Protected Areas of the Muskwa-Kechika Management Area

Ecosystem Overview Assessment

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Confluence ~ Conservation Science and Practice

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Introduction

Located in northern British Columbia and named after two of the great rivers that traverse the area, the Muskwa-Kechika Management Area (M-KMA) spans 6.4 million hectares of mountainous ecosystems and abundant gravel-bed ecosystems in the Northern Rockies within the traditional territories of the Kaska-Dene First Nations, Treaty 8 First Nations and the Tsay Keh Dene.

Established in 1998, the Muskwa-Kechika was intended to showcase a world class model for land planning and management (Muskwa-Kechika Advisory Board, 2015). The vision for the M-KMA developed by the Muskwa-Kechika Advisory Board in a strategic planning process states: "*the M-KMA is a globally significant area of wilderness, wildlife, and cultures, to be maintained in perpetuity, where world class integrated resource management decision-making is practiced ensuring that resource development and other human activities take place in harmony with wilderness quality, wildlife and the dynamic ecosystems on which they depend*."

While the entirety of the M-KMA is subject to a more ecosystem-based or integrated approach to resource management twenty-seven percent of the M-KMA is designated as Provincial Parks, Protected Areas or Ecological Reserves (figure 1). Apart from small portions of the four protected areas that are located adjacent to the Alaska Highway (Northern Rockies, Stone Mountain, Muncho Lake and Liard Hot Springs), these protected areas contain undisturbed watersheds, intact predator-prey relationships, and provide remote, wildland experiences. Many of these areas are large and connected either to other protected areas or via the, as yet undeveloped, special wildland zones which allow for resource extraction with the exception of timber harvesting. The M-KMA was the subject of the first Canadian systematic conservation planning design in which a network of protected areas was identified simultaneously and represents the benchmark of the intentional designation of a system of protected areas (Heinemeyer, 2004). As new information and analysis is conducted on the area (Dena Kayeh Institute, 2019; Suzuki & Parker, 2019; Weaver, 2019; Yellowstone to Yukon Conservation Initiative, 2012) it contributes to our understanding of the values within, and adjacent to, these protected areas.

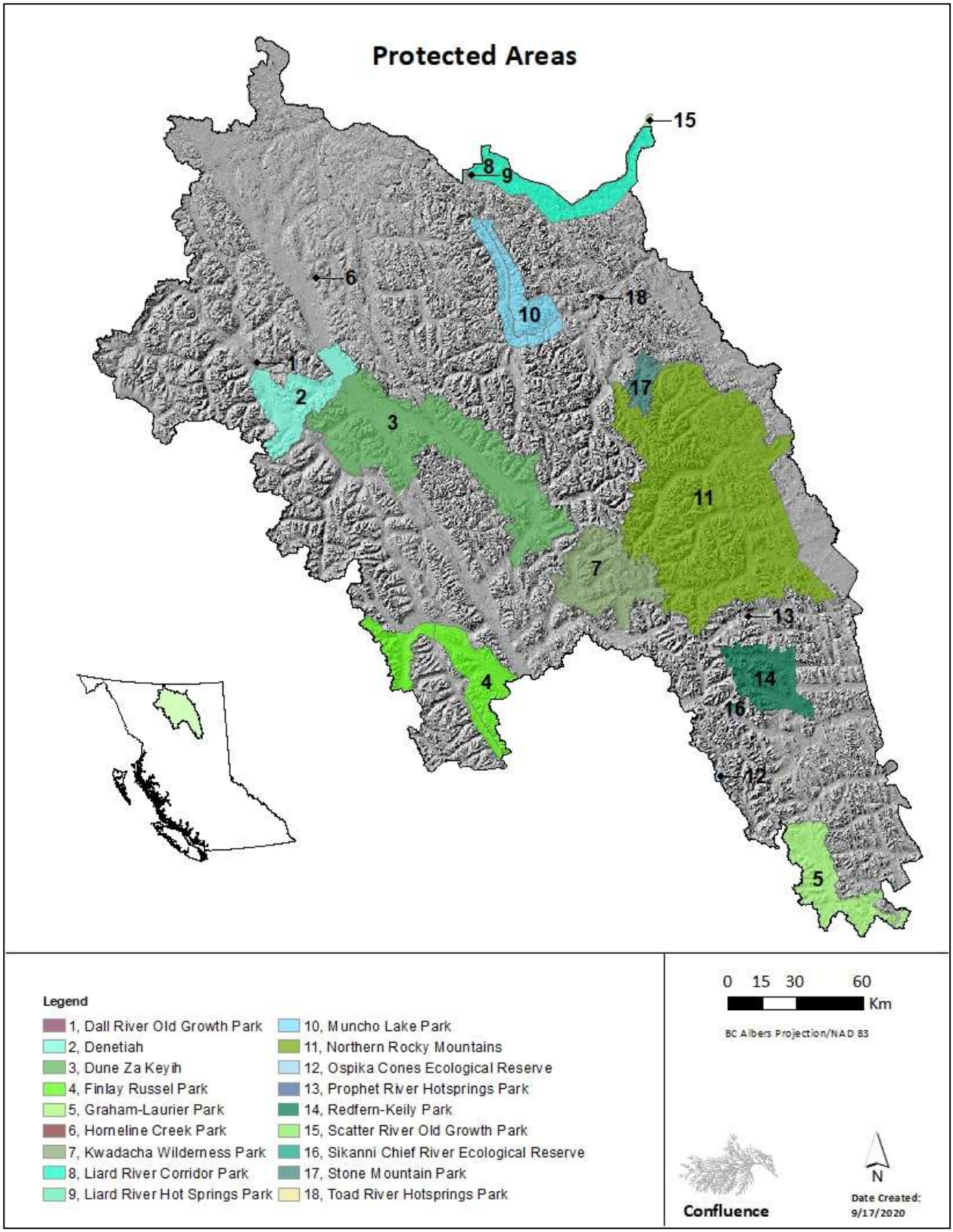


FIGURE 1. PROTECTED AREAS WITHIN THE MUSKWA-KECHIKA MANAGEMENT AREA.

Purpose of the Ecosystem Overview Assessment

An Ecosystem Overview Assessment (EOA) is designed to provide background information for the development of management planning documents, to provide information for ongoing management and to inform an M-KMA Conservation Assessment. There are 16 park and protected areas or ecological reserves within the Muskwa-Kechika Management Area and an additional one (Scatter River Old Growth Park) located immediately outside the borders of the Muskwa-Kechika Management Area that has been included. Two of these park and protected areas (Northern Rocky Mountains Park and Redfern-Keily Park) are mapped and included in this EOA but are subject to separate management planning initiatives.

Methods

The EOA was generated with information primarily from geospatial analysis using datasets including those available from the BC Data Catalogue (DataBC, 2020), UNBC researchers (Anderson, 2018; Suzuki & Parker, 2016, 2019), AdaptWest (AdaptWest, n.d.), the Wildlife Conservation Society (Weaver, 2019), the Biodiversity and Climate Change Assessment (Yellowstone to Yukon Conservation Initiative, 2012), ClimateBC[1], and OpenStreetMap[2]. Non-spatial data came from those sources, literature and other reports generally available on the Muskwa-Kechika Management Area website.[3] Where necessary data was confirmed or supplemented through professional consultations. It is important to note two comprehensive documents that provide significant foundation for this work and provide significantly more detail on a number of topics: the Kaska Dena Conservation Analysis for an Indigneous Protected and Conserved Area in British Columbia (Dena Kayeh Institute, 2019); and the Greater Muskwa-Kechika: Building a better network for protecting wildlife and wildlands (Weaver, 2019).

Data Layers

Spatial layers sourced from the BC Data Catalogue (DataBC, 2020) included:

- Bedrock Geology
- Broad Ecosystem Inventory (BEI)
- Biogeoclimatic Ecosystem Classification (BEC) zones
- Consolidated Cutblocks
- Critical Wildlife Habitat
- Current and Historic Fires
- Digital Road Atlas
- Fisher Habitat
- First Nations Treaty Areas and Lands
- Fisheries Sensitive Watersheds
- Fresh Water Atlas
- Karst Potential
- Old Growth Management Areas
- Protected Areas
- Species and Ecosystems at Risk
- Tenures Database

[1] www.climatewna.com/ClimateBC_Map
[2] www.openstreetmap.com
[3] www.Muskwa-Kechika.com

- Ungulate Winter Range
- Vegetation Resource Inventory (VRI)

Structure of the EOA

This combined EOA summarizes ecological values across the broader Muskwa-Kechika Management Area focusing in on the protected areas. The ecological values are divided into six broad categories: physiography, terrestrial ecosystems, aquatic ecosystems, fish and wildlife, fire and climate change.

Given the number of protected areas included in this EOA, broad summaries across all protected areas are generally provided in the text and maps. This is supplemented by park/protected area-specific tables in certain places. Detailed maps of key conservation features for each individual protected area is available in technical, digital appendices.

Geography and Geology Overview of M-KMA Protected Areas

Ecoregions and Ecosections

The Ecoregion Classification System helps describe small scale ecosystems and habitat diversity hierarchically based on broad, common characteristics of landforms, soils, water features, vegetation and climate (Demarchi, 1996). The two most detailed levels of the system are Ecoregions and Ecosections. There are 47 Ecoregions in British Columbia mapping major physiographic and minor macroclimatic variation. Ecosections, the finest level of the system define minor physiographic and macroclimatic variation.

The Muskwa-Kechika Management Area encompasses the Northern Rocky Mountains straddling the large, flat valley of the Rocky Mountain Trench. Most of the M-KMA's parks and protected areas fall within the Northern Canadian Rocky Mountain ecoregion, with the Boreal Mountains and Plateaus ecoregion encompassing most of the rest. The Northern Canadian Rocky Mountains ecoregion incorporates both the northern Rocky Mountains and the Muskwa Ranges and consists of alpine vegetation, bare bedrock or glaciers above the treeline; birch and willow shrubs or alpine fir and white spruce within the subalpine forest; boreal forests dominated by lodgepole pine or white and black spruces at the lower, warmer elevations[4].

The Boreal Mountains and Plateaus ecoregion includes rugged mountains, high plateaus and lowland areas and the climate is more continental in its eastern reaches and moderate to the west. Vegetation follows the same elevational pattern as the Northern Canadian Rocky Mountains ecoregion.

Dune Za Keyih Provincial Park encompasses 43% of the protected Kechika River Trench ecosection, and the Denetiah Corridor Protected Area encompasses the next largest amount (5.3%) of the same ecosection (Figure 2, Table 1). Liard River Corridor Provincial Park represents 7% of the province's total protected Hyland Plateau ecosection, and Graham-Laurier Provincial Park represents 10.1% of the total protected Misinchinka Ranges ecosection.

[4] www.ecozones.ca

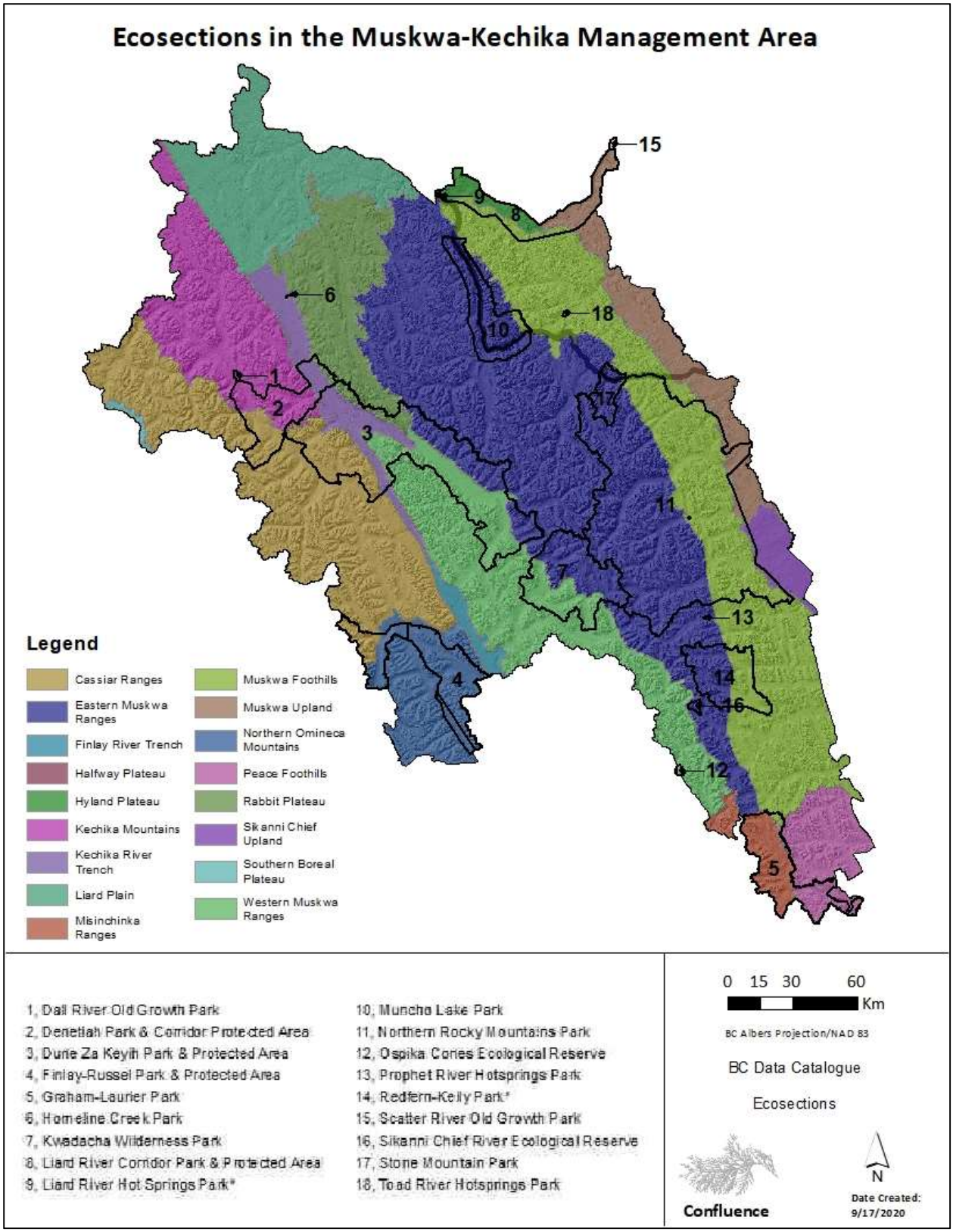


FIGURE 2. ECOSECTIONS IN THE MUSKWA-KECHIKA MANAGEMENT AREA

Table 1. Ecosection representation within each of the Muskwa-Kechika Protected Areas

Protected Area	Ecosection	Total area of Ecosection provincially (ha)	% of Ecosection protected provincially	Area of this Ecosection in this protected area (ha)	% of Ecosection in this protected area
Dall River Old Growth Park	Kechika Mountains	634,966.69	37	644.00	0.1
Denetiah Corridor Protected Area	Kechika River Trench	140,665.29	53	7,445.18	5.3
Denetiah Park	Cassiar Ranges	1,757,487.37	9	30,858.81	1.8
	Kechika Mountains	634,966.69	37	49,674.09	7.8
	Rabbit Plateau	333,513.24	7	3,891.56	1.2
Dune Za Keyih Park	Kechika Mountains	634,966.69	37	5,572.93	0.9
	Kechika River Trench	140,665.29	53	60,531.50	43.0
	Rabbit Plateau	333,513.24	7	18,312.14	5.5
	Western Muskwa Ranges	1,013,876.88	17	96,745.75	9.5
Dune Za Keyih Protected Area	Western Muskwa Ranges	1,013,876.88	17	15,992.64	1.6
Finlay-Russel Protected Area	Northern Omineca Mountains	1,388,499.72	15	13,563.75	1.0
Finlay-Russel Park	Finlay River Trench	168,554.79	3	326.09	0.2
	Northern Omineca Mountains	1,388,499.72	15	90,552.28	6.5
Graham-Laurier Park	Eastern Muskwa Ranges	1,694,095.00	40	91.22	0.0
	Misinchinka Ranges	657,044.87	10	66,066.86	10.1
	Muskwa Foothills	1,086,761.44	31	2,426.11	0.2
	Peace Foothills	654,939.19	6	31,397.45	4.8
Horneline Creek Park	Kechika River Trench	140,665.29	53	298.15	0.2
Kwadacha Wilderness Park	Western Muskwa Ranges	1,013,876.88	17	54,878.52	5.4
Liard River Corridor Park	Hyland Plateau	503,619.60	8	35,323.00	7.0
	Muskwa Foothills	1,086,761.44	31	19,810.78	1.8
	Muskwa Upland	1,258,569.54	4	33,854.00	2.7
Liard River Hotsprings Park	Hyland Plateau	503,619.60	8	1,082.00	0.2
Muncho Lake Park	Muskwa Foothills	1,086,761.44	31	4,628.20	0.4
Ospika Cones Ecological Reserve	Western Muskwa Ranges	1,013,876.88	17	1,283.27	0.1
Prophet River Hotsprings Park	Eastern Muskwa Ranges	1,694,095.00	40	184.62	0.0
Scatter River Old Growth Park	Muskwa Upland	1,258,569.54	4	1,177.52	0.1

Protected Area	Ecosection	Total area of Ecosection provincially (ha)	% of Ecosection protected provincially	Area of this Ecosection in this protected area (ha)	% of Ecosection in this protected area
Sikanni Chief Ecological Reserve	Eastern Muskwa Ranges	1,694,095.00	40	2,176.12	0.1
	Western Muskwa Ranges	1,013,876.88	17	0.21	0.0
Stone Mountain Park	Eastern Muskwa Ranges	1,694,095.00	40	24,459.19	1.4
	Muskwa Foothills	1,086,761.44	31	719.48	0.1
Toad River Hotsprings Park	Muskwa Foothills	1,086,761.44	31	413.70	0.0

Elevation

Elevation in the M-KMA rises from approximately 300 meters above sea level in the Liard River Parks and Protected Areas, to upwards of 2000 meters (Figure 3, Table 2). Low elevation areas are typically more biologically productive and can contain higher levels of biodiversity under current climates. Parks and protected areas in the M-KMA like Scatter River, Horneline Creek, and Liard River Corridor are entirely low elevation. Others, like Sikanni Chief River Ecological Reserve and Redfern-Keily, are mostly high elevation. High elevations are well represented in the M-KMA's protected areas (59%), a pattern consistent across protected areas systems. This diversity in elevation is important as it will provide species with lower temperature refugia as the climate warms (Weaver, 2019).

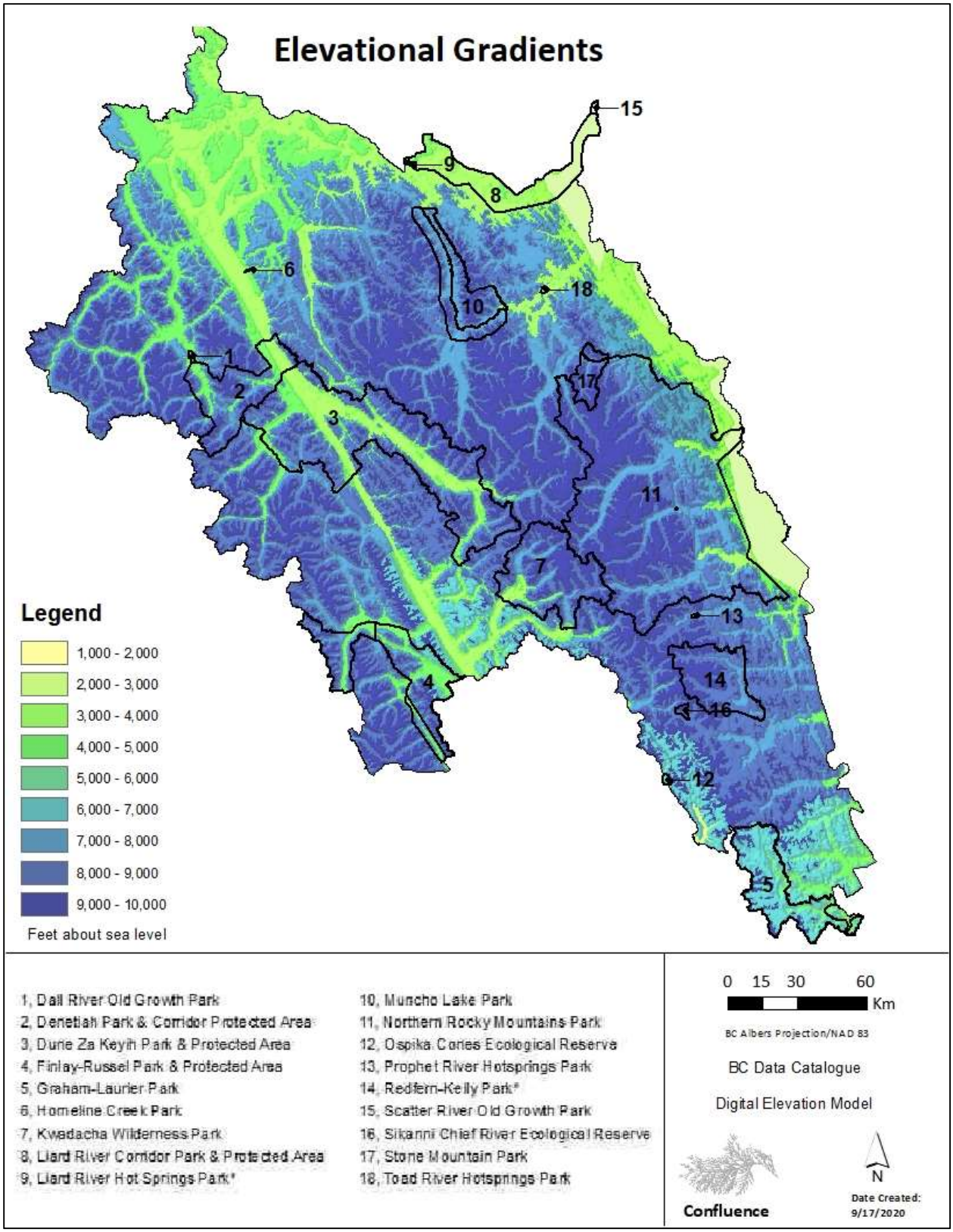


FIGURE 3. ELEVATIONAL GRADIENTS IN THE MUSKWA-KECHIKA MANAGEMENT AREA

Table 2. Elevation classes[5] in M-KMA protected areas			
Protected Area	**Elevation Class**	**Area (Ha)**	**Percent**
Dall River Old Growth Park	Low	630	100.0
Denetiah	Low	24367	24.9
	Medium	20245	20.7
	High	53105	54.4
Dune Za Keyih	Low	117089	33.7
	Medium	36678	10.6
	High	193747	55.8
Finlay-Russel Park	Low	36724	30.1
	Medium	29843	24.4
	High	55618	45.5
Graham-Laurier Park	Low	14883	15.1
	Medium	68292	69.3
	High	15368	15.6
Horneline Creek Park	Low	284	100.0
Kwadacha Wilderness Park	Low	11979	9.2
	Medium	17087	13.1
	High	101124	77.7
Liard River Corridor Park	Low	63332	99.3
	Medium	424	0.7
Liard River Hot Springs Park	Low	1070	100.0
Muncho Lake Park	Low	1062	1.2
	Medium	38667	39.6
	High	46035	47.1
Northern Rocky Mountains	Low	37163	5.6
	Medium	172330	26.0
	High	452190	68.3
Ospika Cones Ecological Reserve	Low	239	19.3
	Medium	669	54.1
	High	329	26.6
Prophet River Hotsprings Park	Medium	152	87.9
	High	21	12.1
Redfern-Keily Park	Medium	8116	10.1
	High	72340	89.9
Scatter River Old Growth Park	Low	1178	100.0
Sikanni Chief River Ecological Reserve	High	2129	100.0
Stone Mountain Park	Medium	1407	5.6
	High	23675	94.4
Toad River Hotsprings Park	Low	348	85.9
	Medium	57	14.1

[5] Elevational classes where Low = 0-4,000 feet, Medium =4,000-7,000 feet, High = 7,000 to 10,000 feet

Size

The larger a protected area the more likely it is sufficient size to enable natural processes and species movement than smaller, individual isolated protected areas. Larger protected areas may be more likely to be capable of maintaining populations of disturbance-sensitive mammals, supporting ecological processes and ecosystem services, and be more resilient to large landscape scale impacts such as climate change. Examined individually, the protected areas within the M-KMA vary greatly in size from the very small (Prophet River Hotsprings Park) to very large (Northern Rocky Mountains Park) (Table 3).

BC Parks recognizes clusters of adjacent protected areas as park complexes: connected protected areas that ecologically work as an individual protected area. The Muskwa-Kechika represents one of the largest of these clusters within the province. Although separated by a corridor just over 2.5 km long that allows for potential resource development, the M-KMA contains one of the Provinces' largest complexes with Dall River Old Growth Park, Denetiah Park and Dune Za Keyih Park and Protected Area the western component and Stone Mountain, Northern Rocky Mountain and Kwadacha Wilderness Parks the eastern component. At 12, 690 km2, the M-KMA park complex is in the upper range of the recommended distribution of protected areas in order to sustain cohorts of large mammals such as black and grizzly bear, and wolves (Gurd & Nudds, 1999; Landry et al., 2001).

