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Linear Feature Restoration in Caribou Habitat: A summary of current practices and a roadmap for future programs

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A final thank you goes out to those who participated in the Linear Restoration Workshop (August 27, 2014) that was associated with this report. A number of individuals with extensive experience in linear restoration participated and shared their ideas openly to help us capture what is working, what is not, and what is needed with respect to linear restoration programs.

Executive Summary

In the past several years, oil sands companies have initiated pilot projects to investigate the restoration of linear features. Efforts and intensity have varied between companies, with some initiating small restoration programs on lease and others initiating extensive programs off lease (e.g. up to 300 km of lines). Interest and investment in these pilot projects has only increased since the release of the Environment Canada Recovery Strategy for Woodland Caribou.

This project was initiated by COSIA in order to:

1. Share knowledge between COSIA members regarding their existing linear restoration pilot projects and plans;
2. Identify and transfer current best practices related to planning and execution that arise from pilot results;
3. Share results from monitoring programs and other indicators of success;
4. Develop recommendations for future linear restoration activities.

This summary report is the culmination of work that included: a) an in person workshop with key academics and practitioners with experience in linear restoration; b) summaries produced for a total of nine restoration projects; and c) interviews with leading individuals from academia, government and industry. The report highlights current activities by COSIA companies, summarizes current practices into a ‘restoration toolbox’, proposes a planning framework to serve as a roadmap for future linear restoration programs, and then concludes with a series of future restoration planning recommendations.

Current Activities of COSIA Companies

We reviewed a total of six projects that are currently being undertaken by COSIA companies (Algar, Cenovus LiDea I and LiDea II, CNRL Kirby North, Shell Grosmont, Suncor Firebag, Statoil line blocking experiment), and three projects from non-COSIA members (Dillon Wildlands Habitat Restoration Program, Little Smoky Pilot Program, MEG Energy Linear Restoration Project).

The programs reviewed generally had well defined objectives that included:

- Access management;
- Recovery of vegetation along linear features; and/or
- Impeding line of sight and/or movement efficiency of wolves.

The restoration programs occur throughout the Athabasca Oil Sands and Cold Lake Oil Sands areas and ranged in scale from very localized experimental treatments (e.g., Statoil line blocking experiment) to programs that had stated objectives to restore up to 350 km of linear features. While these existing programs have played a critical role in testing the feasibility of linear restoration, we observed a clear need for larger scale programs in order to maximize the potential landscape effects of restoration programs.

The planning stage of most programs consisted of a pre-treatment inventory of linear features to help understand the current status and condition along lines to be restored. A range of treatments are being

used to encourage habitat restoration with mounding, planting seedlings and use of woody materials being the most common.

Most monitoring programs included field verifications to ensure treatments were delivered as planned and to a high standard. Longer-term monitoring by companies was mostly focused on vegetation response to treatments. We identified a need to focus more monitoring on the wildlife response to treatments to determine whether core objectives like reducing wolf use of linear features have been achieved. Similarly, wildlife monitoring can help to understand if the treatments are having a positive impact on caribou populations or other values of interest to the programs.

The costs of the programs were highly variable, averaging ~$12,500/km of treated line (range $8,000/km to $17,000/km). These costs typically included: project design and delivery, operational treatments, remote camp facilities etc. The costs did not include monitoring of the treatments. Through our interviews, most individuals believe that the cost of programs can be reduced by focusing on operational programs at larger scales and through collaborations to improve efficiencies.

The Restoration Toolbox

Past and current restoration projects have helped to establish a volume of 'current practices' for linear restoration programs. We compiled these into a 'restoration toolbox' that grouped these practices based on whether they were related to planning, treatments, or monitoring. We further divided these based on which are perceived to be working, which are not working, and which future practices are needed or are being tested.

Planning						
What is working?	Pre-treatment landscape inventory	Integrated Land Management (ILM)	Stakeholder outreach	Relationship building	Modeling outcomes	Operational contingencies
What is not working?	Timing of programs	Lack of coordination between companies				
What is needed?	Testing new equipment and techniques for summer operations	Coordinated adaptive management trials				

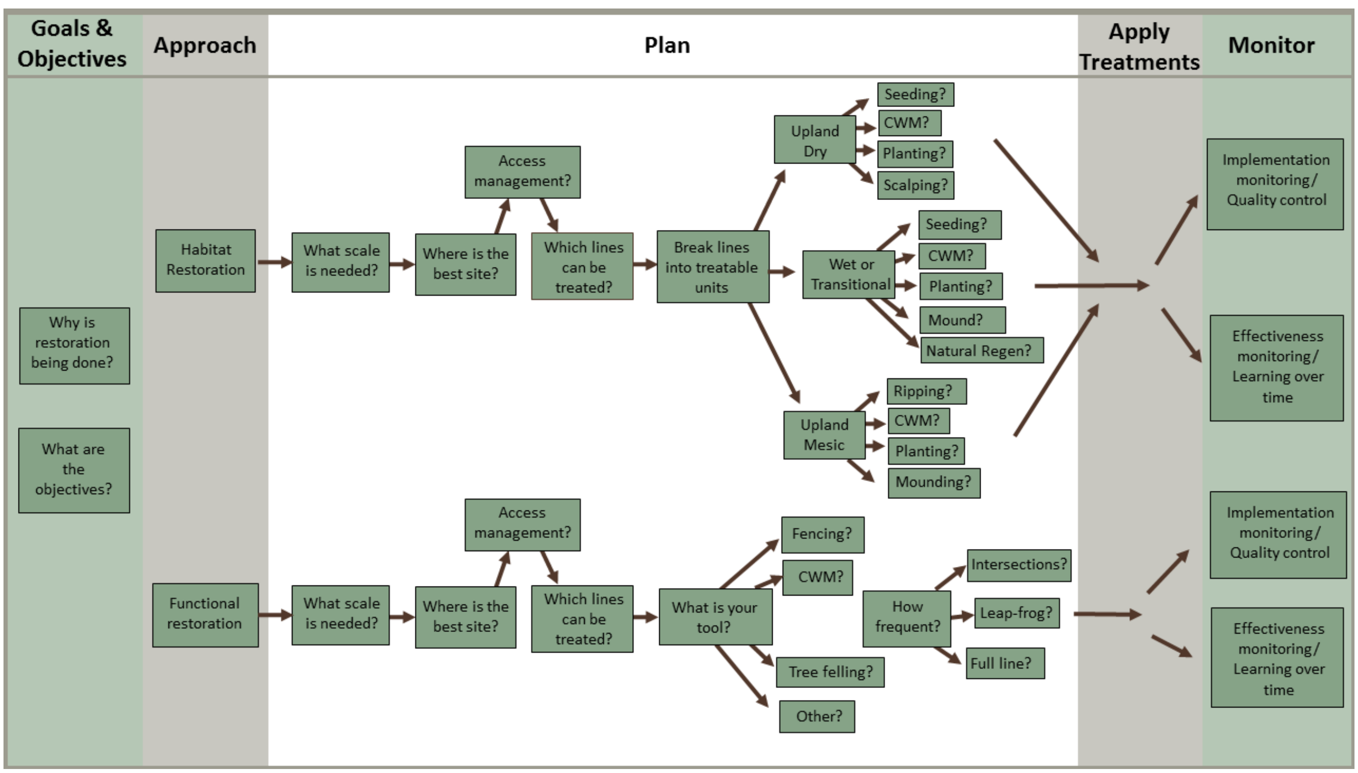
Treatments						
What is working?	Mounding	Ripping	Roll back and coarse woody material	Tree felling	Summer planting	Winter planting
What is not working?	Tree hinging	Tree transplants				
What is being tested?	Tree bending	Line blocking	Fencing	Bar mounding	Angle slicing	

Monitoring								
What is working?	Reporting on tasks and activities completed	Tree survival assessments	Vegetation response plots	Photo boards	Remote cameras	Wildlife tracking	GPS Collars	Fecal pellet counts
What is needed?	Standardized reporting protocol and tracking mechanism	Standardized monitoring protocols	Restoration tracking mechanism	Collaborative adaptive management trials	Increased use of technology for monitoring recovery			

A Planning Framework for COSIA

A key goal of this project was to identify approaches that could lead to improved effectiveness and efficiency of future linear restoration programs. We propose a planning framework that is designed to be flexible to foster innovation, yet structured enough to provide a roadmap for developing effective linear restoration programs. We believe this proposed planning framework, when combined with the expertise of experienced consultants and contractors, should help reduce uncertainties associated with linear restoration and assist in the delivery of effective restoration programs by COSIA companies.

The planning framework consists of five core steps: 1. Identify goals and objectives; 2. Select restoration approach; 3. Plan treatments; 4. Apply treatments; and 5. Monitor.



Future Restoration Planning Recommendations

The final component of the project was to identify a series of future restoration planning recommendations for COSIA. The following were identified for consideration.

Using the planning framework as a foundation for future programs

One of the core objectives for COSIA at the outset of this project was to have a series of recommendations for executing projects, including planning, delivery of treatments and monitoring. The planning framework proposed in this document helps achieve this by providing a roadmap for effective and efficient restoration programs.

Separate innovation from operational deployment to reduce delays and risk

Innovation is critical to advancing linear restoration and there is significant opportunity to explore new and more efficient practices. However, testing new approaches should not undermine the fact that a suite of relatively proven tools already exist, and there is a need to restore significant areas of habitat over relatively short periods of time to have a positive influence on caribou populations. By having a more structured approach to testing new innovations, COSIA can ensure that experimental trials do not limit or slow the pace of restoration programs.

Acknowledge the risks of a sole focus on functional restoration

Functional restoration (i.e., restoration with a primary focus on reducing wolf movement efficiency through use of fences, woody materials etc.) was a topic addressed throughout this project. While functional restoration does have the support of some biologists – who emphasize the need to perform efficient functional restoration over large scales – companies should acknowledge that these techniques are unproven to date and come with high risks. Beyond the risks of the treatments themselves, it is not clear whether the provincial or federal governments would consider such treatments as contributing to restored habitat under the federal recovery strategy for woodland caribou. Should companies undertake functional restoration treatments, they should be conducted in a robust, scientifically credible way and performed at a very large scale such that a measurable effect would be most likely.

Prioritize restoration zones and increase scale

For restoration programs to have a measurable effect on values such as woodland caribou, the scale of restoration programs will need to increase significantly. Developing priority restoration zones provides an opportunity to increase the likelihood of benefit to woodland caribou, and improve coordination between current linear restoration programs. There are also a number of current projects that are modeling priority areas for restoration, and these could be quickly implemented by COSIA. One should also not underestimate the potential effect of such a prioritization exercise on social license. The potential to positively influence large tracts of habitat in a collaborative way could be a significant contribution from COSIA companies.

Improve monitoring effectiveness

Despite linear restoration work occurring for a number of years, there are still significant knowledge gaps caused by an overall lack of effective vegetation and wildlife response monitoring. Most programs have either been poorly designed, or have lacked a commitment to follow-through with long-term monitoring. By developing a consistent, repeatable approach to monitoring that is scientifically credible, COSIA could contribute significantly to advancing the current state of knowledge about linear restoration.

Focus on quality of treatment delivery – it is a key limiting factor

A focus on strategic planning and monitoring is critical for restoration programs, but ultimately a program cannot be successful unless site specific treatments have been delivered by experienced, knowledgeable crews. As a result, delivery of quality treatments should be considered the first rung on the ladder of a successful restoration program. It should be no surprise that restoration is based in ecological principles. Thus a key way to overcome some of the challenges faced is to ensure operators and field staff have an ecological understanding of why treatments are being delivered, and what the treatments are intended to achieve. Hiring experienced contractors and ensuring effective training of these contractors by restoration experts is another key way to achieve improved outcomes through treatments.

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1. Introduction

Why are we talking about linear restoration?

Linear restoration has long been highlighted as an important 'tool in the toolbox' for caribou conservation. The Caribou Range Restoration Program (CRRP) initiated field trials 15 years ago to test the feasibility and effectiveness of linear restoration and more recently the Athabasca Landscape Team (2009) suggested that restoration was a key component for recovery of caribou. Yet, it is not until recently that linear restoration has become a topic of widespread discussion and, more importantly, action. The introduction of the woodland caribou recovery strategy (Environment Canada, 2012), which emphasized the importance of restoration, has certainly contributed to this action. However, even before this announcement, a number of leading companies were committing significant financial resources to linear restoration programs.

An ecological foundation

While studies that have evaluated linear restoration effectiveness have been somewhat rare (but see Neufeld, 2006; Vinge and Lieffers, 2013), the basis for the potential utility of linear restoration is clear. There has been a dramatic shift in spatial separation between wolves and caribou as a result of increased industrial activity and disturbance on the landscape (James et al., 2004; Latham et al., 2011b). Conventional seismic lines are believed to be a main driver of this as they facilitate more efficient travel by wolves, and provide corridors that connect upland and lowland habitats – reducing the spatial separation of wolves and caribou (Latham et al., 2011a). This change in use of the landscape, and predator efficiency, is often described as a change in *functional response*.

Similarly, disturbances within and near caribou habitat, such as industrial land use and fire, increase the amount of early successional forests, which provides additional browse for primary prey – principally moose and deer (Athabasca Landscape Team, 2009). With additional food availability, populations of primary prey can increase – leading to an increase in wolf populations on the landscape. An increased wolf population increases the likelihood that wolves will encounter, and kill, caribou (Latham et al., 2013). This shift in the number of primary prey and wolves is often referred to as a *numerical response.* While the relative contributions of functional versus numerical response to current caribou conservation concerns are often debated, there is a growing appreciation that comprehensive linear restoration strategies require addressing both functional and numerical responses.

Applying the principles

With this as context, many COSIA companies have recognized the fundamental role of legacy footprint on the health of caribou populations, and the overall ecosystem (i.e., other biodiversity values). Efforts and intensity have varied between companies, with some companies completing small restoration programs on lease, and others completing extensive programs off lease (e.g. up to 300km of lines). Interest, and investment, in on-the-ground programs to deliver linear restoration is only increasing and is quickly becoming a common topic of discussion and implementation amongst COSIA companies.

This report was commissioned to bring together the diverse information related to linear restoration, with a primary focus on collating what is working, what is not and why, based on the collective experience of COSIA companies and other key stakeholders. While this report is not intended to be an in depth scientific review, it does draw on scientific literature regularly. The main objective of the report is to provide a roadmap for on-the-ground action with respect to linear restoration. In addition, while we focus on linear features within this report, the approaches and techniques may also apply to well sites and other features encountered during restoration programs.

Background

What is restoration?

There is considerable discussion and debate currently about an appropriate definition of restoration, particularly in reference to caribou conservation (e.g., Golder Associates, 2014a). While we recognize this debate is critical, and support efforts to resolve this definition, the goal of this report was to summarize near term activities that can be implemented on the ground by COSIA companies. In the context of this report, restoration is considered to be actions taken that result (either in combination or in isolation) in a measurable influence on:

- Human access along, and use of, linear features;
- Rate of recovery of non-browse vegetation along linear features;
- Predator access and use of linear features.

We believe these actions are consistent with ongoing dialogue around a definition of restoration, and also provide a clear focus for restoration programs.

Clarifying approaches: structural and functional restoration

There are two dominant approaches to restoration of linear features (i.e., seismic lines, pipelines, trails and roads) in forested landscapes that are generally highlighted. These approaches include structural and functional restoration.

The main focus for structural restoration is to promote and/or facilitate the natural succession and growth of woody vegetation on linear features. To be effective, treatments must address the underlying causes for the delayed or 'arrested' plant succession. These treatments generally consist of some form of site preparation, planting of seedlings and/or application of woody materials to create microsites and limit human access. In contrast, functional restoration has a primary objective of reducing predator (i.e., wolf) movement efficiency as a means of reducing predation rates on caribou. Restricting human access is also an objective of functional restoration as human access has been shown to increase wolf use of lines, particularly in winter months (Keim et al., 2014). Functional restoration treatments generally include felling trees along lines or application of high volumes of woody materials at intersections between linear features.

While we profile each of these restoration approaches in this document, it is important for readers to understand that functional restoration to reduce wolf movements, and human use of features, is generally characterized by high uncertainty and there is little existing science to predict relative effectiveness (e.g., Neufeld, 2006). We offer further perspective to this discussion in the 'Future Restoration Planning Recommendations' section of this report.

How do we define restoration approaches in this report?

Distinguishing between structural and functional restoration objectives is important for designing restoration programs and selecting appropriate treatments, however, the distinction does not mean that a restoration program can only achieve one objective or the other. For example, structural restoration treatments that focus on vegetative recovery often apply woody materials to create microsites for seedlings. If this woody material is applied at high enough volumes it can also function as a barrier to wolf movement and human access along linear features.

For the purposes of this report, we discuss restoration programs and treatments in the context of purely functional approaches (i.e., functional restoration), versus a combined structural/functional approach (i.e., habitat restoration). This is based on our review of existing programs and the fact that very few programs have a purely structural objective, and are often targeting both structural and functional objectives. In this context, we consider that a 'habitat restoration approach' is aligned with a strategy that strives to achieve both structural and functional objectives (Figure 1).

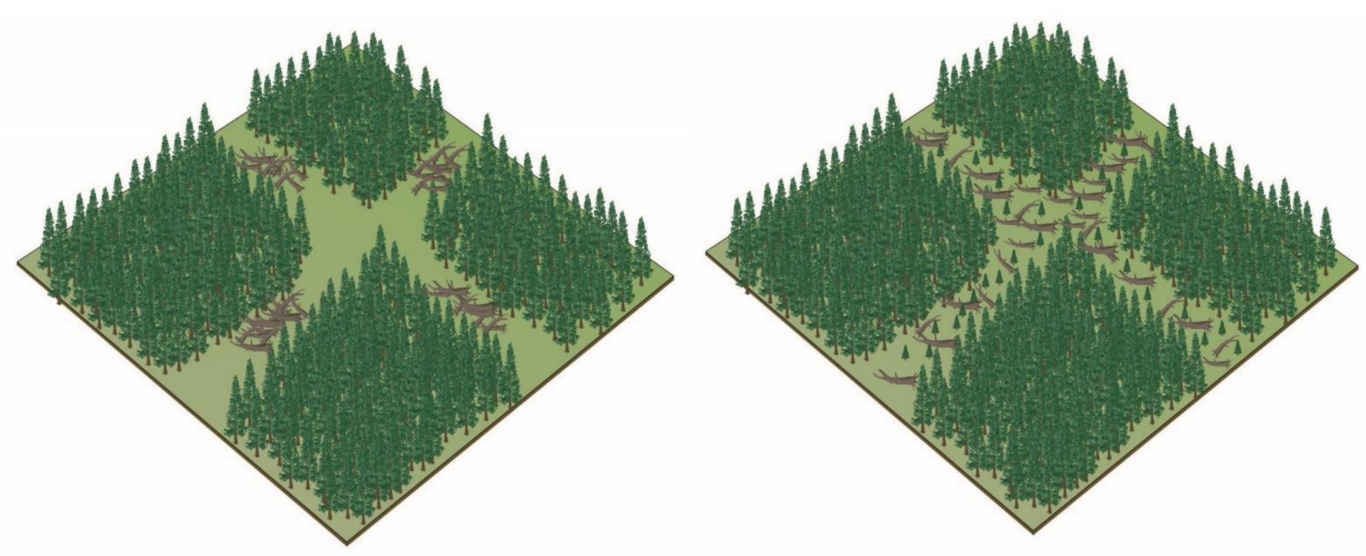


Figure 1. Examples of two different restoration approaches as defined in this report. Functional restoration (left) focuses primarily on reducing wolf movement efficiency and human use of lines. Habitat restoration (right) has a combined focus on vegetative recovery and reducing trafficability of lines.

