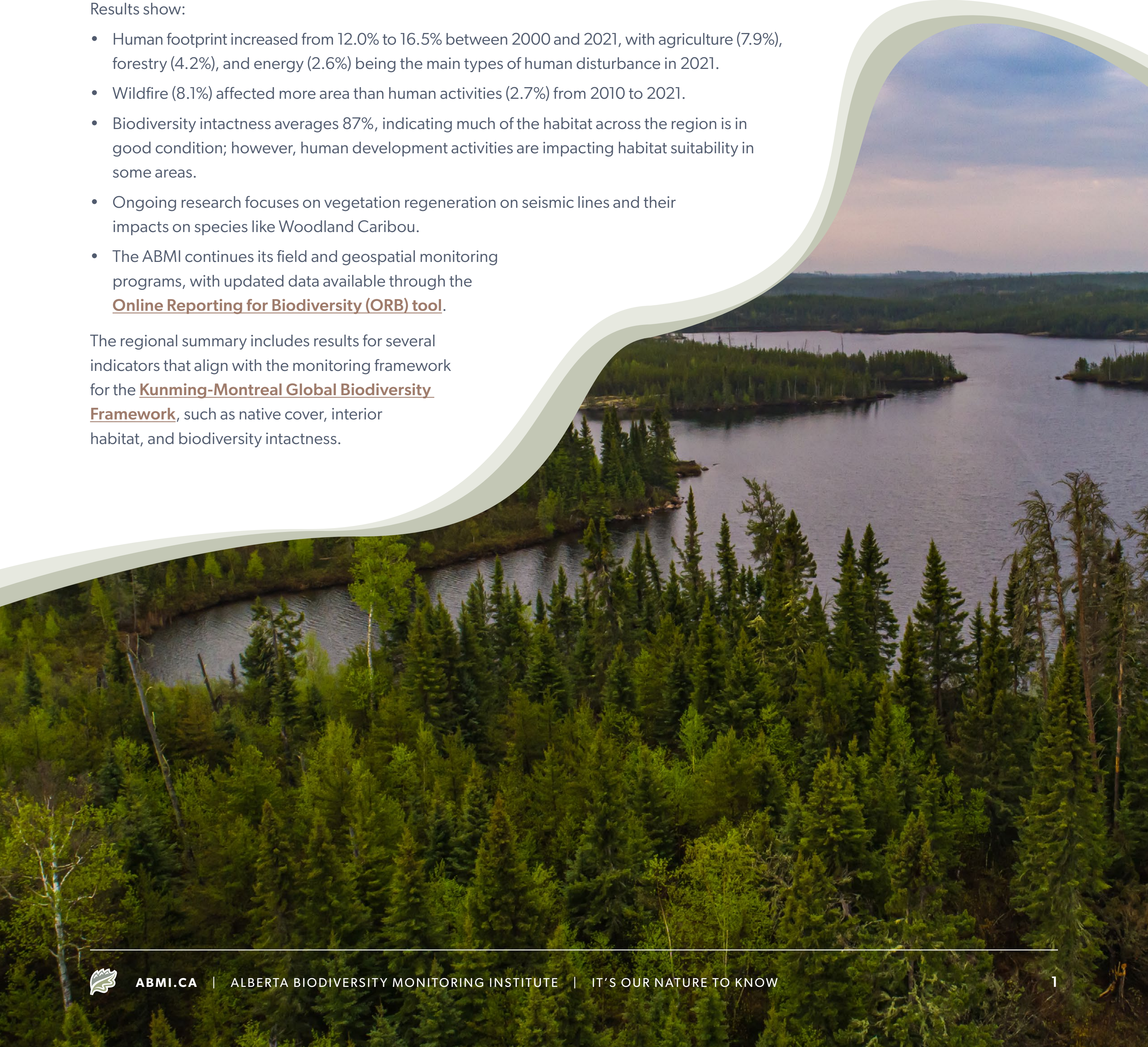
Status of Land Cover & Biodiversity in the Oil Sands Region, Alberta, Canada

This report summarizes the status of land cover and biodiversity in the Oil Sands Region.

Results show:

- Human footprint increased from 12.0% to 16.5% between 2000 and 2021, with agriculture (7.9%), forestry (4.2%), and energy (2.6%) being the main types of human disturbance in 2021.
- Wildfire (8.1%) affected more area than human activities (2.7%) from 2010 to 2021.
- Biodiversity intactness averages 87%, indicating much of the habitat across the region is in good condition; however, human development activities are impacting habitat suitability in some areas.
- Ongoing research focuses on vegetation regeneration on seismic lines and their impacts on species like Woodland Caribou.
- The ABMI continues its field and geospatial monitoring programs, with updated data available through the **Online Reporting for Biodiversity (ORB) tool**.

The regional summary includes results for several indicators that align with the monitoring framework for the **Kunming-Montreal Global Biodiversity Framework**, such as native cover, interior habitat, and biodiversity intactness.



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Introduction

The Oil Sands Region (OSR) of Canada comprises 142,200 km^2 of boreal forest in northeast Alberta (Figure 1). It is on treaty lands and traditional territories of Indigenous Peoples; these areas are vitally important for hunting and fishing, cultural practices, and maintaining traditional ways of life.

The OSR represents the world's fourth largest proven oil reserves. The energy sector in the region includes both oil sands and conventional oil and gas development. Other common land uses include agriculture, forestry, and municipal developments, along with the associated infrastructure to support these activities. Managing the cumulative effects of these multiple land uses is a key challenge in this region.

As part of their commitment to environmental stewardship, the energy sector invests in understanding and minimizing the impact of their activities on species and habitats. This includes collaborative approaches with other land users to reduce human footprint.

This report summarizes the status of land cover and biodiversity in the OSR using up to 20 years of monitoring data collected by the Alberta Biodiversity Monitoring Institute (ABMI), specifically reporting on:

1. Status of land cover
    a. Human footprint, highlighting vegetation regeneration on seismic lines
    b. Landbase change due to fire and human footprint
    c. Native habitat, including native cover and interior native habitat
2. Status of biodiversity
    a. Biodiversity Intactness Index
    b. Effects of energy sector footprint on species habitat suitability
    c. Species of conservation concern

The scientific analysis provided in this regional summary aligns with multiple indicators from the monitoring framework for the Kunming-Montreal Global Biodiversity Framework[1].

