Salmon Habitat Indicator Monitoring Project

Total Land Cover Alteration Analyses

Ministry of Environment. (1998). Bulkley River and Morice Floodplain Mapping

Prepared for The Office of the Wet'suwet'en under the auspices of SkeenaWild Conservation Trust. Prepared by Eclipse GIS and Suskwa Research.

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1. Introduction

Total Land Cover Alteration (TLCA) reflects a suite of potential changes to hydrological processes and sediment generation, with potential impacts to downstream salmon habitat, as well as changes in biodiversity. The Wild Salmon Policy Habitat Working Group has ranked TLCA as a high value pressure indicator.

Total land cover alteration (TLCA) consists of anthropogenic alterations to the land base and natural disturbances. Anthropogenic alterations to the land base include settlements, agricultural activities, transportation infrastructure, and resource-based activities such as forestry, mining, and energy development. Natural disturbances include abiotic elements, such as wildfires, windthrow, and geomorphic activity such as landslides and debris or snow avalanches. Natural biotic disturbances include insect infestation and disease[1]. When viewed over the long-term natural disturbances help preserve a diverse, resilient, and healthy ecosystem[2].

The GIS analyses presented below separates Total Land Cover Alteration into two categories – anthropogenic disturbances, referred to as total human development footprint (HDF) and natural disturbances. The first section analyzes the Total Human Development Footprint and applies interim thresholds to the analyses results. The second part presents analyses based on the natural disturbance agents fire and mountain pine beetle, placed within the context of natural disturbance zones. The final section presents a comparison of the various disturbance agents by natural disturbance type.

2. Total Human Development Footprint Analyses

2.1. GIS Data

The following spatial information was utilized in the analyses:

- Forestry roads (FTEN database)
- Digital Road Atlas (DRA)
- Railway, natural gas pipeline, and transmission lines (NTS 1:50,000)
- Cut blocks (FTEN database)
- Silviculture openings (RESULTS)
- Crown Tenures (Agriculture, Industrial, Utility, Transportation, Commercial, Quarrying, Residential, Community)
- Mineral Tenures/Advanced Exploration Sites
- Bing Maps Aerial photos

[1] Parminter, J., and Daigle P. (July 1997). FORREX Extension Note. Landscape Ecology and Natural Disturbances: Relationships to Biodiversity. Retrieved from www.for.gov.bc.ca/hrs/topics/fire.htm

[2] Wong, C., H. Sandmann, and B. Dorner. 2003. Historical variability of natural disturbances in British Columbia: A literature review. FORREX – Forest Research Extension Partnership, Kamloops, B.C. FORREX Series 12. URL: www.forrex.org/publications//forrexseries/fs12.pdf

2.2. Methodology

The various land cover datasets listed above were integrated to form a comprehensive dataset representing the total human development footprint.

A variable buffer was applied to the roads based on type of road (highway, mainline, secondary, in-block) based on criteria determined by Coombes (2010) for the Lakes Timber Supply Area[3].

The natural gas pipelines, existing (Pacific Northern Gas) and proposed but tenured (Pacific Trails Pipeline) are represented by their tenure boundaries, resulting in a 2 km corridor. Proposed pipelines with no tenure issued were not considered for this analysis. A 50m buffer was applied to the Huckleberry transmission line based on measurements taken from Bing Maps[4] as there was no tenure line work available.

Pending and cancelled cut block tenures were removed from the cut block data. Any overlap in silviculture polygons between the cut block data (FTEN) and Silviculture data (RESULTS) was removed from the cut block data to avoid duplication.

Crown Tenures designated as commercial recreation, environmental conservation and recreation, and miscellaneous land uses were removed for the analyses, as these tenures did not show a significant visible footprint on the ground as per Bing Maps.

Advanced mineral exploration sites (point data) were extended to the relevant mineral claims (polygon data) that contained the exploration activity.

2.3. Thresholds

Interim thresholds used in these analyses follow the recommendations put forth by the Pacific Salmon Foundation's Sockeye Habitat Assessment Project. These threshold values will be further revised once Wet'suwet'en thresholds are determined.

Low risk: < 6.4%
Moderate risk: >= 6.4%
High risk: >= 22%

2.4. Results

The results of the total human development footprint are reported out by analysis units including the Morice Watershed, eighteen sub-watersheds within the Morice Watershed, the Morice Watershed Management Area (designated through the Morice LRMP), and the ten Wet'suwet'en house territories within or partly within the Morice Watershed.

[3] Coombes, T., A. Bernard, and G. Nigh. 2010. Forest access road widths in the Lakes Timber Supply Area. BC Journal of Ecosystems and Management 11 (1&2):84-90. http://jem.forerex.org/index.php/jem/article/view/15/29

[4] Viewed July 5th, 2013 at www.bing.com/map/

2.4.1. Morice Watershed

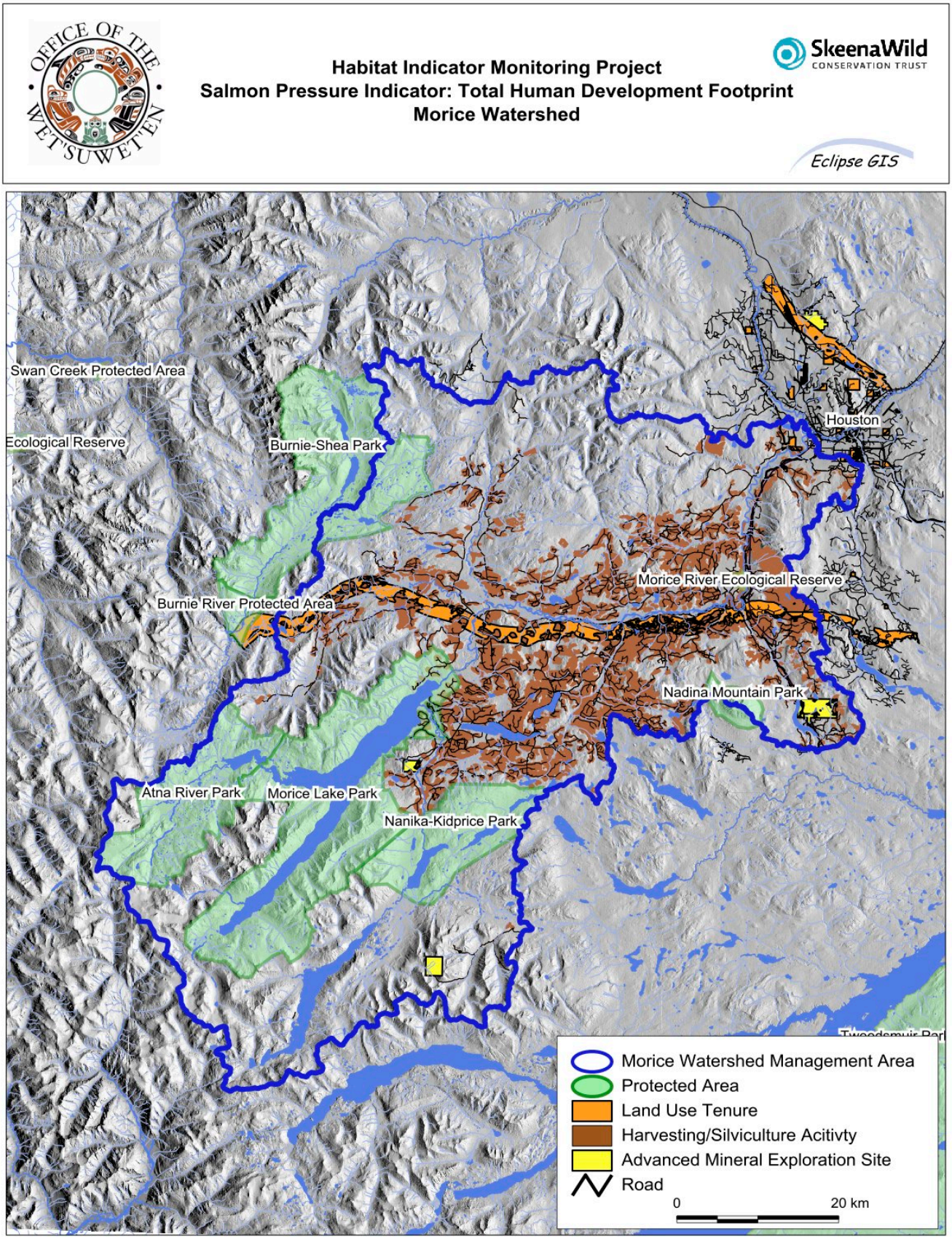
The Morice watershed has a total human development footprint of 771.8 km^2 as shown in Figure 2.4.1.

Table 2.4.1 Total Human Development Footprint within Morice Watershed

Morice Watershed Area (km^2)	**Total HDF Area (km^2)**	**Percentage of THDF within Morice Watershed**
4,379.62[5]	771.8	17.6 %

[5] The Morice watershed boundary is 76 ha larger than the total area of all the sub-watersheds to accommodate the Wet'suwet'en House Territory Boundaries.

