Environment Canada Environnement Canada

Integrated Monitoring Plan for the **Oil Sands**

Terrestrial Biodiversity Component

Canada

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EXECUTIVE SUMMARY

OIL SANDS TERRESTRIAL BIODIVERSITY MONITORING COMPONENT PLAN

On 16 December, 2010 the Federal Oil Sands Advisory Panel presented its report to the federal Environment Minister. The Advisory Panel reviewed current monitoring activities in the lower Athabasca River system, identified key shortcomings, and provided recommendations on what would constitute a world-class monitoring program for the oil sands region (www.ec.gc.ca/pollution/default.asp?lang=En&n=E9ABC93B-1).

In response to this report and other concerns, the Federal Minister of the Environment committed Environment Canada to lead, in collaboration with the Government of Alberta, the development of a world class environmental monitoring plan for the lower Athabasca River and tributaries, starting with water quality. This first phase - a Water Quality Monitoring Plan for the Lower Athabasca River - was released by the Minister on March 24, 2011 (www.ec.gc.ca/default.asp?lang=En&n=FD9B0E51-1) This monitoring plan was designed on the core principles recommended by the Advisory Panel of being: holistic and comprehensive, scientifically rigorous, adaptive and robust, inclusive and collaborative, transparent, and accessible.

This Monitoring Plan has now been expanded into a Phase 2 Monitoring Plan that integrates air and biodiversity monitoring, and includes broader water quality monitoring and biological effects assessments. This integrated monitoring plan builds on existing programs/sites and expands the range of core environmental parameters to be routinely monitored, strengthening the spatial coverage and temporal sampling frequency. It will improve data collection activities to facilitate holistic assessment of: 1) contaminant sources and their transport in the environment, their ultimate fate and effects on aquatic and terrestrial biota, and relevant ecological processes, and; 2) the impacts of habitat disturbance on terrestrial biodiversity and efforts to mitigate impacts.

This chapter addresses the terrestrial biodiversity monitoring component of the Phase 2 Monitoring Plan. Because potential impacts of oil sands activities on terrestrial biodiversity may occur through two main outcomes of oil sands industrial activities - the release of contaminants to the environment, and the loss and degradation of wildlife habitat - this component can be further divided into two important elements: (1) monitoring the impacts of oil sands-related contaminants on selected wildlife indicators, including birds, mammals, amphibians and plants, with a view to identifying broader implications for biodiversity in the region, and; (2) monitoring the impact of habitat disturbance and mitigation on terrestrial biodiversity using a rigorous, question-driven framework. The remainder of this report describes the specific monitoring activities that will be undertaken for contaminants and the approach to be taken to address habitat effects. In conjunction with the other components of the Phase 2 Monitoring Plan, the two terrestrial biodiversity elements will ultimately provide a strengthened scientific base from which to develop and implement an integrated cumulative effects assessment approach in the oil sands region.

TERRESTRIAL BIODIVERSITY MONITORING – CONTAMINANTS

CHAPTER 1. INTRODUCTION

The Federal Government has a mandate to monitor the impacts of environmental contaminants, including those of anthropogenic origin, on the health of wildlife, as required under federal legislation such as the *Canadian Environmental Protection Act* (1999), the *Migratory Birds Convention Act* (1994), and the *Species at Risk Act*. While wildlife health assessments have been performed at numerous contaminated areas across Canada, there has been no history of on-going monitoring for wildlife contaminants levels and effects for the oil sands region of Alberta. This lack of a monitoring history with respect to the impacts of oil sands contaminants on wildlife in the area necessitates identifying and implementing a number of new approaches. Accordingly, this program will initially focus on a variety of wildlife indicators (including birds, mammals, amphibians and plants) in order to identify those components that are most useful in monitoring contaminant impacts. Consistent with the recommendations of the Federal oil sands Advisory Panel, which emphasizes the need to adapt monitoring programs in response to the development of new knowledge and technologies, some of the indicators identified here may be modified based on an analysis of preliminary monitoring results. In a related sense, although the program utilizes standardized techniques and endpoints wherever possible, in some cases (e.g. Section 2.4.3 below) the current state of the science and the lack of available baseline data requires some preliminary research prior to implementation of the full monitoring program to ensure that the methods are logistically feasible and data collected are relevant. Finally, it should be noted that any impacts of oil sands contaminants on wildlife within the region are likely to be expressed differentially according to the ecology of the indicator used. For that reason, the program makes use of a variety of wildlife classes (amphibians, birds, mammals, etc.) whose ecologies also differ. For example, within birds, swallows tend to have small home ranges and are likely impacted by conditions in the immediate vicinity (hundreds of meters) of their nest. In contrast, colonial waterbirds move over much larger areas and thus are integrative of conditions within tens of kilometers of their colony. In summary, by sampling a variety of taxa that occupy differing positions within the food web and which experience contaminant exposure at different spatial and temporal scales this program will be positioned to extrapolate from trends observed in a select group of wildlife indicators to develop a broader understanding of the impacts of oil sands contaminants on terrestrial biodiversity and ecological integrity within the region.

When operationalized, this program will produce data on an annual basis on a variety of oil sands-related contaminants of concern (including PAHs, mercury, arsenic) measured in wildlife tissues (birds, mammals, amphibians and plants) at various locations. The sampling schemes will permit the determination of contaminant levels and trends (used to track the effectiveness of management actions) in the oil sands region. In addition, contaminant concentrations in tissues will be compared to published threshold levels for contaminant effects to identify wildlife populations that may be at risk of health impairment (e.g. lower productivity, increased susceptibility to disease) in the oil sands region. Where toxicity standards and thresholds do not exist, toxicity information generated during the monitoring program can be used to assess effects. Additional information on the strategic design of this program and the incorporation of an adaptive approach to environmental monitoring can be found in the report *An Integrated Oil Sands Environmental Monitoring Plan*.

CHAPTER 2. OBJECTIVES

The primary objective of the Terrestrial Biodiversity (toxics) monitoring is to monitor the levels and effects of oil sands-related contaminants and their influence on the health of individual wildlife and wildlife populations proximal to and at varying distances from oil sands operations.

2.1 Rationale

In order to assure that resource extraction continues in an environmental responsible fashion, a clearer understanding of the levels and effects of contaminants in the oil sands area is required. Also required is the means to measure levels and effects of oil sands-related contaminants using, where available, standard methods and protocols (e.g. standard species and assessment endpoints, standard sampling strategies and frequencies etc.). For instance, oil sands processed water (OSPW) is water that has come into contact with bitumen in the extraction process.. The processed water is often pumped into basins (tailings ponds) to undergo a settling and dewatering process. OSPW contains high concentrations of inorganic ions (sodium, chlorine, sulphate and HCO_3), acid-extractable naphthenic acids (NAs), and low concentrations of polycyclic aromatic hydrocarbons (PAHs), in suspension with sand, silt, clay, residual bitumen and naphtha, and with a pH between 8 and 9. Naphthenic acids are often found in concentrations up to 110 mg/L in OSPW. The fate and transport of NAs and their conjugates are of particular toxicological concern because of reported acute toxicity to aquatic species. In addition, the water quality of adjacent water bodies could be compromised through leaching of contaminants such as NAs, PAHs and heavy metals from tailing ponds into ground water and subsequent connection into natural surface water. The impacts (if any) of these contaminants on the ecosystem of the oil sands region needs to be better understood. The first step in addressing this knowledge gap is the establishment, validation and implementation of a scientifically sound oil sands contaminants monitoring program.

Five separate activities are described here, that together form the wildlife contamination and contaminant trends and effects monitoring component of the integrated oil sands Monitoring Plan.

Priorities

Monitoring the levels and potential impacts of oils sands contaminants on wildlife and biodiversity in north eastern Alberta represents a new dimension to environmental monitoring in this region. A plan of this geographic extent and design complexity must, by necessity, be implemented in a staged manner. While field collections have been initiated in some areas, the remaining sample collection sites must be mapped using current census data for each indicator species and overlaid with locations of air and water contaminant measurement sites to identify areas where biological and supporting contaminant data may be obtained. Information derived from laboratory-based studies designed to inform and support the development of the respective monitoring activities must be used to guide the implementation of field sample collections.. Finally, large volumes of data will be generated detailing concentrations of numerous chemicals of concern in various tissue types. To ensure the reliability of these data and compatibility with other service and contract laboratories, a quality assurance/quality control (QA/QC) program will be developed and implemented.

CHAPTER 3. MONITORING COMPONENTS

3.1 Monitoring the effects of oil sands activities on breeding waterbird populations, diet, and egg contaminants downstream from the oil sands on the Athabasca River and Lake Athabasca.

Goal: To monitor contamination and contaminants effects in migratory birds (primarily colonial waterbirds) exposed to oil sands activities relative to those found in reference sites.

Context: The analysis of contaminants in the eggs of colonial waterbirds is an effective and scientifically proven means of monitoring the levels and trends of contaminants in the environment. Studies measuring contaminants in seabird eggs, such as Great Lakes Herring Gulls (*Larus argentatus*), date back to the 1960s (Keith 1966). This research has been significant in terms of detecting new contaminants (e.g. Gauthier et al. 2009), assessing spatial patterns, temporal trends, and sources (Hebert et al. 1999 for a review; Weseloh et al. 2006; Gauthier et al. 2008 for recent examples), and assessing impacts on wildlife from contaminants (Fox et al. 2007a,b, 2008; Grasman et al. 1996, 2000a,b) and other ecosystem stressors (e.g. Hebert et al. 2009). In the oil sands, in 2009 egg collections were made from Egg Island (Lake Athabasca) and Wood Buffalo National Park. These samples provided baseline information regarding chemical contaminants in the environment, specifically those associated with oil sands development, i.e. mercury (Hg), arsenic (As) and polycyclic aromatic hydrocarbons (PAHs). These data were compared with results from similar samples collected from Egg Island in 1977 and provided the means to evaluate change in chemical contamination possibly as a result of oil sands developments.

Monitoring: This monitoring activity will employ repeated censuses, of and egg collections from, colonial waterbirds (California Gulls *Larus californicus*, Herring Gulls, Ring-billed Gulls *Larus delawarensis*, Caspian Terns *Hydroprogne caspia* and Common Terns *Sterna hirundo*) in the oil sands region employing standard methods and protocols (Hebert et al. 2011; Fig 1.; Table 1) to assess contaminant sources and changes in sources through time. In addition to gulls and terns, and to add a terrestrial component and local contaminant source information to the avian contaminant monitoring program, bank swallows and/or cliff swallows will also be sampled. Samples will be collected on the Athabasca River allowing comparison of contaminant levels in eggs collected upstream and downstream of the oil sands region. In addition, assessments of contaminants and stable isotopes are conducted in the birds (PAH analysis, metals, light and heavy isotopes) to track sources of contaminants.

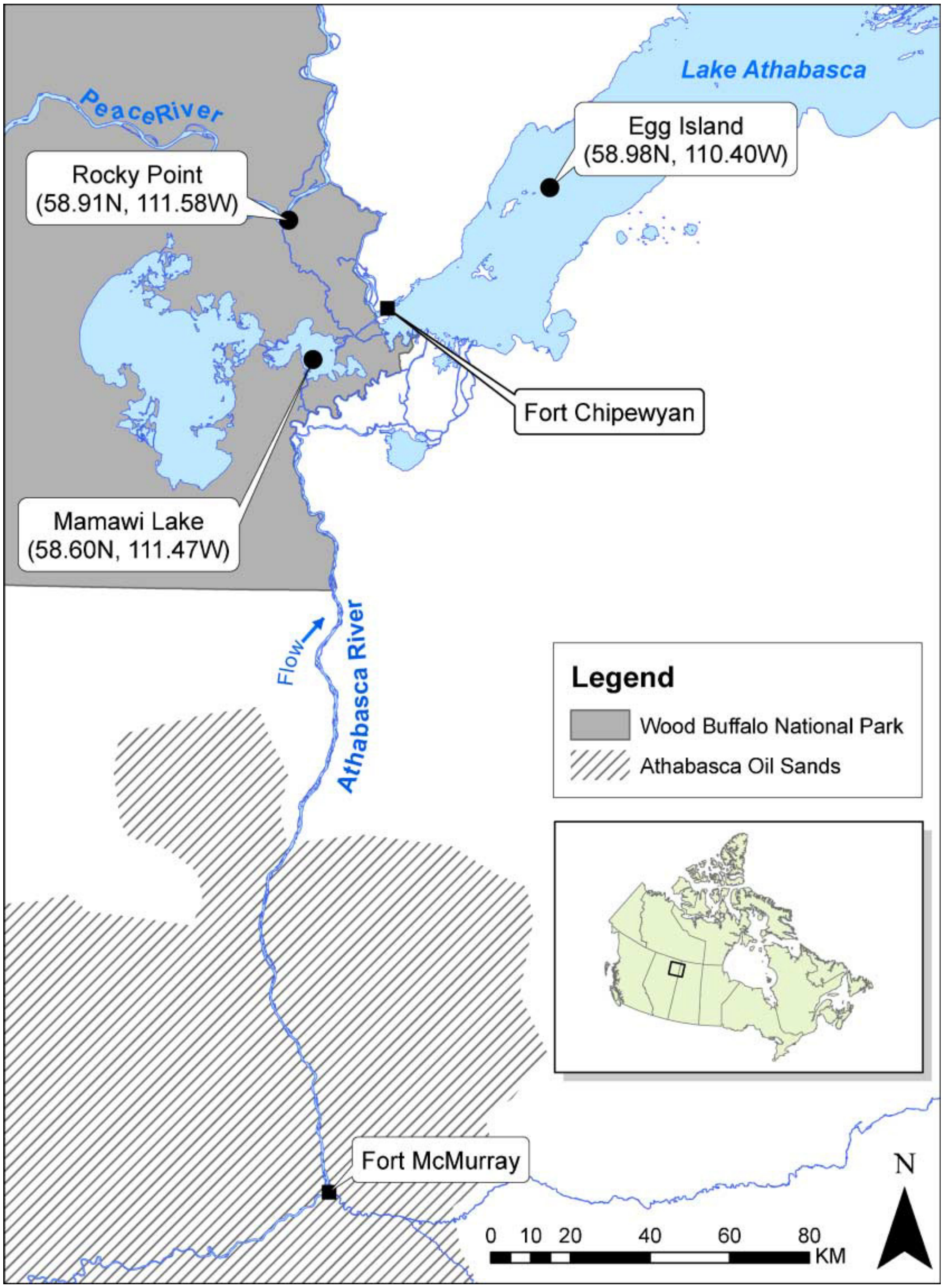

Figure 1. Waterbird egg collection locations (circles) in northern Alberta, Canada. Eggs are collected from two sites (Mamawi Lake and Rocky Point) in Wood Buffalo National Park. Eggs are also collected from Egg Island, Lake Athabasca.

Methods: For oil sands contaminants monitoring, methods follow standardized protocols for the collection and analysis of contaminants in bird eggs (Hebert et al. 2011). The current collection strategy for regional contaminants assessment using gulls and terns (3 collection sites with 2 sites downstream on the Athabasca River at Wood Buffalo National Park and in Lake Athabasca, and one reference site on the Peace River in Wood Buffalo National Park) and local assessment using bank or cliff swallows, with collections every two years, will be assessed for efficacy in detecting levels and trends of contaminants. The number of eggs, number of nests and number of sites necessary to be sampled will be evaluated using an adaptive strategy.

Table 1. Annual sampling to monitor aquatic and terrestrial bird species for oil sands contaminants.