Currently, the absence of resource development in the permitted resource management zones surrounding the protected areas within the M-KMA mean that's with a few exceptions (e.g., the Alaska highway and some popular front-country recreation areas) the entirety of the M-KMA and thus its protected areas are functioning as a large complex.

Table 3. Size distribution of M-KMA protected areas

Protected Area	Area (Ha)
Prophet River Hotsprings Park	185
Hornline Creek Park	298
Toad River Hotsprings Park	414
Dall River Old Growth Park	644
Scatter River Old Growth Park	1178
Ospika Cones Ecological Reserve	1283
Sikanni Chief River Ecological Reserve	2176
Stone Mountain Park	25181
Redfern-Keily Park	80771
Muncho Lake Park	86079
Liard River Hot Springs &Corridor Park	90071
Denetiah	97908
Graham-Laurier Park	99557
Finlay Russel Park	122791
Kwadacha Wilderness Park	130335
Dune Za Keyih	347789
Northern Rocky Mountains	667147

Climate

The climate of the M-KMA is characterized as a northern continental climate influenced predominantly by both its northern latitudes and arctic air masses. A pattern of arctic, low-temperature air descends onto the M-KMA during the winter months, depositing thick snow in most areas. Spring and summer seasons are short, with snow sometimes falling sporadically in summer months in the alpine and higher elevation valleys (Weaver, 2019). Using a low-elevation point within Dune Za Keyih Provincial Park as the benchmark, decadal, seasonal average temperatures show that winters have warmed since 1961 by about 4 degrees Celsius with about 2.5 degrees Celsius warming in spring (Table 4).[6] In contrast to many other locations in the north, seasonal precipitation remains relative unchanged (Table 5).

Table 4. Average seasonal decadal degrees temperature (Celsius)*

Decade	Winter	Spring	Summer	Autumn
1961-1970	-14.6	-1.7	10.5	-1.3
1971-1980	-15	-1.3	10.5	-0.9
1981-1990	-12.2	-0.7	10.4	-2.0
1991-2000	-11.9	0.2	9.8	-0.9
2001-2010	-10.8	-0.3	10.3	-0.2
2011-2018	-10.4	0.8	10.7	-0.6

Table 5. Average seasonal decadal precipitation (Milliliters)*

Decade	Winter	Spring	Summer	Autumn
1961-1970	110	98	201	137
1971-1980	114	96	214	135
1981-1990	104	105	208	145
1991-2000	102	97	228	114
2001-2010	114	96	214	135
2011-2018	108.0	94.7	186.0	116.7

* Benchmark location for calculation was Dune Za Keyih Prov. Park

Geography and Geology

The rugged, mountains of the M-KMA were formed first from sediments deposited hundreds of millions of years ago in a shallow sea. Approximately 60 million years ago these mountains emerged following crustal plate collisions forming the Rocky Mountains. Fifty million years of subsequent erosion was interspersed with intermittent glacial periods that shaped many of the glacial features within the region. As a result, sedimentary rock dominates the M-KMA with bedrock outcrops common. Intrusive rock composes much of the western edge, with some metamorphic and volcanic rock scattered throughout associated with late Tertiary and Pleistocene volcanoes found further west of the M-KMA (e.g., Mount Edziza and Level Mountains). There are a number of glaciers along with sporadic occurrences of discontinuous permafrost in the northern portion of the M-KMA with isolated patches in the southwest.

Soils range from Turbic Cryosolic and Regosolic soils in alpine terrain; to Humo-Ferric Podzols and Dystric Brunisolic with some Cryosolic, Organic, and Gleysolic soils in subalpine terrain; and to Gray Luvisolic and Dystric Brunisolic soils in warmer boreal sections of the area[7] (Figure 4, Table 6).

Some mineral occurrences have been documented in the M-KMA including copper, lead, zinc, silver, barite, gold, tungsten, chalcopyrite, pyrite, dolomite, quartz crystals, malachite, aragonite, mica and azurite[8].

666 http://www.climatewna.com/ClimateBC_Map.aspx
7 www.ecozones.ca
8 www.muskwa-kechika.com

The M-KMA protected areas contain a number of unique geographic and geological features including:

- Unique geothermal features in Liard River Hot Springs, Prophet River Hotsprings, and Toad River Hot Springs
- Folded mountains and large alluvial fans in Muncho Lake Provincial Park
- Rocky mountain trench bisects Dune Za Keyih/Denetiah
- Lloyd George Glacier/Icefields in Kwadacha
- Fossil occurrences such as ammonites in Liard River Park/protected Areas
- Cold water tufa terraces and pool formations in Ospika Cones Ecological Reserve
- Erosion pillars in Stone Mountain

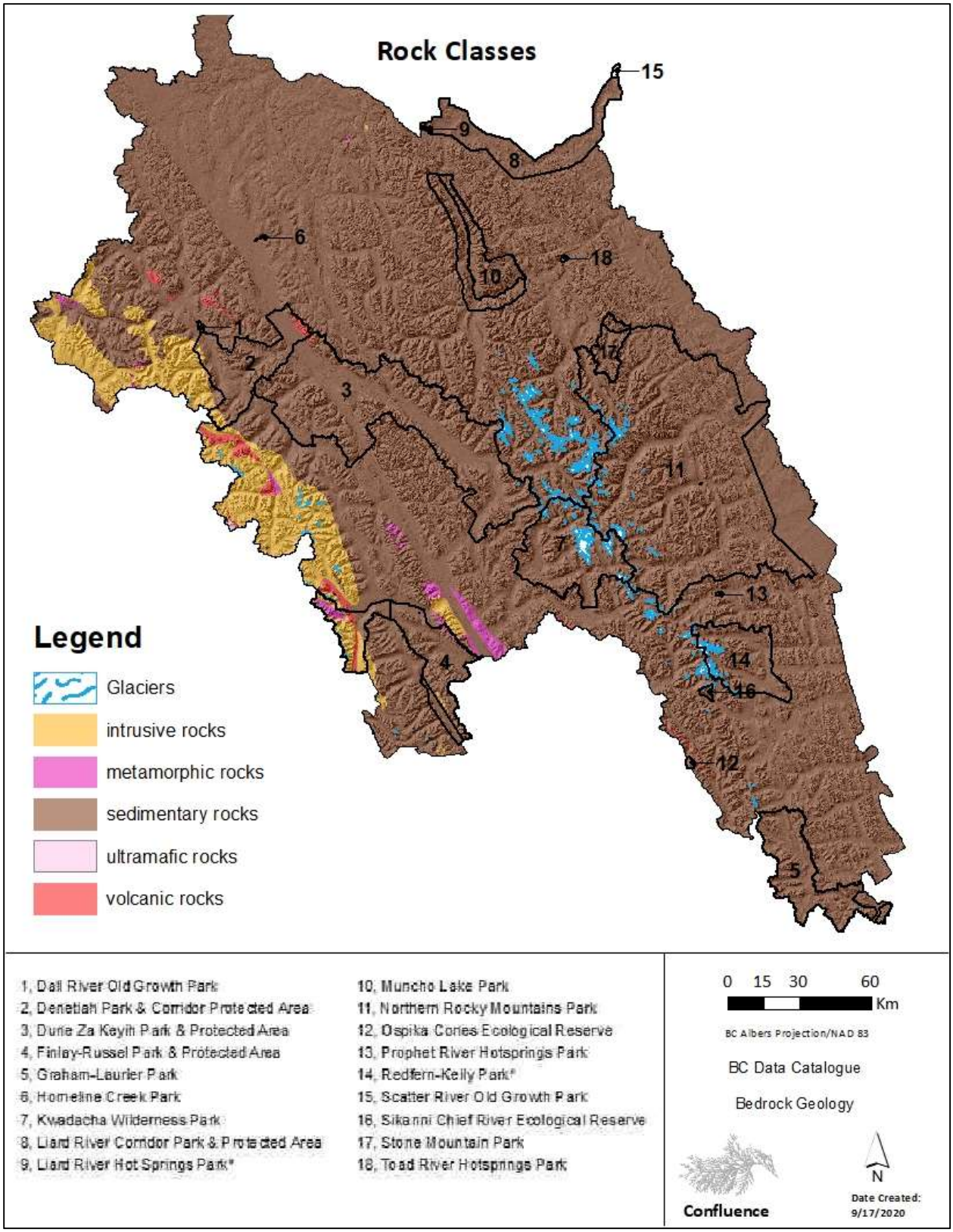


FIGURE 4. ROCK CLASSES WITHIN THE MUSKWA-KECHIKA MANAGEMENT AREA

Table 6. Rock type by protected area

Protected Area	Rock Type	Area (Ha)	Percent
Dall River Old Growth Park	limestone, slate, siltstone, argillite	644	100
Denetiah	alkaline volcanic rocks	2170	2
	fine clastic sedimentary rocks	60	0
	granite, alkali feldspar granite intrusive rocks	6748	7
	limestone, marble, calcareous sedimentary rocks	26000	27
	limestone, slate, siltstone, argillite	19938	20
	mudstone, siltstone, shale fine clastic sedimentary rocks	1557	2
	quartzite, quartz arenite sedimentary rocks	14521	15
	undivided sedimentary rocks	26877	27
Dune Za Keyih	alkaline volcanic rocks	458	0
	conglomerate, coarse clastic sedimentary rocks	1255	1
	fine clastic sedimentary rocks	12894	5
	limestone, marble, calcareous sedimentary rocks	38646	16
	limestone, slate, siltstone, argillite	60640	24
	mudstone, siltstone, shale fine clastic sedimentary rocks	36001	15
	mudstone/laminite fine clastic sedimentary rocks	8635	3
	quartzite, quartz arenite sedimentary rocks	17885	7
	sandstone, siltstone, shale, conglomerate; minor limestone	20190	8
	undivided sedimentary rocks	151185	61
Finlay-Russel Park	argillite, greywacke, wacke, conglomerate turbidites	9530	8
	granite, alkali feldspar granite intrusive rocks	62	0
	granodioritic intrusive rocks	14165	12
	high level quartz phyric, felsitic intrusive rocks	308	0
	limestone, marble, calcareous sedimentary rocks	8172	7
	limestone, slate, siltstone, argillite	32766	27
	lower amphibolite/kyanite grade metamorphic rocks	988	1
	mudstone, siltstone, shale fine clastic sedimentary rocks	4501	4
	orthogneiss metamorphic rocks	4062	3
	quartz monzonitic intrusive rocks	6576	5
	quartzite, quartz arenite sedimentary rocks	11320	9
	undivided sedimentary rocks	25523	21
	undivided volcanic rocks	4818	4
Graham-Laurier Park	chert, siliceous argillite, siliciclastic rocks	10235	10
	dolomitic carbonate rocks	22150	22
	limestone, marble, calcareous sedimentary rocks	13303	13
	limestone, slate, siltstone, argillite	18955	19
	mudstone, siltstone, shale fine clastic sedimentary rocks	20553	21
	undivided sedimentary rocks	14030	14
	undivided volcanic rocks	43	0

Protected Area	Rock Type	Area (Ha)	Percent
Horneline Creek Park	fine clastic sedimentary rocks	298	100
Kwadacha Wilderness Park	argillite, greywacke, wacke, conglomerate turbidites	4392	3
	chert, siliceous argillite, siliciclastic rocks	1153	1
	coarse clastic sedimentary rocks	2	0
	conglomerate, coarse clastic sedimentary rocks	2325	2
	dolomitic carbonate rocks	2105	2
	limestone bioherm/reef	23	0
	limestone, marble, calcareous sedimentary rocks	10444	8
	limestone, slate, siltstone, argillite	5583	4
	mudstone, siltstone, shale fine clastic sedimentary rocks	24430	19
	mudstone/laminite fine clastic sedimentary rocks	1443	1
	quartzite, quartz arenite sedimentary rocks	8445	6
	undivided sedimentary rocks	69991	54
Liard River Corridor Park	coarse clastic sedimentary rocks	15695	18
	mudstone, siltstone, shale fine clastic sedimentary rocks	72746	82
	mudstone/laminite fine clastic sedimentary rocks	547	1
Liard River Hot Springs Park	coarse clastic sedimentary rocks	465	43
	limestone, marble, calcareous sedimentary rocks	0	0
	mudstone, siltstone, shale fine clastic sedimentary rocks	31	3
	mudstone/laminite fine clastic sedimentary rocks	587	54
Muncho Lake Park	coarse clastic sedimentary rocks	941	1
	conglomerate, coarse clastic sedimentary rocks	7588	9
	dolomitic carbonate rocks	48874	57
	limestone, marble, calcareous sedimentary rocks	12700	15
	limestone, slate, siltstone, argillite	4943	6
	mudstone, siltstone, shale fine clastic sedimentary rocks	4138	5
	undivided sedimentary rocks	6895	8
Northern Rocky Mountains	argillite, greywacke, wacke, conglomerate turbidites	63747	10
	chert, siliceous argillite, siliciclastic rocks	3565	1
	coarse clastic sedimentary rocks	68453	10
	conglomerate, coarse clastic sedimentary rocks	8880	1
	dolomitic carbonate rocks	111216	17
	limestone, marble, calcareous sedimentary rocks	61818	9
	limestone, slate, siltstone, argillite	6041	1
	mudstone, siltstone, shale fine clastic sedimentary rocks	151271	23
	mudstone/laminite fine clastic sedimentary rocks	73943	11
	quartzite, quartz arenite sedimentary rocks	951	0
	sandstone, shale, conglomerate, minor coal	3439	1
	undivided sedimentary rocks	113830	17

Protected Area	Rock Type	Area (Ha)	Percent
Ospika Cones Ecological Reserve	limestone bioherm/reef	62	5
	limestone, slate, siltstone, argillite	505	39
	undivided sedimentary rocks	716	56
Prophet River Hotsprings Park	coarse clastic sedimentary rocks	1	1
	undivided sedimentary rocks	184	99
Redfern-Keily Park	argillite, greywacke, wacke, conglomerate turbidites	499	1
	calcareous siltstone, minor limestone	188	0
	chert, siliceous argillite, siliciclastic rocks	1486	2
	coarse clastic sedimentary rocks	1156	1
	dolomitic carbonate rocks	9230	11
	limestone, marble, calcareous sedimentary rocks	10833	13
	limestone, slate, siltstone, argillite	2366	3
	mudstone, siltstone, shale fine clastic sedimentary rocks	21483	27
	quartzite, quartz arenite sedimentary rocks	144	0
	shale, calcareous sandstone, bedded carbonate	332	0
	undivided sedimentary rocks	33053	41
Sikanni Chief River Ecological Reserve	undivided sedimentary rocks	2176	100
Stone Mountain Park	coarse clastic sedimentary rocks	194	1
	dolomitic carbonate rocks	18834	75
	limestone, marble, calcareous sedimentary rocks	3546	14
	limestone, slate, siltstone, argillite	1376	5
	mudstone, siltstone, shale fine clastic sedimentary rocks	199	1
	mudstone/laminite fine clastic sedimentary rocks	1034	4
Toad River Hotsprings Park	coarse clastic sedimentary rocks	74	18
	limestone, marble, calcareous sedimentary rocks	200	48
	mudstone, siltstone, shale fine clastic sedimentary rocks	140	34

Enduring Features

Mapping of land facets, or Enduring Features (EF), was developed for the Muskwa-Kechika by Jim Pojar and was used for the Muskwa-Kechika Management Area Biodiversity Conservation and Climate Change Assessment (2012). Enduring features map the physical landscape into unique groupings based on topography (elevation, slope and aspect), bedrock and surface geology, macro land forms, and major aquatic elements. The result is hundreds of unique groupings, however, mapping the rarest enduring features (top 10%) and the most diverse (top 10%) collections of enduring features is one way to identify these physiological 'hot spots' on the landbase (Figure 5, Table 7).

The EF is relevant because of the notion that this is the "stage" for expressing biodiversity. The most unique and diverse areas are most likely to have novel expressions of biodiversity. EF is also relevant from a climate change perspective. It is perhaps not surprising that some of the smallest protected

areas, designated for their special features, (e.g., Ospika Cones Ecological Reserve, Prophet River Hot Springs Park, and Toad River Hotsprings Park) contain a significant percent of rare and diverse enduring features.

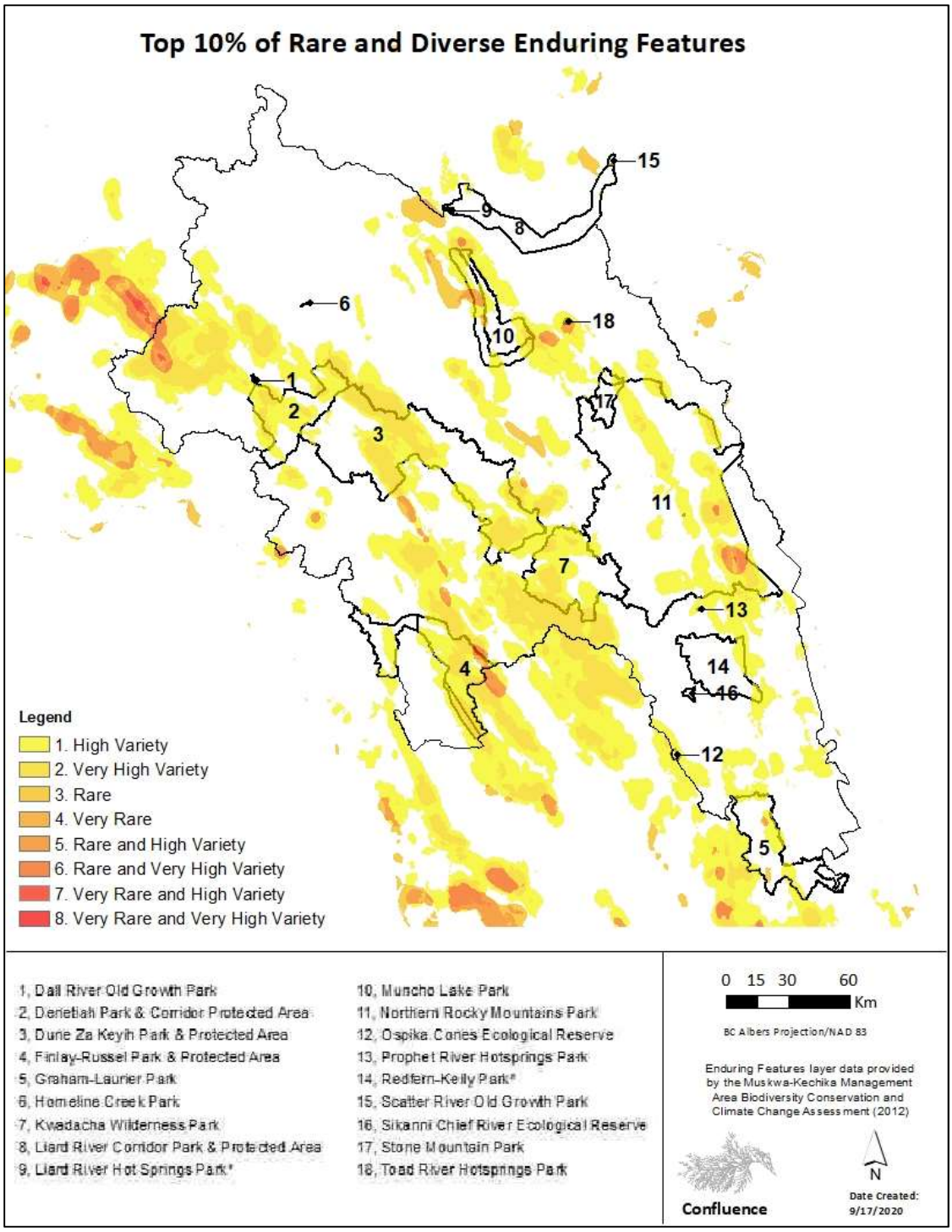


FIGURE 5. TOP RARE AND DIVERSE ENDURING FEATURES WITHIN THE MUSKWA-KECHIKA MANAGEMENT AREA

Table 7. Proportion of top rare and diverse enduring features within each of the M-KMA protected areas

Protected Area	Enduring Feature Rank	Area (Ha)	Percent of Park
Dall River Old Growth Park	Rare	50	8
Denetiah	Rare	49112	50
	Rare and High Variety	17379	18
Dune Za Keyih	Rare	91551	26
	Rare and High Variety	86815	25
Finlay-Russel Park	High Variety	1130	1
	Rare	48355	39
	Very Rare	1666	1
	Rare and High Variety	34406	28
	Very Rare and High Variety	929	1
Graham-Laurier Park	High Variety	2150	2
	Rare	24326	24
	Very Rare	962	1
	Rare and High Variety	115	0
Kwadacha Wilderness Park	Rare	56651	43
	Very Rare	72	0
	Rare and High Variety	29079	22
Liard River Corridor Park	High Variety	412	0
	Very High Variety	37	0
	Rare	1141	1
Liard River Hot Springs Park	Rare	2	0
Muncho Lake Park	High Variety	1633	2
	Rare	25966	30
	Very Rare	3615	4
	Rare and High Variety	7239	8
Northern Rocky Mountains	High Variety	1633	0
	Very High Variety	199	0
	Rare	177145	27
	Very Rare	5899	1
	Rare and High Variety	32420	5
	Very Rare and High Variety	6814	1
	Very Rare and Very High Variety	234	0
Ospika Cones Ecological Reserve	Rare	1194	93
	Rare and High Variety	89	7
Prophet River Hotsprings Park	Rare	144	78
Redfern-Keily Park	Rare	10445	13

Protected Area	Enduring Feature Rank	Area (Ha)	Percent of Park
Scatter River Old Growth Park	High Variety	208	18
Stone Mountain Park	Rare	3499	14
Toad River Hotsprings Park	Rare	204	49
	Very Rare	210	51

Terrestrial Ecosystem Overview

Biogeoclimatic Classification

The M-KMA's protected areas encompass four of the five M-KMA biogeoclimatic (BEC) zones (BWBS, BAFA, ESSF, and SWB (Figure 6, Table 8). The pattern of distribution is driven largely by elevation ranging from cool, wet valley bottoms to well-vegetated alpine tundra. Understanding BEC zone ranges and representation within protected areas can help to identify special features and unique characteristics within existing protected areas, and can be used to identify under-represented ecosystems within the protected area system. Identifying where BEC zones are now can also hint at where they, and the plant and animal species within them, will shift to as climate change continues.