Figure 2.4.1 Total HDF in the Morice Watershed



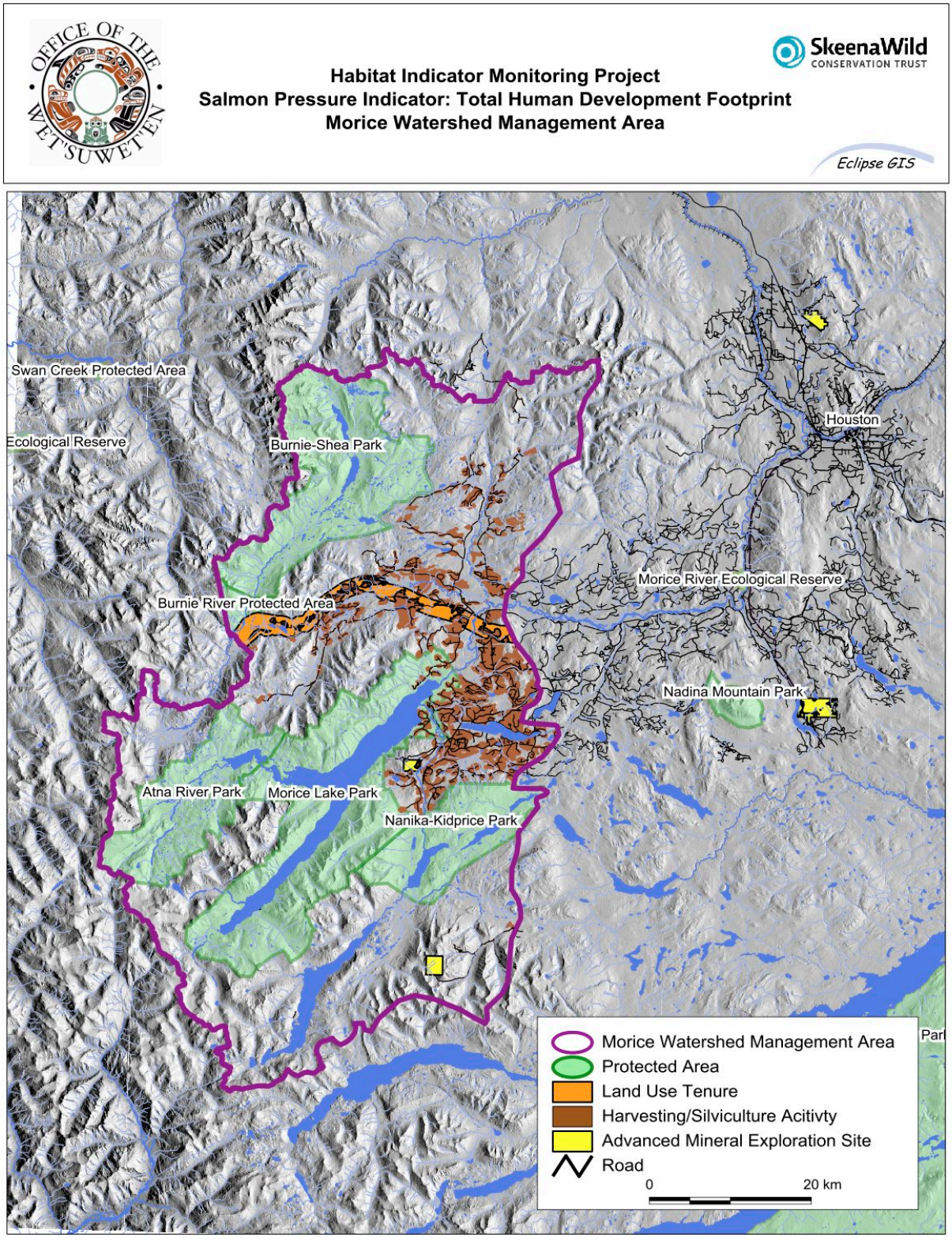
2.4.2. Morice Watershed Management Area

Within the Morice Watershed Management Area 8.8% (300 km^2) of land has been altered by human activities as shown in Figure 2.4.2.

Table 2.4.2 Total HDF within the Morice Watershed Management Area

MWMA Area (km^2)	THDF Area (km^2)	Percentage of THDF within the MWMA
3,403.51	300.0	8.8 %

Figure 2.4.2 THDF within the Morice Watershed Management Area



2.4.3. Wet'suwet'en House Territories within the Morice Watershed

The total human development footprint within the ten Wet'suwet'en House Territories within the Morice Watershed is 17.5%. The total HDF values across the House Territories range from 0.6% in the Nelgi'l'at House Territory to 35.1% in the Bi Wini House Territory. Seven of the ten House Territories have a THDF value greater than 6.4%, falling within the moderate or high threshold range.

Table 2.4.3 Total HDF within Wet'suwet'en House Territories

House Territory	Area (km^2)	Total HDF	% Total HDF
Nelgi'l'at	387.1	2.1	0.6
C'iniggit Nenikekh	1,293.9	8.8	0.7
Talhdzi Wiyez Bin	494.8	17.4	3.5
Bikh C'idilyiz Ts'anli	142.5	12.4	8.7
Ts'in K'oz'ay	280.4	38.9	13.9
C'idi To Stan	505.4	88.2	17.5
Talbits Kwah	710.3	173.6	24.4
Nelgi Cek	215.0	55.9	26.0
Lhudis Bin	989.4	324.3	32.8
Bi Wini	883.3	310.2	35.1
Total	**5,902.1**	**1,031.8**	**17.5**

Figure 2.4.3.1 Total HDF within Wet'suwet'en House Territories

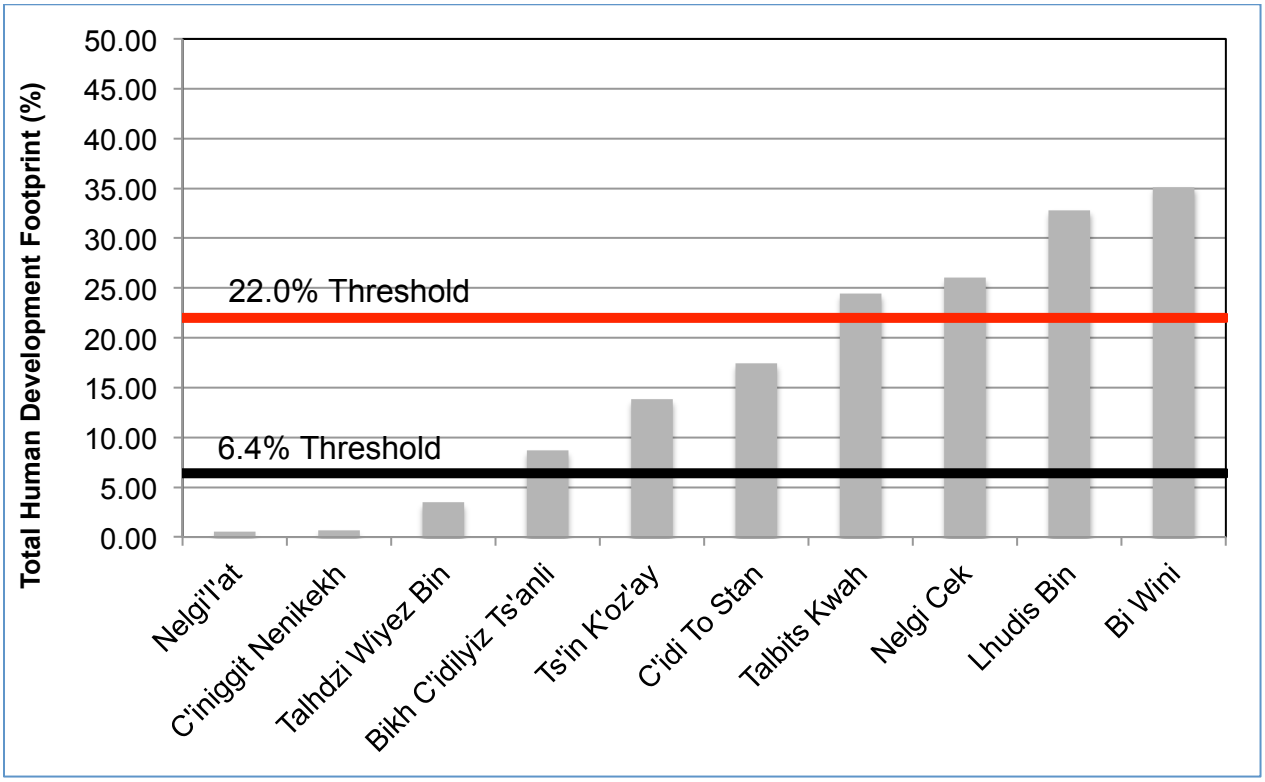
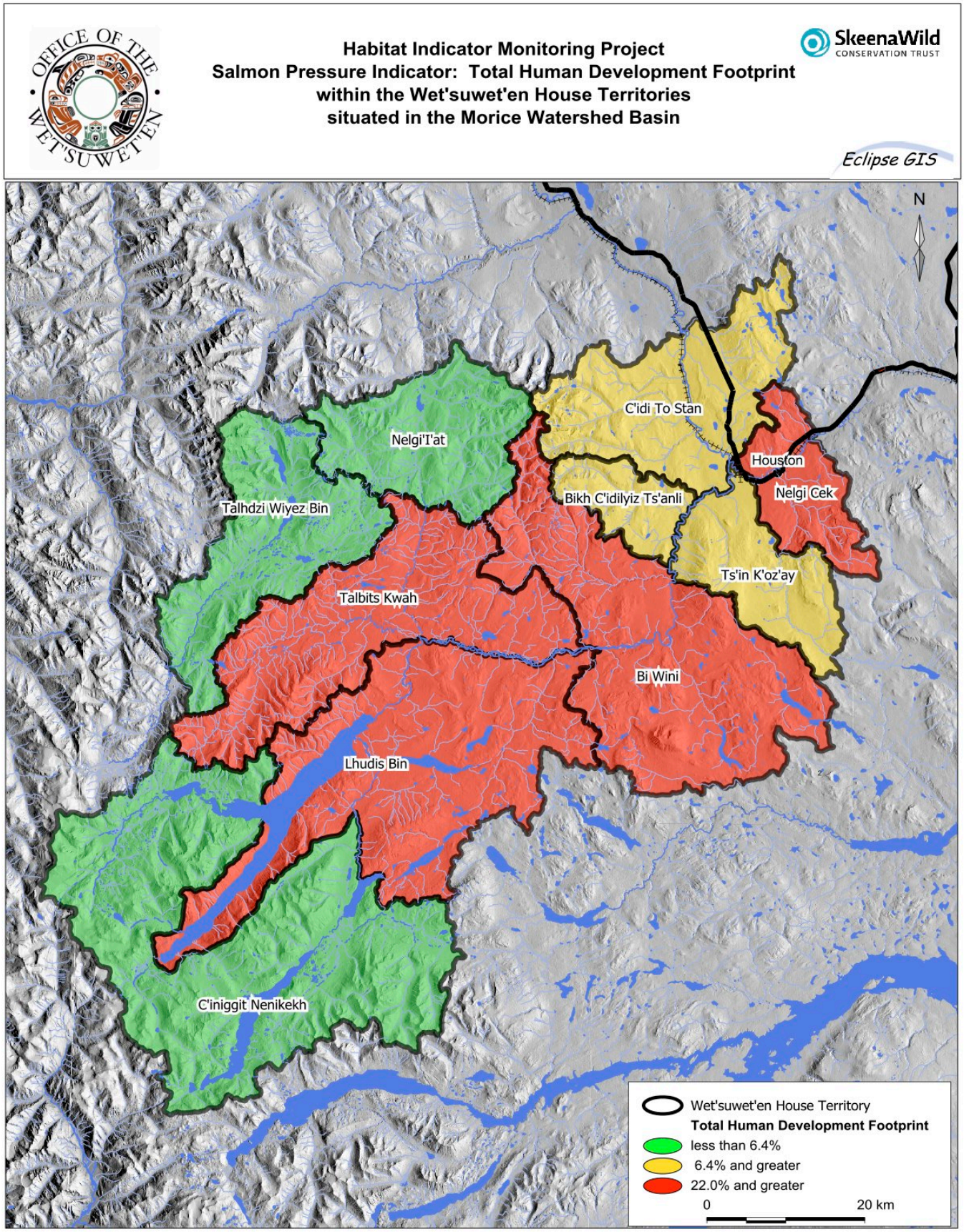