Study Area[1]	**Species**	**Number of eggs collected[2,3]**	**Number of samples screened for organics and heavy metals[4,5]**	**Number of samples screened for N&C stable isotopes**
Gulls/Terns				
Rocky Point WBNP –- Peace River watershed	Ring-billed Gull	10	10	10
Rocky Point WBNP –- Peace River watershed	Common Tern	10	10	10
Mamawi Lake WBNP – Athabasca River watershed	Ring-billed Gull	10	10	10
Mamawi Lake WBNP – Athabasca River watershed	Common Tern	10	10	10
Egg Island, Lake Athabasca	California Gull	10	10	10
Egg Island, Lake Athabasca	Caspian Tern	10	10	10
Egg Island, Lake Athabasca	Herring Gull	10	10	10
Swallows				
Fort McKay N: downstream of oil sands operations	Bank or Cliff Swallow	50	10	10
Fort McKay S: downstream of oil sands operations	Bank or Cliff Swallow	50	10	10
Fort McMurray reference: south of oil sands operations	Bank or Cliff Swallow	50	10	10
Total		**220**	**100**	**100**

[1] WBNP = Wood Buffalo National Park

[2] gulls/terns – 1 egg collected from 10 different nests

[3] swallows – complete clutches of 4-5 eggs collected per nest

[4] gulls/terns – individual eggs will be analyzed

[5] swallows – eggs will be pooled and analyzed by nest to obtain adequate sample mass for chemical analysis

3.2 Monitoring the impacts of contaminants associated with oil sands processing on the health and development of amphibian (wood frog) indicator species.

Goal: The goal of this activity is to evaluate the health of wild amphibians and amphibian populations proximal to and at varying distances from oil sands operations.

Context: Amphibians in the boreal forest use ephemeral and semi-permanent ponds and wetlands for breeding, with snow-melt accounting for the majority of the water in the early spring. Developing eggs and young tadpoles may be exposed to particularly high levels of contaminants from oil sands operations because of aerial deposition of contaminants on snow that accumulates over the winter and then washes into the ponds in a pulse in the spring (Kelly et al. 2010). The reliance of amphibians on small, snowmelt-filled ponds for breeding may therefore make them particularly vulnerable to oil sands related contamination. In addition, there are currently two pathogens that have been identified as potentially significant threats to amphibians in the area: ranaviruses (Family Iridoviridae) and chytrid fungus (*Batrachochytrium dendrobatidis*) (Collins and Storfer 2003; Daszak et al. 2003). The origins and emergence of these pathogens are not well understood although combinations of large scale translocations (e.g. via commercial trade), changes in ecological conditions, and environmental stress have been implicated (Pounds et al. 2006; Gahl and Calhoun 2010). The amphibian species that inhabit the boreal forest of Alberta are widespread, with distributions that reach into the United States. Both ranaviruses and chytrid fungus have been detected as far north as the Northwest Territories (D. Schock, Keyano College, pers. comm.). Preliminary work in 2010 suggests the pathogens are also present in the Fort McMurray region (D. Schock, pers. comm.). Monitoring ranavirus and chytrid fungus infection incidence and disease status in relation to oil sands mining operations will reveal whether substances released during oil sands processing activities increases susceptibility to infection and disease caused by these pathogens.

Monitoring to detect correlations between proximity to oils sands mining activities and physical abnormalities, or malformations, in amphibians will also be conducted. Malformations in amphibians have been the subject of numerous studies and substantive reviews (Ouellet 2000; Blaustein and Johnson 2003; Lannoo 2008) with two potential causes receiving the majority of attention: chemical contamination of amphibian habitats (Gardiner et al. 2003; Taylor et al. 2005), and infections by the trematode parasite *Ribeiroia ondatrae* (Johnson et al. 1999; 2008). Malformations have been documented in the species of amphibians that occur in northern Alberta (reviewed in Ouellet 2000; Carey et al. 2003; Lannoo 2008). Several malformed frogs were encountered during amphibian health surveys in the Fort Smith-Wood Buffalo National Park region in 2009 (D. Schock, pers.comm.). Malformations were documented in wood frogs, boreal chorus frogs, northern leopard frogs and Canadian toads, suggesting a widespread underlying cause.

This monitoring activity focuses on wood frogs (*Lithobates sylvaticus* formerly *Rana sylvatica*) because this species is widely distributed in the boreal forest and because they were the most abundant and frequently encountered species during pilot studies in 2009 and 2010. Wood frogs are susceptible to ranaviruses and chytrid fungus, and wood frogs with developmental abnormalities were found in the region in 2009 and 2010. Breeding populations of wood frogs have been identified near Fort Resolution, Fort Smith, Fort Chipewyan, and the areas around Fort McMurray.

Monitoring: Assessments of the health of wood frog populations in Alberta, Saskatchewan and the Northwest Territories are followed by tests for correlations between proximity to oil sands operations and endpoint measures including the prevalence of two infectious diseases of amphibians (the amphibian pathogens ranavirus and the chytrid fungus *Batrachochytrium dendrobatidis*), rates of developmental abnormalities, and residues of heavy metals and organic contaminants (PAHs and NAs) in amphibian tissues and breeding pond water. Associated laboratory experiments test for mechanistic explanations and causes of patterns found in the field.

Methods: Breeding populations of wood frogs have been identified near Fort Resolution, Fort Smith, Fort Chipewyan, and the areas around Fort McMurray; these areas can be sampled for wood frogs. The study areas west of Fort McMurray, designated "Alberta Sites" 1 and 2, and in Saskatchewan, will be established during the first year of monitoring. Wood frog breeding sites in areas remote from oil sands operations (for instance southwest of the bitumen-bearing region) will be visited to collect reference site animals. Although monitoring focuses on wood frogs, other species may be encountered, including boreal chorus frogs (*Pseudacris maculata*), and Canadian toads (*Anaxyrus hemiophrys = Bufo hemiophrys*) and all individuals of all amphibian species encountered and captured will be examined for malformations and collected if they are abnormal. Amphibian carcasses encountered during surveys will also be collected and submitted for diagnostic evaluation. These animals are not the focus of the monitoring system but may provide insight into the overall health of amphibian populations.

Field methods to be followed depend on the wood frog breeding season. In late April to early May when amphibians are breeding, individuals will be visually inspected for malformations and other signs of poor health such as lesions and behavioural anomalies such as lethargy or absence of an avoidance response. Water samples and whole frogs will be collected for contaminants assessment (Table 2). Other aspects of amphibian population health, such as population size and age distribution, are also recorded at this time. In late June to early July samples are collected for ranavirus and chytrid fungus screening. This is accomplished by asceptically collecting a single hind toe from each frog and then releasing the animal at point of capture (Canadian Council on Animal Care 2006). A small number of whole, apparently normal frogs are also collected for baseline morphological comparisons with malformed frogs encountered throughout the study and for possible disease assessment and diagnosis (see Table 1 below). Assessment of infection by the two pathogens is accomplished using PCR techniques following published methods. Examination of amphibians to document and describe malformations will involve a series of digital photographs (dorsal, ventral and two lateral views), appropriate clearing and staining techniques to reveal soft tissue abnormalities, x-rays to examine skeletal features, and appropriate microscopic (histological) examinations. Laboratory exposures and endpoint analyses follows published methods for the assessment of physiological, molecular and developmental effects of amphibian exposures to contaminants.

The handling and processing of amphibians and water samples to test for organics and heavy metals follows established protocols, as directed by collaborating laboratories. Based on widely-used and reported protocols, whole frogs and associated water samples are collected and then shipped to appropriate laboratories. Tissue processing is conducted following established protocols. Aliquots of the tissues will be requested for preservation and archiving in Environment Canada's Wildlife Specimen Bank at the National Wildlife Research Centre at Carleton University, Ottawa.

Table 2. Annual sampling to test for correlations between amphibian health and proximity to oil sands mining and processing operations.

Study Area[1]	**Tissue samples screened for ranavirus and chytrid fungus**[2]	**Whole, apparently normal frogs collected for baseline morphological comparisons** [3]	**Number of tissue samples screened for organics and heavy metals** [4]	**Number of pond water samples screened for organics and heavy metals** [5]
Fort Resolution	120	12	4	4
Fort Smith/WBNP	120	12	4	4
Fort Chipewyan/WBNP	120	12	4	4
Fort McMurray: within 10 km of oil sands processing	120	12	4	4
Fort McMurray: 30 km south of active oil sands processing	120	12	4	4
Fort McMurray: 20 - 30 km north of oil sands processing	120	12	4	4
Alberta Site 1	120	12	4	4
Alberta Site 2	120	12	4	4
Saskatchewan Site 1	120	12	4	4
Saskatchewan Site 2	120	12	4	4
Total = 10 study areas	***1200***	***120***	***40***	***40***

[1] Each study area includes 4 ponds with breeding populations of wood frogs

[2] Numbers include tissue subsamples taken from frogs collected for baseline morphology comparisons. The total of 120 represents 4 ponds per study area x 30 frogs/pond. Except for the small number of frogs collected for morphological comparisons, these animals are released at point of capture after toe/tail clips are taken. Tissue samples are collected in late June/early July as this is the time of the year when previous studies have found the prevalence of ranaviruses and chytrid fungus infections are highest and therefore most likely to be detected.

[3] 12 = 3 frogs per pond x 4 ponds

[4] 4 samples = 1 tissue sample from each pond, each sample consisting of pooled tissues from 3 frogs. Samples are taken in early spring during breeding activities.

[5] 4 samples = 1 sample per pond x 4 ponds. Samples are taken in early spring during breeding activities.

Linear and logistic regressions are used to test for differences in metrics of population health (e.g., infection rates, malformation rates) among study areas at different distances (upstream/downstream; upwind/downwind) from oil sands mining activities.

3.3 Monitoring the effects of oil sands contaminants on avian health using non-lethal measures of stress and physiological response

Goal: To assess exposure and effects of oil sands atmospheric emissions on wildlife health using non-lethal sampling techniques.

Context: This monitoring activity assesses the efficacy of using a novel, non-lethal method to assess contaminant exposure in a sentinel species. Because the standard methodology to assess atmospheric exposure or wildlife to contaminants requires sacrifice of the animal (with the liver the target organ of choice because it accumulates many of the contaminants of interest and has the greatest concentration of detoxifying enzymes) this monitoring activity will assess the use of feather tissue, since it is likely that detoxifying enzyme activity can also be found and measured in well-vascularized, growing feathers. In addition, exposure of wildlife to emissions is monitored using real time air quality monitors; actual exposure to air borne contaminants is measured using specially designed membranes at the nests.

Monitoring: Birds are sampled at their nests where passive sampling of airborne contaminants also occurs. To monitor exposure and effects, biomarkers are assessed in exposed birds (European starlings or kestrels).

Methods: The biomarker to be assessed to monitor exposure is the induction of cytochrome P450 (CYP). CYP is a family of enzymes capable of detoxifying a wide range of contaminants and has become an accepted and standard means of determining exposure to a wide range of environmental contaminants in wild animals including birds (Melancon 1996, Smits et al. 2000). Based on recent work, CYP activity can be measured in the feather pulp of growing feathers called ‘blood’ or ‘pin’ feathers (Melancon et al 2000). With immunohistochemistry (IHC), assessments are made concerning whether high and low levels of detoxifying enzymes are distinguishable in growing feathers. These measures are matched to other clinical, immunological, and endocrinological measures of health and exposure. Interpretation of monitoring data is aided by experiments using model captive birds.

Field methods include monitoring free-ranging birds inhabiting the oil sands, and other oil and gas production areas in Alberta (Craft and Craft 1996). A total of 20 nest boxes are established in each of three deposition zones to create a gradient study thereby allowing for regression/correlation analysis of PAH/VOC concentrations and biomarker endpoints. Two chicks from each nest box, preferably a male and a female, are used to assess biomarker endpoints. These birds are used to assess contaminant exposure through non-lethal feather analysis along with measurements of actual exposure using real time air chemical monitors at nests. Nest boxes are installed to provide a nesting platform for the wild birds and as a station to place the passive air filtering monitors to capture specific contaminant emissions. Nest boxes are constantly monitored to prevent occupancy by other bird species and to establish appropriate number of nest boxes necessary for an adequate sample size for the monitoring system. Nest boxes are monitored and birds are sampled annually.

Experimental exposures in the laboratory to oil and gas contaminants using an avian model examine detoxifying enzymatic activity in liver and in feather tissue after contaminant exposure in support of the field monitoring program; captive exposures determine and validate appropriate endpoints and establish biomarkers to be measured when monitoring wild birds. An inhalation chamber designed and constructed to allow exposure to air borne contaminants for small bird species will be used (Olsgard and Smits 2008). Birds are exposed to high and low concentrations of VOCs (benzene, ethylbenzene, toluene) and SO_2, while control animals are exposed to medical grade air. Health variables are assessed and related to exposure. Assessments include complete blood count and serum biochemistry analysis, stress hormone activity assessed through heterophil to lymphocyte ratio, and immunotoxicological testing including antibody response, T cell response, leukocyte count determination, and histological evaluation of immune organs (bursa of Fabricius and spleen). In addition, complete necropsies are performed, with hepatic and feather enzymatic activity analyzed and IHC staining on prepared feather tissues to look for different intensities of detoxifying enzyme induction.

Table 3. Annual number of samples analysed in support of the development of a monitoring system to assess effects of oil sands contaminants on avian health

Site[1]	**Air Samplers**[2]	**Hepatic PAH levels**	**Feather pulp enzymes**	**Endocrine (thyroid)**	**Stress Response**[3]	**Immune Function/ biochemistry**	**Growth/Repro**[4]	**Disease Testing**
Field site								
Zone 1: High deposition	20	20	20	20	20	20	20	20
Zone 2: Medium deposition	20	20	20	20	20	20	20	20
Zone 3: Low deposition	20	20	20	20	20	20	20	20
Zone 4: Minimal deposition	20	20	20	20	20	20	20	20
Laboratory Inhalation								
High level	12	12	12	12	12	12	12	N.A.
Low level	12	12	12	12	12	12	12	N.A.
Control	12	12	12	12	12	12	12	N.A.

[1] Nest box locations are in zones with a gradient of exposure from high to lower levels of exposure to airborne contaminants associated with oil sands extraction and processing activities; nest boxes are monitored within one of three zones, each consisting of a 5-km wide band: Zone 1 – within 5 km of extraction operations and mining sites, Zone 2 – between 20 to 25 km to the north of extraction operations and mining sites, Zone 3 – between 75 to 80 km to the north of extraction and mining sites.

[2] Installed at nest box locations

[3] Stress response is measured using corticosterone levels and metabolomic techniques.

[4] Growth determined in the wild at the age that the other tests are conducted; growth in captive birds measured on a daily basis to calculate growth rates and body size measurements; repro= assessment of successful reproduction as determined by hatching success (wild birds only).

3.4 Toxicological assessments of hunter/trapper-harvested wildlife (waterfowl and mammals), and dead and moribund birds in oil sands impacted areas and lower reaches of the Athabasca River.

Goal: Provide monitoring data on oil sands contaminants in wildlife samples obtained by local hunters and trappers and in dead and moribund birds collected in oil sands areas.

Context: Wildlife inhabiting the oil sands region are likely to be exposed to oil sands-related contaminants. In particular, waterfowl migrating through the oil sands region and other wildlife inhabiting the region may be exposed to oil sands-related contaminants and sequester these contaminants in their tissues. These contaminants may have toxicological effects in the exposed wildlife (Rogers et al. 2002) and may cause exposure of consumers of this wildlife. This monitoring activity will quantify contaminant concentrations in the tissues of hunter/trapper-donated wildlife tissues and of birds recovered dead or moribund in oil sands areas relative to the same wildlife species collected outside the oil sands area.

