



Human Footprint in Alberta

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INTRODUCTION

The conversion of natural habitats to habitats marked by human footprint is the greatest threat to biodiversity¹. In central and southern Alberta, most land conversion is associated with agriculture and urban growth, while in northern Alberta, forest harvesting has been the dominant land conversion activity. Over the past few decades, the development of oil and gas and transportation infrastructure has also expanded significantly, resulting in the modification of natural habitats throughout the province. Albertans have said they want to understand the cumulative effects of habitat conversion on Alberta's natural systems and their associated biodiversity². As

a first step in the evaluation of cumulative effects, we used information produced by the Alberta Biodiversity Monitoring Institute (ABMI) to determine the amount and change in human footprint for each of Alberta's natural regions over time. In addition, we evaluated the degree to which different types of native habitat have been converted by each footprint type. This information can be used by planners, managers, and the general public to understand how native habitats and biodiversity in Alberta are changing. Although we present information based on natural region and sub-region here, similar summaries could have been created for any region of interest.

MAPPING HUMAN DISTURBANCE

We define human footprint as the temporary or permanent transformation of native ecosystems to industrial, residential or recreational land uses. Human footprint was determined at two spatial scales: i) coarse: evaluation is conducted at a spatial scale of 1:15,000 for the entire province circa 2010; and, ii) fine: evaluation is conducted at a spatial scale of 1:5000 for each of 1656 sample plots of 21 km² spaced evenly--every 20 km-- throughout Alberta.(Figures 1 & 2).

Coarse-scale information was compiled by ABMI. This information combines GIS layers produced by the Government of Alberta with information created by ABMI. Coarse-scale information was used to describe the amount of human footprint found in Alberta's natural regions and sub-regions and within the habitat types (e.g. pine forest) of each region.

Fine-scale mapping of human footprint in plots was used to describe changes in amounts of footprint between 1999 and 2012. These plots are a systematic sample of Alberta, but encompass only 5% of the province. As such, small patchy human disturbances may have been overlooked in the samples. Footprints in each plot during each year were digitized using high-resolution satellite images obtained from the Government of Alberta. Images were not available for 2000 and 2006, and were of lower quality for 2002 and 2003.

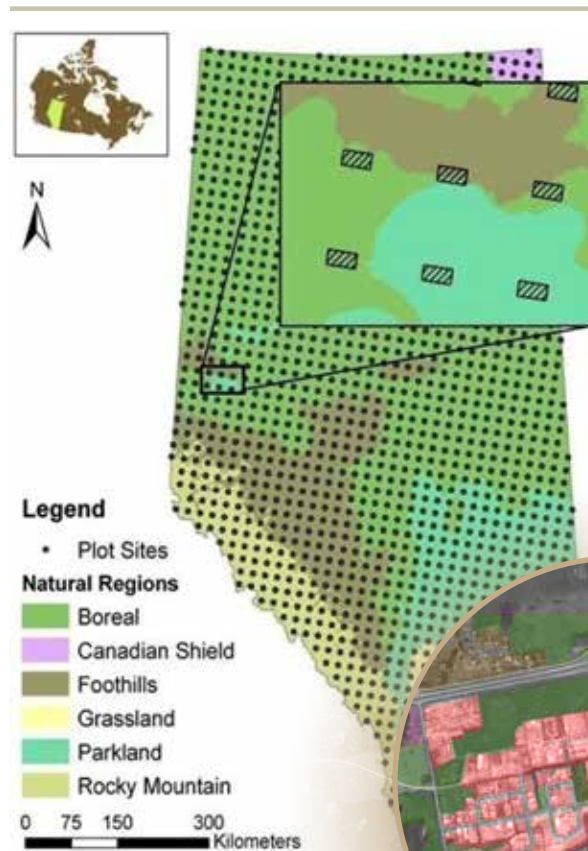


FIGURE 1. Map of the ABMI's systematic sampling grid of 1656 sites superimposed on a map of Alberta's natural regions. The inset is a magnification of seven fine-scale plots, each representing 21 km².



FIGURE 2. Map of human footprint in an area west of Edmonton, Alberta circa 2010.

