Studies Included' section and applied to the hectares of each land cover type in the Elephant Hill wildfire area. Thanks to field data gathered from the Battle Creek Region of the Elephant Hill fire, we have site-specific data from severely burned plots, as well as from unburned control areas (Whitworth & Freeman, 2021). We compared the average carbon storage values from the control and burned plots.

We assumed "tree" hectares are any land cover area labeled as forest. We assumed "non-tree" hectares are any land cover area not labeled forest, urban, or water. Soil carbon storage was applied to "tree" and "non-tree" hectares. The appropriate carbon storage value was then applied to the hectares of each category. Burned and dead trees are expected to release carbon through the process of decomposition, while live vegetation is expected to capture and remove carbon from the atmosphere. For the purposes of this report, positive values represent carbon captured and stored from the atmosphere while negative values represent carbon emitted into the atmosphere.

Total tree carbon storage (biomass) averages 150.6 tCO_2e/ha in the control sites and -68.65 tCO_2e/ha in the burned sites (including both live biomass and lying dead timber). Total non-tree storage (biomass) averages 1.66 tCO_2e/ha in the control sites and 2.04 tCO_2/ha in the burned sites, but this difference was not found to be statistically significant. Total soil carbon storage averages for the top 45 cm of soil was 151.23 tCO_2e/ha in the control sites and 137.72 tCO_2e/ha in the burned sites. We assumed the control plots represented the pre-fire state of the area.

View towards Green Lake in the southeastern section of burn area, showing variation in burn severity, September 2017. Photo credit: Angie Kane.

We valued carbon sequestration and storage benefits by applying two estimates of the social cost of carbon (SCC) to the amount of carbon sequestered or stored.[26] The first estimate comes from Nordhaus (2017) and represents an internationally accepted value for the SCC ($47.73 per metric tonne CO_2). The second estimate is the rate established by Environment and Climate Change Canada (2016) for the 2020-2025 time period ($47.27 per metric tonne CO_2).

Air quality

After careful selection of appropriate studies, we used two studies from the United States that model the human health benefits of natural lands' ability to remove air pollutants. Both studies estimated benefits from changes to several air pollutants due to the pollution removal ability of vegetation. In particular, the studies both assessed nitrogen dioxide (NO_2), ozone (O_3), fine particulate matter (PM2.5), and sulfur dioxide (SO_2). Each study produced an estimate per hectare for both urban and rural areas based on the avoided healthcare costs associated with reductions in these pollutants. We used the rural values for Washington State and applied them to the pre-fire hectares in the Elephant Hill fire boundary to understand the air quality benefits provided by vegetation prior to the Elephant hill fire.

26 For both values, we use a 3% discount rate. The rate of 3% is a central value typically used for this kind of analysis and represents the rate recommended by Canada's Treasury Board Secretariat Analysis Guide, https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

Table 15: Total value of carbon storage

Land cover type	Scenario	Hectares	Tonnes CO_2e/ Hectare	$/Hectare		Total $ (millions)	
				Low estimate	High estimate	Low estimate	High estimate
Forested aboveground vegetation	Pre-burn	139,754	150.6	$7,118	$7,188	$995	$1,005
	Burn		-68.7	-$3,245	-$3,277	-$454	-$458
	Difference		219.3	-$10,363	-$10,465	-$1,449	-$1,463
Non-forest aboveground vegetation	Pre-burn	47,518	1.7	$79	$80	$4	$4
	Burn		2.0	$96	$97	$4	$4
	Difference		-0.4	$17*	$17*	$0.8*	$0.8*
Soil	Pre-burn	187,272	151.2	$7,148	$7,218	$1,338	$1,352
	Burn		137.7	$6,509	$6,573	$1,219	$1,231
	Difference		13.5	-$639	-$645	-$119	-$121
Total	**Pre-burn**		**303.5**	**$14,345**	**$14,486**	**$2,337**	**$2,361**
	Burn		**71.1**	**$3,360**	**$3,393**	**$769**	**$777**
	Difference		**232.4**	**-$10,985**	**-$11,093**	**-$1,568**	**-$1,584**

Source: Values come from Whitworth, G. and Freeman, S. 2021. Biomass and Soil Carbon Field Sampling in the Battle Creek Region of the Elephant Hill Wildfire.

* not significantly different between control and burn plots

RESULTS

Carbon storage and sequestration

Tables 15 and 16 summarize the value of carbon storage and sequestration respectively for the pre-fire conditions of the Elephant Hill area. Negative values represent carbon emissions.

Before the fire, ecosystems in the Elephant Hill area helped to provide around $2.33 to 2.36 billion dollars worth of carbon storage services. This value is measured at one point in time and does not represent an annual value.

Ecosystems in the Elephant Hill region helped to provide $15.2 million to $366.1 million dollars per year in carbon sequestration benefits. After the fire, much of the region has become a source of carbon emissions; this will continue until ecosystems recover and regenerate.

Air quality

Table 17 summarizes the value of air quality services for the pre-fire conditions of the Elephant Hill area. Prior to their loss in the fire, ecosystems in the burned area provided an estimated $905,145 per year in air quality regulation services.