What factors are limiting recovery of linear features?

Field studies have helped highlight a number of key site limiting factors that influence vegetation recovery along linear features. Here we provide a summary of these factors as background to the rest of the report. Although this list is not exhaustive, it does highlight some of the key limiting factors for recovery of linear features, and helps readers understand 'why' certain sites may show limited recovery, and 'how' restoration treatments can address these underlying processes.

Human access

- Access by ATV and other vehicles can cause direct damage to vegetation and reduce recovery of vegetation on a linear feature.
- Packed snow along linear features can increase use by wolves (Keim et al., 2014).
- Upland mesic sites have been shown to have good natural regeneration in sites with limited access (Lee and Boutin, 2006; Van Rensen, 2014).
- Applying treatments that reduce trafficability of lines can help protect natural regeneration and create microsites to assist with recovery.

Too much or too little moisture

- Van Rensen (2014) found that sites showing the least potential to naturally regenerate are generally either too wet (i.e., bogs, fens) or too dry (i.e., upland pine forests).
- Characteristics of these sites means that formal restoration treatments are necessary to restore vegetation along these features and correct these limiting factors.

Microsites

- Microsites are essential for facilitating recovery along linear features.
- Sites with heavy vegetation cover (grass, lichen, moss) can limit sites for seed germination (i.e., contact with mineral soil) and sites with little to no ground cover can experience temperature and moisture extremes which limit growth and recovery along features.
- Treatments which create microsites can protect seeds and established plants and help moderate exposure to extreme conditions (Vinge and Pyper, 2012).

Compaction

- Traditional seismic construction methods resulted in little to no mineral soil being left on sites and, depending on season when the lines were built, could have led to significant compaction issues on sites.
- Treatments can be applied to reduce soil bulk density and increase moisture availability and aeration in soils.

Scope of this Report

Restoration of linear features in caribou habitat is complex and involves a number of activities – ranging from the establishment of high level corporate and ecological goals, down to on-the-ground treatments of linear features. This breadth of activities can best be explained by way of a spectrum that includes strategic, tactical and operational tasks (Figure 2).

While we recognize that strategic, tactical and operational tasks are all critical for successful delivery of an effective linear restoration program, and the eventual improvement of functional caribou habitat, the COSIA project team requested the focus of this report to be on tactical components of this spectrum. While we do touch on essential strategic and operational components throughout this report, particularly in the 'Planning Framework for COSIA' section, we believe this focus on tactical implementation is essential for delivering high quality programs and treatments. This summary of tactical components of linear restoration programs complements ongoing discussions focused on strategic landscape level restoration (Golder Associates, 2014b).

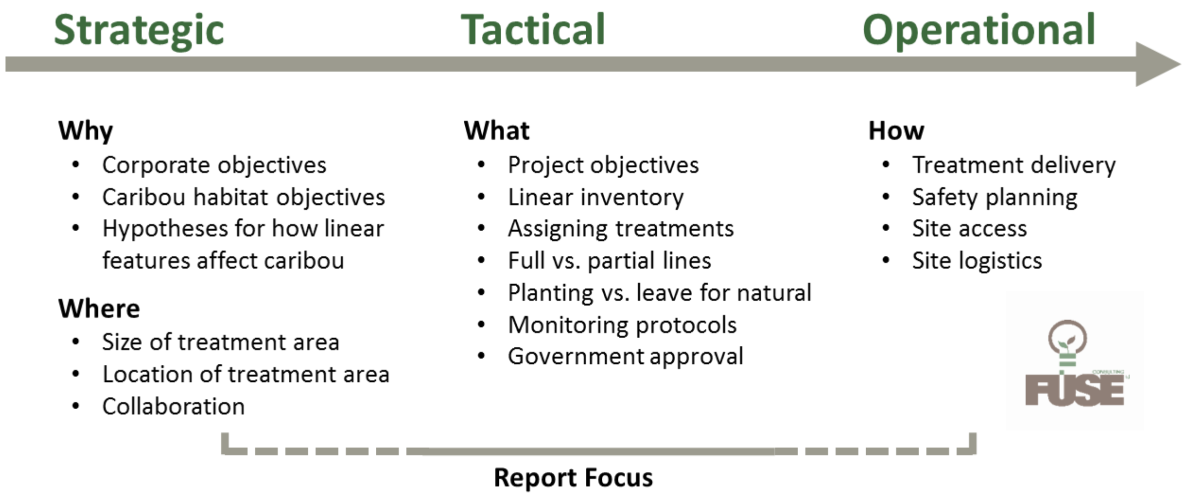


Figure 2. Spectrum of activities included in a linear restoration program.

2. What are Companies Currently Doing?

A number of COSIA companies have recently implemented restoration projects in order to test the operational feasibility of restoration programs and to learn which techniques are working and which are not. We reviewed a total of six projects that are currently being undertaken by COSIA companies (Algar, Cenovus LiDea I and LiDea II, CNRL Kirby North, Shell Grosmont, Suncor Firebag, Statoil line blocking experiment), and three projects from non-COSIA members (Dillon Wildlands Habitat Restoration Program, Little Smoky Pilot Program, MEG Energy Linear Restoration Project).

Detailed summaries for each of these projects can be found in Appendix A. However, we provide a high level summary here to facilitate knowledge sharing between COISA companies and to help inform future restoration programs undertaken by COSIA members. We start by looking at the location and scale of the programs, and then take a closer look at the approaches to planning, treatments and monitoring. We conclude with a summary of the costs programs have encountered.

Where are the programs located?

The restoration programs we reviewed occur throughout the Athabasca Oil Sands and Cold Lake Oil Sands areas (Figure 3), and there is little coordination between programs at this time (but see Appendix A - Regional Industry Caribou Collaboration). Approximately 60% of the COSIA restoration programs we reviewed occur on-lease, with the others located in high-value caribou habitat off-lease of the sponsoring companies.

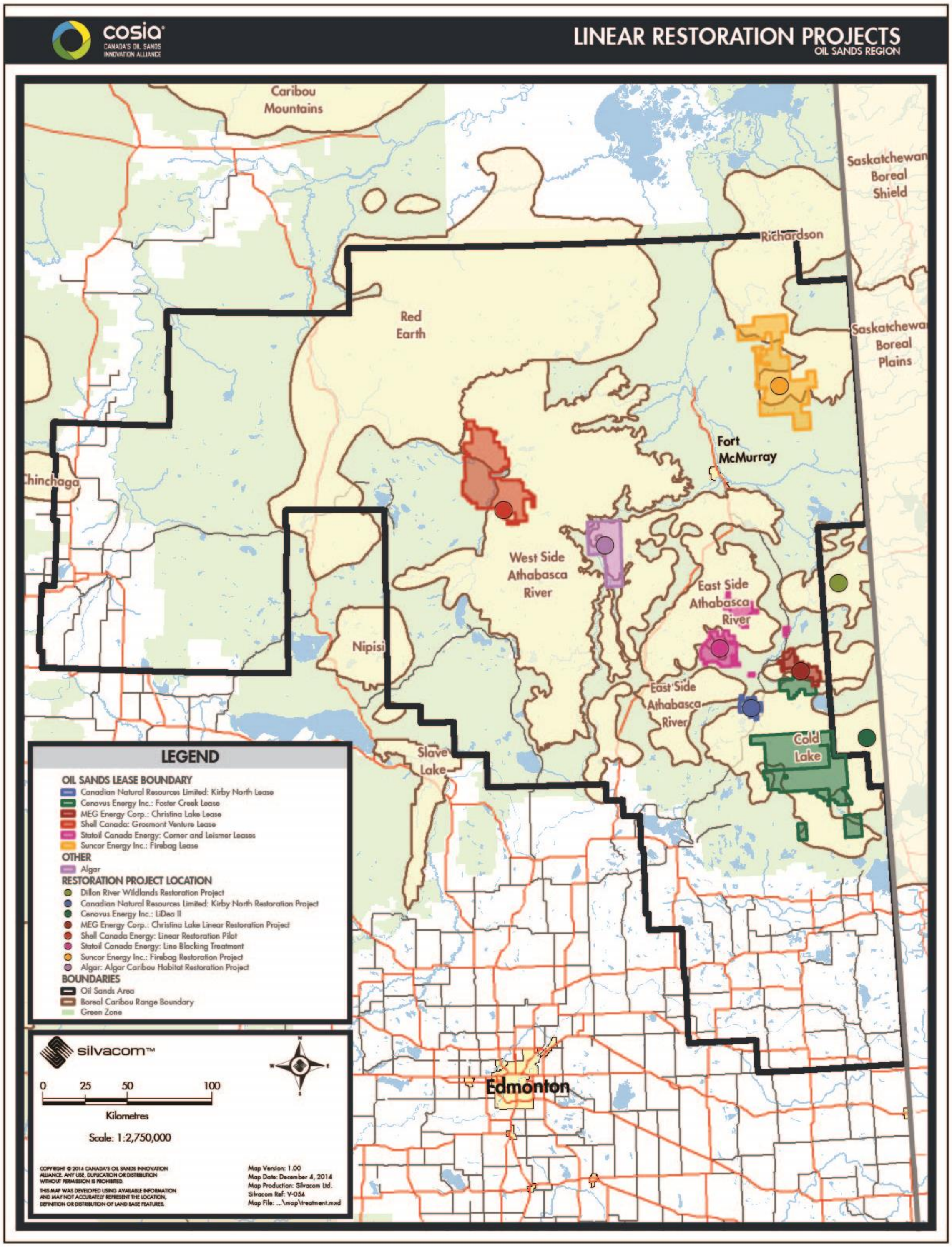


Figure 3. Map highlighting the locations of linear restoration programs summarized in this report.

What scale are programs operating at?

The scale of current restoration programs ranged from very localized experimental treatments (e.g., Statoil line blocking experiment) to programs that had stated objectives to restore up to 350km of linear features (Figure 4).

While some programs have moved from an experimental scale to more of a proof of concept scale (see Box 1), there is a clear need for larger scale programs in order to maximize the potential landscape effects of restoration programs. Programs on the scale of thousands of square kilometres are likely needed to achieve caribou conservation objectives (Athabasca Landscape Team, 2009). While this scale may seem daunting, we discuss a number of mechanisms that could be used to achieve this in the 'Future Restoration Planning Recommendations' section of the report, with a primary focus on identifying priority restoration zones and developing collaborative programs.

Box 1: Clarifying terminology

For the purposes of this document we categorize programs at three different scales:

Experimental – a program to test treatments at a small scale (i.e., < 5-10km of linear features). These program have a heavy focus on new trials, research and monitoring.

Proof of concept – a program that takes learnings from experimental trials and implements them at a larger scale (i.e, several hundred square kilometres). Focus on monitoring and optimizing efficiency of treatments.

Operational – a large scale restoration program (i.e., several thousand square kilometres) focused on maximizing efficiency and kilometres of line restored. Monitoring focused on long term recovery and range scale movements of collared caribou and wolves.

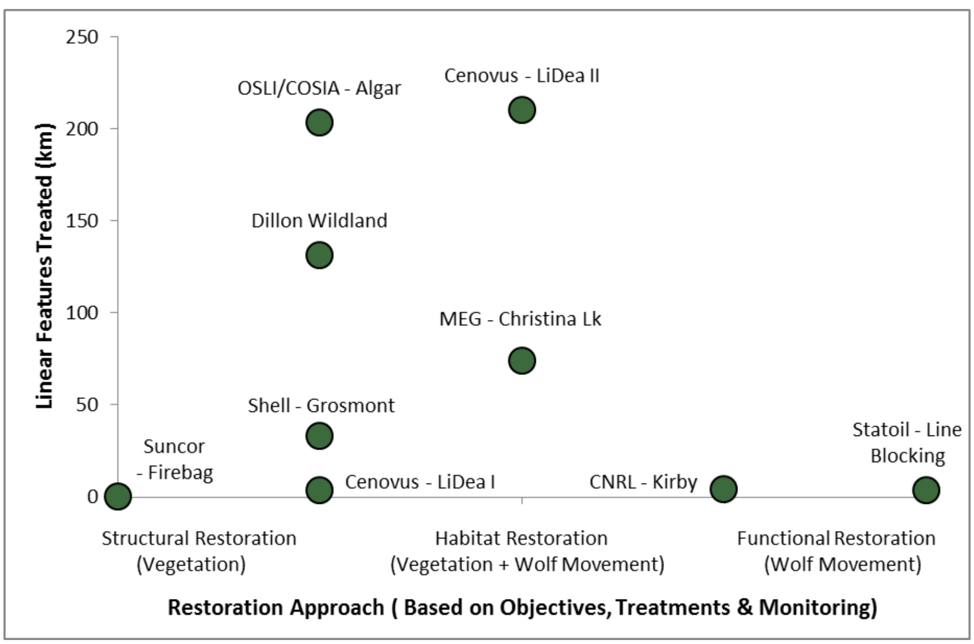


Figure 4. Restoration program sizes and approaches used in nine current and historical linear restoration programs. Restoration approach was assigned categorically based on objectives, treatments and monitoring approaches of programs.

What are the objectives of programs?

The programs reviewed generally had well defined objectives and were clear on the intended outcomes of the restoration programs. Most programs specified objectives that included:

- Access management
- Recovery of vegetation along lines
- Applying woody materials to create structure that would impeded line of sight and/or movement efficiency of wolves.

While there were a range of approaches used in the programs, the majority of programs were focused on habitat restoration (i.e., a combined functional and structural focus) (Figure 4).

What are companies doing in the planning stages of their programs?

The planning stage of most programs consisted of a pre-treatment inventory of linear features to help understand the current status and condition along lines to be restored. This included use of techniques such as LiDAR, aerial photo interpretation, remote sensing, ground truthing and aerial fly overs. Treatments were then assigned to various line segments based on ecosite and other stand characteristics (Figure 5). These pre-treatment inventories were cited by many programs as essential for ensuring efficient, effective restoration. Stakeholder engagement was also an essential step to determine which lines in a planning area were available for treatment. Some companies have also been using the Landscape Ecological Assessment and Planning (LEAP) Framework to model predicted outcomes of restoration activities on a range of values over time (e.g., carbon, landscape intactness etc.).

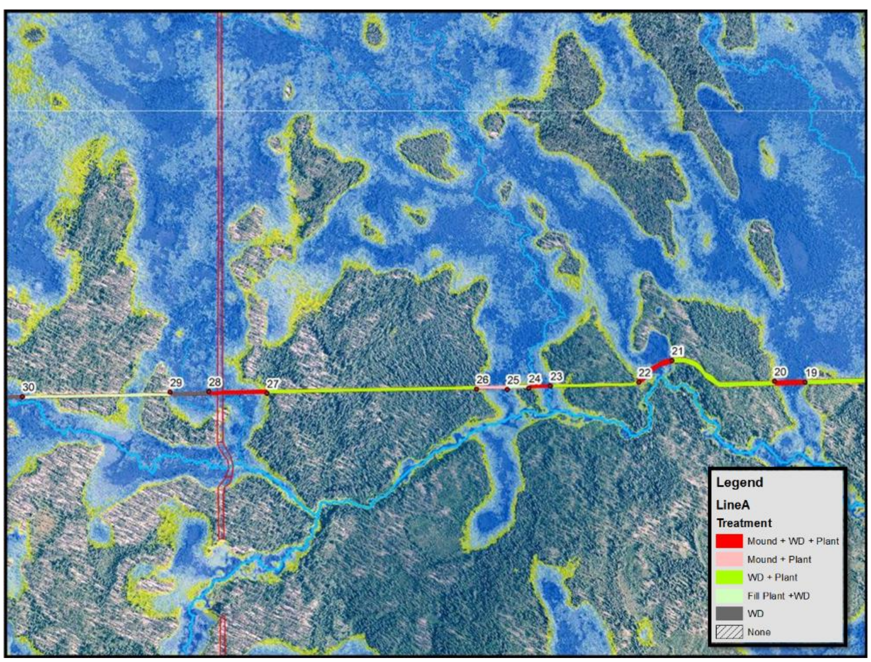


Figure 5. An example showing pre-treatment inventories used to assign restoration treatments on the LiDea II project. Credit: Woodlands North.

Table 1. Summary of planning steps used in linear restoration programs reviewed.

Project	Pre-treatment Inventory	Stakeholder Outreach	Modelling Outcomes
Cenovus Lidea II			
Algar			
MEG Energy			
Shell Grosmont			
Statoil			
Al-Pac Dillon			
Suncor Firebag			
CNRL Kirby North			
Little Smoky Pilot			

What treatments are being applied?

There are a wide range of treatments being applied in restoration programs. A number of these treatments could be considered 'best current practices' and others are in the experimental stage. The detailed treatments are summarized in the 'Restoration Toolbox' section of this report, however, we provide a high level summary for comparison purposes here.

Figure 6. A line blocking treatment using high volumes of woody materials. Credit: Statoil Canada.

In general, only a few companies are testing functional restoration treatments. Treatments currently in use or being proposed for functional restoration include use of heavy volumes of woody materials to 'block' seismic lines (i.e., line blocking) (Figure 6), and fencing installations with the goal of reducing line of sight along lines.

A range of treatments are being used to encourage habitat restoration. Mounding, planting seedlings and use of woody materials are the most common treatments amongst programs (Figure 7). Approximately half of the programs are using summer planting and the other half are using winter planting. Key benefits cited for summer planting included the ability to plant a broader range of species and to only have to access a site once for planting, while winter planting was cited as an efficient way to plant difficult wetland sites as access is frozen in and trees are planted alongside site preparation treatments.

Figure 7. Restoration treatments including (from left to right): bar mounding (Shell Grosmont); mounding (LiDea II) and stem bending (LiDea II).

Table 2. Summary of treatments used in linear restoration programs reviewed.

	Habitat Focus						Functional Focus	
Project	Mounding	Other Site Prep	Summer Planting	Winter Planting	Woody Materials	Other	Fences	Line Blocking
Cenovus Lidea II	■	■	■		■			
Algar	■			■	■			
MEG Energy	■	■			■			
Shell Grosmont	■	■		■	■			
Statoil								■
Al-Pac Dillon			■		■			
Suncor Firebag			■			■		
CNRL Kirby North	■				■	■	■	
Little Smoky Pilot	■	■	■	■	■		■	

What monitoring is occurring?