Figure 2.4.3.2 Total HDF within Wet'suwet'en Territories



2.4.4. Morice Sub-watersheds

Within the eighteen Morice sub-watersheds the total human development footprint is 17.6%. The total HDF varies from no development in the Atna Watershed, to 61.5% in the Morice Reach 2 Southwest face unit. Four sub-watersheds have a THDF value within the low threshold category, four within the moderate category, and ten fall within the high threshold category as shown in Figure 2.4.4.1 and Figure 2.4.4.2.

Table 2.4.4.1 Total HDF within Morice Sub-watersheds

Sub-watershed Unit	Area (km^2)	THDF Area (km^2)	THDF (%)
Gosnell Watershed			
Crystal Creek	62.5	10.0	16.0
Shea Creek	195.0	9.7	5.0
Gosnell Creek	279.4	74.9	26.8
Subtotal	**536.9**	**94.6**	**17.6**
Atna River	283.9	0.0	0.0
Houston Tommy Creek	248.2	47.5	19.2
Lamprey Creek	240.3	129.6	53.9
McBride Creek	115.0	65.0	56.5
Nanika River	889.7	40.1	4.5
Owen Creek	212.4	67.2	31.7
Thautil River	423.0	25.0	5.9
Morice Lake	599.6	3.0	0.5
Subtotal	**3,012.1**	**337.3**	**11.1**
Morice River Face Units			
MR R1 East	71.7	43.3	60.4
MR R1 West	41.0	14.7	35.9
MR R2 North	206.2	87.8	42.6
MR R2 SE	101.6	47.8	47.0
MR R2 SW	61.6	37.9	61.5
MR R3 East	165.8	42.2	25.5
MR R3 West	181.9	25.9	14.2
Subtotal	**829.9**	**299.7**	**36.1**
Total	**4378.9**	**771.8**	**17.6**

Figure 2.4.4.1 Total Human Development Footprint within the Morice Sub-watersheds

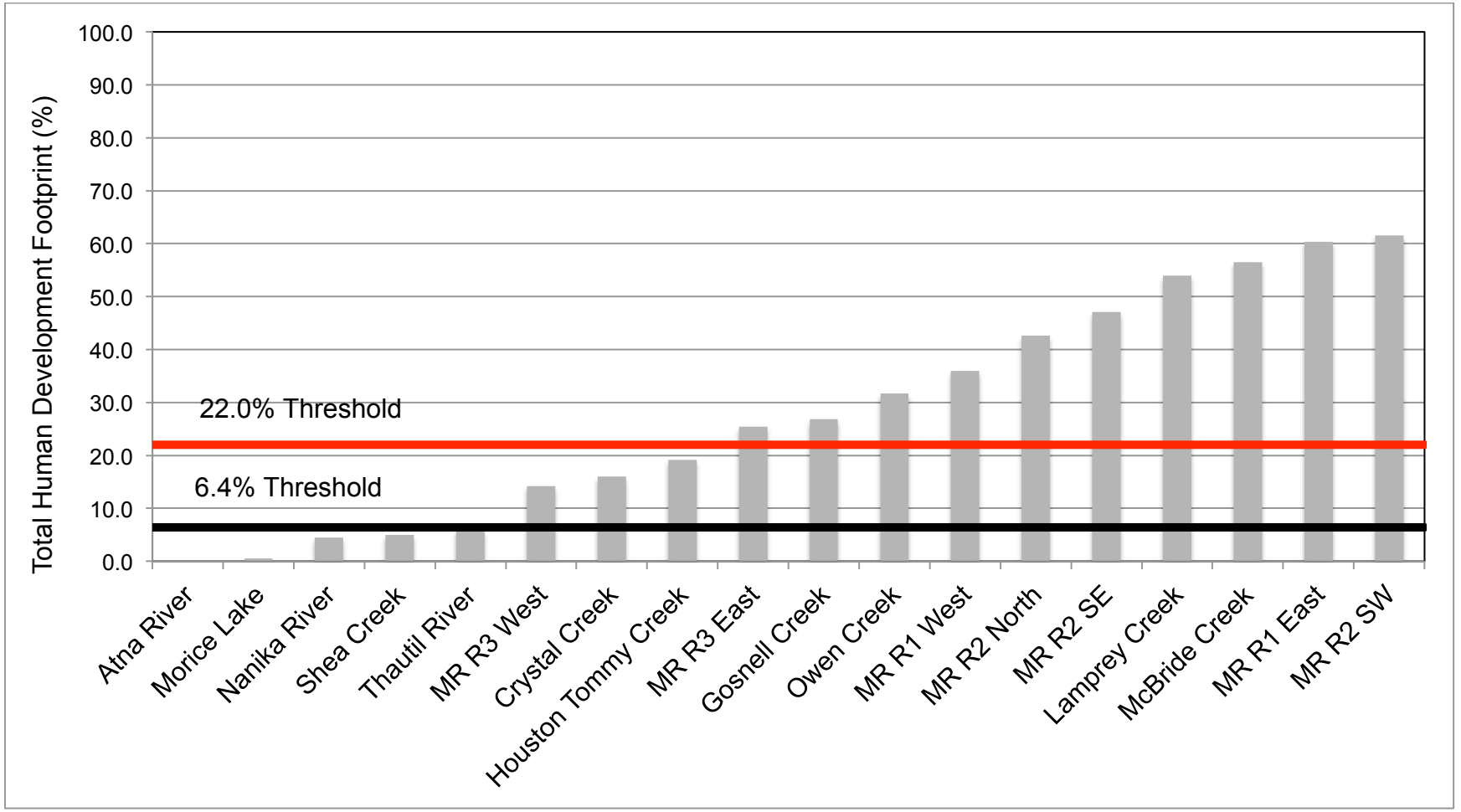
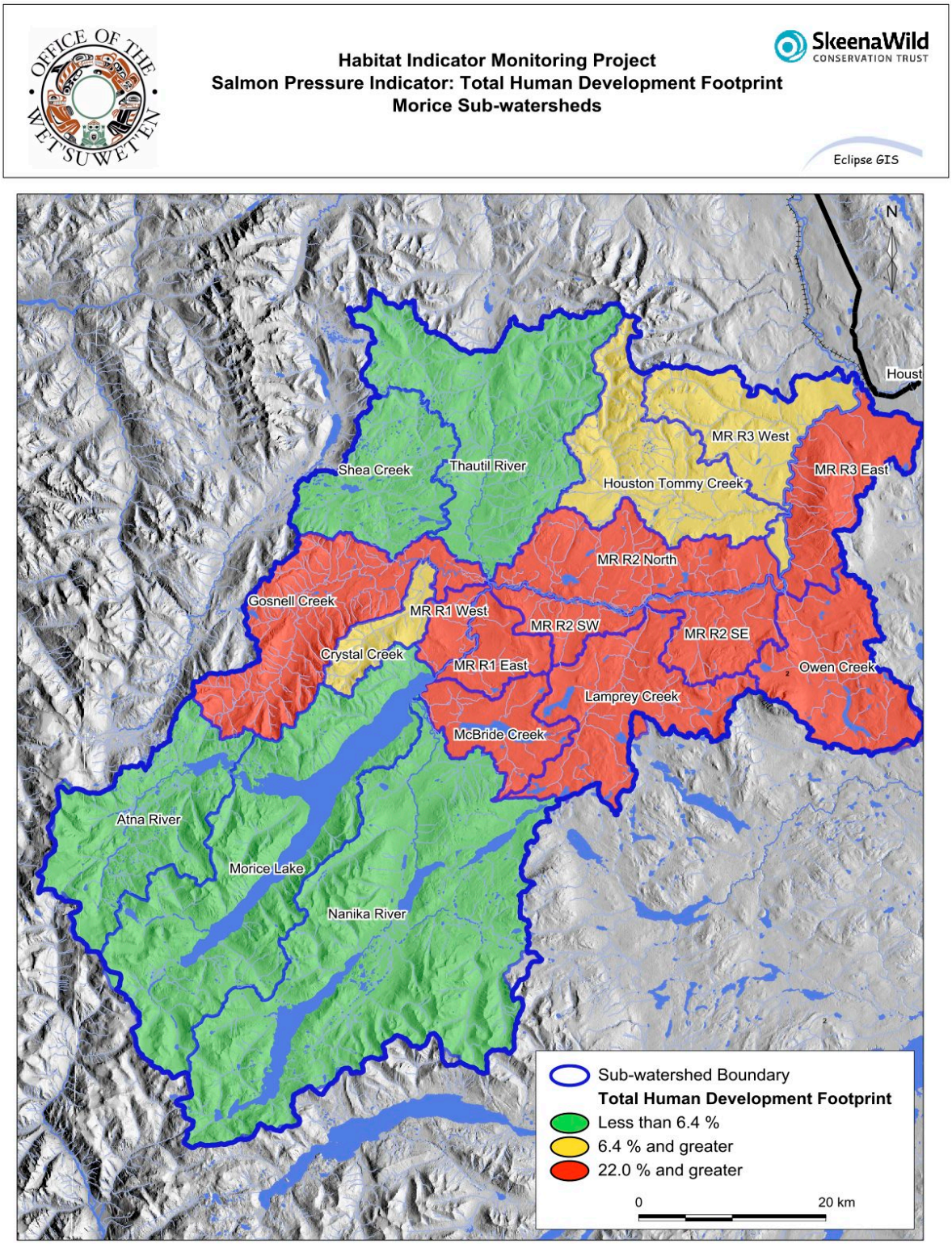