Table 16: Total value of carbon sequestration

Land cover type	Hectares	$/Hectare/Year		$/Year	
		Low estimate	High estimate	Low estimate	High estimate
Barren lands	8,276	–	–	–	–
Cropland	1,424	$25	$127	$35,563	$180,768
Forest, deciduous	595	$90	$1,022	$53,689	$608,353
Forest, evergreen	135,374	$28	$2,539	$3,855,531	$343,804,922
Forest, mixed	3,785	$28	$2,539	$107,788	$9,611,689
Grassland	25,374	$296	$315	$7,511,954	$8,006,237
Shrubland	12,437	$296	$315	$3,682,056	$3,924,332
Water	3,068	–	–	–	–
Wetland	6	$25	$419	$162	$2,711
Total	**190,339**			**$15,246,743**	**$366,139,012**

Table 17: Total value of air quality services

Land cover type	Hectares	$/Hectare/ Year	$/Year
Forest, deciduous	595	$6.42	$3,826
Forest, evergreen	135,374	$6.42	$870,098
Forest, mixed	3,785	$6.42	$24,325
Grassland	25,374	$0.05	$1,319
Shrubland	12,437	$0.45	$5,577
Total	**177,565**		**$905,145**

DISCUSSION

The lost climate and air regulating services in the Elephant Hill area will, left to their own devices, recover slowly over time as vegetation regenerates. However, forests remain at risk of intense fire, resulting from the combined effects of climate change and long term forest management that has prioritized fire suppression and timber harvest, leaving heavy fuel loads on the landscape (Mitchell et al., 2009; Wimberly & Liu, 2014).

The ecological impacts on forests and their ability to sequester carbon can last for decades (Goetz et al., 2006; Law & Waring, 2015; Schindler & Lee, 2010). Indigenous-led restoration and stewardship, including the integration of traditional fire management, may help to accelerate and sustain forest recovery, restoring climate and air quality services (see *Indigenous fire management* in *Introduction to the Project and Study Area*).

SOURCES FOR VALUATION AND OTHER REFERENCES

Social cost of carbon

Social Cost of Carbon. Nordhaus, W.D. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences*. https://www.pnas.org/doi/10.1073/pnas.1609244114

Environment and Climate Change Canada. (2016). *Technical update to Environment and Climate Change Canada's social cost of greenhouse gas estimates*. https://publications.gc.ca/collections/collection_2016/eccc/En14-202-2016-eng.pdf

Carbon storage

Whitworth G., Freeman S. (2021). *Biomass and soil carbon field sampling in the Battle Creek region of the Elephant Hill wildfire*. Report completed for Secwepemcúl'ecw Restoration and Stewardship Society.

Carbon sequestration

CULTIVATED

Crops

Smith, W.N., Desjardins, R.L., & Grant, B. (2001). Estimated changes in soil carbon associated with agricultural practices in Canada. Canadian Journal of Soil Science, 81, 221-227.

FOREST

Deciduous

Black, T.A., Chen, W.J., Barr, A.G., Arain, M.A., Chen, Z., Nesic, Z., Hogg, E.H., Neumann, H.H., & Yang, P.C. (2000). Increased carbon sequestration by a boreal deciduous forest in years with a warm spring. Geophysical Research Letters 27(9), 1271-1274.

Chen, W.J., Black, T.A., Yang, P.C., Barr, A.G., Neumann, H.H., Nesic, Z., Blanken, P.D., Novak, M.D., Eley, J., Ketler, R.J., & Cuenca, R. (1999). Effects of climatic variability on the annual carbon sequestration by a boreal aspen forest. Global Change Biology, 5, 41-53.

Hoover, C. M., Bagdon, B., & Gagnon, A. (2021). Standard estimates of forest ecosystem carbon for forest types of the United States. Gen. Tech. Rep. NRS-202. U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS-GTR-202.

Evergreen

Hoover, C. M., Bagdon, B., & Gagnon, A. (2021). Standard estimates of forest ecosystem carbon for forest types of the United States. Gen. Tech. Rep. NRS-202. U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS-GTR-202.

GRASSLAND

Liu, S., Liu, J., Young, C.J., Werner, J.M., Wu, Y., Li, Z., Dahal, D., Oeding, J., Schmidt, G., Sohl, T.L., Hawbaker, T.J., & Sleeter, B.M. (2012). Chapter 5: Baseline carbon storage, carbon sequestration, and greenhouse-gas fluxes in terrestrial ecosystems of the western United States. In Z. Zhu and B.C. Reed (eds.) Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of the western United States. USGS Professional Paper 1797.

SHRUBLANDS

Liu, S., Liu, J., Young, C.J., Werner, J.M., Wu, Y., Li, Z., Dahal, D., Oeding, J., Schmidt, G., Sohl, T.L., Hawbaker, T.J., & Sleeter, B.M. (2012). Chapter 5: Baseline carbon storage, carbon sequestration, and greenhouse-gas fluxes in terrestrial ecosystems of the western United States. In Z. Zhu and B.C. Reed (eds.) Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of the western United States. USGS Professional Paper 1797.

WETLANDS

Bridgeham, S.D., Megonigal, J.P., Keller, J.K., Bliss, N.B., & Trettin, C. (2006). The carbon balance of North American wetlands. Wetlands, 26(4): 889-916.