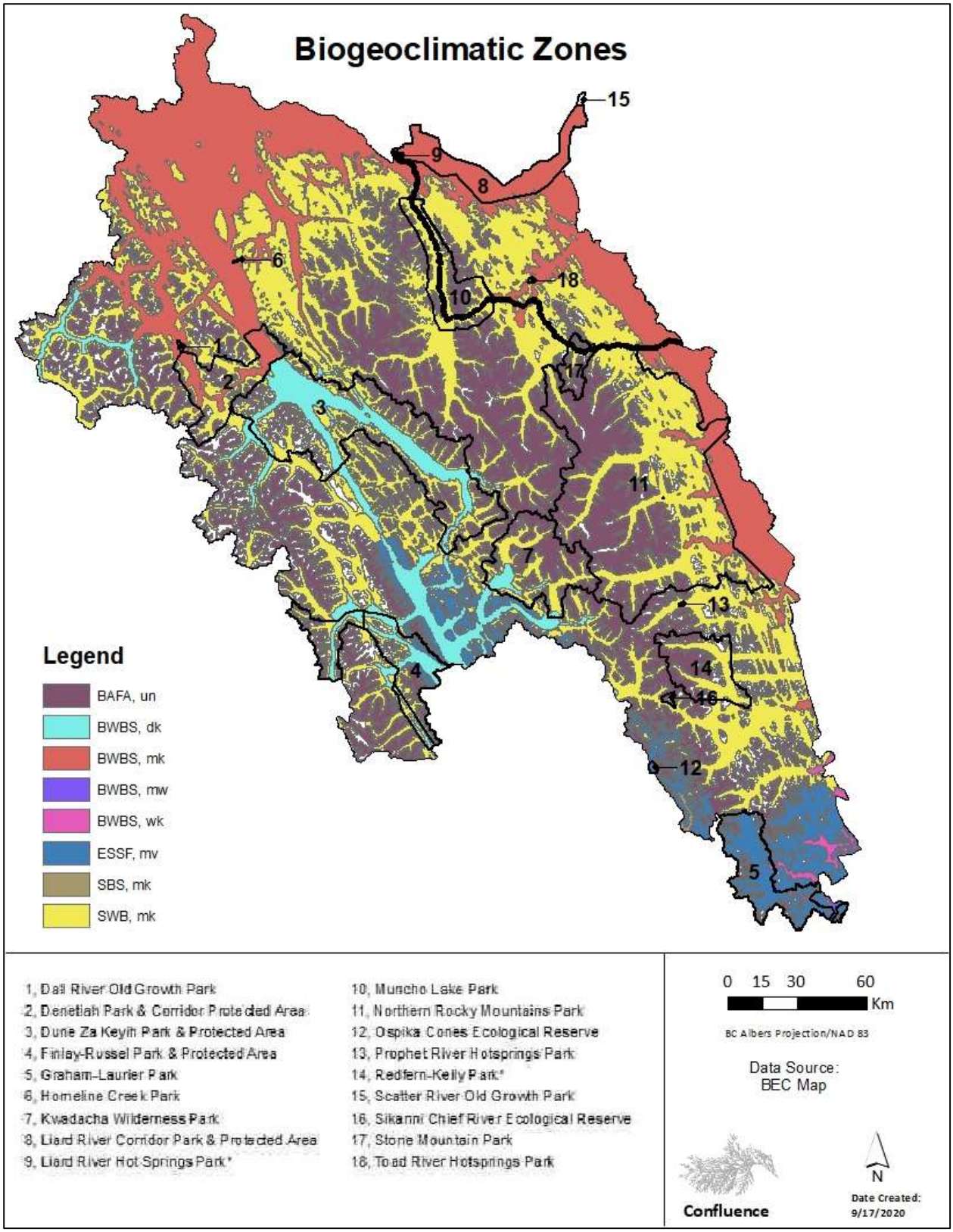


FIGURE 6. BIOGEOCLIMATIC ZONES IN THE MUSKWA-KECHIKA MANAGEMENT AREA

Boreal Altai Fescue Alpine (BAFAun)

The Boreal Altai Fescue Alpine Zone (BAFA) is the coldest, and generally driest, subdivision of Alpine Tundra and lies above the SWB zone in northern British Columbia. These zones occur at high elevations throughout the M-KMA, and experience the harshest climate of any of the biogeoclimatic zones in British Columbia. BAFA zones are characterized by cold temperatures throughout the majority of the year, frequent strong winds, and high precipitation which mostly falls as snow. A thin windblown snowpack is commonly found within BAFA zones although much deeper snowpacks can occur in some areas. Ground freezing and cryoturbation (frost churning) features are also common. The characteristic high elevations and topography of the BAFA biogeoclimatic zone results in a complex mosaic of vegetation and soil types. This is due to the great variability in erosion and/or deposition, soil temperature, moisture, depth of thaw, and exposure to wind. Most of the zonal vegetation found in the Alpine consists of low-growing, evergreen dwarf shrubs. Hence, much of the Boreal Altai Fescue Alpine Zone is well-vegetated with dwarf willows, grasses, lichens and sedges. Dwarf scrubs of prostrate woody plants are some of the most common forms of vegetation in the Alpine Tundra as a whole. They are generally most abundant in the middle elevations of the Alpine zone. Flowered alpine meadows are also common features of these landscapes and they display an array of vascular plants such as various draba species, short-leaved sedge, curved-spiked sedge, fragile sedge, northern paintbrush, diapensia, tundra milk-vetch, northern daisy, Edwards wallflower, rock sandwart, northern sandwart, Arctic sandwart, dotted saxifrage, pale poppy, wedge-leaf primrose, sulphur buttercup, and many wood-rush species. Vibrant herb meadows are also common and can be found at the treeline where soils are deeper, and along alpine rivulets. Dune Za Keyih Park represents over 1% of BC's total protected BAFA area.

Spruce-Willow-Birch (SWB, mk/mks)

The Spruce-Willow-Birch zone (SWB) is the most northerly subalpine zone in British Columbia with the moist cool variant drier and higher than other variants. The Spruce-Willow-Birch zone occupies the middle elevations ranging between 900 and 1500 meters in the north and is usually the subalpine zone found above the Boreal White and Black Spruce Zone (BWBS). White spruce and subalpine fir are the most common species in the zone. Forests on lower slopes and valley bottoms are dominated by white spruce with mixtures of lodgepole pine, black spruce, and trembling aspen. On upper slopes and base rich soils, forests of subalpine fir are common. Open forests and woodlands are found on steep, moist, cold slopes whereas grasslands are found on steep warm-aspects slopes. Balsam popular together with aspen can form the timberline. Alders, scrub birch, and arctic and subalpine willows associate with open canopy stands and form dense thickets in areas with cold-air ponding and in upper elevation scrub/parkland ecosystems.[9] The SWB is well protected provincially (20%) with the mk subzone at 23%.

Sub Boreal Spruce (SBS, mk)

The Sub-Boreal Spruce zone is primarily located in the central interior but stretches up the lower elevation areas along the Williston Reservoir penetrating the M-KMA at the south end. SBS mk represents the Williston Moist Cool variant and is the northern most extent of the SBS zone. The zone consists of thicker coniferous forest with dominant coniferous species are hybrid white spruce, subalpine fir, and occasionally, black spruce, along with lodgepole pine and occasionally Douglas-fir. Underbrush include: lilies, ferns, blueberries, Devil's club, black huckleberry, thimbleberry, highbush-cranberry, Sitka alder, velvet-leaved blueberry, black gooseberry, black twinberry, bunchberry,

[9] https://cfcg.forestry.ubc.ca/resources/cataloguing-in-situ-genetic-resources/swb-zone/

thimbleberry and Queen's Cup. While a number of provincial protected areas contain the SBS zone only 6% in total is protected making it the fourth least protected zone in BC with the MK variants notable with very low (<4%) representation most also reported as being in young forests[10]. This zone is not represented currently within any of the M-KMA protected areas, however, climate change is likely to see current protected M-KMA protected areas represent this BEC zone.

Boreal White and Black Spruce (BWBS, mk and dk1)

The Boreal White and Black Spruce (BWBS) zone is the most widespread zone in Canada, occurring from the Yukon Territory across all the provinces to Newfoundland. It is located below the SWB zone, and sometimes the Engelmann Spruce —Subalpine Fir (ESSF) zone. In northwestern British Columbia, the BWBS zone occurs north of 56° within the valley bottoms and up to 1000-1100 m elevation. The vast majority of the zone occurs above 600 m. Lodgepole pine, black spruce, balsam poplar, tamarack, subalpine fir, common paper birch, and Alaska paper birch are the major tree species in the forested sections of the BWBS. Most of the forests in the BWBS zone are in various successional stages as a result of frequent forest fires. Additionally, most of the forests found within the BWBS can be found in the better-drained plateau, cordilleran, and foothill sections where mixed trembling aspen, and white spruce forests dominate the landscape. White spruce and balsam poplar can reach heights of over 50 m, and productivity can exceed 7 m3/ha per year in the most productive, rich, well drained alluvial sites. On the driest sties, which usually occur on rapidly draining outwash deposits, relatively open pine-lichen forests are common. On poorly drained sites dense black spruce-moss communities often develop. Mixed pine and black spruce stands are also common on level to gently sloping, north-facing sites situated on compacted morainal or lacustrine soils. Generally, the BWBS across most variants, particularly in those areas with older forests is poorly represented provincially however the dk1 variant contained within the M-KMA has approximately 25% protected provincially.

Engelmann Spruce Subalpine Fir (ESSF, mv/mvp)

The ESSF zone with its subboreal climate covers approximately 15% of the province but just reaches into the southern ends of the M-KMA. In the north, it is the most continental and grades into the SWB zone. Englemann spruce and subalpine fir are dominant species throughout forested portions of the zone. In old growth stands at low to mid-elevations, Englemann spruce usually dominates the canopy and subalpine fir the understory. In higher elevation forests, wetter areas and parkland ecosytems, subalpine fir is the dominant species. Across the province, protected areas coverage of the ESSF zone is high, however, only four of the M-KMA protected areas in southern reaches (Finlay-Russel, Graham-Laurier, Kwadacha and Ospika Cones) include ESSF with Graham-Laurier representing the majority.

[10] https://cfcg.forestry.ubc.ca/resources/cataloguing-in-situ-genetic-resources/sbs-zone/

Table 8. Biogeoclimatic representation within each of the Muskwa-Kechika Protected Areas

Park Name/Type	Biogeoclimatic Zone	Total area of BEC provincially (ha)	Percent of BEC protected provincially	Area of this BEC in this protected area (ha)	Percent of BEC contributed by this protected area
Dall River Old Growth Park	BWBS	16028875	8.4	644	0.0
Denetiah Corridor Protected Area	BWBS	16028875	8.4	7445	0.0
Denetiah Park	BAFA	6277470	29.3	17298	0.3
	BWBS	16028875	8.36	27004	0.2
	SWB	8569101	8.4	27004	0.2
Dune Za Keyih Park [A.K.A. Frog-Gataga Park]	BAFA	6277470	23.0	46161	0.5
	BWBS	16028875	29.3	69883	1.1
	SWB	8569101	23	152609	1.7
Dune Za Keyih Protected Area	BAFA	6277470	8.4	109239	0.7
	BWBS	16028875	23.0	152609	1.8
	SWB	8569101	29.3	360	0.0
Finlay-Russel Protected Area	BAFA	6277470	29.3	358	0.0
	BWBS	16028875	8.4	7872	0.0
	SWB	8569101	23.0	7826	0.1
Finlay-Russel Park	BAFA	6277470	29.3	358.34	0.0
	BWBS	16028875	8.36	27242	0.2
	ESSF	17630433	8.4	7347	0.0
	SWB	8569101	23.0	5858	0.1
Graham-Laurier Park	BAFA	6277470	29.3	25531	0.4
	BWBS	16028875	8.36	4319	.0
	ESSF	17630433	8.4	27242	0.2
	SWB	8569101	17.1	8819	0.1
Horneline Creek Park	BWBS	16028875	23.0	47635	0.6
Kwadacha Wilderness Park	BAFA	6277470	29.3	15460	0.2
	BWBS	16028875	8.4	11962	.07
	ESSF	17630433	8.4	4319	0.0
	SWB	8569101	17.1	79459	0.4
Liard River Corridor Park	BWBS	16028875	23.0	27	0.0
	SWB	8569101	8.4	298	0.0
Liard River Hotsprings Park	BWBS	16028875	29.3	57108	0.9

Park Name/Type	Biogeoclimatic Zone	Total area of BEC provincially (ha)	Percent of BEC protected provincially	Area of this BEC in this protected area (ha)	Percent of BEC contributed by this protected area
Muncho Lake Park	BAFA	6277470	29.3	2115	.334
	BWBS	16028875	8.4	11962	0.1
	SWB	8569101	17.1	17	0.0
Northern Rocky Mountains Park	BAFA	6277470	23.0	61250	0.7
	BWBS	16028875	8.4	88570	0.5
	SWB	8569101	23.0	418	0.0
Ospika Cones Ecological Reserve	BAFA	6277470	8.4	1082	0.0
	ESSF	17630433	29.3	2115	0.3
	SWB	8569101	23	66	.00
Prophet River Hotsprings Park	SWB	8569101	8.4	1105	0.0
Redfern-Keily Park	BAFA	6277470	23.0	63825	0.7
	SWB	8569101	29.3	254754	4.0
Scatter River Old Growth Park	BWBS	16028875	8.4	42930	0.3
Sikanni Chief Ecological Reserve	BAFA	6277470	23.0	369461	4.3
	SWB	8569101	29.3	377	0.0
Stone Mountain Park	BAFA	6277470	29.3	14007	0.2
	SWB	8569101	17.1	840	0.0
Toad River Hotsprings Park	BWBS	16028875	23.0	66	0.0
	SWB	8569101	23.0	185	0.0

Broad Ecosystem Inventory

The broad ecosystem inventory (BEI) inventory is mapped data at a 1:250,000 scale derived from imagery and in contrast to biogeoclimatic zones it provides a view of ecosystem types more useful for understanding wildlife use. In the M-KMA, it demonstrates the diversity possible in highly variable topography (Figure 7). High elevation environments provide alpine and subalpine grasslands, meadows, and tundra habitats intermingled. In contrast, spruce forests (black and white) dominate the low elevation valley bottoms and eastern Rocky Mountain foothills.

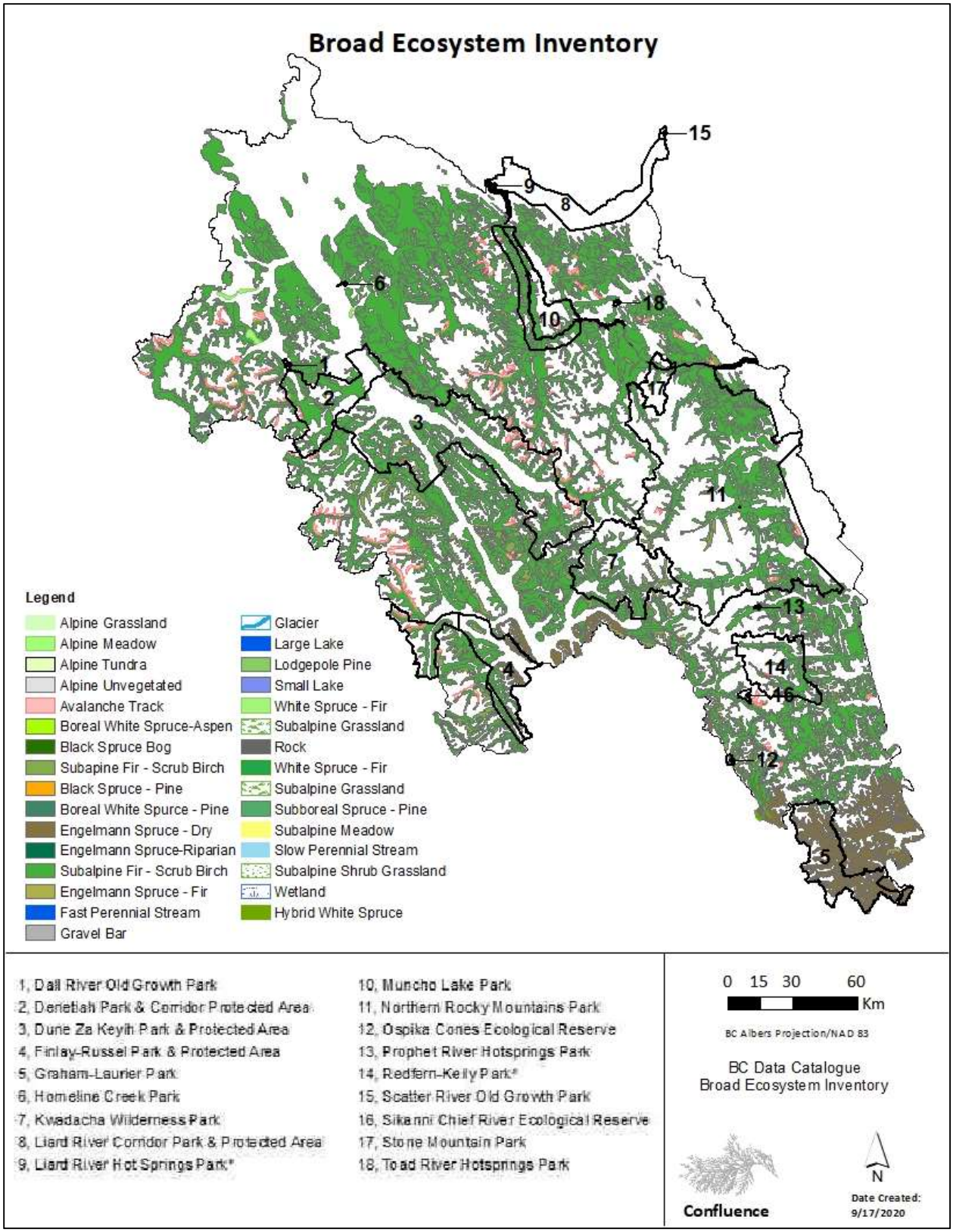


FIGURE 7. BROAD ECOSYSTEM INVENTORY OF THE MUSKWA-KECHIKA MANAGEMENT AREA

Ecosystems at Risk

There are no mapped ecosystems at risk within the provincial parks and protected areas of the M-KMA. Those few ecosystems at risk that have been identified within the M-KMA exist near the Alaska Highway, an area more easily accessed and thus likely to be observed. The BC Conservation Data Centre records possible ecological communities at risk within the areas based on probably distributions (Table 9).

Table 9. Possible ecological communities at risk within the M-KMA protected areas based on projected distribution*

Scientific Name	English Name	Global Status	BC List
Populus balsamifera - Picea glauca / Alnus incana - Cornus sericea	balsam poplar - white spruce / mountain alder - red-osier dogwood	GNR	Blue
Picea mariana / Vaccinium vitis-idaea / Sphagnum spp.	black spruce / lingonberry / peat-mosses	GNR	Blue
Typha latifolia Marsh	common cattail Marsh	G5	Blue
Eleocharis palustris Herbaceous Vegetation	common spike-rush Herbaceous Vegetation	GNR	Blue
Poa glauca ssp. rupicola Herbaceous Vegetation	glaucous bluegrass Herbaceous Vegetation	GNR	Blue
Schoenoplectus acutus Deep Marsh	hard-stemmed bulrush Deep Marsh	G5	Blue
Trichophorum alpinum / Scorpidium revolvens	Hudson Bay club rush / rusty hook-moss	G2	Red
Pinus contorta / Vaccinium membranaceum / Cladina spp.	lodgepole pine / black huckleberry / reindeer lichens	G3	Blue
Pinus contorta / Carex pauciflora / Sphagnum spp.	lodgepole pine / few-flowered sedge / peat-mosses	G2G3	Blue
Alnus incana / Equisetum arvense	mountain alder / common horsetail	G3	Blue
Alnus incana / Cornus sericea / Athyrium filix-femina	mountain alder / red-osier dogwood / lady fern	G3G4	Blue
Salix exigua Shrubland	narrow-leaf willow Shrubland	G5	Red
Eriophorum angustifolium - Carex limosa	narrow-leaved cotton-grass - shore sedge	G3	Blue
Salix lasiandra var. lasiandra / Cornus sericea / Equisetum spp.	Pacific willow / red-osier dogwood / horsetails	G2	Red
Calamagrostis purpurascens Herbaceous Vegetation	purple reed grass Herbaceous Vegetation	G2	Red
Betula nana / Carex aquatilis	scrub birch / water sedge	G4	Blue
Carex limosa - Menyanthes trifoliata / Drepanocladus spp.	shore sedge - buckbean / hook-mosses	G3	Blue
Carex lasiocarpa / Drepanocladus aduncus	slender sedge / common hook-moss	G3	Blue

Scientific Name	English Name	Global Status	BC List
Abies lasiocarpa / Alnus spp. / Equisetum spp.	subalpine fir / alders / horsetails	GNR	Blue
Equisetum fluviatile - Carex utriculata	swamp horsetail - beaked sedge	G4	Blue
Larix laricina / Betula nana / Menyanthes trifoliata	tamarack / scrub birch / buckbean	GNR	Blue
Larix laricina / Carex aquatilis / Tomentypnum nitens	tamarack / water sedge / golden fuzzy fen moss	GNR	Blue
Trichophorum cespitosum / Campylium stellatum	tufted clubrush / golden star-moss	G2G3	Blue
Picea glauca - Picea mariana / Rhododendron groenlandicum / Aulacomnium palustre	white spruce - black spruce / Labrador-tea / glow moss	GNR	Blue
Picea glauca / Gymnocarpium dryopteris - Aralia nudicaulis	white spruce / oak fern - wild sarsaparilla	G3	Blue
Picea glauca / Ribes triste / Equisetum spp.	white spruce / red swamp currant / horsetails	G4	Blue
Picea glauca / Ribes triste / Mertensia paniculata	white spruce / red swamp currant / tall bluebells	G3	Blue
Picea glauca - Abies lasiocarpa / Vaccinium membranaceum / Pleurozium schreberi	white spruce - subalpine fir / black huckleberry / red-stemmed feathermoss	GNR	Blue

*BC CDC. Species and Ecosystems Explorer (August 2020)

Aquatic Ecosystem Overview

Major Watersheds

The M-KMA includes portions of twenty-four major watersheds (Table 10). Northern Rockies, Redfern-Keily, Kwadacha, Denetiah, Dune Za Keyih, Finlay-Russel, and Graham-Laurier protect significant portions of these watersheds.

Table 10. Protected Areas by Major Watershed

Protected Area	Major Watershed	Area within PA	Area of Watershed	% Watershed Protected in PA
Dall River Old Growth Park	Turnagain River	643.9	709817	0.1
Denetiah	Coal River	4.0	494131	0.0
	Frog River	143.3	488214	0.0
	Pitman River	37.6	271251	0.0
	Turnagain River	26641.6	709817	3.8
	Upper Kechika River	71081.6	324469	21.9
Dune Za Keyih	Coal River	5.3	494131	0.0
	Fox River	36.1	429197	0.0
	Frog River	112827.0	488214	23.1
	Gataga River	219147.3	469397	46.7
	Toad River	87.8	730936	0.0
	Upper Kechika River	15685.4	324469	4.8
Finlay-Russel Park	Chukachida River	221.0	126381	0.2
	Finlay River	183.4	548542	0.0
	Firesteel River	1334.7	438575	0.3
	Fox River	13.5	429197	0.0
	Ingenika River	15753.7	532916	3.0
	Toodoggone River	105285.0	485996	21.7
Graham-Laurier Park	Lower Halfway River	99399.1	556803	17.9
	Ospika River	81.6	298038	0.0
	Peace Arm	55.2	589246	0.0
	Upper Halfway River	21.6	378252	0.0
Horneline Creek Park	Upper Kechika River	298.2	324469	0.1
Kwadacha Wilderness Park	Fox River	104762.2	429197	24.4
	Gataga River	30.2	469397	0.0
	Middle Muskwa River	502.8	424645	0.1
	Upper Muskwa River	25040.0	425022	5.9
Liard River Corridor Park	Beaver River	21862.7	613326	3.6
	Dunedin River	9.9	571206	0.0
	Liard River	64526.5	764094	8.4
	Toad River	2589.7	730936	0.4

Protected Area	Major Watershed	Area within PA	Area of Watershed	% Watershed Protected in PA
Liard River Hot Springs Park	Liard River	1082.4	764094	0.1
Muncho Lake Park	Liard River	47815.6	764094	6.3
	Toad River	38263.9	730936	5.2
Northern Rocky Mountains	Fox River	118.7	429197	0.0
	Gataga River	18.0	469397	0.0
	Middle Muskwa River	329812.0	424645	77.7
	Toad River	37704.8	730936	5.2
	Upper Muskwa River	284250.2	425022	66.9
	Upper Prophet River	15243.4	411958	3.7
Ospika Cones Ecological Reserve	Ospika River	1283.3	298038	0.4
Prophet River Hotsprings Park	Upper Prophet River	184.6	411958	0.0
Redfern-Keily Park	Finlay River	192.9	548542	0.0
	Upper Prophet River	75872.8	411958	18.4
	Upper Sikanni Chief River	4705.0	641437	0.7
Scatter River Old Growth Park	Beaver River	1177.5	613326	0.2
Sikanni Chief River Ecological Reserve	Finlay River	9.1	548542	0.0
	Upper Sikanni Chief River	2167.2	641437	0.3
Stone Mountain Park	Dunedin River	6.3	571206	0.0
	Middle Muskwa River	4451.9	424645	1.1
	Toad River	20722.6	730936	2.8
Toad River Hotsprings Park	Toad River	413.7	730936	0.1

Rivers

Named after two of the major rivers that originate in the area, the Muskwa and the Kechika, the M-KMA sits in the Arctic drainage and contains waterways that flow into the two major drainages, the Liard and Peace Rivers (Figure 8, Table 11). Rivers like the Graham, Besa, Kwadacha, Muskwa, Tuchodi, Gataga, Dall and a number of their tributaries have their headwaters in the M-KMA protected areas. These headwaters represent critical sections of rivers moderating temperature and flow, driving functional connectivity across the landscape, and serving as a source for spawning and rearing (Weaver, 2019). Other rivers have significant sections of the river either by size (e.g., Toad, Frog, Finlay, and Trout Rivers) or by feature (e.g., the Grand Canyon of the Liard, Liard River Corridor Park) within the protected areas.

Table 11. Major rivers of the Muskwa-Kechika protected areas	
Protected Area	**Major Rivers**
Dall River Old Growth Park	Dall River
Denetiah	Kechika River
Dune Za Keyih	Gataga River Kechika River Frog River
Finlay Russel Park	Finlay River Toodoggone River
Graham-Laurier Park	Graham River
Kwadacha Wilderness Park	Kwadacha River Muskwa River
Liard River Corridor Park	Liard River Toad River
Liard River Hot Springs Park	Liard River
Muncho Lake Park	Trout River Toad River
Northern Rocky Mountains	Muskwa River Tuchodi River Gathto Creek Wokkpash Creek Tetsa River Chiska River
Ospika Cones Ecological Reserve	Ospika River
Prophet River Hotsprings Park	Prophet River
Redfern-Keily Park	Keily Creek Besa River
Scatter River Old Growth Park	Liard River Scatter River
Stone Mountain Park	North Testsa
Toad River Hotsprings Park	Toad

The rivers and riparian corridors that traverse the M-KMA are important functionally as corridors of connectivity. Large, gravel bed rivers in particular have broad floodplains with complexes of riparian habitat and wetland areas that provide extraordinarily high levels of plant diversity and allow for wildlife movement and migration. Recent research (Hauer et al., 2016) demonstrate that the broad u-shaped river valleys characteristic of glaciated mountain landscapes are "interconnected *longitudinally* downstream, *laterally* from the river channel across the floodplain, and *vertically* from the river channel into the aquifer below" (Weaver, 2019). Weaver (2019) adapted an approach to rank 20 river valleys as

climate-corridors for adaptation to warming climate using a River Corridor Index (RCI) where High = 50-100; Moderate = 30-49; Low = 0-29 (Krosby et al., 2018). Of those rivers located in significant part in the M-K protected areas, three of the four rivers (Gataga, Muskwa and Toad) with the highest RCI scores as climate corridors are significantly within protected areas. An additional 10 of the 20 ranked rivers in protected areas received moderate to lower scores. The benchmark river, the Gataga contained largely within Dune Za Keyih Park and Protected Area epitomizes these broad U-shaped valleys and the protected area spans the low level valley bottom and up to the height of land on either side capturing the full range of connectivity.

