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**MONITORING WETLAND VEGETATION AND RECLAMATION  
ACROSS SPACE AND TIME  
EXECUTIVE SUMMARY REPORT  
PTAC PROJECT NO. 16-ERPC-07**

Report Prepared for:  
**PETROLEUM TECHNOLOGY ALLIANCE CANADA**

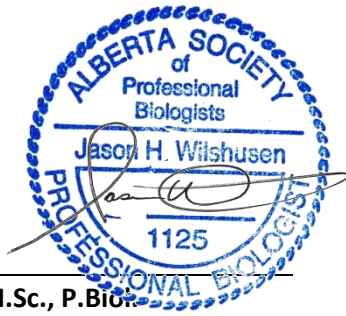
Prepared by:  
**MATRIX SOLUTIONS INC.**

June 2017  
Calgary, Alberta

Suite 600, 214 - 11 Ave. SW  
Calgary, AB, Canada T2R 0K1  
T 403.237.0606 F 403.263.2493  
[www.matrix-solutions.com](http://www.matrix-solutions.com)

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Report prepared for Petroleum Technology Alliance of Canada, June 2017



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**Jason Wilshusen, M.Sc., P.Biol.**  
**Senior Environmental Scientist** *June 29, 2017*



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**Reviewed by**  
**Sheila Luther, M.Sc., P.Agr.**  
**Principal Soil Scientist**

In collaboration with Jonah Keim and Philip DeWitt

**DISCLAIMER**

We certify that this report is accurate and complete and accords with the information available during the site investigation. Information obtained during the site investigation or provided by third parties is believed to be accurate but is not guaranteed. We have exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this report.

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# 1 INTRODUCTION

## 1.1 Background

Wetlands ecosystems are important to water quality, nutrient cycling, and biodiversity, and have been identified as a management priority across Canada. In Alberta and British Columbia, oil and gas operators are responsible for delineating and monitoring wetlands potentially impacted by their activities. Wetland vegetation is influenced by a number of natural processes related to water, nutrients, topography, season, and climate (Vitt and Chee 1990; Vitt et al. 1995; Dimitrov et al. 2014). A key challenge for operators is identifying whether changes to wetland ecosystems are being caused by development or natural processes. Methods are therefore needed to separate development effects from natural sources of variation that occur across space (e.g., nutrient gradients) and time (e.g., seasons and annual climate).

Measuring variability in natural processes requires rigorous data collection and could increase the cost of environmental monitoring for oil and gas operators. Recent advances in remote-sensing and sampling design provide an opportunity to develop cost-effective monitoring strategies that integrate natural variation. We are conducting a phased research program that aims to develop a defensible and cost efficient technique to monitor wetlands, wildlife habitat use, and reclamation success that is broadly applicable to gas, oil, and bitumen producers. Our approach integrates a combination of remote-sensing and survey data to measure natural variation across both time and space at different scales (Table 1). Further, this approach serves as a cornerstone to linking monitoring approaches to broad-scale measures of reclamation completion.

**TABLE 1 Monitoring Vegetation, Wetland, and Wildlife Across Space and Time**

Scale	Spatial	Temporal
Coarse	Landsat imagery (30 × 30 m)	Vegetation plot data (1 per 3 years) RGB-IR imagery (1 per 3 years) LiDAR (1 per 3 years) Hyperspectral (as needed)
Fine	SPOT 6 imagery (6 × 6 m) Vegetation plot data (4 × 4 m) Hyperspectral (<2 m × 2 m) LiDAR (50 × 50 cm) RGB-IR imagery (30 × 30 cm) Wildlife camera data (point location)	SPOT 6 imagery (1 per 4 weeks) Landsat imagery (1 per 2 weeks) Wildlife camera data (continuous)

Conducting joint analyses across these varying data sources is intended to enhance operators' ability to isolate project effects, reclamation effects, and natural processes from one another. This could improve and increase the defensibility of operational decisions, improve environmental performance by economizing reclamation efforts where they are most needed, and reduce costs by combining multiple environmental programs into one all-inclusive program.

## 1.2 Objectives

The study and associated objectives were developed specific to an applied setting for the Connacher Oil and Gas Ltd., Great Divide Expansion Project (Great Divide). As such, the research and monitoring study was conducted to support Connacher's environmental monitoring and mitigation programs (i.e., wildlife, caribou, wetland, and reclamation) for the Great Divide. However, the study design and objectives are also directly applicable to Petroleum Technology Alliance of Canada's (PTAC) policy issue and knowledge gap related to *effective wetland reclamation and monitoring techniques* and support a collaborative research project with the PTAC that was approved under the 2016 Alberta Upstream Petroleum Research Fund. In addition, by linking vegetation to wildlife use data the study provides an opportunity to address knowledge gaps associated with *woodland caribou, moose, deer, and predator behavioural, numerical, and functional response to oil and gas features*.