Monitoring: There are three components to this monitoring activity: 1) local hunters provide harvested birds and other wildlife samples for assessments of oil sands-related contaminants, 2) birds that have been found dead or recovered moribund in oil sands processing areas (including tailings ponds) are submitted for contaminants analyses, and 3) ecotoxicological assessments of furbearers (River Otters) inhabiting oil sands areas are conducted to assess whether commercially-harvested furbearers could be a possible easily accessible sentinel species for oil sands contaminants monitoring. River Otters are selected as biomonitoring species due to their consumption of fish prey, and therefore potential for exposure to oil sands contaminants (Reid et al. 1994).

Methods: For component one of this monitoring activity, local hunters will provide wildlife samples which are submitted to collaborating laboratories for analysis of oil sands-related contaminants (e.g. heavy metals, PAHs and NAs). The sampling strategy involves collection of 60 birds south of the oils sands region and 60 birds in the northern part of the region, each year, to compare contaminants burdens and trends (see Table 4 below). For component two, the same analyses are performed on birds found dead or moribund in oil sands processing areas which are submitted for contaminants analyses. Collaboration with lease-holders ensures birds are collected and submitted for analysis. For furbearers, access to trappers is coordinated with the help of the Alberta Trappers' Association. Trappers provide carcasses and a trapping location, and, if possible, liver samples are collected as the otters are harvested. Body metrics data including body length (cm), body weight (g), fur condition, oral condition, and other remarks are collected prior to liver extraction. Liver and water samples from the trapping site are provided to a laboratory for NA characterisation. NA levels are then modeled as a function of the measured body metrics. An appropriate toxicity threshold for liver NA levels in river otters is established and each otter is then coded as positive (1) or negative (0) for signs of being substantially impacted by NAs or other oil sands-related contaminants. Hepatic NA residue levels are correlated to environmental NA concentrations, and spatial distribution of contamination.

Table 4. Annual sampling for hunter-harvested wildlife and dead and moribund birds in the oil sands region

Study Area[1]	**No. of tissue samples tested for hematocrit and EROD**[2]	**No. of waterfowl or River Otters collected for tissues**	**No. of tissue samples analyzed for PAHs and heavy metals**[3]
Fort McMurray: tailings ponds	0	5 mallards and 5 lesser scaup per tailings pond	50 bile (from 5 tailings ponds)
Edson, AB	20	20 harvested mallards	20 bile
Edmonton, AB	20	20 harvested mallards	20 bile
Vermillion, AB	20	20 harvested mallards	20 bile
Fort McKay	20	20 harvested mallards	20 bile
Fort Chipewyan	20	20 harvested mallards	20 bile
Fort Smith	20	20 harvested mallards	20 bile
Hay River	20	20 harvested mallards	20 bile
Lac LaBiche	20	20 River Otters	20 liver
Fort McMurray	20	20 River Otters	20 liver
Fort Chipewyan	20	20 River Otters	20 liver
Total	200	250	250

[1] Specific collection location may vary by harvesting and trapping location

[2] Ethoxyresorufin-O-deethylase, as a biomarker of exposure

[3] Breast muscle and bile of waterfowl and livers of River Otters would be analysed

[4] Number of birds assessed depends on recovery and submission for analysis of birds following exposure

3.5 Use of native plants to monitor the condition of oil sands-associated wetlands.

Goal: To determine the effects of naphthenic acids on native wetland plant species and determine if these plant species can be used to monitor the contaminant levels in sentinel plant species and the health of wetland plant communities in oil sands areas.

Context: Phytoremediation, the process of decontaminating soil by using plants to absorb heavy metals or other contaminants, is a common means proposed for tailings pond reclamation. It has been demonstrated that certain plant species have decreased the pH of oil sands processed-water (OSPW), increased mineralization rates and increased general microbial population and diversity. OSPW is water that has come into contact with bitumen in the extraction process or within the mine. This waste water is often pumped into basins (tailings ponds) to undergo a settling and dewatering process. OSPW contains contaminants (including NAs) and has a pH between 8 and 9, which slows down natural biodegradation processes. Earlier investigations into the bioremediation of NAs attempted to determine if wetland plant species dissipated individual NAs. This characterization was limited to water samples with no determination of components in plant tissue itself. There is a requirement to quantify NA compounds in plant tissues. In addition, information on the effects of arbuscular mycorrhizal (AM) colonisation in remediating NAs in the oil sands is also needed. The presence or absence of this symbiotic fungus (in aerobic and anaerobic conditions) could improve how the plant uptakes, compartmentalises and biodegrades these toxic compounds. This could inform whether phytoremediation improves wetland habitat quality for biodiversity and whether these plants can be used to monitor wetland reclamation and habitat quality.

Monitoring system: This monitoring activity will monitor the health of wetlands in the oil sands region. Plant monitoring will evaluate the health of target plant species being used in phytoremediation efforts as a measure of wetland health and sample collection would assess the amounts of oil sands-related contaminants in the plant biomonitoring species. More specifically, if through monitoring and analysis the three selected plant species can be confirmed to have phytoremediation potential (i.e. a decrease in NA and PAH contamination in wetlands) and a demonstrated arbuscular mycorrhizal association, annual monitoring of reclamation wetlands would involve sampling these wetland plants for the extent of mycorrhizal associations and the levels of NA in plant tissue (McGonigle et al 1990, Mehta 2006).

Methods: Field methods include the annual sampling of the target species for analysis of NA burdens plus other contaminants, plus evaluation of the extent of arbuscular mycorrhizal associations. For confirmatory information, laboratory analyses are used to correlate findings from field collections. Three plant species that can be colonized by arbuscular mycorrhizal fungi that are found in the oil sands (*Typha latifolia* (common cattail), *Phalaris arundinacea* (reed canary grass) and *Alnus incana* (speckled alder)) are selected for exposures. These plants are commonly found in wetlands of North America and have demonstrated phytoremediation potential. Plants are grown in greenhouses with artificial lights to ensure a 16h/8h photoperiod and light intensity during cloudy days. A full factorial design employs 3 plant species, five chemical treatment levels (2 concentrations of contaminated oil sands extract, 2 concentrations of a commercial mix of NA and 1 control) with 4 mycorrhizal treatment levels (with and without viable fungal inoculum, and with and without aeration of the water/substrate) with 6 replicates. Plants are grown from seed in a sterilized medium (peat and sand). Two plant testing guidelines are followed (Environment Canada 2005, OECD 2006). Plants are grown in 60 L plastic tubs with appropriate levels of nutrients, water and chemicals for a 10 week growth period. Each week, plant height, general conditions, soil pH, water pH and total water dissolved solids are measured. Photosynthetic measurements are taken each week. Photosynthetic carbon assimilation rates (ACO_2), stomatal conductance of water vapour (g), and sub-stomatal carbon dioxide concentrations (Ci) amongst other measures are measured and corrected to account for differences in leaf area between plants. At the end of the growth period, 3 plants from each tub are taken at random to examine the extent of AM root colonization. At harvest, shoots are cut at the soil surface, dried and weighed. Roots are washed clear of soil, dried and weighed similar to shoots. Plant tissue samples (above- and below-ground) are subjected to high-resolution MS for the analysis of NAs. Heavy metals are assessed in plant tissues as well. Data are subjected to parametric statistics to examine phytotoxicity and determine if the presence of AM fungus in wetland plant species has an influence on the uptake and compartmentalisation of NAs and their conjugates in different plant tissues (Headley et al. 2011).

Table 5. Annual sampling to test for correlations between plant health and proximity to oil sands mining and processing operations.

Study Area	**Species richness and abundance surveys**[1]	**Whole plant samples collected for baseline oil sands contaminant characterisation**[2]	**Number of root tissue samples screened for arbuscular mycorrhizae (AM)**[3]	**Number of pond water samples screened for oil sands contaminants**[4]
Fort Resolution	120	120	36	4
Fort Smith/WBNP[5]	120	120	36	4
Fort Chipewyan/WBNP	120	120	36	4
Fort McMurray: within 10 km of oil sands processing	120	120	36	4
Fort McMurray: 30 km south of active oil sands processing	120	120	36	4
Fort McMurray: 20-30 km north of active oil sands processing	120	120	36	4
Alberta Site 1	120	120	36	4
Alberta Site 2	120	120	36	4
Saskatchewan Site 1	120	120	36	4
Saskatchewan Site 2	120	120	36	4
Total= 10 study areas	1200	1200	360	40

[1] Specific richness and abundance plant surveys are conducted at each study area. Plants are surveyed in groups of 3 (using 1m x 1m quadrats); at water's edge, at 1 m from the water, at 3 m from water's edge, at 10 evenly spaced locations around the pond (4 ponds/study area x 30 quadrats = 120 quadrants/site)

[2] Root, shoot and leaf samples are collected for three species (most common and resistant species determined by plant surveys - most likely Common Cattail, Reed Canary Grass and Speckled Alder. Parts of 10 plants of each species (10 x 3 species = 30 plants) are collected at each pond (4 ponds x 30 plants = 120 plants/site) for contaminant residues.

[3] Root sub-samples are stained to screen and assess AM colonisation in each species (3 species x 3 root samples x 4 ponds = 36 root samples/site) as a surrogate for plant health and phytoremediation potential.

[4] 1 water sample per pond x 4 ponds = 4 samples/site

[5] WBNP = Wood Buffalo National Park

CHAPTER 4. REFERENCES

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TERRESTRIAL BIODIVERSITY MONITORING – HABITAT DISTURBANCE

CHAPTER 1. INTRODUCTION AND OBJECTIVES

1.1 Purpose of this plan & questions addressed by monitoring

The conservation and protection of biodiversity, including wildlife and their habitats, is a core value held by Canadians. Canada is blessed with a wealth of natural resources, including the bitumen or oil sands deposits. Collectively, the challenge is to realise the economic wealth of these resources in an environmentally responsible way. This document lays out the framework from which to build a long-term, comprehensive monitoring program for terrestrial biodiversity in the oil sands region in Alberta and Saskatchewan.

The goal of the monitoring program is to determine the response of terrestrial biodiversity (positive, negative or neutral) to activities associated with economic development of oil sands. The program intent is to ensure that appropriate information is available to inform decision-making regarding terrestrial biodiversity within the oil sands region, and for Canadians to understand the consequences of those decisions for biodiversity, now and in the future. Environment Canada recognises that there is a broad array of questions and concerns raised by the public regarding the impact of oil sands on wildlife, including demands for various conservation actions to mitigate those impacts (e.g. Grant *et al.* 2011). There is equivalent demand for information to inform government regulators and industry operators regarding the success of mitigation efforts. Development of the oil sands has altered the landscape and resulted in an influx of people to this region. Major impacts to wildlife are occurring as a result of habitat loss and habitat conversion. Mineable oilsands essentially eliminates the pre-development biodiversity on those sites until reclamation begins. Development of oilsands will change the geography of the regional boreal forest and where mitigation efforts occur, the time lag for recovery may be many decades with no assurances that some habitat types will ever be recovered. A successful monitoring program should address all these demands to report on the effects and inform management of this system through the provision of relevant, accessible, scientifically credible information.

The over-arching questions that the monitoring program will answer are:

1. What is the impact of habitat disturbance caused by development of the oil sands on terrestrial biodiversity through time?
2. What is the success of mitigation efforts to address effects of oil sands development on terrestrial biodiversity through time?

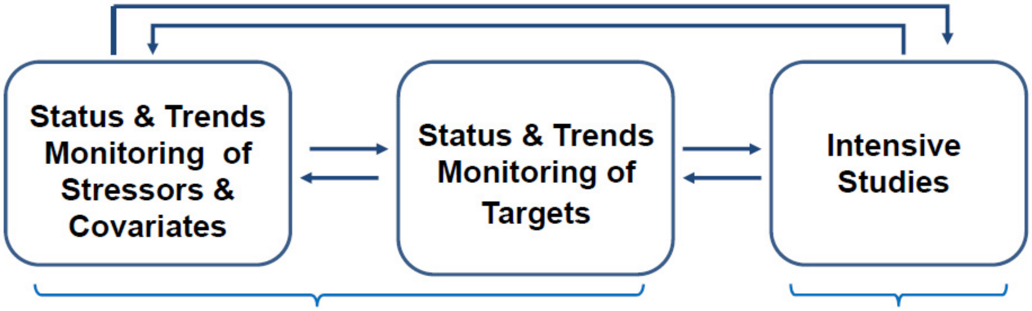
These overarching questions require clarification of the terms biodiversity and mitigation, and require consideration of issues of temporal and spatial scale. Biodiversity refers to the composition, structure and function of living organisms and the ecological complexes of which they are a part. This includes diversity within species, between species, and of ecosystems, and measured at multiple scales (Noss 1990, Environment Canada 1995). Terrestrial biodiversity as used in this document refers to wildlife (plants and animals) and includes species level and higher (i.e. not genetic diversity). Spatial and temporal scale affects all aspects of design and reporting. For the purposes of this document, mitigation refers to a broad array of actions ranging from minor changes in operator practices to major actions such as habitat offsets and reclamation.

Historically, many monitoring programs have been restricted to status and trends (e.g. Breeding Bird Survey http://www.pwrc.usgs.gov/bbs/). This document outlines an intensified approach to status and trends monitoring, and expands on this approach to include cause - effects monitoring. This document comprises Stage 1 and describes the approach to biodiversity monitoring for the oil sands region to report on: (1) the status and trends of wildlife and wildlife habitats; and, (2) provide an understanding of how oil sands activities (from exploration through reclamation) affect wildlife, in order to evaluate management actions. Subsequent stages will involve implementation using the approach described herein.

Decisions regarding the level of development at which a management action should be triggered are separate from the monitoring program. Monitoring results will inform the much-needed discussion of such issues for the oil sands region, but they are decisions informed by a broad range of societal values, of which ecological values are one part. The approach described in this monitoring plan emphasizes a robust series of quantitative methods that will provide the appropriate information on effects and risks to biodiversity. In its final form, this plan will reflect the input from third-party scientific review. The applicability of monitoring results to decision-making represents the ultimate measure of success of the monitoring program.

1.2 Definition of monitoring described by this plan

As stated above, the goal of the monitoring program is to determine the response of terrestrial biodiversity (positive, negative or neutral) to activities associated with development of the oil sands. To properly address this goal, the monitoring program requires a population monitoring component for status and trends, and an effects assessment component to identify causal mechanisms (National Research Council 1995, Mulder *et al.* 1999, Stadt *et al*. 2006, Haughland *et al.* 2010, Gardner 2010). Status and trend monitoring provides information on the state of biodiversity (targets), industrial activities (stressors that are individual or cumulative in nature) and habitats (covariates, typically vegetation, and also drivers of target response) through time. Monitoring of status allows detection of differences “among locations at a given moment in time” and monitoring of trends examines the “changes in value across time at a given location” (Noon 2002). Monitoring for cause-effect relationships is hypothesis-driven and allows for attribution of cause and effect between stressors and targets. These two approaches are complementary and they exist on a gradient, i.e. there are aspects of the other in either approach (Figure 1.1). For example, status and trends monitoring data can be used to test cause-effect hypotheses generated *a posteriori*, and intensive studies can inform and validate status and trends monitoring.