View over Hat Creek valley. Photo credit: Sarah Dickson-Hoyle.

Air Quality

GRASSLAND AND SHRUBLAND

Gopalakrishnan, V., Hirabayashi, S., Ziv, G., & Bakshi, B. R. (2018). Air quality and human health impacts of grasslands and shrublands in the United States. Atmospheric Environment, 182, 193-199.

FOREST

Nowak, D. J., Hirabayashi, S., Bodine, A., and Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. Environmental pollution, 193, 119-129.

Other References

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery.* Secwepemcúl̓ ’ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm

Goetz, S., Fiske, G., and Bunn, A. (2006). Using satellite time-series data sets to analyze fire disturbance and forest recovery across Canada. *Remote Sensing of Environment*, *101*(3), 352-365.

Law, B. E., and Waring, R. H. (2015). Carbon implications of current and future effects of drought, fire and management on Pacific Northwest forests. *Forest Ecology and Management*, *355*, 4-14.

Mitchell, S. R., Harmon, M. E., and O’Connell, K. E. (2009). Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. *Ecological Applications*, *19*(3), 643-655.

Multi-Resolution Land Characteristics Consortium. (2015). https://www.mrlc.gov/data/north-american-land-change-monitoring-system North American Land Change Monitoring System. Dataset.

Schindler, D. W., and Lee, P. G. (2010). Comprehensive conservation planning to protect biodiversity and ecosystem services in Canadian boreal regions under a warming climate and increasing exploitation. *Biological Conservation*, *143*(7), 1571-1586.

Whitworth, G., and Freeman, S. (2021). Biomass and Soil Carbon Field Sampling in the Battle Creek Region of the Elephant Hill Wildfire. Available from Secwepemcúl’ecw Restoration and Stewardship Society upon request.

Wimberly, M. C., and Liu, Z. (2014). Interactions of climate, fire, and management in future forests of the Pacific Northwest. *Forest Ecology and Management*, *327*, 270-279.

CHAPTER 9

Estimate of Loss: Productive Ranching Land

DESCRIPTION OF RANCHING IMPACT

Healthy forests and grasslands provide many benefits, including land that can sustain ranch animals.

Bonaparte First Nation holds a ranching tenure (RAN077749) that was burned to such a degree that a three-year directed non-use order was issued by the B.C. government. The purpose of the order was to allow the ecosystem to recover enough so that it could sustainably support grazing activity, and it was rescinded prior to the start of grazing season in 2020. During this time, Bonaparte First Nation was unable to put animals out to graze these lands resulting in a clear economic loss.

Prior to Elephant Hill, ranching activity for the tenure was permitted for a total of 244 animal unit months (AUM). An AUM is a unit that measures how much forage is necessary to support one 450 kg cow and her calf (i.e., cow/calf pairs) for one month. Assigning 244 AUMs to the ranching tenure prior to Elephant Hill reflects the land's capacity to provide sufficient forage.

METHODS

Being unable to graze livestock—specifically cow/calf pairs raised for beef—for three years represents a clear economic loss to Bonaparte First Nation. To quantify this loss, it is necessary to convert AUMs to cow/calf pairs. To do this, divide total AUMs by the number of months in grazing season, which was 4.5 months pre-fire. This equals 54 cow/calf pairs that the Bonaparte ranching tenure could support pre-fire for one grazing season, rounded down to the nearest whole animal.

As a result of the non-use agreement, Bonaparte First Nation was unable to graze 54 cow/calf pairs each year on its ranching tenure. Average beef prices for mature cows during each year of the non-use agreement are as follows:

Table 18: Average beef prices, mature cows

Livestock	2017	2018	2019
Beef cows	$2,033	$2,026	$1,829

Source: Statistics Canada (2021). Prices for each year have been inflated to 2021 CAD.

Multiplying the maximum allowable 54 cows per year by the average market prices for each year and summing results in a cumulative loss of $317,952.

To create an upper bound for losses, it is necessary to add the value of the allowable calves that are part of the AUM allotment to this estimate. Calf prices differ according to age, and older calves are more valuable. Because the precise timing of calf sales and their ages at date of sale are unknown, this analysis conservatively uses the lower average market price for 0–6-month-old calves:

Table 19: Average beef prices, calves

Livestock	2017	2018	2019
Calves, 0–6 months	$690	$678	$637

Source: Statistics Canada (2021). Prices for each year have been inflated to 2021 CAD

Assuming a one-to-one cow-to-calf relationship, multiplying the 54 allowable calves per year by the average market prices for each year and summing results in a cumulative loss of $108,270.

Grasslands above Cache Creek. Photo credit: Sarah Dickson-Hoyle.

RESULTS

The cumulative loss to the Bonaparte First Nation as a result of the directed non-use order prompted by the Elephant Hill fire is between $317,952 and $426,222 (cows and calves).

Table 20: Cumulative ranching loss over three years

Low estimate (cows only)	High estimate (cows and calves)
$317,952	$426,222

Trembling aspen/meltéllp (Populus tremuloides).
Photo credit: Marianne Ignace.