Broadly, the research program consists of three objectives focusing on evaluating the ability of the framework to provide reliable monitoring data across various scales and regulatory conditions for wetland monitoring, wildlife, and reclamation:

- Evaluate remote sensing approaches (helicopter visual, photograph interpretation, and satellite imagery data) to assess vegetation responses relative to oilsands exploration (OSE) reclamation requirements.
- Monitor wildlife use responses to vegetation conditions, disturbance effects, reclamation, and time.
- Monitor vegetation responses relative to natural variation, project effects, and reclamation for one growing season.

The monitoring program included a task to evaluate (with field data) the use of satellite imagery to measure seasonal vegetation trends across the lease (as they relate to the Project, reclamation, and natural processes in wetland ecosystems) as a complement to field monitoring. Scheduling setbacks experienced by the collaborators responsible for satellite data collection (University of Lethbridge and LOOKNorth) in the 2016-2017 PTAC program prevented the acquisition of remote-sensing data sources to support this study.

## 1.3 Report Organization

This summary report is organized as follows:

- Section 2 - Description of Study Area
- Section 3 - Executive Summary of Results
  - ✦ Section 3.1 - Linear Features
  - ✦ Section 3.2 - Wildlife Monitoring

- ✦ Section 3.3 - Wetland and Vegetation Monitoring
- Section 4 - Best Practices Recommendations
- Section 5 - Tangible Project Outcomes
- Section 6 - Next Steps

Technical reports supporting Section 3 are presented as Appendices as follows:

- Appendix A - *Technical Report #1, Natural Regeneration of 2D Seismic and Winter Roads in Caribou Range: Great Divide Expansion Trial Study*
- Appendix B - *Technical Report #2, Statistical Analysis of Camera Monitoring Data, Great Divide Expansion Project*
- Appendix C - *Technical Report #2, Wetland Vegetation Monitoring Program and Exploratory Statistical Analysis*

## 2 STUDY AREA

### 2.1 Project Description

The research program was conducted at Connacher Oil and Gas Ltd.'s Great Divide Expansion Project. Great Divide incorporates and expands upon two existing projects (Pod One and Algar) operated by Connacher located approximately 70 km southwest of Fort McMurray, Alberta (Map 1 and Map 2). The Pod One Project was approved in July 2006 and began commercial bitumen production in March 2008. The Algar Project was approved in November 2008 and began commercial bitumen production in October 2010. These two projects have a combined design capacity of 3,200 m<sup>3</sup>/day (20,000 barrels per day [bpd]) of bitumen production. Great Divide is designed to expand the capacity of these two projects. Great Divide will use steam-assisted gravity drainage (SAGD) technology and will be constructed to reach an ultimate design capacity of 7,000 m<sup>3</sup>/day (44,000 bpd) of bitumen production.

Great Divide was scheduled to be developed in three phases, with the anticipated timeline for full development:

- Phase 1: 3,800 m<sup>3</sup>/day (24,000 bpd), with construction and operations from 2012 to 2020
- Phase 2: 7,000 m<sup>3</sup>/day (44,000 bpd), with construction and operations from 2018 to 2027
- Phase 3: 7,000 m<sup>3</sup>/day (44,000 bpd), with construction and operations from 2026 to 2034