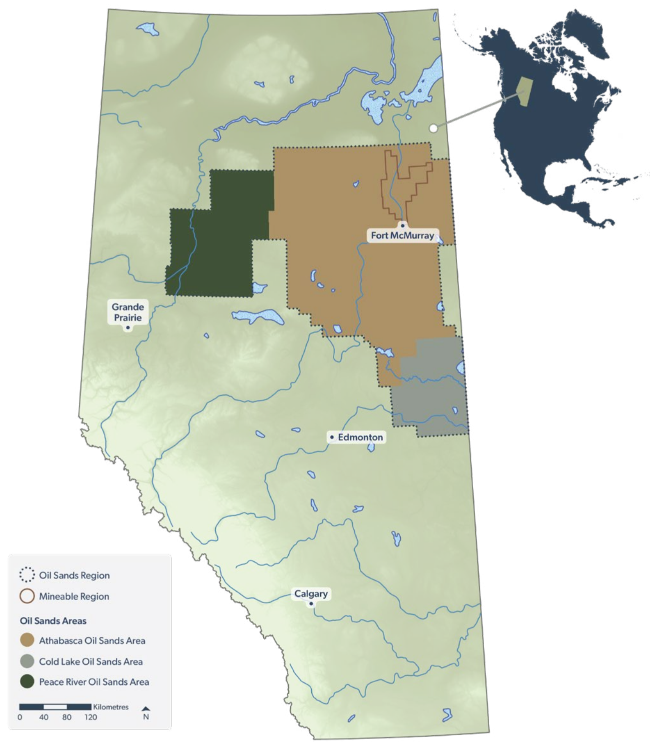
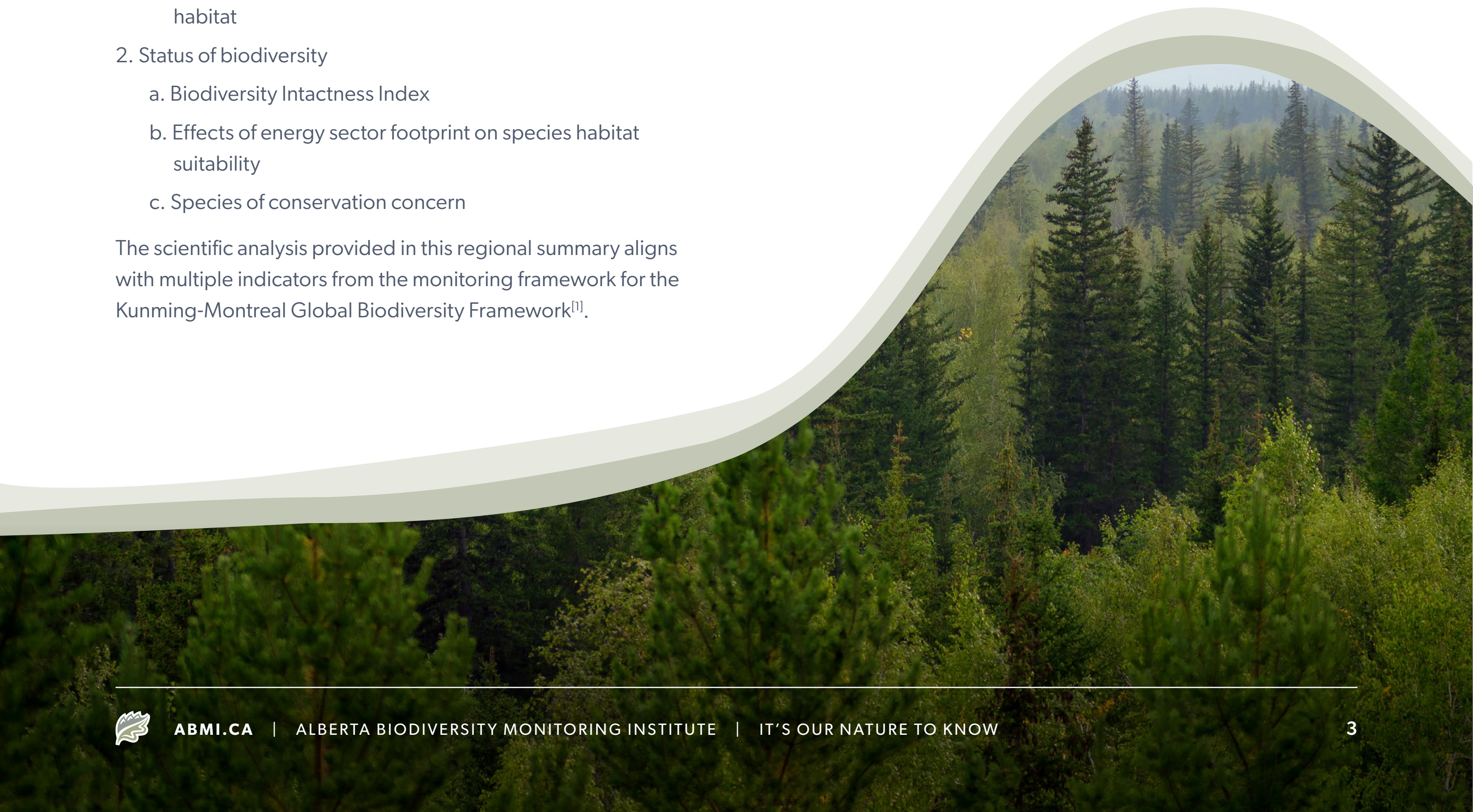


Figure 1. The OSR in Alberta includes three administrative units: the Athabasca, Cold Lake, and Peace River Oil Sands Areas. The Mineable Region is a subregion of the Athabasca OSA, where oil sands surface mining occurs.



About the ABMI

The ABMI is a Canadian non-profit, non-governmental organization. Our mission is to track changes in wildlife and their habitats across Alberta, working collaboratively to provide relevant, scientifically credible, and open information about our living resources. Visit **abmi.ca** for more information.

The ABMI has 350 monitoring sites in the OSR, of which 328 have been visited to date (Figure 2). At each site, we record species that are present and measure a variety of habitat characteristics. The ABMI monitors the status and trend of human footprint and habitat using fine-resolution imagery, light detection and ranging (lidar) data, and satellite imagery. These datasets are used to identify relationships between human land use, habitat, and species abundance.

Detailed information about methods of data collection, data analysis, and full results can be found in the supplementary report accompanying this regional summary.

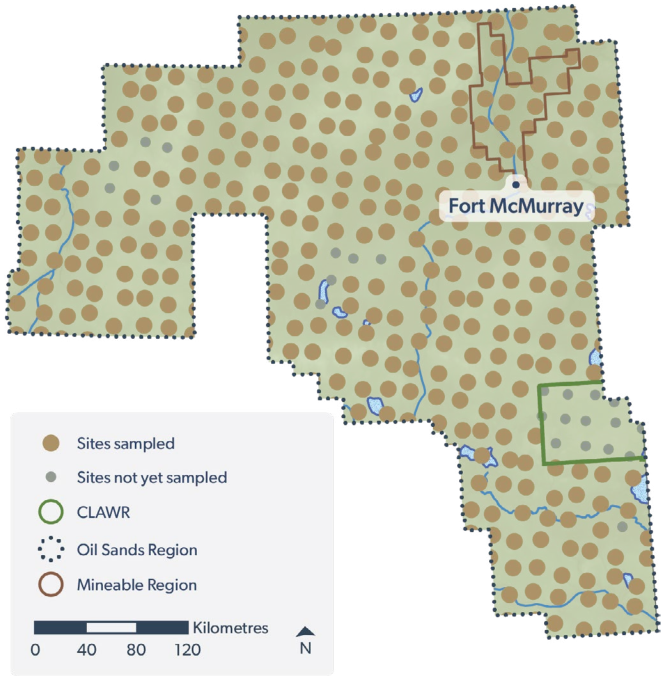


Figure 2. The ABMI has 350 survey sites in the OSR; 328 have been sampled. Data from across the boreal region is used to strengthen analysis. No monitoring has occurred on the Cold Lake Air Weapons Range (CLAWR) because access is restricted.

Status of Land Cover in the Oil Sands Region

Human Footprint

Measurement of human footprint is increasingly being used as a land-use planning tool to monitor the status of landscapes[2]. Human footprint is defined here as the visible alteration* or conversion of native ecosystems to temporary or permanent residential, recreational, agricultural, or industrial landscapes[3].

In addition to development in the energy sector, land uses such as forestry, agriculture, and municipal development also affect native habitats in various ways. In some instances, habitats are temporarily altered but can regenerate, as seen with successional recovery following forest harvesting. However, other activities lead to habitat loss, such as the construction of paved roads, mines, and industrial facilities.

Tracking changes in human footprint is important to understand where impacts occur and to plan for habitat restoration or reclamation where required.

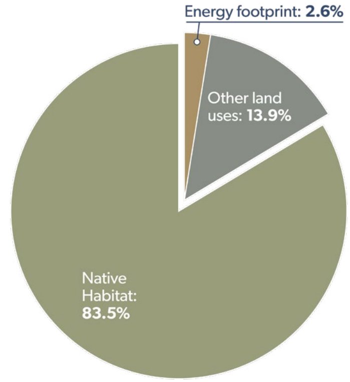
We report on the status (circa 2021; Figure 3) and trend (2000-2021) of human footprint in the OSR, and spotlight research on vegetation regeneration on seismic lines.