As temperatures warm, headwater areas will provide critical, cooler microrefugia to support populations of species as well as macro-refugia for forests and songbirds (Carroll et al., 2017; Stralberg et al., 2018). Cool headwater refugia mapping conducted by Weaver (2019, p. 73) for the M-KMA identified that almost all of the M-KMA protected areas contained these cool headwater refugia that will help moderate the effects of climate change on the area.

These rivers provide movement corridors not just for energy and nutrients but also are important movement corridors for wildlife many of which traverse the mountainous terrain paralleling the rivers. In addition, rivers provide a major access route for humans whether it is horse packing trips that follow the relatively low elevation corridors alongside these rivers, jetboats who deliver anglers, and hunters into the interior of the M-KMA, or paddlers who voyage down these wild waterways such as the Gataga and Liard. Kaska Dena note that large rivers link Kaska values across ancestral territory and "are places for trails, hunting and fishing places, gathering areas, sacred areas, grave sites, and communities" (Dena Kayeh Institute, 2019).

Lakes and Wetlands

Lakes and wetlands are key to safeguarding biodiversity, providing important habitats and driving critical ecological functions. Although larger lakes (>250 ha) are relatively uncommon in the northern rockies, Denetiah, Dune Za Keyih, Kwadacha, Muncho Lake, Northern Rocky Mountains and Redfern-Keily parks and protected areas contain 12 large lakes (Table 11). Muncho Lake at over 1530 ha is the largest of these. Medium-sized lakes are more abundant (46 lakes between 25-250 ha) averaging about 50 ha in size. Only a handful of these lakes are named and most that are names that refer to groups of associated lakes (e.g., Blizzard Lakes, Gataga Lakes). Wetlands and small lakes (<25 ha) that are typically adjacent to wetlands abound numbering in the thousands (Table 12)

The Kaska Dena identified a number of key lakes and wetland areas that have critical conservation value that may be important for gathering, hunting or spiritual and cultural value (Dena Kayeh Institute, 2019). Of these, Rainbow Lake in Finlay-Russel Provincial Park/Protected Area is contained within a protected area. Other lakes may also be of exceptional cultural importance but as lake names are often unrecorded, or are recorded using different place names further consultation is needed (e.g., Dena Kayeh lists Fish Lake while the BC Data Catalogue identifies Fishing Lakes in Finlay-Russel Provincial Park/Protected Area).

Table 11. Large lakes in the protected areas

Protected Area	Large Lakes
Dall River Old Growth Park	
Denetiah	Dall Lake Denetiah Lake
Dune Za Keyih	South Gataga Lakes
Finlay Russel Park	
Kwadacha Wilderness Park	Haworth Lake Quentin Lake
Liard River Corridor Park	Chesterfield Lake
Muncho Lake Park	Muncho Lake
Northern Rocky Mountains	Tuchodi Lakes Wokkpash Lakes
Redfern-Keily Park	Redfern Lake Trimble Lake

Table 12. Area and representation of waterbodies in protected areas in the M-KMA

Water Body	Number	Area (ha)	% in Protected Area
Large Lakes	12	7747	62.95%
Medium Lakes	46	2924	27.28%
Small Lakes	2688	2857	19.43%
Wetlands	2318	13,358	17.20%

Wetland density is highest in the northern parts of the M-KMA outside of protected areas, however, of the larger protected areas, Liard River Corridor, Dune Za Keyih, Finlay-Russel, and Redfern-Keily protected areas have more than 1% of their total area in wetland (Figure 8 and Table 13). The Kaska Dena note the importance specifically of wetland complexes representing “two or more wetlands including vegetation cumulatively greater than 5 h”. (Dena Kayeh Institute, 2019). While all wetlands have importance ecologically and culturally, these wetland complexes are likely to have a higher density of traditional and sustenance use surrounding them given their ecological importance. Almost all of the M-KMA protected areas contain wetlands that meet these criteria with Dune Za Keyih, Liard River Corridor, Finlay-Russel and Graham-Laurier perhaps the most prominent.

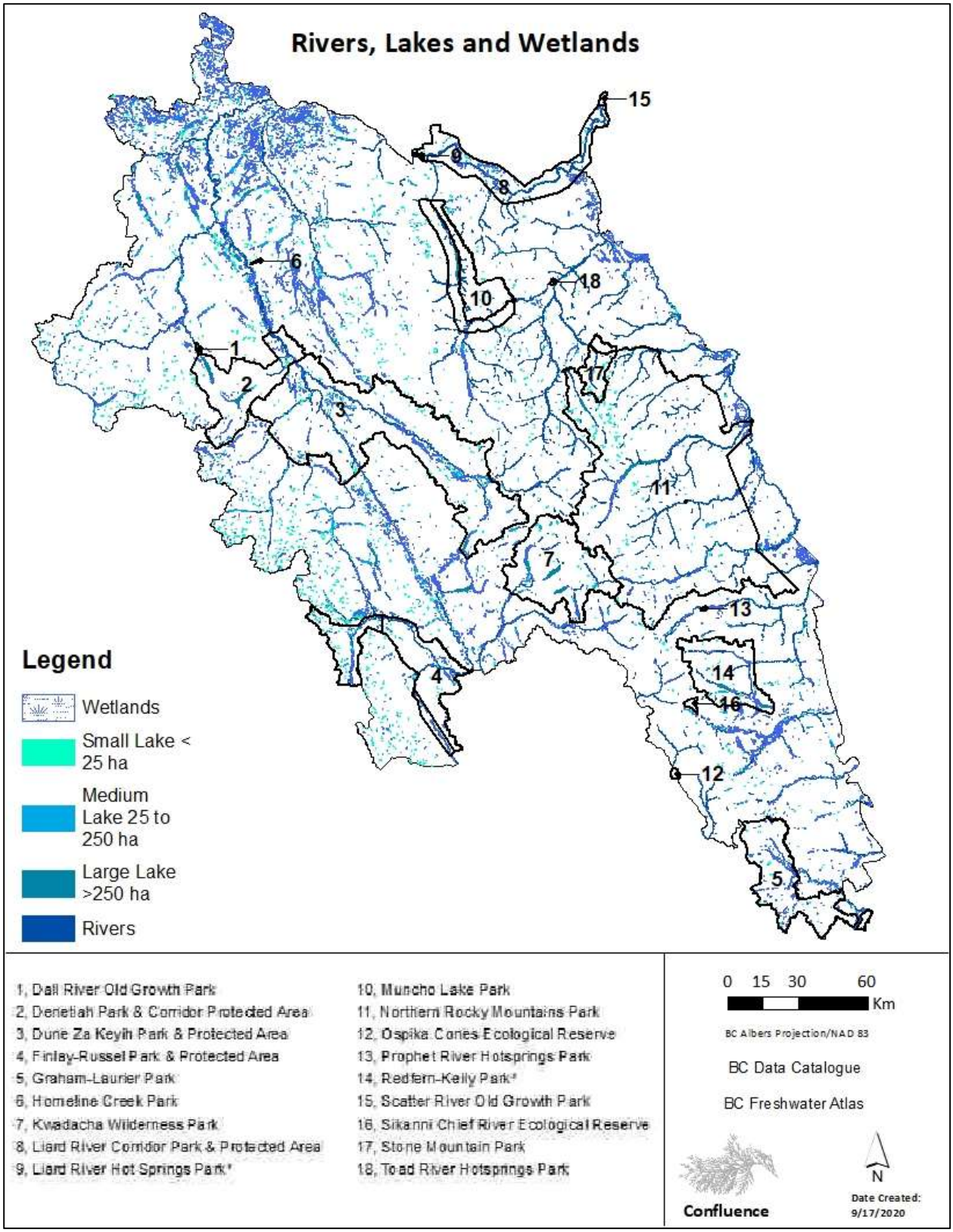


FIGURE 8. RIVERS, LAKES AND WETLANDS IN THE M-KMA

Table 13. Area of wetlands by M-KMA protected area			
Protected Area	**Number**	**Area (ha)**	**% of Protected Area**
Dall River Old Growth Park	3	127.06	19.73
Denetiah	112	775.93	0.79
Dune Za Keyih	569	3599.33	1.03
Finlay-Russel Park	285	1456.62	1.19
Graham-Laurier Park	398	1028.10	1.03
Kwadacha Wilderness Park	148	632.26	0.49
Liard River Corridor Park	237	1697.18	1.91
Liard River Hot Springs Park	6	8.94	0.83
Muncho Lake Park	43	213.69	0.25
Northern Rocky Mountains	383	2946.29	0.44
Ospika Cones Ecological Reserve	1	4.41	0.34
Prophet River Hotsprings Park	2	25.30	13.68
Redfern-Keily Park	125	828.00	1.03
Stone Mountain Park	6	15.11	0.06

Fish and Wildlife Overview

Fish

The waterways of the M-KMA protected areas have varied distribution of freshwater and anadromous fish. Species include Arctic Grayling (*Thymallus arcticus*), Bull Trout (*Salvelinus confluentus*) (blue-listed; COSEWIC special concern), Burbot (*Lota lota*), Chum Salmon (*Oncorhynchus keta*), Flathead Chub (*Platygobio gracilis*), Inconnu (*Stenodus nelma*), Lake Trout (*Salvelinus namaycush*), Lake Whitefish (*Coregonus clupeaformis*), Longnose Dace (*Rhinichths cataractae*), Longnose Sucker (*Catostomus catostomus*), Mountain Whitefish (*Prosopium williamsoni*), Northern Pike (*Esox luxius*), Rainbow Trout (*Oncorhynchus mykiss*), Slimy Sculpin (*Cottus cognatus*), Spoonhead Sculpin (*Cottus ricei*), Lake Chub *(Cousius plumbeus*) and White Sucker (*Catostomus commersonii*).

Information on species at risk is limited as a result of limited inventory in the region. The BC Species and Ecosystems Explorer identified 10 fish species/populations that may be within the region (Appendix 4). Provincial Red-listed species are those that are at risk (extirpated, endangered or threatened) and Blue-listed are species of special concern.

Records for species presence in all of the rivers and lakes of the M-KMA protected areas are not complete. Primary sources include M-KMA PPA Purpose Statements or draft management plan, Historical Fisheries Information from the Muskwa-Kechika Management Area (Woods & Branch, 2000 and 2001), and other fisheries research available on the M-KMA website[11]. Available data is summarized in Table 14.

[11] https://www.muskwa-kechika.com/resource-library/m-kma-research

Table 14. Species recorded in lakes and rivers of M-KMA protected areas.																			
Protected Area	**Watercourse**	**Arctic Grayling**	**Bull Trout**	**Burbot**	**Chum Salmon**	**Flathead Chub**	**Inconnu**	**Lake Trout**	**Lake Whitefish**	**Lake Chub**	**Longnose Dace**	**Longnose Sucker**	**Mountain Whitefish**	**Northern Pike**	**Rainbow Trout**	**Sculpin**	**White Sucker**	**Dolly Varden**	**Pygmy Whitefish**
Dall River Old Growth Park	Unspecified	x							x					x	x			x	
Denetiah	Dall Lake	x	x					x	x			x				x			
	Denetiah Lake											x	x		x	x			
	Unspecified		x						x									x	
Dune Za Keyih	Gataga Lakes	x																	
	Gataga River	x	x																
Finlay Russel Park	Finlay River	x	x																
Graham-Laurier Park	Emmerslund Creek									x						x			
	Graham River		x													x			
	Lady Laurier Lake	x																	
	Needham Creek		x												x				
	Unspecified	x								x		x			x	x	x		
Kwadacha Wilderness Park	Muskwa River	x	x	x	x								x						
	Kwadacha River	x	x	x			x		x			x	x		x	x	x		x
	Quentin Lake																		x

Protected Area	Watercourse	Arctic Grayling	Bull Trout	Burbot	Chum Salmon	Flathead Chub	Inconnu	Lake Trout	Lake Whitefish	Lake Chub	Longnose Dace	Longnose Sucker	Mountain Whitefish	Northern Pike	Rainbow Trout	Sculpin	White Sucker	Dolly Varden	Pygmy Whitefish
Liard River Corridor Park	Trout River	x	x										x			x			
	Deer River	x	x										x			x			
	Canyon Creek	x	x									x	x			x			
	Liard River	x	x		x		x		x	x	x	x	x	x					
	Moule Creek	x	x									x	x						
	Brimstone Creek	x										x	x				x		
	Scatter River	x	x																
Liard River Hot Springs Park										x									
Muncho Lake Park	Muncho Lake	x	x	x				x				x	x	x	x		x	x	
	Trout River	x																x	
	Toad River	X																x	
Northern Rocky Mountains	Gathto River	x	x										x			x			
	Grizzly Lake	x													?				
	Kluachesi Lake	x	x	x								x					x		
	Kluachesi River	x	x										x			x			
	Muskwa River	x	x										x		x	x			
	Tetsa Lake							x											
	North Tetsa River	x	x										x	x		x			

Protected Area	Watercourse	Arctic Grayling	Bull Trout	Burbot	Chum Salmon	Flathead Chub	Inconnu	Lake Trout	Lake Whitefish	Lake Chub	Longnose Dace	Longnose Sucker	Mountain Whitefish	Northern Pike	Rainbow Trout	Sculpin	White Sucker	Dolly Varden	Pygmy Whitefish
	Tuchodi Lakes		x	x				x	x	x		x	x			x			
	Tuchodi River	x										x	x			x			
	Wokkpash Lake		x																
	Wokkpash River		x													x			
Ospika Cones Ecological Reserve								*No records*											
Prophet River Hotsprings Park								*No records*											
Redfern-Keily Park	Redfern Lake	x						x	x				x						
	Trimble Lake	x													x				
	Fairy Lake														x				
Scatter River Old Growth Park					x		x												
Stone Mountain Park	Summit Lake							x	x			x	x		x				
	MacDonald Creek	x	x																
Toad River Hotsprings Park	Toad River	x	x										x						

Wildlife

The enormous size, intact functioning ecosystems, low levels of human use, and limited habitat fragmentation mean that the Muskwa-Kechika Management Area supports the largest intact predator-prey system within North America. The varied habitat provided by the complexity of wetland areas, mineral licks, gravel-bed rivers, mountain ranges, and diverse forests and alpine areas provide habitat for ungulates including: Caribou (*Rangifer tarandus*, blue-listed, northern mountain populations); COSEWIC special concern), Elk *(Cervus canadensis)*, Stone Sheep (Blue-listed), Mountain Goat (*Oreamnos americanus)*, Moose (*Alces alces)*, Bison (*Bison bison bison* and *Bison bison athabascae, red-listed)*, and Mule (*Odocoileus Hemionus*) and White-tailed (*Odocoileus virginianus*) Deer. Grizzly (*Ursus arctos horribilis, red-listed*) and American Black (*Ursus americanus*) bear, Grey Wolves (*Canis lupus*), Fisher (*Pekania pennanti*, blue-listed Boreal population and red-listed Columbian population), Lynx (*Lynx canadensis*), Wolverine (*Gulo gulo luscus*, blue-listed; COSEWIC special concern), Martin (*Martes Americana*), Cougar (*Puma concolor*), along with other fur bearers.

The M-KMA is also home to numerous nesting and migrating bird species. The Rocky Mountain Trench, Denetiah and Dune Za Keyih protected areas in particular, contain important migration corridor for many birds, particularly waterfowl such as Western Grebe (*Aechmorphorus occidentalis,* red-listed*)* and Surf scoter *(Melanitta perspicillata,* blue-listed) for both staging and resting areas. Ridges along the Rocky Mountains (e.g., Northern Rockies, Stone Mountain, and Muncho Lake protected areas) are important migration corridors for raptors including the Swainson's Hawk *(Buteo swainsoni, red-listed)*, Rough-legged Hawk (*Buteo lagopus)*, and Golden Eagle (*Aquila chrysaetos).* The rich riparian forests and upslope forests provide diverse habitat for nesting species such as Winter wren (*Troglodytes troglodytes hiemalis, blue-listed)*, Canada (*Cardellina canadensis*, blue-listed) and Cape May (*Setophaga tigrina*, blue-listed) warblers.

Focal Species Wildlife Habitat

Species whose conservation status is listed as either Yellow (least risk), Blue (special concern), or Red (endangered) may be of particular concern for protected areas management. Among them are caribou, mountain goat, stone's sheep, grizzly bear, fisher, elk, and moose. These species are of priority because they might be keystone and/or umbrella[12] species (grizzly bear), genetically distinct (stone's sheep), or endangered (caribou).

High value habitat has been identified for a number of these species, including fisher (www.bcfisherhabitat.ca), caribou, mountain goats, stone's sheep, grizzly bear, elk, and moose (Suzuki & Parker, 2019; Heinemeyer, 2004). Fisher habitat is designated by Type 1 or Type 2, while the other species listed above typically have their habitat values described as either High, Medium, or Low.

Fisher

The fisher, *Pekania pennant (aka Martes pennant),* is a mid-level carnivore that includes both a Red-listed population (Columbia) and a Blue-listed population (Boreal) in British Columbia. It has a preference for low elevation riparian forests. In the M-KMA, the fisher is typically found in low

[12] Keystone species play a direct and significant role in prevalence and population levels of other species within their ecosystem. In contrast, umbrella species play an indirect role but typically have habitat requirements that encompass a number of other species.

elevations and along the eastern edge of the M-KMA, predominantly in the north and along the eastern edge of the M-KMA as well as the Rocky Mountain Trench bisecting Dune Za Kayih and Denetiah protected areas. Fisher habitat is classified as Type 1 habitat composed of forested stands which support 75% of the animals' activity (denning, foraging, and movement); and Type 2 forest stands that do not meet as many activity needs as Type 1, but are still important to survival and reproduction (Figure 9, Table 15).

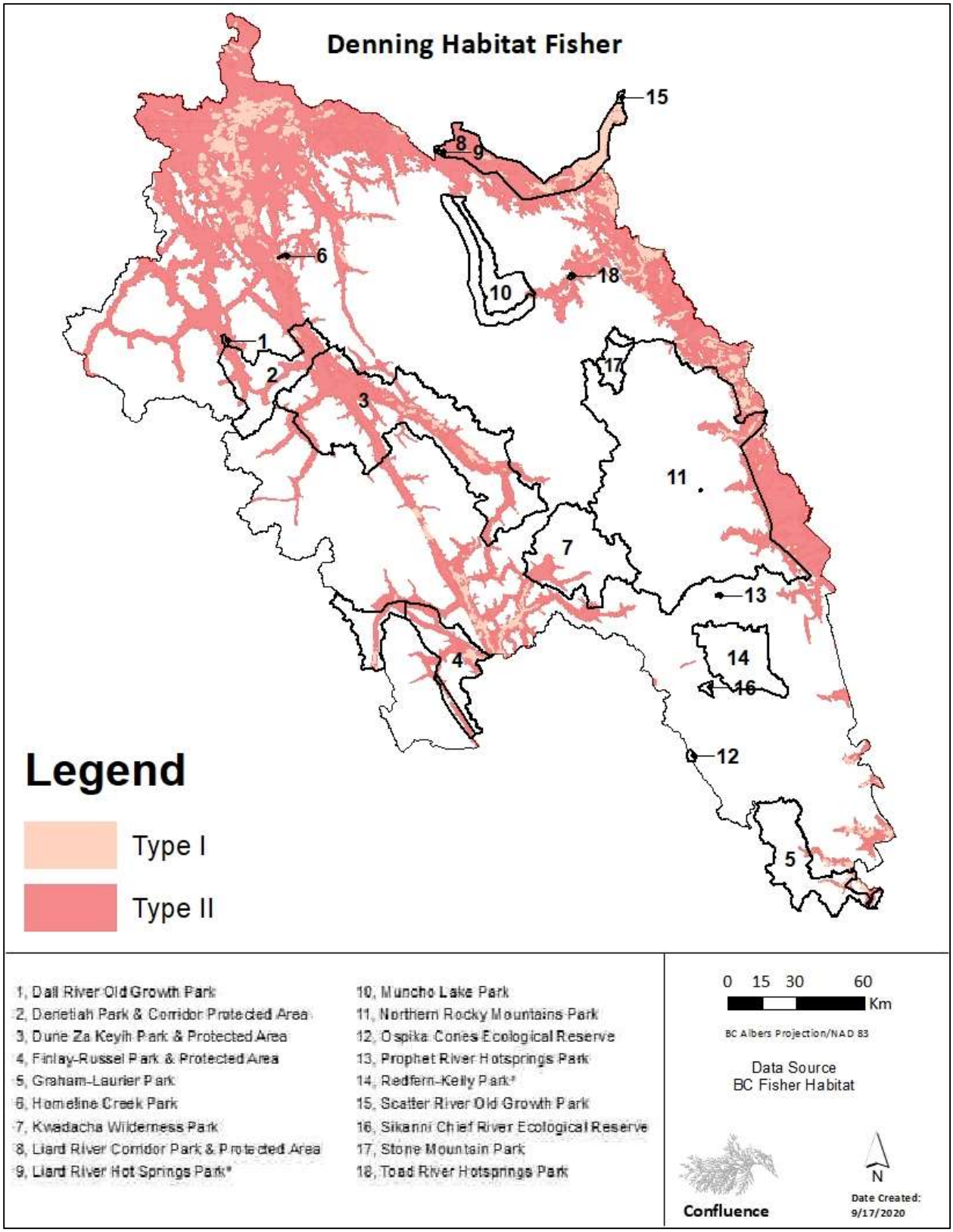


FIGURE 9. DENNING HABITAT FOR BOREAL FISHERS

Table 15. Protected areas with fisher habitat			
Protected Area*	Habitat Type	Area (Ha)	Percent of PA
Dall River Old Growth Park	Type II	644	100
Denetiah	Type I	3340	3
	Type II	31108	32
Dune Za Keyih	Type I	9668	3
	Type II	107442	31
Finlay-Russel Park	Type I	6397	5
	Type II	28193	23
Graham-Laurier Park	Type I	601	1
	Type II	3717	4
Horneline Creek Park	Type II	298	100
Kwadacha Wilderness Park	Type I	282	0
	Type II	11683	9
Liard River Corridor Park	Type I	20845	23
	Type II	67722	76
Liard River Hot Springs Park	Type I	762	70
	Type II	321	30
Muncho Lake Park	Type I	51	0
	Type II	1055	1
Northern Rocky Mountains	Type I	3402	1
	Type II	39529	6
Toad River Hotsprings Park	Type I	45	11
	Type II	295	71

**Only parks with Fisher habitat are included*

Moose, Stone Sheep, Mountain Goat, Caribou, Elk

For Stone Sheep (aka Dall sheep, thinhorn sheep or Stone's sheep *Ovis dalli stonei*), Sikanni Chief River Ecological Reserve and Muncho Lake Park have the most high-quality habitat protection within the M-KMA. Muncho Lake Provincial Park has similarly high percentages of high-quality habitat for mountain goat (*Oreamnos americanus)* and caribou (*Rangifer tarandus)*. Denetiah and Dune Za Keyih also provide quality habitat for all three species due to the parks' high elevations and size Figure 11, Table 16).

High quality habitat for caribou, sheep, and goat is typically in high elevation areas while high quality moose (*Alces alces*) habitat is found in the lower elevation areas along the northern and eastern edges of the M-KMA, and along valley bottoms throughout. High quality elk (*Cervus canadensis*) habitat is concentrated on the eastern slopes of the M-KMA, with a significant concentration in Northern Rocky Mountains Park and Redfern-Kelly Park (though neither are included in the Muskwa-Kechika Protected Area Strategic Management Plan) (Figure 11).

Grizzly Bear & Wolf

Far ranging predator species like grizzly bear *(Ursus arctos horribilis)* and wolf *(Canis lupus)* experience their highest value habitat at mid-elevation (Figure 11). Graham-Laurier Park is nearly 60% high quality grizzly bear habitat, while Denetiah and Kwadacha Wilderness Park have similarly large shares of high quality grizzly habitat. High quality wolf habitat is concentrated along the eastern side of the M-KMA, with protected areas like Redfern-Keily and Northern Rocky Mountains Park and typically associated with primary prey species.

