

NPSCAPE PRODUCTS

Presenting example of maps and statistical tables derived through NPScape

November, 2010



A collaborative project between

National Park Service,

University of Calgary,

Crown Managers Partnership, and

US Fish and Wildlife Service Landscape Conservation Cooperative

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NPScape Background and Audience

NPScape is a national landscape dynamics monitoring project that produces and delivers to parks a suite of landscape-scale data sets, maps, reports, and other products to inform resource management and planning at local, regional, and national scales. Changes in the composition and configuration of different landcover types within and adjacent to National Parks has been shown to greatly affect biological and physical processes within those parks, such as habitat availability, animal movements, potential for invasion by exotic plants, water quality, and in-stream habitat for fish and other aquatic organisms. Information about changes and trends in landscape-scale indicators in and around parks can help park managers anticipate, plan for, and manage associated effects to park resources.

The target audience for NPScape spans the range from GIS specialists who will benefit from the geospatial data and tools, to ecologists or park resource management specialists who will be interested in general landscape metrics presented in a local and regional context, to park superintendents who can incorporate the maps and graphics into reports or briefings. The methods can be applied to multiple scales, but it is important to note that the intention of NPScape is to provide a broad-brush insight into landscape level dynamics.

NPScape Measures

At its core, NPScape delivers a suite of products that focus on a set of information-rich, landscape-scale indicators for 270+ parks with significant natural resources. The initial analyses summarized and delivered measures in 6 major categories (population, housing, roads, landcover, pattern, and conservation status) that broadly address the environmental drivers, natural attributes, and conservation context of National Park Service (NPS) units. Example measures in each category are illustrated in the table below. In aggregate, these measures contribute to assessments of current natural resource status, potential threats, and conservation vulnerability and opportunity.

Category	Measure
Population	Total Density Recent Change in Total and Density Historic Change by County Projected Change by County Percent total Density
Housing	Current Density Recent Change in Density Historic Density Projected Density
Conservation Status	Area Protected Ownership Area / Category Ownership
Roads	Road Density Weighted All roads Major roads Distance from Roads All roads Major roads Area without Roads > 500 m from all roads > 500 m from major roads
Landcover	Percent Natural vs. Converted Change in Natural vs. Converted Area / Category Percent Impervious
Pattern	Grassland Morphology Forest Morphology Patch Size (grassland) Patch Size (forest)

NPScape Products

The key products from NPScape are data, methods, analyses, and results. NPScape products represent the culmination of a significant amount of data mining, processing, analysis, and summarization. The parameters and scale of these products can be customized. Deliverables include:

- All source and processed data and associated metadata;
- A draft interpretive guide describing the ecological relevance of NPScape data and measures as they relate to our understanding of current and anticipated landscape dynamics;
- An example draft report demonstrating the applicability of NPScape to management and planning at one park (Buffalo NR);
- A Standard Operating Procedure (SOP) for each measure consistent with I&M protocols and data processing scripts for parks and networks to efficiently generate new customized products;
- Scale-based maps of each measure in multiple formats for non-GIS specialists, including interactive kml files for Google Earth and geo-pdf files for Adobe Acrobat;
- Graphical summaries of the measures to enable parks and networks to understand their results in a comparative context; and
- A Measurement Description Summary (MDS) that details the data relevant to each NPScape measure and how the measure relates to landscape dynamics.

NPScape Product Status for the Crown of the Continent Ecosystem

The National Park Service, Natural Resource Program Center has generated customized NPScape products for the Crown of the Continent Ecosystem (CCE). These outputs are produced for four areas of analysis (AOAs):

- CCE Extent
- North American Commission for Environmental Cooperation (CEC) Level III Ecoregions
- CCE Watersheds
- Waterton-Glacier International Peace Park

Currently, five measures have been delivered and are outlined in this document:

- Road Density (km/km²)
- Distance from Roads (Euclidian distance in meters)
- Landcover (percent area for each defined landcover class)
- Natural vs Converted (based on the landcover data)
- Morphology (forest and grassland spatial connectivity patterns)

There are six measures in which the products are pending delivery:

- Morphology Spatial Pattern Analysis (MSPA)
- Effective mesh size
- Population density
- Population projection
- MODIS graphed summaries
- Table summaries by AOA
 - Roads
 - Population
 - Housing
 - Stream and road crossings
 - Riparian corridor



Figure 1. Scale overview: Crown of the Continent and Waterton-Glacier International Peace Park.

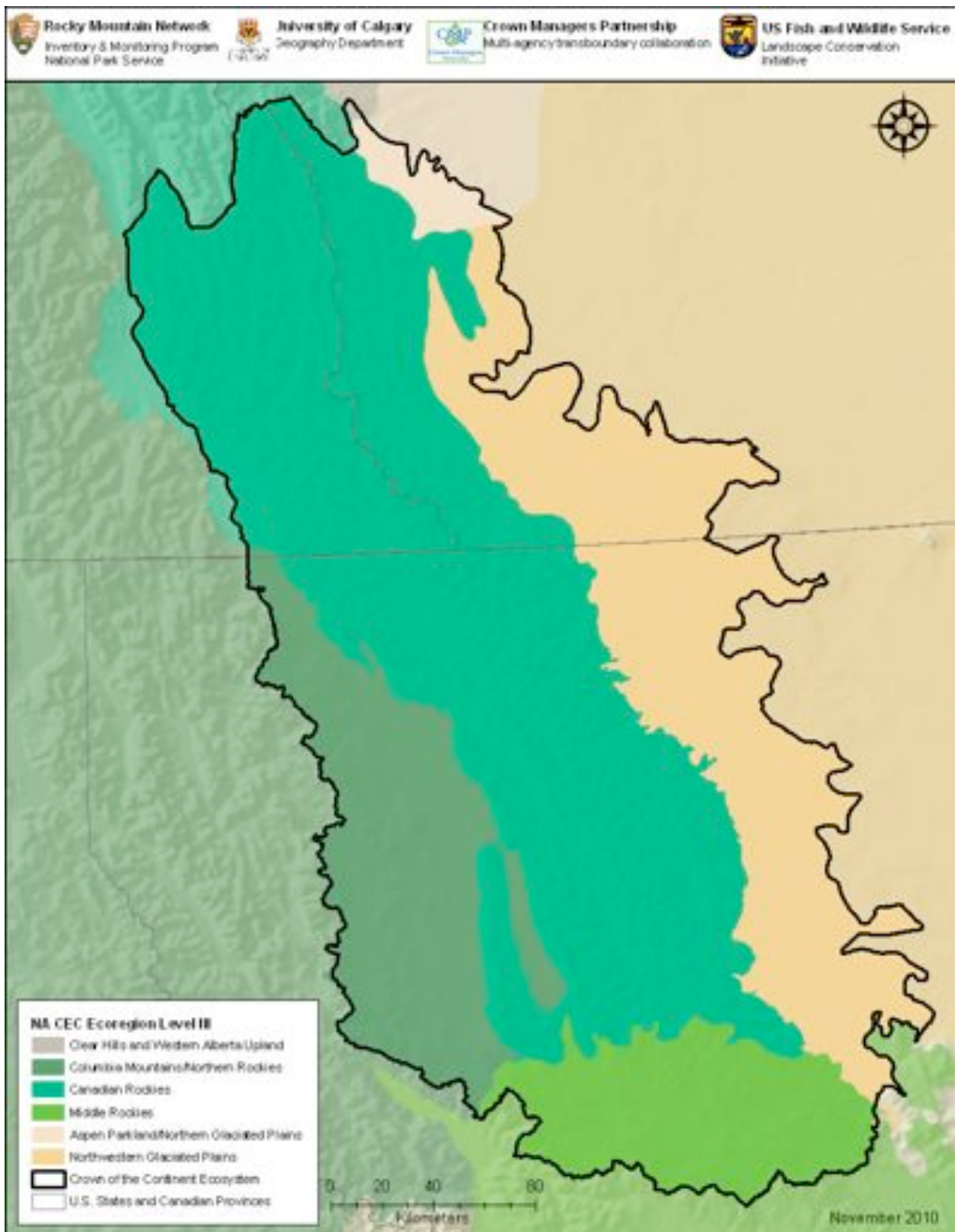


Figure 2. Scale overview: Ecoregions.

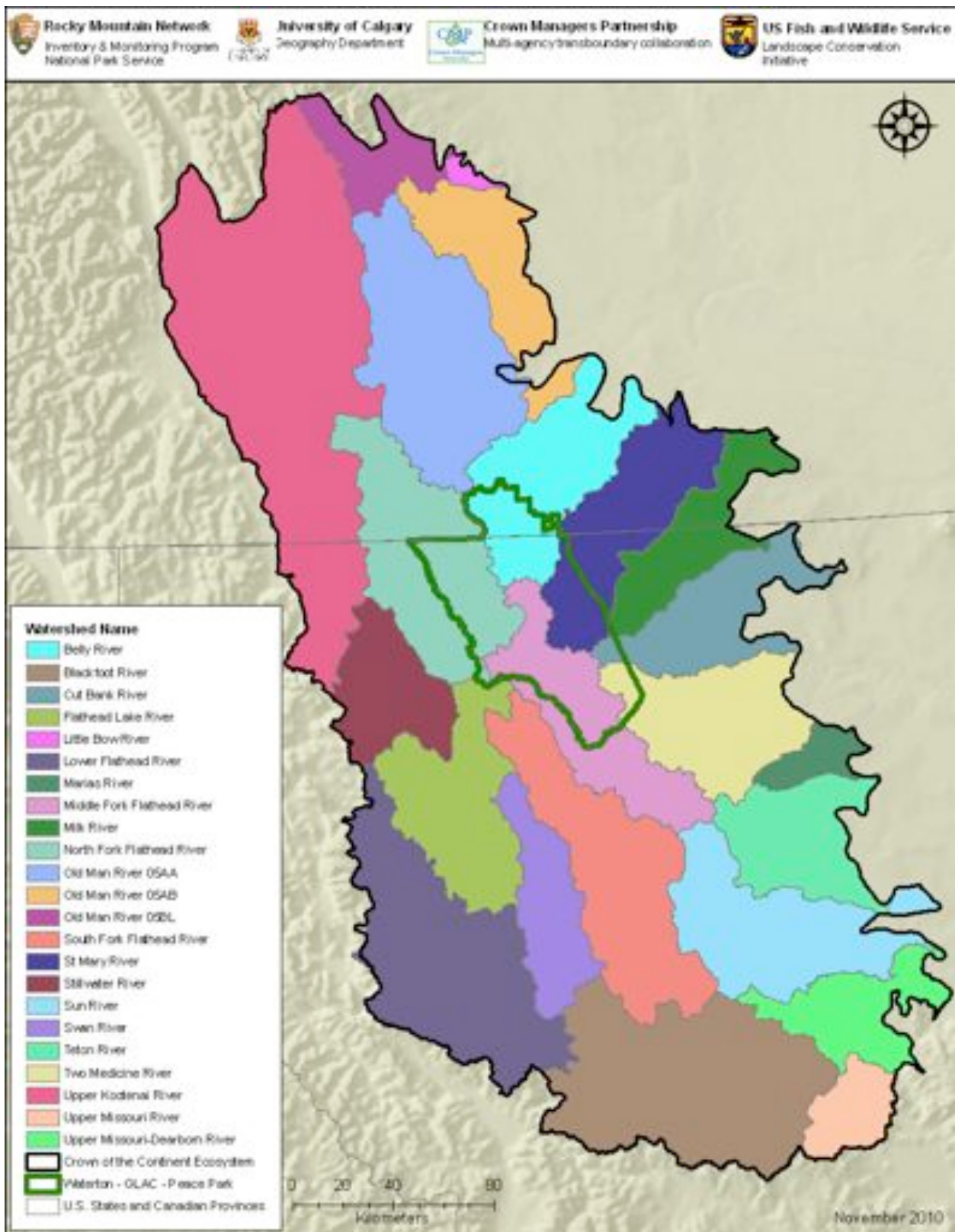


Figure 3. Scale overview: Watersheds.