LIMITATIONS

While ranching is re-authorized for the Bonaparte First Nation tenure at a level of 244 AUMs, ranching activity has not yet resumed. Whether this is because the available forage provided by the land has still not recovered, fencing to constrain cattle to the rangeland has been damaged by the fire and not replaced, or some other reason, nearly $150,000 in annual losses from reduced ranching activity continues.[27]

This calculation does not account for the presence of bulls, which will be present in any standalone ranching operation, and which are included in the allotment of AUMs for the ranching tenure. Bulls, though they fetch a higher market price, are not typically sold each year. For simplicity, this analysis only accounts for cow/calf pairs, thereby overstating slightly the presence of marketable livestock and slightly biasing the estimate upwards.

27 $426,222 cumulative losses / 3 years of losses = $142,074 in annual losses

DISCUSSION

The Elephant Hill region is home to several ranches, some of which employ Indigenous citizens while others are owned by First Nations.[28] As Ignace and Ignace (2017) explain, ranches were introduced on traditional territories following European settlement in the region in the early 20th century; the associated changes in the land, economy, and law led to radical changes in the Secwépemc way of life. Secwépemc Chiefs used the term 'ranch' to refer to their homeland; this idea was compatible with settler terminology, even as the definition incorporated additional cultural land uses beyond just agriculture and ranching.

First Nation-owned ranch impacts were not limited to just grazing losses. Dickson-Hoyle and John (2021) identify additional ranching impacts to fencing and other ranch infrastructure as well as additional costs for reseeding burned areas and mitigating soil erosion. Losses to First Nation-owned ranching interests can be recovered with support from the provincial and federal governments, likely through the AgriRecovery framework that in 2017 opened $20 million in funds to assist ranchers with extraordinary costs related to the fire (Public Safety Canada, 2017). Additional investment in restoring the landscape post-fire will aid ranchers by restoring lost animal forage as well as restore land productivity more broadly. Ecosystem restoration supports not only ranching interests, but the additional cultural uses of hunting, fishing, and forage suggested by the original and expansive use of the term 'ranch' by Secwépemc Chiefs: a homeland and all that it provides—not simply a place for grazing.

REFERENCES

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery.* Secwepemcúl'ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm

Ignace, M., & Ignace, R.E. (2017). *Secwépemc people, land, and laws.* McGill-Queen's University Press. doi: 10.14237/ebl.9.2.2018.1380.

Public Safety Canada. (2017). Governments of Canada, British Columbia meet with First Nations community leaders and Canadian Red Cross to discuss progress and next steps in B.C. wildfires response. News release. https://www.canada.ca/en/public-safety-canada/news/2017/09/governments_of_canadabritishcolumbiameetwithfirstnationscommunit.html

Statistics Canada. (2021). Table 32-10-0124-01: Value per head of livestock at July 1. https://doi.org/10.25318/3210012401-eng

28 Several Indigenous-owned ranches that are near the Elephant Hill fire include:

- Stswecem'c Xgat'tem First Nation owns the Big Bar Guest Ranch http://www.bigbarranch.com/whoweare
- The Skeetchestn Indian Band has purchased three ranches: the Ronny Craig Ranch, the X-J Ranch, and Bob George Ranch http://www.skeetchestn.ca/natural-resources-corp
- The Canoe Creek Band purchased a ranch at Meadow Lake - https://www.nsculturalsociety.ca/bands.html
- The (Kamloops) Tk'emlúps te Secwėpemc (TteS) purchased Harper Ranch, now known as the Spiyu7ullucw Ranch Corporation https://tkemlups.ca/profile/history/our-story/

CHAPTER 10

Estimate of Loss: Timber Benefits

PUTTING TIMBER BENEFITS IN PERSPECTIVE

Before the Elephant Hill fire, the land was roughly 70% forested with large areas of commercially valuable lodgepole pine and Douglas-fir.

As we have seen throughout this report, healthy forest ecosystems provide a wide range of valuable services year after year. Throughout the project we heard from community members that forestry, as conventionally practised, undermines other forest services of value to SRSS communities (Anderson, M. interview February 29, 2020; SRSS Technical Committee meeting December 2, 2021). These practices include fire suppression and the prioritization of commercially valuable species to the exclusion of other species needed for a diverse and healthy ecosystem (see also Introduction to the Project and Study Area).

However, First Nations do receive some benefits from timber harvesting through revenue sharing programs. We therefore estimated the timber revenues lost to First Nations when the timber stocks burned, as a point of comparison with the annual ecosystem services values. We consider this a one-time loss because the timber stocks would not be harvestable again for decades.

CONTEXT FOR LOST REVENUE SHARING

First Nations communities in the region receive economic benefits based on the forest harvest activities that take place in their traditional territory through individual Forest Consultation and Revenue Sharing Agreements (FCRSA) or Interim Forestry Agreements (IFA). The market value of lost timber to First Nations is estimated via reduced revenue sharing receipts from the B.C. government.[29]

The Elephant Hill fire burned significant tracts of forest in the 100-Mile House and Kamloops timber supply areas (TSA). Revenue sharing, in the amount of 3% or 5%, occurs when TSA harvests intersect First Nation traditional territories. The revenue sharing agreements suggest a complex formula based on the amount of overlap between the traditional territories and the TSA.[30] In practice, 5% of the logging revenues are set aside and distributed equally among any First Nation communities with traditional territories that intersect the TSA. The 5% is a maximum amount, to be distributed to a single First Nation band (in the case of a 1:1 match between a TSA and a single traditional territory) or to multiple First Nation bands (in the case of a 1:many match between a TSA and multiple traditional territories). For the First Nation bands who have not signed an agreement, the amount shared is reduced to 3%.