We separated our review of monitoring techniques into either implementation monitoring (i.e., did you do what you said you would do) or effectiveness monitoring (i.e., did it achieve what you thought it would achieve) (Bunnell and Dunsworth, 2009).

Within the projects we reviewed, implementation monitoring was focused on having field crews and consultants verify that woody material volumes, mounding densities and planting densities had been achieved. This is a very important phase of the monitoring in that if seedlings are handled or planted improperly, or if site preparation treatments are not completed properly, they may have significant impacts on the outcomes of the restoration treatments (Vinge and Lieffers, 2013).

The focus of effectiveness monitoring was variable but most programs focused on monitoring of vegetation response to treatments (Table 3). As programs begin to scale up, there will be a need to focus more monitoring on the wildlife response to treatments to determine whether core objectives like reducing wolf use of linear features have been achieved. In addition, wildlife monitoring can help to understand if the treatments are having a positive impact on caribou populations or other values of interest to the programs.

Table 3. Summary of effectiveness monitoring approaches used in linear restoration programs reviewed.

	Habitat		Wildlife			
Project	Line of Sight	Veg Plots	Winter Tracking	Cameras	Radio Collars	Other
Cenovus Lidea II						
Algar						
MEG Energy						
Shell Grosmont						
Statoil						
Al-Pac Dillon						
Suncor Firebag						
CNRL Kirby North						
Little Smoky Pilot						

What do the programs cost?

The costs of the programs were highly variable, averaging ~$12,500/km of treated line (range $8,000/km to $17,000/km). While this cost range is useful, it is important to note that each program uses different assumptions for calculating costs. For example, the high end of the costs listed here (i.e., $17,000/km) is based on inclusion of segments of lines that were left for natural (i.e., not technically treated). If only the sites treated are included (i.e., leave for natural segments are not included) this cost increases to $26,000/km. Developing a standardized way of reporting on program costs would help clarify variances in costs between programs. For the programs we reviewed, cost estimates typically included: project design and delivery, operational treatments, remote camp facilities etc. The costs did not include monitoring of the treatments or modelling work completed prior to treatments.

Program costs are influenced by a number of variables including: how remote the treatment site is, the need for remote camp or safety precautions and the amount of frost in the ground at the time of treatment. However, costs can be greatly reduced through advanced planning to ensure efficient program delivery. Accessing sites earlier in the season was also highlighted as a way of extending the operating season and improving cost efficiencies.

3. The Restoration Toolbox

Thanks to past restoration projects, a volume of 'current practices' are amassing for linear restoration programs. These current practices serve as an excellent foundation to help guide new COSIA restoration programs. Here, we have compiled these current practices into a 'Restoration Toolbox'. This toolbox is based on our review of current and historical restoration programs (e.g., Golder Associates, 2012; Nova Gas Transmission Ltd; Pyper and Vinge, 2012), and our synthesis of participant feedback from a workshop that was held on August 27, 2014 in conjunction with this project (Nishi et al., 2014). For more information on some of the current and historical programs we summarized please see Appendix A. For a copy of the summary report from the workshop, please contact Jeremy Reid (Jeremy.Reid@dvn.com).

Structure of the Restoration Toolbox

For any restoration program to be successful, companies must work through three core components: planning, applying treatments and monitoring. The following restoration toolbox is therefore broken out into these three components and helps identify what practices are currently working well (i.e., current practices); which practices have been tried but are not working, and which practices are being tested or are needed in the future to improve restoration effectiveness and/or efficiency.

Planning

Planning is defined here as activities undertaken prior to delivery of restoration treatments that help improve efficiency and effectiveness of restoration programs.

What is working?

Planning Activity	What is it?	Key Benefit	Examples
Pre-treatment landscape inventory	Conducting an inventory of regeneration status on lines to better understand current landscape conditions.	Results in significant cost savings when applying treatments. Enables a well thought out plan that is designed to suit local site conditions (e.g., ecosites, access management concerns etc.)	A variety of techniques are being used by companies including: LiDAR, Wet Areas Mapping (GOA), High Resolution Aerial Photo Interpretation (E.g., Nash, 2010), ground truthing and aerial inventories.
Integrated Land Management (ILM)	Working collaboratively with other landscape users to plan and coordinate use of new and existing footprints.	An essential activity to ensure the long-term value and viability of restoration treatments.	Various COSIA programs. Stoney Mountain 800 program (CEMA, 2013).

Planning Activity	What is it?	Key Benefit	Examples
Stakeholder outreach	Engaging key land users whom may be actively using lines, or a portion of lines on the land base of interest.	Build support for program and helps ensure program is sensitive to other land users.	All COSIA programs currently have a stakeholder outreach component.
Relationship building	Engaging provincial government staff (local biologists and forest officers) early in the process to clarify program goals and align program to government of Alberta priorities.	Achieve buy in and support early on for program. Helps to avoid unnecessary delays in the approval process.	Numerous COSIA programs.
Modeling outcomes	Using models to predict the outcomes of treatments on a range of ecosystem values (e.g., forest growth, carbon values, caribou, other biodiversity values).	Allows companies to understand early in the process what implication different management techniques will have for outcomes of interest.	Landscape Ecological Assessment and Planning (LEAP). Little Smoky Pilot Program (Appendix A)
Operational contingencies	Contingency plans for other areas contractors can operate if conditions are not favourable.	If frost depth is not sufficient, operators may not be able to perform treatments. Having contingency plans and/or locations improves efficiency.	

What is not working?

Planning Activity	Key issue	Possible Solutions
Timing of programs	Programs are starting too late in the winter and this late start is a primary driver of high treatment costs.	Earlier planning and securing of permits would allow for timely initiation of field work.
Lack of coordination between companies	By having a series of fragmented restoration programs on the landscape, the potential benefit for caribou (and social license) may not be fully realized.	Increased coordination between companies. Exploring large scale restoration areas and using an adaptive management approach. Could be a possible role for leadership from the provincial government.

What is needed?

Planning activity	Key benefit
Testing new equipment and techniques for summer operations	Would allow efficiencies to be gained by using OSE construction teams during their slow season. Would increase the window of opportunity for treatments. Could possibly treat more area, more efficiently.
Coordinated adaptive management trials	Adaptive management in its simplest form is 'learning by doing'. For COSIA companies, this could mean developing a set of mutually agreed on treatments and testing them across different sites, or working together to identify treatments with the highest amount of uncertainty and testing these in a coordinated way across multiple operations. The main goal would be to undertake treatments, and monitor response, in a consistent, repeatable way such that knowledge can be gained over time. A coordinated, collaborative approach such as this would enable more efficient use of monitoring dollars through standardizing experimental treatments and improving monitoring with a core goal of increasing learning over time.

Treatments

Treatments are defined as the physical applications that are performed to help achieve the restoration program objectives.

What is working?

Treatment	What is it?	Why would you use it?	Where would you use it?	Key Considerations	References
Mounding	An excavator is used to dig holes and place the soil beside the hole creating an elevated 'mound'.	Mounds create an elevated microsite that increases soil temperature and improves growing conditions (for natural regeneration and/or planted seedlings). Mounds can help create an access barrier for human use and may influence wildlife movement on lines.	Lowlands with high water tables (moisture concerns) Dry stands to improve moisture availability (pooling of water in mound holes) Uplands to address competition concerns (grasses etc.)	Operator training is essential. While mounds may appear simple, proper construction is critical to ensure moisture wicking for seedling growth, and also to ensure structural stability and integrity through annual freeze-thaw cycles.	Von der Gönna, 1992

Treatment	What is it?	Why would you use it?	Where would you use it?	Key Considerations	References
Ripping	A dozer with either ripping teeth or a specialized plow are used to decompact soil.	Reduces site compaction, improves moisture availability, soil aeration and potential for root development.	Generally used on upland sites where compaction issues are present.	May use ripping teeth on dozers but ripping plows (RipPlow) have additional benefits.	McNabb et al., 2012
Roll back and coarse woody material	Woody materials from beside the line, or from nearby operations, are placed on the line.	Creates microsites for vegetation establishment and protection of seedlings (natural and planted). Creates a human access barrier when applied at high enough volumes.	Anywhere microsites would help regeneration or where access management is required.	Wood availability may be limited and is dependent on historical exploration practices. Wood may also be transported from active operations.	Vinge and Pyper, 2012; Pyper and Vinge, 2012
Tree felling	Trees from adjacent to the treatment line are felled across the seismic line.	Creates microsites for vegetation establishment and protection of seedlings (natural and planted). Creates a human access barrier when applied at high enough volumes.	Any sites where microsites would benefit regeneration or where access management is required.	Approvals required to fell trees from adjacent stands. Dependent on adjacent stand density. Prioritizing felling on south sides of lines may improve light availability on lines.	
Summer planting	Seedlings are planted to encourage regeneration.	Can help ensure desirable species mixes. Puts vegetation on a long-term recovery trajectory to a restored condition.	Any sites where improving regeneration is desirable. Wetlands can be difficult to plant in summer (access challenges).	Species should be selected based on local site conditions. Provides opportunity for planting additional species compared to winter planting.	

Treatment	What is it?	Why would you use it?	Where would you use it?	Key Considerations	References
Winter planting	Seedlings are planted to encourage regeneration.	Establishes conifer cover on sites and puts vegetation on a long-term recovery trajectory to a restored condition.	Generally used in treed wetlands where site preparation (mounding) has occurred. Enables planting of wetlands when access is possible (i.e., frozen ground conditions).	Planting occurs alongside site preparation. Currently, winter planting is limited to black spruce. Proper storage and handling of seedlings is critical. Covering seedlings with snow will help protect from desiccation.	Tan and Vinge, 2011

What is not working?

Treatment	What is it?	Where has it been tested?	Why is it not working?
Tree hinging	A process by which trees are felled and then lifted back up onto the stump to reduce line of sight and improve movement obstruction.	Various programs have tested the technique.	While it improves visual obstruction, treatments are often applied in the winter and may be too logistically challenging to implement safely (i.e., with deep snow and operation of chainsaws).
Tree transplants	Established trees adjacent to the treatment lines are excavated and moved onto treatment lines	Various attempts have been made, including Cenovus LiDea, Suncor Firebag.	Transplanted trees generally fail to establish on the sites and quickly die. Establishment of roots appears to be limiting success.

What is being tested?

Treatment	What is it?	Why is it being tested?	Key learnings to date	Where is it being tested?	Contact
Tree bending	A process by which trees are pulled over using winches or heavy equipment.	Felling trees results in rapid loss of needles. Stem bending is being tested to try maintain root contact with soils and extend the life of the tree while still creating a line-of-sight and movement barrier for wolves.	Winter applications are difficult and frequently result in the stem breaking. Summer applications are being trialed but costs are high at this time.	The Cenovus LiDea project has experimented with both summer and winter applications.	Michael Cody (Cenovus); Geoff Sherman (Woodlands North)
Line blocking	Heavy applications of woody material over short segments of lines (e.g., 200 metres).	Goal is to reduce movement efficiency of wolves and to deter human use of lines.	Current trials have placed heavy wood applications at intersection of lines and show reduced wolf use. Trials have only been small scale to date.	Statoil has a small scale replicated experiment in place.	Terry Forkheim (Statoil); Jonah Keim (Matrix Solutions)
Fencing	Wooden fences are constructed at predetermined locations along lines.	Goal is to reduce wolf sight lines along linear features.		No active trials within COSIA companies at this time.	Brian Coupal (Golder Associates)
Bar mounding	A variation on mounding where instead of digging small holes, piles of soil are placed in rows perpendicular to lines.	Goal is to create a microsite similar to a mound, but to reduce cost of operations (improve efficiency).	Trials are in early stages. Uncertain whether microsite effect will match that of mounds. Uncertain whether soil compaction below bar mounds will be an issue.	Shell Grosmont operations.	Clayton Dubyk (Shell); John Peters (Silvacom)
Angle slicing	A variation on mounding where a dozer's blade is tilted to create a small ditch and mound/row of soil along lines.	Goal is to create a microsite similar to a mound, but to reduce cost of operations (improve efficiency).	Trials are in early stages. Uncertain whether microsite effect will match that of mounds.	MEG Energy Operations	MEG Energy (Mike Robbins)

Monitoring

Monitoring is defined here as the critical follow-up activities to ensure: a) treatments were applied as you had intended (implementation monitoring); and b) that the treatments applied are helping to achieve the objectives of the restoration program (i.e., effectiveness monitoring).

What is working?

Monitoring Activity	What is it?	Key Benefit
Implementation Monitoring		
Reporting on tasks and activities completed	Field crews are generally tasked with measuring and reporting implementation results such as mounding density and CWM volumes post-treatment. Also serves as a quality assurance step whereby consultants and specialists perform site visits and quality checks during field operations.	Allows companies to verify they have achieved what they set out to achieve.
Effectiveness monitoring		
Tree survival assessments	Regular monitoring of seedling growth and survival (particularly in the first 3-5 years). Monitoring beyond the first year is key to ensure seedlings survive beyond the life of their nutrient plug. Monitoring over 3-5 years also helps to understand what treatments promote the best survival.	Helps inform managers and operators about improving treatment protocols.
Vegetation response plots	Plots established to monitor vegetation growth over time.	Provides an indicator of growth rates and treatment success over time.
Photo boards	Tripods with boards erected at regular distances away from sample locations (i.e., 10m, 50m, 100m).	Enables testing of line-of-sight, but also a indicator of biomass growth over time.
Remote cameras	Monitors wildlife use of treated and untreated lines to assess change in use over time following treatments.	Provides an efficient indicator of wildlife use/impacts of treatments.
Wildlife tracking	Snow transects used to monitor and assess wildlife use of lines.	Provides an indication of wildlife use of lines.
GPS Collaring	Live capturing and collaring of wolves, moose and caribou.	Locations from collars are used to monitor wildlife movements and helps assess: use of linear features; kill sites; habitat use; population response etc.
Fecal pellet counts	Winter collection of fecal pellets through use of scat dogs.	Abundance estimates through genetic mark and recapture analyses.

What is needed?

Monitoring Activity	What is it?	Key Benefit
Implementation Monitoring		
Standardized reporting protocol and tracking mechanism	A system and process to consistently document and report on types of treatments applied, conditions during treatment, location and spatial extent of treatments etc.	Would enable COSIA to develop a tracking system to document where restoration activities are occurring and to assist with knowledge sharing.
Effectiveness monitoring		
Standardized monitoring protocols	A standardized approach that all COSIA companies would use for monitoring treatment response.	Would facilitate comparison between programs and expedite learning. Current fragmented monitoring impedes innovation and results in unnecessary duplication in programs.
Restoration tracking mechanism	A system for tracking current restoration programs in relation to each other and also in relation to other anthropogenic disturbances on the landscape.	Critical for prioritizing restoration locations and tracking performance towards achieving caribou and/or habitat objectives.
Collaborative adaptive management trials	In order to truly assess the success of restoration treatments at a landscape scale, companies will need to work together to implement standardized trials and monitoring programs that help advance restoration knowledge. This could mean developing a set of mutually agreed on treatments and testing them across different sites, or working together to identify treatments with the highest amount of uncertainty and testing these in a coordinated way across multiple operations.	A robust adaptive management approach would utilize monitoring dollars more efficiently and in a more coordinated way. It would also allow companies to test key uncertainties and advance the science of restoration.
Increased use of technology for monitoring recovery	Technologies such as remote sensing and LiDAR provide an efficient way for companies to monitor recovery over time.	Reduced costs and ability to cover larger areas.

4. A Planning Framework for COSIA

As we have highlighted throughout this document, developing an efficient and effective restoration program requires investment in planning, selecting treatments, and monitoring. However, a successful program also requires a clear definition of what the goals and objectives of the restoration program are. This section of the document builds on earlier sections to propose a planning framework for use by COSIA companies when developing future restoration programs.

The goal of this framework is to increase the efficiency and effectiveness of current and future restoration programs. The planning framework has been designed to be flexible to foster innovation, yet structured enough to provide a roadmap for developing effective linear restoration programs. It also facilitates coordination and collaboration between programs, and can function as a foundation for delivering landscape level restoration programs. As a first iteration it will no doubt need to be fine-tuned and adjusted over time.

The framework is based on elements of an adaptive management approach (Holling, 1978), in that users define their goals and objectives and ensure that planning activities, treatments, and monitoring programs are all supportive of these goals and objectives – fostering learning over time (Figure 8). It is worth noting that an adaptive management approach was highlighted as 'what is needed' in both the planning and monitoring sections of the 'restoration toolbox'. Thus, by applying this framework, programs can provide more clarity to goals and objectives, select treatments that are linked to program objectives, and conduct monitoring in such a way that programs can evaluate success based on their original goals and objectives.

Figure 8. The underlying process of the planning framework that encourages setting goals and objectives, and committing to learning over time to address key uncertainties is the restoration program.

In addition to having a foundation in adaptive management, this framework is designed to help address the issue of scale in linear restoration planning. As we discussed in the introduction to this document, while restoration is focused at a site specific level, the core objectives or definitions of success are often evaluated at a landscape scale (e.g., restoring large areas of suitable caribou habitat, population response of caribou). Thus, it is critical for restoration programs to begin to link their planning at the site level to more landscape level objectives in order for restoration programs to contribute to recovery of caribou populations. The intent of the planning framework is to help provide a roadmap for considering this issue of scale in restoration planning.

What are the components of the planning framework?

The planning framework consists of five steps as indicated in Figure 8. These steps are defined as follows:

> *Identify goals and objectives* – Goals are clear, concise statements of high level intent of the program. 'Why' is the program being undertaken? Objectives specify the way in which you will achieve your goals. 'How' are you going to achieve your goals? Objectives should be SMART (i.e., specific, measurable, achievable, realistic, time bound).
>
> *Select approach* – selecting a functional restoration approach or a habitat restoration approach (i.e., combined functional/structural restoration) for the program.
>
> *Plan* – the steps required to plan and coordinate an efficient, effective program that will achieve the program objectives. Includes linkages to specific site conditions and desirable treatments.
>
> *Treat* – applying the treatments on the ground.
>
> *Monitor* – follow-up monitoring and assessments to resolve key uncertainties and adjust future programs for improved performance. Clearly linked to objectives and goals of program.

Based on these five steps, the below flow-chart helps visualize the extent of a restoration program and some of the key steps along the way from defining goals to monitoring program results (Figure 9). This framework is then expanded on to provide additional context to the suggested steps.