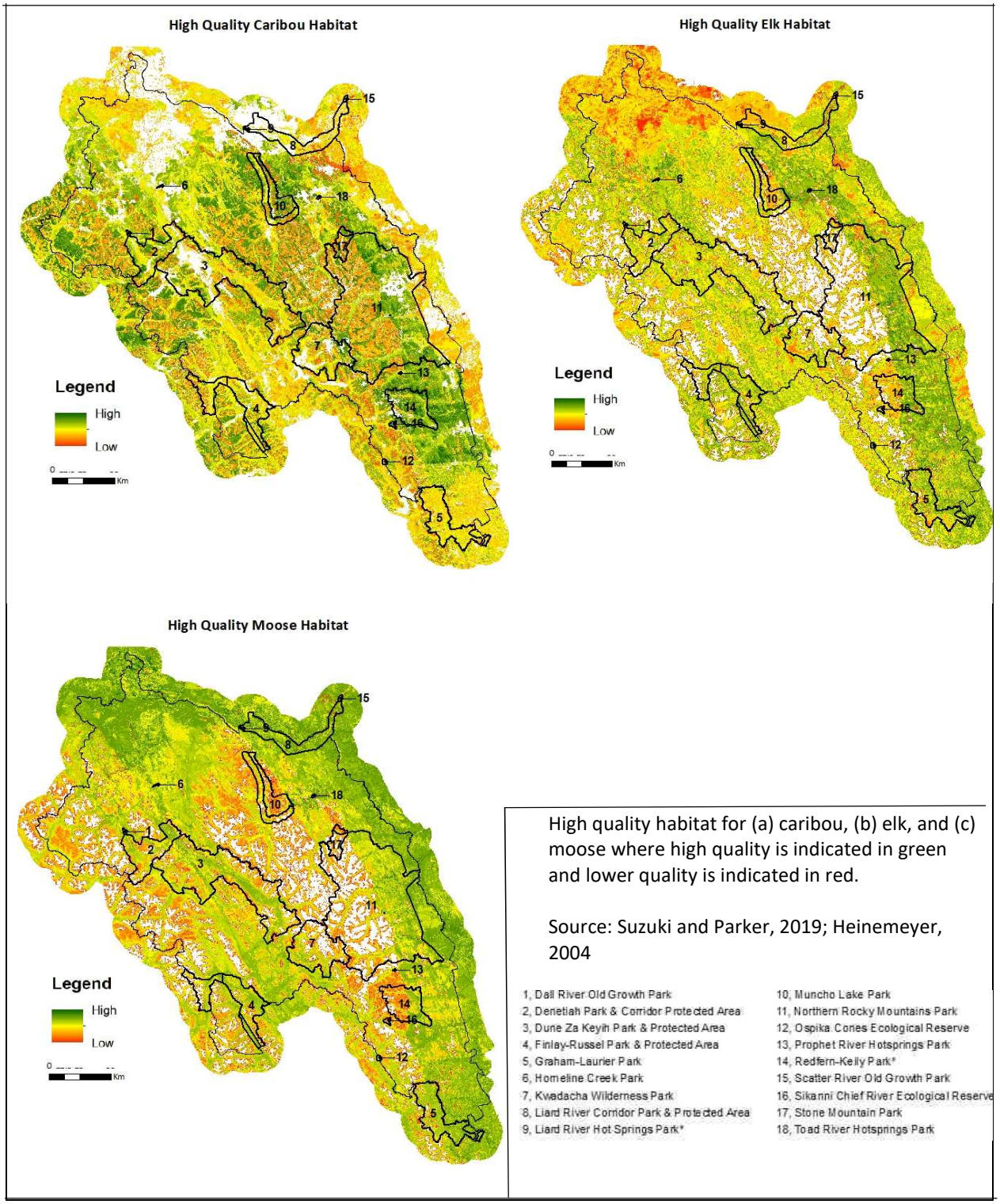
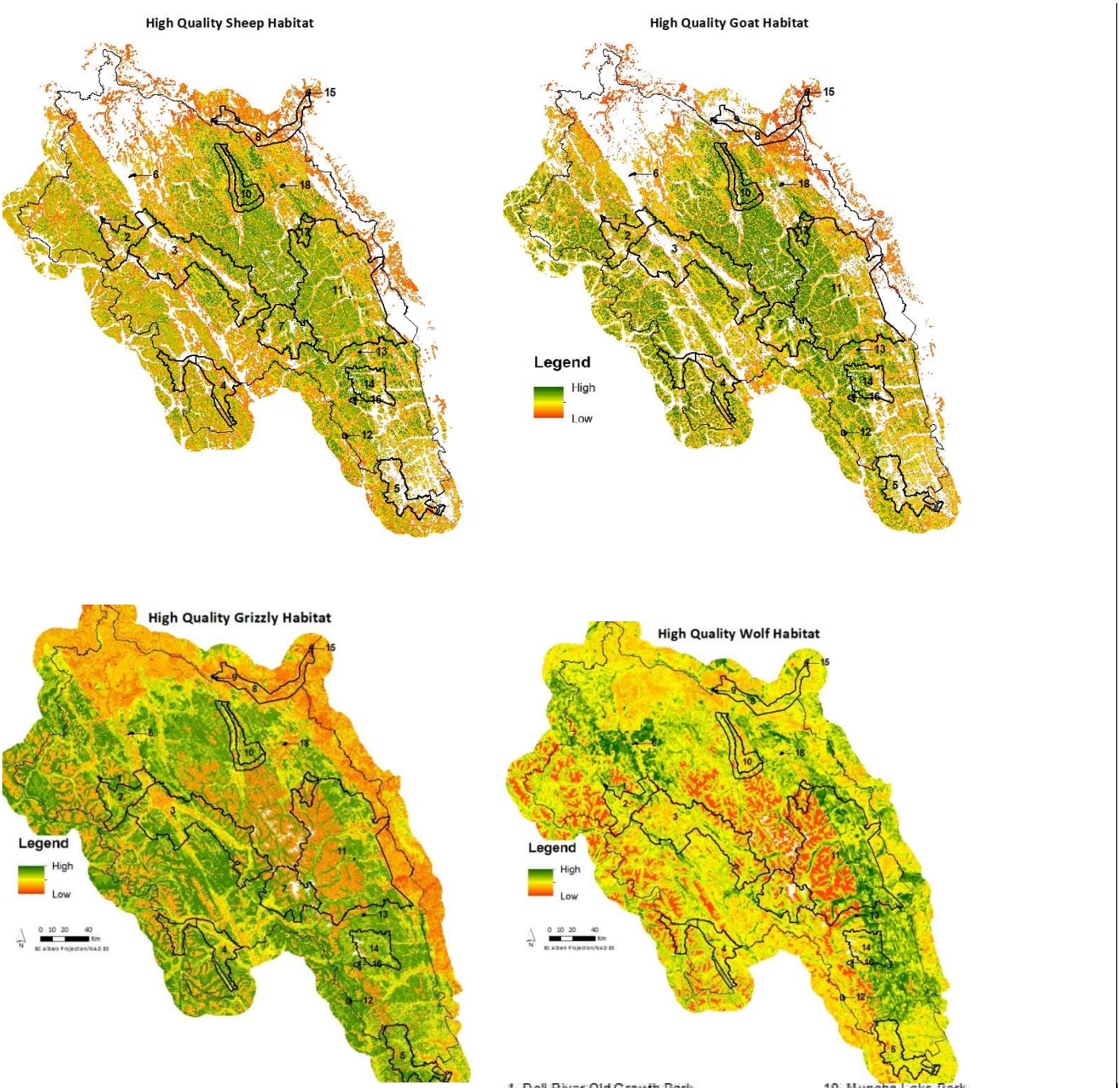


FIGURE 10. HIGH QUALITY HABITAT FOR CARIBOU, ELK AND MOOSE



High quality habitat for (a)sheep (b) goat, (c) grizzly and (d) wolf, where high quality is indicated in green and lower quality is indicated in red.

Source: Suzuki and Parker, 2019; Heinemeyer, 2004

FIGURE 11. HIGH QUALITY HABITAT FOR SHEEP, GOATS, GRIZZLY AND WOLF

Table 16. Wildlife Habitat Quality for Select Species

Protected Area	Habitat Quality	Sheep		Wolf		Moose		Grizzly		Goat		Elk		Caribou	
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Dall River Old Growth Park	Low	299	44	328	51	7	1	259	40	312	48	113	18	17	3
	Medium	16	3	315	49	105	16	345	54	14	2	208	32	469	73
	High	0	0		0	524	81	29	5		0	320	50	87	14
Denetiah	Low	31003	32	12211	12	18395	19	22671	23	25003	26	7259	7	12483	13
	Medium	19464	20	69912	71	27997	29	31095	32	21700	22	43084	44	44328	45
	High	19206	20	15687	16	40737	42	43910	45	22128	23	35665	36	30786	31
Dune Za Keyih	Low	105455	30	47459	14	67688	19	90183	26	62177	18	27544	8	72592	21
	Medium	69219	20	263012	76	100133	29	102229	29	86060	25	154267	44	139010	40
	High	88796	26	36882	11	137714	40	154042	44	96938	28	123799	36	76309	22
Finlay-Russel Park	Low	37978	31	17333	14	14093	11	27294	22	27300	22	9016	7	21462	17
	Medium	28837	23	84139	69	29006	24	44657	36	32999	27	34359	28	70401	57
	High	19215	16	7319	6	63919	52	50022	41	32758	27	63655	52	18899	15
Graham-Laurier Park	Low	27898	28	3903	4	7228	7	10364	10	22231	22	7333	7	18773	19
	Medium	13441	14	86282	87	19038	19	29410	30	25451	26	36630	37	71916	72
	High	6264	6	9274	9	70153	70	59423	60	9744	10	52583	53	4910	5
Horneline Creek Park	Low	223	75	297	100	14	5	297	100	63	21	14	5	0	0
	Medium	69	23		0	102	34	0	0	7	2	99	33		0
	High	0	0		0	177	59		0	2	1	181	61		0

Protected Area	Habitat Quality	Sheep		Wolf		Moose		Grizzly		Goat		Elk		Caribou	
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Kwadacha Wilderness Park	Low	32299	25	26836	21	32299	25	30843	24	15018	12	12975	10	26659	20
	Medium	26113	20	81359	62	32963	25	25158	19	43235	33	56723	44	43947	34
	High	44060	34	11217	9	29615	23	63265	49	46059	35	24010	18	30458	23
Liard River Corridor Park	Low	44657	50	3486	4	1458	2	67263	76	37013	42	8354	9	12072	14
	Medium	6747	8	74183	83	10952	12	21589	24	1349	2	39216	44	38053	43
	High	151	0	11305	13	76414	86	46	0	171	0	39967	45	1213	1
Liard River Hot Springs Park	Low	357	33	24	2	49	5	541	50	433	40	150	14	217	20
	Medium	145	13	1020	94	119	11	535	49	72	7	878	81	705	65
	High	18	2	35	3	897	83		0	16	1	12	1	0	0
Muncho Lake Park	Low	20349	24	7269	8	36872	43	12319	14	18093	21	9928	12	12982	15
	Medium	19955	23	69351	81	22128	26	37147	43	18627	22	41308	48	29767	35
	High	35368	41	9186	11	18827	22	36370	42	36366	42	25830	30	33548	39
Northern Rocky Mountains	Low	178573	27	186606	28	121187	18	239661	36	148939	22	55476	8	158204	24
	Medium	146254	22	240995	36	148891	22	131973	20	154282	23	145025	22	182075	27
	High	257135	39	231979	35	208769	31	287112	43	256866	39	273512	41	246584	37
Ospika Cones Ecological Reserve	Low	410	32	1247	97	163	13	27	2	261	20	27	2	447	35
	Medium	448	35	33	3	401	31	38	3	497	39	873	68	463	36
	High	331	26		0	705	55	1211	94	464	36	377	29	338	26

Protected Area	Habitat Quality	Sheep		Wolf		Moose		Grizzly		Goat		Elk		Caribou	
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Prophet River Hotsprings Park	Low	129	70	184	99	8	4	15	8	129	70	15	8	169	91
	Medium	14	8		0	116	18	23	4	14	2	114	18		0
	High	0	0		0	56	9	145	23		0	53	8		0
Redfern-Keily Park	Low	14795	18	1978	2	35153	44	3568	4	12909	16	7614	9	3698	5
	Medium	19561	24	42826	53	18746	23	26178	32	20945	26	32030	40	15345	19
	High	27020	33	32554	40	21881	27	47481	59	27642	34	35531	44	52992	66
Scatter River Old Growth Park	Low	343	29	121	10	69	6	893	76	364	31	315	27	155	13
	Medium	23	2	583	49	329	28	284	24		0	252	21	593	50
	High	0	0	471	40	776	66		0		0	545	46		0
Sikanni Chief River Ecological Reserve	Low	15.81	16	16	1	1690	78	11	1	151	7	303	14	125	6
	Medium	27.71	28	2155	99	391	18	653	30	796	37	1642	75	375	17
	High	53.4	53		0	77	0	1503	6	1203	5	214	1	1543	6
Stone Mountain Park	Low	18.6	19	10559	42	9200	37	11526	46	3577	14	2851	11	9319	37
	Medium	20.52	21	10522	42	4009	16	4665	19	5692	23	8146	32	4239	17
	High	53.38	53	4088	16	1529	6	8935	35	13613	54	3586	14	9010	36
Toad River Hotsprings Park	Low	55.07	55	402	97	59	14	226	55	135	33	77	19	4	1
	Medium	21.5	22	11	3	67	16	150	36	70	17	26	6	171	41
	High	15.22	15		0	284	69	36	9	64	15	310	75	36	9

Species at Risk

Information on species at risk is limited as a result of limited inventory. The BC Species and Ecosystems Explorer was used to identify 77 of vertebrate and invertebrate species/populations that may be within the region (Appendix 1-4). Provincial Red-listed species are those that are at risk (extirpated, endangered or threatened) and Blue-listed are species of special concern. Of vertebrate animals, 21 red-listed, 46 blue-listed and 10 yellow-listed species may occur within the M-KMA and M-KMA protected areas.

An interim protocol for cumulative effects assessments in BC piloted the approach with examination of grizzly bears in the northeastern part of the province and covering the eastern and northern portions of the M-KMA (Ministry of Environment, 2017). Within the 25 assessment units (AU) in the M-KMA, all are assessed as viable with population estimates ranging from 7 to 91 (AU) and averaging 48 with a population density averaging 17.6/1000km2.

For caribou, there are eight named Northern Mountain caribou herds intersecting with the M-KMA protected areas and seven of them are categorized as blue-listed/special, with one – the Graham herd identified as blue-listed/threatened coincident with Graham-Laurier Provincial Park. For much of Finlay-Russel, Denetiah, Dall River protected areas along with the northwestern tip of Dune Za Keyih Provincial Park there are no identified herds in the area remaining and only trace occurrences of caribou reported. Population estimates for herds range from approximately <25 to 1000 with inventory data ranging from 2001-2018. The Gataga herd, centered around Dune Za Keyih and Kwadacha Wilderness PPA is reported as stable, while three (Muskwa, Pink Mountain and Graham) are reported as declining. Status of the remaining four is unknown.

Connectivity

The M-KMA sits in the northern portion of the continental movement corridor up the spine of the Rocky Mountains. It serves an important role continentally as well as regionally. The significant size and intact nature of the M-KMA (98% roadless) generally means that species can move freely within it restricted primarily by the small footprint, slope, and inhospitable land covers (e.g., glaciers). Connectivity analysis was conducted by first constructing a landscape resistance layer. The resistance layer refers to the difficulty of moving across a landscape and was based on the human footprint, slope and landcover. This was then used to examine connectivity between protected areas where protected areas with a common border were combined for analysis (Figure 12). Given that some protected areas are located right on the edge of the M-KMA the area of analysis was increased by 15km. Figure 13 tightens or focuses the criteria for connectivity from the initial analysis with the areas in green narrowed in to identify the areas where movement is easier.

The results across the entire M-KMA indicate a highly connected landscape allowing relative ease of movement except associated with the human footprint associated with the Alaska Highway and the ATV trails in the SE quadrant of the M-KMA or the high slope and glacial coverage in the centre of the M-KMA between Dune Za Keyih and Northern Rockies Parks. Within the protected areas, resistance to connectivity is largely associated with the higher levels of human use around the Alaska Highway in Liard Hotsprings, Muncho Lake and Stone Mountain parks and protected areas findings supported by Weaver (2019). The blue lines indicate the shortest pathway connecting adjacent protected areas while avoiding the human footprint, very steep slopes and terrains like glaciers that are too difficult to cross.

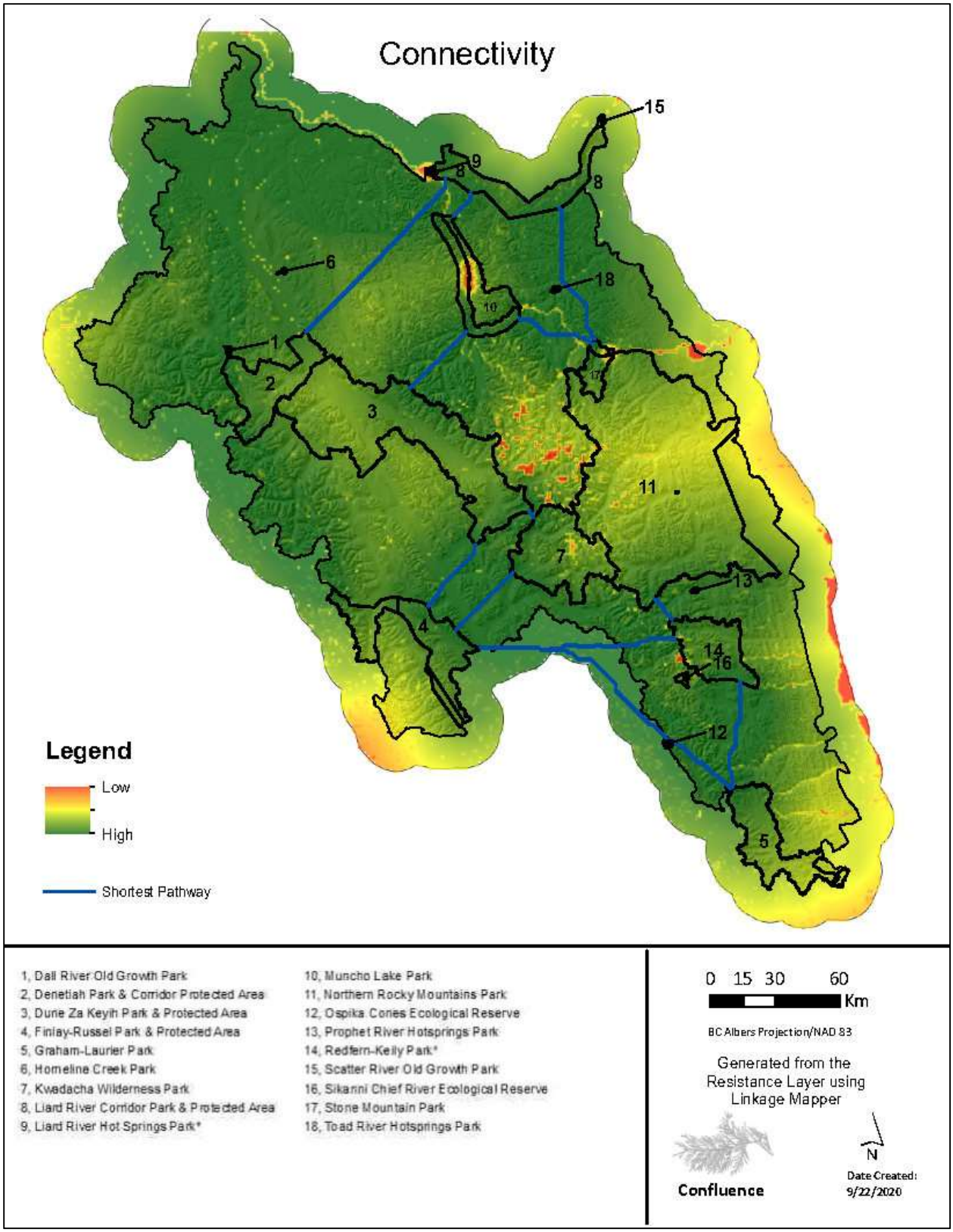


FIGURE 12. LANDSCAPE CONNECTIVITY BETWEEN PROTECTED AREAS IN THE MUSKWA-KECHIKA MANAGEMENT AREA

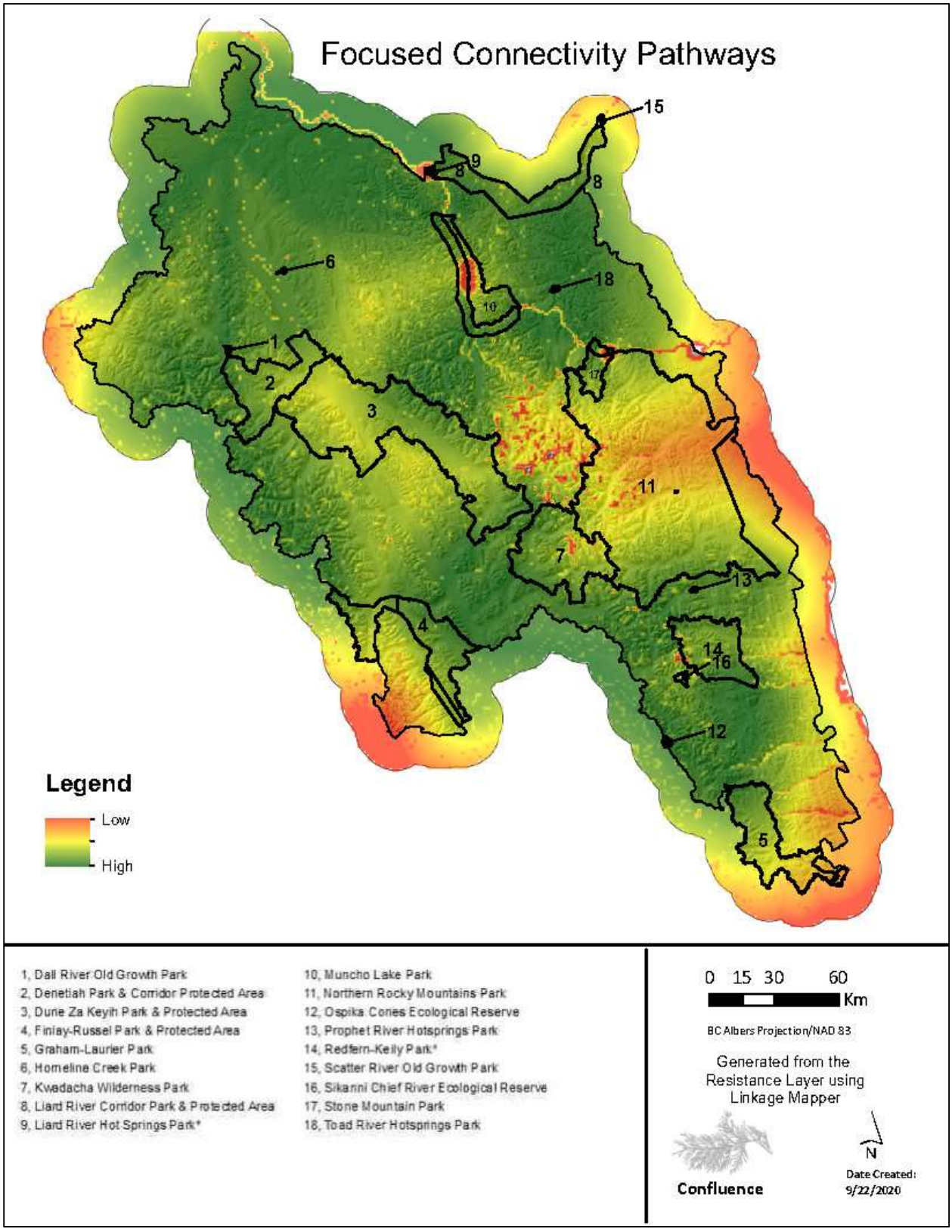


FIGURE 12. FOCUSED CONNECTIVITY PATHWAYS ACROSS THE MUSKWA-KECHIKA MANAGEMENT AREA

Disturbance

Natural disturbances such as fire, insects, disease, windthrow, herbivory and many others are agents of ecosystem health and functions of renewal. At the landscape scale disturbances drive ecosystems and create heterogeneity and the pattern of ecosystem patches. These disturbances operate at different spatial and temporal scales and varying in type and intensity. The frequency, size and severity of a disturbance varies with ecosystem and with type of disturbance (Daust & Price, n.d.).[13]

Frequent stand-initiating events in the M-KMA follow a pattern of low elevation, while infrequent stand-initiating events are most prevalent in mid-elevation areas (Figure 14, Table 17). Disturbance in the Muskwa-Kechika Management Area is dominated by fire (Wong et al., 2004 in Daust & Price, n.d.). Frequent stand-initiating disturbances dominated by fire occur in just over half of the M-KMA protected areas while infrequent stand-initiating events, occur in about 38% of the area. Other disturbance mechanisms, such as insects, wind throw and herbivory interact with fires creating not only a complex patch structure over the landscape (horizontal patchiness) but also vertical structural complexity within patches. Protected areas like Dall River Old Growth, Horneline Creek, and Liard River Corridor are almost entirely within regimes of frequent stand-initiating events. Others, like Kwadacha Wilderness Park and Muncho Lake Park, more often experience infrequent stand-initiating events, while natural disturbance in the alpine and subalpine are much less frequent. In addition to wildfires, prescribed fire has been used by Indigenous and non-Indigenous groups to maintain optimal habitat for wildlife specifically to improve late-winter, early-spring forage for ungulates (Lousier et al., 2009). Data accurately recording the application of fire in the M-KMA is not accurately recorded within the government data sets thus getting a more accurate picture of its use, and an examination of the conservation implications of fire in the region, are needed.