Since TSA are large areas relative to the area affected by the Elephant Hill fire, harvest levels across both affected TSA remained steady before and after the fire, or at least did not appear to be responsive to the fire.[31] Put another way, total timber harvest in the TSA that overlap the Elephant Hill fire did not change significantly, suggesting that harvest simply shifted away from Elephant Hill and to other areas within the TSA, which in turn suggests that revenue sharing receipts to First Nations remained steady.

29 This calculation only examines expected losses in revenue sharing, and does not account for the direct impact to First Nations that hold timber or woodlot licenses/tenures that were burned in the Elephant Hill fire. For those First Nations, the economic loss is significantly greater because they would be expected to retain significantly more from their own harvest operations than they would receive from revenue sharing. By not accounting for, at minimum, the impacted tenures of Whispering Pines/Clinton and High Bar First Nations, the present analysis produces an underestimate of lost timber revenue.

30 GIS polygons for traditional territories are unavailable, making it impossible to back-calculate the timber harvest and revenue share using the given formulas.

31 Per harvest reports from B.C Harvest Billing System, available from: https://a100.gov.bc.ca/pub/hbs/

Some trees that are not encouraged for timber production, have other values. Subalpine (balsam) fir (Abies lasiocarpa), found at higher elevations, has high cultural value, including for food and medicine. Photo credit: Nancy Turner.

This means that it is not possible to estimate annual losses due to the fire, because harvest levels (and thus revenue sharing) do not appear to be responsive to pre- and post-fire conditions (i.e., the harvest levels do vary, but this is true every year, and is most likely a function of market conditions; no dramatic reduction in harvest that would signal a response to reduced timber stocks was observed in the immediate aftermath of the Elephant Hill fire).

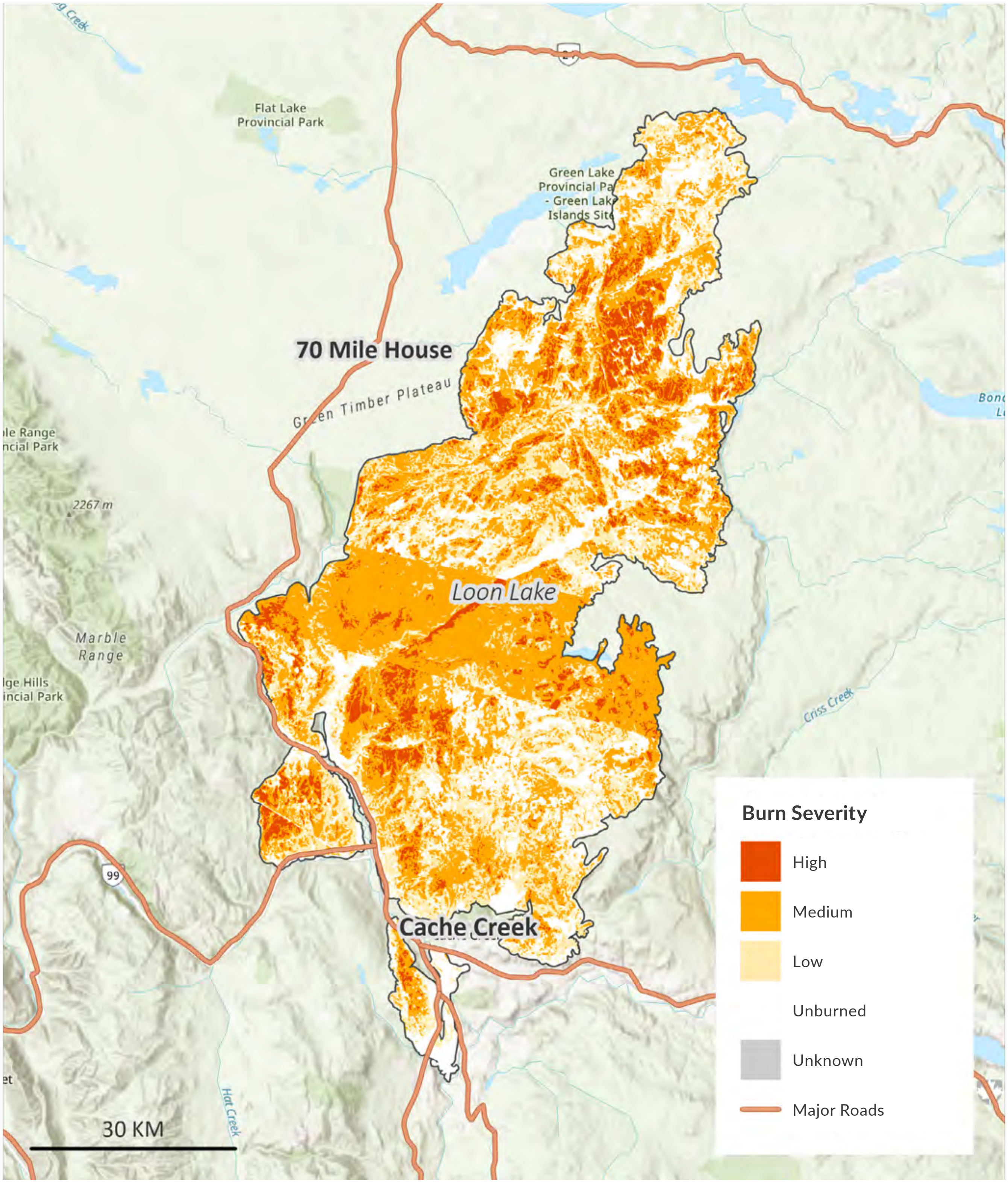
Though existing data do not show year-over-year reductions in harvest levels pre- and post-Elephant Hill fire, the timber lost to the blaze would have been eligible for harvest at some future date, and thus eligible for revenue sharing with the B.C. government.