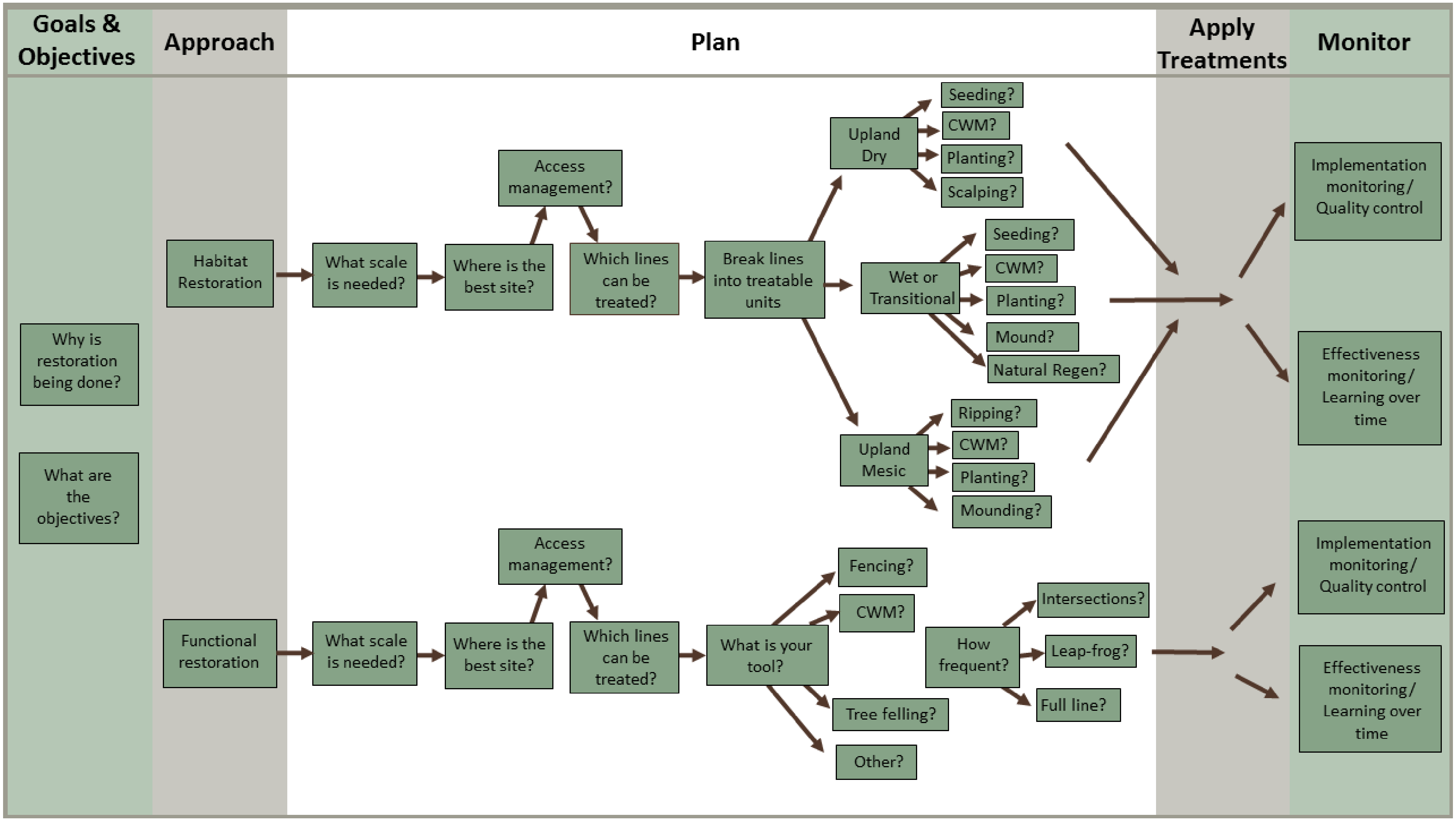


Figure 9. Schematic of the proposed Planning Framework for COSIA linear restoration programs.

A closer look at the planning steps

Define Goals and Objectives

The first step in the framework is defining the goals of the restoration program. The goals are intended to be high level, visionary statements about the long-term desires of the program. Goals will reflect corporate objectives but also answer the key question: why is the restoration program being undertaken? Defining this 'why' is essential as goals will serve as the foundation for the actions taken and references for determining success of the restoration programs. It is worth mentioning that restoration projects are not only designed to address ecological objectives, but they are also developed to build social license. Scale is an important consideration here as well. If the program is experimental, it will drive different choices than if the program is intended to be more operational.

Defining the objectives then moves the program from defining the 'why' to defining 'how' the goals will be achieved. Objectives are intended to be SMART (specific, measurable, achievable, realistic and time bound). Examples of program objectives of current programs can be found in appendix A, but might include:

- Increasing the abundance and growth of conifers over the short term (i.e., 1-2 years);
- Impeding the movement of wolves within the program area immediately; or
- Reducing public access along restored lines immediately.

Select Approach

The next step in the planning framework is to select either a functional restoration or habitat restoration approach. Again, a functional approach focuses on reducing wolf movement efficiency on the landscape and a habitat restoration approach focuses on both promoting the natural succession and growth of woody vegetation on the linear feature and reducing wolf movement efficiency (Figure 1). Deciding on which approach the program will use informs the planning and selection of treatments for the program.

Plan

Planning is a major component of successful restoration programs, and is a critical step for minimizing restoration program costs. During the workshop held in conjunction with this project, numerous participants highlighted the importance of investing in thorough planning to control program costs (Nishi et al., 2014).

To simplify this section, we describe the planning steps for a habitat restoration approach and functional restoration approach independently – as is presented in the planning framework flow chart (Figure 9).

Habitat Restoration Planning

What scale of program is required?

Considering the scale required to achieve the restoration goals and objectives helps to overcome the fact that restoration treatments are site specific, while goals are generally more focused at the landscape level (e.g., population response in caribou, or increased forest connectivity). In addition, a restoration program may need to be several thousand square kilometres to have a measurable effect on caribou populations (Athabasca Landscape Team, 2009). While this scale may seem daunting, remember this scale is a high level goal and treatments can be delivered over time to restore this large of an area. In addition, collaborations can help to pool resources and address larger scale restoration projects.

Where is the best site?

Once scale has been considered, the next step is considering where the best place on the landscape is to deliver the restoration program. Generally, this considers corporate plans for development on leases, activities of other land users (e.g., forestry) and priority caribou restoration zones. When considering the best site, companies may wish to consider whether an off-lease restoration program in collaboration with the provincial government and other industrial land users (i.e., energy companies or forestry industry) may be the best way to achieve the goals and objectives of the restoration program.

In addition, there is immense value considering what the condition of the forest is currently, and what it might be in 40-60 years when growth from the restoration treatments are fully realized. For example, restoring an area that might undergo forest harvesting within 20 years may compromise the program goals and objectives because the restoration sites will be out of sync with the surrounding land base. While this consideration should not limit momentum towards restoration, it is important to consider the influence of other land users over time.

Which lines can be treated?

Once the best site is selected companies must then consider which lines can actually be treated. This generally requires consideration of active dispositions and consultation with other land users (e.g., other energy companies, local trappers etc.). In some cases, COSIA programs have been able to treat all lines in their program areas, in other cases up to 80% of lines were deemed untreatable through the consultation process. This step is critical for not only achieving buy in with local stakeholders, but also understanding if the selected landscape can help to achieve the goals and objectives of the program.

Box 2: Securing Planting Stock

For many programs, a key limiting factor in their delivery is securing trees and shrubs for planting. Securing trees and shrubs from nurseries requires significant lead times (multiple years in some cases), and thus companies should secure their planting stock as early as possible for their program. The COSIA Oil Sands Vegetation Cooperative may also be a useful resource for securing seed stock.

Another step which may be undertaken is predicting how treatments will impact key landscape values over time through a modelling approach. An example of this is the LEAP project used by the Algar and Shell Grosmont programs (See Appendix A for more information).

How much of a concern is access management?

Access management is a critical consideration in the planning of a restoration program, as numerous studies have cited its impacts on the recovery of linear features (Bayne et al., 2011;

Lee and Boutin, 2006; Van Rensen 2014; Vinge and Pyper, 2012). At this point in the framework, the goal is to understand to what extent access management is a concern on the landbase of interest.

Understanding access management issues will drive the decisions made later in the framework when selecting treatments. For example, some programs are applying coarse woody materials at higher densities where linear features intersect major roads to limit access onto restored lines. Such applications are likely to be effective in deterring recreational OHV users, particularly when paired with regular coarse woody material applications along lines by way of tree felling, stem bending, or roll back. However, concentrated treatments only at the start of lines are likely to function similar to gates and berms and be generally ineffective (Vinge and Pyper, 2012).

Break lines into treatable units based on site conditions

For the lines that are treatable on a program area, generally companies have found significant benefits in conducting an inventory of the current condition of lines. This is often achieved through the use of LiDAR based methods or also interpretation of high resolution aerial imagery (e.g., Greenlink, 2010). Aerial survey and/or ground truthing a subset of sites or entire lines is also often used to verify modelling projections of site conditions, and to better understand operational realities that will be faced when delivering the treatments.

This step can help in answering a series of key site level questions. For example, is there existing natural regeneration on significant portions of lines that may impede access or require protection? Is access management a major or minor concern on sites? What is limiting the site? Are sites too wet? Too dry? Having this level of information about the site will enable programs to match their treatments to the specific conditions on lines and maximize potential for successful treatments.

Assign treatments based on ecosite

Based on the site inventory, there are a range of tools available to programs. Here we describe a number of the most common tools. While this framework provides a general working model for selecting treatments, success of treatments will be significantly improved by understanding the ecological conditions unique to the site. Cook book restoration prescriptions rarely work in nature, particularly on challenging sites like linear features. The best approach is to understand what is limiting on sites (e.g., moisture, nutrients, competition etc.) and ensure treatments address these site limiting factors appropriately.

To help in demonstrating the range of treatments available for different site conditions, we have combined various ecosites into a simplified, three zone approach based on findings from Van Rensen (2014). Treatments may also be assigned based on ecosite or some other combination of factors to maximize relevance of treatments to site conditions (e.g., Appendix A – Dillon Project Summary, Cenovus LiDea Summary).

Upland dry sites

These sites are generally characterized by sparse pine stands and coarse textured (sandy) soils. These sites are generally moisture and nutrient limited (xeric sites). Van Rensen (2014) identified these sites as some of the most likely to not regenerate naturally, because of the numerous limiting factors on these sites (moisture, nutrients).

Coarse woody materials (CWM)

Application of CWM can create microsites and help hold moisture on sites. Stand characteristics along a linear feature will vary considerably and in some areas may be quite sparse, so densities may be difficult to achieve or wood may need to be transported into these sites, particularly to achieve access management objectives.

Lite surface disturbance (scalping)

Scalping can help remove the thick cover of lichen which often characterizes these sites to expose microsites for natural regeneration (Von der Gönna, 1992). Without these microsites, seeds lack the conditions necessary to germinate and establish on sites.

Mounding may also be considered on these sites. While mounding is often used in lowland sites, mounding can create areas where moisture can collect and therefore support growth of seedlings on sites (Tim Vinge; *personal communication*).

Seeding

Seeding may be a preferred treatment as nutrients are often limiting on sites and therefore seedlings may not have the resources required to grow. Application of pine cones may also be an effective option as the cones themselves help to create microsites on the ground and facilitate germination of seeds.

Planting

Planting may be a good option on these sites if site conditions are appropriate. Planting is particularly useful if mounding is used to create locations for water to pool. Seedlings would be planted to maximize uptake of moisture when available.

Wet or transitional sites

These sites are generally bogs or fens, and transitions out of these sites, and require significant efforts to facilitate natural recovery. Typical limiting factors on these sites include excessive moisture (high water table) and cold soils. Again, linear features in these sites were identified by past studies as the least likely to regenerate naturally, with some projections suggesting these disturbed sites may remain stagnant for upwards of 100-200 years (Van Rensen, 2014; Lee and Boutin, 2006).

Mounding

Mounding creates elevated microsites which in turn provides warmer soil conditions, facilitates nutrient availability, addresses moisture issues and generally improves growth of vegetation (Von der Gönna, 1992). Mounding is often a required technique on these sites. However, alternate applications of woody materials are being trialed in remote areas that cannot be accessed by equipment (Appendix A - Dillon Project Summary).

Coarse woody material (CWM)

Placement of CWM can further enhance microsites and help produce a movement barrier along sites (i.e., wolf movement, human access management). It has also been used in areas that are inaccessible by equipment to create micro topography in lowland sites (Appendix A - Dillon Project Summary)

Planting, seeding or natural regeneration

Planting can help get a leg up on competing vegetation, but significant natural regeneration has been documented on numerous programs (e.g., Cenvous LiDea, Algar). The challenge is to ensure that natural regeneration is composed of non-browse species.

Upland mesic

These sites are generally upland deciduous, mixedwood or conifer dominated stands. Van Rensen (2014) as well as Lee and Boutin (2006) suggested that these sites had the greatest potential for natural regeneration if site conditions were appropriate. However, they can also be some of the trickiest sites in that site limiting factors can often be much more variable than on dry or wet sites (Tim Vinge, *personal communication*). For example, soil compaction, competition, nutrient availability, seed source availability and moisture availability can all greatly impact the success of regeneration on these sites.

Coarse woody material

Coarse woody material is often applied to these sites and is considered an effective access management tool when applied at high enough densities and regularly along the lines (Vinge and Pyper, 2012).

Planting

Planting may be effective on upland mesic sites as long as there are no site limiting factors. For example, straight planting into highly compacted soils may pose issues to seedlings. Similarly, straight planting sites that are moisture limited may limit seedling success. Planting, when applied in the appropriate site conditions, may prove beneficial in establishing conifer cover on sites.

Ripping or other site preparation

Depending on site specific conditions, some form of site preparation may also be helpful for site recovery. For example, highly compacted soils may benefit from a ripping treatment, while moisture limited sites or sites with extensive competing vegetation may benefit from mounding treatments (Von der Gönna, 1992).

Functional Restoration Planning

What scale of program is required?

Similar to an approach focused on habitat restoration, considering the scale required to achieve functional restoration goals and objectives is a critical step. One key consideration is that because functional restoration is focused on reducing wolf movement efficiency, the scale of treatments required to have a measurable influence is likely very large (Neufeld, 2006; Vinge and Pyper, 2012). While there are few scientific data to determine an appropriate scale for a functional restoration treatment in caribou range, it is potentially on the scale of thousands of square kilometres. One of the key advantages highlighted by proponents of functional restoration is that because treatments can be delivered more efficiently and cost effectively, programs should be able to restore a large number of lines over a short time frame. However, this approach to restoration is characterized by high levels of uncertainty about potential success of treatments. Thus, if a functional approach is selected, it must be delivered in a structured, measurable way. We discuss further some of the uncertainties associated with this approach in the 'Future Recommendations' section of this report.

Where is the best site?

The primary variable for selecting a program site should be the opportunity to influence populations or behaviours of the target species (e.g., wolves, caribou). While other land users (i.e., forestry and energy companies) may be less of a consideration when applying functional restoration treatments because the treatments have a shorter term focus, considering the amount of access and frequency of recreational use in an area is likely a key consideration. Based on past programs, recreational users have a propensity for damaging restoration trials and signage (e.g., Appendix A - Little Smoky Summary; Vinge and Pyper, 2012) and treatments, such as fences, are likely to suffer similar fates in high traffic areas.

Which lines can be treated?

Because a primary goal of functional restoration is limiting use of lines by wolves, treatments will also have a direct impact on human use of lines so consultation with local stakeholders will be important for functional restoration treatments. Through our discussions with key stakeholders we learned that some treatments, such as fences, have been proposed with gates to enable trapper access into key areas, while still permitting a visual obstruction on the lines. However, wolves are known to use lines with packed snow more frequently (Keim et al., 2014) and therefore the net gain of such a treatment in the winter season is unclear.

How much of a concern is access management?

Similar to a focus on habitat restoration, access management is a critical consideration in the planning of a functional restoration program. Again, a key starting point is understanding to what extent access management is a concern on the landbase of interest. Depending on the nature of the tool used for functional restoration, access management may inherently be achieved (e.g., through use of woody materials) or additional treatments may be required (e.g., in the case of fences). Based on the tool selected, a plan should be developed to address access management concerns along the restored lines.

What is your tool?

Once the site and lines have been selected, there are a variety of tools currently proposed for functional restoration. This includes use of coarse woody materials, stem bending or felling of trees perpendicular to lines, line blocking and use of fences (see Restoration Toolbox). It is possible that other functional restoration treatments may be envisioned as well. However, it is critical that any new treatments be grounded in ecological principles.

How frequently will treatments be applied?

Functional restoration is often advocated as a more cost effective way to treat a larger number of lines in a program area. However, there is little evidence to suggest what the appropriate treatment configuration should be. Based on our review of current programs, the main treatment configurations currently being discussed include: full line, leap frog (where treatments are applied intermittently along lines), and treatments at intersection to lines.

Neufeld (2006) found that trees felled at intervals of approximately 15 metres had little influence on wildlife use of treated lines. Meanwhile, the Statoil line blocking experiment has treated only intersections of lines and shown that wolf movements are impacted in the vicinity of the treatments (Keim et al., 2014). However, this study has only been conducted at a site specific level, and how study findings relate to larger landscape level influences on wolf movement and predation rates on caribou are unclear.

Apply Treatments

Once companies have worked through the ‘plan’ section of the planning framework, the next component is applying treatments. While a critical part of the planning framework, a detailed look at the operational deployment of treatments was beyond the scope of this project. However, we do highlight some general observations in the ‘Future Recommendations’ section of this report. Most important among these considerations are the selection of qualified operators and establishing contingency plans for treatments.

Monitor

The final step in the planning framework is monitoring. While we do not provide an exhaustive list of monitoring options here, a summary of current monitoring techniques can be found in the 'Restoration Toolbox' section of this report. Instead, the focus of this section of the framework is on ensuring that monitoring programs are designed in such a way that:

a) They evaluate whether treatments have been carried out as initially planned and scheduled, and have been delivered to a high standard; and
b) They permit an evaluation or test of whether the implemented treatments have achieved the original goals and objectives of the restoration program.

While we do not discuss functional and habitat restoration separately in this part of the framework, we do break this section out into implementation monitoring/quality control and effectiveness monitoring (sensu Bunnell and Dunsworth 2009).

Implementation Monitoring (...have we done what we said we would?)

Implementation monitoring generally occurs directly after treatments have been applied and provides a clear assessment of whether the actual treatments conducted in the field went according to plan, and whether they were delivered to a high standard. Thus, one of the key roles of implementation monitoring is to serve as a quality control measure to detect any errors or inconsistencies that might have occurred that would impact treatment success. Some examples might include:

- Whether seedlings were stored and handled properly;
- Whether mounding treatments were delivered in an effective way;
- Whether trees were planted properly, and in the correct location in relation to any site preparation treatments (e.g., position on mounds).