Landcover

Definitions

Agriculture – Cultivated agricultural land; annual or perennial crops; pasture

Barren – Barren land; exposed land (manually assessed); rock or rubble (manually assessed)

Coniferous Forest – Coniferous forest with dense, sparse, or open canopy

Deciduous Forest – Deciduous forest with dense, sparse, or open canopy

Developed – Impervious land

Herb/Grassland – Herbaceous land; grassland

Mixedwood – Mixed wood with dense, sparse, or open canopy

Scrub/Shrub – Tall or low shrubland; exposed land (manually assessed); rock or rubble (manually assessed)

Snow/Ice – Permanent snow or ice

Water – Permanent water body

Wetland – Wetland with tree, shrub, or herbaceous cover

No Data – Data gap (present in all sources); cloud (present in all sources); shadow (present in all sources)

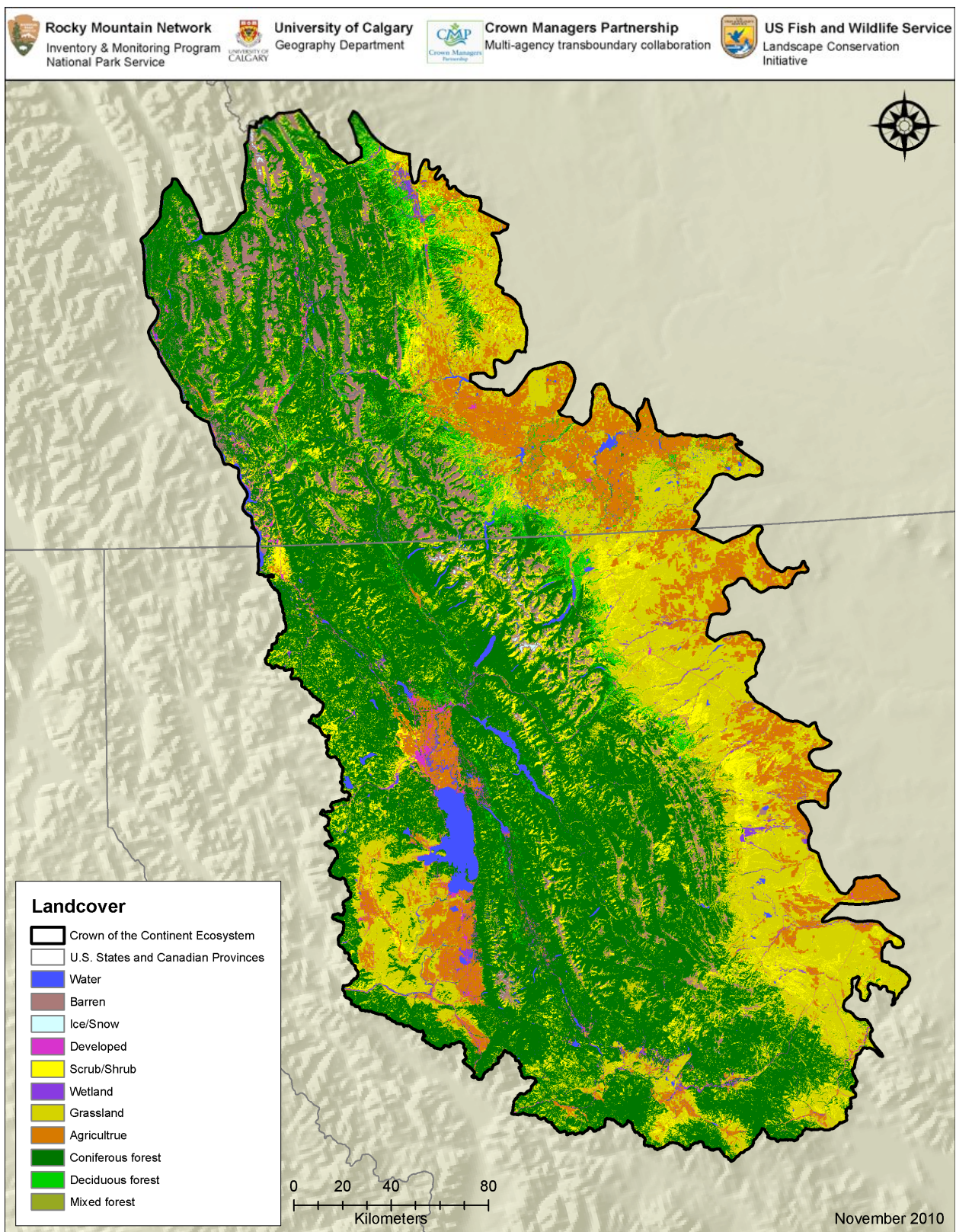


Figure 4. NPScape product - Landcover. Scale: Crown of the Continent Ecosystem.

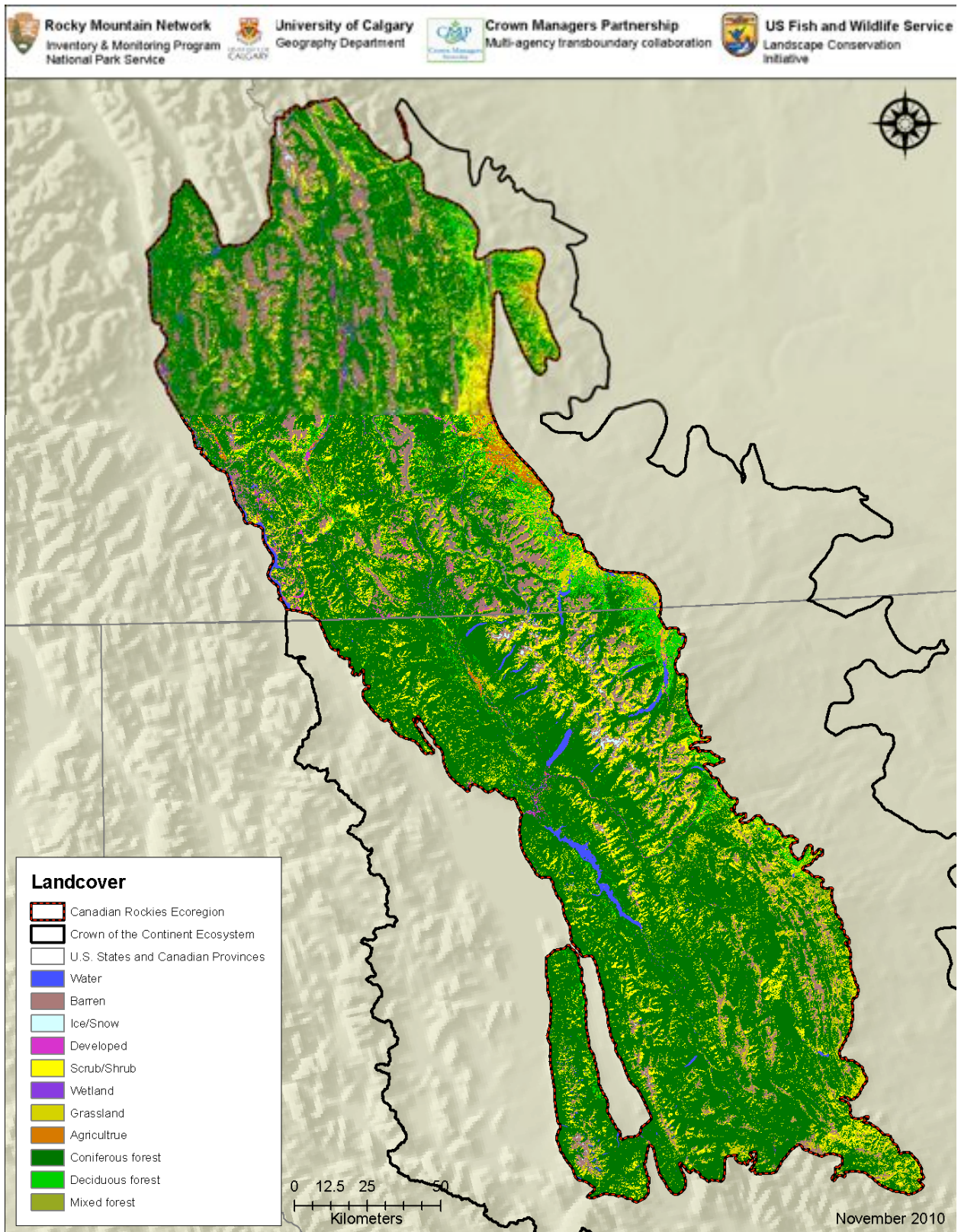


Figure 5. NPScape product - Landcover. Scale: Canadian Rockies Ecoregion.

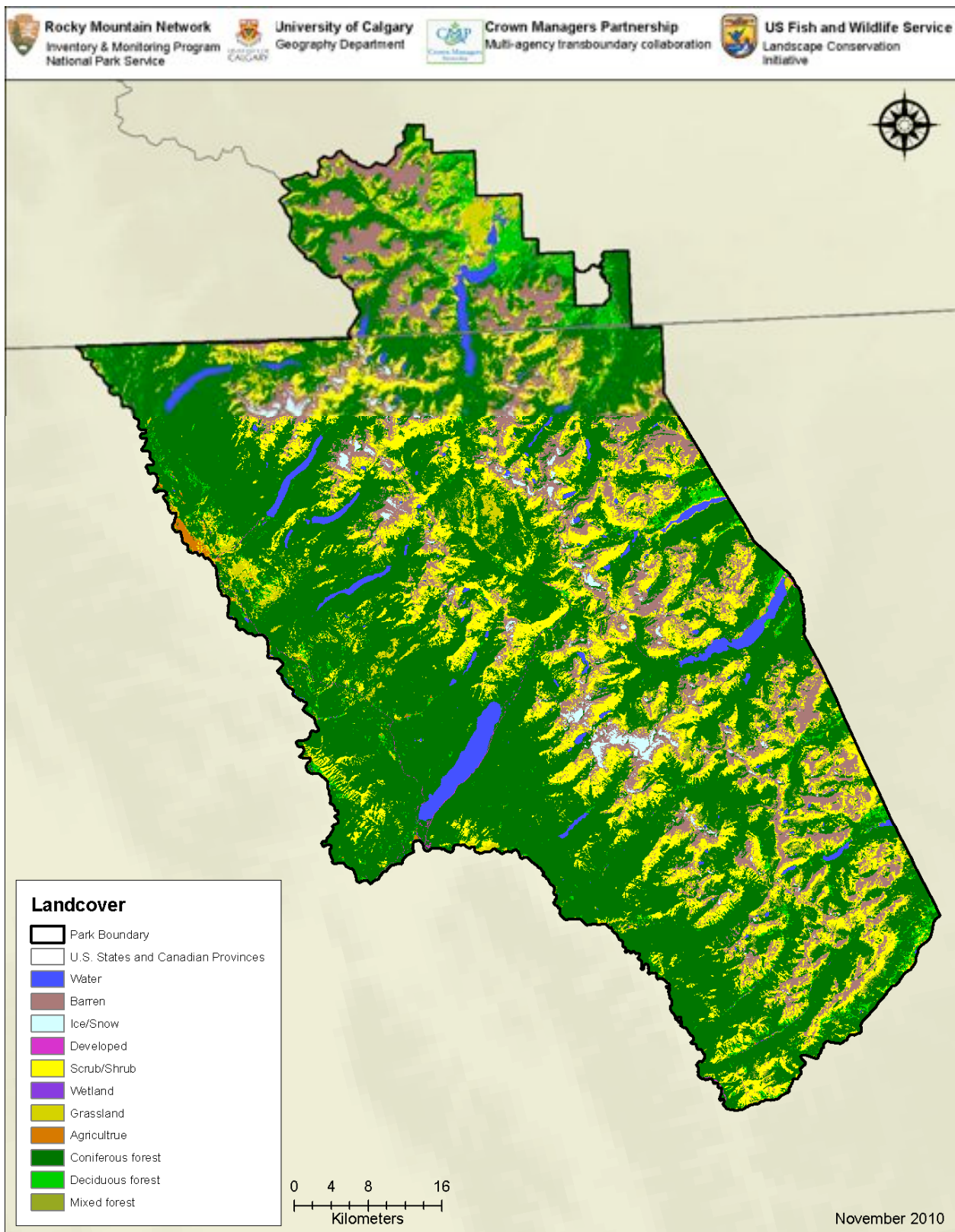


Figure 6. NPScape product - Landcover. Scale: Waterton-Glacier International Peace Park.