Figure 2.4.4.2 Total HDF within the Morice Sub-watersheds



3. Natural Disturbance Agents: Mountain Pine Beetle and Wildfire

In order to determine the impact on the land base by anthropogenic factors, it is useful to first have an understanding of the underlying natural disturbance regimes at work. Information on natural disturbance types, including their distribution and extent, frequency, and intensity is essential to better understanding the level of natural landscape biodiversity.[2] Natural disturbance is relevant in that "when an ecosystem is managed within its historical range of variability, it will remain diverse, resilient, productive and healthy." Natural disturbances are now "considered to be part of the process of forest and landscape development rather than an external goal of destruction".[6]

Currently within British Columbia five natural disturbance types (NDTs) are recognized, based on Biogeoclimatic subzones and variants:[3]

NDT1 – Ecosystems with rare stand-initiating events
NDT2 – Ecosystems with infrequent stand-initiating events
NDT3 – Ecosystems with frequent stand-initiating events
NDT4 – Ecosystems with frequent stand-maintaining fires
NDT5 – Alpine Tundra and Subalpine Parkland ecosystems

Although the NDTs in BC were created to set landscape level biodiversity objectives, which is beyond the scope of this project, the NDTs do provide a broad stratification of the landscape based on disturbance zones. The NDTs provide an ecological framework that provides context for the frequency and extent of natural disturbance analyses included below.

The Morice Watershed consists of three natural disturbance types as shown in Figure 3.0. The map of corresponding BEC subzones is included in Appendix A.

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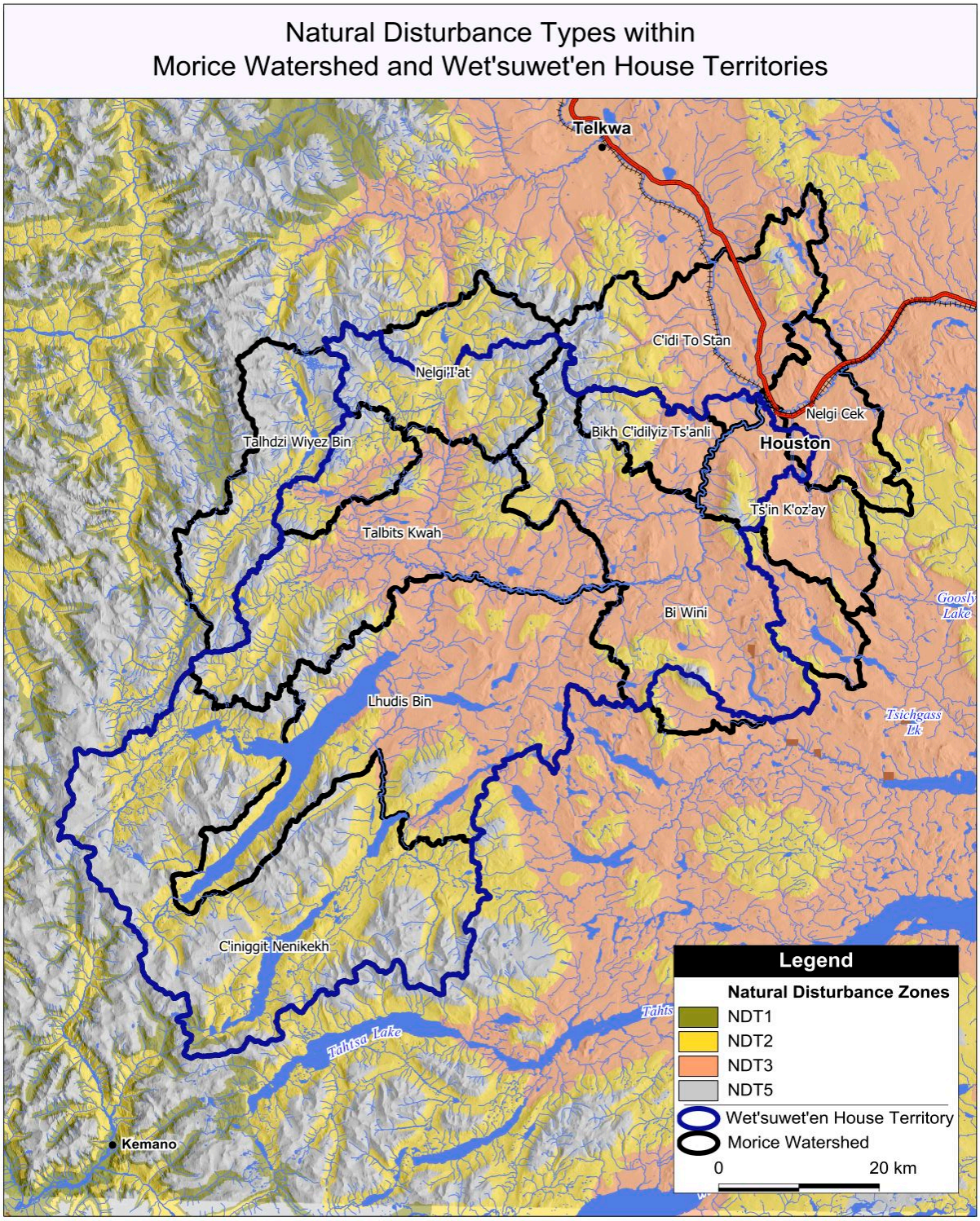
[6] Forest Practises Code (September 1995). Biodiversity Guidebook. Retrieved from www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/BIODIV/biotoc.htm

Figure 3.0


Natural Disturbance Types within
Morice Watershed and Wet'suwet'en House Territories
Telkwa
C'idi To Stan
Nelgi;I'at
Nelgi Cek
Bikh C'idilyiz Ts'anli
Houston
Talhdzi Wiyez Bin
Ts'in K'oz'ay
Talbits Kwah
Bi Wini
Goosly Lake
Lhudis Bin
Tsichgass Ek
C'iniggit Nenikekh
Tahtsa Lake
Kemano
Legend
Natural Disturbance Zones
NDT1
NDT2
NDT3
NDT5
Wet'suwet'en House Territory
Morice Watershed
0
20 km

3.1. GIS Data

The following spatial information was used in the natural disturbance analyses:

- Historical fire data from 1920 to 2011 (Fire Protection Branch, BC Gov't)
- Current fire data from 2012 (spot fires excluded) (Fire Protection Branch, BC Gov't)
- Forest Health data specific to Mountain Pine Beetle, from 2001 to 2012, excluding 2008[7]. (Forest Health Program, BC Gov't)
- Natural Disturbance Types (NDTs) (Research Branch, MoF)

Spatial data for other biotic natural disturbance agents were available but not included as it was beyond the scope of the analysis. Reliable data for abiotic natural disturbance agents, such as windthrow, was not available. The wildfire data does not include traditional aboriginal burn sites. The wildfire database attempts to capture the historical frequency and extent of wildfires dating back to 1920, but there are limitations, especially in the 1940 – 1959 interval[8].

3.2. Methodology

The forest health data specific to the mountain pine beetle was culled to include only those identified areas with more than 10% infestation[9]. Forest health data from 2001 to 2012 was combined and where severity ratings across years overlapped, the higher severity rating prevailed.

Severity ratings are taken from the Aerial Overview survey methods and were revised in 2004 as follows:

Severity	Code	Percent of Trees in Polygon With Red Attack
Trace	T	< 1% attack
Light	L	1 - 10% attack
Moderate	M	11 – 30% attack
Severe	S	31 – 50% attack
Very Severe	V	> 50% attack

The severity rating here applies to the extent, not the intensity, of the infestation.

The historical fire data from 1920 to 2011 was used as is, with the current 2012 fire polygons added (the spot fires were excluded).

[7] The 2008 survey year experienced technical difficulties resulting in a poor quality data set.

[8] K. Rabnett, personal communication, September 9, 2013.

[9] The analysis method used here is dependent on the structure of the data. This analysis takes a conservative approach and removed Mountain Pine Beetle infestation areas with less than 10% infestation. The approach eliminated large polygons with low infestation rates which could skew the analyses results.

3.3. Thresholds

The natural disturbance types provide a general framework for extent and frequency of disturbances such as mountain pine beetle infestations, fire, and possibly anthropogenic disturbances. Thresholds applied to the Total Human Development Footprint do not directly transfer to natural disturbance agents such as mountain pine beetle and wildfires[10].

3.4. Results

The results of the natural disturbance agents fire and Mountain Pine Beetle are reported out by analysis units including the Morice Watershed, eighteen sub-watersheds and face units within the Morice Watershed, the Morice Watershed Management Area, and the ten Wet'suwet'en house territories within or partly within the Morice Watershed. Natural Disturbance Type further breaks down each resultant table. The results for Mountain Pine Beetle and Fire History are reported separately. Analysis results for Mountain Pine Beetle combine grey and red attack stages.