¹ D. Wilcove, D. Rothstein, J. Dubow, A. Phillips, E.Losos, 1998, *BioScience*, 48:607-615
² Alberta Environmental Protection and Enhancement Act, 2010, Revised Statutes of Alberta 2000 Chapter E-12, 40(c), <http://www.qp.alberta.ca/documents/Acts/E12.pdf>



AMOUNT OF HUMAN DISTURBANCE BY NATURAL REGION

We classified human footprint into six broad categories (see text box). For each category we determined the area converted to human footprint based on the coarse-scale province-wide human footprint map, and change in amount

CATEGORIES OF HUMAN FOOTPRINT

- a. Agriculture
- b. Forest Harvest
- c. Mines, Wells & Other Energy Features
- d. Urban, Rural & Industrial
- e. Transportation
- f. Human-created Water Bodies

of human footprint over time based on the fine-scale plot information. Results were presented for each natural region (Table 1 and 2, Figure 3), and for

regions dominated by private (Table 3) versus public (Table 4) land ownership. Due to its small area, the Canadian Shield was combined with the Boreal in all analyses.

Agricultural development was the most abundant human footprint in the province with this land use occupying 67% and 48% of the Parkland and Grassland regions respectively (Table 1). Agriculture footprint in the Boreal occurred mainly in the Dry Mixedwood. Forest harvesting was the next most abundant footprint type, occupying 17% of the Foothills and 3% of the Boreal and Rocky Mountains (forest harvest in the Rocky Mountains occurred mainly in the Montane sub-region). Mines, well sites and other energy features were most common in the Foothills, but were present throughout all natural regions. Transportation, urban, rural and industrial footprints occupy less than 4% of all regions but were most common in the Parkland followed by the Grassland. Human-created water bodies occupied low percentages of all regions but were most common in the Grassland.

TABLE 1. Percentage of each natural region converted to human footprint.

Footprint Type	Boreal ^a	Foothills	Rocky Mountain	Parkland	Grassland	Total Province
Area (km ²)	390,766	66,436	49,070	60,748	95,565	662,587
Agriculture	10.60	3.04	0.80	66.94	47.63	19.65
Forest Harvest ^b	2.71	16.87	2.98	0.02	0.00	3.51
Mines, Wells & Other Energy Features	1.70	2.49	0.52	1.68	2.48	1.81
Urban, Rural & Industrial	0.43	0.26	0.27	3.57	1.31	0.82
Transportation	0.70	1.20	0.48	3.36	2.24	1.20
Human-created Water Bodies	0.05	0.12	0.09	0.18	0.61	0.15
All Human Footprints	16.19	23.98	5.14	75.75	54.27	27.14

a – Information for the Boreal and Canadian Shield was combined

b – This is an over-estimate of forestry influences on biodiversity because vegetation recovery in harvested areas has not been accounted for

Over the past decade, land converted to human footprint increased for all footprint types across all natural regions (Figure 3, Table 2). However, total footprint increased more than four times faster in the Foothills compared to other regions – an additional 6.5% of the Foothills was converted to human footprint during the past decade. Increase in agriculture footprint was highest in the Grassland, although this land use also increased moderately in all regions except the Rocky Mountains. Increase in forest

harvest was highest in the Foothills, followed by the Boreal and Rocky Mountains. Mines, well sites and other energy features increased at moderate rates in the Boreal and at smaller rates in other natural regions. Urban/industrial footprint increased the most in the Parkland with smaller rates of increases in the Foothills, Grassland and Boreal. Transportation and human created water bodies had only small rates of increases in all natural regions.