METHODS

This analysis calculates the First Nations share as a percentage of the value of the total timber lost in the Elephant Hill fire, per the rules outlined in the relevant FCRSA and IFA. We used the vegetation resources inventory (VRI) geospatial data (Figure 5) produced by the B.C. provincial government (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2021), to determine the total forested area and total volume of timber prior to the Elephant Hill fire.

Combining these data with burn severity estimates (Figure 10) (Forest Analysis and Inventory, 2020) and estimates of the percentage volume killed for each burn severity class (Nicholls & Ethier, 2018) produces an estimate of the total timber volume lost in the Elephant Hill fire. The economic losses to First Nations is equal to five percent of the total volume lost multiplied by the relevant timber prices.

Figure 10: Burn severity



Sources: Esri, USGS, GeoBC, BC Forest Analysis and Inventory

Step 1. Calculate the volume of lost timber

The forested classes within the VRI ("deciduous leading," "mature," "recent cut," and "young") inside the Elephant Hill boundary are retained, and non-forested layers are removed.

For each of the forested classes within the Elephant Hill boundary, the total hectares for each are calculated.

For each forested class, the variable "WHOLE_STEM" presents tonnes per hectare. Multiplying the total hectares of each forested class by the tonnes per hectare provided by "WHOLE_STEM" results in an estimate of the total tonnes of stem biomass for all species and all forested classes (used in Step 2), which is then converted to board-feet (used in Step 3).[32]

Some of the forested classes exist within provincial parks that are protected from harvest; this volume of timber is removed from the total, as there is no plausible harvest scenario where these forested lands would be logged for profit, and revenue shared with First Nations.[33]

The total tonnes and board-feet lost are then interacted with the burn severity layer to produce two different estimates of the total volume of stem biomass—a proxy for what can be turned into timber products—lost to the Elephant Hill fire (Forest Analysis and Inventory, 2020).

The burn severity classes assigned to Elephant Hill were matched to research that looked back on the 2017 fire season and determined through fieldwork that low, medium, and high burn severity corresponded to volume losses of 14%, 27%, and 85%, respectively (Nicholls & Ethier, 2018).[34]

Step 2. Generate a low value estimate

Forest products sold per tonne are less profitable than those sold by board-feet, and the least-profitable forest product sold per tonne is newsprint. Multiplying the total tonnes of lost stem biomass by the 2021 annual average price for newsprint ($781/tonne), as reported in the weekly British Columbia Forest Product Prices report (Economics and Trade Branch, 2022) sets a low bound for losses, as it assumes that all timber—including that which would have been converted to more valuable products measured in board-feet—is sold for newsprint.

Step 3. Generate a high value estimate

Forest products measured in board-feet are more valuable than those sold per tonne; SPF Stud (2x4, KD, PET, f.o.b. mill) is the least valuable forest product measured in board-feet (Economics and Trade Branch, 2022). Multiplying the total board-feet of lost stem biomass by the 2021 annual average price for SPF Stud ($973/1,000 board-feet) sets a high bound for losses.

Some of the volume lost would undoubtedly have been sold as lumber products that are more valuable than SPF Stud (e.g., SPF 2x4); this establishes a more conservative estimate of the high bound for losses. However, lumber products measured in board-feet are commonly only produced from timber with 25.4 cm diameter, and not all biomass included in this calculation can be converted to lumber because the "WHOLE_STEM" variable from the VRI dataset provides tonnage for trees that are 4 cm diameter and greater. The overestimate created by including smaller trees (i.e., those with a diameter between 4cm and 25.4 cm) in this analysis is likely to outweigh the underestimate created of selecting the least-valuable forest product measured in board-feet to generate the estimate. The result is that this value is likely an overestimate of the total value lost; it is difficult to know how much of an overestimate it is.

32 This analysis focuses only on stem biomass—which is distinct from branch, foliage, and bark biomass in the VRI dataset—because the stem is the source of most valuable forest products.

33 Less than .01% of the hectares burned were Schedule A private lands, which would not participate in revenue sharing. Because only a fraction of that small fraction would be forested, these lands were dismissed as *de minimus* and for simplicity were treated as Crown lands, which do participate in revenue sharing. This assumption will very slightly bias the estimate upward, but not in a way that would meaningfully change the magnitude of the final estimate.