- Focused on a broad assessment of the state of biodiversity
- Enables *a posteriori* assessment of impacts of development and mitigation activities

- Focused on *a priori* assessment of impacts of development and mitigation activities
- Informs and validates status & trends monitoring

Figure 1.1. Diagram of the two types of monitoring described in this plan: status and trends monitoring for targets, stressors and covariates, and monitoring of cause-effect relationships through intensive studies. Arrows indicate the linkages between all components, as results from one aspect will inform the design of others in an iterative, adaptive manner.

Implicitly excluded from this plan is compliance monitoring, which is audit-style monitoring that determines whether regulations, policies or guidelines have been implemented (Gardner 2010). Compliance monitoring asks the question “Were the rules followed?” and is not tied to ultimate conservation outcomes (efficacy) or validation of management actions. As such, it is not the focus of monitoring to address impacts nor is it part of this monitoring plan.

Our approach of status and trends monitoring combined with cause-effects monitoring requires that we develop a conceptual framework of the ecosystem and the effect of oil sands on biodiversity. This plan lays out a process for developing that framework, identifying and prioritizing stressors and targets, developing the overall design, data management, potential data applications and an independent performance evaluation of the overall program.

1.3 Legislative context

This monitoring plan is intended to assist with delivery of federal and provincial mandates for the conservation and protection of wildlife and wildlife habitats in the oil sands region. At the federal level, this includes the *Species At Risk Act,* the *Migratory Birds Convention Act* and the *Canadian Environmental Assessment Act*. At provincial level, this includes the *Wildlife Act* and the *Environment Protection and Enhancement Act* for Alberta, and the *Wildlife Act* and the *Environmental Assessment Act* for Saskatchewan. Canada is also a signatory to the Convention on Biological Diversity and as such is committed to the conservation of biodiversity and the sustainable use of biological resources. This program will have wide-ranging benefits that inform federal and provincial decision-making processes related to the management of natural resources in this region.

1.4 Ecological and industrial context

There are over 80,000 species in Alberta and Saskatchewan, many of which are found in the oil sands region. Most species are arthropods, algae, protozoans, and fungi, with vertebrates (mammals, birds, amphibians, reptiles) only composing ~0.5% (Royal Alberta Museum, Saskatchewan Conservation Data Centre pers. comm.). For the majority of species, we have limited knowledge of population and community level dynamics.

No monitoring program could monitor the entirety of biodiversity due to sheer number of species, and limitations of logistics and resources. This plan focuses on terrestrial biodiversity but includes wetland-associated species such as wetland birds and amphibians. While recognising the value of long term, multi-taxal monitoring across the breadth of terrestrial biodiversity, the initial approach focuses primarily on monitoring of wildlife and their habitats, that is, plants and animals, where we arguably have more knowledge and where there is high societal interest. Many principles of this approach are relevant to biodiversity monitoring generally, recognising there are design considerations specific to the life history of species and to the spatial and temporal scale of interest.

The oil sands region of Alberta and Saskatchewan lies within the Boreal Plains ecoregion of western Canada (Figure 1.2). The forest here is characterized by upland and lowland systems. Upland forests are dominated by mixedwood stands (varying in ratio of aspen and white spruce from pure deciduous to pure coniferous), and to a lesser extent, Jack pine. Lowland systems are dominated by peatlands and other wetlands, black spruce and/or tamarack stands (Rowe 1972). White birch and balsam fir are also found in this system but with lower frequency than in eastern boreal systems. The Boreal Plains, like the rest of the boreal forest in North America, is an inherently dynamic ecosystem. Large-scale disturbances naturally occur in this system, primarily through wildfire, but also through insect outbreaks and smaller scale disturbances such as beaver activity (damming, tree-felling) and tree falls (Pastor *et al*. 1996, Schneider 2002, Song 2002). Boreal wildlife populations are adapted to these disturbances and unique ecological communities and community dynamics (abundance and number of species) arise when they occur on the landscape (e.g. Song 2002, Fisher and Wilkinson 2005, Schieck and Song 2006). The challenge in monitoring these systems is their inherent variability as well as the relative lack of knowledge of populations and communities here.

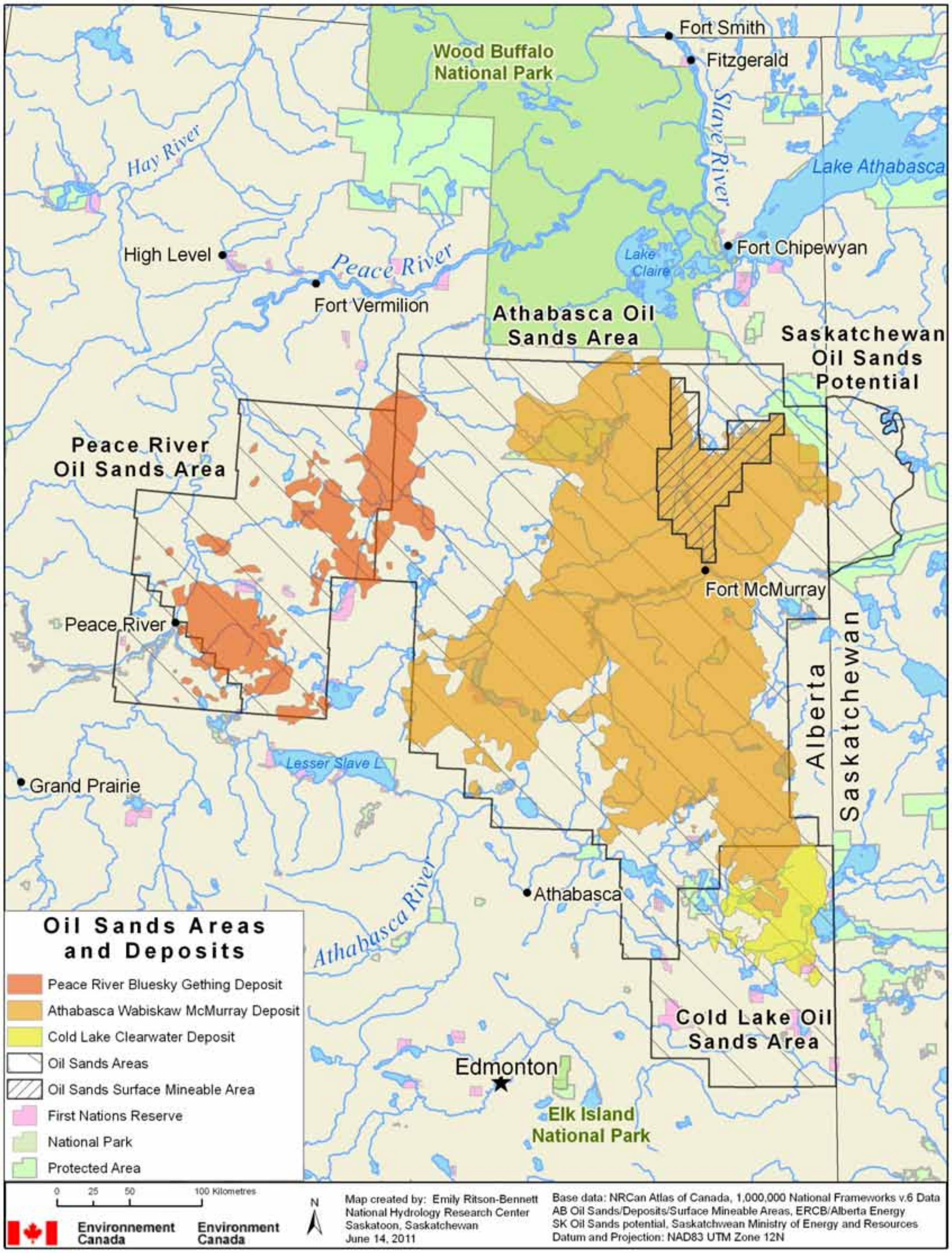


Figure 1.2. Map of geographic distribution of bitumen deposits in Alberta and Saskatchewan.

The disturbance to wildlife and wildlife habitat from oil sands development is primarily focused over the spatial extent of the bitumen deposits in Alberta and to a much smaller extent in western Saskatchewan (Figure 1.2). To date there have been a number of scientific investigations examining specific impacts in or issues germane to the oil sands region (e.g. Dyer et al. 2001, Dyer et al. 2002, Bayne *et al*. 2005a, Bayne *et al*. 2005b, Lee and Boutin 2006, Machtans 2006, Habib *et al.* 2007, Bayne *et al.* 2008, , Sorenson *et al.* 2008). There is also substantial unpublished information within environment assessments for developments and historical data from Alberta Environment's Alberta Oil Sands Environmental Research Program. Furthermore, understanding of the nature of the impact of oilsands can often be well informed by disturbance studies from other boreal regions with similar biodiversity (e.g. Song 2002).

Human activities may cause direct mortality to species, directly change available habitat for species, or change habitat suitability (e.g. through changes to predator/prey dynamics). The most familiar disturbance are the mines associated with surficial extraction of bitumen as well as the tailings ponds, the by-products of on-site oil sands processing. Across the oil sands area, most bitumen (approximately 80%) is buried too deeply to be accessed through traditional mining (Government of Alberta undated). Over time, the ecological footprint from *in situ* techniques (drilling to extract bitumen while leaving sand in place) is expected to vastly exceed that of the conventional mine sites (Jordon *et al.* 2009, ERCB 2010). Typical sources of habitat disturbance from oil sands development include linear disturbance such as seismic lines, pipelines and roads and polygonal disturbance such as mine sites, well pads, and compressor stations. Beyond clearing of vegetation, there is disturbance to habitat through noise and dust generated by machinery and vehicles, through altered water regimes arising from disturbance to hydrological systems, and through invasive species, either non-native species or through landscape conversion that creates habitat for species that would not typically occupy contiguous boreal forest.

There are also indirect effects of oil sands development on wildlife and wildlife habitats such as the infrastructure and urbanisation to support and move people and products, and other secondary and tertiary economic development that arises in concert with oil sands extraction. These effects are manifested not only within the spatial boundaries of the bitumen deposits but also on a broader geographic scale. The scope of this plan in this current stage is bound to the habitat disturbance occurring across the scale of the bitumen deposits, although it is recognized that additional monitoring outside this area is required for ecological context.

Oil sands development is only one of the large-scale anthropogenic activities influencing habitat within this area of the Boreal Plains. There are large forest operations, focused on harvesting of aspen and white spruce trees. There is also natural gas extraction, as well as agriculture, mining of peat-moss, and numerous human settlements. Another indirect effect of human activity on wildlife is global climate change, the effects of which encompass the boreal forest and beyond (Parry *et al*. 2007). These activities contribute to the cumulative impact of habitat disturbance by human activities within the oil sands region and must be addressed at some scale when considering monitoring the impacts of oil sands.

Finally, beyond disturbance to habitat, release of contaminants in air and watersheds by oil sands development may have a major impact on wildlife, and is an additional factor potentially driving status and trends of populations. The specific impacts of contaminants are dealt with through a separate piece of this Integrated Monitoring Plan. The framework outlined for monitoring of habitat disturbance impacts on wildlife is robust to accommodation of such additional cause-effect relationships.

The description above addresses the current types of activities associated with oil sands and other economic development relevant to assessing impacts on wildlife and wildlife habitat. However, the active exploration and extraction of oil sands is expected to occur over the next 80-100 years or longer, depending on technology and demand, with reclamation activities continuing beyond that (Athabasca Regional Issues Working Group 2005). Complete ecosystems will need to be restored at multiple scales (Johnson and Miyanishy 2008). The time to successfully restore historic biodiversity (composition, structure and function) is currently unknown because there are currently no technologies to restore some ecosystem components. Reclamation of peatlands and their associated hydrology, for example, is not possible with current approaches and technology. The design of any program, therefore, must be adaptive to long time scales and the impacts of changing technologies for exploration, extraction and reclamation, through time.

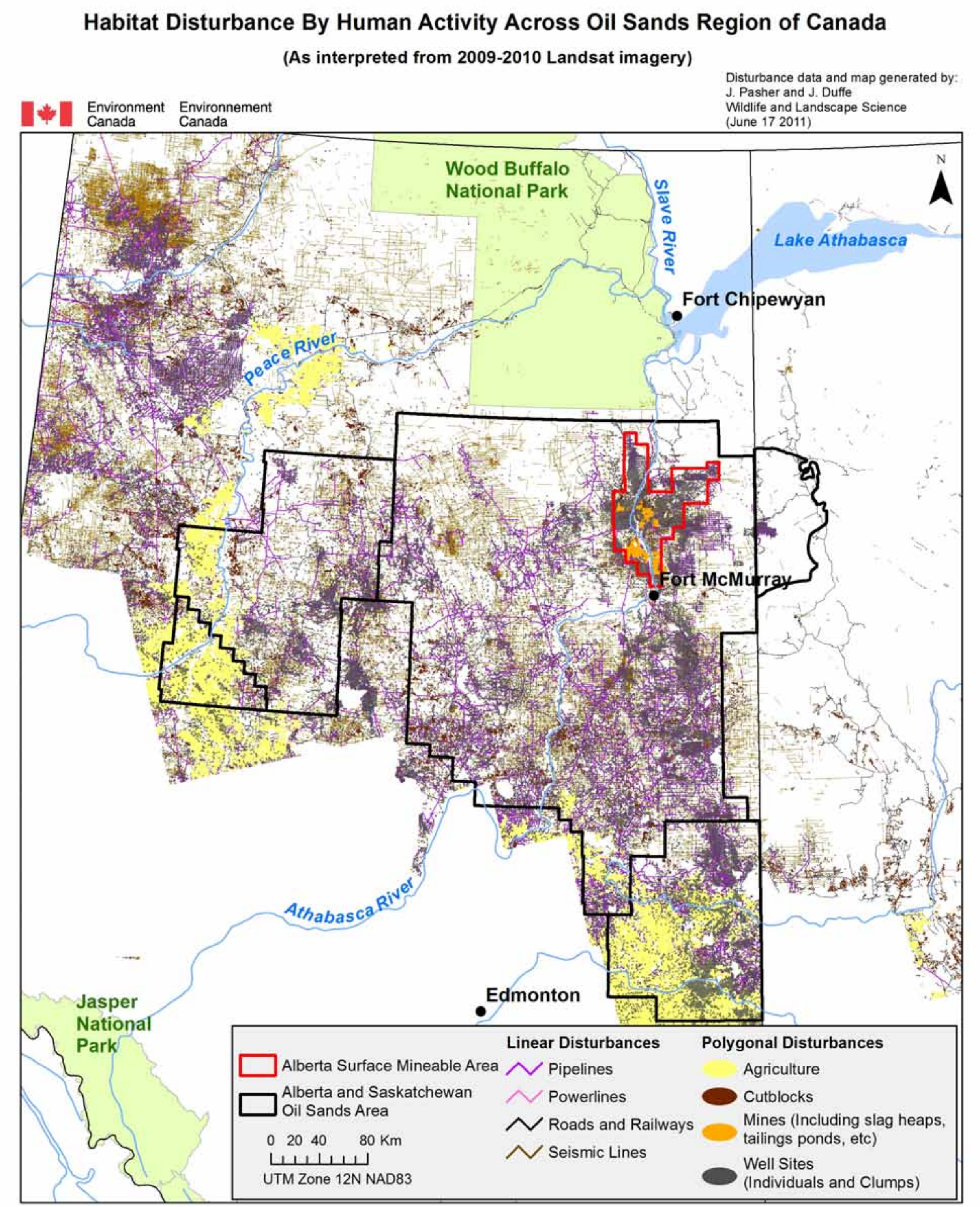


Figure 1.3. Map of linear and polygonal disturbances to habitat from oil sands development and other economic activity in the oil sands region of Alberta and Saskatchewan. Footprint from conventional mines is within the red border; footprint from *in situ* as well as other energy and economic development is distributed across a much broader area.