### 2.2 Lease Setting

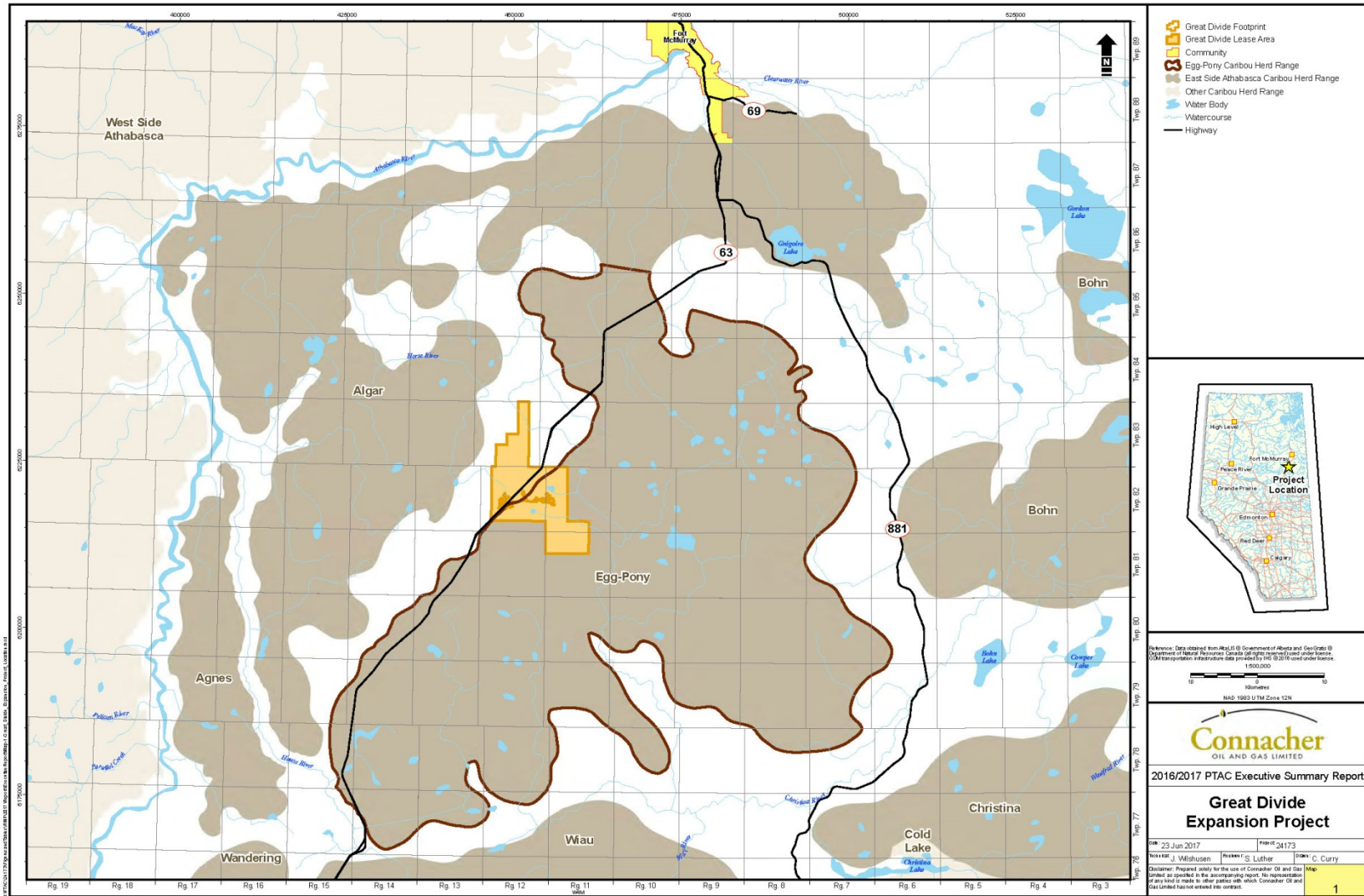
The Great Divide Project lease contains a mosaic of peatland and upland ecosystems typical of the boreal forest. Great Divide is located on the western edge of the Egg-Pony caribou herd range, which is one of seven caribou herds located in the East Side Athabasca River (ESAR) caribou range. Raised peat

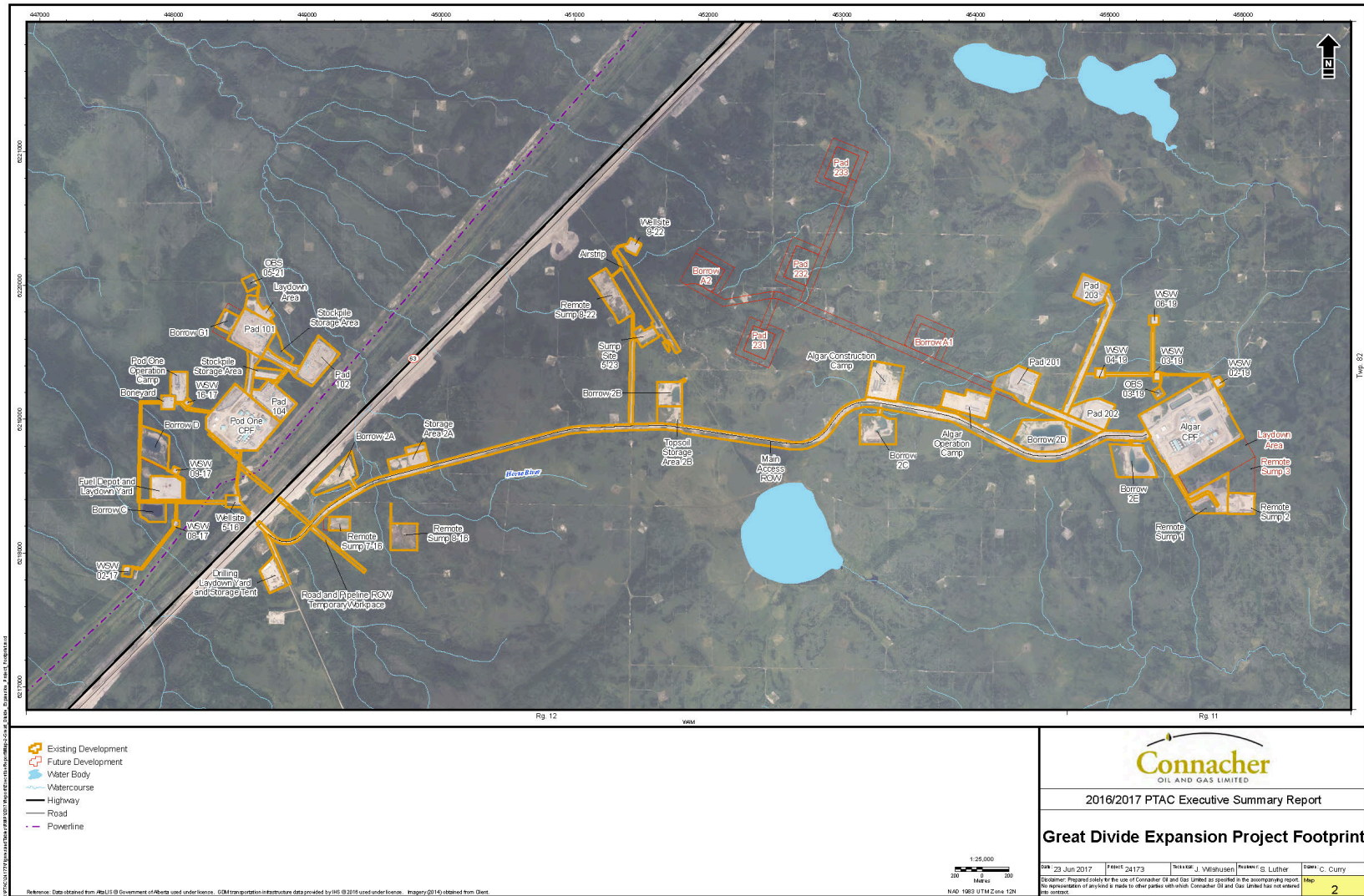
soils containing terrestrial lichen ground cover and black spruce tree cover are common habitat conditions within bogs across the ESAR caribou range; however, most of the lease area that overlaps caribou range was burned during the 1995 Mariana Lake Wildfire. As a result of the wildfire, most of the lease within caribou range is characterized by regenerating fen and bog ecosystems with small unburned remnants. Field observations suggest that unburned remnant conifer stands tend to support more abundant caribou forages than burned portions of the lease. Approximately one half of the Great Divide Lease that is located outside of caribou range contains a mosaic of upland and peat wetland ecosystems typical of the boreal plains.