[13] Research shows disturbance intervals for M-KMA BEC variants as averaging 250 years for BWBS variants, 150 years for SBS mk, 275 years for SWB mk, and 400 years for ESSF mw (Daust & Price, n.d.; Wong et al., 2003).

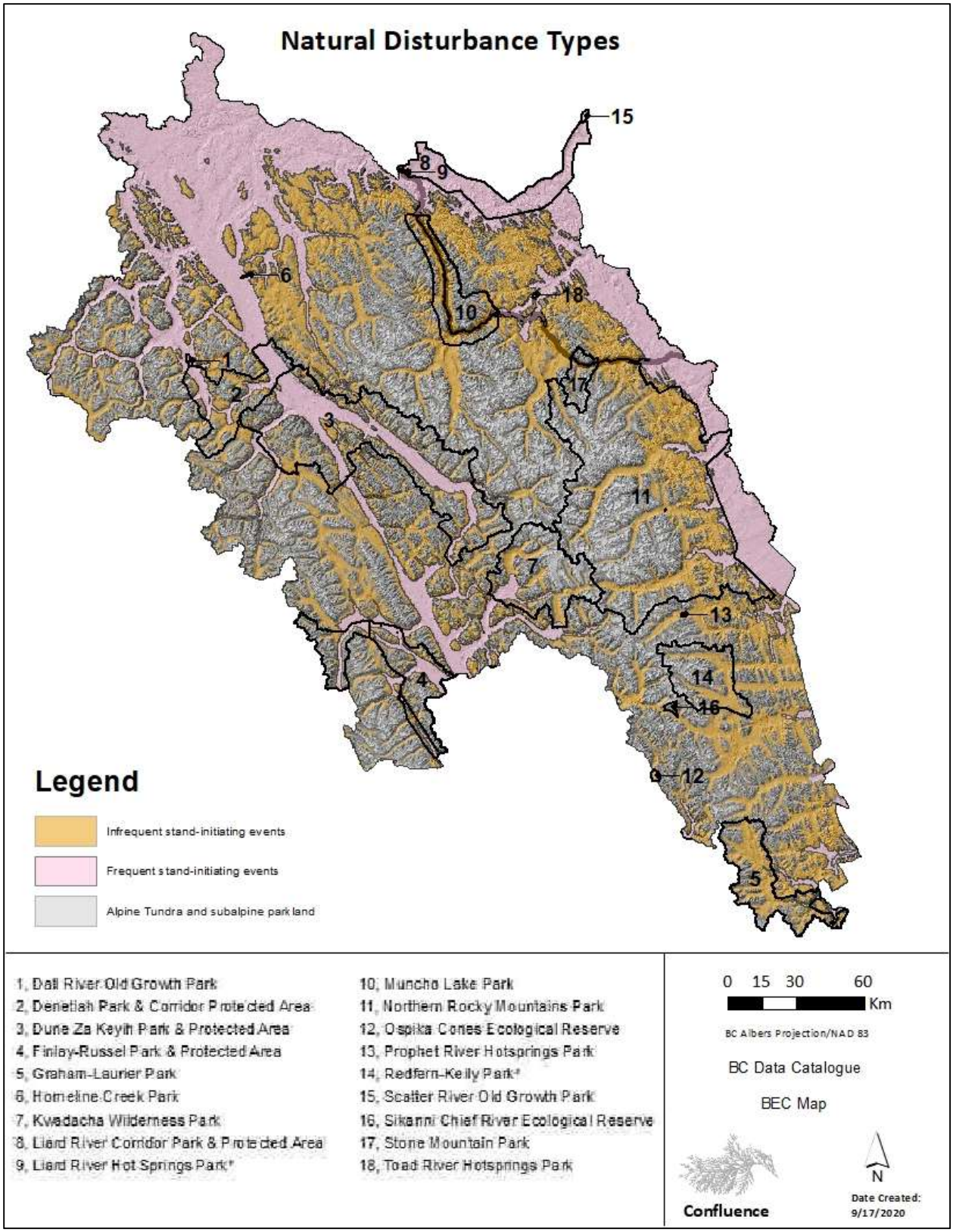


FIGURE 13. NATURAL DISTURBANCE REGIMES WITHIN THE M-KMA

Table 17. Natural Disturbance Type by Protected Area

Protected Area	Natural Disturbance Type	Hectares	Percent
Dall River Old Growth Park	Frequent stand-initiating events	644	99.98
Denetiah	Infrequent stand-initiating events	68	0.07
	Frequent stand-initiating events	34436	35.17
	Alpine tundra and subalpine parkland	1788	1.83
Dune Za Keyih	Infrequent stand-initiating events	1105	0.32
	Frequent stand-initiating events	6	0.00
	Alpine tundra and subalpine parkland	1723	0.50
Finlay-Russel Park	Infrequent stand-initiating events	3822	3.11
	Frequent stand-initiating events	27242	22.19
	Alpine tundra and subalpine parkland	2041	1.66
Graham-Laurier Park	Infrequent stand-initiating events	2	0.00
	Frequent stand-initiating events	996	1.00
	Alpine tundra and subalpine parkland	671	0.67
Horneline Creek Park	Frequent stand-initiating events	298	100.05
Kwadacha Wilderness Park	Infrequent stand-initiating events	49407	37.91
	Frequent stand-initiating events	11962	9.18
	Alpine tundra and subalpine parkland	1813	1.39
Liard River Corridor Park	Infrequent stand-initiating events	65	0.07
	Frequent stand-initiating events	88485	99.43
Liard River Hot Springs Park	Frequent stand-initiating events	1082	100.03
Muncho Lake Park	Infrequent stand-initiating events	56659	65.82
	Frequent stand-initiating events	1105	1.28
	Alpine tundra and subalpine parkland	351	0.41
Northern Rocky Mountains	Infrequent stand-initiating events	13	0.00
	Frequent stand-initiating events	42931	6.43
	Alpine tundra and subalpine parkland	16885	2.53
Ospika Cones Ecological Reserve	Infrequent stand-initiating events	66	5.15
	Alpine tundra and subalpine parkland	117	9.15
Prophet River Hotsprings Park	Infrequent stand-initiating events	185	99.79
Redfern-Keily Park	Infrequent stand-initiating events	31276	38.72
	Alpine tundra and subalpine parkland	340	0.42
Scatter River Old Growth Park	Infrequent stand-initiating events	1178	100.00
Sikanni Chief River Ecological Reserve	Infrequent stand-initiating events	256	11.75
	Alpine tundra and subalpine parkland	1407	64.64
Stone Mountain Park	Infrequent stand-initiating events	6511	25.86
	Alpine tundra and subalpine parkland	11940	47.42
Toad River Hotsprings Park	Infrequent stand-initiating events	66	15.88
	Frequent stand-initiating events	340	82.14

Climate Change

As climate changes, there will be dramatic changes to the BC landscape. Climate projection data developed to examine climate change impacts on conservation identifies that the M-KMA region will be affected by the changing climate, but will also provide some regional resilience to this change.

Climate vulnerability assessment involves examination of a number of different measures. Different measures are important at different scales and help to tell different parts of the story. Vulnerability is a product of examining the exposure of a biodiversity component to climate change compared to the inherent sensitivity of that component to change. Ideally, the resulting potential impact is then examined considering the inherent adaptive capacity in the system to respond to that impact, or the ways in which management can enhance the adaptive capacity of the system to mitigate the potential impact (Figure 15).

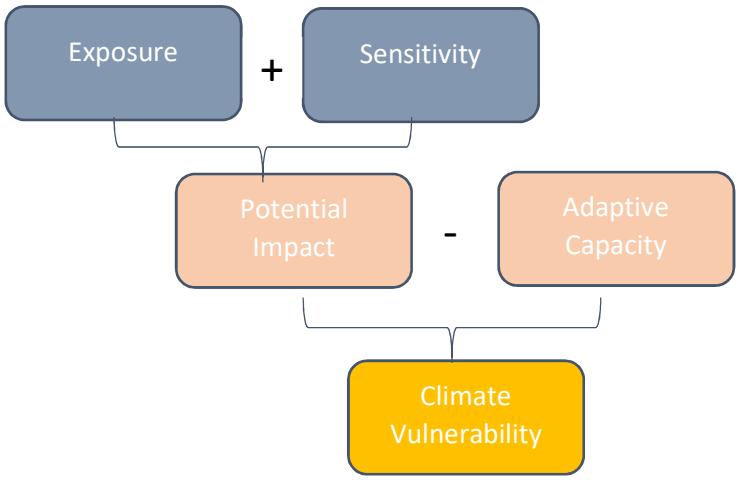


FIGURE 14. CLIMATE VULNERABILITY ASSESSMENT

We used a broad vulnerability assessment to identify climate features (for which data was available) that could be used in mapping where current biodiversity values may change because of future climate implications.

Changing Temperature and Precipitation

Climate projections predict that it will be warmer and wetter in the M-KMA area over the next 100 years. Mean Annual Temperatures (MAT) will rise typically by 5 degrees from historic averages to 2085, with winters experiencing the greatest warming (Figure 16).

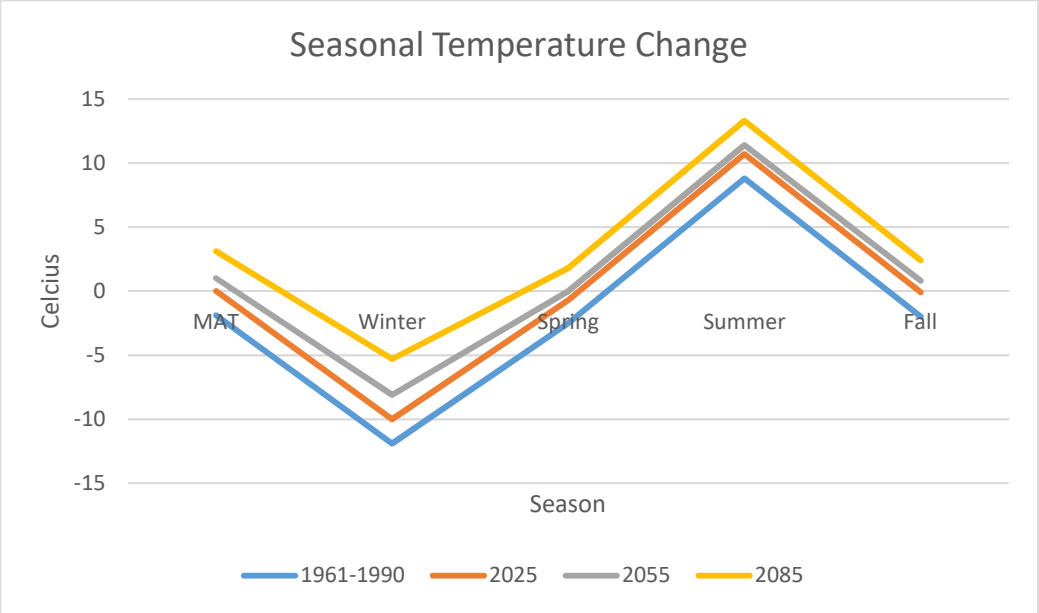


FIGURE 15. PREDICTED SEASONAL TEMPERATE CHANGE IN THE M-KMA FROM 1961 TO 2085

Precipitation will also increase approximately 172 mm (from historic averages to 2085) with the largest increases coming in fall and summer (Figure 17).[14]

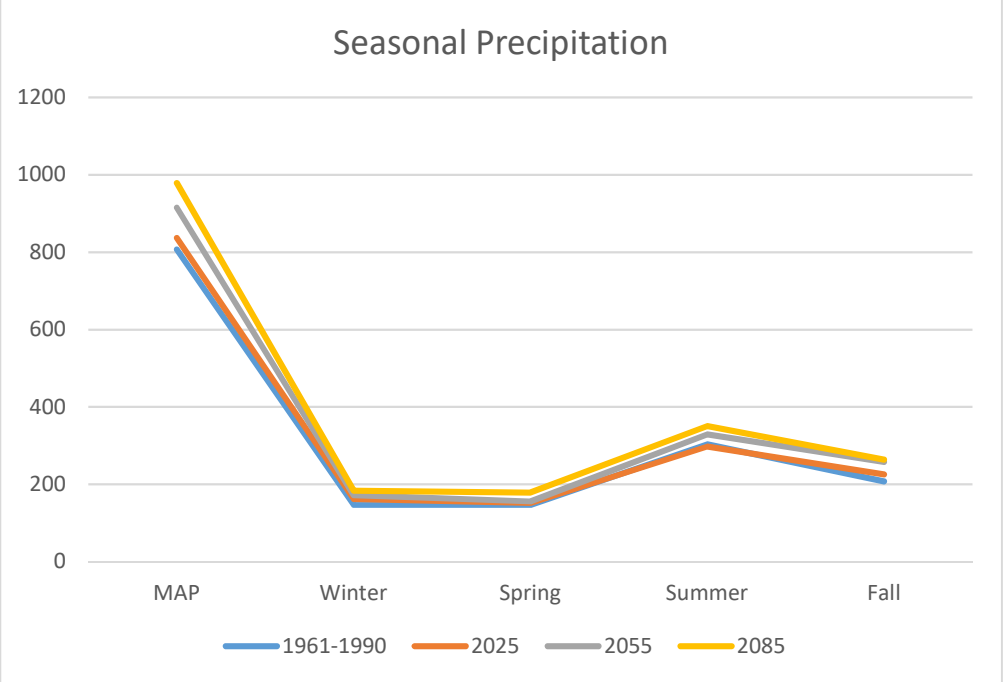


FIGURE 16. PREDICTED SEASONAL PRECIPITATION CHANGE IN THE M-KMA FROM 1961 TO 2085

[14] MAT and MAP predictions provided from www.climatebc.ca

Shifting Vegetative Communities

At a broad level, changes in temperature and precipitation will drive shifts in vegetative communities generally in either latitudinal or elevation directions. Current vegetative community distribution by three BEC zones: BWBS, SWB and BAFA that broadly parallel increased elevation (Figure 18 and 19). The Engelmann Spruce Subalpine Fir (ESSF) zone appears only in relatively small amounts in the southern parts of the M-KMA (although it does dominate in Graham-Laurier Park).

In mountainous environments like the M-KMA, the alpine zone (BAFA) will shrink as trees colonize further up mountains. However, where there is insufficient soil development (as is the case on what is now, or what has recently been glaciated landscapes) these areas will not be able to support vegetative shifts upward. In 2085 biogeoclimatic envelope modeling suggests that there will be an increase in BWBS and a significant decrease in the alpine BAFA zone. Models also predict that the SWB zone will dramatically decline and remain only in trace amounts. In addition, the ESSF forests that occurred only in trace amounts in current conditions will expand significantly. There are also trace amounts of numerous other BEC zones expected to occur within the area by 2085.

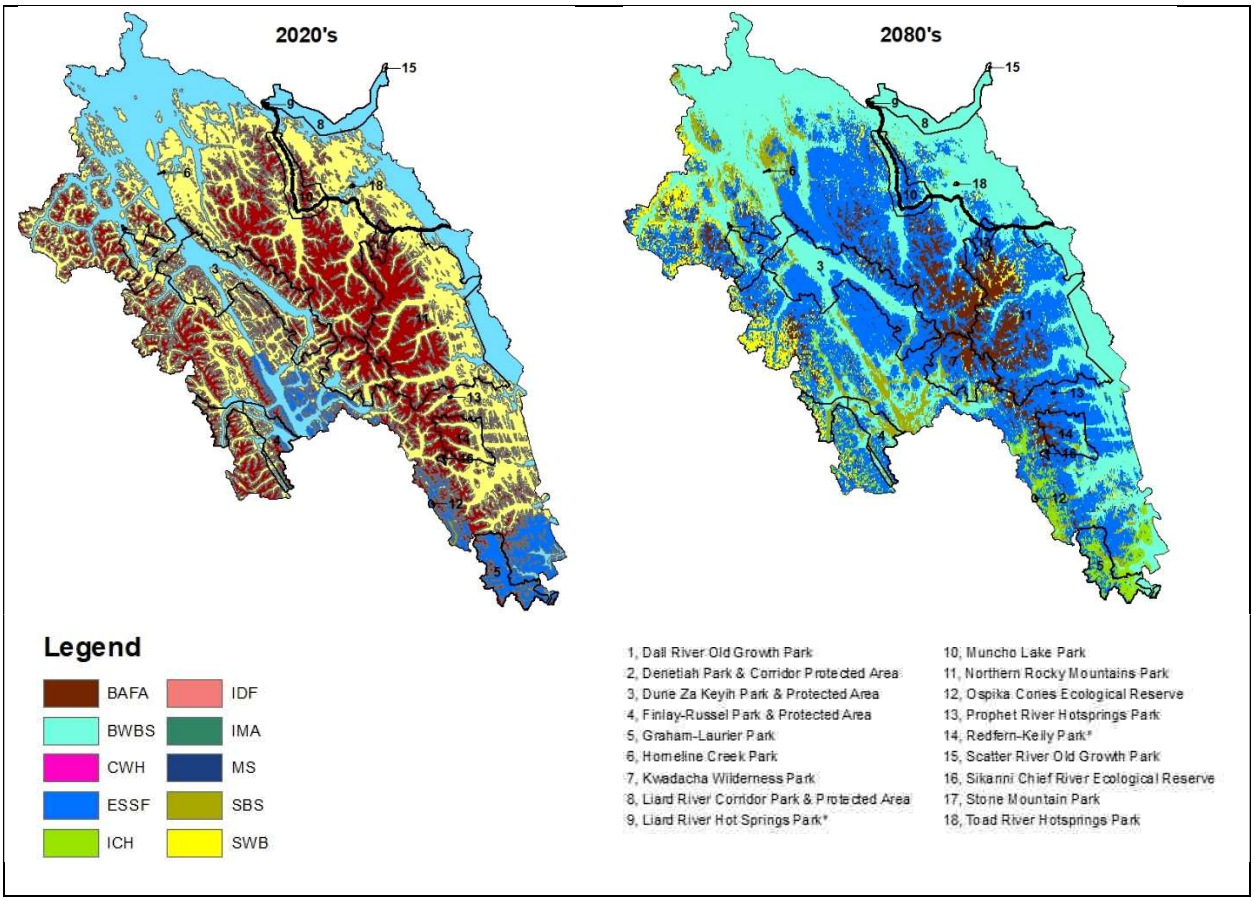


FIGURE 17. CURRENT AND PROJECTED (2080) BIOGEOCLIMATIC ZONES

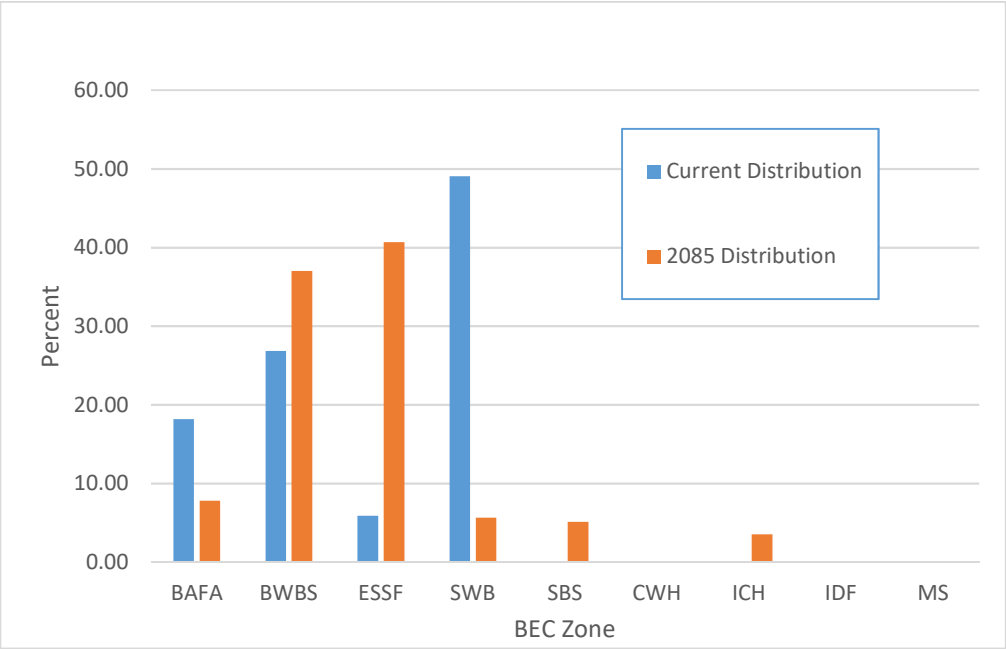


FIGURE 18. CURRENT VS PROJECTED BEC ZONES IN THE M-KMA

Forward Velocity

Forward climatic velocity identifies the rate which an organism currently in a location must move to find a similar climate in the future. It is a straight line distance between a given location's current climate type and the closest site with the same climate type in the future. This helps us understand how well resident species and ecosystems may persist in the area. In mountainous environments, species and ecosystems in lower elevations can potentially move either north or up-slope in response to changing climate. However, high elevation alpine residents and ecosystems will be likely to experience very high levels of forward velocity because the nearest area with a similar climate may be a distant mountaintop. However, low elevation areas can also have high velocity if the nearest similar climate analog is too far away, or bottlenecked by mountain ranges for example, to reach. Hotter colours in Figure 20 indicate areas of high forward climate velocity, suggesting that species and ecosystems that reside there currently are at a higher level of risk as climate changes. Within the M-KMA ecosystems and species within Stone Mountain PP and the east slope of Northern Rockies PP are the most vulnerable.

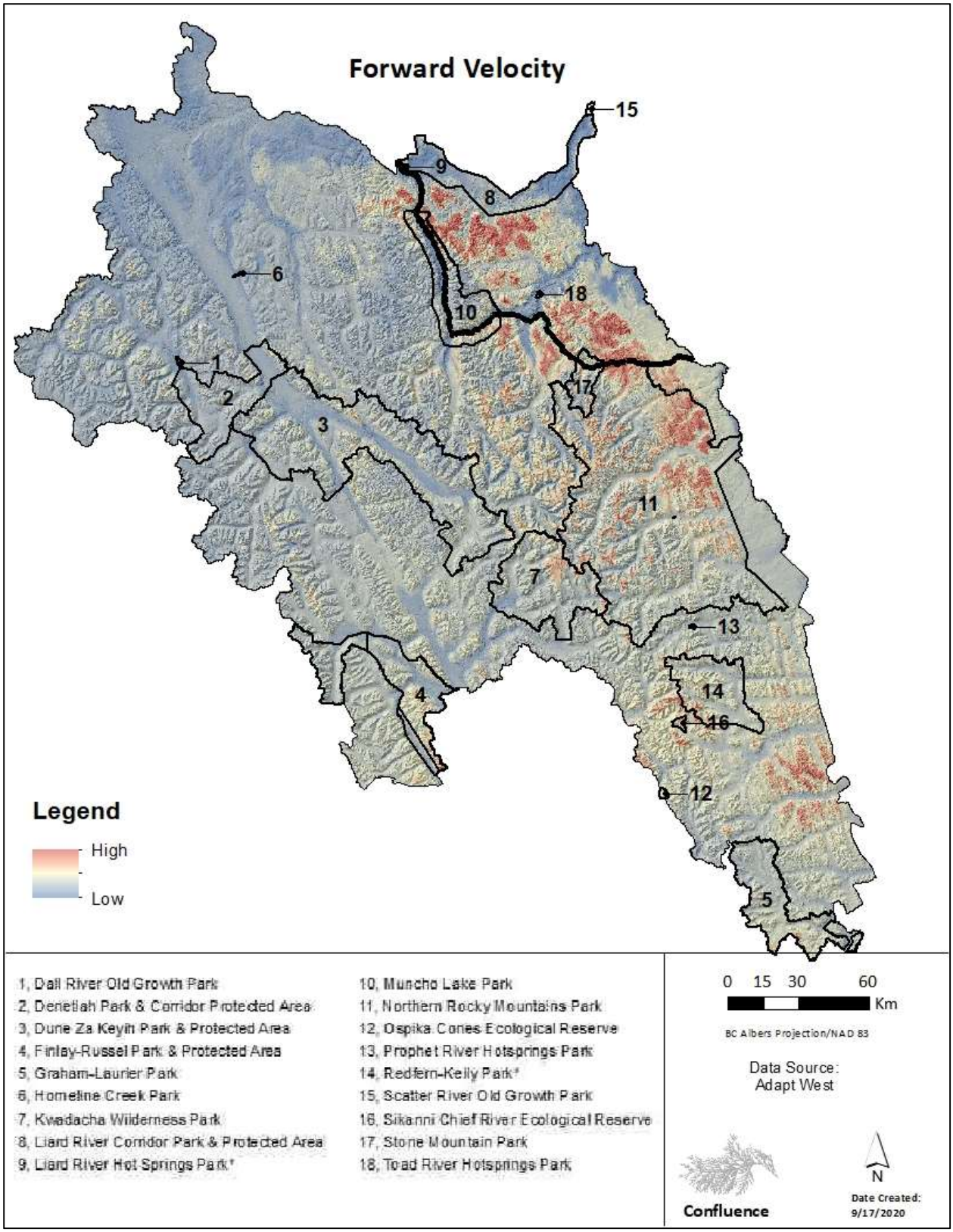


Figure 19. Forward velocity: High velocity indicates where species are likely to be at greater risk as ecosystems are changing faster than species can move.