1.5 Phased approached to planning and implementation of monitoring

1.5.1 Stage 1: Development of a framework and approach to monitoring

This plan represents the first step in the design and implementation of a program to specially monitor the impacts of oil sands on wildlife and wildlife habitat. Reviews of monitoring programs (Nichols and Williams 2006, Gardner 2010, Lindenmayer and Likens 2010) consistently cite the importance of a set of good, evolving questions drawn from a conceptual framework of the system under study, and the need for an adaptive approach, as critical elements of an effective program. This document outlines the approach to applying these principles to wildlife monitoring to assess how (status and trends) and why (cause-effect relationships) wildlife and wildlife habitats are affected by the development of the oil sands region.

The reviews cited above emphasize the crucial role of partnerships and commitment to long term implementation as fundamental to successful implementation. This document sets the stage for further discussion and collaboration with the range of regulatory authorities and other decision-makers and affected parties with mutual interest in, and responsibility for, the monitoring and conservation of wildlife in the oil sands region.

1.5.2 Stage 2: Application

In the second phase of this plan we will work in collaboration with experts in monitoring and build on long standing cooperation between provincial and federal wildlife agencies and other institutions to refine the monitoring framework, and implement the resulting program. The emphasis will be on direct impacts of oil sands development on wildlife and wildlife habitat. Target species will focus on wildlife species of federal responsibility, specifically species-at-risk and migratory birds, as well as species under provincial management. The plan will cover the geographic scale of the bitumen deposits, recognising the full extent of oil sands development potential. It will also accommodate collaborative opportunities associated with land-use planning.

Collaboration between interested parties is invited in the application of the process described in this plan and subsequent implementation of the monitoring program. Evaluation of existing programs to facilitate efficient delivery of this monitoring plan is a fundamental step in Stage 2. Environment Canada recognises that there are valuable existing programs of relevance to monitoring of oilsands impacts on wildlife and these will be considered as part of this evaluation. Currently, however there is no one existing program that comprehensively addresses all of the elements proposed in this plan.

1.5.3 Stage 3: Continued implementation and expansion of target scope

Subsequent stages of this monitoring plan will increase the scope to incorporate additional taxa, and direct and indirect impacts. Using the adaptive approach, the program direction must be informed by data from previous stages, our evolving understanding of the impacts of oil sands on wildlife, and the dynamic nature of the boreal ecosystem and oil sands development.

CHAPTER 2. MONITORING COMPONENTS

2.1 CONCEPTUAL FRAMEWORK FOR MONITORING

2.1.1 Components of a conceptual framework for monitoring

In this document (Stage 1), we provide the overall framework for monitoring and thereby outline the foundation for refinement and implementation in subsequent stages. Monitoring sits as one element within a broader adaptive management framework (*sensu* Walters 1986, Walters and Holling 1990), testing hypotheses regarding the effects of management actions (individually and cumulatively) and using results to inform planning and design of future activity. See Figure 2.1 for a generalised example.

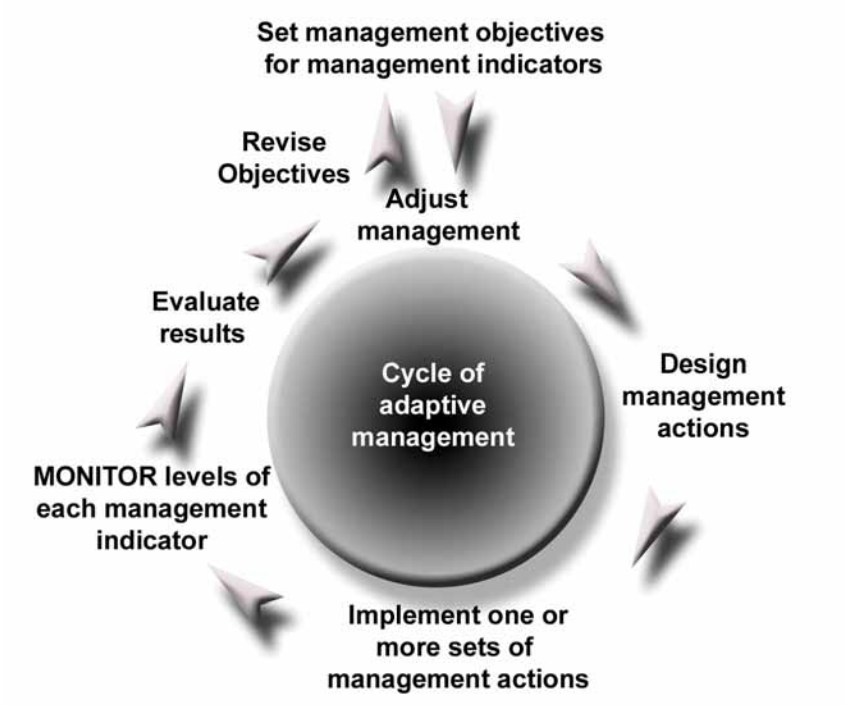


Figure 2.1. Role of monitoring within a generalised adaptive management cycle

We describe a conceptual framework for biodiversity monitoring that carries forward the principles of adaptive management into monitoring itself. Below, we describe the steps for developing a monitoring program (Figure 2.2) through the following steps:

a. Identify the goals and objectives of monitoring, the conceptual framework of ecosystem function and initial questions to drive monitoring design. Part of this process is to identify targets (receptor of an impact), potential stressors (sources of habitat disturbance) as well as covariates (Program Framework Design in Figure 2.2).

b. Evaluation of existing programs for their ability to deliver the defined goals and objectives. This stage reduces the risk of program redundancy and identifies collaborations between programs that need to be established for delivery. Analysis of existing knowledge and data is component of this program.
c. Rigorous design of surveys to measure targets, stressors and covariates, where programs are not already in place. Design of survey protocols appropriate to data collection of targets, stressors and covariates. Data collection and validation of protocols.
d. Development of a data management system to deal with all wildlife and geospatial data considerations, and facilitate an open, transparent system of access. Data analysis for basic reporting.
e. Reporting on outcomes of monitoring through a publicly available site, including the provision of data in forms suitable for other applications.
f. Application and/or development of analytical tools for management applications. This stage recognises the need for additional tools that can render monitoring results useful for management e.g. to assess risk to species and habitats, to identify priority actions for conservation and protection.
g. Applications of results from basic reporting (e) and from analytical tools (f) are then applied in wildlife management but also management of oil sands. Similarly, these results also guide the design of research that can inform the subsequent design and interpretation of monitoring results.
h. Steps above, individually and collectively, must be subject to a formal evaluation to determine if the program successfully delivered on monitoring goals and objectives.
i. The results generated by the program, the outstanding questions and new questions that arise, all serve to inform an exercise to identify new and ongoing information requirements for the management of habitat disturbance impacts on wildlife by oil sands development. Following the iterative approach, results of this exercise inform a re-evaluation of the program framework including goals and objectives described in (a).

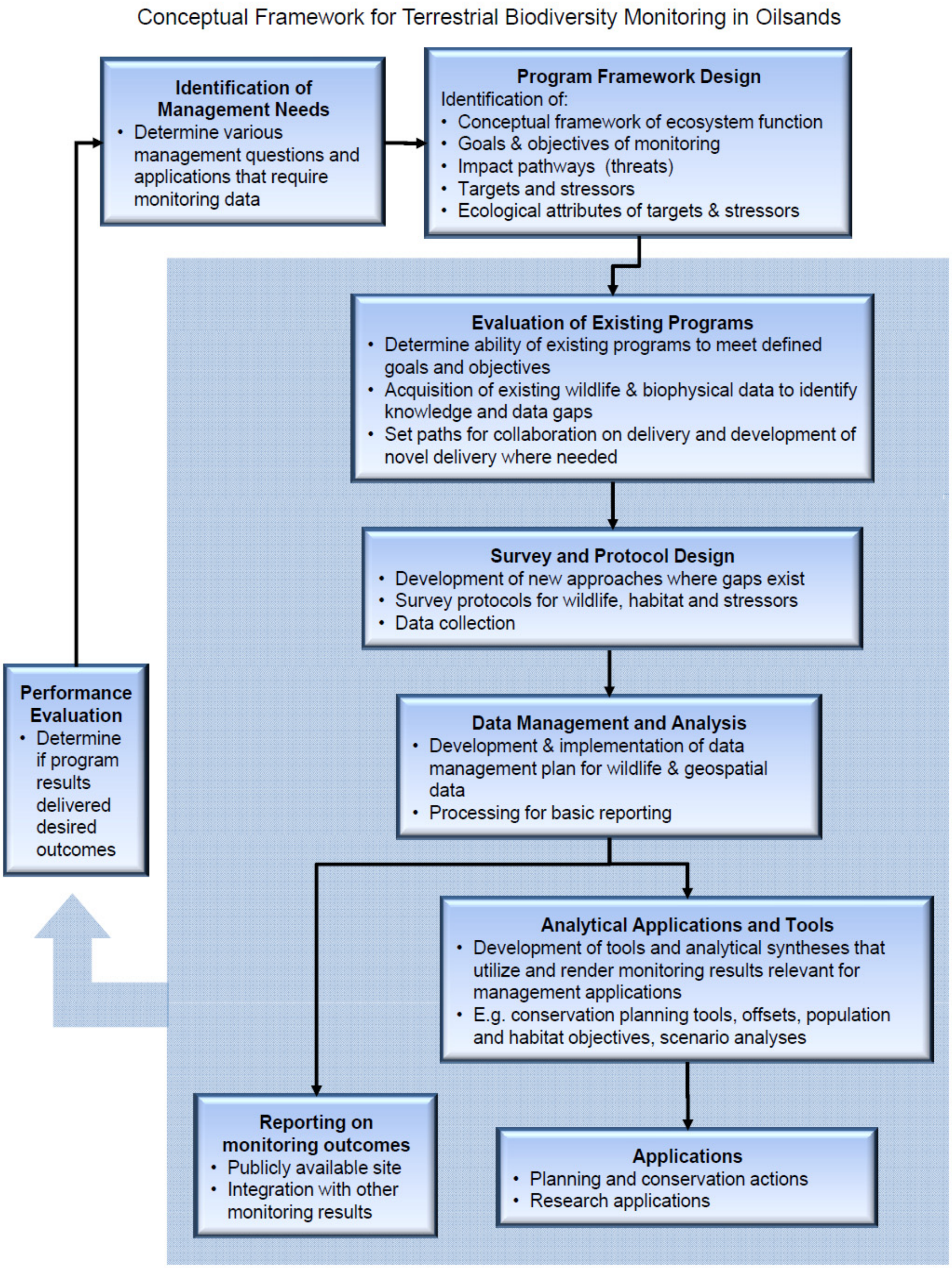


Figure 2.2. Conceptual framework for the design of a biodiversity monitoring program for oil sands.

In the remainder of this document, we apply this conceptual framework for biodiversity monitoring to the approach for developing a biodiversity monitoring program in the oil sands region of Alberta and Saskatchewan. Section 2.2 Program Framework Design describes the development of a guiding framework, wherein we outline the process to develop clearly defined goals and objectives that will provide the foundation for both status and trends, and cause-effects, monitoring program. We then describe a process for the development of a conceptual model of how the ecological components and processes of a target ecosystem or population interact, and how stressors may affect this system (Noon 2002, Gardner 2010, Lindenmayer and Likens 2010). This guides the identification of targets, stressors, and their ecological attributes.

Section 2.3 Principles of Monitoring Design outlines an approach to monitoring which employs both status and trends monitoring and examination of cause-effects relationships. The approach presented combines population monitoring with methods aimed at identifying and quantifying cause-effect relationships between species and spatial footprints of oil sands activities. This combined approach facilitates reporting on patterns in the status of biodiversity and the degree to which causality in observed patterns are attributable to specific processes (Andrew and Mapstone 1987). This joint “pattern-process” approach to monitoring will be directed by *a priori* questions about cause-effect relationships about how oil sands operations affect wildlife populations. The combination of observational and explanatory methods places the monitoring program in a position to report on status and trends in biodiversity and to identify aspects of oil sands development that have the greatest influence on biodiversity over time.

In Section 2.4 we provide information on Data Management and, in Section 2.5, a summary of Data Applications and Tools. We provide a summary of tools that provide context for the monitoring program and a summary of specific conservation planning tools. Finally, in Section 2.6, we outline principles for performance evaluation including an independent scientific review of the program.

2.1.2 Program Framework Design

There is substantial literature outlining the critical elements, steps, and processes that can be used to design monitoring programs (Mulder *et al.* 1999, Farr *et al.* 1999, Noon 2002, Gardner 2010, and multiple reports from US National Parks Service http://science.nature.nps.gov/im/monitor/MonitoringPlans.cfm). In this section on the design of the program framework, we explain the importance of a conceptual model of the ecosystem and the role of stressors, and present an example using migratory birds. . We describe an approach to developing goals and objectives from the conceptual model and a process for selecting targets, stressors and covariates, and their ecological attributes.

2.1.2.1 Development of a conceptual model of ecosystem function and the role of oil sands development

The development of a conceptual model of ecosystem function and how the development of oil sands interacts with ecosystem components is fundamental to determine appropriate study questions and parameters to evaluate those questions. Identification of these questions and parameters are, in turn, essential to the success of a monitoring program (Noon 2002). Lack of a conceptual model was identified as a key shortcoming by the US National Research Council evaluation of the Environmental Monitoring and Assessment Program (EMAP) in the US (National Research Council 1995). Such models are a concrete representation of the rationale and assumptions regarding the linkages between receptors and stressors (Gardner 2010). Ideally these models show the relative importance of relationships, and thus provide the foundation for selecting and prioritizing targets, stressors, and their interactions that inform monitoring design.

As scale changes, the questions for monitoring change. Spatial and temporal scale is a major consideration in design of the conceptual model of ecological function and impact pathways (Wiens 1989). Impacts may differ by scale. For example, landscape matrix affects probability of fragmentation effects (Bayne and Hobson 1997), and predation effects may take years to manifest. The scale of impacts is also related to species morphology and demography. Generally, the smaller the area occupied by a species, the smaller the scale at which we may wish to look for an effect. Life span or generation time of the target and/or stressor will also affect what time scale is appropriate to examine, as will dispersal ability (e.g. ability to “escape” an activity; ability to re-colonise a reclaimed habitat).

Noon (2002) suggests a process to develop a conceptual model and effects of stressors through the following steps:

- Characterize the anticipated stressors and disturbances
- List the ecological processes and resources affected by the stressors
- Ordinally rank the stressors according to their degree of impact and/or degree of irreversible consequences
- Develop conceptual models of the ecological system. Outline the pathways from stressors to the ecological effects on one or more resources.

We provide a general example that is a step towards this process using migratory birds. Our example examines the range of stressors that result from oilsands development across a range of spatial and temporal scales that are relevant to breeding grounds of migratory birds. With this example, we are striving for understanding of population impacts at the regional level. In Stage 2, more fulsome models will be developed with formal engagement of experts. This will include a process to prioritize impacts and due consideration of scale, as Noon (2002) recommends. However, the conceptual model and impact pathways will continue to be refined through time, reflecting new monitoring results and the adaptive approach.