Implementation monitoring goes well beyond simply quality control, however, and is a critical foundation for also monitoring the effectiveness of treatments. By collecting site specific information and data about how treatments were delivered, this data can then be used to analyze 'why' treatments were successful or not successful. As an example, envision a scenario where recovery rates on two sites are very different, despite being in relatively similar ecosites. Implementation monitoring can be used to analyze 'why' these sites differ in their response (e.g., Was a different contractor used? Different planting stock?), thus fostering quicker, more process based learning over time.

This 'why' information can be useful from a project management perspective to improve treatments over time, but it is also critical information to foster learning between programs. For example, COSIA may wish to evaluate the relative merits of summer versus winter planting. Having consistent implementation monitoring data between companies can greatly improve the ability to perform meta-analyses to assess differences and, more importantly, determine why those differences might exist.

Effectiveness Monitoring (... did our actions achieve our objectives?)

Effectiveness monitoring serves as a critical component of an adaptive management approach. It includes the collection of empirical data in a coordinated and planned way (including pre-treatment and post-treatment monitoring). The core questions that effectiveness monitoring can be used to answer include:

1. Did the restoration treatments result in biotic or abiotic changes on, or adjacent to, the restored areas?
2. Did the restoration treatments achieve the stated objectives of the program?
3. How can we learn from the restoration treatments applied and can we determine ways to improve treatments to optimize ecosystem recovery and/or minimize treatment costs?

Clearly, there is an important linkage here to implementation monitoring in that well executed implementation monitoring provides important input into effectiveness monitoring analyses. However, effectiveness monitoring requires a reasonably well thought out approach and design. In addition, while implementation monitoring is primarily focused at the site level, effectiveness monitoring tests questions both at the site and landscape level, as defined by project objectives. For example, if one of the objectives is to influence wolf movement efficiency or use of linear features, then effectiveness monitoring would be designed to test this response.

This connection to landscape scale, wildlife responses, is something we noted as lacking in most current restoration programs (Table 3). We found that only a small number of programs have paired site level vegetative growth monitoring with more landscape level wildlife response monitoring. This is a clear knowledge gap and more information is needed to understand how, when and why restoration treatments might influence wildlife populations.

While a detailed plan for effectiveness monitoring is beyond the scope of this report, there are a variety of useful references that companies are encouraged to consult (Bunnell and Dunsworth 2009; Burton et al., 2014). In addition, during our workshop it was noted that Golder Associates Ltd., in collaboration with the Foothills Research Institute, have been encouraging the use of a standardized monitoring protocol to enable more effective comparisons between restoration programs (Paula Bentham, *personal communication*). Companies are encouraged to explore these resources further.

5. Future Restoration Planning Recommendations

Using the planning framework as a foundation for future programs

One of the core objectives for COSIA at the outset of this project was to have a series of recommendations for executing projects, including planning, delivery of treatments and monitoring. The planning framework proposed in this document helps achieve this by providing a roadmap for effective and efficient restoration programs. It also provides a systematic way to address concerns that have limited traditional restoration programs – two of the principal concerns being linkages between site and landscape level objectives, and committing to effective monitoring that improves learning over time. The proposed planning framework, when combined with the expertise of experienced consultants and contractors, should help in the delivery of effective programs by COSIA companies.

Separate innovation from operational deployment to reduce delays and risk

Innovation is critical to advancing linear restoration and there is significant opportunity to explore new and more efficient practices. For example, testing new types of equipment or testing ways to operate in the summer are areas where innovation could provide significant gains. However, testing new approaches should not undermine the fact that a suite of relatively proven tools already exist, and there is a need to restore significant areas of habitat over relatively short periods of time to have a positive influence on caribou populations (Athabasca Landscape Team, 2009).

By having a more structured approach to testing new innovations, COSIA can ensure that experimental trials do not limit or slow the pace of restoration programs. In addition, this will help minimize the risk of new trials.

Acknowledge the risks of a sole focus on functional restoration

Functional restoration was a topic we addressed throughout this document, but we reserved discussion about its relative risks until this section. While functional restoration does have the support of some biologists – who emphasize the need to perform efficient functional restoration over large scales – companies should acknowledge that these techniques are unproven to date and come with high risks. Site level impacts of functional restoration treatments have been documented (Keim et al., 2014). However, it is unclear whether these site level responses will translate into landscape level or population effects if applied at larger scales.

Beyond the risks of the treatments themselves, it is not clear whether the provincial or federal governments would consider such treatments as contributing to restored habitat. As Hervieux et al., 2013 stated: “Despite the proximate role of predation in driving declines, ultimately habitat recovery and protection will be required to recover populations.”

Should companies undertake functional restoration treatments, they should be conducted in a robust, scientifically credible way and performed at a very large scale such that a measurable effect would be most likely. Small scale, fragmented, and uncoordinated trials are unlikely to reduce uncertainties associated with this treatment and will take critical resources away from habitat restoration programs.

Prioritize restoration zones and increase scale

For restoration programs to have a measurable effect on values such as woodland caribou, the scale of restoration programs will need to increase significantly (Athabasca Landscape Team, 2009). Even COSIA programs that are currently restoring up to five townships worth of lines recognize that much more needs to be done to achieve conservation objectives. Developing priority restoration zones provides an opportunity to increase the likelihood of benefit to woodland caribou, and reduce the fragmented and uncoordinated nature of independent linear restoration programs. An additional key benefit of such prioritization is that it will likely lead to significant efficiencies and cost savings through development of collaborative programs.

There are also a number of existing efforts that have begun to model priority areas for restoration, and these could be quickly applied by COSIA. For example, Van Rensen (2014) developed an optimization model to determine where restoration treatments could be applied most efficiently. Similar work is also being conducted in support of the provincial biodiversity management framework (Scott Nielsen & Tim Vinge, *personal communication*). Finally, signatories of the Canadian Boreal Forest Agreement are currently in the process of proposing a landscape zonation approach for prioritizing forest harvesting areas within the Alberta-Pacific forest management agreement area, and this could serve as a foundation for COSIA priority restoration zones.

One should also not underestimate the potential effect of such a prioritization exercise on social license. The potential to positively influence large tracts of habitat in a collaborative way could be a significant contribution from COSIA companies. A structured, collaborative approach to such a prioritization exercise, as was completed by CEMA in the Stoney Mountain 800 area, may provide an important foundation for such an effort (CEMA, 2013).

Improve monitoring effectiveness

Despite linear restoration work occurring for a number of years, there are still significant knowledge gaps caused by an overall lack of vegetation and wildlife response monitoring (Golder and Associates, 2012). Most programs have either been poorly designed, or have lacked a commitment to follow-through with long-term monitoring. By developing a consistent, repeatable approach to implementation monitoring and linking this to well designed, scientifically robust effectiveness monitoring programs, COSIA could contribute significantly to advancing the current state of knowledge.

Participants in our workshop highlighted this as one of the highest needs for COSIA to undertake (Nishi et al., 2014). Work on the Cenovus LiDea project provides an excellent model, as well as the Regional Industry Caribou Collaboration (RICC) currently being explored in the Cold Lake and East Side Athabasca Ranges by a number of COSIA companies. The goal of the RICC program is to coordinate research, integrated land management and active, science-based adaptive management to contribute to caribou conservation and habitat recovery. Some of the early documents from the Little Smoky pilot restoration program also serve as a useful reference for developing an effective, credible monitoring program (Suncor, 2005). Similarly, recent discussions around a collaborative, scientifically robust initiative that would focus on implementation of integrated resource management at both the stand and landscape levels could provide significant benefits for overcoming key uncertainties in linear restoration. Such an initiative would include both the forestry and the oil and gas sectors, and would be based, in part, on principles and learnings from the Ecosystem-based Management Emulating Natural Disturbance (EMEND) project. Coordinated, robust monitoring programs such as these are much more likely to provide tangible benefits and learning over time for COSIA than fragmented, project specific monitoring programs. In addition, they likely provide a far more efficient use of monitoring dollars.

Focus on quality of treatment delivery – it is a key limiting factor

A focus on strategic planning and monitoring is critical for restoration programs, but ultimately a program cannot be successful unless site specific treatments have been delivered by experienced, knowledgeable crews. As a result, delivery of quality treatments should be considered the first rung on the ladder of a successful restoration program. As an example, Vinge and Lieffers (2013) found that despite considerable efforts in the Little Smoky restoration pilot program, many of the treatments showed limited success because of implementation. One example highlighted was challenges in creating effective mounds because of challenging frost conditions. Similarly, trees planted on mounds were often planted in the wrong location, or not deep enough, and so seedling success was limited on the sites.

It should be no surprise that restoration is based in ecological principles. Thus a key way to overcome some of the challenges faced is to ensure operators and field staff have an ecological understanding of why treatments are being delivered, and what the treatments are intended to achieve. Hiring experienced contractors and ensuring effective training of these contractors by restoration experts is another key way to achieve improved outcomes through treatments.

Future actions and knowledge gaps

Through this project, a number of future actions emerged which COSIA could act on in the short-term. These include:

- Coordinated and collaborative adaptive management trials. Adaptive management in its simplest form is ‘learning by doing’. For COSIA companies, this could mean developing a set of mutually agreed on treatments and testing them across different sites, or working together to identify treatments with the highest amount of uncertainty and testing these in a coordinated way across multiple operations. The main goal would be to undertake treatments, and monitor response, in a consistent, repeatable way such that knowledge can be gained over time. A coordinated, collaborative approach such as this would enable more efficient use of monitoring dollars through standardizing experimental treatments and improving monitoring with a core goal of increasing learning over time.

- Operator training materials/programs (with videos) that explain the purpose of treatments, illustrate restoration techniques and show past successes.
- Develop a standardized system and process to consistently document and report on types of treatments applied, conditions during treatment, location and spatial extent of treatments. Such a system will improve knowledge of where activities are at, where new activities could be located to leverage existing work, and to help in consistent monitoring of treatments over time. Standardized monitoring protocols would further extend the value of this and would permit testing and comparing treatments between programs – expediting the rate and efficiency of learning.
- Increasing the use of technologies for monitoring recovery along linear features could significantly improve the efficiency of monitoring programs. For example, technologies such as remote sensing and LiDAR may provide an efficient way for companies to monitor recovery over time.
- Development of a standardized metric for reporting on program costs is required to help understand cost variances between programs. Standardized criteria could easily be developed and used by all programs to report on program costs.
- Follow-up and monitoring of treatments highlighted as currently being tested in the restoration toolbox (i.e., tree bending, line blocking, fencing, bar mounding, angle slicing) is required to evaluate their relative utility. In particular, tree bending and line blocking may provide promising results in the future.

A number of key knowledge gaps also emerged through development of this report. These included:

- How feasible is transporting wood from 'donor sites' to restoration programs? Investigation of issues and feasibility related to wood transport from donor locations to restoration sites (availability, storage, transportation methods, cost etc.) is a key short term need.
- Investigation of strategies/methods for improving conditions on lines related to sunlight. Some programs (e.g., Cenovus LiDea II) have prioritized felling on south sides of lines to improve light availability. Understanding the utility of this technique, and when and where it is beneficial is an important knowledge gap.
- Can we develop 'growth and yield' curves to understand at what rate different ecosites will recover over time and to use these curves to better understand when a site is on a trajectory towards being 'restored'? Or is more of a step-ladder type approach required whereby a series of sequential, multi-step goals would be achieved over time for a site to be considered restored (Palmer et al., 1997)?
- If treatments were prioritized to treat sections of lines that connected critical peatland habitat for caribou to upland habitat frequented by wolves and primary prey (i.e., a zoned approach to restoring lines whereby zones close to peatlands are prioritized), would this achieve a measurable impact on populations or is treating all lines in an area required?

- At what scale do restoration treatments need to be conducted to have a measurable influence on key values such as woodland caribou (functional and numerical response) (i.e., thousands of square kilometres?)?
- What improvements can be made to existing equipment, or what new equipment can be designed, to improve operational efficiencies? Could alternate equipment be used to deliver treatments in snow free conditions?

Literature Cited

Athabasca Landscape Team. 2009. Athabasca Caribou Landscape Management Options Report. 99 pp.http://www.albertacariboucommittee.ca/

Bayne, E., H. Lankau and J. Tigner. 2011. Ecologically-based criteria to assess the impact and recovery of seismic lines: The importance of width, regeneration, and seismic density. Report No. 192. Edmonton, AB. 98 p.

Blanco, J.A., W. Clive, J.P. Kimmins, B. Seely, and D. Mailly. 2009. Guidelines for modeling natural regeneration in boreal forests. The Forestry Chronicle, 85:427-439.

Bunnell, F.L., and G.B. Dunsworth. 2009. Forestry and Biodiversity: Learning How to Sustain Biodiversity in Managed Forests. UBC Press, Vancouver, BC.

Burton, A.C., D. Huggard, E. Bayne, J. Schieck, P. Solymos, T. Muhly, D. Farr, and S. Boutin. 2014. A Framework for adaptive monitoring of the cumulative effects of human footprint on biodiversity. Environmental Monitoring and Assessment, 186:3605-3617.

CEMA. 2013. Stoney Mountain 800 Linear Footprint and Access Management. Prepared by: Compass Resource Management, Vancouver, BC. http://library.cemaonline.ca/dataset/fc40bed9-75a7-467a-ae66-1bb939ab303a/resource/c2e9fbab-3aed-4b95-b964-4d01821f399a/download/sm800linearfootprintandaccessmanagement.pdf

Environment Canada. 2012. Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population, in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. xi + 138pp.

Golder Associates. 2012. Boreal caribou habitat restoration. Report # 12-1372-0012. Submitted to BC Ministry of Forests, Lands, and Natural Resource Operations. March 2012.

Golder Associates. 2014a. Woodland caribou restoration workshop. Report # 13-1334-0040-2000. Submitted to Canadian Association of Petroleum Producers. March 2014.

Golder Associates. 2014b. Enabling solutions for landscape level restoration – Workshop. December 8, 2014, Edmonton, AB.

Greenlink Inc. 2010. Lineal inventory of the Little-Smoky caribou range. Pp.75 Submitted to the Foothills Landscape Management Forum, Hinton, AB.

Hervieux, D., M. Hebblewhite, N.J. DeCesare, M. Russell, K. Smith, S. Robertson, and S. Boutin. 2013. Widespread declines in woodland caribou (Rangifer tarandus caribou) continue in Alberta. Canadian Journal of Zoology, 91:872-882.

Holling, C.S. 1978. Adaptive Environmental Assessment and Management. Wiley, Chichester.

James, A.R.C., S. Boutin, D.M. Hebert, and A.B. Rippin. 2004. Spatial Separation of caribou from moose and its relation to predation by wolves. Journal of Wildlife Management, 68(4):799-809.

Keim, J.L., P.D. DeWitt, T. Shopik, J. Fitzpatrick, S.R. Lele. 2014. Understanding and mitigating the effects of linear features and snow condition on caribou predator-prey overlap in the Alberta oil sands. 15th North American Caribou Workshop, Whitehorse, YT.

Latham, A.D.M., M.C. Latham, M.S. Boyce and S. Boutin. 2011a. Movement responses by wolves to industrial features and their effect on woodland caribou in northeastern Alberta. Ecological Applications, 21(8):2854-2865.

Latham, A.D.M., M.C. Latham, K.H. Knopff, M. Hebblewhite and S. Boutin. 2013. Wolves, white-tailed deer, and beaver: implications of seasonal prey switching for woodland caribou declines. Ecography, 36:1276-1290.

Latham, A.D.M., M.C. Latham, N.A. McCutchen, and S. Boutin. 2011b. Invading White-Tailed Deer Change Wolf-Caribou Dynamics in Northeastern Alberta. Journal of Wildlife Management, 75(1):204-212.

Lee, P., and S. Boutin. 2006. Persistence and developmental transition of wide seismic lines in the western Boreal Plains of Canada. Journal of Environmental Management, 78: 240–250.

McNabb, D.H., J-M. Sobze and A. Schoonmaker. 2012. Tilling compacted soils with RipPlows: A disturbed soil restoration technique. NAIT Boreal Research Institute Technical Note.

Nash, J.C. 2010. Lineal inventory of the Little Smoky Caribou Range. Final Report (unpublished) submitted to Foothills Landscape Management Forum.

Neufeld, L.M. 2006. Spatial dynamics of wolves and woodland caribou in an industrial forest landscape in west-central Alberta. University of Alberta, Edmonton.

Nishi, J., M. Pyper, L. McNeil. 2014. COSIA Caribou Habitat Linear Disturbance Restoration – Workshop Report.

NOVA Gas Transmission Ltd. 2012. Preliminary caribou habitat restoration plan for the Leismer to Kettle River Crossover Project.

Palmer, M.A., F.A. Ambrose, and N.L. Poff. 1997. Ecological Theory and Community Restoration Ecology. Restoration Ecology, 5(4):291–300.

Pyper, M. and T. Vinge. 2012. A visual guide to handling woody materials for forested land reclamation. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta Report No. TR-31. 10 pp.

Suncor Energy and ConocoPhillips 2005. Little Smoky Habitat Restoration Pilot Project.

Van Rensen, C.K. 2014.Predicting Patterns of Regeneration on Seismic Lines to Inform Restoration Planning in Boreal Forest Habitats. MS thesis. University of Alberta

Vinge, T. and V. Lieffers. 2013. Evaluation of forest reclamation efforts on linear corridors of the Little Smokey. Unpublished report.

Vinge, T. and M. Pyper. 2012. Managing woody materials on industrial sites: Meeting economic, ecological, and forest health goals through a collaborative approach. Department of Renewable Resources, University of Alberta, Edmonton, Alberta. 32 pp.

Von der Gönna, Marc A. 1992. Fundamentals of mechanical site preparation (FRDA report, ISSN 0835-0752 ; 178): http://www.for.gov.bc.ca/hfp/publications/00084/FRDA178.pdf

Appendix A: Current and Past Linear Restoration Program Summaries

Algar Linear Restoration Program

Cenovus Linear Deactivation (LiDea) Program

CNRL Kirby North

Dillon Wildlands Caribou Restoration Project

Little Smoky Pilot Program

Meg Energy Christina Lake

Shell Grosmont

Statoil Linear Deactivation

Suncor Firebag

Regional Industry Caribou Collaboration

CANADA'S OIL SANDS INNOVATION ALLIANCE

Algar Caribou Habitat Restoration

Nexen Energy ULC, ConocoPhillips Canada, Shell, Statoil, Suncor Energy, Total

Overview

The Algar caribou habitat restoration program is focused on restoring linear features within six townships over the course of five years. The project was designed as a proof of concept program with the goal of testing: 1) the feasibility of linear restoration to restore boreal forest habitat; and 2) the feasibility of a large landscape scale collaboration between industrial partners.

A unique aspect of the Algar program was the use of the Landscape Ecological Assessment and Planning (LEAP) process. LEAP was used to model and evaluate different restoration scenarios and project their impacts on caribou habitat, carbon sequestration and quality of late seral stage forests. As of 2014, three of five restoration phases have been completed.