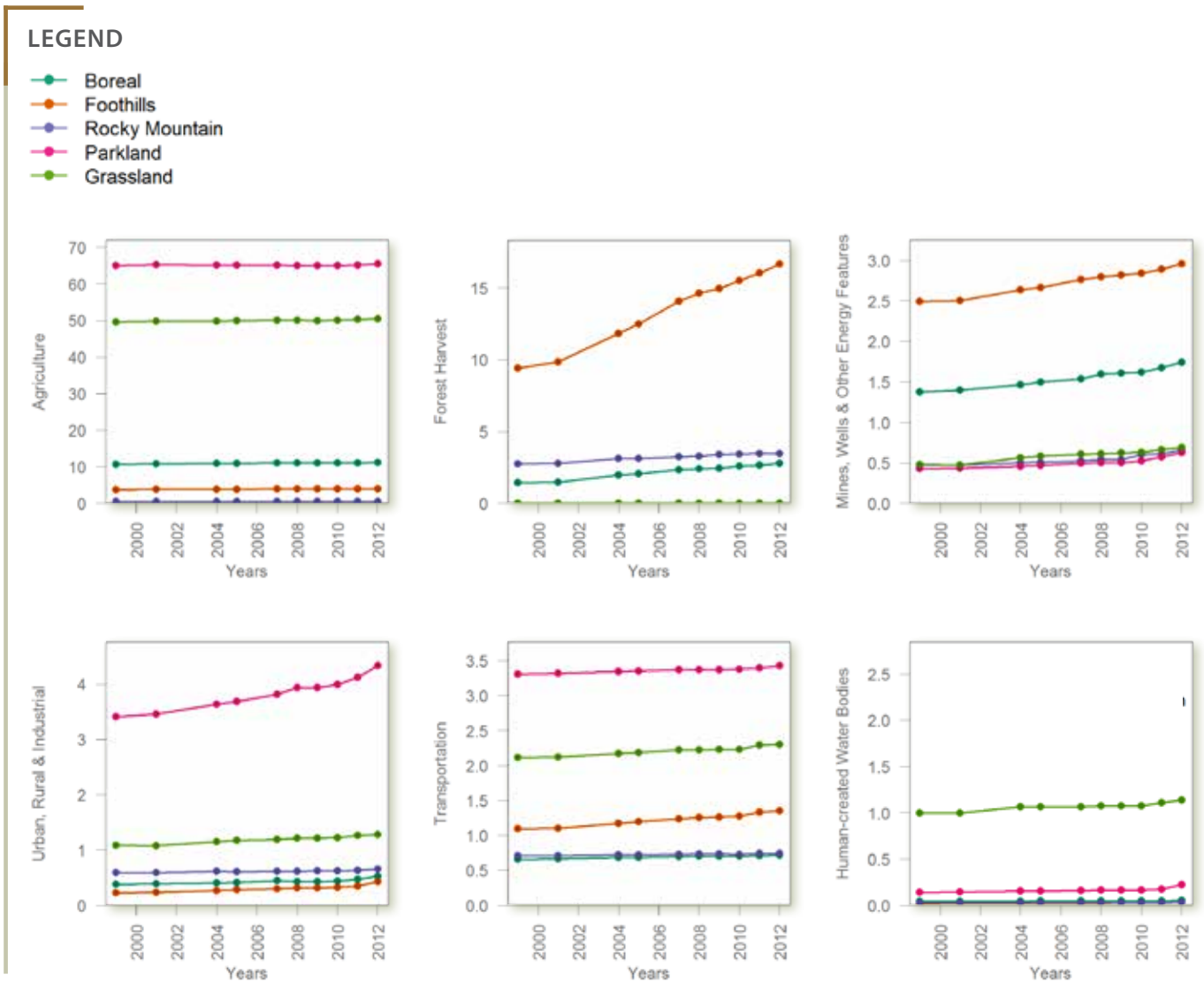


TABLE 2.

Rate of native habitat converted during the last 10 years (expressed as a percent of the total area) for each footprint type in each natural region. Rates were calculated from data presented in Figure 3.

Footprint Type	Boreal	Foothills	Rocky Mountain	Parkland	Grassland	Total Province
Agriculture	0.32	0.23	0.02	0.36	0.70	0.35
Forest Harvest	1.05	5.58	0.55	0.00	0.00	1.20
Mines, Wells & Other Energy Features	0.28	0.36	0.14	0.15	0.16	0.03
Urban, Rural & Industrial	0.11	0.15	0.05	0.71	0.15	0.25
Transportation	0.04	0.20	0.02	0.09	0.14	0.07
Human-created Water Bodies	0.01	0.01	0.00	0.06	0.11	0.17
All Human Footprints	1.73	6.53	0.76	1.30	1.19	2.07

FIGURE 3. Percentage of each natural region occupied by each human footprint type for the years 1999–2012.