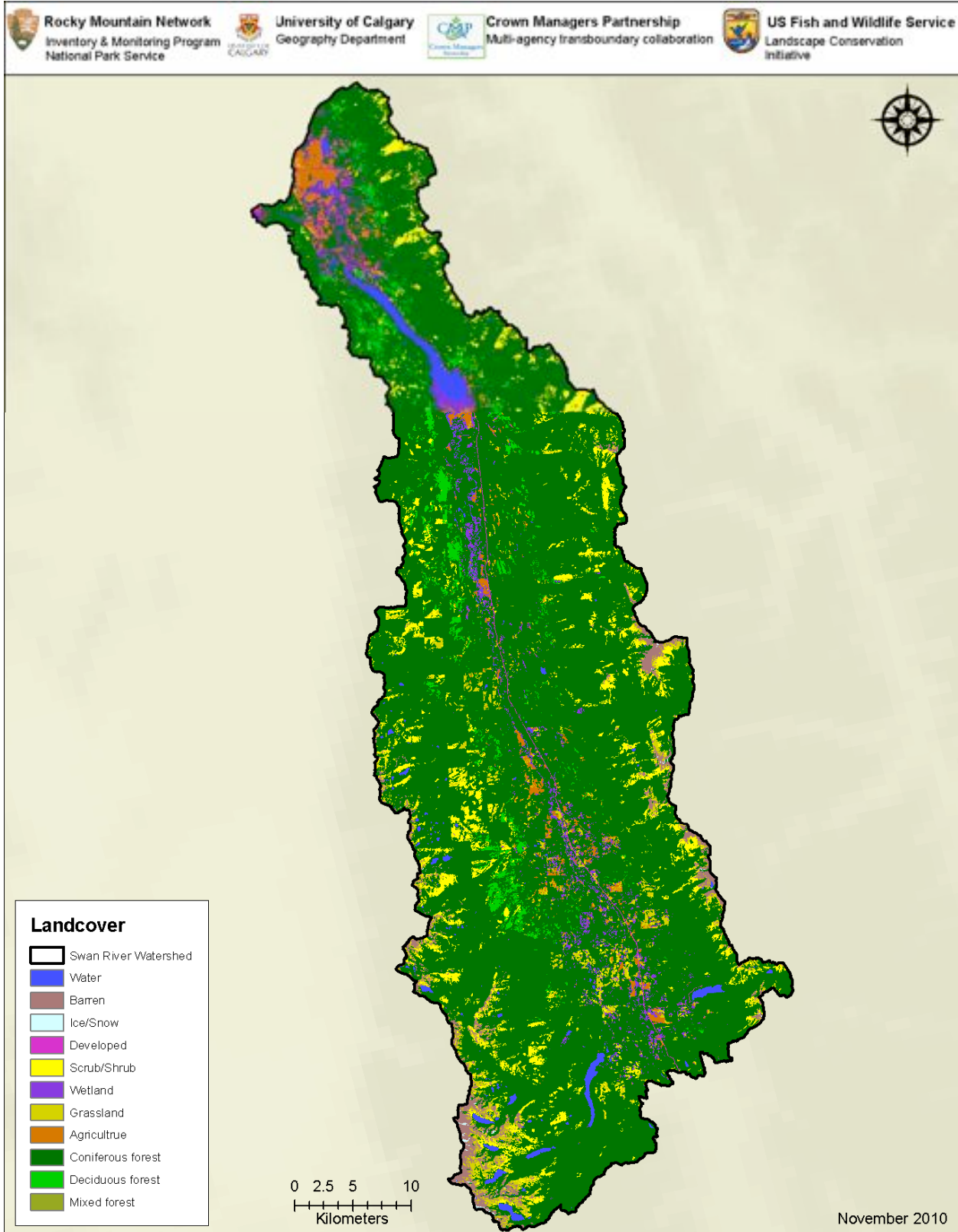


Figure 7. NPScape product - Landcover. Scale: Swan River Watershed.

Table 1. Landcover statistics derived through NPScape at various scales: (A) Crown of the Continent, (B) Ecoregions, (C) Waterton-Glacier International Peace Park, and (D) watersheds.

(A) CCE scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Water	72188.50	1358.60	1.88	Crown of the Continent
Barren	72188.50	3600.59	4.99	Crown of the Continent
Snow/Ice	72188.50	70.14	0.10	Crown of the Continent
Developed	72188.50	790.33	1.09	Crown of the Continent
Scrub/Shrub	72188.50	7803.64	10.81	Crown of the Continent
Wetland	72188.50	758.61	1.05	Crown of the Continent
Grassland	72188.50	13830.00	19.16	Crown of the Continent
Agriculture	72188.50	7348.83	10.18	Crown of the Continent
Coniferous Forest	72188.50	34077.50	47.21	Crown of the Continent
Deciduous Forest	72188.50	2217.48	3.07	Crown of the Continent
Mixed Forest	72188.50	332.79	0.46	Crown of the Continent

(B) Ecoregions scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Water	1052.98	10.07	0.96	Aspen Parkland Northern Glaciated Plains
Barren	1052.98	1.87	0.18	Aspen Parkland Northern Glaciated Plains
Developed	1052.98	4.27	0.41	Aspen Parkland Northern Glaciated Plains
Scrub/Shrub	1052.98	147.81	14.04	Aspen Parkland Northern Glaciated Plains
Wetland	1052.98	68.05	6.46	Aspen Parkland Northern Glaciated Plains
Grassland	1052.98	308.23	29.27	Aspen Parkland Northern Glaciated Plains
Agriculture	1052.98	198.22	18.82	Aspen Parkland Northern Glaciated Plains
Coniferous Forest	1052.98	88.09	8.37	Aspen Parkland Northern Glaciated Plains
Deciduous Forest	1052.98	224.52	21.32	Aspen Parkland Northern Glaciated Plains
Mixed Forest	1052.98	1.86	0.18	Aspen Parkland Northern Glaciated Plains
Water	36430.50	447.48	1.23	Canadian Rockies
Barren	36430.50	3494.68	9.59	Canadian Rockies
Snow/Ice	36430.50	69.58	0.19	Canadian Rockies
Developed	36430.50	223.12	0.61	Canadian Rockies
Scrub/Shrub	36430.50	4341.89	11.92	Canadian Rockies
Wetland	36430.50	127.40	0.35	Canadian Rockies
Grassland	36430.50	1695.10	4.65	Canadian Rockies
Agriculture	36430.50	315.67	0.87	Canadian Rockies
Coniferous Forest	36430.50	23795.70	65.32	Canadian Rockies
Deciduous Forest	36430.50	1639.20	4.50	Canadian Rockies
Mixed Forest	36430.50	280.75	0.77	Canadian Rockies

Barren	33.47	0.25	0.76	Clear Hills and Western Alberta Upland
Scrub/Shrub	33.47	1.22	3.64	Clear Hills and Western Alberta Upland
Wetland	33.47	0.22	0.66	Clear Hills and Western Alberta Upland
Grassland	33.47	1.62	4.83	Clear Hills and Western Alberta Upland
Coniferous Forest	33.47	25.55	76.36	Clear Hills and Western Alberta Upland
Deciduous Forest	33.47	4.55	13.59	Clear Hills and Western Alberta Upland
Mixed Forest	33.47	0.05	0.16	Clear Hills and Western Alberta Upland
Water	10420.40	683.77	6.56	Columbia Mountains Northern Rockies
Barren	10420.40	15.33	0.15	Columbia Mountains Northern Rockies
Developed	10420.40	315.28	3.03	Columbia Mountains Northern Rockies
Scrub/Shrub	10420.40	949.17	9.11	Columbia Mountains Northern Rockies
Wetland	10420.40	214.96	2.06	Columbia Mountains Northern Rockies
Grassland	10420.40	1665.04	15.98	Columbia Mountains Northern Rockies
Agriculture	10420.40	1411.95	13.55	Columbia Mountains Northern Rockies
Coniferous Forest	10420.40	5087.48	48.82	Columbia Mountains Northern Rockies
Deciduous Forest	10420.40	75.94	0.73	Columbia Mountains Northern Rockies
Mixed Forest	10420.40	1.47	0.01	Columbia Mountains Northern Rockies
Water	7103.46	30.24	0.43	Middle Rockies A
Barren	7103.46	31.98	0.45	Middle Rockies A
Snow/Ice	7103.46	0.53	0.01	Middle Rockies A
Developed	7103.46	48.38	0.68	Middle Rockies A
Scrub/Shrub	7103.46	817.90	11.51	Middle Rockies A
Wetland	7103.46	98.28	1.38	Middle Rockies A
Grassland	7103.46	987.63	13.90	Middle Rockies A
Agriculture	7103.46	216.66	3.05	Middle Rockies A
Coniferous Forest	7103.46	4838.24	68.11	Middle Rockies A
Deciduous Forest	7103.46	4.69	0.07	Middle Rockies A
Mixed Forest	7103.46	28.92	0.41	Middle Rockies A
Scrub/Shrub	1.65	0.42	25.27	Middle Rockies B
Wetland	1.65	0.00	0.05	Middle Rockies B
Grassland	1.65	0.89	53.88	Middle Rockies B
Agriculture	1.65	0.02	1.15	Middle Rockies B
Coniferous Forest	1.65	0.27	16.27	Middle Rockies B
Mixed Forest	1.65	0.06	3.38	Middle Rockies B
Water	17146.00	187.04	1.09	Northwestern Glaciated Plains
Barren	17146.00	56.48	0.33	Northwestern Glaciated Plains
Snow/Ice	17146.00	0.02	0.00	Northwestern Glaciated Plains
Developed	17146.00	199.29	1.16	Northwestern Glaciated Plains
Scrub/Shrub	17146.00	1545.24	9.01	Northwestern Glaciated Plains
Wetland	17146.00	249.69	1.46	Northwestern Glaciated Plains
Grassland	17146.00	9171.47	53.49	Northwestern Glaciated Plains

Agriculture	17146.00	5206.31	30.36	Northwestern Glaciated Plains
Coniferous Forest	17146.00	242.22	1.41	Northwestern Glaciated Plains
Deciduous Forest	17146.00	268.58	1.57	Northwestern Glaciated Plains
Mixed Forest	17146.00	19.68	0.11	Northwestern Glaciated Plains

(C) Park scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Water	4580.49	123.57	2.70	Waterton Glacier International Peace Park
Barren	4580.49	551.68	12.04	Waterton Glacier International Peace Park
Snow/Ice	4580.49	45.19	0.99	Waterton Glacier International Peace Park
Developed	4580.49	9.97	0.22	Waterton Glacier International Peace Park
Scrub/Shrub	4580.49	811.48	17.72	Waterton Glacier International Peace Park
Wetland	4580.49	2.84	0.06	Waterton Glacier International Peace Park
Grassland	4580.49	107.67	2.35	Waterton Glacier International Peace Park
Agriculture	4580.49	10.27	0.22	Waterton Glacier International Peace Park
Coniferous Forest	4580.49	2699.82	58.94	Waterton Glacier International Peace Park
Deciduous Forest	4580.49	154.40	3.37	Waterton Glacier International Peace Park
Mixed Forest	4580.49	63.61	1.39	Waterton Glacier International Peace Park

(D) Watershed scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Water	2209.90	48.12	2.18	Belly River (10010001_A)
Barren	2209.90	65.41	2.96	10010001_A
Snow/Ice	2209.90	0.01	0.00	10010001_A
Developed	2209.90	23.39	1.06	10010001_A
Scrub/Shrub	2209.90	104.88	4.75	10010001_A
Wetland	2209.90	18.45	0.83	10010001_A
Grassland	2209.90	564.89	25.56	10010001_A
Agriculture	2209.90	1084.44	49.07	10010001_A
Coniferous Forest	2209.90	86.28	3.90	10010001_A
Deciduous Forest	2209.90	203.84	9.22	10010001_A
Mixed Forest	2209.90	10.18	0.46	10010001_A
Water	13.60	0.19	1.40	10010001_B
Barren	13.60	0.02	0.14	10010001_B
Developed	13.60	0.01	0.10	10010001_B
Scrub/Shrub	13.60	0.68	5.01	10010001_B
Wetland	13.60	0.01	0.05	10010001_B
Grassland	13.60	1.23	9.03	10010001_B
Coniferous Forest	13.60	5.03	36.97	10010001_B
Deciduous Forest	13.60	6.28	46.18	10010001_B