Connecting Indicators

As part of the **Kunming-Montreal Global Biodiversity Framework**, ABMI's land cover datasets can be used to measure and report on several complementary indicators related to terrestrial forest ecosystems, such as forest fragmentation index and rate of tree cover loss and gain[1].

Highlights

As of 2021, total human footprint covered 16.5% of the OSR, a 37% increase from 2000 to 2021 (rising from 12.0% to 16.5%).



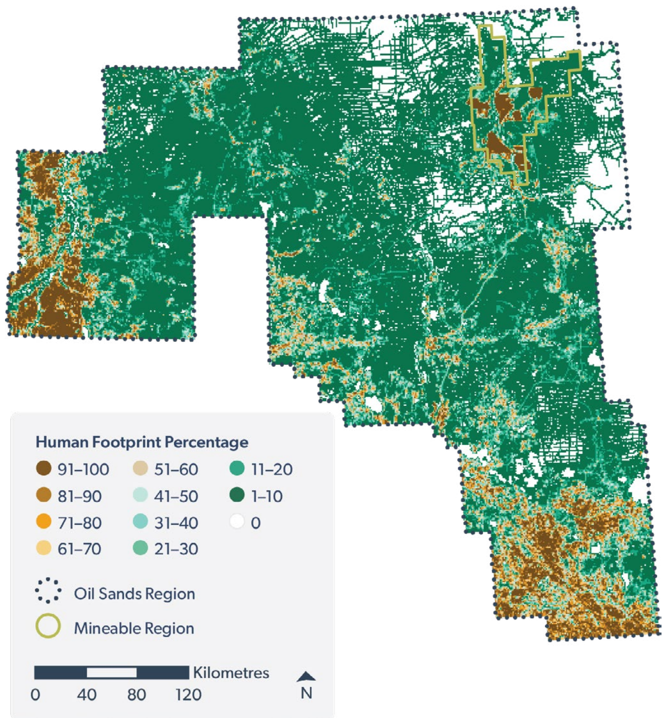
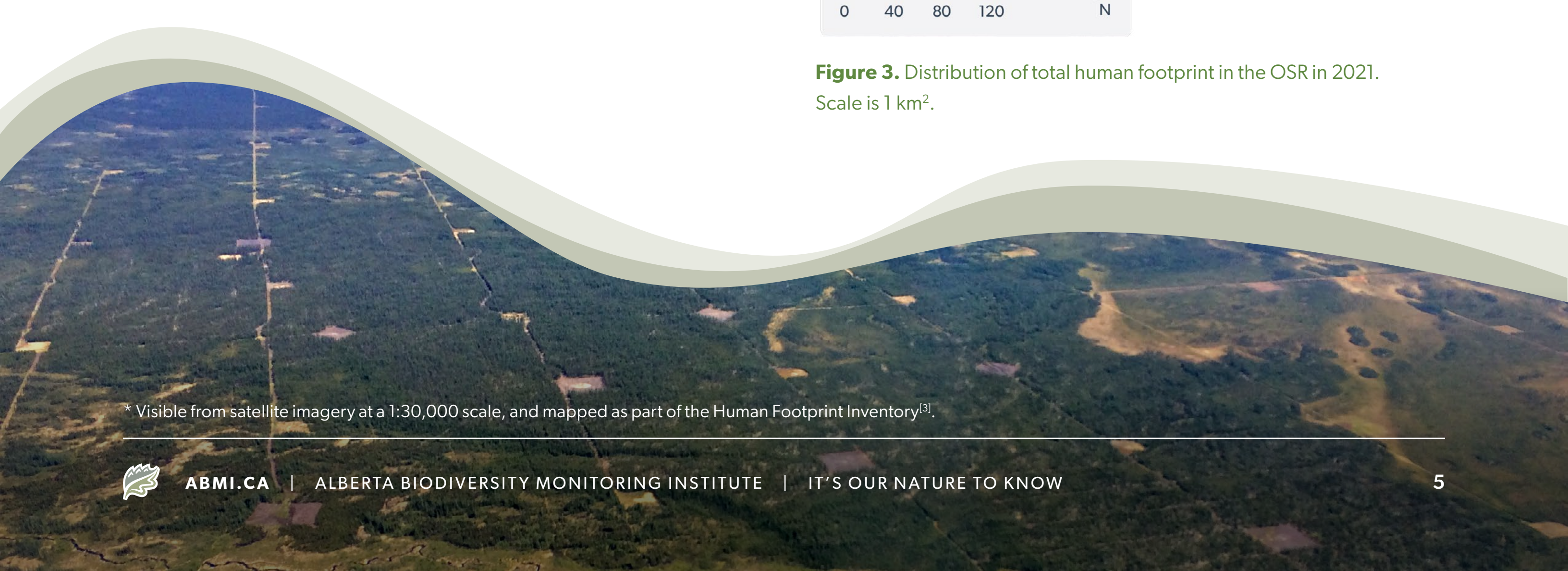
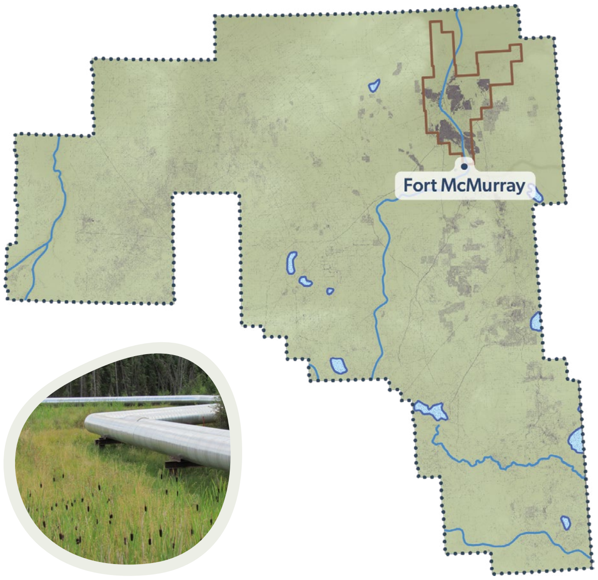


Figure 3. Distribution of total human footprint in the OSR in 2021. Scale is 1 km^2.



* Visible from satellite imagery at a 1:30,000 scale, and mapped as part of the Human Footprint Inventory[3].



Energy: 88% increase between 2000 and 2021 (from 1.4% to 2.6%).

While the total area of energy footprint across the entire OSR is low (2.6%), it is higher in the Mineable Region (20.3%). This subregion of the OSR, covering an area of 4,800 km^2, is where oil sands industrial activities are concentrated.

Other types of energy footprint (e.g., well pads, seismic lines) are more evenly distributed across the rest of the landscape.

Agriculture: 4% increase between 2000 and 2021 (from 7.6% to 7.9%).

This type of human footprint covers the largest area in the OSR.

Agriculture is concentrated in two areas: the west and the south of the OSR.

Other human footprint: small increases in area between 2000 and 2021.

The remaining categories of human footprint each covered <1% of the region including transportation (0.9%), urban/industrial (0.8%), and human-created water bodies (0.1%),

Forestry: 120% increase between 2000 and 2021 (from 1.9% to 4.2%)

The recovery of harvested areas partially mitigates increases from new harvesting: when recovery of regenerating forest is considered, the change in forestry footprint is from 1.7% in 2000 to 2.9% in 2021.