### **2.3 Integrated Vegetation, Wetland and Wildlife Monitoring Program**

Connacher received *Environmental Protection and Enhancement Act* (EPEA) Approval No. 00240008-00-04, as amended (the Approval), to construct, operate, and reclaim the Great Divide from December 17, 2013, to September 30, 2018. Connacher has initiated an Integrated Vegetation, Wetland and Wildlife Monitoring Program that uses a holistic approach designed to support each of the following objectives:

- restoring 2D seismic and OSE winter roads in caribou range
- restoring OSE well pads
- linking wildlife use to restoration efforts
- monitoring potential impacts to wetlands from the Project footprint
- monitoring natural variation in wetlands
- developing conservation and reclamation (C&R) plans that integrate vegetation and wildlife





## 3 STUDY RESULTS

### 3.1 Evaluation of Vegetation Monitoring Approaches and Natural Regeneration of Vegetation on Linear Features

#### 3.1.1 Objective

Matrix and Connacher initiated a trial study measuring natural regeneration of vegetation on 2D seismic lines and OSE winter roads. The study satisfies the first project objective, which is to evaluate remote sensing approaches (helicopter visual, photograph interpretation, and satellite imagery data) to assess vegetation responses relative to OSE reclamation requirements. The results of the program are discussed in detail in *Technical Report #1, "Natural Regeneration of 2D Seismic and Winter Roads in Caribou Range: Great Divide Expansion Trial Study"* (Appendix A).

#### 3.1.2 Study Design

Sampling effort was plotted against linear feature age, habitat type, depth to water table, and forest canopy closure, to ensure representation of various conditions and ecosystems within the Project. Ecologists flew to each of 95 monitoring sites located within the Egg-Pony caribou herd range and collected vegetation data using a paired, matched design that compares conditions on OSE features to conditions in the adjacent forest. Statistical models were then used to link average vegetation cover (proportion) and average tree height (m) on linear features to ecological covariates derived from field data, photograph interpretation, and GIS layers.

#### 3.1.3 Key Findings

##### 3.1.3.1 Vegetation Responses on Disturbances

- Vegetation ground cover and shrubs are regenerating naturally in most ecological conditions on disturbances within the Egg-Pony caribou herd range, but trees require more time to recover to control conditions. Analyses reveal that vegetation ground cover and shrub cover would not benefit from management actions in most areas. Vegetation communities within the Egg-Pony caribou herd range tend to have low site index values (predicted heights for a specific tree species at 50 years; Beckingham and Archibald 1996) and slow rates of tree regeneration are expected.
- Vegetation ground cover, shrub cover, and tree height were negatively affected by ATV disturbance. Results show that persistence of ATV disturbances was related to accessibility and time since development. Managing access is therefore expected to improve natural regeneration rates.
- Some ecological conditions may require restoration actions to put them on a trajectory to control conditions. Any such efforts should likely focus on linear features located in well-drained soils with

low vegetation cover in control plots (i.e., >4 m to groundwater, <25% ground cover, <20% forest canopy; elevated pine stands) as these sites had the lowest recovery in terms of vegetation ground cover, shrub cover, and tree cover. Photograph interpretation may help identify particularly problematic sites that may require restoration actions.