34 This same research identified 3% of volume killed in unburned plots, which suggests it would have been appropriate to include that volume in the loss calculation. However, this analysis assumes that this volume loss does not impact the "WHOLE_STEM" variable (i.e., volume lost is constrained to the leaves and minor branches of a tree, not affecting the stem from which most forest products are sourced). Therefore, to produce a more conservative estimate, no part of the unburned forested acreage was included in the loss calculation.

Medicine Creek, in Hat Creek valley. Photo credit: Sarah Dickson-Hoyle.

Table 21: Timber revenue loss

Burn Severity	Area Burned, Hectares	Stem Biomass Lost, Tonnes	Stem Biomass Lost, Board-Feet	Total Value Lost, Low Estimate	Total Value Lost, High Estimate	Lost Revenue to FN, Low Estimate	Lost Revenue to FN, High Estimate
Low	6,497	286,852	379,440,871	$224,030,379	$369,118,862	$11,201,519	$18,455,943
Medium	22,334	1,091,333	1,443,586,390	$852,325,699	$1,404,316,207	$42,616,285	$70,215,810
High	13,673	751,047	993,465,993	$586,564,547	$966,440,529	$29,328,227	$48,322,026
Total	**42,504**	**2,129,232**	**2,816,493,254**	**$1,662,920,626**	**$2,739,875,599**	**$83,146,031**	**$136,993,780**

RESULTS

The total economic loss to First Nations as a result of the Elephant Hill fire is estimated to be between $83 million and $137 million. This is equal to five percent of the total revenue that would have been generated based on current prices from the lost timber, in accordance with the revenue sharing agreements between the provincial government and First Nations.

This approach to quantifying the value of lost timber assumes an unrealistic harvest scenario, where all of the timber lost to the Elephant Hill fire is cut and sent to market all at once. However, this simple approach is preferable to attempting to back-calculate a plausible harvest scenario that would account for the different ages, species, and quality of lost timber over a typical forest rotation cycle. Additionally, this approach avoids adding additional uncertainty by attempting to project future volatile market prices, unknown fire regimes, and how these forces would combine to alter future allowable cuts.

DISCUSSION

Preserving forest health and restoring what has been lost is essential for SRSS communities. The timber resource guaranteed by healthy forests provides a sustainable revenue stream for participating First Nations via the revenue sharing agreements with the provincial government. Beyond the market value of timber, healthy forest ecosystems provide the foundation for other economically and culturally important functions, such as supporting fish habitat and culturally significant plant growth.

SRSS is already taking steps to ensure forest health, working to restore the forest to a pre-colonial and pre-logging state. SRSS is planting "Douglas-fir, yellow pine, spruce, lodgepole pine, aspen, cottonwood, birch, and willow at densities that more accurately represent the landscape that existed before logging and significant fire suppression practices came to the area" (SRSS, 2021). As described in *Culture and Well-being Services*, SRSS communities are actively developing inventories of culturally significant, non-timber plants found in planned cut-blocks. To promote a healthy, diverse forest that can continue to deliver cultural services, there is also a need for tree nurseries to include non-timber and deciduous species in addition to the more marketable species (Kim et al., 2012).

The collaborative agreement between the federal, provincial, and Tsilhqot'in Nation governments to work jointly on emergency response presents an example of meaningful collaboration between First Nations and the Canadian government that can contribute to enhanced forest health and resilience (Tsilhqot'in National Government, 2018). Such an example could be replicated for the First Nations communities affected by Elephant Hill and expanded to include co-management of wildfire preparedness and forest restoration activities.

REFERENCES

Boutsalis, Kelly. (2020). The art of fire: Reviving the Indigenous craft of cultural burning. The Narwhal. Retrieved January 19, 2022, from https://thenarwhal.ca/Indigenous-cultural-burning/

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery*. Secwepemcúl̓ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm

Economics and Trade Branch. (2022). British Columbia Forest Product Prices, Selected Statistics for the Week Ending January 7, 2022. Ministry of Forests, Land, Natural Resource Operations and Rural Development. https://www2.gov.bc.ca/gov/content/industry/forestry/competitive-forest-industry/forest-industry-economics/weekly-prices

Forest Analysis and Inventory. (2020). Fire Burn Severity – Historical. Dataset. British Columbia Data Catalogue. Retrieved January 19, 2022, from https://catalogue.data.gov.bc.ca/dataset/fire-burn-severity-historical

Kim, I. A., Trosper, R. L., and Mohs, G. (2012). Cultural uses of non-timber forest products among the Sts' ailes, British Columbia, Canada. Forest Policy and Economics, 22, 40-46.