3.4.1. Mountain Pine Beetle

3.4.1.1. Morice Watershed

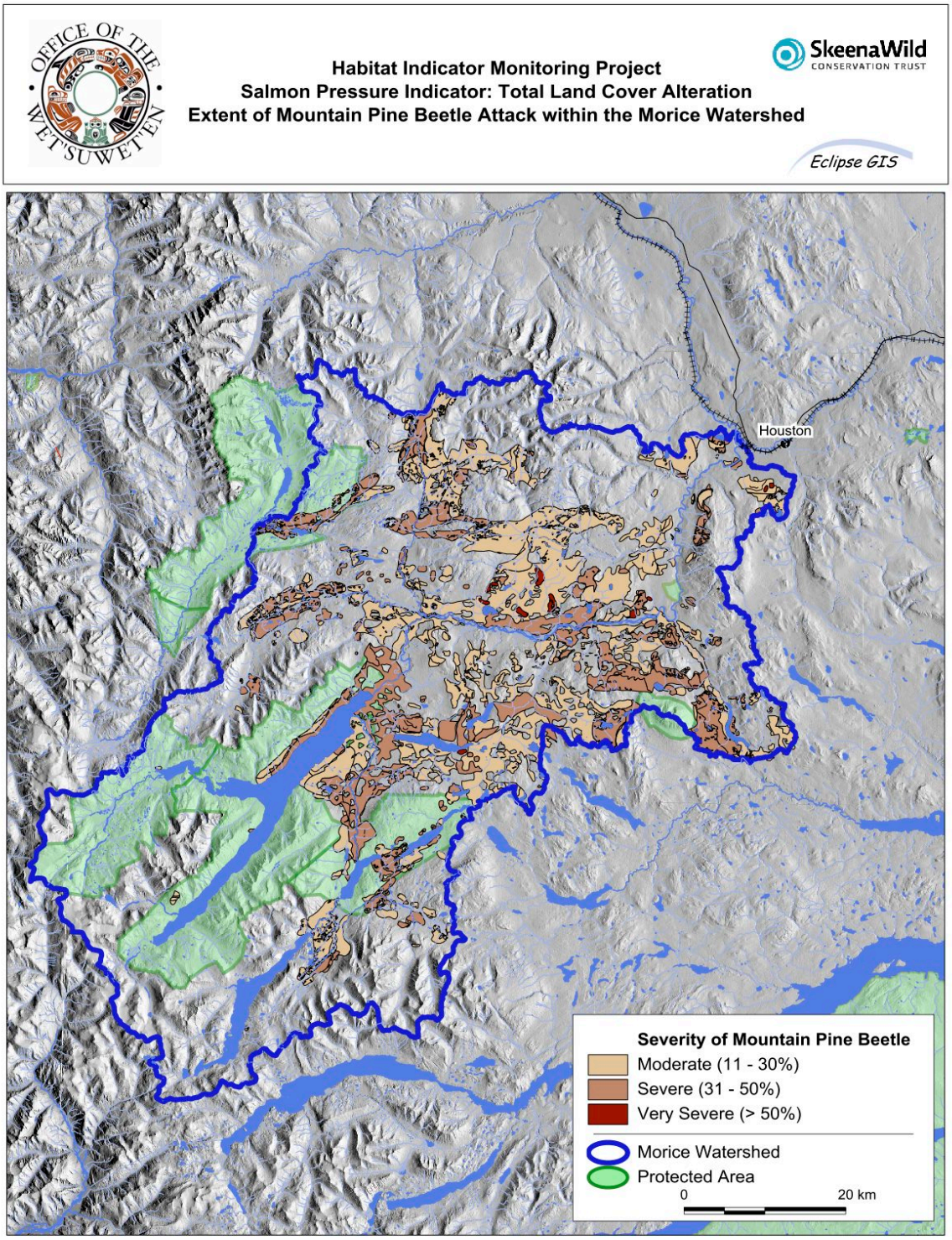
The forest health data from 2001 to 2012 indicate that 15.2% of the stands are rated moderate severity, with a total extent of 24.3% of the stands with a severity rating of moderate or higher. The majority of the disturbance (69.2%) occurred within the NDT3 zone, which is classified as an ecosystem with frequent stand-level initiating events. However, NTD2 comprises 30% of Mountain Pine Beetle activity.

Table 3.4.1.1 Mountain Pine Beetle Severity by Natural Disturbance Type

Severity Rating	NDT2	NDT3	NDT5	Total Disturbance (km^2)	% of Watershed
Moderate (11 - 30%)	207.1	449.4	8.8	665.3	15.2
Severe (31 - 50%)	111.3	280.7	0.5	392.5	9.0
Very Severe (> 50%)	0.0	7.3	0.0	7.3	0.2
Total	**318.5**	**737.4**	**9.3**	**1065.1**	**24.3**

[10] Price,M. 2011. Summary of Habitat Indicators for the Conservation of Wild Pacific Salmon. Unpublished report prepared for Skeena Wild Conservation Trust.

Figure 3.4.1.1 Summary of MPB Attack Within the Morice Watershed



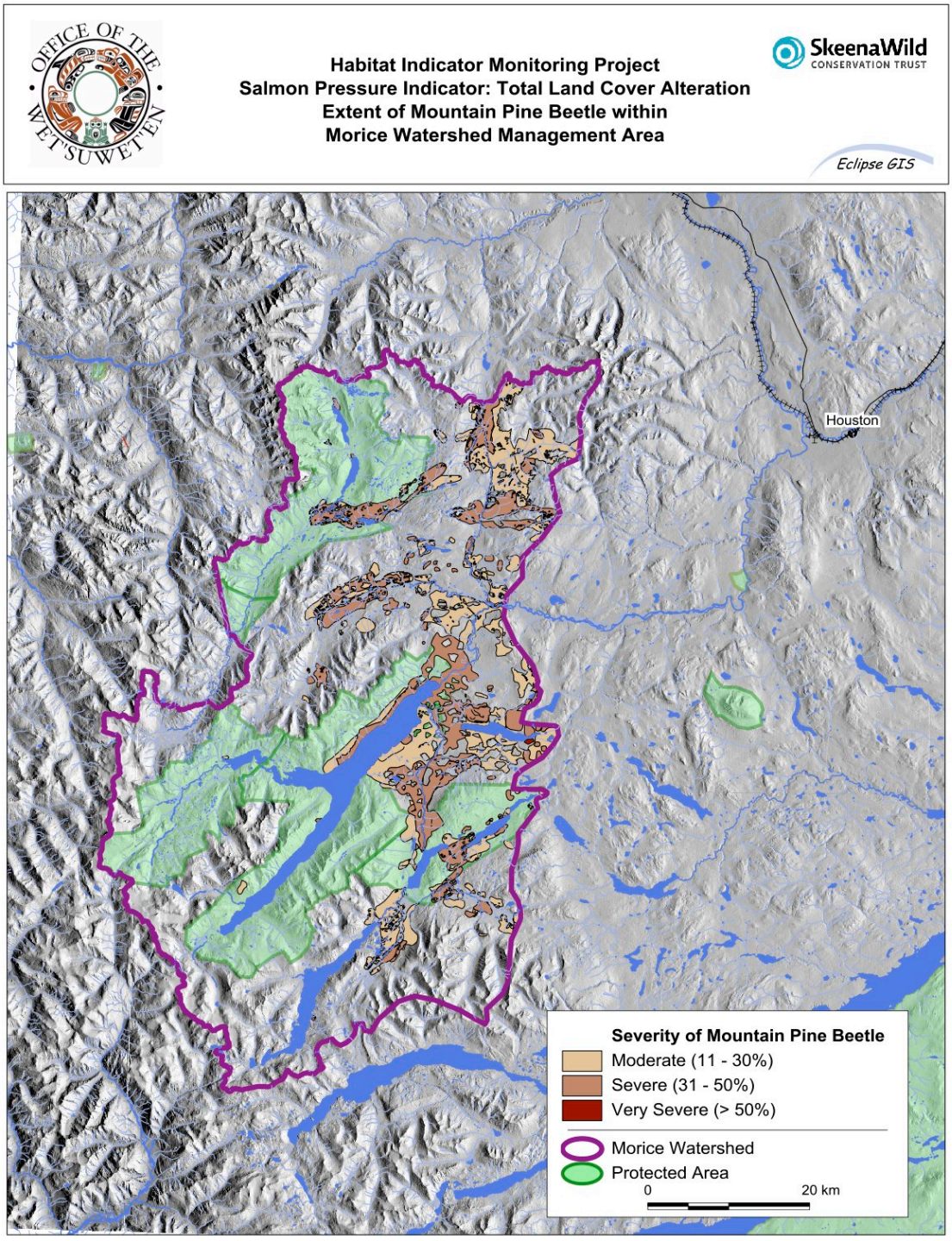
3.4.1.2. Morice Watershed Management Area

Across the MWMA, Mountain Pine Beetle affects 15.1% of pine leading stands. The majority of the disturbance events have occurred in the NTD2 (47.2%) and NTD3 (51.8%) zones. The NDT2 zone is more prevalent to the west, and therefore the MWMA has a greater representation of the NDT2 zone than the Morice watershed.

Table 3.4.1.2 Mountain Pine Beetle Severity by Natural Disturbance Type

Severity Rating	NDT2	NDT3	NDT5	Total (km^2)	% of MWMA
Moderate (11 - 30%	144.3	129.2	5.0	278.5	8.2
Severe (31-50%)	98.5	136.9	0.2	235.7	6.9
Very Severe (> 50%)		0.5		0.5	0.0
Total	**242.9**	**266.7**	**5.2**	**514.7**	**15.1**

Figure 3.4.1.2 Summary of MPB Attack Within the Morice Watershed Management Area



3.4.1.3. Wet'suwet'en House Territories within Morice Watershed

Across the Ten Wet'suwet'en House Territories situated within the Morice Watershed, Mountain Pine Beetle has affected 24.5% of the area. The extent of the Mountain Pine Beetle varies across the house territories, ranging from 5.2% in the C'iniggit Nenikekh House to 42.4% in the Bi Wini House. The NDT2 and NDT3 zones were respectively 33% and 67% and collectively contained 99% of the disturbance.