### 3.1.3.2 Remote Sensing Techniques

- Normalized difference vegetation index (NDVI) and wet areas mapping (WAM) improved models' ability to estimate vegetation recovery on linear features. NDVI indexes vegetation productivity; therefore, reflects sites' potential vegetation growth rates; whereas WAM calculates depth to groundwater which is important for both productivity and plant community composition. These two layers were more valuable than more traditional forms of vegetation mapping (e.g., Alberta Vegetation Inventory and Alberta Wetlands Inventory data), likely because of the higher spatial and temporal resolution.
- Manual interpretation of aerial photographs did not improve models after considering GIS and field data within the models, suggesting that an ecologist can only reliably identify sites where ground cover is not recovering (i.e., without field data). Photograph interpretation may be useful for delineating 'problem areas' requiring restoration actions. However, because photograph interpretation does not provide information on how sites differ, it is less valuable at identifying operational mitigations or restoration treatment options.

Image quality may limit the ability to reliably interpret photographs. Coarse pixel resolution made it difficult to differentiate vegetation ground cover from low lying shrubs (e.g., both are green and have similar textures). Further, photograph interpretation of two dimensional images also limited the ability to determine vegetation height to relative values.

## 3.2 Wildlife Monitoring

### 3.2.1 Objective

Remote motion-activated cameras were used by Matrix and Connacher to determine how woodland caribou and other large-mammal species (including: bear, deer, moose, wolf, and lynx) are responding to the Project and associated activities, and are intended to support adaptive learning so that projects can optimize operations and reclamation to mitigate potential impacts on wildlife. The study satisfies the second project objective, which is to monitor wildlife use responses to vegetation conditions, disturbance effects, reclamation, and time. Detailed methods and results are outlined in detail in *Technical Report #2, "Great Divide Expansion Project Statistical Analysis of Camera Monitoring Data"* (Appendix B).

### 3.2.2 Study Design

Continuous camera data were collected on humans and wildlife at 61 monitoring sites located on linear features between October 2014 and November 2015. Rates of mammal use were estimated as counts of events over time using a zero-inflated Poisson process (Cook and Lawless 2007). Predictor variables included a combination of spatial and temporal covariates based on vegetation plot data and remote sensing data.

### 3.2.3 Key Findings

#### 3.2.3.1 *Seasonal (Temporal) Patterns.*

- The remote camera monitoring program indicated that all wildlife species exhibited strong seasonal patterns in their habitat use.
- Woodland caribou were detected more frequently (one animal every 3 days) during the fall rutting season (September to November) and may be leaving the area to access habitats that are more abundant with forage lichens during the late-winter and spring calving period between January and June.
- Caribou were detected at lower frequencies during late-winter and early-spring than in other seasons. The relationship between caribou and human use in time was insignificant, which suggests that woodland caribou may be dispersing away from the lease during the late-winter and spring calving period due to natural processes and not as result of human interactions.
- The greatest rates of habitat use by all other species (i.e., wolf, black bear, moose, and deer) occurred within spring and summer months outside of caribou range.

#### 3.2.3.2 *Spatial Patterns.*

- Camera monitoring results show there was limited overlap between caribou, predators, and alternate-prey habitat use in either space or time across the Project, and that habitat use by woodland caribou was negatively related to their predators (i.e., wolf and black bear) and alternate-prey species (i.e., moose and deer).
- Caribou were detected almost exclusively within the Egg-Pony caribou herd range whereas the greatest rates of habitat use by all other species occurred outside of caribou range.
- Within the Egg-Pony caribou herd range, caribou were detected with higher intensity in low-productivity bogs or open-canopied bogs and fens (compared to other ecosystems). However, the greatest average rates of caribou use were detected within preferred caribou habitats located in older-aged forests in the far southeast corner of the Project, which differed from the spatial patterns of habitat use by all of the other species evaluated.

## 3.3 Wetland and Vegetation Monitoring Program

### 3.3.1 Objective

Matrix and Connacher conducted a vegetation survey at Great Divide to monitor vegetation responses relative to natural variation, project effects, and reclamation, which satisfied the third and final objective of the PTAC research study. Detailed methods and results are outlined in *Technical Report #3, "Wetland Vegetation Monitoring Program and Exploratory Statistical Analysis"* (Appendix C).

### 3.3.2 Study Design

Matrix ecologists conducted a field survey in July 2016 across the Great Divide Lease at 500 sampling locations (347 undisturbed, 72 in OSE well pads, 81 along OSE 2D seismic or winter access roads). A rapid data collection method was used to optimize the sample size of vegetation plots. At each plot location, field crews collected ecological data that could be related to remote sensing methods or to vegetation community composition.