Legend for Agriculture, Energy, and Forestry Maps

Energy
Agriculture
Forest Harvest
Oil Sands Region
Mineable Region
Kilometres
0 40 80 120
N

Spotlight: Vegetation Regeneration on Seismic Lines

Seismic lines created for oil and gas exploration are a specific type of linear disturbance that are common to the OSR[4].

Density of linear features in the OSR (circa 2021) †

1.5 km/km²
Conventional seismic line density

2.1 km/km²
Total linear feature density

Although small in total area, these narrow linear disturbances (similar to roads and pipelines) create extensive forest edges, reducing the area of interior native habitat. This fragmentation impacts various components of biodiversity differently—some positively and some negatively.

Vegetation recovery on seismic lines can be slow due to persistent environmental changes such as altered soil conditions, water drainage, wildlife use, and human activities. The sheer number of seismic lines across the landscape has made this a significant management challenge.

Seismic lines are a common linear disturbance in the OSR.

Major research efforts are ongoing to identify lines needing treatment to promote vegetation regeneration, and those that are expected to regenerate naturally. Two major research programs include:

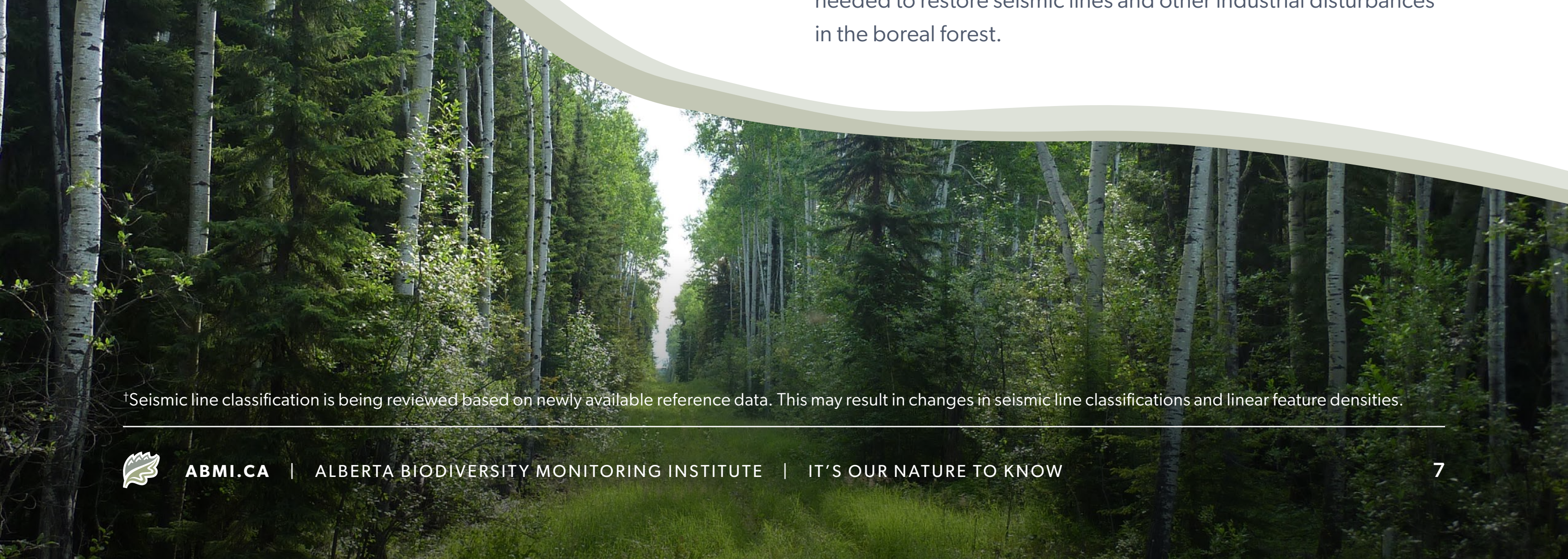
Remote Sensing

Lidar data and imagery are being used to assess vegetation regeneration on seismic lines as part of the **Oil Sands Monitoring Program**, contributing to a larger initiative by the Government of Alberta to evaluate seismic lines across all caribou ranges. This detailed information can help identify lines that are regenerating naturally and those where restoration is most needed.

Revegetating older and wider legacy seismic lines is an important part of habitat recovery for woodland caribou—a species at risk in the OSR.

Boreal Ecosystem Recovery and Assessment (BERA) program

The **BERA program** is a multi-sectoral research partnership aimed at developing the knowledge, tools, and workflows needed to restore seismic lines and other industrial disturbances in the boreal forest.



†Seismic line classification is being reviewed based on newly available reference data. This may result in changes in seismic line classifications and linear feature densities.

Landbase Change from 2010 to 2021

Wildfire is the primary natural disturbance in boreal forests. Fires and other natural disturbances such as insect outbreaks and disease, create a mosaic of stands of different ages from young forests to forests more than 150 years old. This mosaic of ages helps maintain biodiversity across the OSR.

Native vegetation disturbed by fire and human footprint

10.8%

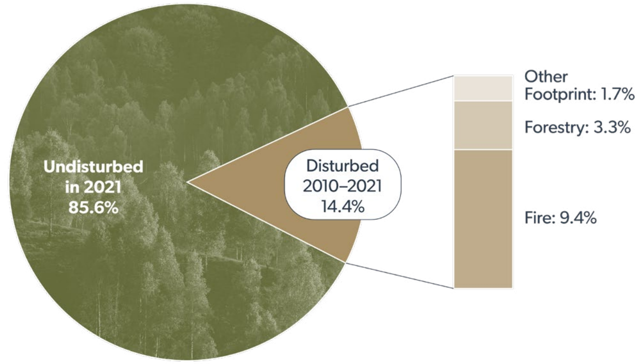
between 2010 and 2021

While wildfires are natural events, there is concern that they are increasing in frequency and severity due to factors such as a changing climate. It is important to consider how fires alongside human activities, such as energy development, are collectively impacting native habitat in the boreal forest.

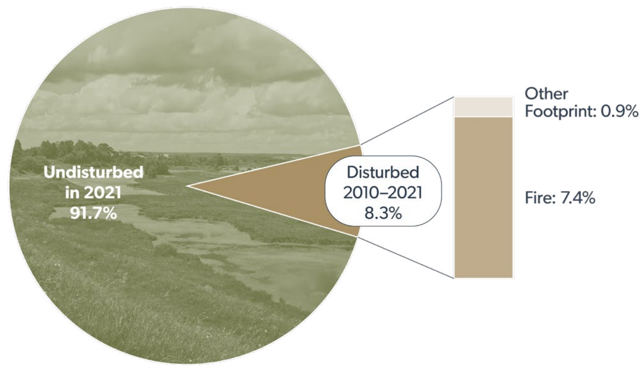
In this section we directly report on how native habitat‡ has changed in the OSR due to fire, along with new forestry and non-forestry footprint from 2010 to 2021.

Wildfires were the dominant disturbance across the OSR between 2010 and 2021.

Out of a total of 49,895 square kilometres of **Upland Forest** native habitat in 2010:



Out of a total of 57, 561 square kilometres of **Lowland** native habitat in 2010:



Highlights

Of the native habitat disturbed in the OSR between 2010 and 2021:

- Fire disturbed more area than all human activities combined, affecting 9.4% of upland forest and 7.3% of lowland vegetation.
- Forestry footprint affected 3.3% of upland forest areas, where productive forests are found.
- Other human footprints, like energy and transportation, were more evenly spread across the OSR, impacting 1.7% of upland forest and 0.9% of lowland habitats.

Fire creates new habitat for early seral species, but species reliant on mature/old forests are losing habitat due to fires, forestry, and other types of human footprint.

‡ Native habitat impacted by disturbance is summarized for two dominant vegetation types: upland forest which is composed of deciduous, mixedwood, pine, and spruce forest stand types; lowland which is composed of open, shrubby, and treed wetlands. Shrub and grass vegetation types occupy a small area in the OSR and are therefore not shown in this report. Results are available in the Supplementary Report.