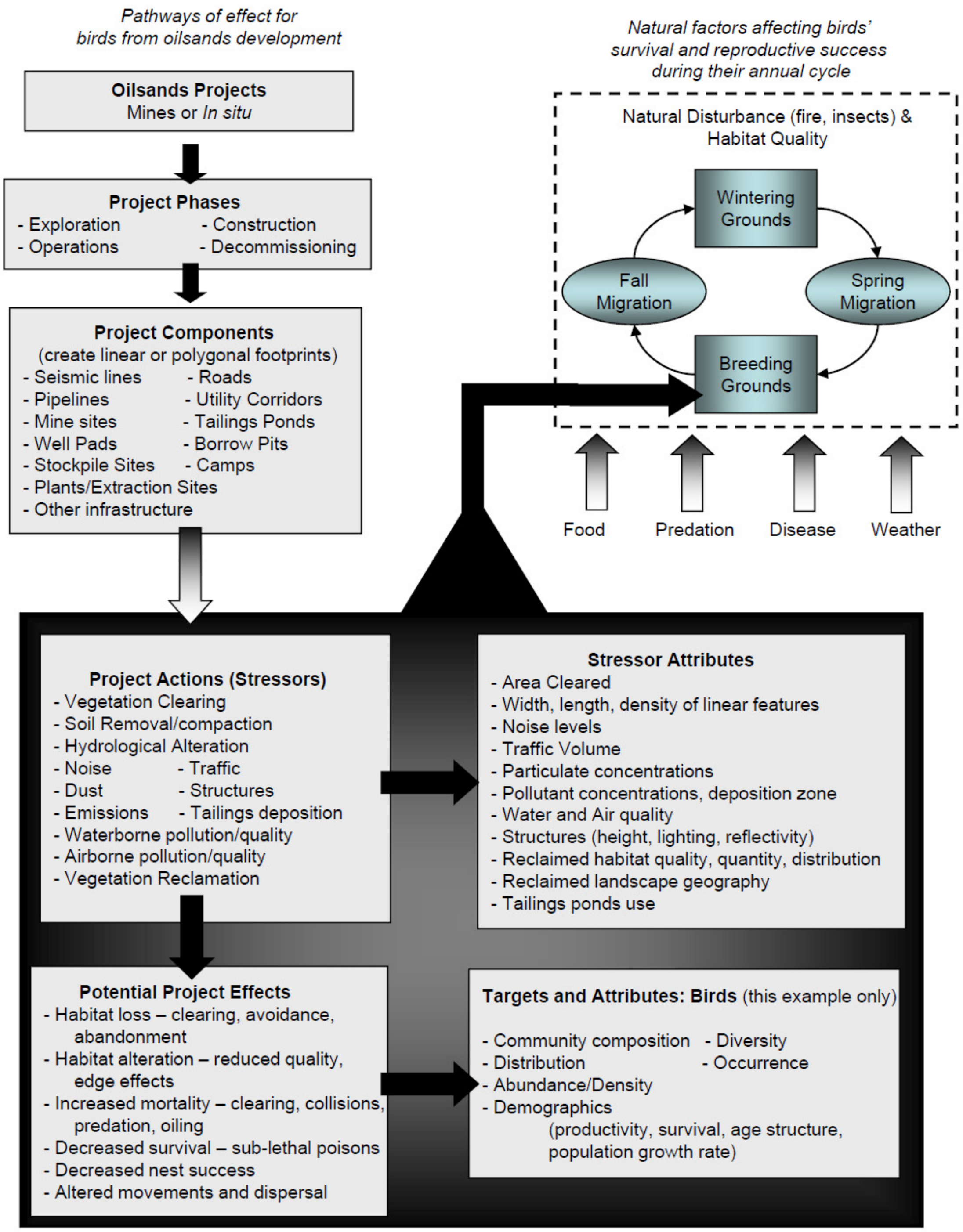


Figure 2.3. An example of a generalized impact pathway diagram for birds and oilsands. This depiction first shows that birds have multiple parts of their annual cycle where their survival and reproductive success are impacted by natural factors (upper right, adapted from Sherry and Holmes 1995). Then, the impacts of oilsands are additional factors influencing birds while on the breeding grounds. In spite of not being comprehensive and only representing a single group of animals, the potential number of links that must be explored, weighted, ranked and potentially subject to monitoring or detailed study is demonstrably large. Anthropogenic factors other than oilsands were not included for brevity, such as hunting or other human-caused mortality.

Our example illustrates the complexity of interactions between wildlife and oil sands developments. Beyond scale effects, potential effects of developments on wildlife, such as habitat loss and mortality, can vary depending on type of development (*in situ* vs. mining), phase of development (exploration, construction, operations or decommissioning) Response of targets to development may be positive, negative or neutral (e.g. avoidance or attraction to edges). Thus, the effects of oil sands developments on wildlife will vary not only over time and space but also by species, resulting in complex challenges to developing a biodiversity monitoring plan.

The potential effects of *in situ* and conventional oil sands mines on wildlife are numerous and include habitat loss, habitat fragmentation, habitat alteration or degradation, habitat avoidance, altered movements and increased mortality. Effects can occur at a variety of scales, from the local (micro-site and patch level) to regional (landscape), and may vary temporally and by species. Mines create a relatively large *polygonal* footprint on the landscape (e.g., mine pit, tailings ponds), while *in situ* developments create a high density of *linear* footprint (e.g., seismic lines, pipelines and roads) that results in a high degree of habitat fragmentation or dissection over a much greater area. Impacts may occur individually or cumulatively; where cumulative effects exist, they may be additive, multiplicative or cancel each other out. The predictive relationships between these effects and the distribution, abundance and demographics of wildlife populations in the oil sands region are largely unknown, and underscore the value of a monitoring program to address these gaps.

2.1.2.2 Goals & Objectives

Critiques of monitoring programs (e.g. Nichols and Williams 2006, Lindenmayer and Likens 2010) emphasize that the need for clearly defined questions as a requirement for a successful monitoring design. This plan is designed to address the questions “What is the impact of habitat disturbance of oil sands on biodiversity through time?” and “What is the success of mitigation efforts to address effects of oil sands development on terrestrial biodiversity through time?” However, given the general nature of these questions, further elucidation is required.

A dedicated exercise will be led at the outset of design of the monitoring program to determine the specific questions for each of the components of the monitoring program. The nature and specificity of the questions will differ between each of the monitoring components. This process will be informed by the target of interest and the impact pathways, from individual to cumulative effects, and across stages of oil sands development. It will also need to address the appropriate temporal and spatial scale for the design of the monitoring program and reporting.

2.1.2.3 Selection of targets, stressors and ecological attributes

In this section, we describe the approach for the selection of target species or species assemblages, stressors and other covariates that may affect target response, and ecological attributes of both targets and stressors.

2.1.2.3.1 Target species and species assemblages

Targets are the species or assemblages of species that we select to evaluate the effect of oil sands development and associated mitigation efforts. Collection of data on all species is not possible due to their rarity, accessibility of sites or species, availability of resources, etc. Further, data on all species may not be desired nor required to achieve monitoring objectives and specific study questions that arise through the development of the impact pathways. A defensible process is necessary to select a sub-set of species (Rempel *et al.* 2004, Noon *et al.* 2008, Weins *et al.* 2008, Cushman *et al.* 2010). Here, we recommend criteria for selection of monitoring targets in the oil sands region. They are presented in a descending hierarchical order:

1. Geographic overlap of species breeding range(s) with bitumen deposits. There is highest concern for species that utilise the oil sands regions for breeding habitat, because this life stage is the frequently the limiting factor for population sustainability. Breeding habitat is the habitat required for successful bearing and rearing of young to independence. In cases where oil sands activities pose particular risks to species migrating through the oil sands region (e.g. migrating birds that may land on tailings ponds and use them as stopover sites) then these species may also be included as targets for monitoring.

2. Existing risk to species. Species that have known population declines are found in a relatively small geographic range, or are strongly dependent upon vulnerable and difficult-to-recruit habitats (e.g. wetlands, old growth forests) are of particular interest as targets for monitoring. These populations may be at higher risk and less resilient to oil sands activities. Species listed under the *Species At Risk Act* (Canada) and as endangered or threatened under the *Wildlife Act* (Alberta, Saskatchewan), must be priorities for monitoring. Bird Conservation Region Plans (e.g. Mahon *et al*. 2011) identify priority species for conservation, and can serve as a guide for potential targets that should be the focus of monitoring efforts. General status reports from provincial governments provide further guidance on species that may be vulnerable to development.

3. Sensitivity to impacts of habitat disturbance. Species that are very sensitive or very insensitive are not particularly well-suited to evaluating the impacts of habitat disturbance and associated mitigation because they will either disappear at low levels of disturbance or be detected regardless of management action (Gardner 2010). Ideally, a suite of species with that show a range of response (positive or negative) to gradients of stressors/activities of interest are best suited for measuring management actions. An initial selection of targets that meet this criterion can be made following a combination of literature and expert

review, and by quantitative analyses based on existing or field-collected data. Noon *et al*. 2008 describe a range of approaches that could be used for selecting this suite of species including allometric relationships, home range size, demographic characteristics, tropic position, and habitat associations.

4. Species of societal interest and value. There are species that are of high interest to civil society, or sectors therein, because they have cultural, traditional, nutritional, economic, aesthetic or other value beyond their inherent value. These species should be identified and included in the monitoring program. Species that are of cultural or traditional value to Aboriginal Peoples should be identified through consultation with affected communities and relevant organizations in the oil sands region.

5. Covered by sampling through standard protocols. There are many standard protocols for collection of data that will simultaneously capture information on a variety of species, such as point count techniques for birds and winter tracking for mammals. Many of these species therefore do not need to be explicitly targeted by the sampling design. Standard techniques can also provide information on the structure and dynamics of species assemblages (communities) that may be unique. Measuring such species can provide further insight on functional relationships and potential conservation action. Common species may be habitat generalists and less sensitive to impacts; thus we should be able to report on the full range of responses to oil sands.

2.1.2.3.1.1 Targets as performance indicators

The challenge of selecting targets due to their value as indicators of the response or characteristics of other species or species assemblages can be problematic because functional relationships between species have not been clearly established (Fleishman and Murphy 2009, Lindenmayer and Likens 2009, Nielsen *et al.* 2009). While recognising the need to monitor a subset of species, we intentionally refer to monitoring of targets and avoid representing these species as indicators. The term ‘indicator’ generally means measuring one thing to represent the state of another. Given the early stage of the understanding of biodiversity in the western boreal forest, and the dearth of information on functional relationships, the prudent approach is not to extend results beyond the target that is the subject of the monitoring (Cushman *et al*. 2010).

2.1.2.3.2 Stressors and covariates

In this plan, we are evaluating the impact of habitat disturbance by oil sands and therefore selection of stressors is bound to activities that result in this disturbance. Stressors may be measured as individual activities, components of activities, or cumulatively. As mentioned, spatial and temporal scale are considerations for selecting stressors for monitoring design. We use and add to Noon’s (2002) guidance to characterise stressors as follows:

- Frequency (number of occurrences per unit time)

- Extent (area over which the event occurs)
- Magnitude:
    - Intensity (degree of effect on the biota)
    - Duration (length of stressor event)
- Selectivity (portion of the biota affected)
- Variability (probability distribution for each of the above)
- Reversibility of the disturbance

Characterization and prioritization of stressors is part of building the conceptual framework described in Section 2.2.1.

Wildlife is strongly influenced by the characteristics of stand and landscapes e.g. structure and composition of vegetation, as well as climatic and other biogeophysical variables, that compose 'habitat'. The exact relationship is specific to the target or set of targets. The refined version of the conceptual model and the impact pathways will consider these natural population drivers as factors that will inform monitoring design.

To obtain the causal relationships necessary to assess impacts of oil sands development, we will need to monitor targets and stressors simultaneously. Site-based observation of wildlife and habitats will be complemented with “continuous coverage” datasets such as remote sensing imagery including satellite-based images and aerial photos to provide a comprehensive picture of the study area over time. This approach provides context for site-based sample data and facilitates interpolation of population estimates across the landscape through use of species-habitat relationships. Analysis and interpretation of remote sensing imagery information is a standard tool for evaluating landscape change over time and for estimating effects of changes on wildlife populations. Identification of sources and criteria for assessing suitability will be part of the initial evaluation of existing programs described in the conceptual monitoring framework (Figure 2.2).

2.1.2.3.3 Ecological attributes

Ecological attributes of targets or stressors are the metrics used to report their state. Typical attributes at the species level are related to population descriptors of presence (occupancy) or abundance (abundance, density, distribution) or demography (productivity, recruitment, survival, and dispersal) either at a point in space (status) or through time (trend). For assemblages of species such as guilds, communities or all species, typical metrics include diversity, richness, intactness and turnover (change)..

The monitoring program will need to inform management actions across a range of scales and thus will require the ability to report from the individual species to an overall statement regarding the impact of oil sands on wildlife and wildlife habitats, depending on the need. We will apply tenets derived from Overton *et al*. (2002) in the development of higher scale attributes:

- Derive higher level attributes from underlying data;
- Ensure that the process of integration and generalization of lower order attributes is objective, transparent, replicable, rigorous and explicit;
- Develop all levels of attributes (from site or species levels to broad categories) simultaneously to ensure appropriate hypothesis-generation and data collection for populating the attributes and reporting; and,
- Ensure attributes are relevant to address questions established by conceptual framework and ultimately, the management agencies that will utilise monitoring results.

Selection of attributes should appropriately characterize risk to species. Attributes such as abundance may obscure lagged or compensatory effects on productivity, survival or dispersal (Van Horne 1983, Hannah *et al*. 2008). Higher order attributes (Lamb *et al*. 2009) can communicate effectively on overall conservation status but may obscure risk to individual species if not presented in context.

2.1.3 Principles of Monitoring Design

> *"The key to a rigorous monitoring protocol is proper sampling design, that is, one that yields unbiased… …and precise trend estimates at a reasonable effort"*
>
> Thompson *et al.* 1998

This section identifies principles of monitoring design for each component of the monitoring program outlined in section 1.2. Each component has an approach to data collection which is either based on complete observational coverage of the target or on samples of the target population or combinations thereof. Conclusions drawn from sample-based data are inherently subject to uncertainty due to incompleteness of knowledge on the target population. Design considerations for components that rely on sample data are therefore reviewed. The complementary roles of sample-based data and continuous coverage data are described in the context of each monitoring component. Monitoring design principles for the program in general are summarized with particular reference to the roles of reference conditions against which to quantify change and statistical considerations related to ensuring that the monitoring program has sufficient power to detect ecologically relevant changes and effect sizes.

2.1.3.1 The need for a sample-based approach

Monitoring biodiversity over an area as large as the oil sands region will require a sampling-based approach as opposed to a census-based approach to monitoring target populations. Unlike a census or complete count approach to measuring populations, sampling involves estimation of population parameters from observations on a subset of sites representative of the study area. Sampling is less expensive and more practical than a census, but the resulting data are reliable only if the sample design is based on sound statistical design principles (Green

1979). The design principles relevant to the monitoring questions in each component of the program are discussed in more detail below.

2.1.3.2 Design for monitoring status and trends in target populations and co-variates

The monitoring program identifies two general classes of entities as the subjects of long-term status and trend monitoring: target species populations and environmental stressors and co-variates. A robust biodiversity monitoring design needs to address both change in target species and change in “coarse filter” factors such as habitat supply and quality over time. Different sample designs are required for these two distinct levels of biological observation.