### 3.3.3 Exploratory Statistical Analysis

Vegetation plot data analysis was aimed at isolating development and reclamation effects from natural processes. Two types of statistical models were used to analyze the vegetation data:

- Classification Tree Models
- Beta Regression Models

Classification tree models (Breiman et al. in 1984) were estimated to test to what degree, and by what conditions human and natural disturbances could be distinguished from one another using the collected vegetation plot data. Human and natural disturbance vegetation data were sampled in boreal bog, fen, swamp and upland ecosystems; the natural disturbance plots in the dataset had a successional age between 21 and 85 years since a wildfire event, while the human disturbance plots had a successional age between 5 and 21 years since an OSE seismic line or well pad disturbance event. A series of three classification tree models were fit to evaluate covariates for sub-canopy trees and mulch cover, and the ground cover of vascular and nonvascular plants.

Zero-inflated beta regression models (Keim et al. 2017, Ospina and Ferrari 2010) were employed to assess whether there was any evidence for successional trends across ecosystems and natural and human disturbance regimes in the collected vegetation data. This statistical assessment was conducted for plant species and plant groups that distinguished human and natural disturbances using classification tree models. The plant species and plant groups considered in the analysis were:

- sub-canopy tree cover
- ground cover of Labrador tea

- ground cover of terrestrial lichens
- ground cover of mosses
- ground cover of blueberry
- ground cover of willow
- ground cover of cotton grass

### 3.3.4 Key Findings

#### 3.3.4.1 Classification Tree Models

- Predictions from all classification tree models discerned natural disturbances from human disturbances with greater than 92% accuracy. However, human disturbances were discerned from natural disturbances with lower accuracies (range: 61-88%). The most predictive model incorporated covariates for sub-canopy tree conditions and mulch ground cover.
- Understory tree cover (>5% closure), height (>1.5 m), and the presence of mulch, differentiated project disturbances from natural conditions with an accuracy of 88% to 93% (depending on reference condition). The analyses showed that relevant indicator tree species include black spruce, jack pine and paper birch.
- Plant cover in the vegetation understory could only distinguish human disturbances from natural disturbances at 61% of the human disturbance plots. This result suggests that the abundances of understory vegetation on human disturbances were often indistinguishable from that in naturally disturbed ecosystems within the sampling extent (39% of the disturbance plots). In addition, the analysis identified specific understory species that are useful as an early indicator of reclamation success or failure when monitored for their abundance. Relevant indicator species included:
  - ✦ Labrador tea and terrestrial lichens, which were less abundant on human disturbances.
  - ✦ Blueberry, willow and cotton grass species, which were more abundant on human disturbances.

#### 3.3.4.2 Beta Regression Models

- Natural and human disturbance effects were significant in the estimated models for all plant species and plant groups evaluated. However, time since disturbance effects were statistically significant in only five of the seven models evaluated: sub-canopy tree cover and the ground covers of Labrador tea, terrestrial lichens, mosses, and blueberry.
- Sub-canopy tree cover, Labrador tea and terrestrial lichens revealed successional stagnation (lower abundances in time) in response to human disturbances relative to natural disturbance ecosystems. However, all three species also revealed a trajectory toward increasing abundances between 0 and 21 years since a human disturbance event (OSE seismic line or well pad construction). Within the same ecosystem types, the mean abundances of sub-canopy trees, Labrador tea, and lichens was

between 5 and 20% lower 20-years following a human disturbance event as compared to a natural disturbance event.

## 4 BEST PRACTICE RECOMMENDATIONS

The outcomes of the research suggest multiple best practice recommendations that integrate aspects of monitoring design and techniques, statistical data analysis, disturbance techniques and access control, and reclamation.

### Monitoring Design

- Data collection should be focused on identifying ecological characteristics located within the lease, and obtaining enough vegetation plots to characterize the natural variability within the lease.
- An unbiased sample (i.e., group of sampling locations) should be obtained from a population of potential sampling sites across the lease. Sample plots in this study occurred on a combination of undeveloped sites, 2D seismic lines, winter access roads, OSE well pads that have passed inspection, OSE well pads where actions have already been implemented, and OSE well pads that likely require active management. Monitoring sites were selected within 2.5 km of a permanent access road on the Project lease using a randomized design.