Goals and Objectives

The overarching goal of the Algar program is to ensure restoration efforts produce significant ecological benefits over a broad landscape. Success is defined as:

- Establishing self-sustaining boreal forests on treated sites;
- Demonstrating that leadership and mitigation strategies have positive impacts;
- Restoring ecological function on the landscape for medium and large mammals;
- Restoration of the habitat.

Location

The Algar program is located off-lease and is located south-west of Fort McMurray along the Athabasca River. The site is located within the range of the East Side of the Athabasca River caribou herd.

How was the site selected?

The project team initially considered two project locations, the Algar site and a site within what is now the Gipsy-Gordon Wildland Park. Key criteria used in the selection of the Algar site included: low amount of industrial activity; caribou location data (minimum convex polygons); data from previous work conducted in the area using scat dogs; and the publicly available estimated bitumen value per township.

Site description

The Algar area covers a total of 56,915 ha of which 88% is forested. Black spruce is the dominant stand type representing approximately 66% of the total forested area. Most of the forested area is mature (80 to 119 years).

Treatments

How were lines selected for treatment?

The anthropogenic footprint in the area totals 830 ha, including well pads, seismic lines and pipelines. However, the Algar restoration program has chosen to focus on restoration of only seismic lines. A number of these seismic lines are currently being used by trappers or intersect other footprint types and these lines have been excluded from the restoration program. In total, 392 km of seismic lines (264 ha) were included as part of the restoration program.

A seismic line inventory conducted by Green Link Forestry Inc. was also used to determine which areas had regenerated naturally and, therefore, did not require treatment. Criteria used to determine if lines were sufficiently regenerated included: regeneration is $\geq$ 1.5 m, crown cover density is "C" (51 to 70 percent) or "D" (71-100 percent); and covers 50% or more of the line inventory polygon.

In addition to this inventory, an extensive field inventory was conducted. Ecosite was assigned to each seismic line segment based on the trees and shrubs located on the treatment line and adjacent stands. Additional abiotic factors were also used to assign the ecosite, including:

- moisture regime;
- nutrient regime;
- topographic position;
- slope and aspect.

The field inventory was further used to collect information related to:

- line length and width;
- presence of natural regeneration;
- coarse woody debris presence and sources;
- water course and pipeline crossings;
- accessibility;
- and other operational and logistical information.

What treatments were applied?

Mounding

Mounding was used on all lowland sites or depression upland areas to improve soil drainage and to create an elevated microsite for seedlings. Mounding was completed during the winter with the mounding density being approximately 600 - 1200 mounds/ha.

Planting
Given the dominance of lowland ecosites throughout the treatment area, winter planting of black spruce was the most commonly applied planting treatment. Pine and white spruce were, however, prescribed for seeding on upland sites. The most common planting density used was ~1200 stems/ha, to ensure that final regeneration densities were high enough to meet site restoration objectives.

Woody material
Woody material was applied to lines to improve the microsite conditions, help protect planted seedlings and reduce trafficability along lines. Application rates were increased in areas where high wildlife use was noted and within upland sites to reduce usage of the line. When seismic lines intersected access corridors (e.g., roads) woody material was applied at higher densities to deter human access and reduce line of sight along the line. In general, three strategies were employed for woody material application:

1. Objective: Microsites for vegetation reestablishment; Treatment: CWM applied at rates of 25-50m3/ha to uplands;
2. Objective: Restriction of wildlife movement; Treatment: CWM applied at 50-75m3/ha to uplands;
3. Objective: Microsites for vegetation reestablishment on lowlands; Treatment: 0-25m3/ha to lowlands.

Woody material was generally placed using a mounding excavator. In cases where mounding was not applied to lines, a chainsaw crew was used to recruit woody material onto the line. Woody material was added to lines from the following sources, in order of priority:

- Piled dead trees (roll back)
- Dying or damaged trees (dead standing trees were left as wildlife trees)
- Live deciduous trees
- Live conifer trees

Natural regeneration protection
Segments of treatment lines that showed signs of natural regeneration were protected wherever possible. In some cases, woody materials were also added at low densities to improve site conditions for natural regeneration and to protect existing regeneration. Higher application rates were sometimes used in upland areas as a means of blocking access to existing corridors.

How did treatments vary along lines?

Site prescriptions were developed based on the combined goals of restoring the lines to a condition similar to the adjacent forests, and reducing the access/ease of use of the lines for both wildlife and humans. A combined approach that included: linear inventory; use of the

Alberta Vegetation Inventory; and field verification; was used to develop detailed prescriptions for all segments of the treated lines. Site characteristics used to develop line prescriptions included:

- Ecosite (tree/shrub vegetation characteristics, nutrient regime, moisture regime)
- Presence or absence of existing natural regeneration
- The condition of existing natural regeneration (species, average height, relative abundance)
- Estimated sunlight conditions
- Soil organic layer depth
- Estimated line of sight distance
- Presence or absence of CWM operational sources
- Evidence of frequent wildlife use
- Likelihood of use by industrial/recreational users

Monitoring

Effectiveness monitoring

To ensure monitoring of treatment response over time, a number of biological indicators are being measured. Specific objectives of the monitoring program include:

- Monitoring growth and productivity of planted trees
- Testing LEAP modeling assumptions
- Measuring vertical diversity
- Assessing carbon footprint
- Wildlife usage (passive monitoring through documentation of sightings, tracks or other physical signs to confirm presence of a species)
- Wildlife cameras are also being considered as a monitoring tool

A representative sample of the treatment area has also been selected to capture field based measurements of both pre and post treatment line conditions.

Vegetation plots

Vegetation plots consisted of a 1.78m fixed radius plot, established at the plot centre. Trees within the plot were tallied based on species and height class, while shrubs were tallied within the plots based on height class. Only trees greater than 15cm in height, and shrubs greater than 50 cm in height were included in the inventory.

Line of sight photographs

A series of photos are being collected at each plot to document the change in vegetation response following treatment of the lines. This includes:

- A 360 degree panoramic photo to document the general condition of the line at the plot centre.

- Placement of a 'photo board' at distances of 10 metres and 100 metres from the plot centre, in both directions along the seismic line. Photo boards were placed at a height of 1.2 metres to mimic the average height of the back of a caribou.

Implementation monitoring

Implementation monitoring was also performed for coarse woody materials in order to assess whether target volumes had been achieved on the sites. Transects were established every 200 metres on treated lines. A tape measure was placed in the middle of the plot and extended out 20 metres running parallel to the treated line. When the line crossed a piece of woody material greater than 4cm, the total length and diameter at the middle of the stem was taken. Transects were then used to compile the rate of woody material applied to the lines.

Planning + Logistical Challenges

Stakeholder engagement

Consultation with local trappers was aided through the support of the Government of Alberta, and representatives were able to convey the importance and rationale for the work being conducted. This has resulted in positive interactions with these key stakeholders.

Regulatory approval

Relationships and support within the government for the Algar project have been critical in receiving regulatory approval. Applications for work like the Algar project are typically new for field administrators and therefore require extra effort on the regulators part. Support and by-in about the importance of the program have been critical.

Timelines

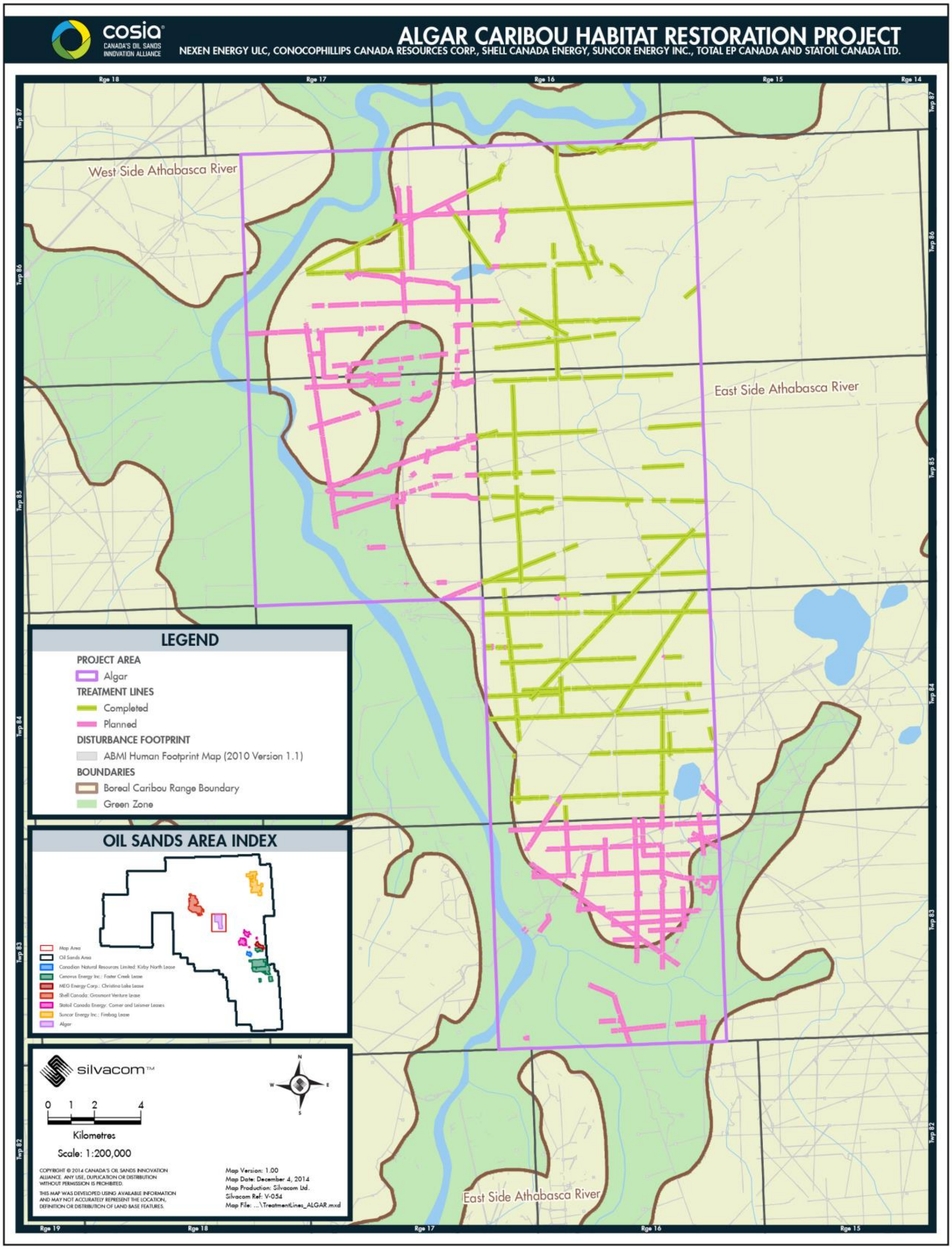
Approvals for the work can take between 6-12 months depending on the scale and complexity of the work being proposed.

Access

The remote location of the Algar project has proven challenging in terms of both logistics and potential safety challenges. To reduce travel time to the site, a remote field camp is established to house the contractors and increase the daily productivity. The Algar project has also relied on positive interaction with CNRL, and the project is dependent on a CNRL winter road.

Equipment

The only equipment related issues that have arisen are related to the lack of cold temperatures early in the season which can greatly complicate operations by reducing frozen ground conditions.


ALGAR CARIBOU HABITAT RESTORATION PROJECT
NEXEN ENERGY ULC, CONOCOPHILLIPS CANADA RESOURCES CORP., SHELL CANADA ENERGY, SUNCOR ENERGY INC., TOTAL EP CANADA AND STATOIL CANADA LTD.
West Side Athabasca River
East Side Athabasca River
East Side Athabasca River
LEGEND
PROJECT AREA
Algar
TREATMENT LINES
Completed
Planned
DISTURBANCE FOOTPRINT
ABMI Human Footprint Map (2010 Version 1.1)
BOUNDARIES
Boreal Caribou Range Boundary
Green Zone
OIL SANDS AREA INDEX
Map Area
Oil Sands Area
Canadian Natural Resources Limited: Kirby North Lease
Cenovus Energy Inc.: Foster Creek Lease
MEG Energy Corp.: Christina Lake Lease
Shell Canada: Grosmont Venture Lease
Statoil Canada Energy: Corner and Leismer Leases
Suncor Energy Inc.: Firebag Lease
Algar
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Cenovus Linear Deactivation (LiDea)

Cenovus Energy Inc.

Overview

The Cenovus Linear Deactivation project (LiDea) includes a small scale experimental trial (LiDea I), and a larger scale proof of concept trial (LiDea II). LiDea I is designed to test different restoration techniques and determine the best way to develop a cost effective, ecologically meaningful linear deactivation program. This includes testing a variety of silvicultural and site preparation treatments and woody debris applications.

Following this smaller scale project, LiDea II has been developed to apply the lessons learned from LiDea I at the scale of four townships. A unique feature of LiDea II is its robust experimental design and monitoring program, which includes the main treatment area and two control areas. Within these treatment and control areas, a suite of variables are being monitored, ranging from site level vegetation response to landscape level wildlife response. A core focus of LiDea II is understanding how to effectively implement linear deactivation techniques at the landscape level. For the purposes of this summary report, most of the content describes the LiDea II program.

Goals and Objectives

1) To restore, on previously disturbed lines, ecological characteristics associated with later seral stage forests;
    a. Increase the abundance and growth of conifers
    b. To influence the distribution of species of management concern, with preference to pre-disturbance conditions.
2) To deactivate, on previously disturbed lines, some of the current undesirable ecological functions;
    a. Reduce trafficability
    b. Reduce sightlines

Location

LiDea I is located within the Foster Creek operations of Cenovus, in the Cold Lake Air Weapons Range. LiDea II is located off-lease in the north-east corner of the Cold Lake Air Weapons Range. The location is within the range of the Cold Lake caribou herd.

How was the site selected?

Because LiDea I was intended as an experimental site – with a focus on testing new techniques – the location was selected on-lease based on exposure and ease of access. By selecting the site in this way, it allowed people to get their 'boots on the ground' and to easily see what was working and what was not in terms of restoration treatments and the corresponding habitat response.

The site of Lidea II was selected in consultation with the Government of Alberta and located within a high priority caribou restoration area – as defined by the province. This high priority area was identified based on information about caribou relocations, historic anthropogenic disturbances and historical fire data. The target area had to meet a variety of criteria:

1. It was significant in terms of caribou habitat;
2. It had sites across a range of moisture regimes;
3. It had a low chance of future anthropogenic development; and
4. It had a low number of seismic lines such that large areas of intact forest could be re-established.

A total of four townships were selected for treatment, forming an area the approximate size of one caribou home range.

Site description

LiDea II is located within a treed bog and fen, interspersed with upland ridges of dry, sandy soil. Black spruce and tamarack are typical of the low lying areas with an understory of sphagnum mosses, Labrador tea and dwarf birch. Upland sites are characterised by jack pine with an understory of black spruce, blueberry, bearberry, feather mosses and lichens.

Seismic line density in the area is low (<1km/km2), however, there are 250km of lines present in the project area.

Treatments

How were lines selected for treatment?

All lines within LiDea II are scheduled for treatment. The area is unique in that it has few land users or tenure holders. This means that limited consultation was required and no lines were required to be left open for access (e.g., for trappers).

What treatments were applied?

Three core questions were used to guide selection of site treatments:

- To what extent will it improve the establishment of coniferous forest on the site?
- To what extent will it impede the movement of large mammals down the line?
- To what extent will it impair the distance one can see down the line?

Based on these questions, consultation with experts and experience gained from LiDea I, three treatments were selected: mounding, planting and woody material application.

Mounding

Mounding was used on all lowland sites (that could be accessed). Mounding was completed during the winter with the mounding density designed to mimic the density of the surrounding forest (~1300 mounds/ha). Mounds were targeted to be large in size, with a target of 1 metre deep, 1 metre long and 0.75 m wide. Mounds were distributed irregularly on the lines such that there was no clear linear path down the line.

Planting

Planting was completed in the summer months with black spruce (Picea mariana) and tamarack (Larix laricina) being planted on wet sites, jack pine (Pinus banksiana) and black spruce being planted on mesic sites, and jack pine planted on upland xeric sites. Summer planting enabled a more diverse selection of species to be planted (as opposed to winter planting of black spruce) and provided efficiencies in planting of uplands and lowlands during the same season. Planting density varied based on the density of the surrounding stands, density of natural regeneration and the number of available planting sites.

Woody materials

Woody material was applied to lines based on achieving three key objectives:

- access management;
- ecological continuity and function; and
- vegetative abundance and growth rates.

Treatments also helped to alter the physical conditions on the line by increasing the average size of coarse woody material and reducing shading on the line (via recruiting wood from stands adjacent to the edges of lines via thinning).

Woody material was applied to sites by either spreading existing woody material (roll back) or by thinning stands adjacent to the lines (tree felling). For the tree felling, operators were instructed to recruit up to 1 tree in every ten (i.e., up to 10%) and preference was for thinning the south or west sides of the lines to reduce the shading on the lines.

In some cases, 'stem bending' was used in place of tree felling (photo at right). This technique, developed by Woodlands North and Cenovus, used machines to bend trees over the line with the goal of maintaining root contact with the soil. These trees were then intended to function as additional visual obstructions and maintain their needles for longer than trees that were felled onto the lines.

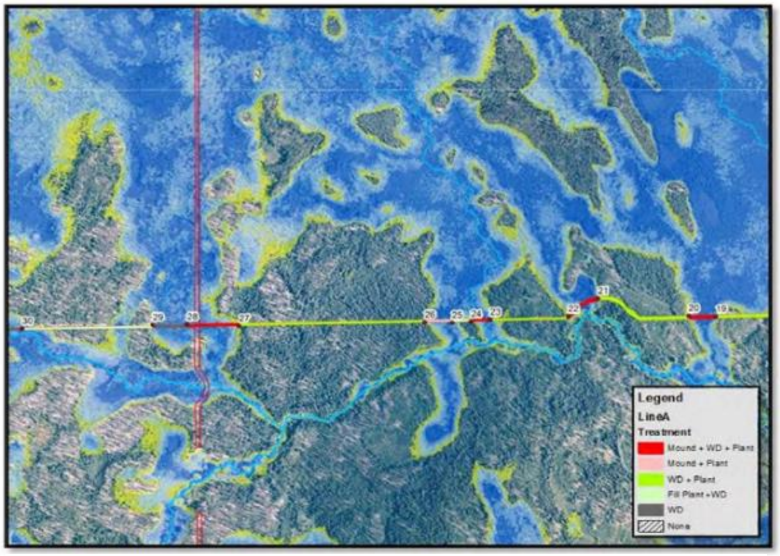
In addition, the stress induced by the stem bending was anticipated to create a seed crop from the trees, aiding in natural regeneration along the lines.

How did treatments vary along lines?