CONVERSION OF EACH HABITAT TYPE BY HUMAN DEVELOPMENT

Some human disturbances are focused on particular vegetation and soil types. The ABMI created a GIS layer summarizing soil information into broad categories³ for southern Alberta, and created a second GIS layer describing the vegetation that would have been expected throughout the province if human footprint was not present⁴. The vegetation layer was created by integrating existing vegetation layers from the Government of Alberta, Parks Canada and the ABMI and then “backfilling” human footprints in these layers to native vegetation types by nibbling the surrounding vegetation into the footprints. As part of this process only upland habitats were nibbled into cutblocks and cultivation. By overlaying the 2010 wall-to-wall human footprint layer on top of the soil and backfilled layer we estimated the degree to which each soil and vegetation type have already been converted to human footprint.

Privately Owned Land:

For natural sub-regions in the province dominated by privately owned land (ie., Grassland, Parkland, Dry Mixedwood), we determined the percentage of each soil type⁵ that has been converted to each type of human footprint (Table 3). Agriculture was the dominant footprint type in this region and occurred mainly on productive soil types, although saline soil types also had a disproportionate amount of agriculture. Percentage of productive soil converted to agriculture, however, varied among natural sub-regions – approximately 80% in the Peace River Parkland and Central Parkland, but only 51% in the Dry Mixedgrass were converted by agriculture activities. Energy, urban, rural and industrial and transportation footprint types occupied moderate percentages of the region, and occurred on all soil types. The small amount of forest harvest that was present, occurred mainly on productive soils.

TABLE 3.

Percentage of each soil type in the combined Grassland, Parkland and Dry Mixedwood that has been converted to human footprint.

Footprint Type	Productive ^a	Saline ^b	Rapidly Drained ^c	Wetland / Riparian ^d	Total (excluding open water)
Area (km ²)	163,804	27,522	16,841	1,111	209,280
Agriculture	65.1	47.05	23.24	20.41	59.12
Forest Harvest ^b	0.34	0.01	0.14	0.03	0.28
Mines, Wells & Other Energy Features	1.82	2.95	3.30	3.22	2.10
Urban, Rural & Industrial	2.44	1.45	1.56	6.14	2.26
Transportation	2.94	2.64	2.06	2.62	2.83
Human-created Water Bodies	0.05	0.08	0.04	0.07	0.05
All Human Footprints	72.69	54.18	30.34	32.49	66.63

a – Soil types Clayey, Limy, Loamy and Subirrigated were classified as productive

b – Soil types Blowout, Overflow and Saline Lowland were classified as saline

c – Soil types Badland, Choppy Sandhills, Gravel, Sand, Shallow to Gravel, Sandy and Thin Breaks were classified as rapidly drained

d – Soil types Lentic Alkali, Lentic Semi-Permanent, Lentic Temporary, Lentic Seasonal, Lentic Coniferous, Lentic Deciduous, Lentic Herbaceous and Lentic Shrub were classified as wetland/riparian

³ Unpublished GIS layer created by the Alberta Biodiversity Monitoring Institute.

⁴ Unpublished GIS layer created by the Alberta Biodiversity Monitoring Institute.

⁵ Soil types are described in

http://www.albertapcf.org/rsu_docs/grassland-vegetation-inventory-specifications-5th-edition--june-29-2010-revised---november-9-2011.pdf



Publicly Owned Land:

For natural sub-regions in Alberta that are largely composed of publicly owned land (ie., Rocky Mountains, Foothills, Shield and Boreal [excluding the Dry Mixedwood]), we calculated the proportion of each vegetation type that has been converted to each human footprint type (Table 4). Human footprint occupied a much smaller percentage of public land compared to private land (Table 3 vs Table 4; 9.6% vs 47.4% respectively). With the exception of bare ground (mainly found in alpine areas), much higher percentages of upland habitat types were converted to human footprint than for lowland habitat types (Table 4). The main human footprint found in shrub and grass habitats was agriculture. The main human footprint found in upland forest was forest harvest. However, the percentage of upland forest that has been harvested varied among natural sub-regions – Lower and Upper Foothills had more than 20% of their upland forests harvested, whereas only very low percentages of upland forest were harvested in natural sub-regions in the far northern areas of Alberta. Deciduous and mixedwood forest had substantial amounts of both forest harvest and agriculture. Mines, wells and other energy features converted approximately similar percentages of all vegetation types in the region.