Mixed Forest	13.60	0.15	1.13	10010001_B
Water	974.66	29.25	3.00	10010001_C
Barren	974.66	190.73	19.57	10010001_C
Snow/Ice	974.66	8.37	0.86	10010001_C
Developed	974.66	3.29	0.34	10010001_C
Scrub/Shrub	974.66	151.46	15.54	10010001_C
Wetland	974.66	0.54	0.06	10010001_C
Grassland	974.66	52.28	5.36	10010001_C
Agriculture	974.66	0.37	0.04	10010001_C
Coniferous Forest	974.66	443.65	45.52	10010001_C
Deciduous Forest	974.66	81.31	8.34	10010001_C
Mixed Forest	974.66	13.40	1.38	10010001_C
Water	706.45	25.72	3.64	St Mary River (10010002_A)
Barren	706.45	128.91	18.25	10010002_A
Snow/Ice	706.45	13.21	1.87	10010002_A
Developed	706.45	1.52	0.22	10010002_A
Scrub/Shrub	706.45	169.40	23.98	10010002_A
Wetland	706.45	0.10	0.01	10010002_A
Grassland	706.45	6.84	0.97	10010002_A
Agriculture	706.45	0.36	0.05	10010002_A
Coniferous Forest	706.45	329.20	46.60	10010002_A
Deciduous Forest	706.45	16.61	2.35	10010002_A
Mixed Forest	706.45	14.58	2.06	10010002_A
Water	2394.77	87.09	3.64	10010002_B
Barren	2394.77	10.35	0.43	10010002_B
Snow/Ice	2394.77	0.01	0.00	10010002_B
Developed	2394.77	35.60	1.49	10010002_B
Scrub/Shrub	2394.77	101.46	4.24	10010002_B
Wetland	2394.77	14.03	0.59	10010002_B
Grassland	2394.77	781.24	32.62	10010002_B
Agriculture	2394.77	911.27	38.05	10010002_B
Coniferous Forest	2394.77	175.47	7.33	10010002_B
Deciduous Forest	2394.77	270.50	11.30	10010002_B
Mixed Forest	2394.77	7.76	0.32	10010002_B
Water	1028.17	0.49	0.05	Upper Missouri River (10030101)
Barren	1028.17	0.53	0.05	10030101
Developed	1028.17	10.54	1.03	10030101
Scrub/Shrub	1028.17	134.10	13.04	10030101
Wetland	1028.17	3.70	0.36	10030101
Grassland	1028.17	297.07	28.89	10030101
Agriculture	1028.17	22.25	2.16	10030101

Coniferous Forest	1028.17	551.61	53.65	10030101
Deciduous Forest	1028.17	0.06	0.01	10030101
Mixed Forest	1028.17	7.82	0.76	10030101
Water	1899.59	2.35	0.12	Upper Missouri-Dearborn River (10030102)
Barren	1899.59	19.21	1.01	10030102
Snow/Ice	1899.59	0.01	0.00	10030102
Developed	1899.59	22.10	1.16	10030102
Scrub/Shrub	1899.59	280.35	14.76	10030102
Wetland	1899.59	11.83	0.62	10030102
Grassland	1899.59	1071.48	56.41	10030102
Agriculture	1899.59	90.41	4.76	10030102
Coniferous Forest	1899.59	383.52	20.19	10030102
Deciduous Forest	1899.59	1.26	0.07	10030102
Mixed Forest	1899.59	17.06	0.90	10030102
Water	3656.71	20.87	0.57	Sun River (10030104)
Barren	3656.71	133.66	3.66	10030104
Snow/Ice	3656.71	0.01	0.00	10030104
Developed	3656.71	20.71	0.57	10030104
Scrub/Shrub	3656.71	401.96	10.99	10030104
Wetland	3656.71	39.16	1.07	10030104
Grassland	3656.71	1266.75	34.64	10030104
Agriculture	3656.71	388.14	10.61	10030104
Coniferous Forest	3656.71	1376.27	37.64	10030104
Deciduous Forest	3656.71	0.66	0.02	10030104
Mixed Forest	3656.71	8.52	0.23	10030104
Water	217.83	3.72	1.71	Two Medicine River (10030201_A)
Barren	217.83	38.46	17.65	10030201_A
Snow/Ice	217.83	0.49	0.23	10030201_A
Developed	217.83	0.01	0.00	10030201_A
Scrub/Shrub	217.83	53.08	24.37	10030201_A
Wetland	217.83	0.14	0.07	10030201_A
Grassland	217.83	2.37	1.09	10030201_A
Agriculture	217.83	0.31	0.14	10030201_A
Coniferous Forest	217.83	97.88	44.93	10030201_A
Deciduous Forest	217.83	12.48	5.73	10030201_A
Mixed Forest	217.83	8.90	4.09	10030201_A
Water	2819.10	10.37	0.37	10030201_B
Barren	2819.10	61.08	2.17	10030201_B
Snow/Ice	2819.10	0.01	0.00	10030201_B
Developed	2819.10	19.14	0.68	10030201_B
Scrub/Shrub	2819.10	437.64	15.52	10030201_B

Wetland	2819.10	45.98	1.63	10030201_B
Grassland	2819.10	1299.14	46.08	10030201_B
Agriculture	2819.10	228.23	8.10	10030201_B
Coniferous Forest	2819.10	549.76	19.50	10030201_B
Deciduous Forest	2819.10	122.49	4.35	10030201_B
Mixed Forest	2819.10	45.26	1.61	10030201_B
Water	2278.69	6.85	0.30	Cut Bank River (10030202_A)
Barren	2278.69	6.04	0.27	10030202_A
Developed	2278.69	36.12	1.59	10030202_A
Scrub/Shrub	2278.69	114.35	5.02	10030202_A
Wetland	2278.69	30.18	1.32	10030202_A
Grassland	2278.69	1285.09	56.40	10030202_A
Agriculture	2278.69	728.07	31.95	10030202_A
Coniferous Forest	2278.69	22.36	0.98	10030202_A
Deciduous Forest	2278.69	48.50	2.13	10030202_A
Mixed Forest	2278.69	1.13	0.05	10030202_A
Water	104.04	0.66	0.63	10030202_B
Barren	104.04	23.42	22.51	10030202_B
Snow/Ice	104.04	0.77	0.74	10030202_B
Scrub/Shrub	104.04	30.90	29.70	10030202_B
Wetland	104.04	0.03	0.03	10030202_B
Grassland	104.04	1.61	1.55	10030202_B
Agriculture	104.04	0.27	0.26	10030202_B
Coniferous Forest	104.04	40.45	38.88	10030202_B
Deciduous Forest	104.04	2.34	2.25	10030202_B
Mixed Forest	104.04	3.58	3.44	10030202_B
Water	623.49	0.26	0.04	Marias River (10030203)
Barren	623.49	0.85	0.14	10030203
Developed	623.49	7.65	1.23	10030203
Scrub/Shrub	623.49	114.07	18.29	10030203
Wetland	623.49	4.18	0.67	10030203
Grassland	623.49	258.42	41.45	10030203
Agriculture	623.49	234.09	37.54	10030203
Coniferous Forest	623.49	3.47	0.56	10030203
Deciduous Forest	623.49	0.02	0.00	10030203
Mixed Forest	623.49	0.50	0.08	10030203
Water	2339.81	5.27	0.23	Teton River (10030205)
Barren	2339.81	74.87	3.20	10030205
Snow/Ice	2339.81	0.01	0.00	10030205
Developed	2339.81	13.87	0.59	10030205
Scrub/Shrub	2339.81	280.21	11.98	10030205

Wetland	2339.81	80.11	3.42	10030205
Grassland	2339.81	1124.89	48.08	10030205
Agriculture	2339.81	415.52	17.76	10030205
Coniferous Forest	2339.81	343.20	14.67	10030205
Deciduous Forest	2339.81	0.48	0.02	10030205
Mixed Forest	2339.81	1.40	0.06	10030205
Water	6.48	0.00	0.01	Milk River (10050001_A)
Barren	6.48	2.05	31.65	10050001_A
Scrub/Shrub	6.48	1.36	20.94	10050001_A
Grassland	6.48	0.26	4.01	10050001_A
Coniferous Forest	6.48	2.51	38.79	10050001_A
Deciduous Forest	6.48	0.01	0.08	10050001_A
Mixed Forest	6.48	0.29	4.51	10050001_A
Water	2044.11	18.54	0.91	10050001_B
Barren	2044.11	3.07	0.15	10050001_B
Developed	2044.11	14.96	0.73	10050001_B
Scrub/Shrub	2044.11	264.88	12.96	10050001_B
Wetland	2044.11	16.64	0.81	10050001_B
Grassland	2044.11	1176.02	57.53	10050001_B
Agriculture	2044.11	407.08	19.91	10050001_B
Coniferous Forest	2044.11	69.53	3.40	10050001_B
Deciduous Forest	2044.11	69.21	3.39	10050001_B
Mixed Forest	2044.11	4.17	0.20	10050001_B
Water	10745.40	159.01	1.48	Upper Kootenai River (17010101)
Barren	10745.40	1691.45	15.74	17010101
Snow/Ice	10745.40	16.97	0.16	17010101
Developed	10745.40	136.61	1.27	17010101
Scrub/Shrub	10745.40	1241.47	11.55	17010101
Wetland	10745.40	66.60	0.62	17010101
Grassland	10745.40	113.60	1.06	17010101
Agriculture	10745.40	72.49	0.67	17010101
Coniferous Forest	10745.40	6913.09	64.34	17010101
Deciduous Forest	10745.40	271.36	2.53	17010101
Mixed Forest	10745.40	62.75	0.58	17010101
Water	5998.24	29.81	0.50	Blackfoot River (17010203)
Barren	5998.24	40.96	0.68	17010203
Snow/Ice	5998.24	0.53	0.01	17010203
Developed	5998.24	38.03	0.63	17010203
Scrub/Shrub	5998.24	691.14	11.52	17010203
Wetland	5998.24	95.39	1.59	17010203
Grassland	5998.24	691.25	11.52	17010203

Agriculture	5998.24	195.53	3.26	17010203
Coniferous Forest	5998.24	4190.69	69.87	17010203
Deciduous Forest	5998.24	4.90	0.08	17010203
Mixed Forest	5998.24	20.01	0.33	17010203
Water	1157.57	30.74	2.66	North Fork Flathead River (17010206_A)
Barren	1157.57	65.07	5.62	17010206_A
Snow/Ice	1157.57	10.54	0.91	17010206_A
Developed	1157.57	1.52	0.13	17010206_A
Scrub/Shrub	1157.57	148.68	12.84	17010206_A
Wetland	1157.57	1.18	0.10	17010206_A
Grassland	1157.57	28.35	2.45	17010206_A
Agriculture	1157.57	8.14	0.70	17010206_A
Coniferous Forest	1157.57	836.61	72.27	17010206_A
Deciduous Forest	1157.57	22.45	1.94	17010206_A
Mixed Forest	1157.57	4.31	0.37	17010206_A
Water	1528.05	4.20	0.27	Middle Fork Flathead River (17010207_B)
Barren	1528.05	35.03	2.29	17010207_B
Snow/Ice	1528.05	1.86	0.12	17010207_B
Developed	1528.05	8.20	0.54	17010207_B
Scrub/Shrub	1528.05	192.22	12.58	17010207_B
Wetland	1528.05	3.22	0.21	17010207_B
Grassland	1528.05	45.16	2.96	17010207_B
Agriculture	1528.05	4.36	0.29	17010207_B
Coniferous Forest	1528.05	1212.42	79.34	17010207_B
Deciduous Forest	1528.05	7.12	0.47	17010207_B
Mixed Forest	1528.05	14.28	0.93	17010207_B
Water	1528.05	4.20	0.27	17010207_B
Barren	1528.05	35.03	2.29	17010207_B
Snow/Ice	1528.05	1.86	0.12	17010207_B
Developed	1528.05	8.20	0.54	17010207_B
Scrub/Shrub	1528.05	192.22	12.58	17010207_B
Wetland	1528.05	3.22	0.21	17010207_B
Grassland	1528.05	45.16	2.96	17010207_B
Agriculture	1528.05	4.36	0.29	17010207_B
Coniferous Forest	1528.05	1212.42	79.34	17010207_B
Deciduous Forest	1528.05	7.12	0.47	17010207_B
Mixed Forest	1528.05	14.28	0.93	17010207_B
Water	3085.20	549.96	17.83	Flathead Lake River (17010208)
Barren	3085.20	0.26	0.01	17010208
Developed	3085.20	135.37	4.39	17010208
Scrub/Shrub	3085.20	204.91	6.64	17010208