Treatment application varied along lines based on the ecological conditions present. The range of treatment combinations included:

- Mounding + planting + woody material recruitment
- Mounding + planting
- Planting + woody material recruitment
- Fill planting + woody material recruitment
- Woody material recruitment
- Leave for natural

Specific locations for treatments were assigned based on a combination of site reconnaissance, high resolution aerial imagery (1:10,000) and modeling of predicted streams and depth to water. Site specific treatments were then assigned based on this combined information.



An example of the pre-treatment inventory used to assign treatments to sites.

Monitoring

Effectiveness monitoring

An extensive monitoring system has been developed for the LiDea sites. As part of this, a suite of variables are being considered, ranging from site level vegetation response to landscape level wildlife response.

Monitoring of the response to treatments is aided by an unprecedented experimental design. This design includes the treatment area, and adjacent untreated but similarly disturbed site (Control A in image below) and an undisturbed and untreated site (Control B in image below).

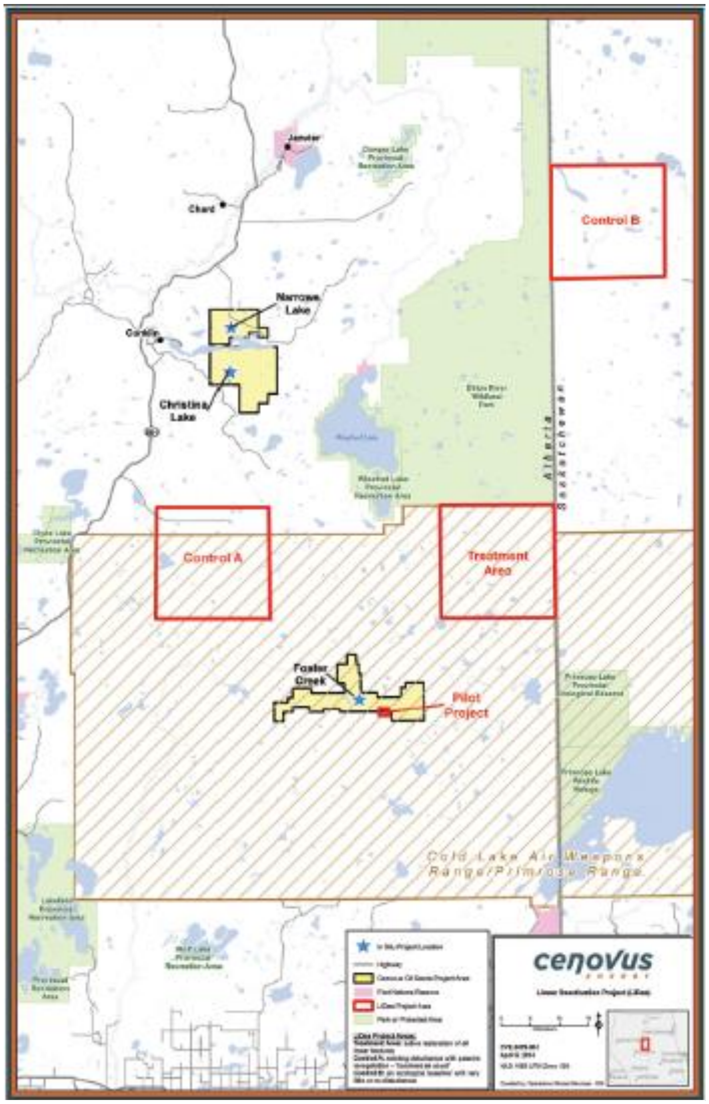
Habitat response

Standard vegetation measurements are being performed, including measurement of height, diameter, vigour and density of vegetation response. Coarse woody material along lines is being measured through the use of linear transects. Photographs will also be taken at a height of 1.3 metres to measure the canopy light transmission onto the lines. Finally, a helicopter fitted with a forward looking infrared radiometer (FLIR) is being used to monitor vegetation levels on lines, and any vegetation recovery following treatments.

Wildlife Response

Track counts are being used to monitor wildlife response to the treatments applied. This includes establishing transects along treated lines and within control areas to assess treatment effects. The protocols for the track surveys are similar to those used by the Alberta Biodiversity Monitoring Institute (ABMI 2010). Motion triggered cameras are also being used to assess use of lines by different species.

GPS radio collars are also being used to monitor individual level responses by caribou, moose and predators to the LiDea treatments. Caribou collaring is being handled by Alberta ESRD as part of their provincial level monitoring program. In addition to this, a total of ten wolf packs are targeted for collaring and 15 moose. Animal locations are being used to monitor: a) use of linear features by species; b) identify kill sites and their proximity to linear features; and c) determine natural mortality and their proximity to linear features.



Map showing design for wildlife monitoring, including two control sites.

Results to date

While monitoring is in its early stages on the LiDea project, there are a few short term responses that have been noted. The first is that untreated seismic lines are functioning as a soft barrier to small mammal movement. However, both mounding and application of coarse woody debris seems to have reduced this barrier effect, particularly for the small mammal community (e.g., voles). Additional monitoring results are anticipated in both the short and long term.

Planning + Logistical Challenges

Stakeholder engagement

Stakeholder engagement is an ongoing priority for LiDea II, however the consultation process for LiDea is simplified because of its location in the Cold Lake Air Weapons Range. Primary stakeholders include the Cold Lake First Nation, and the Ministry of Defence.

Regulatory approval

Relationships have proven to be a very important component of the regulatory approval process. Establishing relationships early on and fostering those relationships is a key learning from LiDea. This includes relationship building with both the local biologists and the land officers.

Timelines

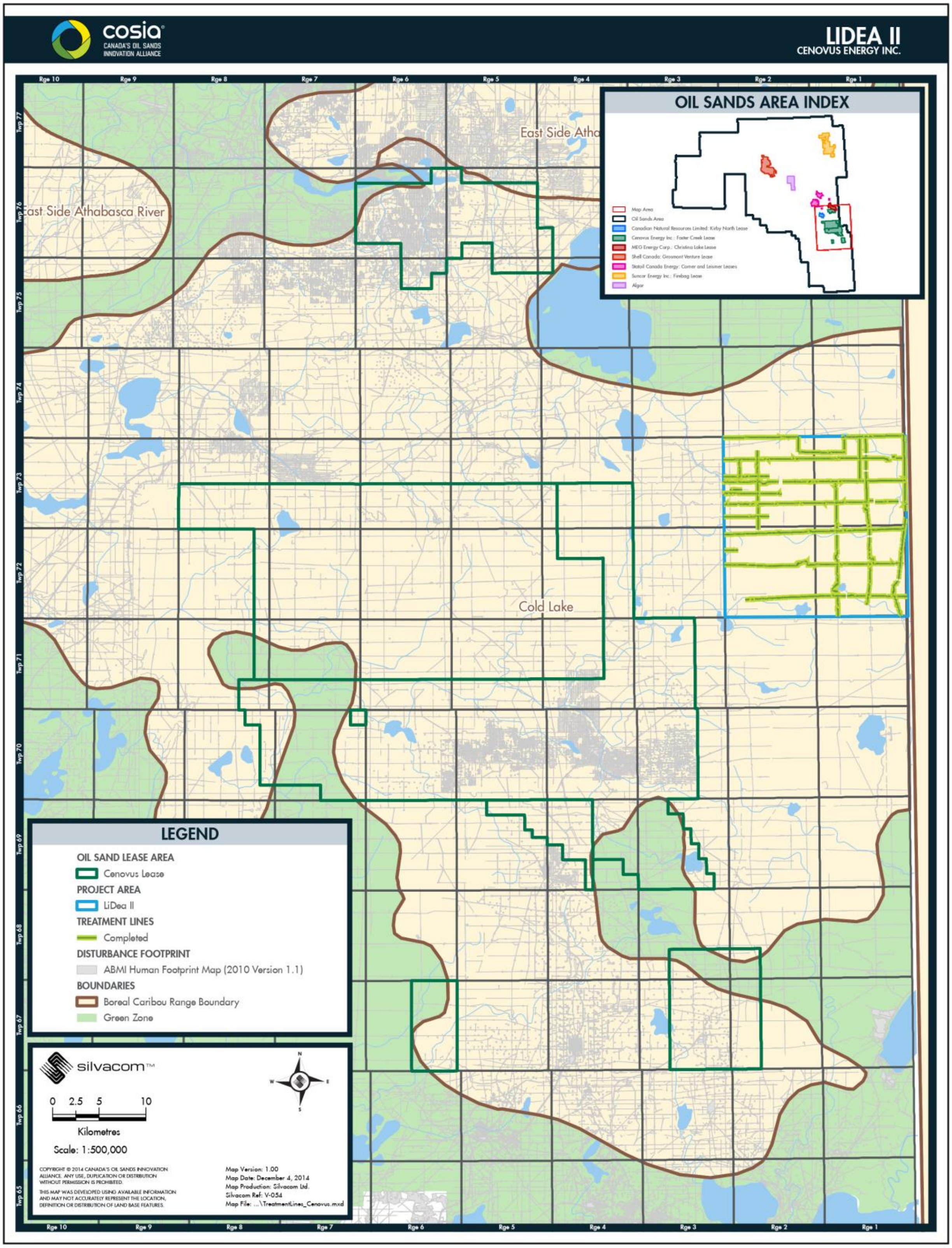
Approvals for the work can take between 6-12 months depending on the scale and complexity of the work being proposed.

Access

Access into the site has been aided by an all-weather access road that enters the treatment site.

Equipment

The only equipment related issues that have arisen are related to the lack of cold temperatures early in the season which can greatly complicate operations.


cosia CANADA'S OIL SANDS INNOVATION ALLIANCE
LIDEA II
CENOVUS ENERGY INC.
OIL SANDS AREA INDEX
East Side Athabasca River
Cold Lake
LEGEND
OIL SAND LEASE AREA
Cenovus Lease
PROJECT AREA
LiDea II
TREATMENT LINES
Completed
DISTURBANCE FOOTPRINT
ABMI Human Footprint Map (2010 Version 1.1)
BOUNDARIES
Boreal Caribou Range Boundary
Green Zone
silvacom
0 2.5 5 10
Kilometres
Scale: 1:500,000
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CANADA'S OIL SANDS INNOVATION ALLIANCE

CNRL Kirby North Linear Deactivation

Canadian Natural Resources Limited (CNRL)




Overview

Canadian Natural Resources Limited (CNRL) operates the Kirby In Situ Oil Sands Expansion Project ("Kirby Expansion Project"), which is an in situ oil sands project that uses the steam assisted gravity drainage (SAGD) recovery process. The project lease area is ~28,700 ha in size and occurs within the East Side of Athabasca River (ESAR) caribou range and located adjacent to the north-west boundary of the Cold Lake Air Weapons Range (CLAWR).

CNRL has developed an on-lease deactivation and restoration program of legacy linear features. Treatments to be used in the program include tree-felling or bending, fencing, mechanical site preparation, planting of tree seedlings, application of coarse woody material (CWM), and combinations thereof. Suitable sites were initially selected based on a desktop analysis and then verified with a helicopter overflight. Field work was conducted in February 2014; a tree-felling deactivation treatment was applied across six legacy seismic lines for a cumulative length of 4.75 km. Trees were felled at 15-20 m intervals, with downed trees oriented perpendicular to the axis of the seismic line. To reduce line-of-sight down a line, felled trees were positioned back on to the cut stump when possible. Pending suitable ground conditions for access, additional work will occur in winter 2015. Effectiveness monitoring will be done in collaboration with a graduate research project at the University of Alberta.

Goals and Objectives

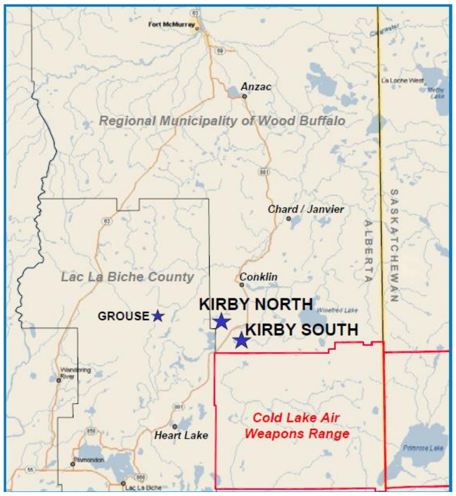
CNRL's linear feature deactivation and restoration initiative has the following objectives:

1. access control targeting pre-existing human and predator access along legacy linear features and potentially active dispositions such as Licence of Occupation (LOC) and Pipeline Agreement (PLA);
2. line-of-sight blockages for predators where natural topography or bends in the features do not exist; and
3. directly restore habitat by introducing tree and shrub seedlings and enhancing the recovery of naturally occurring and introduced vegetation. [1]

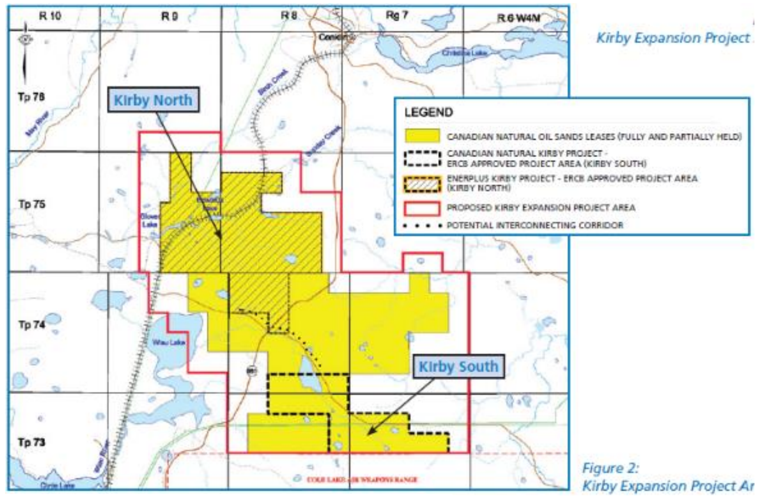
[1] The Kirby Expansion Project occurs within the Athabasca oil sands area and amalgamates two approved projects - Kirby South (KS) and Kirby North (KN). Kirby South was approved in 2010 for bitumen production of 45,000 bbl/d; Kirby North was also approved in 2010 for bitumen production of 10,000 bbl/d. Project expansion will occur in several phases and will result in a total bitumen production of 140,000 bbl/d over approximately 30 years.

Location

The Kirby Expansion Project occurs primarily in the Regional Municipality of Wood Buffalo and is located approximately 75 km northeast of Lac La Biche and 10 km south of Conklin. Small portions of the project lease extend in to Lac La Biche County.



Location of CNRL Kirby North program



CNRL Kirby North Lease Area

Site description

The Kirby Expansion Project Lease occurs within the Central Mixedwood Natural Subregion of Alberta, which is characterized by a cool, moist boreal climate conducive to the growth of mixed aspen-spruce forests. It also contains a high proportion of poorly drained wetlands dominated by wooded bog-poor fen, wooded fen and non-treed wetlands.

Treatments

How were lines selected for treatment?

Candidate sites for linear deactivation and restoration were initially selected based on a desktop exercise, which applied multiple considerations.

- Treatments would not be applied in areas where the Kirby Expansion Project footprint would grow due to infrastructure build-out or key activities such as seismic programs and drilling oil sands evaluation wells, which would continue throughout development of the Project to delineate the underlying bitumen.
- Treatments would not occur within areas of recently burned, young forest (i.e., < 40 years old), because those areas are not considered to be suitably old to provide functional caribou habitat.
- Candidate treatment sites were identified by overlaying Project development plans, wildfire maps, and an inventory and interpretation of vegetation regeneration on linear features based on remote sensing with LiDar (completed by HabTech).

- If possible, treatments would occur within areas of current or historical use by caribou; available telemetry data for boreal caribou in the region was reviewed to define patterns of range use.
- Using available data for the region, the historical 'legacy' disturbance footprint and potential access corridors for implementing treatments within caribou range was reviewed and mapped.
- Access to treatment areas would be based on existing potential corridors and not rely on creating new access or disturbing vegetative on potential linear features.
- Trap-line holders were consulted to confirm locations of their trap-lines and access routes, and to plan treatment areas to avoid potential conflicts.
- Legal disposition of potential treatment and access sites was checked through a Land Status Automated Search (LSAS).
- Availability of coarse woody material and merchantable timber stands was assessed from the Canadian Natural Kirby North 2014 development plans. This information was used to determine logistics of sourcing coarse woody material on-site, or whether material could be efficiently transported from new clearings.
- Available data on wolf locations and movements was reviewed so that treatment sites could be selected in areas that had an existing baseline of information. These baseline data could contribute to monitoring treatment effectiveness and also support a graduate research project on wolf ecology by M. Dickie at the Integrated Land Management Lab, University of Alberta (Supervisor: S. Boutin)[2]

Following, the desktop assessment to identify candidate treatment areas, a helicopter reconnaissance flight was conducted to confirm field conditions and to select the lines that would receive deactivation treatment.

What treatments were applied?

Treatments were conducted over a 5-day period in February 2014. Heavy equipment such as excavators was not used because of time constraints, so restoration treatments were restricted

Site reconnaissance at CNRL Kirby North

Tree felling at CNRL Kirby North

[2] http://www.biology.ualberta.ca/faculty/?Page=111208

to tree-felling across linear features. The tree-felling deactivation treatment was applied across six legacy seismic lines for a cumulative length of 4.75 km. Trees were felled at 15-20 m intervals, with downed trees oriented perpendicular to the axis of the seismic line.

Tree-felling sites were located closer together at intersections of linear features to further deter access. Merchantable trees, i.e., ≥ 15 cm diameter at breast height, were preferred because the larger size of stems and branches created a larger visual barrier. However, depending on characteristics of the adjacent forest, non-merchantable trees were also used.

To reduce line-of-sight down a line, felled trees were positioned back on to the cut stump when possible.

Example of tree hinging treatments

How did treatments vary along lines?

Tree-felling treatments were applied along sections of a seismic line. The average length of treatment on a line was 0.8 km with a range of 0.17 – 1.36 km.

Monitoring

Effectiveness monitoring

Effectiveness monitoring will be established to determine if the deactivation treatments have a measurable effect on reducing wolf travel rates. The monitoring program will be done in collaboration with a University of Alberta graduate research project.

Planning + Logistical Challenges

Stakeholder engagement

Engagement of local trap-line holders has been important to address immediate concerns related to the linear feature deactivation project.

Regulatory approval

Approval to conduct linear deactivation activities was obtained through the Temporary Field Authorization process (TFA) through Alberta Environment and Sustainable Resource Development. TFA applications were based on three different activity classes including fencing, reforestation, and tree falling/woody debris. The maximum one year approval limit was sought for each application to allow for flexibility in applying treatments and to account for the longer duration required for reforestation activities. The current TFAs expire in February 2015.

Access

Access to treatment areas was based on existing linear features, subjected to a check on disposition.