Backward Velocity

Backward climatic velocity in contrast helps identify where species and ecosystems must come from to reach a similar climate. Backward velocity is usually low in the alpine because species and ecosystems can move upward from lower elevations. Protected areas with a low backward velocity can serve as refugia. Within the M-KMA protected areas generally in the western portion of the area are more likely to serve as climate refugia for species and ecosystems migrating to them (Figure 21). Redfern-Keily and Finlay-Russel are two of the more prominent protected areas that will serve as refugia for climate migrants.

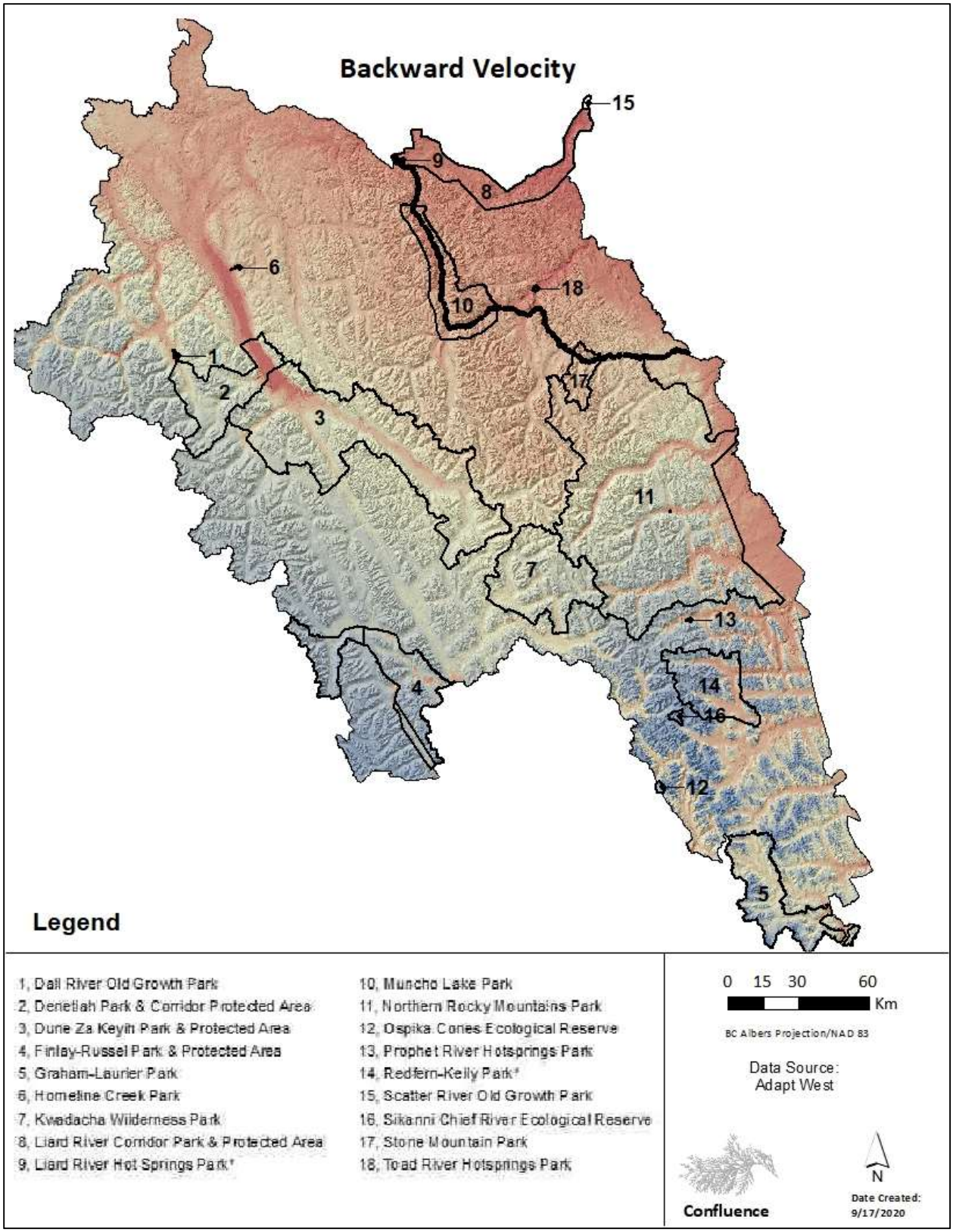


Figure 20. Backward velocity: High backward velocity indicates where species are likely to be at greater risk as ecosystems are changing faster than species can move. Low velocity areas may serve as refugia.

Above- and Below-Ground Carbon

Climate adaptation involves planning and management measures to address climate change through efforts to increase resilience amongst other strategies. In addition, however, protected areas contribute in a larger context to climate mitigation strategies through sequestration of carbon in standing forests and in soils. In this way, protected areas, where soils/forests are more likely to be undisturbed, are natural solutions to climate change. Above-ground carbon refers to the woody biomass of trees (stems, bark, branches and twigs) while below-ground carbon includes carbon contained in soils including the root biomass of trees and peat soils.

Below-carbon is highest in boreal moist forests and thus protected areas in the boreal are particularly critical to soil carbon conservation. Northern forests sequester approximately twice as much carbon in the soil than above ground. Below-ground carbon gives soil water-retention capacity, fertility and soil. When exposed it oxidizes losing the carbon. Forests rich in below-ground carbon have minimal soil exposure and erosion, have dense matts of roots and rootlets common in boreal forests, and have abundant mycorrhizal fungi whose threadlike filaments called hyphae store 70% more carbon per unit of nitrogen in soil. Compared to the overall area of the M-KMA, the M-KMA protected areas have proportionately higher levels of soil carbon and this is particularly the case in Stone Mountain Provincial Park and the north western portion of Northern Rockies Provincial Park (Figure 22, Table 20).

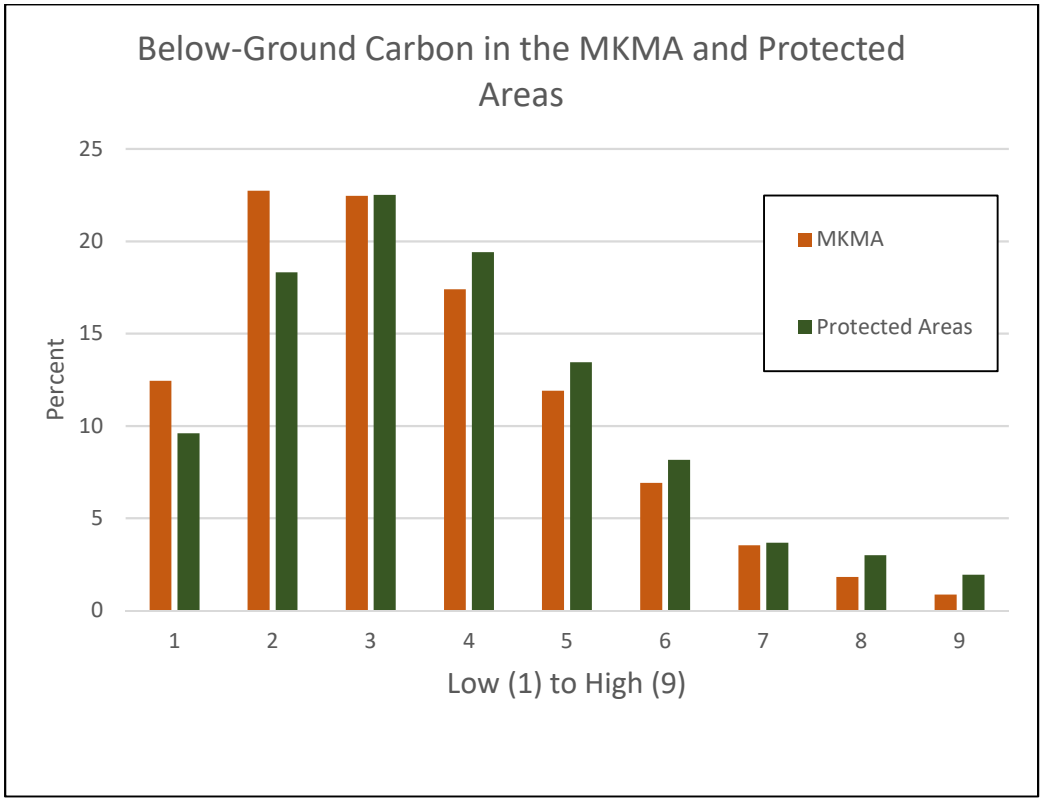


FIGURE 21. BELOW GROUND CARBON IN THE M-KMA

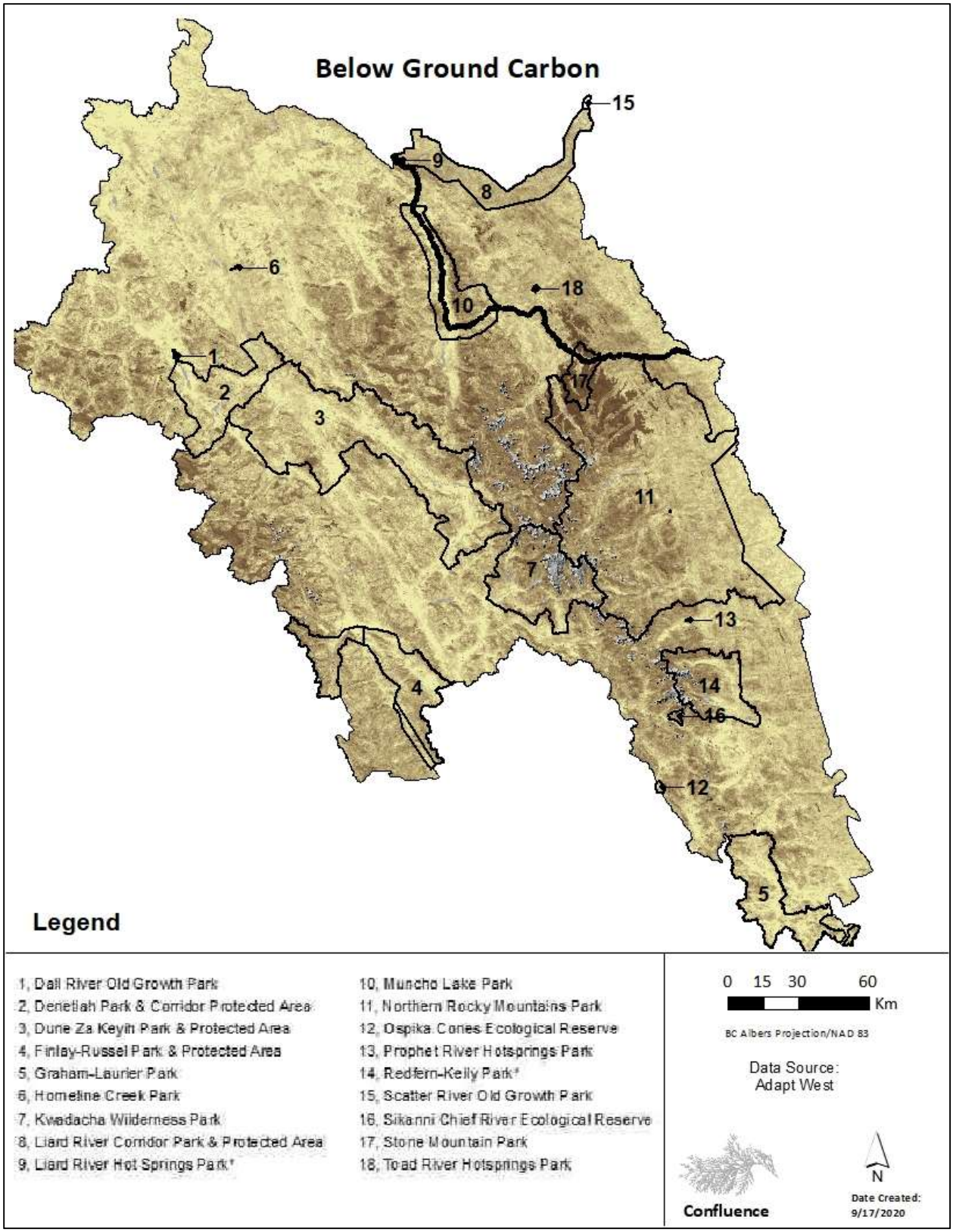


FIGURE 22. BELOW GROUND CARBON (BGC) IN THE MUSKWA-KECHIKA MANAGEMENT AREA

In contrast Above Ground Carbon (AGC) is generally the inverse of BGC in this particular case lower elevation areas (e.g., Liard, Graham-Laurier, Dune Za Keyih, Finlay-Russel and western part of Kwadacha) have higher levels of AGC (Figure 24 and 25). Overall, M-KMA protected areas tend to be located in areas with lower amounts of AGC compared to the entirety of the M-KMA. This is particularly the case for the higher elevation alpine and sub-alpine areas that have little to no forest cover.

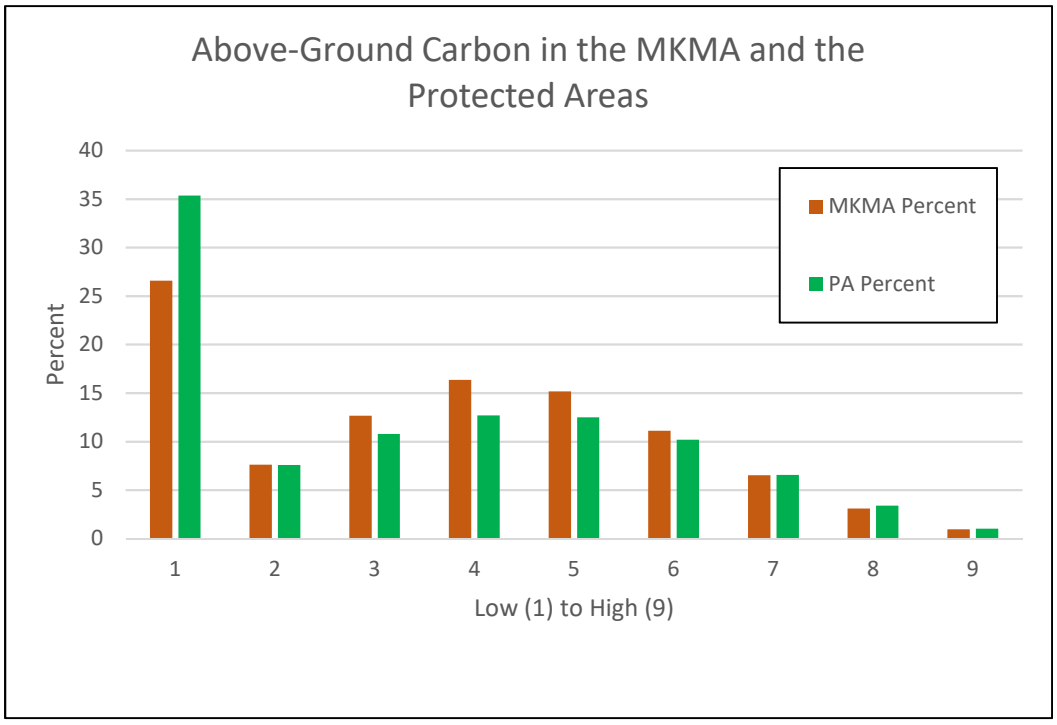


FIGURE 23. ABOVE-GROUND CARBON IN THE M-KMA

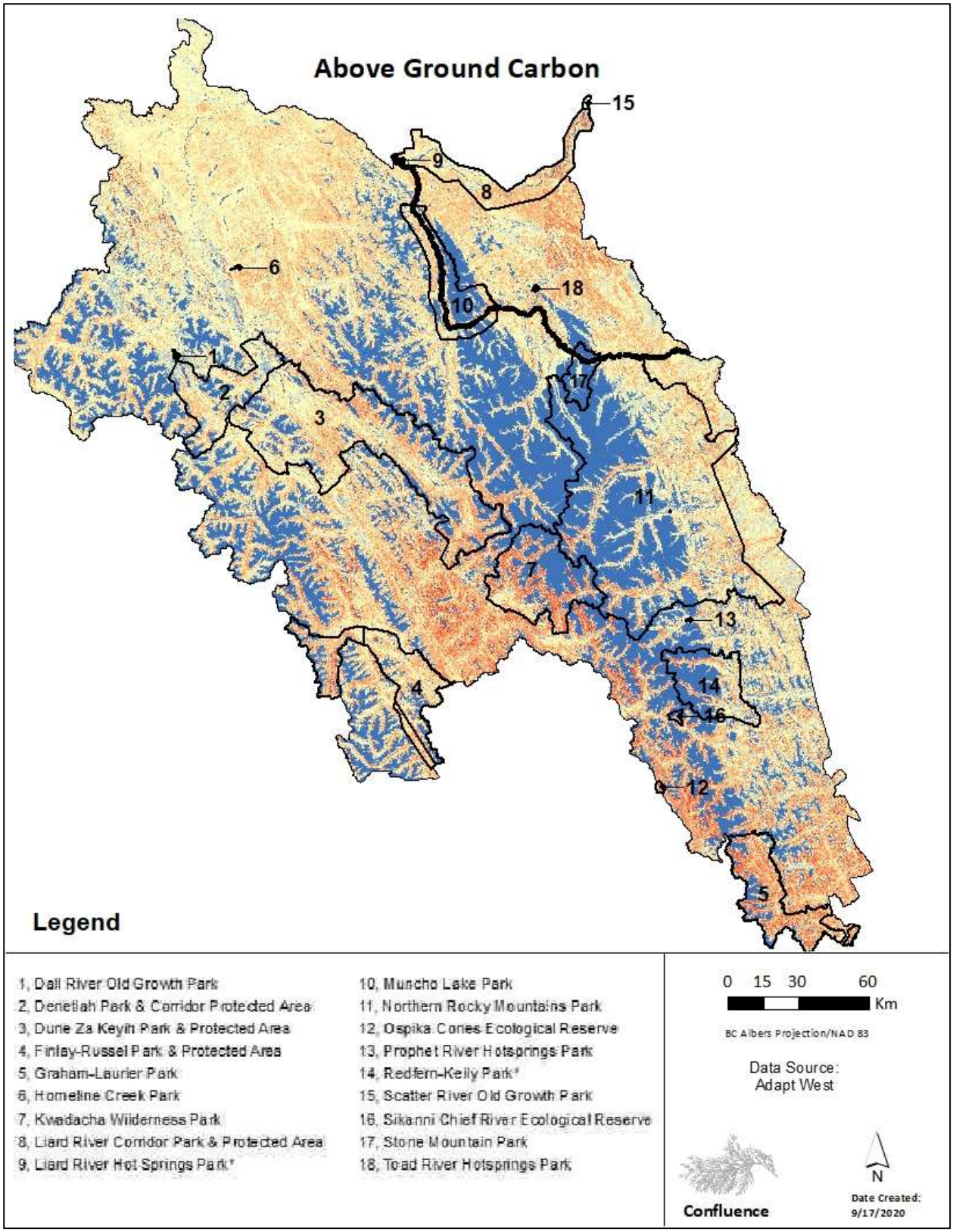


FIGURE 24. ABOVE GROUND CARBON (AGC) IN THE MUSKWA-KECHIKA MANAGEMENT AREA

Climate Connectivity

A species or ecosystem's ability to adapt to a changing climate will be due in part by its' ability to disperse to a new suitable habitat. Climate connectivity areas are climate corridors that identify the best routes at a landscape scale the routes, often circuitous, that the species or ecosystem will use to avoid hostile climates in their path. We used data from Carroll et al. (2018) to look at the overlap at numerous different dispersal metrics. Dispersal and climate connectivity are influenced by topography and tend to be associated with valley systems as well as the drier, eastern slopes of north-south mountain ranges. Although current human footprints are not included in this analysis it will negatively impact climate connectivity. In Figure 26 we combined both forward (where things go to) and backward (where things come from) climate connectivity metrics to identify those areas with higher rates of connectivity under either scenario. One major important climate connectivity corridor is located on the eastern edge of the M-KMA particularly in the Liard park/protected area network and in the eastern edge of Northern Rockies Park. A second climate corridor runs from Liard and bisects the M-KMA forking in Dune Za Keyih with one branch moving south-west across the middle and another moving south along the western edge of Dune Za Keyih connecting Kwadacha, Redfern-Keily, Sikanni Chief and Graham-Laurier. Both the first and second climate corridors cross the Alaska Highway. Minimizing the human footprint as it effects movement in these areas over the long term will be critical to maintaining their effectiveness.

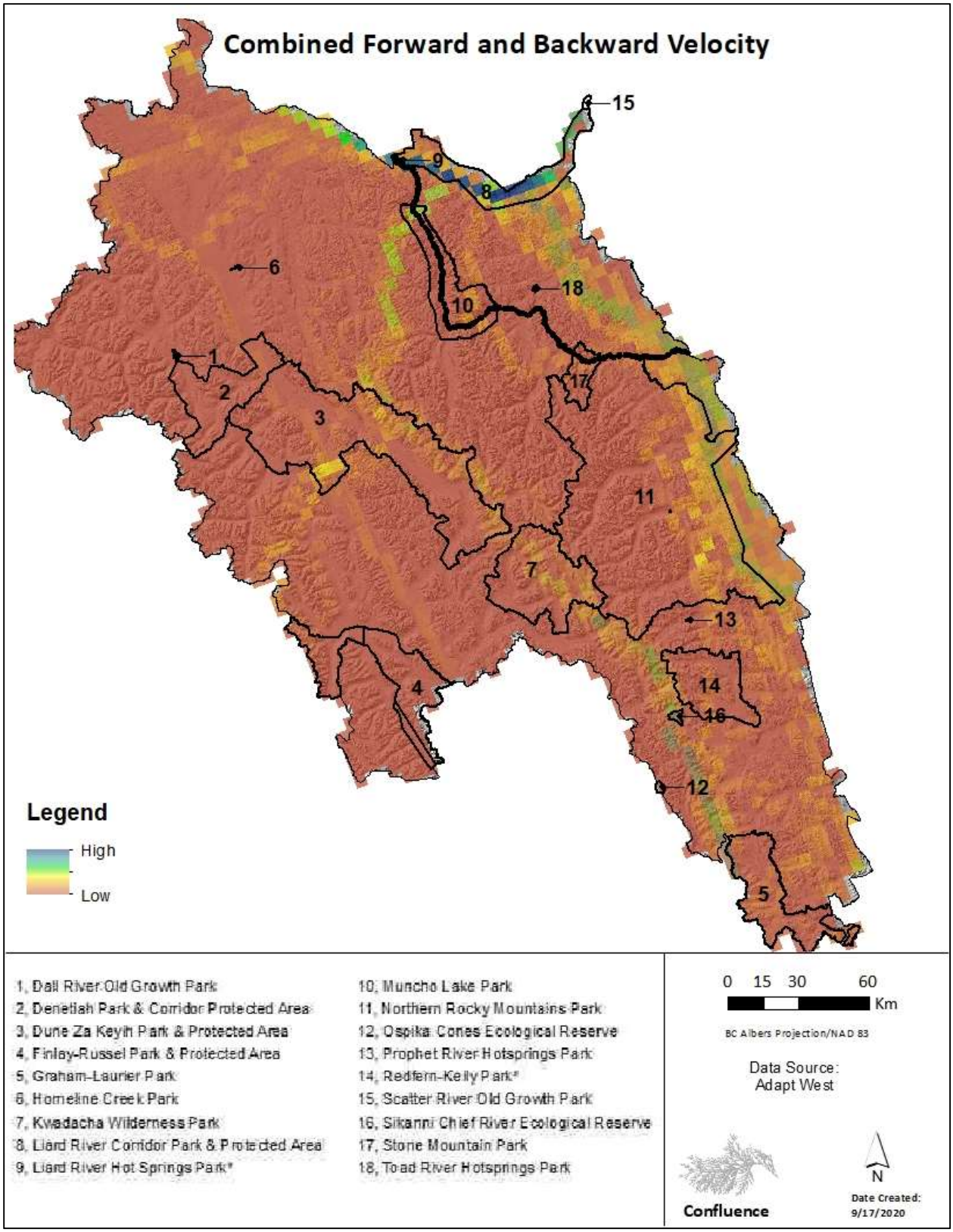


FIGURE 25. COMBINED FORWARD AND BACKWARD CLIMATE VELOCITY

M-KMA Protected Area Role in BC Protected Area System

The Muskwa-Kechika Management Area, and the parks and protected areas within it, are spectacular, large and intact. Containing more than 50 undisturbed watersheds and an intact predator – prey system the M-KMA The protected areas of the M-KMA are set within a matrix of special management that is intended to protect wildlife and wilderness across the larger landscape in perpetuity: an approach that should minimize impact to the protected areas and help integrate them into the larger landscape. Unlike most provincial protected areas, the M-KMA protected area complex is of sufficient size that if connectivity between protected areas is maintained should be large enough to sustain populations of most large mammals.