Native Habitat

Undisturbed natural areas, or native habitats, are important to maintain biodiversity and ecosystem functions[5]. The conversion of native habitats to other land uses due to human activities is one of the main threats to biodiversity[6].

Area of native cover
(circa 2021)

94.5%
Aquatic & wetland habitat

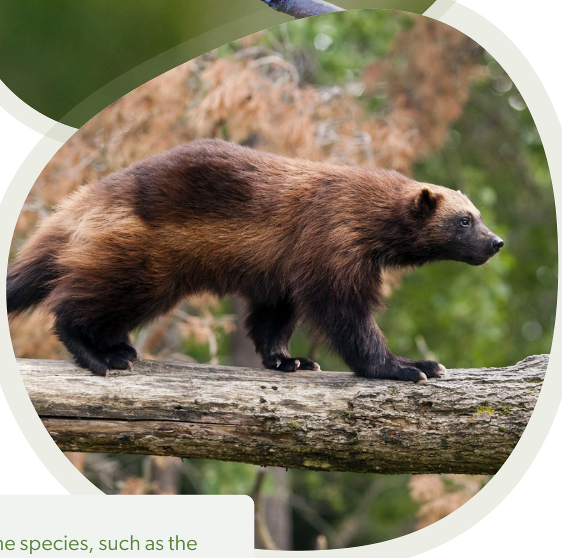
76.8%
Terrestrial habitat

In addition to direct loss or alteration, native habitat can be indirectly affected by nearby human footprint—a concept known as edge effect. For example, some wildlife species prefer edge habitats while others require remote undisturbed areas away from human footprint (i.e., interior habitat).

As discussed previously, linear features (e.g., seismic lines) are pervasive across the OSR, contribute to edge effect, and lower the availability of interior native habitat in the region.

In this section we present:

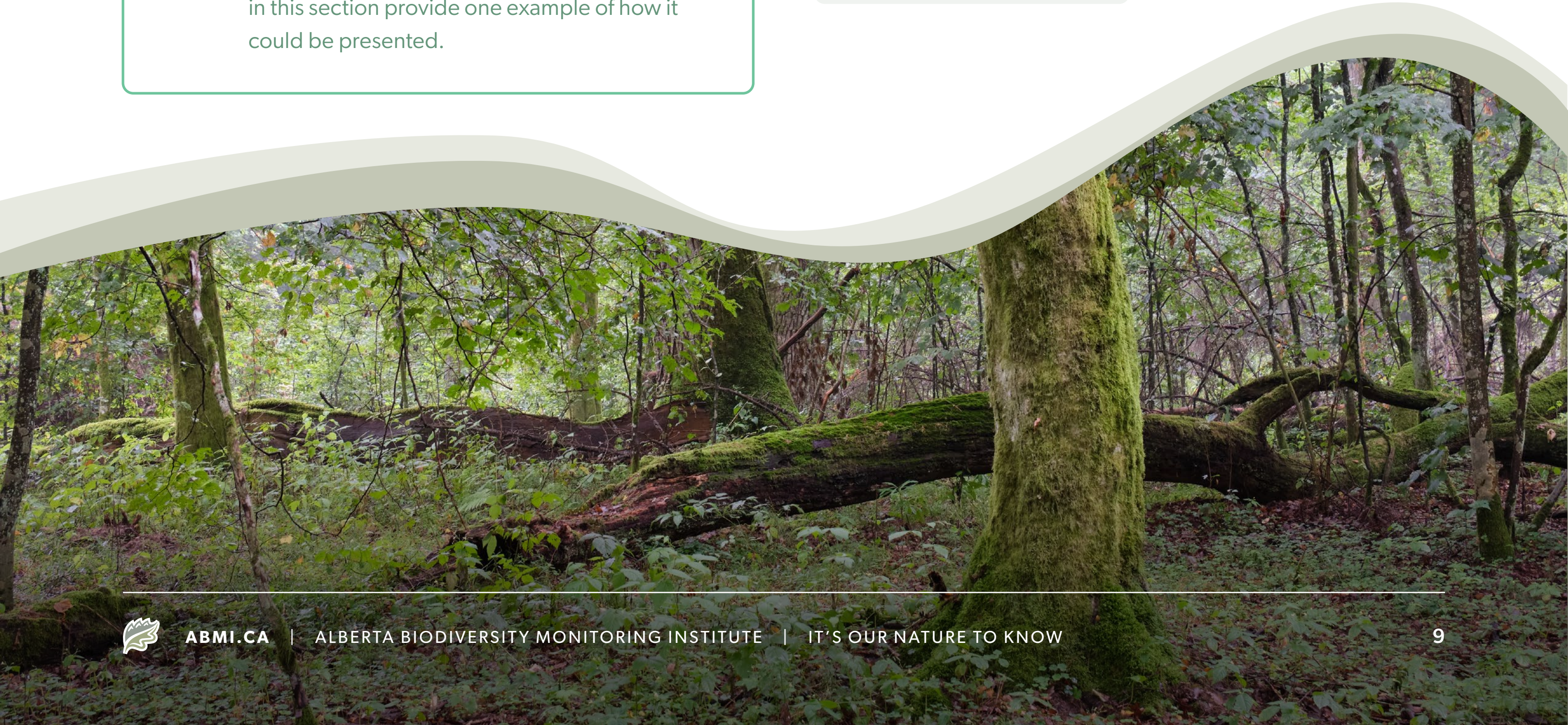
- area of native cover[7] for terrestrial ecosystems and aquatic and wetland ecosystems in the OSR, and:
- area of interior habitat[8] at three distances from human footprint: 50 m, 200 m, and 500 m.



Some species, such as the Dark-eyed Junco, can use habitat that is adjacent to human footprint. Other species prefer habitat that is more distant from human footprint, such as Wolverine.

Connecting Indicators

Extent of natural ecosystems is an indicator included in the **Kunming-Montreal Global Biodiversity Framework**[1]. Although methods to calculate this indicator have not been defined as part of the framework, the results shown in this section provide one example of how it could be presented.



Highlights: Native Cover

Native cover is defined as areas that are free of visible human land use (i.e., human footprint). In the OSR (Figure 4):

- Aquatic and wetland native cover (i.e., lowland habitat) is high at 94.5%;
- Terrestrial native cover (i.e., upland habitat) is lower at 76.8%; and
- These results indicate that, when summarized based on area, human footprint is disproportionately impacting upland terrestrial habitats in the OSR. Specifically, agriculture and forestry footprint mainly occur in upland terrestrial habitats, while other footprint types, like energy and transportation, are fairly evenly distributed throughout upland and lowland habitats.