Table 3.4.1.3. Mountain Pine Beetle Severity by House Territory and Natural Disturbance Type

	NDT2				NDT3				NDT5					
House Territories	**Moderate**	**Severe**	**Very Severe**	**Total**	**Moderate**	**Severe**	**Very Severe**	**Total**	**Moderate**	**Severe**	**Very Severe**	**Total**	**Total (km^2)**	**% of House Territory**
Bi Wini	57.5	22.1	1.0	80.7	160.8	120.4	9.0	290.2	3.5	0.2		3.7	374.6	42.4
Bikh C'idilyiz Ts'anli					13.0	0.6		13.5					13.5	9.5
C'idi To Stan	18.0	2.9	0.2	21.1	72.1	17.9	1.6	91.6	2.7			2.7	115.4	22.8
C'iniggit Nenikekh	45.6	17.7		63.3	0.1	3.0		3.1	0.3			0.3	66.7	5.2
Lhudis Bin	43.7	25.7		69.4	174.4	119.8	0.5	294.7	0.3			0.3	364.4	36.8
Nelgi Cek	14.1	0.1		14.2	44.6	8.9	0.7	54.2					68.4	31.8
Nelgi'l'at	80.7	21.0		101.7	8.0	2.0		10.0	4.6	0.1		4.7	116.4	30.1
Talbits Kwah	31.0	25.1		56.1	96.4	51.9	5.0	153.4	0.3	0.1		0.4	209.9	29.6
Talhdzi Wiyez Bin	2.8	15.9		18.7	4.2	11.3		15.4	0.2			0.2	34.3	6.9
Ts'in K'oz'ay	14.0	7.6		21.6	30.6	31.7	0.1	62.3		0.1		0.1	84.0	30.0
Total	**307.5**	**138.1**	**1.2**	**446.8**	**604.2**	**367.3**	**16.9**	**988.4**	**11.8**	**0.5**		**12.3**	**1447.5**	**24.5**

Figure 3.4.1.3 Area Affected by Mountain Pine Beetle by House Territory and Natural Disturbance Type

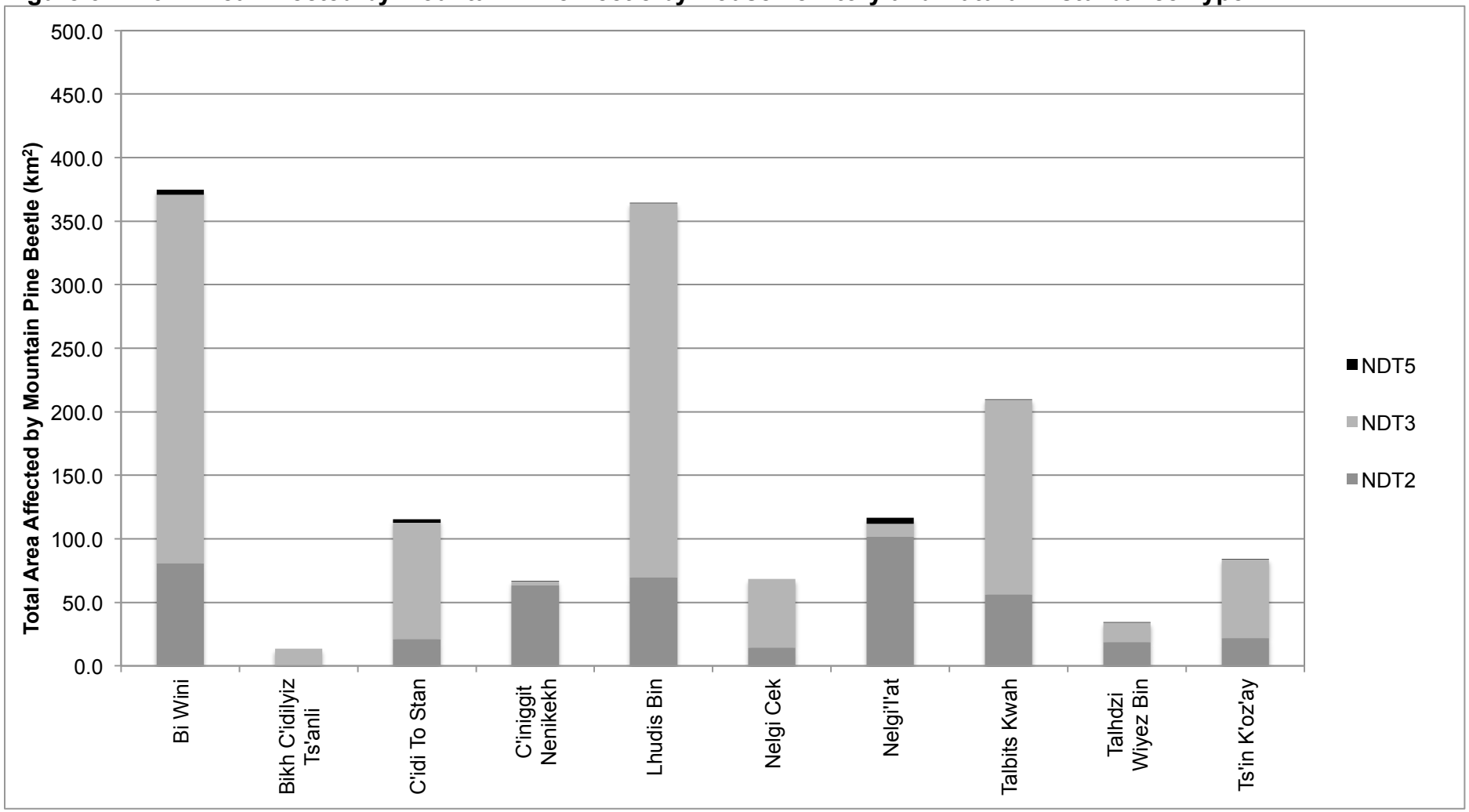
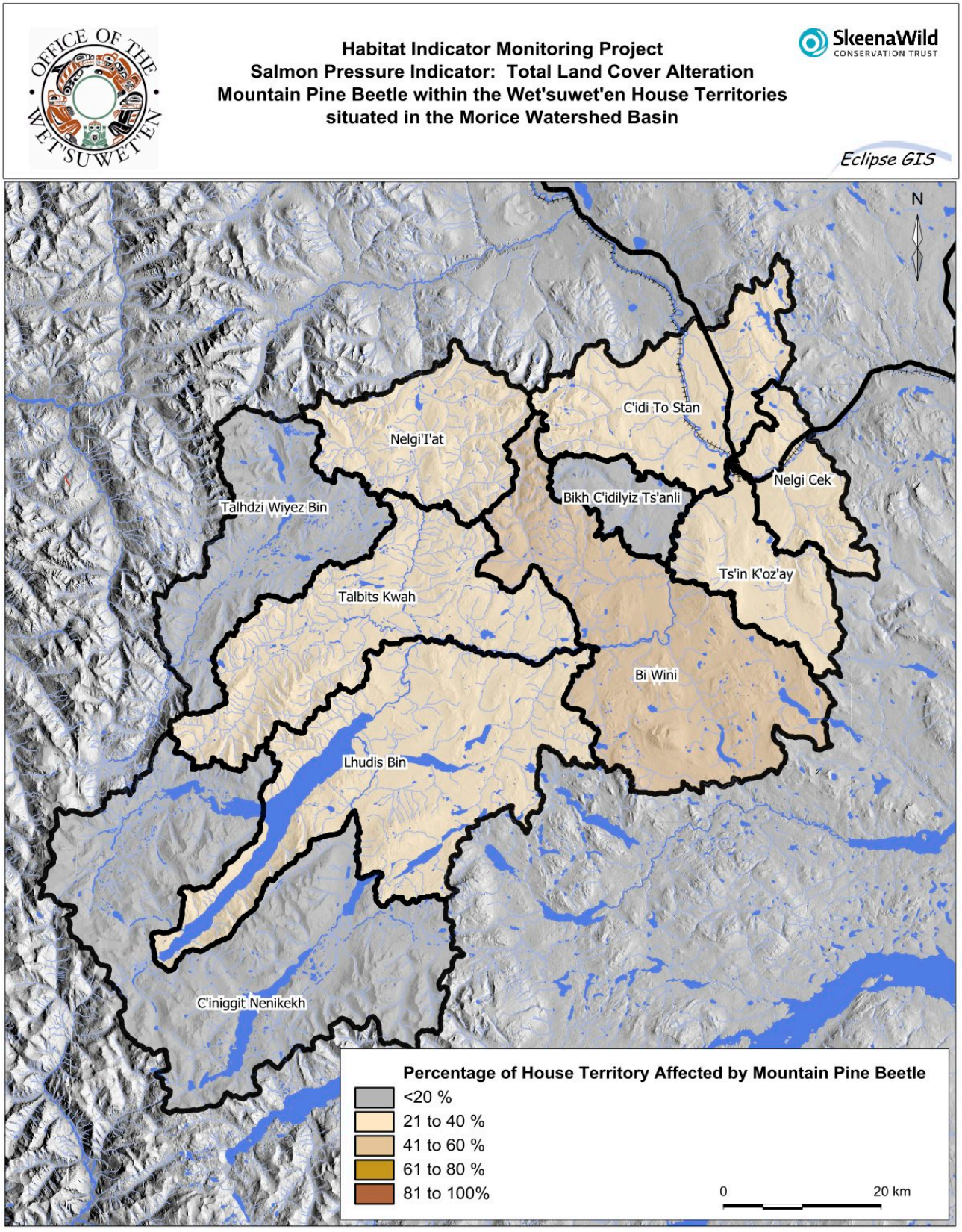


Figure 3.4.1.3.2 Percentage of House Territory Affected by Mountain Pine Beetle



3.4.1.4. Morice Sub-watersheds

The extent of the Mountain Pine Beetle within the eighteen Morice sub-watersheds varies from 0.1% in Atna River to 61.2% in Morice River Reach 1 West. Four additional sub-watersheds have an extent of greater than 50% including Morice River Reach 2 Southeast (56.0%), McBride Creek (56.6%), Lamprey Creek (57.3%), and Morice River Reach 2 North (58.6%).
The majority of the disturbance occurred in NDT3 (69.2%), with 30.0% occurring in the NDT2 zone.