2.1.3.2.1 Design considerations for monitoring target species

The simplest sampling designs to implement for estimating population status and trends are simple random sampling and systematic sampling (Green 1979, Overton and Stehman 1996). These methods are inherently unbiased (accurate) but will have poor precision if the target population is not randomly distributed across the landscape (Thompson 2002). If the target population has clumped distribution patterns (such as individual bird species over a region, for example), a simple random sample will provide an accurate estimate with uncertainty that is inversely proportional to the sample size (Thompson 2002). In such cases, a more precise estimate can be obtained by weighting the probability of selecting potential samples using prior information to focus sampling effort where target species are likely to be observed or to areas where population densities are most variable. This is particularly important for understanding rare species or rarely occurring disturbances, which, under a systematic or simple random sampling design, could easily go unobserved. This would result in an undesirably large variance estimate and, potentially, very wide confidence intervals for the parameter estimates such as population size or population density of target species (Thompson 2002).

Ideally each species of interest under this program would be monitored based on a customized sampling design defined on the considerations identified above. In practice however, “monitoring effort cannot be optimized for all species simultaneously” (Nielsen *et al*. 2009). A generalized monitoring design is needed such that specificity and accuracy of estimates on individual species are balanced with the efficiencies of sampling many species with less precision. Biodiversity monitoring programs therefore often employ simple random or systematic designs (see for example Stadt *et al*. 2006). These designs are expected to work well for common species that are more or less distributed broadly across the study area (Thompson 2002, Hill *et* al. 2006, Manley *et al.* 2004).

In cases where monitoring of specific species is desirable, customized designs may be required in addition to a generalized multi-species approach. In these cases, greater accuracy and precision of parameter estimates may be important and more advanced sampling designs may be warranted. Examples are “unequal probability designs” that focus sampling effort in areas of expected species occurrence. Unequal probability designs improve the accuracy and precision of estimates in structured (non-random) populations at the cost of imposing "structure" and complexity to the sampling design (and subsequent analysis) (Overton and Stehman 1996). For example, methods of analysing data from unequal probability designs from permanent plots subject to change over time are not yet proven in long-term monitoring initiatives (Thompson 2001). Thus the advantages of this approach need to be evaluated on a case-by-case basis. Alternatives to unequal probability designs applicable to clustered or rare species are adaptive cluster designs which can be used as extensions to simple random or systematic grid approach (Thompson 2004).

The considerations described above outline the principles for developing the sample frame for monitoring and generally argue for a two-tier frame: one tier comprising a general purpose sample frame for distributing points broadly across the landscape and a second tier of sampling frames that addresses a relatively small number of target species that require more precise status and trend estimates. With these principles for establishing the sample frame in mind, the considerations for how sampling will be conducted across sites comprising the frame can be discussed.

Once the set of sampling units is defined, monitoring plots will need to be established at each selected location. Permanent monitoring plots are recommended because trends estimated from repeated observations at permanent sample points generally have better precision and higher likelihood of detecting significant changes over time (Scott 1998). The size and shape of these permanent monitoring plots is a key consideration. The spatial and temporal scales of measurement of target parameters on the sample grid must be matched to the spatial scale and temporal scale at which the target species function (Schneider 2001, Sandel and Smith 2009). For instance, different plot sizes may be used for resident bird species compared to migratory bird species (Shank *et al*. 2002). Again, the problem arises that a single size of monitoring plot and frequency of revisiting cannot be optimized for all species of interest (Nielsen *et al.* 2009). For example, species with large home ranges such as caribou will require large sampling units to accurately characterize habitat use and occupancy; species with very localized movements may require sampling plots several orders of magnitude smaller in order to represent them sufficiently in the sampled population. This problem can be addressed by using analyses of species' home ranges and correlates thereof to find a manageable set of combinations of spatial area and temporal variation for defining the sampling program (Noon *et al*. 2008, Theobold and Hobbs 2002). In this approach, the potential for species that have similar area requirements and timing of life history events to be monitored on common sample plots and schedules can be evaluated. Appropriate sizes of sampling units for poorly understood species may not be known initially. Pilot studies may be required for these species to determine the resolution/grain at which populations function (Sandel and Smith 2009, Reynolds *et al.* 2011).

Efficiencies in sampling effort can potentially by gained by scheduling revisits to monitoring plots on various time scales since a regular schedule of annual visits, for example, may not be needed for each target. Monitoring plots can be grouped into sets of plots that are revisited at a frequency that is determined by the temporal resolution of the sampling program. This approach can be extended to identify multiple time scales for sampling different sets of plots as a means of capturing within one design temporal dynamics that operate on short and long time scales (Overton *et al*. 1990). Although complex, this approach should be explored as a means of addressing groups of species that respond to environmental change on different time scales.

2.1.3.2.2 Design for monitoring stressors and covariates

Continuous coverage datasets such as satellite-based remote sensing images and aerial photos can provide a comprehensive picture of the study area over time. Unlike sampling at discrete locations, these images provide snapshots that can be processed into a census (*i.e*. full coverage) of landscape features that are expected to affect biodiversity over time. These features may, for example, comprise the vegetation cleared for industrial development or areas currently under reclamation. It may also include information on non-industrial factors that affect biodiversity such as natural variation in hydrology, forest fires and insect infestations. Processing of remote sensing data, at appropriate repeated intervals, into censuses of stressor and covariate allows the *post-hoc* exploration of species-habitat correlations as well as reporting on coarse-filter biodiversity statistics such as change in habitat/vegetation conditions over time. This approach provides context for site-based sample data and facilitates interpolation of population estimates across the landscape through use of species-habitat relationships. For instance, remote sensing imagery can fill the gaps between the permanent sampling plots to facilitate spatial distribution of species across the landscape over time when data are of sufficient quality and quantity to build species distribution models (Elith and Leathwick 2009). This capacity is especially important for reporting on status and trends of species of conservation concern for which detailed understanding of local distributions are important (Fleishman *et al*. 2002).

2.1.3.3 Design for intensive effects assessment

Detecting and measuring cause-effect relationships requires sampling designs that can separate and control for the effects of many factors that influence the target species under study. This objective of isolating effects can only be achieved in retrospective observational studies by ensuring that the factors of interest are represented in the set of sample sites from which the effect sizes will be estimated. This is achievable by use of geographic information systems to intersect and cross-classify available spatial information on the predictors of a target population in order to define “strata” for each stressor and co-variate of interest (Danz *et al*. 2005). The polygons resulting from these intersections represent domains from which samples can be randomly drawn to ensure that target populations measured at each site are subject to the intended levels of each stressor as well as combinations of stressors and covariates. This is called a mensurative experiment and relies on the contrast of existing conditions on the landscape. It is in contrast to a before-after-control-impact (BACI) design where specific manipulations are done on the landscape for the purposes of the experiment. This latter case yields the strongest inference (Green 1979).

The approach of intentionally focussing observational effort is recommended for this component since it is generally recognized that "it is hard to give a useful general rigorous justification for letting a random device [such as simple random or systematic sampling] decide which units should be observed" (Royall 1970). This is especially the case when replication of sites subject to similar "doses" of stressor or covariate effects is needed to determine effect sizes (Green 1979). For example, Royall (1970) identifies that the estimates for the slope of a regression line will be better from samples based on some level of intentional sampling across the predictor variable of interest than from samples based on simple random sampling.

In cases where cause-effect relationships cannot be evaluated under a pure experimental design such as the BACI approach described above, design for this component will employ a site selection method that provides representation of habitat suitability for the species of interest cross-classified with all levels of variation in disturbance footprints within the sample (Danz *et al*. 2005). This cross-classification approach corresponds to a factorial experimental design for separating effects the influence of different causal factors in species population trends such as changes in habitat suitability, habitat loss and habitat dissection. A factorial experimental design based on this approach is optimal for separation of causal effects but has its limitations: observational studies are subject to biases from hidden treatment effects that may be partially correlated with the variables of interest (Cochran 1983). When hidden treatments are important but not controlled the importance of the causal factors of interest can be diluted or artificially magnified. Determination of the appropriate sampling design for making hidden treatments explicit and measurable is therefore an important consideration.

Observational studies attempting to identify cause-effect relationships can address the hidden treatment problem using one of two general approaches: *a priori* stratification of samples across gradients in treatment and background variables, or reliance on large sample sizes and statistical power to obtain representation of gradients in explanatory variables by chance. The key here is that samples are required to be drawn that are subject to the range of all potentially important covariates so that the effect sizes can be estimated and controlled for using statistical methods (Cochran 1983).

In either case, ecological land classifications that correspond to general habitat types for each target should be adopted for defining the frames from which to draw the sample of sites for this monitoring component. Use of ecologically defined sampling units such as forest stand types or ecosite phase map units will facilitate more precise cross-classification of targets and stressors than will use of an arbitrary sampling grid used for general biodiversity monitoring. The scale of ecological land classification appropriate for a given target species will depend on the life history requirements of the species or species group (Sandel and Smith 2009).

Based on the approaches described above, Danz *et al*. (2005) identify a generic set of steps for targeting sampling effort in a way that attains representation of relevant levels of each ecological gradient that needs to be considered within the set of sample sites to be studied:

1. Divide the study area into sampling units which are appropriate for monitoring the response of interest (in this case species abundance). Examples of such units are watersheds or habitat types relevant to the target.
2. Measure each explanatory variable of interest in each unit. This involves using stressor and covariate data from remote sensing to determine the physical area of influence of each stressor being considered for having an effect. The physical area of each stressor needs to be calculated for every sampling unit defined in step 1 above. The extent of suitable habitat for the target will be quantified in the same way. Habitat mapping and remote sensing images will be the primary source of data for this requirement;
3. Identify groups of sampling units (strata) that have similar levels of each environmental explanatory variable (strata). Geographic information systems can be used to identify the spatial locations of available sampling units that meet criteria for each stratum and cross-classification of strata; and,
4. Select sites within each stratum for conducting surveys based on species/indicator-specific protocols (*i.e.* sampling for the target species needs to be constrained to areas of suitable habitat for that species).

The stratified approach to data collection for effects assessment described above has clear advantages for its intended purpose over the systematic and/or simple random sampling designs in that the stratification approach of Danz *et al*. (2005) explicitly focuses sufficient sampling effort in areas where effects are likely to be taking place as opposed to randomly selected areas within the region. This approach improves sampling efficiency and precision of parameter estimates (Royall 1970), and decreases the amount of time and data needed to determine effect sizes with confidence. However, the relationships identified through such a heavily stratified approach are unlikely to be representative of the regional importance of the effects unless validated by regional sampling such as in the proposed status and trend monitoring component. The importance of the effects ‘on the ground’ can only be determined by qualifying the effect sizes by the extent of their footprints in the landscape. This can be done using geographic information systems to quantify the areal extent of each type of disturbance to which the observed cause-effect relationships apply.

Use of this set of procedures for each target species is a significant undertaking which cannot be realistically made for each species in the region. A reductionist approach to combining species into sets of target populations as discussed in section above will be required.

Once estimates of effect size for cause-effect relationships between changes in specific disturbances and wildlife populations have been obtained, they are not expected to change on short time scales (*i.e.* less than 5 years). The sampling design for this component will be based on temporary sampling plots distributed across disturbance gradients according to stratified random sampling methods. This design is optimal when sampling must be highly targeted and the variables being studied are not time-dependent (Overton and Stehman 1996, Thompson 2001, Hill *et al*. 2006). For example, the effect of seismic line length per square kilometre on forest birds would not be expected to change over time. However, the importance of this factor in the landscape would be expected to change as seismic line density increases or decreases over time. The cause-effect relationships can therefore be characterized by synoptic (snap shot) sampling based on the approach described above. As the landscape changes over time, these studies may have to be repeated on 5 to 10 year intervals to update estimates of effect size and to revisit the relative importance of stressors and co-variates over time (*i.e*. as industrial activities move from land clearing phases through to reclamation phases). Repetition of these studies over time can be thought of as "recalibrating" relationships as the ecosystem changes over time (Kimmins *et al*. 2007).

An example of how the cause-effect study component is used along with landscape monitoring of disturbance footprint is provided for clarification. As a hypothetical example, if the proposed controlled observational study for forest birds identifies that the average population density of forest birds measured on 1 km^2 monitoring plots declines with increasing density of seismic lines at a linear rate of -1 breeding pair per unit increase in seismic line density, the resulting effect size is -1 pair/km increase in seismic lines. The relationship identifies that linear disturbance footprints of, for example, 10 km/km^2 will result in an expected reduction of 10 breeding pairs per km^2 compared to the same area of equivalent habitat not subject to seismic line footprint This effect size contains no information on the importance of this effect on the landscape since the importance of species-disturbance type relationships at any given time will be proportional to the footprint of each disturbance type at that time (time lag effects notwithstanding; see discussion on measurement error below). Remote-sensing imagery and infrastructure mapping will be key resources for estimating the amount of disturbance footprint in each 1km^2 portion of the landscape at each time interval. Other examples of linear and polygonal disturbance types for consideration in this controlled observational study component of the monitoring program are described in section 2.2.2.

2.1.3.4 Integration of status and trend monitoring and cause-effect monitoring

The scope of the monitoring initiative identifies two objectives: determination of status and trends in target species and identification of the contribution of industrial activities to changes in status over time (cause and effect). The two distinct approaches to the monitoring designs described above are needed to support each component. Ideally, a single design would facilitate both objectives but fundamental differences in these objectives argue for a combination of designs that are complementary to fulfill the overall long-term monitoring objectives (Vanclay 1992). Such "hybrid designs" (*sensu* Kimmins *et al*. 2007) provide a means of addressing monitoring questions related to species patterns (e.g. population trends and distribution) and the underlying causal processes (such as causes of habitat change). Intensive studies using stratified designs are better for cause-effect assessments while long-term extensive, status and trend studies are better for tracking net effects of combined disturbance factors on focal species or indicators at the broader levels over time, *i.e.* cumulative effects (Simcik 2005). In combination, the approaches provide a robust foundation for understanding changes in the status of biodiversity over time and how those changes can be addressed if needed.

2.1.3.5 Considerations for sample-based inference: handling and managing uncertainty

Both status and trend monitoring of target populations and cause-effect monitoring rely on sampling target populations. In addition to uncertainty around attributes of a population estimated from a sample (sampling error), there are sources of error associated with observation and measurement in the field that are relevant to both monitoring designs. Although these sources of error are inherent in environmental measurement and not a fault of the sampling approach, they are important to consider as they have the potential to magnify error and introduce bias even with unbiased sample designs (Camp 2007). Examples of sources of measurement error in biodiversity monitoring that require control are: inter-observer variability (Lotz and Allen 2007, Diefenbach *et al*. 2003), detection error (MacKenzie *et al*. 2005), and methodological errors in mismatching scales of observation with scales at which processes and patterns of interest operate (Andrew and Mapstone 1987; Schneider 2001; Sandel and Smith 2009). Time lags in species responses to habitat change are an example where species' response may vary on a different temporal scale than habitat change (Debinski and Holt 2000). All of these errors originate in human processes that, to some degree, can be reduced through training, allocation of case-specific observation effort, and statistical models using random effects. Adaptive sampling for idiosyncratic circumstances (such as insect outbreaks) will very likely be required in order to adjust the temporal and spatial windows of sampling beyond a fixed, regularized period.

These sources of error have the potential to bias sample results without mitigation. In some cases, bias can result in detection of spurious effects of opposite direction and/or unrepresentative magnitudes relative to the actual effect in nature. The misinterpretation of poor habitat as high suitability is plausible in cases where a species is less detectable in higher than lower suitability habitat. Habitat models based on apparent abundances that are not corrected for the heterogeneous detectability rates between habitats would very likely misclassify high suitability habitat as low (Gu and Swihart 2003, Ruiz-Guiterrez and Zipkin 2011).