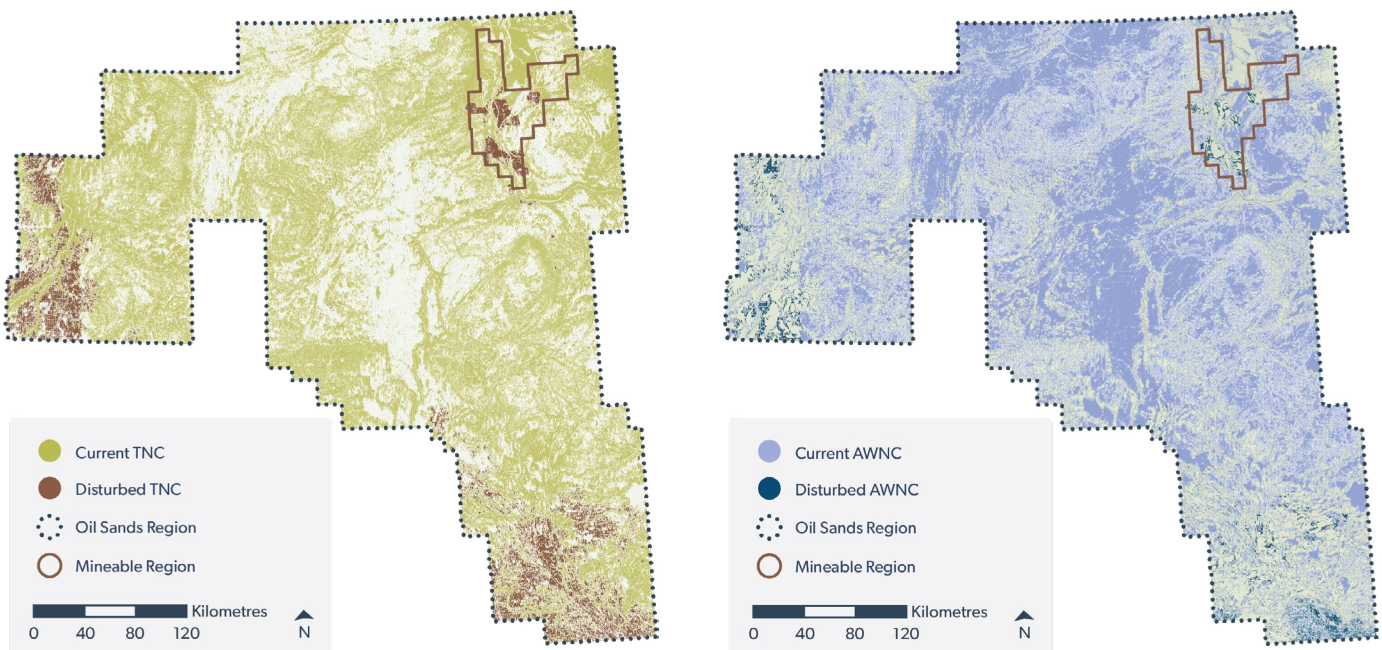


Figure 4. Distribution of terrestrial native cover (TNC) and aquatic and wetland native cover (AWNC) in the OSR.

Highlights: Interior Habitat

Interior habitat is the percent area of native vegetation that is away from the influence of human footprint including edge effects[8]. Per cent area of the OSR composed of interior habitat was (Figure 5):

- 69.9% at least 50 m from human disturbance
- 42.5% at least 200 m from human disturbance
- 12.5% at least 500 m from human disturbance

Given boreal forests are characterized by relatively weak edge effects (<25 m)[9], much of the native vegetation in the OSR can be considered interior habitat for many components of biodiversity.

However, there is limited interior habitat at least 500 m from human footprint in the OSR. These areas maintain natural ecosystem processes; increase resilience to natural disturbances and climate change; support wide-ranging and/or migratory species; and, sustain species sensitive to disturbance[5,10].

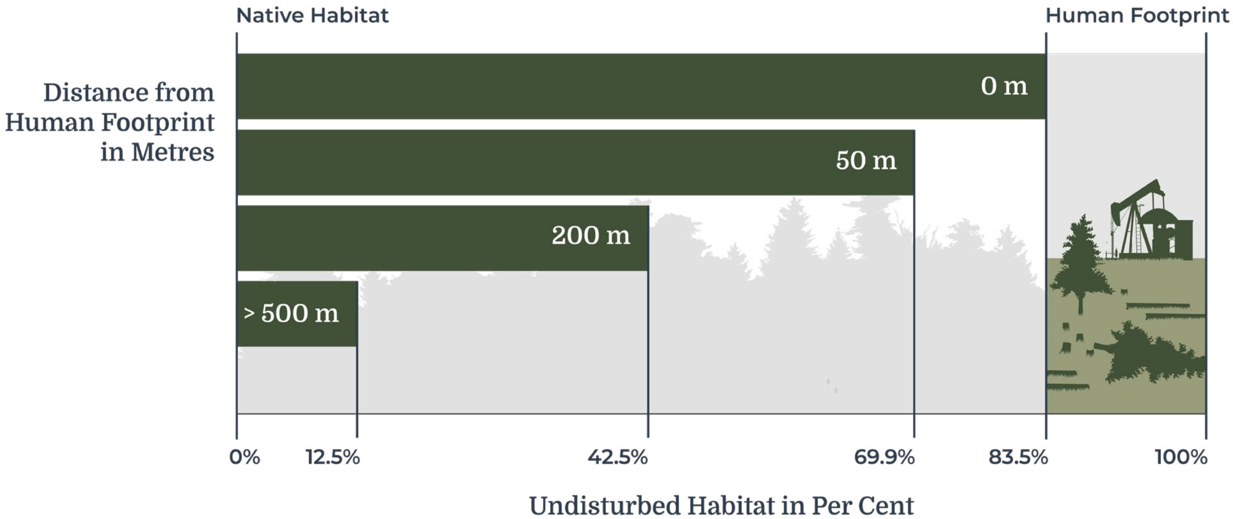


Figure 5. Per cent area of native habitat (0 m) and per cent area of interior native habitat at three distances from human footprint: 50 m, 200 m, and 500 m. Area of interior native habitat calculations include adjustments for width of human footprint and age of forestry footprint[8].

Status of Biodiversity in the Oil Sands Region

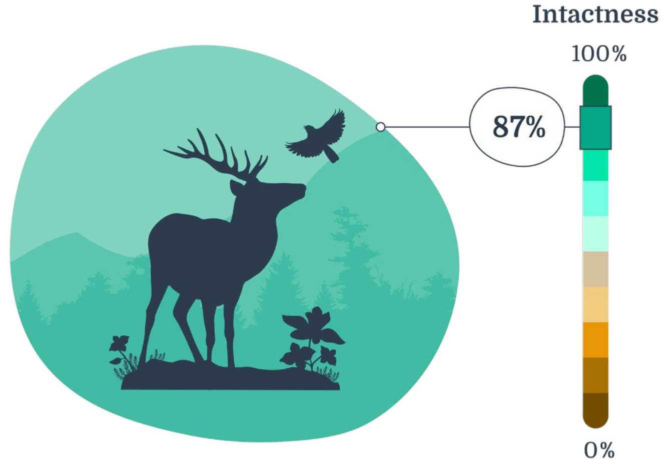
Biodiversity Intactness

The Biodiversity Intactness Index ("intactness") shows how the suitability of species' habitat has been modified due to human footprint[11].

Intactness declines as suitable habitat for each species is predicted to decrease or increase due to human footprint compared to the same area without any human footprint.

Habitats with minimal disturbance have high intactness scores compared to highly modified habitats, which have low intactness scores.

Intactness for overall biodiversity in the OSR is summarized in this section.



Connecting Indicators

The Biodiversity Intactness Index is an indicator included in the **Kunming-Montreal Global Biodiversity Framework**[1]. Although calculated differently, the ABMI's Biodiversity Intactness Index similarly measures the impact of changing land use on biodiversity.