Table 3.4.1.4 Mountain Pine Beetle Severity by Sub-watershed and Natural Disturbance Type

	NDT2				NDT3				NDT5					
Sub-watershed Unit	**Moderate**	**Severe**	**Very Severe**	**Total**	**Moderate**	**Severe**	**Very Severe**	**Total**	**Moderate**	**Severe**	**Very Severe**	**Total**	**Total (km^2)**	**% of Sub-watershed**
Atna River	0.3			0.3									0.3	0.1
Crystal Creek		0.2		0.2	4.4	1.2		5.6					5.8	9.3
Gosnell Creek	10.8	13.5		24.3	14.8	13.8		28.6	0.0			0.0	52.9	18.9
Houston Tommy Creek	39.6	0.6		40.2	48.3	2.4		50.7	3.4	0.2		3.6	94.5	38.1
Lamprey Creek	13.3	2.8		16.1	85.2	36.5		121.7					137.8	57.3
McBride Creek	1.3			1.3	27.7	35.6	0.5	63.9					65.1	56.6
Morice Lake	13.5	4.3		17.8	9.6	9.7		19.3	0.5			0.5	37.6	6.3
MR R1 East	3.9	0.1		3.9	11.2	7.1		18.3					22.3	31.1
MR R1 West		2.6		2.6	11.0	11.5		22.5					25.1	61.2
MR R2 North	4.2	0.2		4.4	82.7	27.7	6.0	116.5					120.9	58.6
MR R2 SE	0.2	9.3		9.5	23.3	24.1		47.3					56.9	56.0
MR R2 SW	3.4			3.4	11.7	0.2		11.8					15.3	24.8
MR R3 East	0.2	2.0		2.2	17.2	6.2	0.6	24.0		0.1		0.1	26.3	15.9
MR R3 West					24.2	2.9		27.1					27.1	14.9
Nanika River	58.4	35.8		94.3	19.6	28.7		48.3	0.0			0.0	142.6	16.0
Owen Creek	1.6	3.1		4.6	29.7	42.6	0.2	72.5					77.1	36.3
Shea Creek	1.9	10.8		12.7	7.3	13.7		21.1					33.8	17.3
Thautil River	54.7	25.9		80.6	21.5	16.9		38.3	4.8	0.2		5.0	123.9	29.3
Total	**207.1**	**111.3**		**318.5**	**449.4**	**280.7**	**7.3**	**737.4**	**8.8**	**0.5**		**9.3**	**1065.1**	**24.3**

Figure 3.4.1.4.1 Area Affected by Mountain Pine Beetle by House Territory and Natural Disturbance Type

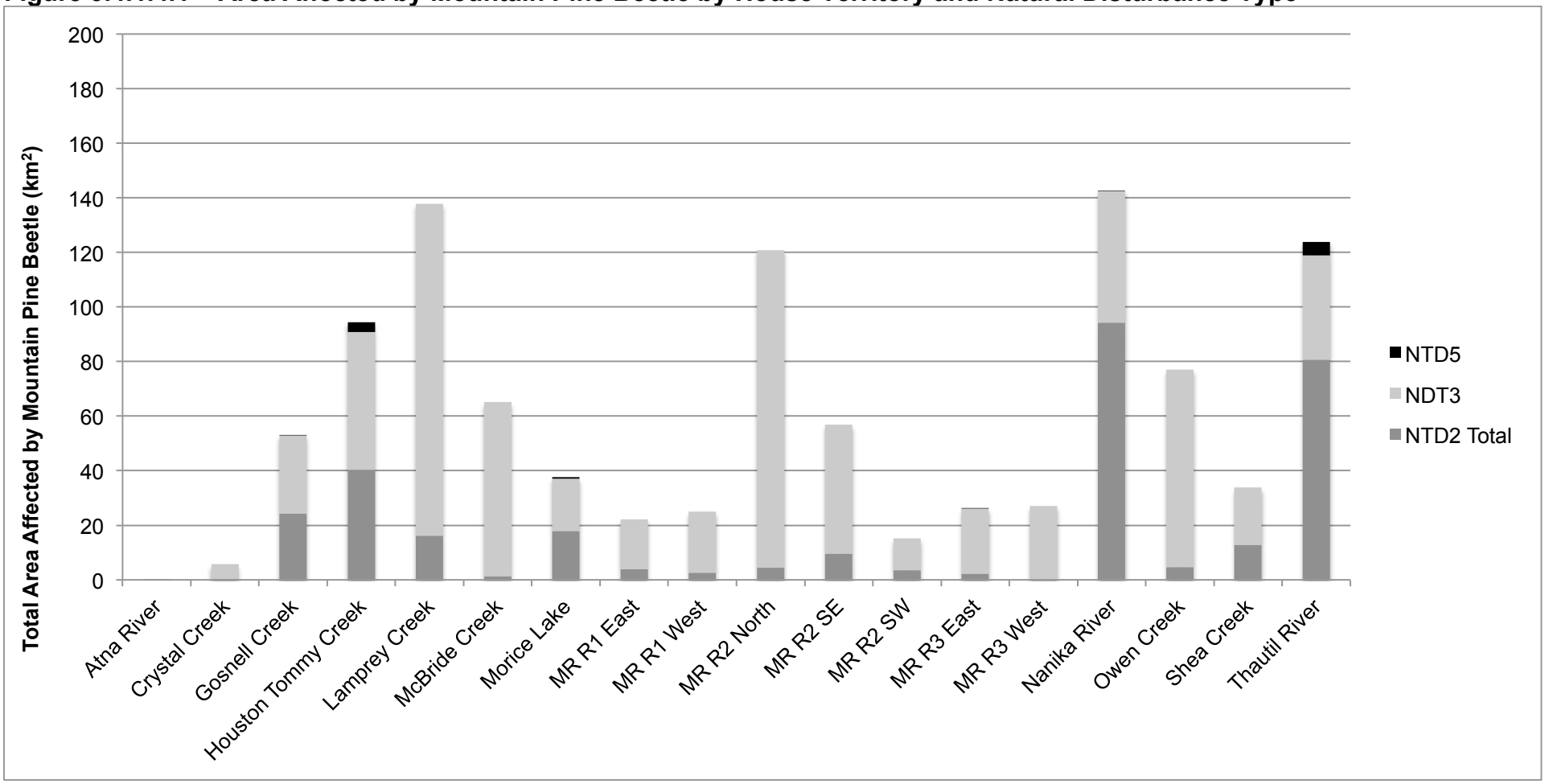
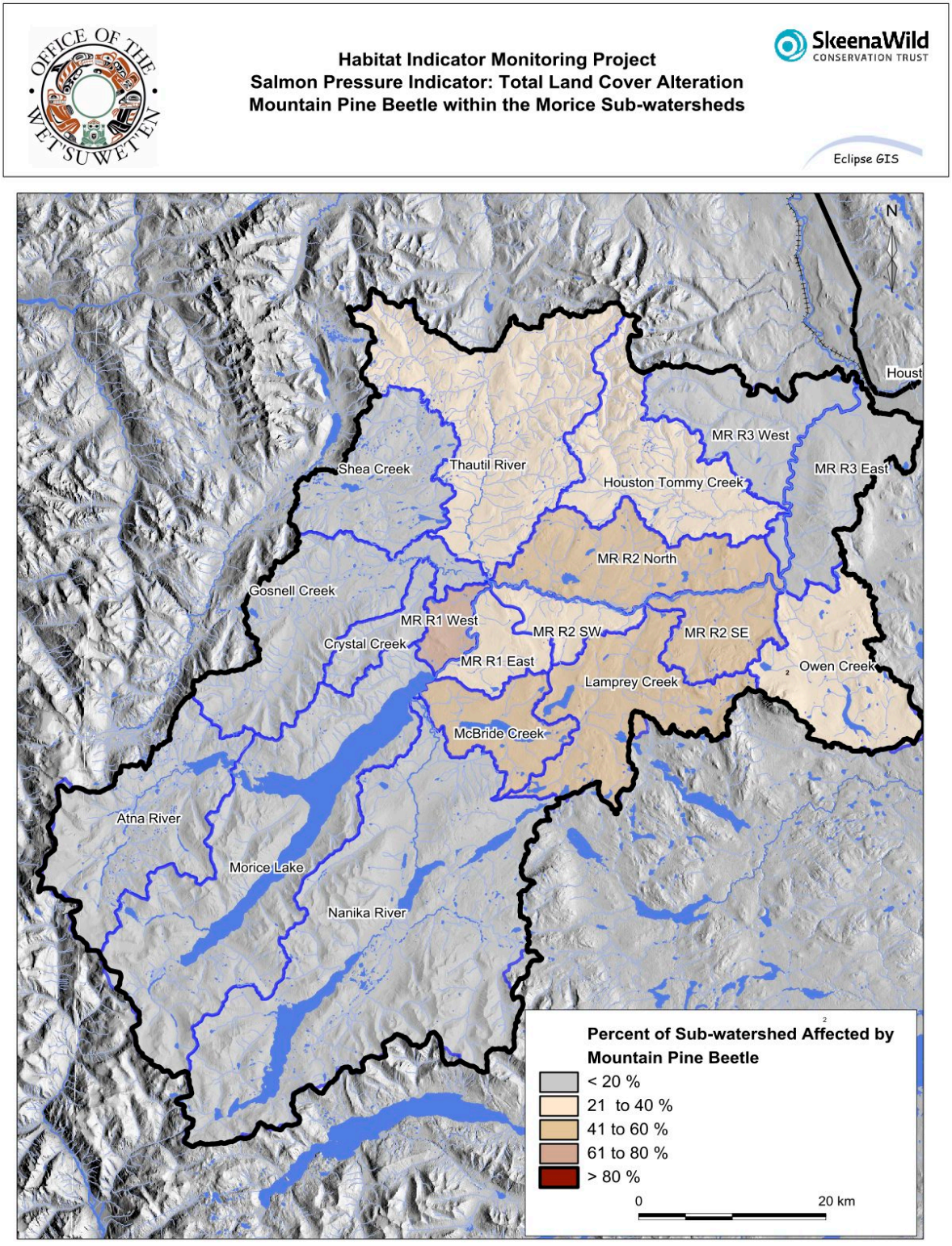


Figure 3.4.1.4.2 Percentage of Sub-watersheds affected by Mountain Pine Beetle.