Wetland	3085.20	58.04	1.88	17010208
Grassland	3085.20	206.69	6.70	17010208
Agriculture	3085.20	368.87	11.96	17010208
Coniferous Forest	3085.20	1517.35	49.18	17010208
Deciduous Forest	3085.20	43.12	1.40	17010208
Mixed Forest	3085.20	0.63	0.02	17010208
Water	4344.62	103.75	2.39	South Fork Flathead River (17010209)
Barren	4344.62	122.52	2.82	17010209
Snow/Ice	4344.62	2.21	0.05	17010209
Developed	4344.62	1.65	0.04	17010209
Scrub/Shrub	4344.62	381.29	8.78	17010209
Wetland	4344.62	6.53	0.15	17010209
Grassland	4344.62	140.53	3.23	17010209
Agriculture	4344.62	2.29	0.05	17010209
Coniferous Forest	4344.62	3557.51	81.88	17010209
Deciduous Forest	4344.62	23.80	0.55	17010209
Mixed Forest	4344.62	2.54	0.06	17010209
Water	2018.32	28.13	1.39	Stillwater River (17010210)
Barren	2018.32	1.45	0.07	17010210
Developed	2018.32	46.58	2.31	17010210
Scrub/Shrub	2018.32	271.34	13.44	17010210
Wetland	2018.32	27.53	1.36	17010210
Grassland	2018.32	16.30	0.81	17010210
Agriculture	2018.32	126.42	6.26	17010210
Coniferous Forest	2018.32	1484.48	73.55	17010210
Deciduous Forest	2018.32	13.39	0.66	17010210
Mixed Forest	2018.32	2.70	0.13	17010210
Water	1889.28	33.98	1.80	Swan River (17010211)
Barren	1889.28	42.26	2.24	17010211
Snow/Ice	1889.28	1.01	0.05	17010211
Developed	1889.28	10.97	0.58	17010211
Scrub/Shrub	1889.28	114.19	6.04	17010211
Wetland	1889.28	49.14	2.60	17010211
Grassland	1889.28	50.86	2.69	17010211
Agriculture	1889.28	38.67	2.05	17010211
Coniferous Forest	1889.28	1497.38	79.26	17010211
Deciduous Forest	1889.28	49.39	2.61	17010211
Mixed Forest	1889.28	1.42	0.08	17010211
Water	5203.82	61.25	1.18	Lower Flathead River (17010212)
Barren	5203.82	38.63	0.74	17010212
Snow/Ice	5203.82	1.73	0.03	17010212

Developed	5203.82	116.71	2.24	17010212
Scrub/Shrub	5203.82	400.98	7.71	17010212
Wetland	5203.82	66.56	1.28	17010212
Grassland	5203.82	1432.76	27.53	17010212
Agriculture	5203.82	858.69	16.50	17010212
Coniferous Forest	5203.82	2216.26	42.59	17010212
Deciduous Forest	5203.82	10.14	0.19	17010212
Mixed Forest	5203.82	0.12	0.00	17010212
Water	4847.08	46.78	0.97	Old Man River 05AA (511)
Barren	4847.08	386.76	7.98	511
Snow/Ice	4847.08	0.20	0.00	511
Developed	4847.08	32.63	0.67	511
Scrub/Shrub	4847.08	512.51	10.57	511
Wetland	4847.08	23.42	0.48	511
Grassland	4847.08	712.32	14.70	511
Agriculture	4847.08	666.29	13.75	511
Coniferous Forest	4847.08	2091.95	43.16	511
Deciduous Forest	4847.08	350.35	7.23	511
Mixed Forest	4847.08	23.88	0.49	511
Water	2347.09	8.69	0.37	Old Man River 05AB (512)
Barren	2347.09	12.48	0.53	512
Developed	2347.09	12.52	0.53	512
Scrub/Shrub	2347.09	297.09	12.66	512
Wetland	2347.09	36.80	1.57	512
Grassland	2347.09	935.59	39.86	512
Agriculture	2347.09	409.67	17.45	512
Coniferous Forest	2347.09	329.44	14.04	512
Deciduous Forest	2347.09	300.76	12.81	512
Mixed Forest	2347.09	4.06	0.17	512
Water	168.86	0.68	0.40	Little Bow River (513)
Barren	168.86	0.00	0.00	513
Developed	168.86	0.47	0.28	513
Scrub/Shrub	168.86	25.84	15.30	513
Wetland	168.86	2.61	1.54	513
Grassland	168.86	50.45	29.88	513
Agriculture	168.86	73.06	43.27	513
Coniferous Forest	168.86	3.02	1.79	513
Deciduous Forest	168.86	12.62	7.48	513
Mixed Forest	168.86	0.09	0.05	513
Water	1290.19	4.62	0.36	Old Man River 05BL (530)
Barren	1290.19	115.52	8.95	530

Snow/Ice	1290.19	0.12	0.01	530
Developed	1290.19	3.08	0.24	530
Scrub/Shrub	1290.19	132.06	10.24	530
Wetland	1290.19	47.74	3.70	530
Grassland	1290.19	110.19	8.54	530
Agriculture	1290.19	28.91	2.24	530
Coniferous Forest	1290.19	656.47	50.88	530
Deciduous Forest	1290.19	188.53	14.61	530
Mixed Forest	1290.19	2.96	0.23	530

Natural vs Converted

Definitions

Natural – Landcover classification of:

- a. Barren
- b. Coniferous Forest
- c. Deciduous Forest
- d. Herb/Grassland
- e. Mixedwood
- f. Scrub/Shrub
- g. Snow/Ice
- h. Water
- i. Wetland

Converted – Landcover classification of:

- a. Agriculture
- b. Developed

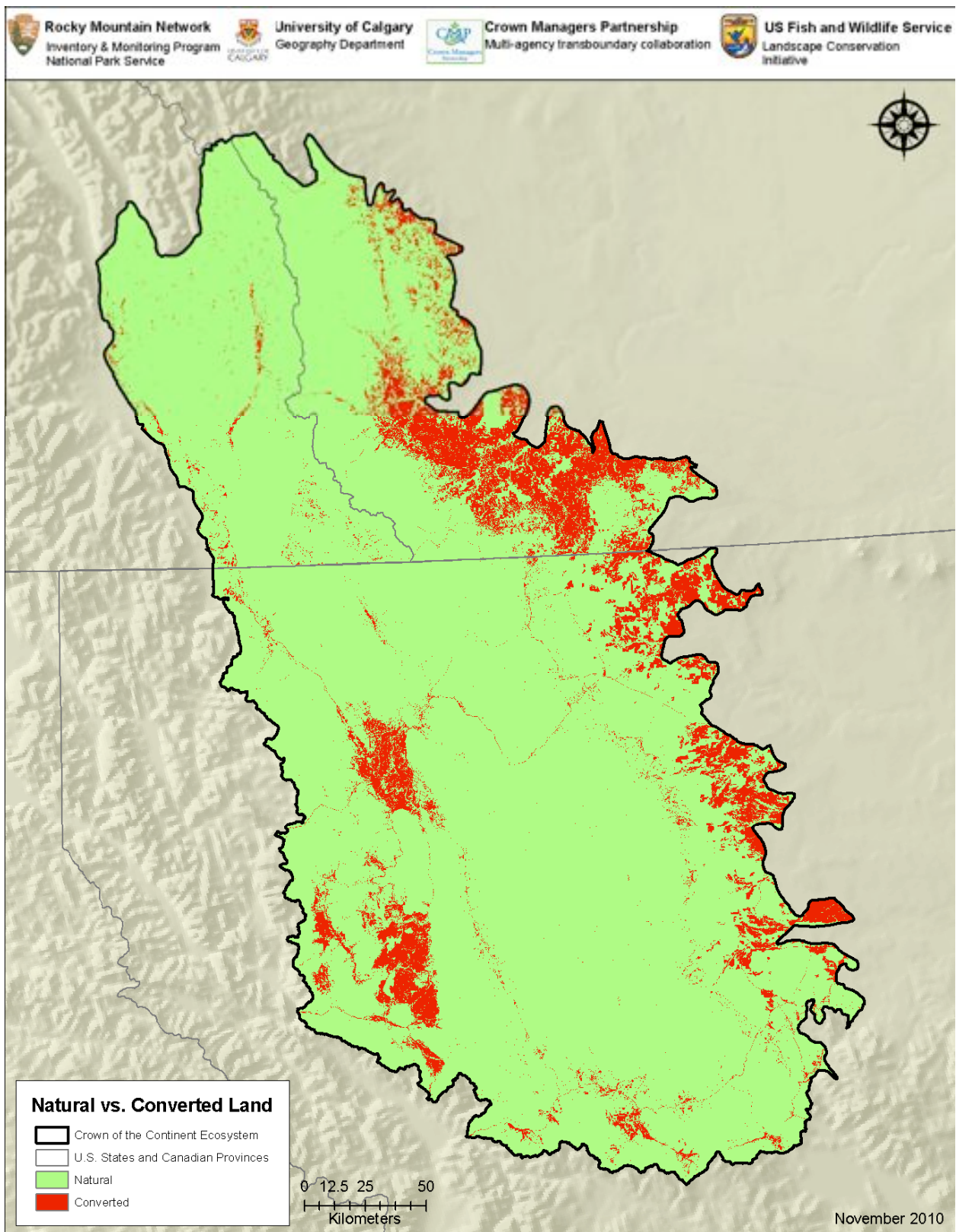


Figure 8. NPScape product - Natural versus Converted Land. Scale: Crown of the Continent Ecosystem.

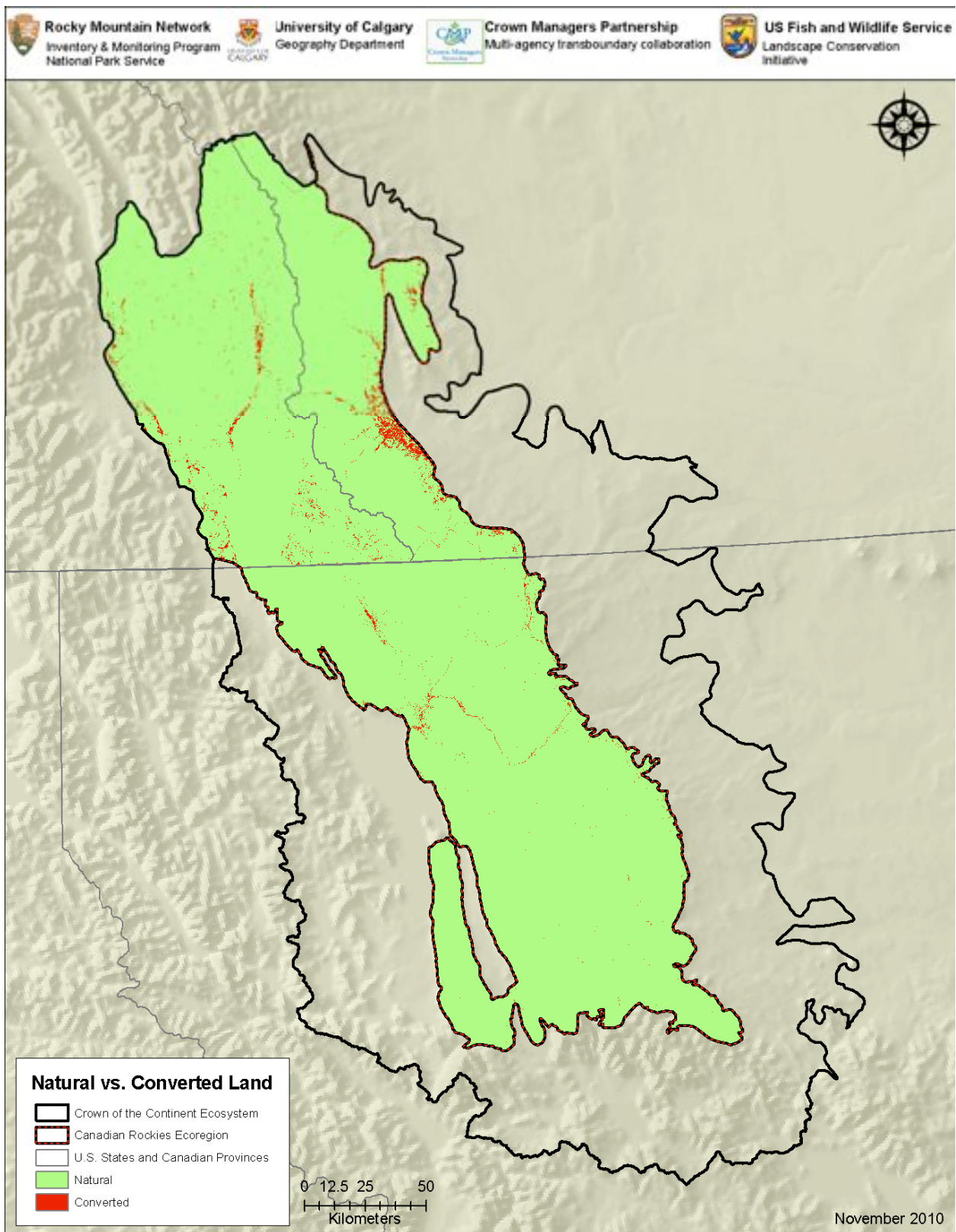


Figure 9. NPScape product - Natural versus Converted Land. Scale: Canadian Rockies Ecoregion.