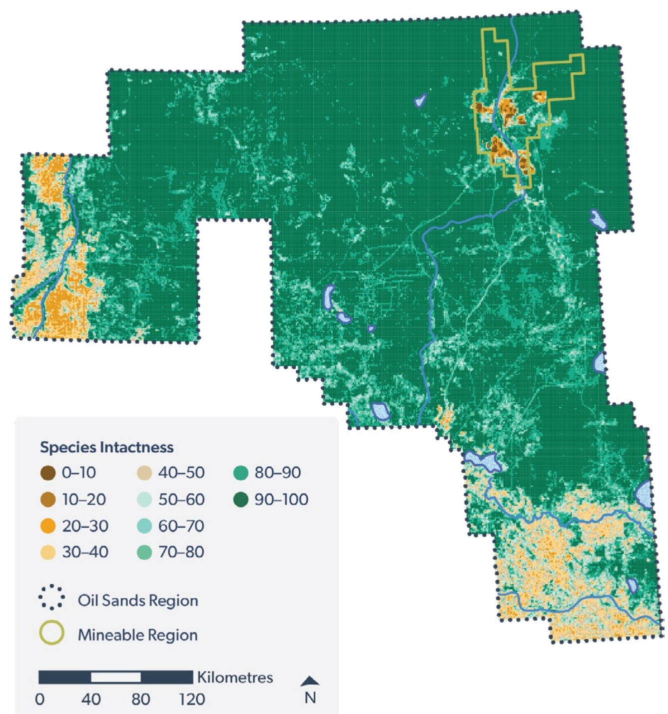


Figure 6. Spatial distribution of average biodiversity intactness (0-100%) in the OSR. Brown indicates areas with low intactness while dark green areas indicate areas with high biodiversity intactness. Map resolution is 1 km².

Highlights

The overall intactness of 719 species was found to be, on average[§], 87%.

- This means much of the habitat across the region is in good condition, but human development activities are impacting habitat suitability in some areas (Figure 6). Average intactness ranged from 82% for vascular plants to 92% for mosses.
- All groups except mammals had some "strong decreaser" species with disproportionately low intactness—meaning the drop in intactness from 100% was greater than the percentage of human footprint in the region. Many of these species are associated with mature/old forest habitats and are negatively affected by activities that impact their preferred habitat.
- For birds, mites, and particularly vascular plants, lower overall intactness is also due to a number of increaser species; for these species, habitat suitability is predicted to increase as a result of human footprint. Increaser species benefit from human footprint and are otherwise uncommon in native vegetation or are habitat generalists that use both native habitat and human footprint.

Vascular Plants
Average:
82%

Mites
Average:
86%

Birds
Average:
87%

Mammals
Average:
88%

Mosses
Average:
92%

Lichens
Average:
89%

[§] Intactness is calculated as an average of six taxonomic groups (birds, mammals, soil mites, lichens, mosses, and vascular plants); these groups are monitored as part of the ABMI's Ecosystem Health Program.

Effects of Energy Sector Footprint on Species Habitat Suitability

Effects of energy footprint on species habitat suitability:

Local scale

70% of species had lower habitat suitability in energy footprint

Regional scale

±2.5%

of reference conditions for most species.

Identifying the species that are most affected by energy sector development can guide management and land-use planning efforts aimed at mitigating risks and minimizing disturbance to particular habitats.

This section provides a summary of the local and regional impacts of the energy sector[¶] on the habitat suitability of species in the OSR.

Highlights

The ABMI reports on two aspects of energy footprint: 1) local scale effects reflect how habitat suitability changes inside areas disturbed by energy footprint, and 2) regional effects show how much habitat suitability is expected to have changed in the region due to energy footprint.

- Habitat suitability was lower within energy footprint compared to the native vegetation it replaced for approximately 70% of species in six taxonomic groups. Lichens and mosses were the groups most negatively affected by energy footprint.
- Species with over a 50% decline in habitat suitability within energy sector footprints are mainly those dependent on mature or old forests.
- Habitat suitability increased in energy footprint for a few species in each taxonomic group, particularly among birds and plants. The species that thrive in energy footprint live in open habitats and/or are adapted to disturbed conditions.
- In general, the effects of energy footprint on habitat suitability at the regional scale were small—between -2.5% and +2.5% for most species—because energy footprint occupies a small total area in the OSR.

See infographic on p. 15 for visual interpretation.

[¶] Sector effects for other human footprint types, including agriculture, forestry, transportation, and urban footprint types are not presented in this report.

ENERGY-SPECIFIC EFFECTS* ON SPECIES HABITAT

Local Scale

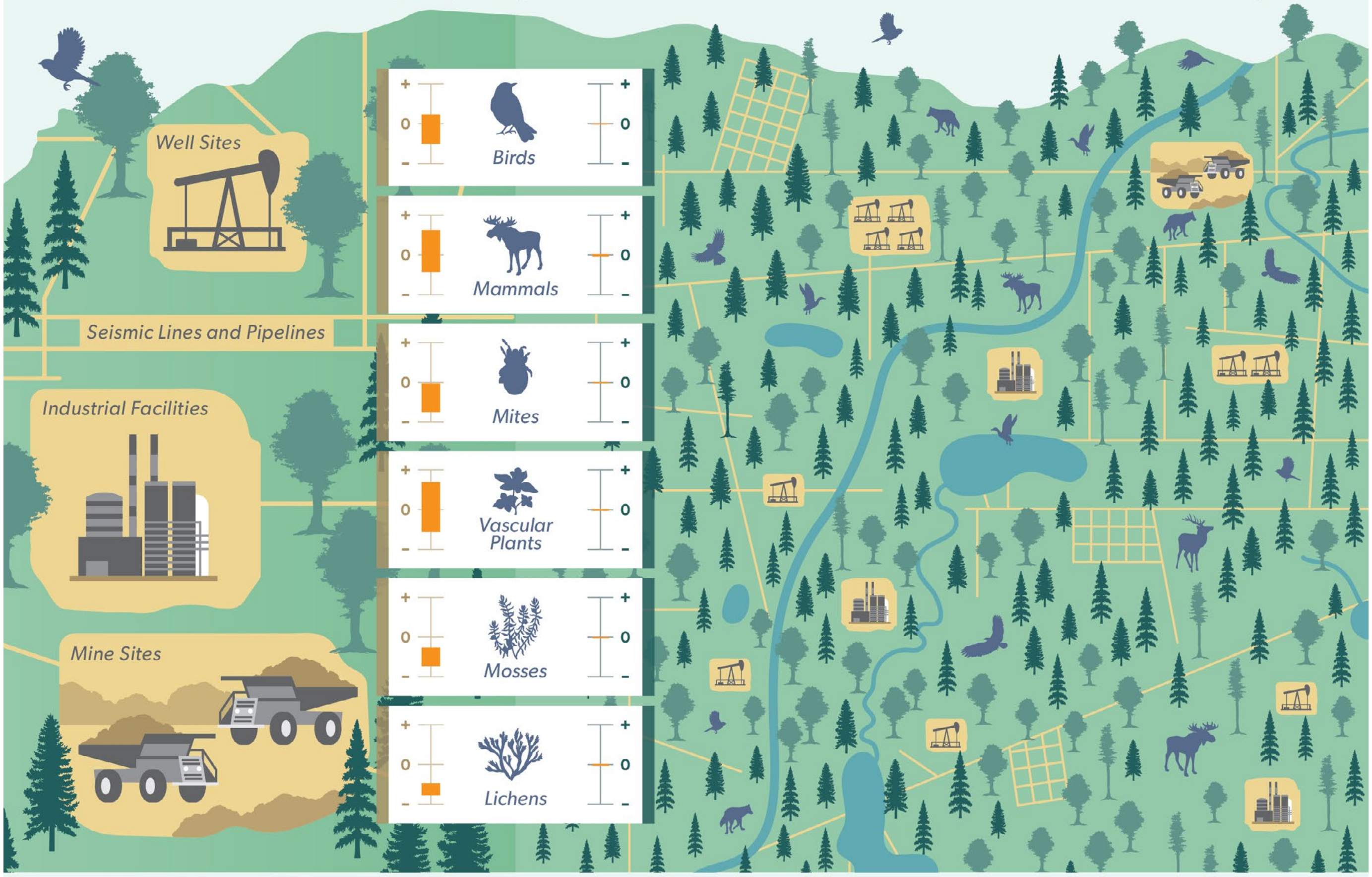
Where energy footprint occurs, there are large changes in habitat suitability for many species.