TABLE 4.

Percentage of each vegetation type in the combined Rocky Mountains, Foothills, Shield, and Boreal (excluding the Dry Mixedwood) that has been converted to human footprint.

Footprint Type	Deciduous	Mixed- Deciduous & Coniferous	Spruce/ Fir	Pine	Shrub	Grass	Bare	Bog	Fen	Swamp/ Marsh	Total (excluding open water)
Area (km ²)	78,508	20,122	52,956	48,073	10,187	6,525	13,134	53,377	60,449	52,198	395,695
Agriculture	5.99	5.55	0.92	0.14	5.04	8.72	0	0.18	0.23	0.93	2.07
Forest Harvest	7.9	16.47	10.56	13.27	1.22	2.15	0.02	0	0.02	0	5.50
Mines, Wells & Other Energy Features	2.22	2.41	1.3	1.33	1.03	2.18	0.02	2.28	2.03	1.88	1.83
Urban, Rural & Industrial	0.39	0.36	0.18	0.1	0.28	0.68	0.04	0.07	0.06	0.09	0.18
Transportation	0.91	1.01	0.49	0.66	0.46	1.13	0.02	0.29	0.18	0.27	0.51
Human-created Water Bodies	0.04	0.04	0.01	0.01	0.01	0.03	0	0.02	0.01	0.02	0.02
All Human Footprints	17.45	25.84	13.46	15.51	8.04	14.89	0.1	2.84	2.53	3.19	10.11

SUMMARY & CONCLUSIONS

Understanding the amount, pattern and rate of change of human disturbance in a region is the first step to understanding cumulative effects of human development on biodiversity. Conversion of native vegetation to human footprint has been shown to affect the species present at a site and in the surrounding landscape^{6,7}. Species that require native vegetation decrease, whereas species that live and breed in human modified environments increase as amount of human footprint in the region increases⁸. By understanding how habitats are changing in a region, planners, managers and the general public can start to understand how biodiversity is also changing.

⁶ Alberta Biodiversity Monitoring Institute. 2011. The Status of Biodiversity in the South Saskatchewan Planning Region: Preliminary Assessment. (00063) Version 2011-08-13. Alberta Biodiversity Monitoring Institute, Alberta, Canada. www.abmi.ca

⁷ P. Solymos, L. Mahon, E. Bayne, S. Song, D. Duncan. 2014. Development of Predictive Models for Migratory Landbirds and Estimation of Cumulative Effects of Human Development in the Oil Sands Areas of Alberta. Environment Canada, Edmonton, AB.

⁸ Alberta Biodiversity Monitoring Institute. 2013. The Status of Biodiversity in the Athabasca Oil Sands Area: Preliminary Assessment. Alberta Biodiversity Monitoring Institute, Alberta, Canada. www.abmi.ca



Major findings

Regions dominated by private land ownership:	Regions dominated by public land ownership:
<ul style="list-style-type: none"> • Approximately 76% and 54% of the native habitats in Parkland and Grassland (respectively) have been converted to human footprint. • Most of the conversion was due to agriculture. • Conversion of native habitat was highest on productive soils. • Conversion of native habitat is continuing — an additional 1.2% of the region was converted to human footprint during the last decade. 	<ul style="list-style-type: none"> • 24%, 16% and 5% of the native habitats in Foothills, Boreal and Rocky Mountains, respectively, have been converted to human footprint. • More than half of the footprint in these regions was forest harvest. • Conversion of native habitat is continuing — an additional 2.2% of the region was converted during the last decade. • Rate of conversion of native habitats has been four times faster in the Foothills compared to other natural regions.

Although we analyzed information based on natural regions and sub-regions, similar summaries could have been created for any region of interest.

Results must be interpreted with caution because native vegetation recovers in many types of human footprint (e.g., vegetation regrows in harvested areas, seismic lines), and thus amount of human footprint is not a direct measure of biodiversity intactness in the area. We are presently evaluating how vegetation recovery influences biodiversity in human footprints.

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