3.4.2. Fire Disturbance

Fire History data from 1920 to 2012 was analyzed by frequency as well as extent. In order to maintain a watershed perspective, the results are presented only by the extent of the largest analysis unit, the Wet'suwet'en House Territories situated within the Morice Watershed. The fire disturbance data is summarized by 20-year intervals, and further broken down by Natural Disturbance Type.

3.4.2.1. Fire Frequency

From 1920 to 2012, average fire frequency within the study area is 1.6 fires per year. The breakdown of fire frequency by Natural Disturbance Type is 18.9% in NDT2, 60.1% in NDT3, and 20.0% in NDT5.

Table 3.4.2.1 Fire Frequency by Year and Natural Disturbance Type

Fire Year	NDT2	NDT3	NDT5	Total
1920-1939		47		47
1940 - 1959	2	11	15	28
1960 - 1979	2	7	2	11
1980 - 1999	4	9	7	20
2000 - 2012	19	12	6	37
Total	27	86	30	143

The cause of wildfires within the Morice watershed has shifted over the past 12 years. Historically, prior to 2000, man caused 64% of the fires within the Morice watershed. Since 2000, lightening strikes have caused 36 of 37 wildfires.

3.4.2.2. Fire Extent

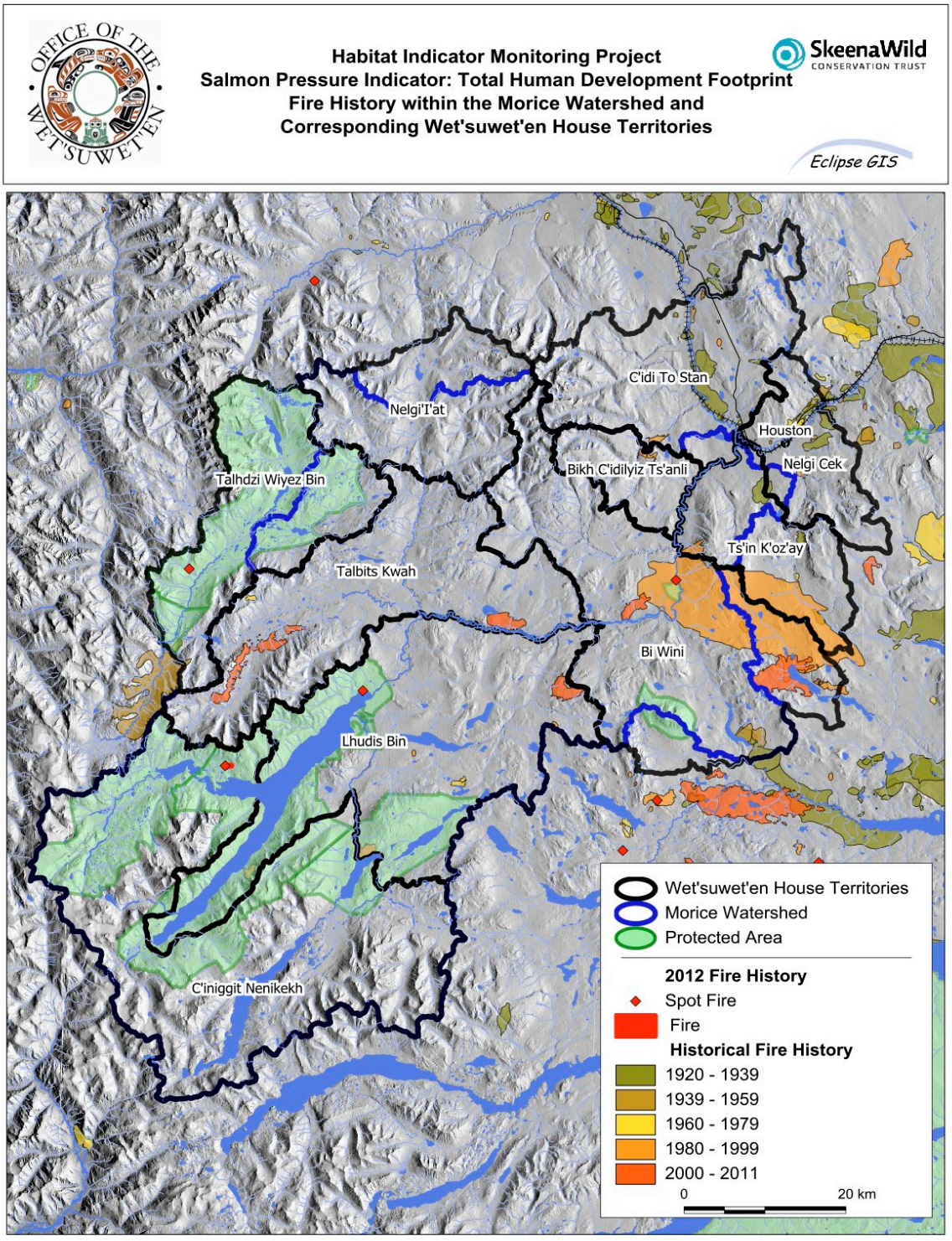
The average fire size from 1920 to 2012 is 2.26km^2. Excluding the Swiss fire of 1983, average fire extent drops to 0.84 km^2. 85.2% of the fires occurred in the NDT3 zone, 13.9% in the NDT2 zone, and the remaining in the 0.9% within the NTD5 zone. Although 19.7% of the fires occurred in the NTD5 zone from 1940 – 2012, they were all small fires covering a total extent of 2.8 km^2.

Table 3.4.2.2 Fire Extent by Year and Natural Disturbance Type

Fire Year	NDT2	NDT3	NDT5	Total
1920 -1939	0.0	51.6	0.0	51.6
1940 - 1959	1.3	9.1	0.6	11.1
1960 - 1979	0.5	4.2	0.2	5.0
1980 - 1999	25.3	191.2*	1.9	218.4
2000 - 2012	20.8	36.3	0.1	57.3
Total	47.9	292.5	2.8	343.4

- The Swiss fire in 1983 was 21,576.8 ha (216 km2) and spanned NDT3, NDT2 and NDT5.

Figure 3.4.2.1 Historical Fire History in the Morice Watershed



4. Summary Of Analyses by Natural Disturbance Type

These analyses present a synoptic look at the extent of three disturbance agents including current development, wildfire and mountain pine beetle. The analyses provide a high level comparison of the footprint of current development, mountain pine beetle and wildfire, placed within the context of thresholds as well as natural disturbance regimes.

Table 4.1 Extent of Disturbance Agent by Natural Disturbance Type

	NDT2	NDT3	NDT5	Total HDF
Total HDF (km^2)	82.1	684.0	5.8	771.8
Extent of MPB (km^2)	318.5	737.4	9.3	1065.1
Extent of Wildfire (km^2)	47.9	292.5	2.8	343.4

The relative extent of the three disturbances, ranked from lowest to highest, are wildfire, human development, and mountain pine beetle. Wildfire has the lowest footprint at 343.4 km^2. The human development footprint (771.8 km^2) is over double the footprint of wildfire. Mountain pine beetle activity covered the largest footprint at 1,065.1 km^2. All three disturbances are more prevalent within the NDT3 zone, with a relatively low disturbance footprint within the NDT5 zone.

The wildfire and mountain pine beetle analyses presented in this report only look at the extent of the disturbance. The report does not look at the severity (intensity) of the disturbance, as the extent of the disturbance does not necessarily indicate the severity (intensity) of the disturbance. It is possible that the level of mountain pine beetle is more extensive in some areas, but the intensity could be much lower than wildfire or human disturbance.

The results presented in these analyses represent a snapshot in time, as natural disturbance regimes are dynamic processes. The interaction between natural disturbance agents and development activities is not well understood. Natural disturbance regimes are complex processes, and our "understanding and prediction of even current forest disturbance regimes is elementary and disparate among disturbance types, making projections into the future under a warmer climate extremely difficult."[11]

[11] Haughian, S.R., P.J. Burton, S.W. Taylor, & C. L. Curry. 2012. Expected effects of climate change on forest disturbance regimes in British Columbia. BC Journal of Ecosystems and Management 13(1):1-24 Published by FORREX Forum for Research and Extension in Natural Resources. http://jem.forrex.org/index.php/jem/article/viewFile/152/107

5. Conclusion

Recent events over the last 50 years have shown that the Total Human Development Footprint in Morice Watershed is considerable. The majority of the THDF is located in the easily accessible central portion of the watershed.

This analysis shows that particular territories – Talbits Kwah, Lhudis Bin, and Bi Wini – have had significant environmental changes. Alterations in land use and cover are the most far-reaching of environmental changes. Land use change in the Morice has been unsustainable and has impacted fish, wildlife, and health. It has created harmful adverse effects on water, air, biodiversity and created conflict with land use planning.