Species Response

Below is the range where the middle 50% of the data falls. While habitat suitability declines due to energy footprint for most species, it is improved for some.

Regional Scale

Energy footprint occupies a small portion of the OSR, resulting in only minor changes to overall habitat suitability for many species across the region.



*Other natural disturbances (e.g., fire) and human activities (e.g., forestry, agriculture) are also affecting habitat suitability across the landscape; these disturbances are not shown here.

Species that prefer open habitats, like the Clay-coloured Sparrow, respond positively to energy footprint.

For most mosses and lichens, such as the Star-tipped Reindeer Lichen shown here, habitat suitability is reduced in areas affected by energy development.

Lakeland Métis Nation

Program Spotlight: Indigenous-led Monitoring in the Oil Sands Region

The ABMI supports Indigenous-led biodiversity monitoring through meaningful partnerships with Indigenous communities to advance their own self-determined monitoring approaches. In the OSR, this has often meant supporting communities in using wildlife cameras to monitor species of cultural importance.

One such partnership is with the **Lakeland Métis Nation** in a program aimed at enhancing the understanding of the cumulative effects of oil sands operations on moose—a species of significant cultural importance to many Indigenous communities in the OSR and crucial to traditional Indigenous hunting practices.

The goal of this collaborative study is to assess how Steam Assisted Gravity Drainage (SAGD)—a process used to extract oil from deep underground without surface mining—impacts moose in traditional hunting areas. Moose occupancy is tracked around SAGD sites and reference areas, combining traditional Métis insights from knowledge holders with western scientific methods for data collection and analysis.

This project[#] emphasizes the importance of partnership between Indigenous communities and western science wildlife experts. While data collection is ongoing, results from this study will contribute to collective environmental monitoring goals in the OSR and help support Indigenous hunting rights.

Wildlife camera training session.

Moose hold deep cultural significance for many Indigenous communities.

[#] This project is funded by the **Oil Sands Monitoring Program**.

Species of Conservation Concern

Understanding the status of biodiversity in a region includes an assessment of species that are naturally rare or that have previously demonstrated a significant decline in abundance.

These species are generally referred to as "species at risk" or "species of conservation concern" because future declines in abundance or habitat may result in the loss of the species from an area.

Monitoring the changes in the abundance of species of conservation concern and the habitat they rely on is vital to understanding how land use affects not only sensitive species but the health of entire ecosystems. Further, monitoring data can inform status updates by identifying species that are more, or less, common than previously believed.

Highlights

The ABMI detected** 179 species of conservation concern in the OSR, including:

- 18 species designated as species at risk by federal and/or provincial legislation
- 161 species of conservation concern ranked provincially

Research Spotlights

There are ongoing research and monitoring efforts in the OSR to track impacts of energy development on some species of conservation concern.

Some research highlights include:

Woodland Caribou *(Rangifer tarandus caribou)*—the highest profile species at risk in the OSR—is federally and provincially listed as "threatened." Caribou require large, undisturbed areas to find food and avoid predators. Habitat protection and restoration are crucial aspects for caribou recovery[12]. Numerous projects in the OSR are dedicated to tracking caribou habitat and supporting its recovery.

Yellow Rail *(Coturnicops noveboracensis)* is a bird that exclusively uses graminoid wetland fens in boreal Alberta during the breeding season and is federally listed as "Special Concern." Management efforts focus on identifying breeding sites and important regional habitats, and monitoring and mitigating the impacts of development.

Punctured Ramalina *(Ramalina dilacerata)* is a lichen species commonly found in the OSR, and elsewhere across Alberta[13]. It was formerly listed as rare (S2)[14] but its status has been revised to S3 (vulnerable) to reflect its broader distribution as determined by monitoring data.

Comprehensive research and monitoring programs to mitigate the impacts of energy development on species of conservation concern in the OSR are ongoing. Balancing economic interests with environmental stewardship is important and remains a significant ongoing challenge in this important ecological area.

** Note that the ABMI does not detect all species of management concern that may occur in the OSR.

Looking Forward

Currently, monitoring in the OSR is coordinated by the joint Canada-Alberta **Oil Sands Monitoring (OSM) program**. It includes a range of integrated environmental monitoring programs to understand the cumulative effects of oil sands development in the region.

The ABMI has been monitoring wildlife and habitats in this region since 2007 through diverse field and geospatial monitoring programs. Current OSM-funded programs delivered by the ABMI in the region include:

- Regional monitoring of birds and mammals in terrestrial environments
- High-resolution mapping of seismic lines and vegetation regeneration using lidar data and imagery
- Vegetation data collection and analysis to support regional surveillance monitoring in wetlands
- Development of approaches for mapping groundwater-dependent ecosystems

We support several Indigenous-led community-based monitoring programs that are examining local impacts to wildlife, and addressing community interests.

The most up-to-date information on the status of species, habitats, and human footprint is available online for the OSR and many other areas in the province of Alberta through the **ABMI's Online Reporting for Biodiversity (ORB) tool**.

Preparation

All analysis and content was independently completed by the Alberta Biodiversity Monitoring Institute.

Preferred Citation

Alberta Biodiversity Monitoring Institute. 2024. Status of Land Cover & Biodiversity in the Oil Sands Region, Alberta, Canada. Available at: **abmi.ca/publication/652**.

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About COSIA

Canada's Oil Sands Innovation Alliance (COSIA) is part of Pathways Alliance—Canada's largest oil sands companies working together to provide energy the world needs while advancing environmental innovation. Formed in 2012, COSIA is focused on collaborative action and innovation in oil sands environmental technology in four key environmental priority areas: tailings, water, land and greenhouse gases. Through the COSIA Challenges initiative, they identify specific environmental challenges in the oil sands and invite innovators from around the world to help solve them. This approach brings together global expertise to find solutions that have the potential to improve environmental performance in Canada's oil sands.

References

1. Convention on Biodiversity. 2024. Monitoring framework for the Kunming-Montreal Global Biodiversity Framework. Available at: **https://www.cbd.int/doc/c/5044/ea79/105d29801a3efae8df742c93/cop-16-l-26-en.pdf**.
2. Venter, O. et al. 2016. Nature Communications. v7:12558. **DOI: 10.1038/ncomms12558**.
3. ABMI. 2023. Status of human footprint in Alberta. Available at: **https://archive.abmi.ca/home/reports/2023/human-footprint**.
4. Dabros, A. et al. 2018. Environmental Review 26:214-229. **https://doi.org/10.1139/er-2017-0080**.
5. Potapov, P. et al. 2017. Science Advances 2017; 3: **DOI: 10.1126/sciadv.1600821**.
6. IPBES. 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. **DOI 10.5281/zenodo.3831673**.
7. Alberta Environment and Protected Areas. 2024. Native cover indicator for Alberta. Available at: **https://open.alberta.ca/publications/native-cover-indicator-for-alberta**.
8. Alberta Environment and Protected Areas. 2022. Interior habitat indicator for Alberta. Available at: **https://open.alberta.ca/publications/interior-habitat-indicator-for-alberta**.
9. Franklin, C.M.A. et al. 2020. Canadian Journal of Forest Research 51:274-282. **https://doi.org/10.1139/cjfr-2020-0308**.
10. Allan, J.R. et al. 2017. Scientific Data 4:170187 | **https://doi.org/10.1038/sdata.2017.187**.
11. ABMI. 2017. ABMI Essentials: Intactness. Available at: **https://abmi.ca/publication/496**.
12. Environment and Climate Change Canada. 2020. Amended Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. xiii + 143pp.
13. ABMI. 2023. Punctured Ramalina (*Ramalina dilacerta*). Available at: **https://abmi.ca/species/ramalina-dilacerata**.
14. ABMI. 2007. Biodiversity Notes: Rethinking rarity. Available at: **https://abmi.ca/publication/148**.