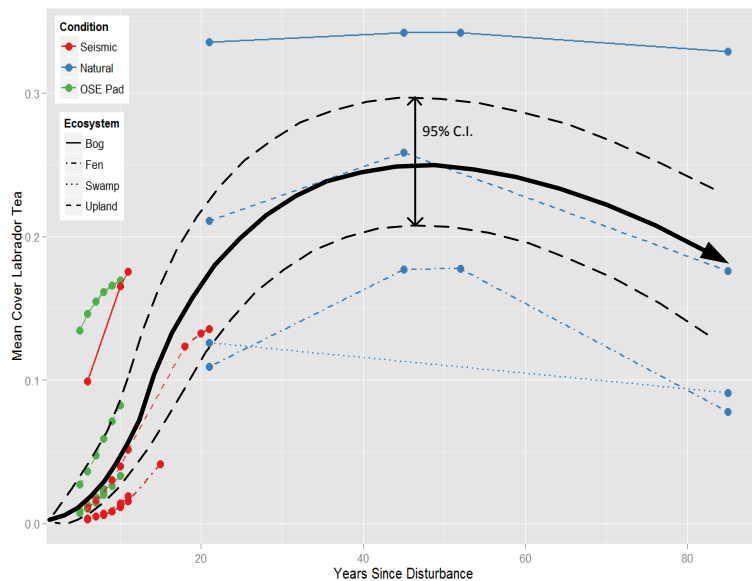
### Monitoring Techniques

- NDVI and WAM improved models estimating vegetation recovery on linear features. These two layers were more valuable than more traditional forms of vegetation mapping (e.g., Alberta Vegetation Inventory and Alberta Wetlands Inventory data), likely because of the higher spatial and temporal resolution. Practitioners should consider the use of these datasets in monitoring design.
- Manual interpretation of aerial photographs did not improve models (estimating vegetation recovery) after considering GIS and field data within the models, suggesting that an ecologist can only reliably identify sites with manual interpretation where ground cover is not recovering (without field data). Photograph interpretation may be useful for delineating ‘problem areas’ requiring restoration actions. However, because aerial photograph interpretation does not provide information on how sites differ, it is less valuable at identifying operational mitigations or restoration treatment options.
- Remote wildlife cameras, deployed and used as described in this study (Appendix B), are effective at describing spatial and temporal patterns of wildlife (large mammal) use across a project area, and should be considered in integrated monitoring designs.

## Statistical Analysis of Monitoring Data

- Beta regression analyses and associated results show that successional trajectories of specific indicator species against the covariate ‘time-since-disturbance’ can be used as models for determining which sites and site conditions require corrective action and active management. For example, regression analysis demonstrated that Labrador tea recovery on seismic and OSE disturbances (7 to 20 years old) lags that of older natural disturbances (burns; >20 years old) by 10 to 20% across various ecosystems (i.e., peat, fen, mineral upland, swamp). However, the successional trajectory (mean, over time) of Labrador tea on project disturbances is similar to natural disturbances (example in Figure 1).

**FIGURE 1 An Example of the Use of Successional Trends of Vegetation Indicators (i.e., Labrador Tea; Mean Cover) to Measure Restoration or Reclamation Success on a Former Disturbance at a Point in Time**



*The solid black line represents a hypothetical mean; the hashed black lines represent a hypothetical 95% confidence interval. Data points (ex. Mean Cover of Labrador Tea) outside of the 95% confidence interval at any given time after disturbance may indicate a potential reclamation issue. Successional trends are developed using zero-inflated beta regression, as presented in Keim et al. (2016).*

## Disturbance Techniques and Access Control

- Evidence in the wetland and vegetation monitoring research clearly suggests that disturbance practices should eliminate or minimize mulching, as human disturbances (OSE well sites, roads and lines) could be easily distinguished from natural disturbances by the presence of mulch.
- The effectiveness of access controls should be assessed. Results show that vegetation on linear features was negatively affected by ATV disturbance. Managing ATV access is therefore expected to reduce disturbance and thereby improve natural regeneration rates. Measuring human and wildlife

use rates within a project area using a remote camera monitoring program may help guide the placement and design of access mitigations.

## Reclamation

- Not all linear features within a project area have the same degree of wildlife use, rates of restoration, or restorative capacity. Environmental performance can be improved by economizing reclamation efforts where they are most needed, both in terms of location and issues (i.e., identifying what specific issues require effort) as opposed to engaging in active restoration of all disturbances.
- Problematic sites that may require immediate restoration actions should be identified selectively. Results show that restoration may be required in well-drained soils with low vegetation cover (primarily elevated pine stands); however, the benefits of actively restoring some sites may not outweigh the cost of impeding caribou habitat recovery. Mapping the location of these sites could help operators determine where restoration actions are justified and where accessing these sites with machinery may do more harm than good.
- Sub-canopy species at reduced abundances on OSE pads and lines in this project area relative to natural disturbances include: trees (black spruce), terrestrial lichen, and Labrador tea. These generally occurred in low productivity ecosystems such as open, upland conifer stands that have low moisture and nutrient regimes (i.e., A1/B1 ecosite phases) and peatland bogs. Reclamation techniques aimed at expediting the recovery of these ecosystems and vegetation may minimize the difference in restoration trajectories between naturally and human disturbed ecosystems on the landscape.
- Blueberry (particularly on linear features in upland ecosystems) and willow (particularly on well pads in fens and swamp ecosystems) showed positive responses to human disturbance. The increase in abundance could result in a change in forage behaviour and wildlife use in otherwise low productivity areas by bear and moose and should be monitored.