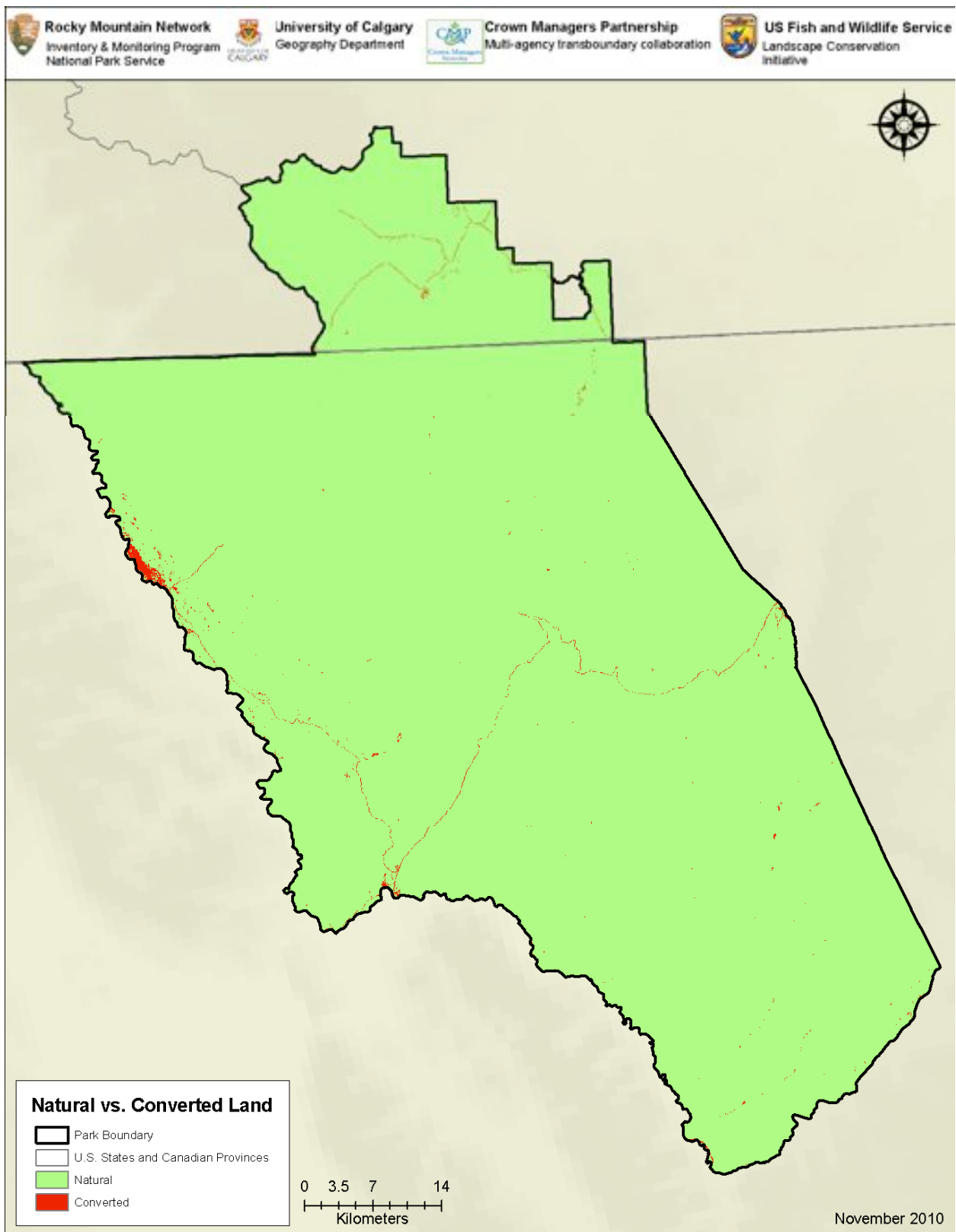


Figure 10. NPScape product - Natural versus Converted Land. Scale: Waterton-Glacier International Peace Park.

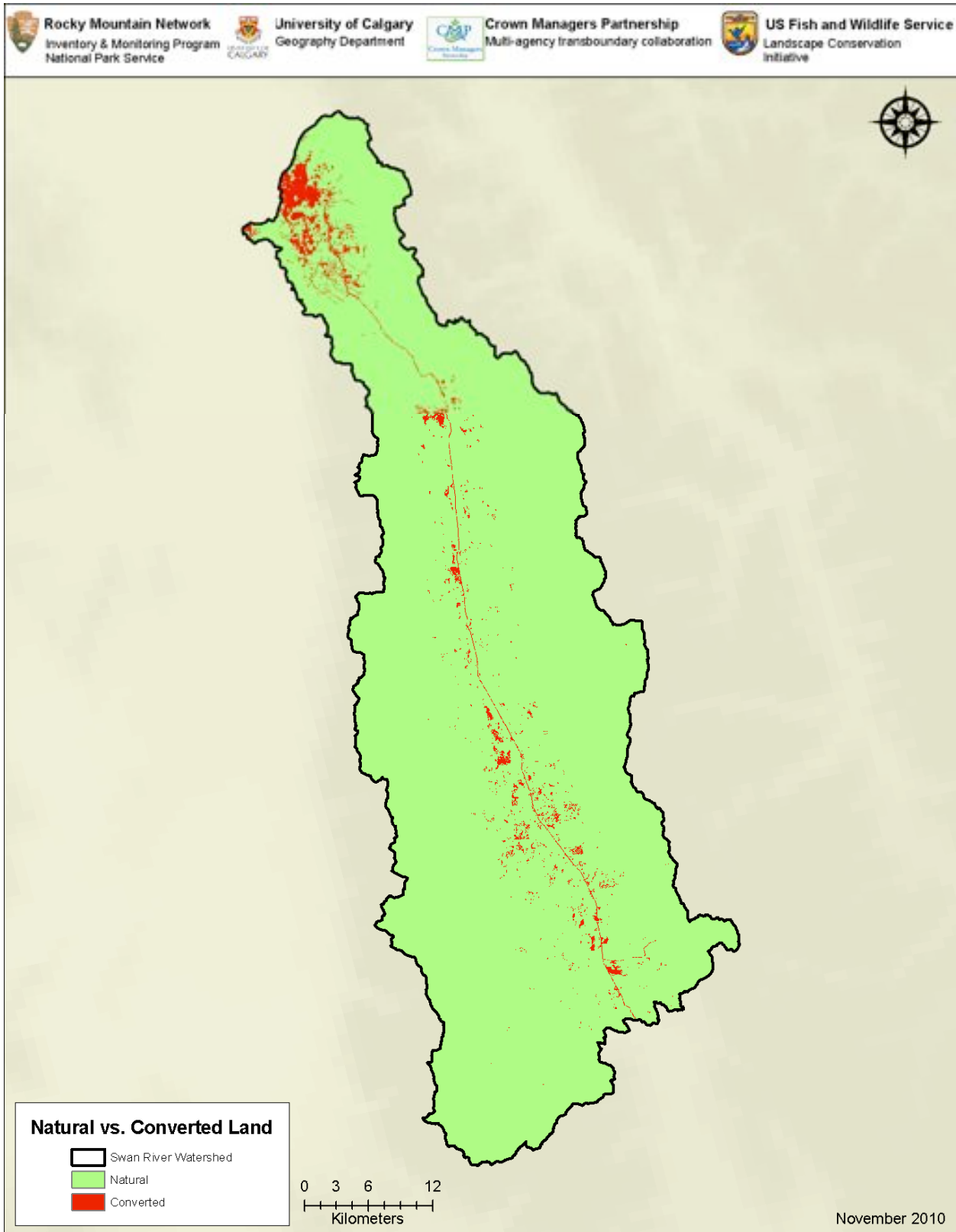


Figure 11. NPScape product - Natural versus Converted Land. Scale: Swan River Watershed.

Table 2. Natural versus Converted statistics derived through NPScape at various scales: (A) Crown of the Continent, (B) Ecoregion, (C) Waterton-Glacier International Peace Park, and (D) watersheds.

(A) CCE scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Natural	72188.50	64049.30	88.73	Crown of the Continent
Converted	72188.50	8139.17	11.27	Crown of the Continent

(B) Ecoregion scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Natural	1052.98	850.49	80.77	Aspen Parkland Northern Glaciated Plains
Converted	1052.98	202.49	19.23	Aspen Parkland Northern Glaciated Plains
Natural	36430.50	35891.80	98.52	Canadian Rockies
Converted	36430.50	538.79	1.48	Canadian Rockies
Natural	33.47	33.47	100.00	Clear Hills and Western Alberta Upland
Natural	10420.40	8693.14	83.42	Columbia Mountains Northern Rockies
Converted	10420.40	1727.23	16.58	Columbia Mountains Northern Rockies
Natural	7103.46	6838.42	96.27	Middle Rockies A
Converted	7103.46	265.04	3.73	Middle Rockies A
Natural	1.65	1.63	98.85	Middle Rockies B
Converted	1.65	0.02	1.15	Middle Rockies B
Natural	17146.00	11740.40	68.47	Northwestern Glaciated Plains
Converted	17146.00	5405.60	31.53	Northwestern Glaciated Plains

(C) Park scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Natural	4580.49	4560.25	99.56	Waterton Glacier International Peace Park
Converted	4580.49	20.24	0.44	Waterton Glacier International Peace Park

(D) Watershed scale

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Area of Analysis
Natural	2209.90	1102.06	49.87	Belly River (10010001_A)
Converted	2209.90	1107.84	50.13	10010001_A
Natural	13.60	13.59	99.90	10010001_B
Converted	13.60	0.01	0.10	10010001_B
Natural	974.66	971.00	99.62	10010001_C
Converted	974.66	3.66	0.38	10010001_C
Natural	706.45	704.57	99.73	St Mary River (10010002_A)
Converted	706.45	1.88	0.27	10010002_A
Natural	2394.77	1447.90	60.46	10010002_B
Converted	2394.77	946.87	39.54	10010002_B

Natural	1028.17	995.37	96.81	Upper Missouri River (10030101)
Converted	1028.17	32.79	3.19	10030101
Natural	1899.59	1787.08	94.08	Upper Missouri-Dearborn River (10030102)
Converted	1899.59	112.52	5.92	10030102
Natural	3656.71	3247.86	88.82	Sun River (10030104)
Converted	3656.71	408.85	11.18	10030104
Natural	217.83	217.51	99.86	Two Medicine River (10030201_A)
Converted	217.83	0.32	0.15	10030201_A
Natural	2819.10	2571.73	91.23	10030201_B
Converted	2819.10	247.37	8.77	10030201_B
Natural	2278.69	1514.50	66.46	Cut Bank River (10030202_A)
Converted	2278.69	764.19	33.54	10030202_A
Natural	104.04	103.77	99.74	10030202_B
Converted	104.04	0.27	0.26	10030202_B
Natural	623.49	381.76	61.23	Marias River (10030203)
Converted	623.49	241.74	38.77	10030203
Natural	2339.81	1910.43	81.65	Teton River (10030205)
Converted	2339.81	429.38	18.35	10030205
Natural	6.48	6.48	100.00	Milk River (10050001_A)
Natural	2044.11	1622.07	79.35	10050001_B
Converted	2044.11	422.04	20.65	10050001_B
Natural	10745.40	10536.30	98.05	Upper Kootenai River (17010101)
Converted	10745.40	209.10	1.95	17010101
Natural	5998.24	5764.68	96.11	Blackfoot River (17010203)
Converted	5998.24	233.56	3.89	17010203
Natural	1157.57	1147.92	99.17	North Fork Flathead River (17010206_A)
Converted	1157.57	9.65	0.83	17010206_A
Natural	2898.92	2855.42	98.50	17010206_B
Converted	2898.92	43.50	1.50	17010206_B
Natural	1413.53	1409.07	99.68	Middle Fork Flathead River (17010207_A)
Converted	1413.53	4.46	0.32	17010207_A
Natural	1528.05	1515.50	99.18	17010207_B
Converted	1528.05	12.55	0.82	17010207_B
Natural	3085.20	2580.96	83.66	Flathead Lake River (17010208)
Converted	3085.20	504.24	16.34	17010208
Natural	4344.62	4340.68	99.91	South Fork Flathead River (17010209)
Converted	4344.62	3.94	0.09	17010209
Natural	2018.32	1845.32	91.43	Stillwater River (17010210)
Converted	2018.32	173.00	8.57	17010210
Natural	1889.28	1839.63	97.37	Swan River (17010211)
Converted	1889.28	49.64	2.63	17010211
Natural	5203.82	4228.42	81.26	Lower Flathead River (17010212)
Converted	5203.82	975.40	18.74	17010212
Natural	4847.08	4148.16	85.58	Old Man River 05AA (511)
Converted	4847.08	698.93	14.42	511
Natural	2347.09	1924.90	82.01	Old Man River 05AB (512)