The M-KMA protected areas play a critical role in representing northern ecosystems and providing intact, connected habitat for species at risk. These protected areas are also invaluable in providing a continental link for species moving up and down the Rocky Mountain cordillera and the trench.

The human footprint within the entirety of the M-KMA is limited to a section of the Alaska Highway and a limited footprint from recreation use either clustered near the Highway or in limited numbers in the backcountry. The past resource-development footprint in the M-KMA was limited and most areas of previous disturbance e.g., seismic lines on the eastern flank of the M-KMA and some mining operations were either actively restored[15] or are recovering with time. No new developments have been initiated in the M-KMA and provisions being developed by the M-KMA Advisory Board (MKAB) and the government are intended to limit the footprint.

There are two likely trajectories for the M-KMA:

- The Kaska Dena have proposed creation of a 40,000 km^2 Indigenous Protected and Conserved Area (KIPCA) in their Ancestral Territory that would encompass the lands outside of the majority of the M-KMA protected areas. Likely designated as a Conservancy under provincial protected areas legislation this option would significantly reduce potential threats from currently permitted resource extraction around the M-KMA protected areas.
- Without the designation as an IPCA, development around the M-KMA protected areas will proceed although likely gradually. The legislation and special requirements for resource development in the area will shield the protected areas from many of the impacts that protected areas normally face. However, some of the important values contained within protected areas, and resulting from the current connectivity of the group of protected areas (e.g., between the Dune Za Keyih and Kwadacha/Northern Rockies parts of the complex) may be threatened.

As awareness about the M-KMA increases and as areas in southern British Columbia become more heavily used, backcountry travel in the M-KMA and the protected areas will likely increase. Although travel time to get to the area and the difficulty and time required to reach protected areas on the increase is significant, anecdotal reports say that recreation use is increasing across the board in the M-KMA. To date, recreation management has been relatively limited. There are some restrictions on

[15] Churchill Copper Mine Reclamation http://muskwa-kechika.com/uploads/documents/mining/churchillmine_cleanup_techreport%202004.pdf

mechanisms of access (e.g., designated ATV trails) but there is little enforcement ability and there are reports of trail access inside a protected area. Recreation use and access to protected areas in the M-KMA will be challenging but a proactive approach is a more positive approach to maintain quality wilderness experiences and the wilderness quality of the M-KMA.

References

AdaptWest. (n.d.). *AdaptWest Climate Adaptation Data Portal*. AdaptWest- A CLimate Adaptation Conservation Planning Database for North America. Retrieved October 20, 2018, from adaptwest.databasin.org

Anderson, L. (2018). *Mapping wilderness character in the Muskwa-Kechika Management Area* [Master's thesis, University of Northern British Columbia]. https://unbc.arcabc.ca/islandora/object/unbc%3A58881?solr_nav%5Bid%5D=d3c8650bcc4b0ca6d1f9&solr_nav%5Bpage%5D=0&solr_nav%5Boffset%5D=0

Carroll, C., Roberts, D. R., Michalak, J. L., Lawler, J. J., Nielsen, S. E., Stralberg, D., Hamann, A., Mcrae, B. H., & Wang, T. (2017). Scale-dependent complementarity of climatic velocity and environmental diversity for identifying priority areas for conservation under climate change. *Global Change Biology*, *23*(11), 4508–4520. https://doi.org/10.1111/gcb.13679

Daust, D., & Price, K. (n.d.). *Natural Disturbance*.

Demarchi, D. A. (1996). *An introduction to the ecoregions of British Columbia*. Wildlife Branch, Ministry of Environment, Lands and Parks Victoria, BC.

Dena Kayeh Institute. (2019). *Kaska Dena Conservation Analysis for an Indigenous Protected and Conserved Area in British Columbia*. Kaska Dene Council.

Gurd, D. B., & Nudds, T. D. (1999). Insular biogeography of mammals in Canadian parks: A re-analysis. *Journal of Biogeography*, *26*(5), 973–982.

Hauer, F. R., Locke, H., Dreitz, V. J., Hebblewhite, M., Lowe, W. H., Muhlfeld, C. C., Nelson, C. R., Proctor, M. F., & Rood, S. B. (2016). Gravel-bed river floodplains are the ecological nexus of glaciated mountain landscapes. *Science Advances*, *2*(6), e1600026.

Heinemeyer, K. (2004). Conservation area design for the Muskwa-Kechika Management Area (MKMA). Vol. 1. Final report. British Columbia Ministry of Sustainable Resource Management, Victoria. *British Columbia, Canada*.

Krosby, M., Theobald, D. M., Norheim, R., & McRae, B. H. (2018). Identifying riparian climate corridors to inform climate adaptation planning. *PloS One*, *13*(11), e0205156.

Landry, M., Thomas, V. G., & Nudds, T. D. (2001). Sizes of Canadian national parks and the viability of large mammal populations: Policy implications. *The George Wright Forum*, *18*, 13–23. http://www.georgewright.org/181landry.pdf

Lousier, J. D., Voller, J., McNay, R. S., Sulyma, R., & Brumovsky, V. (2009). Response of wildlife to prescribed fire in the Peace Region of British Columbia: A problem analysis. *Wildlife Infometrics Inc. Report*, *316*.

Ministry of Environment, M. of F., Lands, and Natural Resource Operations. (2017). *Interim Assessment Protocol for Grizzly Bear in British Columbia (Tier 1 Provincial Scale Grizzly Bear Assessment Protocol)* (Version 1.1; p. 39).

Stralberg, D., Carroll, C., Pedlar, J. H., Wilsey, C. B., McKenney, D. W., & Nielsen, S. E. (2018). Macrorefugia for North American trees and songbirds: Climatic limiting factors and multi-scale topographic influences. *Global Ecology and Biogeography*, *27*(6), 690–703.

Suzuki, N., & Parker, K. L. (2016). Potential conflict between future development of natural resources and high-value wildlife habitats in boreal landscapes. *Biodiversity and Conservation*, *25*(14), 3043–3073. https://doi.org/10.1007/s10531-016-1219-2

Suzuki, N., & Parker, K. L. (2019). Proactive conservation of high-value habitat for woodland caribou and grizzly bears in the boreal zone of British Columbia, Canada. *Biological Conservation*, *230*, 91–103. https://doi.org/10.1016/j.biocon.2018.12.013

Weaver, J. (2019). *The Greater Muskwa-Kechika—Building a better network for protecting wildlife and wildlands > WCS Canada*. https://www.wcscanada.org/Latest-News/ID/12920/The-Greater-Muskwa-Kechika--Building-a-better-network-for-protecting-wildlife-and-wildlands.aspx

Wong, C., Sandmann, H., & Dorner, B. (2003). Historical variability of natural disturbances in British Columbia: A literature review. FORREX-Forest Research Extension Partnership, Kamloops. *FS12. Pdf*.

Woods, A., & Branch, F. (2000). *Historical fisheries information from the Muskwa-Kechika management area*. Tech. Report for Fisheries Branch, Ministry of Environment, Lands and Parks ….

Yellowstone to Yukon Conservation Initiative, J. (2012). *Muskwa-Kechika Management Area Biodiversity Conservation and Climate Change Assessment*. Yellowstone to Yukon Conservation Initiative.

Appendices

Appendix 1. Wildlife species (vertebrate) at risk with potential to occur within M-KMA protected areas

Latin Name	Common Name	Global Status	BC Status
Recurvirostra americana	American Avocet	G5	Blue
Botaurus lentiginosus	American Bittern	G5	Blue
Pluvialis dominica	American Golden-Plover	G5	Blue
Sorex palustris	American Water Shrew	G5	Blue
Pelecanus erythrorhynchos	American White Pelican	G4	Red
Icterus galbula	Baltimore Oriole	G5	Blue
Tyto alba	Barn Owl	G5	Red
Hirundo rustica	Barn Swallow	G5	Blue
Setophaga castanea	Bay-breasted Warbler	G5	Red
Eptesicus fuscus	Big Brown Bat	G5	Yellow
Cypseloides niger	Black Swift	G4	Blue
Setophaga virens	Black-throated Green Warbler	G5	Blue
Dolichonyx oryzivorus	Bobolink	G5	Blue
Branta bernicla	Brant	G5	Blue
Buteo platypterus	Broad-winged Hawk	G5	Blue
Larus californicus	California Gull	G5	Blue
Cardellina canadensis	Canada Warbler	G5	Blue
Setophaga tigrina	Cape May Warbler	G5	Blue
Rangifer tarandus pop. 15	Caribou (Northern Mountain Population)	G5T4T5	Blue
Hydroprogne caspia	Caspian Tern	G5	Blue
Ascaphus truei	Coastal Tailed Frog	G4	Yellow
Ochotona collaris	Collared Pika	G5	Blue
Chordeiles minor	Common Nighthawk	G5	Yellow
Oporornis agilis	Connecticut Warbler	G4G5	Blue
Ovis dalli dalli	Dall's Sheep	G5T5	Blue
Phalacrocorax auritus	Double-crested Cormorant	G5	Blue
Podiceps nigricollis	Eared Grebe	G5	Blue
Coccothraustes vespertinus	Evening Grosbeak	G5	Yellow
Pekania pennanti	Fisher (Boreal Pop)	S3	Blue
Pekania pennant	Fisher (Columbia Pop)	S2	Red
Sterna forsteri	Forster's Tern	G5	Red

Hiodon alosoides	Goldeye	G5	Blue
Ardea herodias herodias	Great Blue Heron, herodias subspecies	G5T5	Blue
Ursus arctos	Grizzly Bear	G4	Blue
Falco rusticolus	Gyrfalcon	G5	Blue
Lasiurus cinereus	Hoary Bat	G3G4	Yellow
Limosa haemastica	Hudsonian Godwit	G4	Red
Chondestes grammacus	Lark Sparrow	G5	Blue
Myotis lucifugus	Little Brown Myotis	G3	Yellow
Myotis evotis	Long-eared Myotis	G5	Yellow
Myotis volans	Long-legged Myotis	G4G5	Yellow
Clangula hyemalis	Long-tailed Duck	G5	Blue
Zapus hudsonius alascensis	Meadow Jumping Mouse, alascensis subspecies	G5T4T5	Blue
Oreamnos americanus	Mountain Goat	G5	Blue
Ammospiza nelsoni	Nelson's Sparrow	G5	Red
Accipiter gentilis atricapillus	Northern Goshawk, atricapillus subspecies	G5T5	Blue
Myotis septentrionalis	Northern Myotis	G1G2	Blue
Contopus cooperi	Olive-sided Flycatcher	G4	Blue
Stercorarius parasiticus	Parasitic Jaeger	G5	Red
Falco peregrinus anatum	Peregrine Falcon, anatum subspecies	G4T4	Red
Bison bison bison	Plains Bison	G4T4	Red
Falco mexicanus	Prairie Falcon	G5	Red
Progne subis	Purple Martin	G5	Blue
Phalaropus lobatus	Red-necked Phalarope	G4G5	Blue
Buteo lagopus	Rough-legged Hawk	G5	Blue
Archilochus colubris	Ruby-throated Hummingbird	G5	Blue
Euphagus carolinus	Rusty Blackbird	G4	Blue
Limnodromus griseus	Short-billed Dowitcher	G5	Blue
Asio flammeus	Short-eared Owl	G5	Blue
Lasionycteris noctivagans	Silver-haired Bat	G3G4	Yellow
Calcarius pictus	Smith's Longspur	G4G5	Blue
Ovis dalli stonei	Stone's Sheep	G5T4	Blue
Melanitta perspicillata	Surf Scoter	G5	Blue
Buteo swainsoni	Swainson's Hawk	G5	Red
Sorex tundrensis	Tundra Shrew	G5	Red
Bartramia longicauda	Upland Sandpiper	G5	Red
Tringa incana	Wandering Tattler	G4G5	Blue
Aechmophorus occidentalis	Western Grebe	G5	Red
Anaxyrus boreas	Western Toad	G4	Yellow

Troglodytes hiemalis	Winter Wren	G5	Blue
Gulo gulo luscus	Wolverine, luscus subspecies	G4T4	Blue
BBos bison athabascae	Wood Bison	G4T3Q	Red
Coturnicops noveboracensis	Yellow Rail	G4	Red
Icteria virens	Yellow-breasted Chat	G5	Red

Appendix 2. Invertebrate species at risk with potential to occur within M-KMA protected areas

Scientific Name	English Name	Global Status	BC List
Oeneis alberta	Alberta Arctic	G5	Red
Boloria alberta	Albert's Fritillary	G3	Blue
Speyeria aphrodite manitoba	Aphrodite Fritillary, manitoba subspecies	G5T5	Blue
Agriades glandon lacustris	Arctic Blue, lacustris subspecies	G5TNR	Blue
Carterocephalus palaemon mandan	Arctic Skipper, mandan subspecies	G5T5	Red
Hesperia assiniboia	Assiniboine Skipper	G5	Red
Boloria astarte distincta	Astarte Fritillary, distincta subspecies	G5T5	Blue
Galba truncatula	Attenuate Fossaria	G5	Blue
Boloria natazhati	Beringian Fritillary	G3	Blue
Lycaena hyllus	Bronze Copper	G5	Blue
Vertigo arthuri	Callused Vertigo	G5	Blue
Coenonympha tullia benjamini	Common Ringlet, benjamini subspecies	G5T5	Blue
Cercyonis pegala nephele	Common Wood-nymph, nephele subspecies	G5T5	Blue
Satyrium titus titus	Coral Hairstreak, titus subspecies	G5T4T5	Red
Agriades optilete	Cranberry Blue	G5	Blue
Polites draco	Draco Skipper	G5	Blue
Callophrys niphon	Eastern Pine Elfin	G5	Red
Somatochlora forcipata	Forcipate Emerald	G5	Blue
Lymnaea atkaensis	Frigid Lymnaea	G4G5	Blue
Colias gigantea gigantea	Giant Sulphur, gigantea subspecies	G5T5	Blue
Galba obrussa	Golden Fossaria	G5	Blue
Speyeria cybele pseudocarpenteri	Great Spangled Fritillary, pseudocarpenteri subspecies	G5T5	Red
Euchloe naina	Green Marble	G4G5	Blue
Colias hecla	Hecla Sulphur	G5	Blue
Physella wrighti	Hotwater Physa	G1Q	Red
Oeneis jutta alaskensis	Jutta Arctic, alaskensis subspecies	G5T5	Blue
Somatochlora kennedyi	Kennedy's Emerald	G5	Blue
Euchloe ausonides ogilvia	Large Marble, ogilvia subspecies	G5T5	Blue
Pieris marginalis guppyi	Margined White, guppyi subspecies	G5T3Q	Blue
Planorbula campestris	Meadow Rams-horn	G4G5	Blue
Colias meadii	Mead's Sulphur	G5	Blue
Speyeria mormonia eurynome	Mormon Fritillary, eurynome subspecies	G5TNR	Red
Erebia mackinleyensis	Mt.McKinley Alpine	G5	Red

Pristiloma arcticum	Northern Tightcoil	G3G4	Blue
Papilio machaon hudsonianus	Old World Swallowtail, hudsonianus subspecies	G5T5	Red
Papilio machaon pikei	Old World Swallowtail, pikei subspecies	G5T3	Red
Oeneis philipi	Philip's Arctic	G3G5	Red
Parnassius phoebus	Phoebus Parnassian	G5	Red
Ischnura damula	Plains Forktail	G5	Red
Oeneis polixenes yukonensis	Polixenes Arctic, yukonensis subspecies	G5T5	Red
Coenagrion angulatum	Prairie Bluet	G5	Blue
Somatochlora brevicincta	Quebec Emerald	G4	Blue
Calopteryx aequabilis	River Jewelwing	G5	Blue
Pisidium fallax	River Peaclam	G5	Blue
Acroloxus coloradensis	Rocky Mountain Capshell	G3G4	Blue
Physella propinqua	Rocky Mountain Physa	G5Q	Blue
Pontia sisymbrii beringiensis	Spring White, beringiensis subspecies	G5T3T4	Red
Sphaerium striatinum	Striated Fingernailclam	G5	Blue
Satyrium liparops	Striped Hairstreak	G5	Red
Phyciodes batesii	Tawny Crescent	G5	Blue
Planorbula armigera	Thicklip Rams-horn	G5	Red
Valvata tricarinata	Threeridge Valvata	G5	Red
Oeneis uhleri	Uhler's Arctic	G5	Blue
Boloria epithore sigridae	Western Meadow Fritillary, sigridae subspecies	G5T2T4	Blue
Erebia pawloskii	Yellow-dotted Alpine	G5	Red

Appendix 3. Plant species at risk with reported occurrences in M-KMA protected areas[16]

Protected Areas Name	Common Name	Scientific Name	BC Status	Provincial Ranking	Global Ranking
Kwadacha Wilderness Park	Smooth Draba	Draba glabella	Red	SH	G5
	Milky Draba	Draba lactea	Yellow	S4?	G5
	Raup's Willow	Salix raupii	Red	S2	G2
	Smooth Draba	Draba glabella	Red	SH	G5
Liard River Corridor Park	Taimyr Campion	Silene ostenfeldii	Blue	S3?	G4?
	American Chamaerhodos	Chamaerhodos erecta	Yellow	S3S4	G5
	Davis' Locoweed	Oxytropis campestris var. davisii	Blue	S3	G5T3
	White Adder's-mouth Orchid	Malaxis brachypoda	Yellow	S3S4	G4G5Q
	Hudson Bay Sedge	Carex heleonastes	Yellow	S3S4	G4
Liard River Hot Springs Park	American Chamaerhodos	Chamaerhodos erecta	Yellow	S3S4	G5
	Davis' Locoweed	Oxytropis campestris var. davisii	Blue	S3	G5T3
	Yukon Lupine	Lupinus kuschei	Blue	S2S3	G3G4
	White Adder's-mouth Orchid	Malaxis brachypoda	Yellow	S3S4	G4G5Q
	Hudson Bay Sedge	Carex heleonastes	Yellow	S3S4	G4
	American Chamaerhodos	Chamaerhodos erecta	Yellow	S3S4	G5
	Yukon Lupine	Lupinus kuschei	Blue	S2S3	G3G4
	Davis' Locoweed	Oxytropis campestris var. davisii	Blue	S3	G5T3
	Yukon Lupine	Lupinus kuschei	Blue	S2S3	G3G4
	White Adder's-mouth Orchid	Malaxis brachypoda	Yellow	S3S4	G4G5Q
	Hudson Bay Sedge	Carex heleonastes	Yellow	S3S4	G4
	Davis' Locoweed	Oxytropis campestris var. davisii	Blue	S3	G5T3
Muncho Lake Park	Marsh Felwort	Lomatogonium rotatum	Blue	S3	G5
	Porsild's Bryum	Haplodontium macrocarpum	Red	S1	G2G3

[16] These observations are not from systematic surveys but rather incidental observations and thus reported in PPA closer to major access routes. These and other species may also occur in the other M-KMA protected areas.

	Arctic Bladderpod	Physaria arctica	Blue	S3	G4
Northern Rocky Mountains	Northern Swamp Willowherb	Epilobium davuricum	Red	S1S3	G5
	Whitish Rush	Juncus triglumis ssp. albescens	Blue	S3	G5
	Northern Swamp Willowherb	Epilobium davuricum	Red	S1S3	G5
	Whitish Rush	Juncus triglumis ssp. albescens	Blue	S3	G5
	Edwards Wallflower	Eutrema edwardsii	Yellow	S3S4	G4
	Abbreviated Bluegrass	Poa abbreviata ssp. pattersonii	Blue	S2S3	G5T5
	Arctic Bladderpod	Physaria arctica	Blue	S3	G4
	Tundra Milk-vetch	Astragalus umbellatus	Yellow	S3S4	G4
	Rock-dwelling Sedge	Carex petricosa var. petricosa	Blue	S3	G4TNR
	Short-leaved Sedge	Carex fuliginosa	Yellow	S3S4	G5
	Entire-leaved Daisy	Hulteniella integrifolia	Blue	S3	G5
	Tundra Milk-vetch	Astragalus umbellatus	Yellow	S3S4	G4
	Rock-dwelling Sedge	Carex petricosa var. petricosa	Blue	S3	G4TNR
	Short-leaved Sedge	Carex fuliginosa	Yellow	S3S4	G5
	Entire-leaved Daisy	Hulteniella integrifolia	Blue	S3	G5
	Northern Swamp Willowherb	Epilobium davuricum	Red	S1S3	G5
	Tundra Milk-vetch	Astragalus umbellatus	Yellow	S3S4	G4
	Rock-dwelling Sedge	Carex petricosa var. petricosa	Blue	S3	G4TNR
	Short-leaved Sedge	Carex fuliginosa	Yellow	S3S4	G5
	Entire-leaved Daisy	Hulteniella integrifolia	Blue	S3	G5
	Whitish Rush	Juncus triglumis ssp. albescens	Blue	S3	G5
	Tundra Milk-vetch	Astragalus umbellatus	Yellow	S3S4	G4
	Rock-dwelling Sedge	Carex petricosa var. petricosa	Blue	S3	G4TNR
	Short-leaved Sedge	Carex fuliginosa	Yellow	S3S4	G5

	Entire-leaved Daisy	Hulteniella integrifolia	Blue	S3	G5
	Northern Swamp Willowherb	Epilobium davuricum	Red	S1S3	G5
	Whitish Rush	Juncus triglumis ssp. albescens	Blue	S3	G5
Redfern-Keily Park	Mount Sheldon Butterweed	Senecio sheldonensis	Yellow	S3S4	G3
	Marsh Felwort	Lomatogonium rotatum	Blue	S3	G5
	Porsild's Draba	Draba porsildii	Blue	S3	G3G4
	Hornemann's Willowherb	Epilobium hornemannii ssp. behringianum	Blue	S2S3	G5T4
	Davis' Locoweed	Oxytropis campestris var. davisii	Blue	S3	G5T3
	Smooth Draba	Draba glabella	Red	SH	G5
	Porsild's Draba	Draba porsildii	Blue	S3	G3G4
	Mount Sheldon Butterweed	Senecio sheldonensis	Yellow	S3S4	G3
	Hornemann's Willowherb	Epilobium hornemannii ssp. behringianum	Blue	S2S3	G5T4
	Davis' Locoweed	Oxytropis campestris var. davisii	Blue	S3	G5T3
	Smooth Draba	Draba glabella	Red	SH	G5
Stone Mountain Park	Edwards Wallflower	Eutrema edwardsii	Yellow	S3S4	G4
	Abbreviated Bluegrass	Poa abbreviata ssp. pattersonii	Blue	S2S3	G5T5
	Arctic Bladderpod	Physaria arctica	Blue	S3	G4
	Edwards Wallflower	Eutrema edwardsii	Yellow	S3S4	G4
	Abbreviated Bluegrass	Poa abbreviata ssp. pattersonii	Blue	S2S3	G5T5
	Arctic Bladderpod	Physaria arctica	Blue	S3	G4
	Austrian Draba	Draba fladnizensis	Yellow	S3S4	G4
	Entire-leaved Daisy	Hulteniella integrifolia	Blue	S3	G5
	Edwards Wallflower	Eutrema edwardsii	Yellow	S3S4	G4
	Short-leaved Sedge	Carex fuliginosa	Yellow	S3S4	G5

	Rock-dwelling Sedge	Carex petricosa var. petricosa	Blue	S3	G4TNR
	Abbreviated Bluegrass	Poa abbreviata ssp. pattersonii	Blue	S2S3	G5T5
	Arctic Bladderpod	Physaria arctica	Blue	S3	G4
	Austrian Draba	Draba fladnizensis	Yellow	S3S4	G4

Note: There are only three listed ecological communities at risk within the MKMA none of which are within the boundaries of a protected area.

Appendix 4. Fish species at risk with potential to occur within M-KMA protected areas

Scientific Name	English Name	Global Status	BC List
Stenodus leucichthys	Inconnu	G5	Blue
Couesius plumbeus pop. 2	Lake Chub - Liard Hot Springs Populations	G5TNR	Red
Chrosomus eos x Chrosomus neogaeus	Northern Redbelly Dace X Finescale Dace	GNA	Red
Coregonus sardinella	Least Cisco	G5	Blue
Coregonus nasus	Broad Whitefish	G5	Red
Salvelinus confluentus	Bull Trout	G5	Blue
Coregonus artedi	Cisco	G5	Red
Oncorhynchus clarkii clarkii	Cutthroat Trout, clarkii subspecies	G5T4	Blue
Oncorhynchus clarkii lewisi	Cutthroat Trout, lewisi subspecies	G5T4	Blue
Notropis hudsonius	Spottail Shiner	G5	Red