## 5 TANGIBLE OUTCOMES

Our research program tested a method of monitoring wetland vegetation, wildlife habitat use, and reclamation. The expected benefit of this study was to reduce the cost of terrestrial monitoring while increasing the defensibility of monitoring efforts. The research provided the following benefits to operators, practitioners, and regulatory policy and enforcement:

## Financial Value

- Integration is likely to reduce costs by combining multiple environmental monitoring programs (i.e., monitoring wetland vegetation, reclamation, and caribou habitat recovery) into one all-inclusive program. Assuming wetland and reclamation field-monitoring programs are integrated in design and execution, occur once every three-to-five years, and are backfilled by remote sensing techniques (i.e., NDVI), cost savings could be reduced by at least 30% assuming a 3-year program. It is not possible to determine an overall project-by-project cost reduction due to variability in project scopes, intensity and regulatory commitments and programs.
- Connacher's Integrated Vegetation, Wetland and Wildlife Program was developed to satisfy aspects of objectives from various regulatory and EPEA approval requirements, which include the following:
  - ✦ annual C&R reporting
  - ✦ caribou mitigation and monitoring program
  - ✦ wildlife mitigation and monitoring program
  - ✦ comprehensive wildlife reporting
  - ✦ wetland monitoring program
  - ✦ OSE reclamation
  - ✦ facility pre-disturbance assessments and C&R plans, including revegetation plans
  - ✦ Project Level Conservation and Reclamation Closure Plan (PLCRCP; in development)

It is not possible (at this time) to determine the total cost savings that will be realized to satisfy regulatory reporting and program development requirements by integrating monitoring design, data collection and analysis, and reporting, by way of integrated monitoring.

- Prioritizing reclamation efforts on a site- or project-specific basis, rather than advocating less discriminate reclamation of human disturbances across broader areas, will also result in cost savings that cannot be determined solely within the scope of this research.

## Environmental Net-Benefit

- An integrated program can increase restorative response on human disturbance by reducing the intensity of field-level activities (i.e., monitoring and reclamation) that impede vegetation recovery, as well as reducing active reclamation work on features that are demonstrating restoration trajectories similar to natural disturbances.
- Rationalize and improve environmental performance by accounting for natural variation that occurs in both space and time. Accounting for natural variation is needed to help operators identify whether changes to wetlands are being caused by development, natural variation, or both. Ultimately, this improves and increases the defensibility of operational decisions.

## Health & Safety Improvements

- Increase worker safety by reducing the amount of vegetation field work conducted on an annual basis.

## 6 NEXT STEPS

Based on the work conducted above, Matrix and Connacher believe they have demonstrated an approach to identify sites that are outside the expected natural variability of plant abundance and wildlife use, and can confidently monitor and measure restoration succession using an integrated monitoring program. The following steps are being undertaken to refine the monitoring program:

- Assess the effectiveness of existing access controls. Managing ATV access is expected to improve natural regeneration rates and reduce the rates of predator use on linear developments.
- Identify problematic sites that may require restoration actions and develop and execute appropriate restoration prescriptions. Results show that restoration may be required in well-drained soils with low vegetation cover; however, the benefits of actively restoring some sites within the lease may not outweigh the cost of impeding caribou habitat recovery at other sites. Mapping the location of these sites could help Connacher determine where restoration actions are justified and where accessing these sites with machinery may do more harm than good.
- Continued motion-activated camera monitoring to:
  - ✦ Confirm the temporal patterns of wildlife use across the lease, which is relevant to timing windows (e.g., caribou mitigation) and habitat restoration management on the lease.
  - ✦ Inform operations in methods of maintaining spatial separation between caribou and their predators.
  - ✦ Test wildlife mitigations (access and line blocking) and restorations.
- Deploy an additional 25 monitoring sites across the lease (cameras and ecosystem plots) in naturally disturbed conditions (e.g., wildlife trails). These supplemental monitoring stations are intended to provide additional data on natural ecological conditions in the study area and to ultimately assess the responses of vegetation and wildlife to natural conditions and managed (re-vegetated) seismic lines.

The monitoring program included a task to use satellite imagery to measure seasonal vegetation trends across the lease (as they relate to the Project, reclamation, and natural processes in wetland ecosystems) as a complement to field monitoring. If successful in approach, employing imagery to monitor vegetation responses in some (but not all) years, could reduce field effort and monitoring costs for operators. Scheduling setbacks by several collaborators (University of Lethbridge and LOOKNorth) in

the 2016 to 2017 PTAC Program prevented the acquisition of remote sensing data sources to support this analysis; however, Connacher and Matrix are continuing to collect field data in 2017 and have entered into a sharing agreement with the collaborators to continue this effort.

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