Converted	2347.09	422.19	17.99	512
Natural	1290.19	1258.20	97.52	Old Man River 05BL (530)
Converted	1290.19	31.99	2.48	530

Morphology

Definitions

Forest – Landcover classification of:

- a. Coniferous Forest
- b. Deciduous Forest
- c. Mixedwood

Grassland – Landcover classification of:

- a. Herb/Grassland

Foreground – Pixels you wish to classify

Background – Pixels with data complementary to Foreground

Connector Pixels – Groups of foreground pixels linking core connected components so that their removal would modify the homotopy of the input image

Boundary Pixels – Unclassified foreground pixels whose distance to the core pixels is lower than or equal to the given size-parameter (s)

Branch – Pixels that do not belong to any of the other defined categories

They emanate either from boundaries (edge or perforation) or connectors (bridge or loop)

Bridge – Connector pixels emanating from two or more core connected components

Core – Foreground pixels whose distance to the background is greater than the given size-parameter (s)

Edge – Outer boundary. Subtraction of perforation pixels from boundary pixels of a connected component

Islet – Foreground connected components that do not contain any core pixel

Loop – Connector pixels emanating from the same core connected component

Perforated – Inner boundary. Boundary pixels within a distance (s) to a connected component of the background that does not contain any pixel of the border of the image

Transition – Pixels of an edge or a perforation where the core area intersects with a loop or a bridge

Transition On – Illustrates all detected connections

Transition Off – Perforation and edges will be closed core boundaries. Loop/bridge pixels may be hidden under the edge/perforation

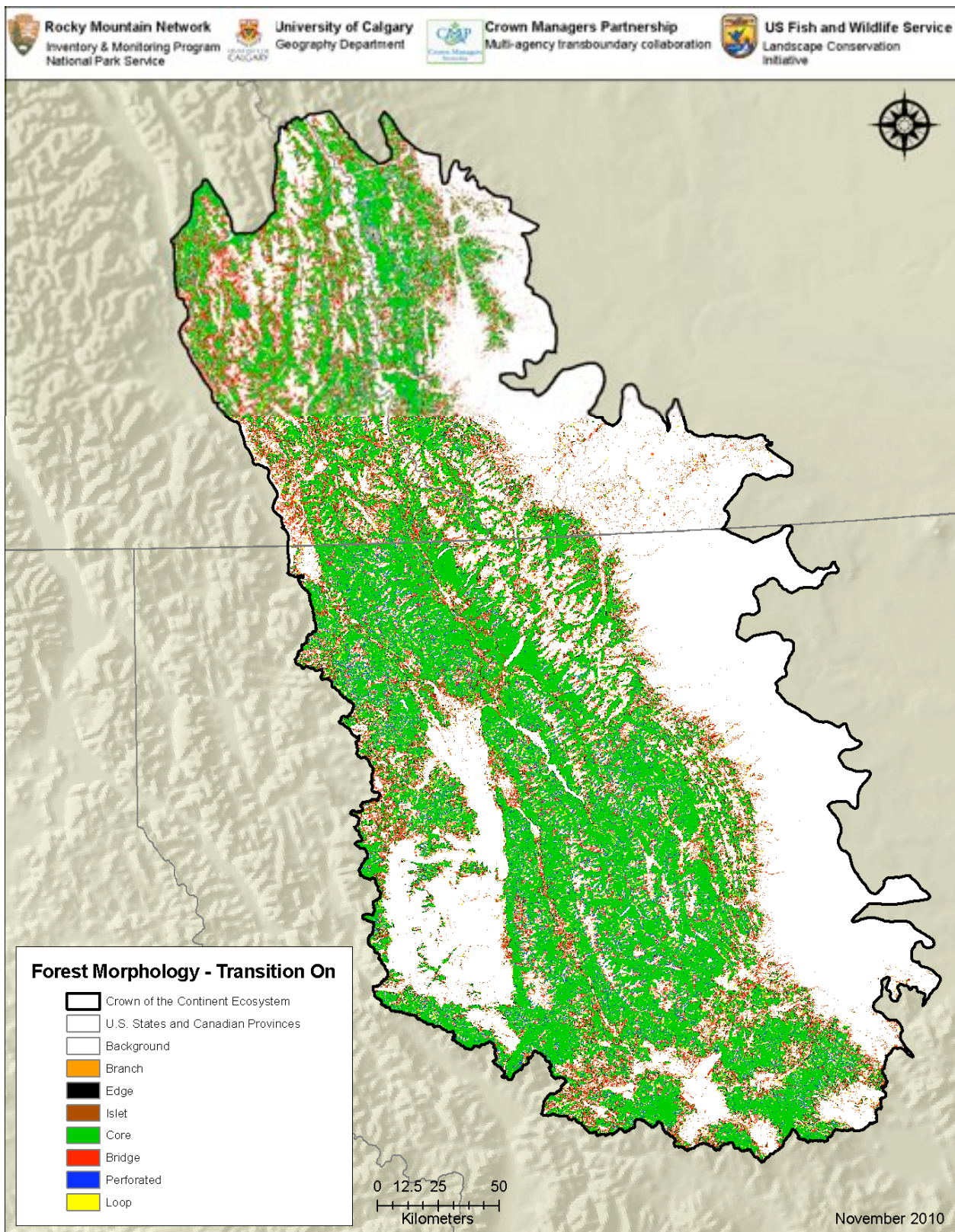


Figure 12. NPScape product – Forest Morphology Transition ON. Scale: Crown of the Continent Ecosystem.

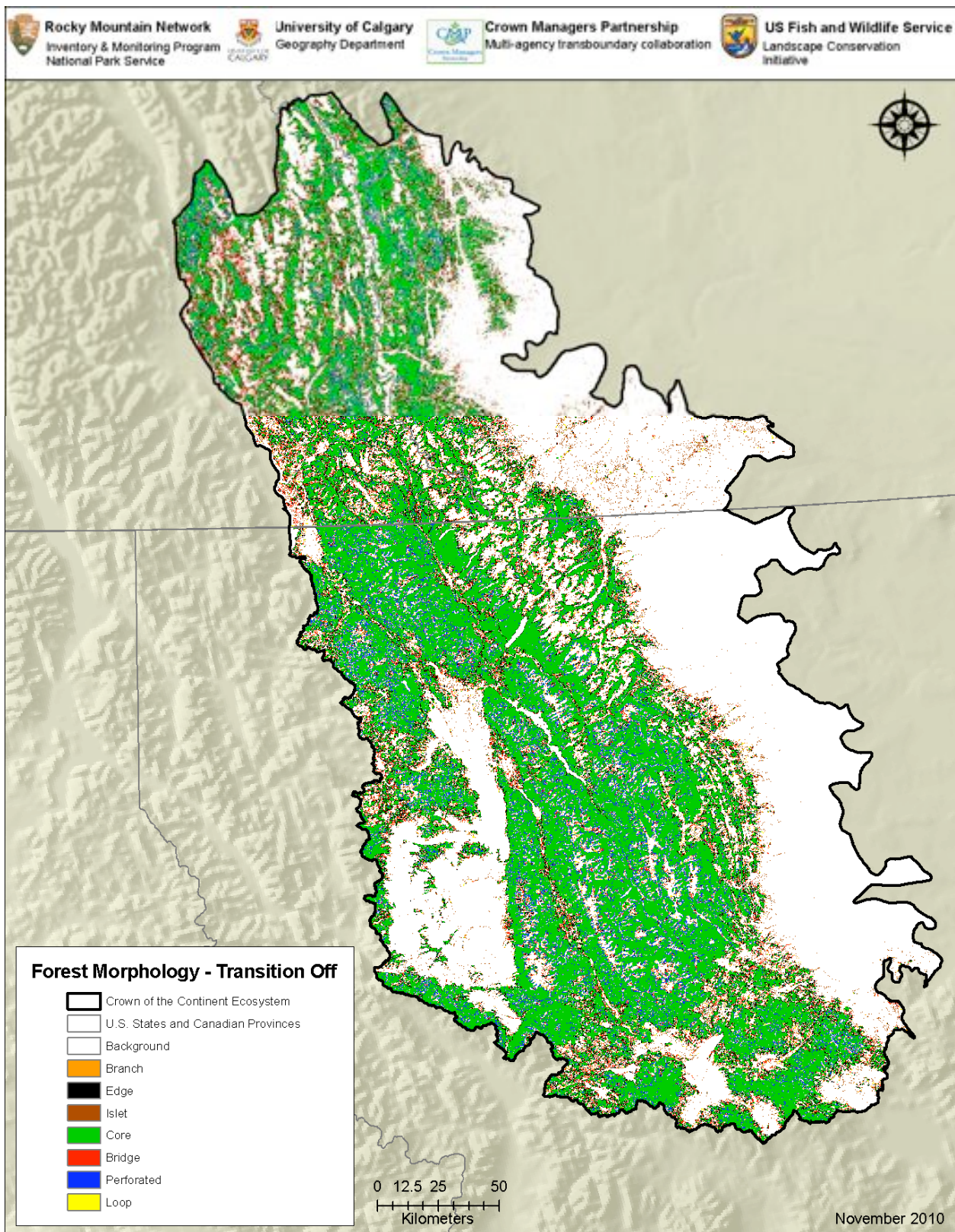


Figure 13. NPScape product – Forest Morphology Transition OFF. Scale: Crown of the Continent Ecosystem.