Ministry of Forests, Lands, Natural Resource Operations and Rural Development. (2021). VRI - Historical Vegetation Resource Inventory (2002—2019). Dataset. British Columbia Data Catalogue. Retrieved January 19, 2022, from https://catalogue.data.gov.bc.ca/dataset/vri-historical-vegetation-resource-inventory-2002-2019-

Nicholls, D., and Ethier, T. (2018). Post-Natural Disturbance Forest Retention Guidance—2017 Wildfires. Ministry of Forests, Lands, Natural Resource Operations and Rural Development. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/2017_fire_report_revised.pdf

Secwepemcul'ecw Restoration and Stewardship Society (SRSS). (2021). February Newsletter. Retrieved January 19, 2022, from https://www.srssociety.com/blog/february-newsletter-2021.htm

Tsilhqot'in National Government. (2018). Collaborative Emergency Management Agreement. Retrieved January 19, 2022, from https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/consulting-with-first-nations/agreements/tng_collaborative_emergency_management_agreement_signed.pdf

Conclusion

Even though we looked at only a subset of ecosystem services and often with a limited scope, it is apparent that the Elephant Hill area was delivering ecosystem benefits of significant value to SRSS communities and other beneficiaries prior to the 2017 fire.

Table 22 summarizes the findings from our study (all figures in 2021 Canadian dollars). It distinguishes between annual values related to services that would normally be delivered year after year, and one-time losses. The total estimate of annual values ranges from $512 million to just under $1 billion. The estimate of one-time losses ranges from $1.65 to $1.72 billion.

The order of services in the table generally follows an expanding interpretation of beneficiaries. For cultural and well-being services, biodiversity existence and food provisioning the calculation focused on services to the SRSS communities. To the extent that other people in the region enjoy similar benefits, the value to British Columbians could be much higher.

Water services and natural hazard mitigation services were calculated over the area of the Elephant Hill fire, but given the nature of water flows and the presence of critical infrastructure in the area (for example Highway 97), the benefits of these services may already extend beyond the SRSS communities. Air quality benefits are local, but carbon sequestration and storage have global application. The ranching and timber benefit losses were calculated based on revenue losses to SRSS community members.

It is worth noting that the one time loss in timber revenues to First Nations is significantly less than the total value of annual ecosystem services values that were provided before the fire.

Table 22: Summary of natural capital values

Ecosystem service	Low estimate	High estimate
	Annual values	
Culture and well-being	$2,568,325	$26,710,580
Biodiversity*	$286,131	$425,819
Material contributions	$1,256,346	$39,900,630
Water supply	$128,395	$24,339,558
Water purification	$433,498,473	$433,498,473
Flood and landslide mitigation	$58,396,592	$101,480,687
Carbon sequestration	$15,246,743	$366,139,012
Air quality	$905,145	$905,145
Total annual value	**$512,286,150**	**$993,399,904**
	One time values	
Carbon storage loss	$1,568,000,000	$1,584,000,000
Ranching loss**	$317,952	$426,222
Timber benefit loss**	$83,146,031	$136,993,780
Total one time value	**$1,651,463,983**	**$1,721,420,002**

* represents residual existence value not already included in other services

** represents lost revenue to First Nations

As a check on the reasonableness of our valuation, we compared the total annual value to a valuation done by Earth Economics for another massively destructive fire – the 2013 Rim fire in the Sierra Nevada of the California (Batker et al. 2013). The Elephant Hill fire was approximately double the size of the Rim fire (103,600 hectares). If we adjust the Rim fire valuation to the size of the Elephant Hill fire and adjust for inflation and currency conversion, our low and high estimates for the Elephant Hill fire would both fall between adjusted estimates of $275 million to $2 billion for this other large fire.

The results of this study lead us to the inescapable conclusion that the Elephant Hill area was delivering ecosystem services of significant value before the fire and much of this value was degraded by the fire.

This conclusion echoes a finding by Dickson-Hoyle & John (2021), "Secwépemc health, wealth and well-being are dependent upon the land, [and] the Elephant Hill wildfire caused deep and lasting impacts to Secwépemc territories and communities' cultures, economies and ways of life that are not adequately captured in reporting or recognized by governments."

Restoring this value will require ongoing stewardship of the ecosystems affected. The SRSS communities have demonstrated that, historically and currently, they have the capacity to care for this natural capital (see Introduction and Dickson-Hoyle and John 2021).

Given the severity of the Elephant Hill fire, Indigenous-led restoration and stewardship will be critical for accelerating the recovery of the area's ecosystems. Indigenous-led restoration and stewardship is about "... *confronting the underlying issues of unsustainable resource extraction and land and fire management that have created the conditions for these 'unprecedented mega-fires.' It is about strengthening Indigenous stewardship to revitalize ecologies and cultures and mitigate the impacts of the climate crisis that we collectively face*" (Dickson-Hoyle & John, 2021). Examples of Indigenous-led stewardship have been provided throughout this report.

Yellowbell (Fritillaria pudica), is a culturally and spiritually important early spring bulb. Photo credit: Marianne Ignace.

Maintaining capital also requires high quality information about its condition. In this report we have suggested areas for research that could refine the values in this study. The same tools, for example hydrological modeling, water monitoring, and fish and wildlife monitoring, could be used to help communities steward their natural capital for generations to come.

REFERENCES

Batker, D., Christin, Z., Schmidt, R. and de la Torre, I. (2013). Preliminary assessment: the economic impact of the 2013 Rim Fire on natural lands. Earth Economics. https://www.hcd.ca.gov/grants-funding/docs/earth_economics_rim_fire_report_11.27.2013.pdf

Dickson-Hoyle, S. & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery*. Secwepemcúl'ecw Restoration and Stewardship Society. Available at: https://www.srssociety.com/lessonslearned.htm