2.1.3.6 Error and statistical power: implications for decision-making

Sampling error and measurement error interact with environmental variation to reduce the precision of population estimates and rates of change over time. These sources of error increase the time required for status and trend monitoring to detect ecologically significant changes. They also affect the ability of the cause-effect monitoring component to detect effects because sampling and measurement error reduce the ability to detect the strength of cause-effect relationships in "noisy" data. These sources of variation become less influential with increasing sample size. The specific sampling protocols that will be designed for each monitoring component will therefore need to determine the sample sizes required to reach desired levels of confidence in trend estimates and cause-effect relationships. The challenge of identifying the requisite sample sizes can be addressed using analyses of statistical 'power' or precision (see for example ABMI 2009).

Statistical power identifies the sample size required to obtain a specified level of confidence that a specified degree of population change has occurred or that an effect estimate of, for example, habitat loss on a population, was of a certain magnitude. Implementation of the monitoring plan will require pilot studies that provide estimates of the amount of sampling effort required to answer a given monitoring question with confidence (Green 1989, Reynolds *et al.* 2009). In some cases, existing information may provide insight into information needed for power analysis (e.g. Habib et al. 2007). Where needed, pilot studies and power analysis approaches must be carefully designed to reflect the complex structure of ecological data in order to provide accurate assessments on which to base the program (Elzinga *et al*. 1998, Legg and Nagy 2006).

Prescription of specific effect sizes and sample sizes needed are beyond the scope of this document. General principles for defining these parameters are that the effect size thresholds should be ecologically significant for the species in question and the level of precision required for resulting estimates should be proportional to the importance of the species. Importance could be determined by economic, social, ecological considerations or combinations thereof (Noon *et al*. 2008). Species at risk for example, may require higher levels of precision to guide conservation action as opposed to more common species that are of less immediate conservation concern. Generally, rare species are the most difficult for which to obtain precise population estimates and estimates of disturbance response (Thompson 2004). Meeting this challenge highlights the importance of using the best monitoring design for the species of conservation concern.

2.1.3.7 Comparison of observations to reference conditions

The approach to monitoring design proposed here moves beyond passive monitoring approaches toward a systems-based understanding of what is happening to biodiversity and why (Kimmins *et al*. 2007). The focus of this approach is to report on incremental and cumulative changes from the starting point of the program forward through time. In addition to incremental change, a comparison with a natural reference condition will put the contemporary trends observed in the industrial landscape in context. Quantitative data on ecological conditions prior to oil sands development, for example, would provide a useful coarse-filter reference condition against which cumulative changes in proxies of biodiversity (such as vegetation cover) could be evaluated. Contemporary reference conditions can be used to separate effects related to industrial activities from background variation in target response caused by factors such as regional weather patterns, and fluctuations in population density of migratory species due to continental effects (for example, disturbances in wintering grounds of migratory birds). Ecological benchmarks within and outside the oil sands region will be necessary to control for, and remove, such background variation when estimating the contributions of industrial activities to population change. Approaches to establishing ecological benchmarks are well-established (e.g. Schmiegelow *et al.* 2008) and need to be incorporated into program implementation.

2.1.3.8 Path forward

Clearly the challenges associated with both designs for monitoring are significant when considering the complexity of the pathways of effects, the number of receptors/monitoring targets and the need for moving beyond simple correlations. We propose that meeting this challenge will start with the premise that a useful predictive model of impacts can be parameterized for major impacts based on existing data and relationships from the oil sands region and from other systems where the ecological processes and targets are relevant. Scientific opinion as quantified through structured elicitation (e.g. Analytic Hierarchy Process, Schmoldt *et al*. 2001) is not often used in constructing ecological response models in wildlife research (compared to fisheries research for example), but represents a valid interim approach to hypothesis building and testing. We therefore expect that reasonable statistical models of response to oil sands effects can be built at the outset, and evolved using the iterative designs discussed above.

2.1.4 Data management

The monitoring activities resulting from implementation of this plan will generate large volumes of data. A data management plan is needed to ensure the quality, security and long-term availability of data resulting from this program. Principles, standards and infrastructure for data management are the subject of data management principles outlined in the Introduction section of Phase 2 of the overall environmental monitoring overview. Management of sampling and remote sensing data collected through the biodiversity monitoring program described herein will be conducted according to the principles and recommendations of the 2010 Federal Oil Sands Advisory Panel Report. Standards of practice for data collection, data management and data documentation will be followed to ensure that information collected under this program can be integrated with data from other environmental programs as efficiently as possible. The highly domain-specific and multi-variate nature of biodiversity data warrants some specific considerations for data documentation and archiving of large remote sensing files., The monitoring design implicitly identifies spatial data and observation data as two main types of information that will require management over time. Spatial datasets covering a large portion of the oil sands region will be acquired at regular intervals (likely on the order of every 2 to 5 years). Examples are satellite imagery, aerial photographs and forest resource inventory mapping. Other spatial data sets relevant to environmental monitoring generally include digital maps of industrial infrastructure, road networks and landscape disturbances such as forest fires and insect outbreaks. Where possible, these datasets will be acquired and/or licensed in cooperation with custodians already managing this information. These data will require management in spatial format that facilitate mapping in geographic information systems for analysis. Storage of these data will require assessment of optimal file size and file organization. A long term plan for server storage space and archiving will be an important support component of the monitoring program.

Unlike sensor-based data collection that can use automated data collection instruments, observational data on wildlife are largely collected manually and will also require integration and management in digital format. Raw observational data will require geo-referencing and will be stored in a digital format that facilitates direct integration of observations of target species and indicators with spatial datasets on environmental conditions. Field-based information will therefore be processed and documented using standards that align with storage and management of sensor-based information to the degree possible.

2.1.5 Data applications and tools

Monitoring data are an integral component for wildlife conservation management. In this section, we explore the potential applications of monitoring data and the potential management tools that could be developed. We describe examples of tools and data products that could assist with interpretation of results of biodiversity monitoring in the oil sands region, and for a range of conservation planning and management activities.

The primary application of monitoring data is to determine what changes are occurring in biodiversity due to development and to facilitate integration of this information with other ecosystem monitoring results to inform decision-makers about the combined effects of oil sands development on the environment. Additional applications that can advance the understanding of the ecosystem and expected changes in biodiversity over time are discussed below.

2.1.5.1 Data products and tools that provide context for results

2.1.5.1.1 Cumulative effects assessment and the role of hindcasting

Monitoring data and resulting status and trend information are bound to the time period in which they were collected. It may be useful to examine the entire time period through which oil sands have been under development to put results in this larger context. For example, a baseline dataset of habitat conditions across the study area prior to oil sands development would facilitate assessment of cumulative loss of different types of habitat to date. Such information would be useful to avoid the problem of “shifting baselines” when assessing effects relative change between short time periods. Pauly (1995) points out the importance of measuring change against the original state of a system, rather than relative to more recent states that have already experienced change. Without a meaningful temporal baseline, absolute estimates of habitat change and biodiversity impacts of oil sands operations cannot be made. As another point of comparison, we may wish to know what the state of wildlife would have been in the oil sands region if the oil sands hadn’t been developed.

Proven model-based techniques could be used to generate both the pre-development baseline condition and the state of the oil sands through time if there had been no development. Aerial photographs and disturbance datasets such as fire statistics data (Burton *et al.* 2008) can be used to recreate the historical landscape condition of the oil sands region before significant development (i.e. prior to the mid 1960s; Oil sands Advisory Panel 2010). This historical condition will represent the range of habitats (age-class composition, spatial distribution) that occurred within the oil sands region in the mid 1960s when only natural disturbance agents (fire, insects, disease) influenced the landscape. Detailed biological data suitable for modeling also exists from the AOSERP studies in the 1970s and 1980s (Alberta Environment), adding the potential for temporal control of trends through time unrelated to oil sands development (e.g. comparing current bird densities in undisturbed habitat). Land-use models can use the historical condition as a starting point (initial composition) and simulate landscape dynamics in the absence of land use (i.e. only natural disturbance agents like fire, insects, and disease influenced the landscape). Wildlife-habitat models can be applied to the historical condition and simulated conditions at defined intervals (e.g. 10 year intervals) to determine: 1) the simulated population size of target species before the mid 1960s (status), and 2) the simulated population size over time from the mid 1960s to present (population trend). This provides a pre-development baseline trend that can be compared to future trend data which includes predicted data generated using land use models to assess cumulative effects on target species and observed field data to monitor target species.

2.1.5.1.2 What is the current and future condition of the oil sands region?

The development of oil sands is a very intensive activity: once the habitat disturbance has occurred it can be many decades before the habitat is restored. In some cases conversion to other habitat types may be permanent. Therefore, we may wish to predict the effects of current and future land-use decisions on wildlife, rather than waiting to collect monitoring data after the activity has occurred.

Land use models and wildlife-habitat models can be used to assess the current cumulative effects of numerous large-scale anthropogenic disturbances (oil sands extraction, forestry, natural gas extraction, agriculture, mining of peat-moss, human settlements), natural disturbances (fire, insects, disease), and climate change on the population size of target species (Schneider *et al.* 2003). Field-based trend data (observed state) can be compared to simulated trend (predicted state) to assess the reliability of the cumulative effects assessment at the regional or study area scale.

These models can be utilised to develop a range of possible future management scenarios for the oil sands region, for example, to evaluate a range of levels and type of economic development and/or conservation and protection actions (e.g. Carlson *et al*. 2009). There is a solid foundation for such modelling efforts in a variety of existing programs and these programs will be integral in the development of these tools.

2.1.5.1.3 What are range-wide implications for target species?

Monitoring data (field based trend data) within the study area provides a detailed assessment of population trend for target species within the oil sands region. For species with distributions that extend well beyond the spatial extent of this region, wildlife manager may wish to understanding the relative importance of the impacts of oil sands activities for the entire population. Comparisons with other regions across the boreal forest (with and without oil sands activities) may indicate the presence of region-specific declines for target species. Development of boreal-wide biodiversity monitoring programs (e.g. Machtans and Schmiegelow 2007) would facilitate comparisons across the spatial extent of breeding ranges of many target species.

2.1.6 Performance evaluation

Throughout this document we have emphasized important steps, processes, and design principles that can help ensure the monitoring program achieves its objectives. Formalized oversight is a key shortcoming of many monitoring programs and such oversight could have often caught errors or design issues before they became significant problems (Reid 2001). For this reason, as part of Stage 2, we will create a formal performance management framework for the monitoring program. The performance management framework for the biodiversity monitoring program will be split into two key functions: a management audit and a scientific performance assessment, with each function incorporating independent review. Independent scientific review represents continued commitment to ensure scientific credibility for the program.

2.1.6.1 Management Audit Function

The management audit will verify if all aspects of the program are functioning as planned and as measured against pre-determined milestones. Milestones and targets will include both high- and low-level measures. Potential examples include:

- Funding and staffing levels against targets through time
- Number of sites sampled versus planned
- Percent of data entered by target dates
- Percent of data proofread and released publicly by target dates
- Percent of data analyzed by target dates
- Percent of reports issued by target dates

In short, the management audit function verifies that all the parts of the programs are functioning as planned, are resourced, and are reporting out on results. A full suite of management targets and timelines will be created as the program is developed.

2.1.6.2 Scientific Performance Assessment

The scientific performance assessment serves a critical role, especially early in the monitoring program. The main role is to verify the design of the individual data collection programs/studies by validating *a priori* power and precision analyses against the data actually collected. The failure to analyze data quickly to reveal design and practical sampling issues has been a key failure in many programs (Reid 2001, Lindenmayer and Likens 2010). Especially because the sample-based designs will often be short-term research style questions, validating their design after the first year of data collection will be crucial to not wasting resources and ensuring timely, accurate results. Sampling intensity and designs will be adjusted as a result of the scientific performance assessment in an iterative fashion. A significant side benefit is that simply analyzing data often uncovers basic data management issues, including entry errors, formatting issues, and missing data. The scientific performance assessment should therefore help significantly with verifying that the data management goals have been achieved.

2.2 Report on expert review

An earlier version of this plan was reviewed by experts in landscape ecology, conservation biology, and monitoring design. Environment Canada wishes to thank those individuals who participated in the expert review, and who provided thoughtful input and critique of the draft document during the expert workshop held in mid-June 2011:

Dr. Erin Bayne	University of Alberta
Dr. Stan Boutin	University of Alberta
Dr. Colleen Cassady St. Clair	University of Alberta
Dr. Richard Elliot	Environment Canada
Dr. Daniel Farr	Biota Research Ltd.
Dr. Barry Noon	Colorado State University
Dr. Jim Schieck	Alberta Innovates
Dr. David Schindler	University of Alberta

Some of the key issues raised at the expert workshop were:

- Clarification of terminology.
- Importance of temporal and spatial scales.
- Complementarity of differing types of monitoring which exist along a gradient.
- Importance of trends and status monitoring.
- Stratified sampling design for a multi-taxal program is problematic.
- Reference/baseline conditions should be a core component.
- Independent, time-bound scientific oversight of the program is critical.
- Development of explicit triggers for management action is needed.
- Governance needs to be developed with consideration for independence, program longevity and representation.

Although we undertook to address the comments received within the scope of this document, the final content of this document represents the views of Environment Canada and does not necessarily represent the views of those experts or their organization.

2.3 Next steps

Following the release of this plan, Environment Canada will continue to work collaboratively with our provincial counterparts and other experts on refinement and implementation. Stage 2 will be implemented in the next 12 months; priority actions are outlined in Box 2.1.

Box 2.1 Priority actions for Stage 2 to monitor impacts of habitat disturbance by oilsands on wildlife and wildlife habitats:

1. Participate in broader consultation efforts to ensure the plan reflects the interests of all affected parties with a particular focus on engagement with Aboriginal Peoples,
2. Using the program framework design as described in Section 2, define the first set of questions, targets and stressors,
3. Complete an evaluation of existing programs and their ability to deliver on program goals and objectives,
4. Develop collaborative relationships for program delivery where existing programs can meet goals,
5. Develop the monitoring survey design, site selection and protocols for an initial set of targets, focusing on priority species at risk and migratory birds, and species of provincial interest; EC commenced some efforts in this regard in Spring 2011,
6. Ensure biodiversity considerations are included in broader data management planning, and,
7. Initiate data collection, protocol testing, analysis and reporting recognising the opportunity for cooperative efforts at the scale of regional land-use planning units.

2.4 Conclusion

This plan lays the foundation for a rigorous approach to monitoring the impacts of oil sands on wildlife. It recognises the challenge of monitoring a broad array of species in a highly dynamic, complex system over multiple spatial and temporal scales, and sets forth a staged, iterative approach to development and implementation. This plan includes both status and trends monitoring of wildlife and wildlife habitat, and an effects assessment component to identify causal mechanisms. The plan also embodies an adaptive approach which will provide a very transparent and scientifically credible program on the impacts of oil sands development on wildlife.

Environment Canada has benefited from the experience and critiques of this plan and other programs, and we will continue to proceed in a collaborative and transparent manner, welcoming further scrutiny and ideas to assist refinement and implementation of the plan. With this plan, EC demonstrates a commitment to biodiversity monitoring in the oil sands region in collaboration with others. Successful implementation relies on a cooperative approach. Environment Canada will actively work to build on existing partnerships and invites new collaborations as we move forward.

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