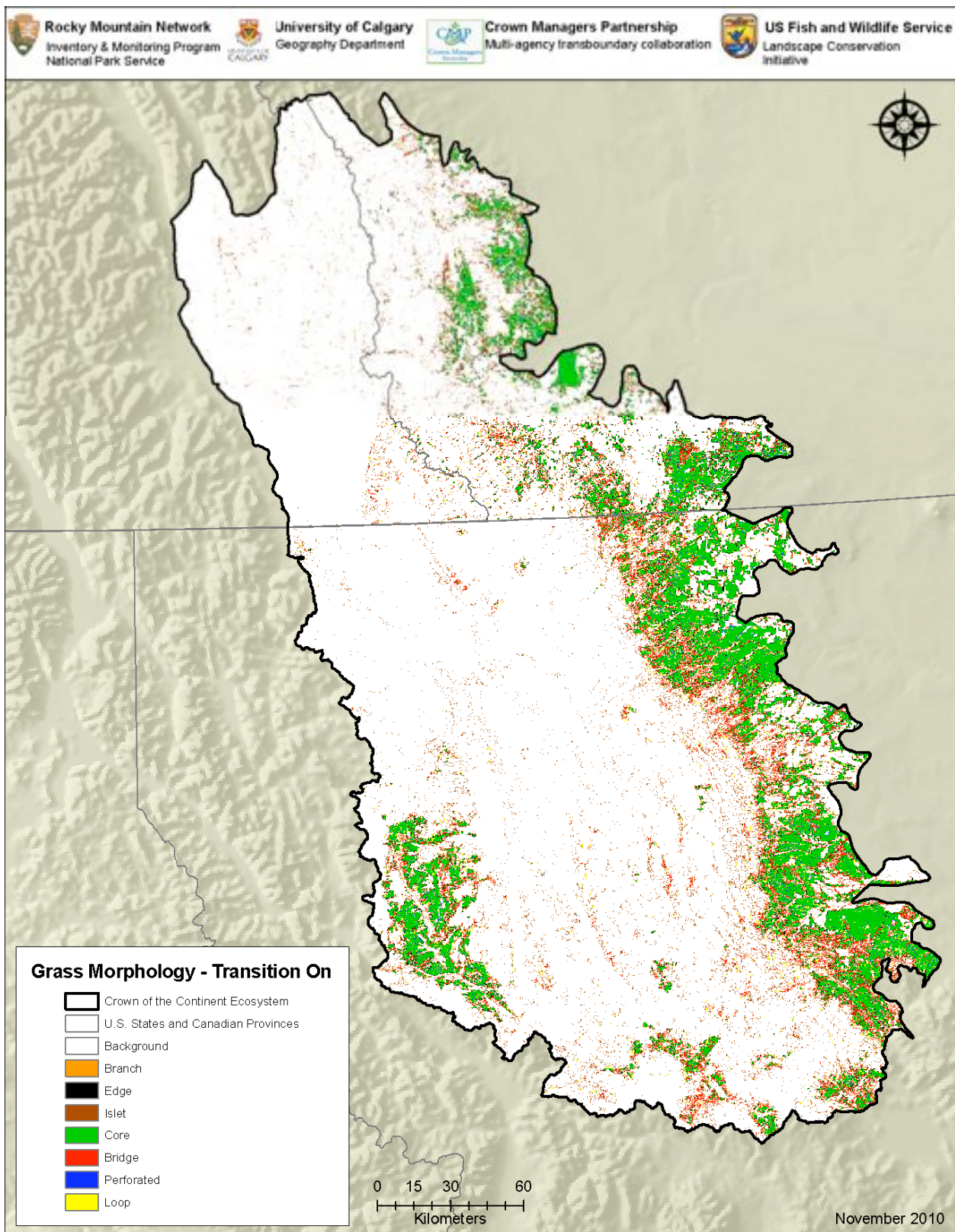


Figure 14. NPScape product – Grassland Morphology Transition ON. Scale: Crown of the Continent Ecosystem.

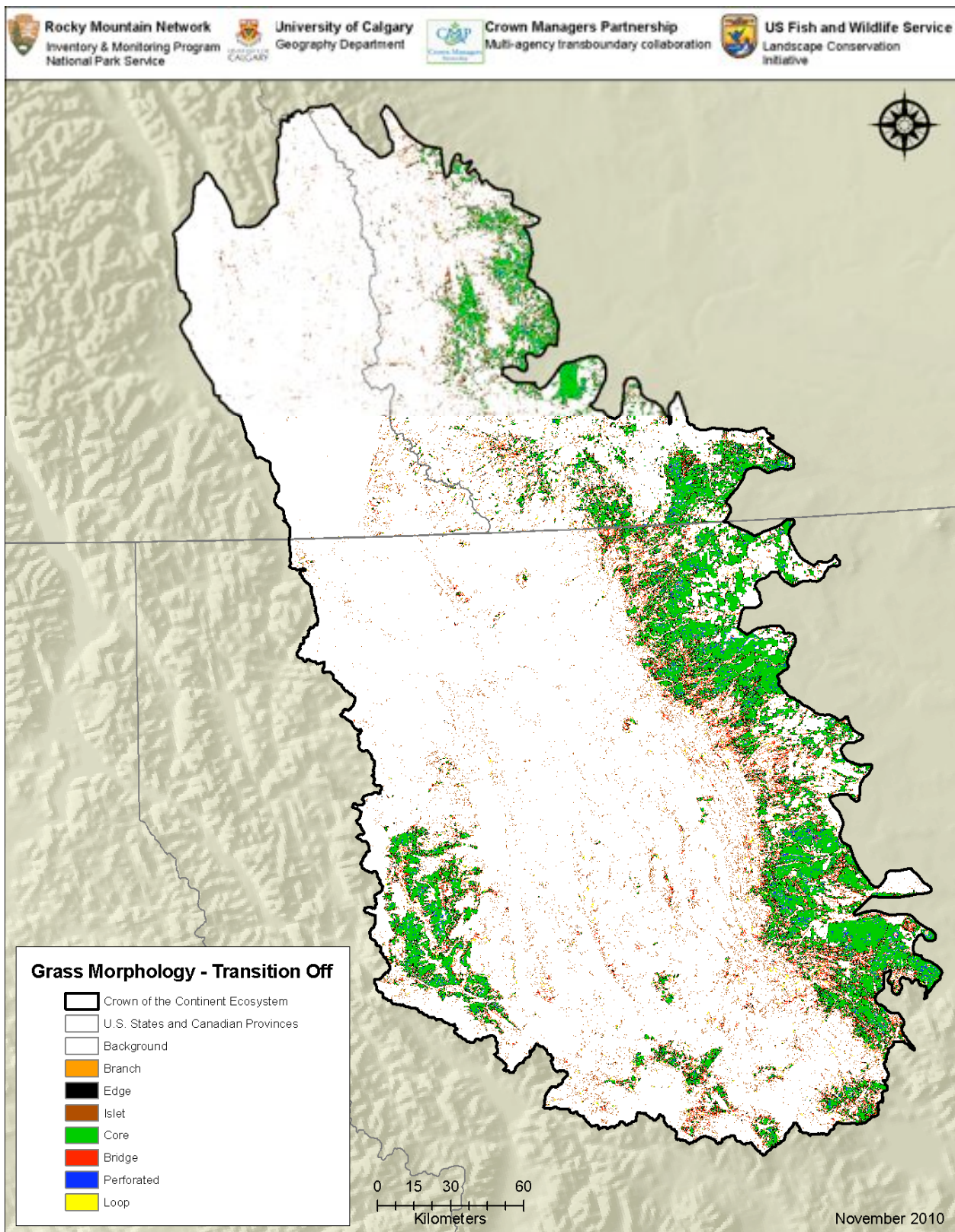


Figure 15. NPScape product – Grassland Morphology Transition OFF. Scale: Crown of the Continent Ecosystem.

Table 3. (A) Forest and (B) Grassland morphology statistics derived through NPScape at the Crown of the Continent scale.

(A) Forest Morphology (CCE scale)

Classification	Total Area (km ²)	Class Area (km ²)	Class % of Area	Transition
Background	72191.00	35563.10	49.26	On
Branch	72191.00	1226.33	1.70	On
Edge	72191.00	2818.03	3.90	On
Islet	72191.00	846.80	1.17	On
Core	72191.00	22393.60	31.02	On
Bridge	72191.00	4762.69	6.60	On
Perforation	72191.00	1934.59	2.68	On
Loop	72191.00	2645.87	3.67	On
Background	72191.00	35563.10	49.26	Off
Branch	72191.00	1226.33	1.70	Off
Edge	72191.00	5832.71	8.08	Off
Islet	72191.00	846.80	1.17	Off
Core	72191.00	22393.60	31.02	Off
Bridge	72191.00	2231.57	3.09	Off
Perforated	72191.00	3225.51	4.47	Off
Loop	72191.00	871.38	1.21	Off

(B) Grassland Morphology (CCE scale)

Classification	Total Area (Km2)	Class Area (Km2)	Class % of Area	Transition
Background	72191.00	58361.00	80.84	On
Branch	72191.00	743.33	1.03	On
Edge	72191.00	1719.71	2.38	On
Islet	72191.00	1367.86	1.89	On
Core	72191.00	6391.84	8.85	On
Bridge	72191.00	2464.42	3.41	On
Perforation	72191.00	263.44	0.36	On
Loop	72191.00	879.37	1.22	On
Background	72191.00	58361.00	80.84	Off
Branch	72191.00	743.33	1.03	Off
Edge	72191.00	3265.56	4.52	Off
Islet	72191.00	1367.86	1.89	Off
Core	72191.00	6391.84	8.85	Off
Bridge	72191.00	1261.12	1.75	Off
Perforated	72191.00	439.66	0.61	Off
Loop	72191.00	360.61	0.50	Off

Roads

Definitions

Road Density – Density of dirt and paved roads measured in kilometers per square kilometer (Km/Km²)

Distance From Roads – Euclidean distance from dirt and paved roads measured meters (m)

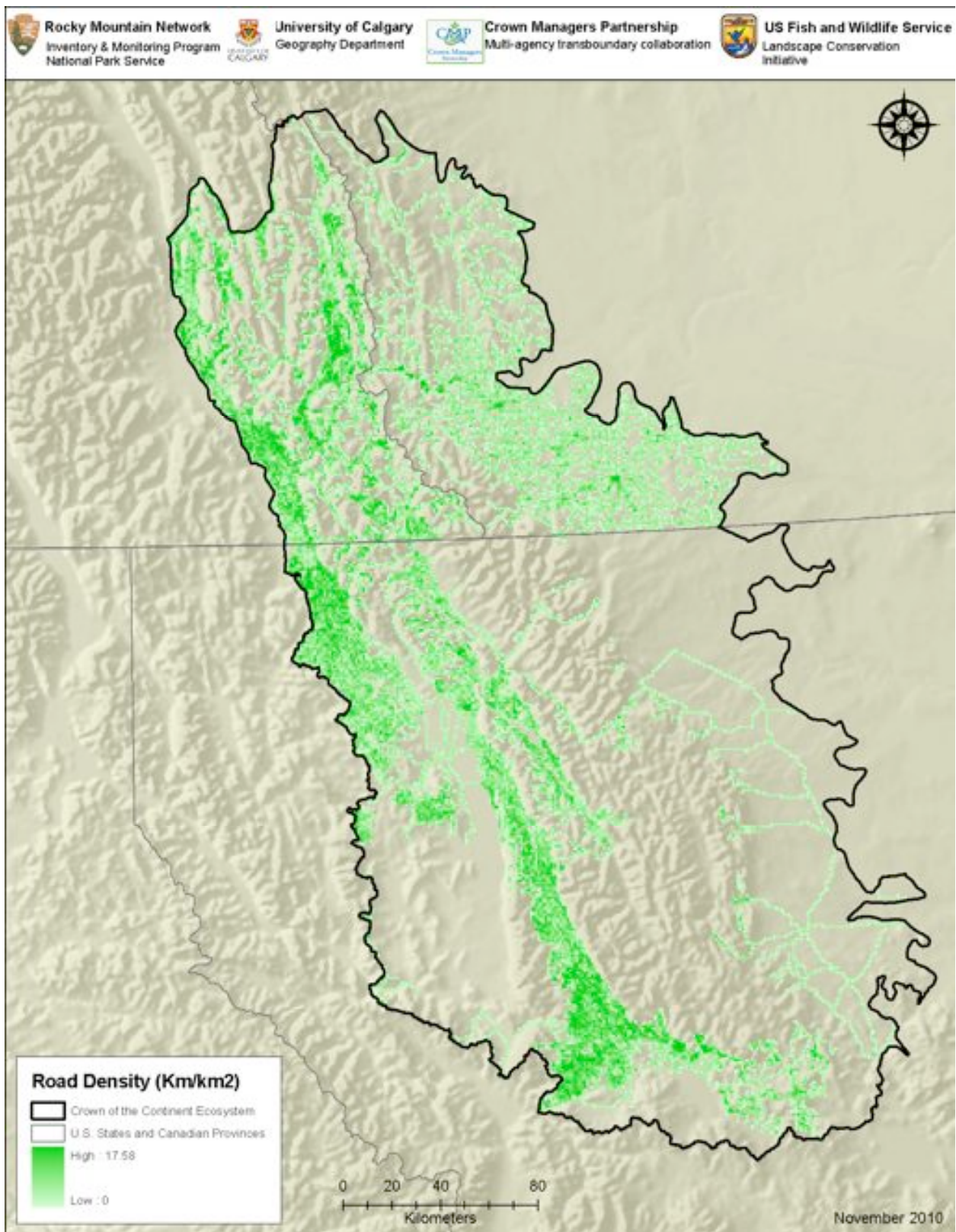


Figure 16. NPScape product – Road Density (km/km²). Scale: Crown of the Continent Ecosystem.

Table 4. Road density statistics derived through NPScape at the Crown of the Continent scale.

Classification	Total Road Length		Total Density (km/km ²)	Area of Analysis
	Total Area (km ²)	(km)		
All Merged Roads	72191.00	43464.78	0.60	Crown of the Continent

Definition References

Soille, P. and Vogt, P. (2009): Morphological segmentation of binary patterns. *Pattern Recognition Letters*. DOI: 10.1016/j.patrec.2008.10.015

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