Equipment

To date, the field work has been conducted by crews accessing the site by snowmachine. It is anticipated that heavy equipment will be used in future, which will facilitate additional treatments including site preparation and planting.

Future plans

Project specific plans

Additional restoration treatments will be applied to linear features in winter 2015 once ground conditions are suitable for field access.

Key References

Canadian Natural Resources Limited. 2011. Proposed Development Plan: Kirby In Situ Oil Sands Expansion Project – Plain Language Project Summary. 11 pp.

Canadian Natural Resources Limited. 2011. Kirby In Situ Oil Sands Expansion Project. Volume 5 – Terrestrial Resources. Environmental Impact Assessment and Application for Approval. 387 pp.

Duffy, G., and P. Bentham. 2014. Canadian Natural Resources Limited Kirby North Linear Deactivation Report. Golder Associates Ltd., Edmonton, AB. 23 pp.

Dillon River Wildlands Caribou Habitat Restoration

Alberta Pacific Forest Industries Inc., Trans Canada Pipelines Ltd., Alberta Parks, Alberta Environment and Sustainable Resource Development

Overview

The Dillon Caribou Habitat Restoration Project is a collaborative project undertaken to offset the residual effects of the development of the Trans Canada Pipeline Ltd. (TCPL) Leismer to Kettle River Crossover pipeline project and the Northwest Mainline Expansion project. As part of the development of these pipeline projects, approvals were subject to conditions set by the National Energy Board relating to the need to conduct restoration activities to offset the residual effects of TCPL activities on caribou habitat as outlined under the federal Caribou Habitat Recovery Strategy. Phase 1 of the restoration project was implemented by Alberta Pacific Forest Industries in the summer 2014.

The habitat restoration program is located within the recently proposed Dillon River Wildland Park and focuses on a portion of the East Side Athabasca Range. While heavy equipment was not used on the project, a variety of silvicultural treatments including coarse woody materials, tree planting, and microsite creation were applied on the site. The treatments were completed in summer 2014 and a program is in place to monitor the response of treatments over time.

Goals and Objectives

The core objectives of the Dillon River Wildlands Caribou Habitat Restoration Project are:

- Revegetation to promote a ‘natural forest trajectory’ in the mid to long term;
- Access management to inhibit access by humans and promote vegetation establishment in the short to mid term;
- Use of non-palatable species for revegetation
- Coarse woody material treatments to promote microsite development and natural recovery in transitional/wetter habitats that traditionally would be mechanically treated.

Location

The Dillon Habitat Restoration project is located within the Dillon River Wildland Park, south east of Ft. McMurray, and includes a portion of the East Side Athabasca caribou herd. The wildland park is located along the Alberta/Saskatchewan border and was recently proposed as part of the Lower Athabasca Regional Planning process of the Alberta Land Use Framework.

How was the site selected?

Site selection for the restoration program took into consideration:

- range planning directives based on discussions and consultation with provincial and federal agencies
- areas with no or minimal traditional use needs based on consultation with local Aboriginal communities
- areas of lower potential for future bitumen or hydrocarbon extraction, including existing infrastructure; pipeline and transmission corridors
- areas adjacent to, or in close proximity of existing/developing research and monitoring programs with focus on habitat restoration or other wildlife/landscape management objectives; and,
- areas (i.e. linear features or other available footprint) with minimal or no further industrial access requirement, including known recreational access where feasible.

Site description

The Dillon restoration project covers approximately five townships with 300+ km of linear features including several active LOCs. Most of the linear features are legacy features that are 15+ years old, and there are varying stages of regeneration along the lines (ranging from minimal to advanced regeneration). The site is remote and is located more than 30 kilometres from all-weather access roads. The remote location and advanced regeneration meant that use of heavy equipment was not feasible without causing significant damage to the advanced regeneration and required delivery of the program entirely by helicopter.

Forest composition is a mix of jackpine-white spruce or deciduous dominated mixedwoods on the uplands, intermixed with extensive fen and black spruce/tamarack lowlands. The jackpine uplands are open with extensive lichen/blueberry mats and sandy soils while the deciduous mixedwoods have dense shrubby understories and deep, rich soils. Linear features and game trails are prevalent throughout the area especially within the jackpine uplands where revegetation along linear features may be slower to respond.

Treatments

How were lines selected for treatment?

Alberta-Pacific's Alberta Vegatation Inventory (AVI) and many other spatial data sets were used, along with LiDAR and a detailed linear feature inventory, to determine current condition of linear features in terms of advanced regeneration. The next step was to identify sites that could be planted based on a set of silvicultural criteria, as well as sites for natural recovery and coarse woody material applications. Tree planting treatments combined with coarse woody material were applied to upland sites while transitional habitat types were treated with coarse woody material to promote natural recovery in the study area. Open fen and wetland areas were not treated. In total, approximately 104 hectares were treated.

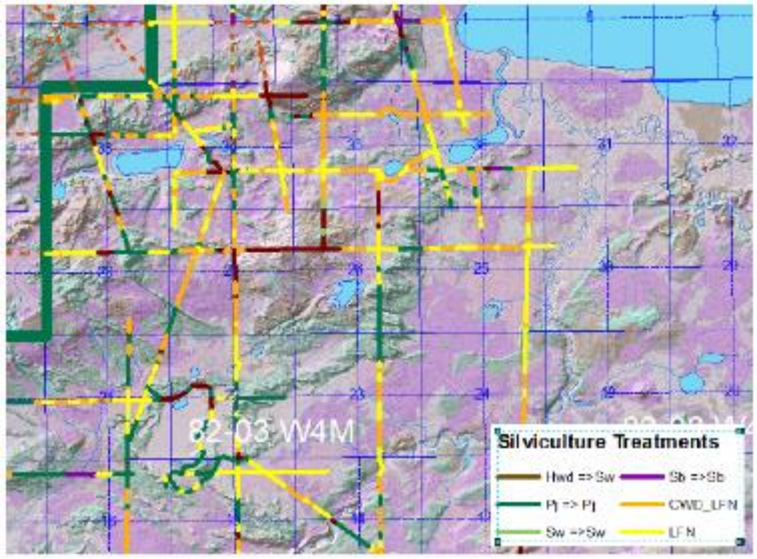
What treatments were applied?

When assigning treatments to linear features, a variety of decision criteria were used to prioritize activities including:

- Placing priority on upland or transitional habitat types as they generally provide favorable conditions for habitat restoration and are presumed to facilitate predator and primary prey mobility within the range;
- Using existing biophysical conditions to maximize offset effectiveness. This includes capitalizing on terrain complexity and available coarse woody material;
- Understanding existing linear feature condition (i.e., successional state, terrain complexity) to facilitate, enhance and accelerate offset effectiveness;
- Using adjacent habitat condition as a measure to facilitate, enhance and accelerate equivalent ecological processes of the locations.

Planting

Planting treatments were assigned to sections of linear features based on ecosite, topographic position (upland, lowland, transitional), timber productivity rating (a metric of potential productivity of a stand based on the height and estimated age of dominant and co-dominant trees adjacent to the line) and current condition.



Pre-treatment inventory used to assign site treatments

Species selected for planting (based on site characteristics above) included jack pine, white spruce, and black spruce. Planting density was typically 1500-2500 stems per hectare.

Woody material

Depending on the site characteristics and restoration objectives, woody material was applied to sites in one of three ways:

- Application of coarse woody material along the full length of the line to limit human access
    - Treatment was generally applied to upland and transitional spruce sites
    - Variable spacing was used with volume targets of 60m3/ha

  - Stumps were generally hinged and left taller to increase visual obstruction
  - 25m fire breaks were applied every 250m
- Application of coarse woody material along the full length of lines to promote natural regeneration
  - Treatment was applied to black spruce sites where straight planting would likely not succeed and mounding would traditionally be used
  - The objective was for trees to serve as future microsites for seed establishment and promote development of `hump and hollow' topography
  - Trees were de-limbed so that the bole was no more than 30 cm from the ground
  - Target volume was 30-50m3/ha
  - 25m fire breaks were applied every 250m

Leave for natural and/or natural regeneration protection
In lowland sites where planting was unlikely to be successful due to soil/moisture conditions, woody material was applied and the sites were left for natural regeneration. Based on discussions with Tim Vinge, AESRD, the program decided to apply woody material within black spruce sites to promote the development of hump and hollow topography which would provide seedling microsites in the future. The limitation with this treatment was the availability of suitable trees to use for the woody material application. In many of the poorer quality lowlands the trees were not high or dense enough to use for the woody material treatment. In addition some of the richer, upland sites that showed significant natural regeneration were treated with a woody material access management application only and left to continue on their established successional trajectories.

How did treatments vary along lines?

Treatments were adjusted based on ecosite and site conditions along the lines. A minimum treatment unit of 200 m was used to develop silvicultural treatments and adjust for changing site conditions.

Monitoring

Effectiveness monitoring

A combination of aerial and ground-based plots are being used to assess site performance at intervals of 1, 3 and 5 years following treatment. The plots will be used to assess:

- Vegetation establishment and growth
- Evidence of human access
- Line of sight measures
- Incidental wildlife signs

The aerial program will be used to survey approximately 1240 plots along 124 kilometers of treated lines. The goal is to collect detailed biophysical data and relate this information to targets and restoration performance criteria.

Ground based plots will also be used to: verify aerial results; provide details on species composition and ecological conditions; and to confirm that treated sites are on a trajectory towards establishment of natural ecosystem types. A total of 15 ground based plots will be surveyed per treatment type per year.

Implementation monitoring

Al-Pac personnel worked on site during restoration activities to assure quality control and oversight of all activities. All treatment areas were flown to confirm treatment applications and rates. A subset of sites were selected for permanent sample plots to track survival and growth. Plots were established in each forest/treatment type combination and will be measured periodically over the next 5 years.

Planning + Logistical Challenges

The collaboration among project partners provided a dynamic planning environment and an integrated approach to implementation.

- Al-Pac: Project planning and coordination, liaison with project partners, logistics planning and operational delivery
- TransCanada Pipelines Ltd: developed caribou habitat offset management plan and direct liaison with National Energy Board. Provided funding for field component and monitoring.
- Alberta ESRD: provided advice on project methodology, local knowledge on caribou habitat and utilization, and assisted with application approvals. Assistance with development of helipads.

Stakeholder engagement

A total of three trapping areas fell within the Dillon restoration project. Preliminary consultation was conducted with the trappers and additional outreach was performed once the final plan was complete. One of the trappers asked that a section of two lines be left open to provide future access. This was readily incorporated into the project design, as well as consideration of existing LOCs that remain active and could not be restored at this time.

The contractor who applied the coarse woody material treatments was from the nearby community of Janvier.

Regulatory approval

Approval obtained from ESRD via a TFR application. Parks was instrumental to moving the project proposal and approval process quickly ahead to meet project timelines. There was also a signed agreement of intent between the collaborating agencies.

Access

Helicopter access for all aspects of project including aerial reconnaissance prior to treatment, delivery of planters, contractors and trees on daily basis to treatment sites and establishment of monitoring plots.

Overview

The Little Smoky caribou range houses some of the first linear restoration trials in Alberta. A number of activities were undertaken in this area under the leadership of the Caribou Range Restoration Project (CRRP). The program was in operation from 2001 to 2007 with the goal of testing a variety of linear restoration techniques to speed the recovery of historical linear features. Trials as part of this program included mounding, slash rollback, tree planting, transplanting live trees from the adjacent stand, signage installation and fencing trials.

In addition to these various trials, the CRRP managed a large scale habitat restoration pilot program in association with Suncor Energy and ConocoPhillips. The pilot was developed as part of an application by Suncor Energy and ConocoPhillips to construct a 102 km gas pipeline in the Little Smoky range. This project tested a range of methods including slash rollback, mounding, tree planting, and fencing trials. The most complete documentation available for work completed in the Little Smoky range is for this project. Thus, it is the main focus of this summary.

Goals and Objectives

The Little Smoky habitat restoration pilot identified three main goals as described in the May 2005 implementation and monitoring report prepared by Suncor and ConocoPhillips:

1) Apply restoration techniques to speed the recovery of historical man-made linear features on a portion of the Little Smoky Range to reduce the negative effects of these features on caribou, including reducing permeability of caribou habitat to predators;
2) Work in consultation with government, industry, academics and other interested and affected stakeholders to develop and implement the pilot; and
3) Advance understanding of the practical and scientific aspects of habitat restoration in caribou ranges and its potential role in the recovery of woodland caribou populations.

In addition to defining these goals, the program also established broad objectives to assist with learning and evaluating success of the program. These included:

1) Use restoration techniques that will facilitate aggregation of existing patches of caribou habitat that have resulted from historical linear disturbances.
2) Use restoration techniques that will begin immediately to impede the movement of wolves within the selected pilot area in the Little Smoky range.
3) Restore cutlines using tree species and techniques that will expedite establishment of tree cover suitable for caribou habitat.
4) Use techniques that will discourage public access on cutlines where restoration work has been carried out.
5) Achieve long-term retention/sustainability of restoration work through effective communications and consultations with all potential land users.
6) Analyze costs of applying restoration techniques for a large scale project located in a multi-use land base setting.

Location

The restoration pilot program was conducted within the Little Smoky Caribou range, in west-central Alberta. Developing specific locations for treatments within the Little Smoky range made use of significant analyses and planning to select the treatment area. Caribou location data, a resource selection function and forest cover data were first used to analyze the entire Little Smoky range. Through this process a total of three candidate areas were considered for further analysis.

Through consultation with researchers from the University of Alberta, the Alberta Government, the CRRP and the two primary forestry companies in the area, a single site was selected for restoration treatments. Subsequent outreach to the oil and gas industry occurred to obtain support for the restoration area. This outreach led to an agreement that if restored areas had to be re-disturbed, an equivalent amount of habitat would be restored.

Site description

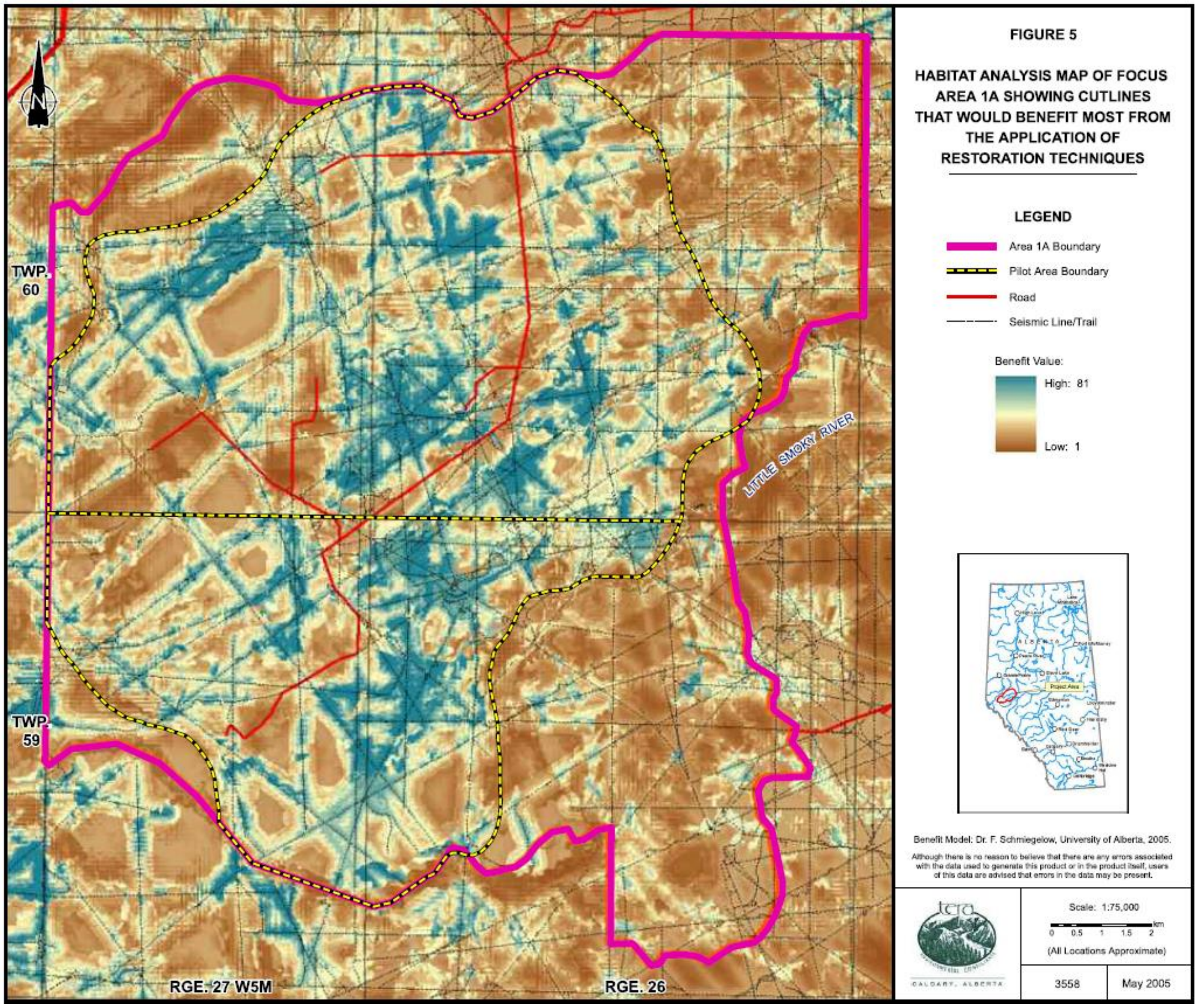
The study area contained large amounts of black spruce lowlands, pine uplands, and black spruce/tamarack covered muskeg. The area included over 500 km of seismic lines, pipelines and access corridors.

Treatments

How were lines selected for treatment?

Following the extensive process used for site selection, consultation with trappers occurred. Through this process, cabin locations and access routes were identified for exclusion during the restoration program. In addition to this, further analyses were used to highlight the portions of linear disturbances where restoration would potentially result in the greatest benefit to caribou in the Little Smoky range.

The study area was also broken into a total of 22 treatment units and a specific treatment prescription was developed for each unit (i.e., species to be used in planting, locations for site preparation, specific logistical considerations like pipeline crossings and creek crossings etc.).



An example map showing how caribou habitat use informed selection of linear features for treatment.

What treatments were applied?

Mounding

Mounding was used as a treatment across a large portion of the Little Smoky Pilot program. Mounds were applied using an excavator and a ‘dual path’ mounder was also used over a large portion of the site (Tim Vinge – *personal communication*).

Planting

A variety of species were planted during the summer months throughout the pilot area. On appropriate sites, straight planting occurred while on other sites planting occurred following mounding and other site preparation treatments. Black spruce, white spruce and pine were used in the planting program. Alder was also used to increase the rate of vegetation growth on some sites.

Woody material
Where possible, slash rollback occurred along the lines and capitalized on historical slash piles from the original clearing of the seismic lines. Trees were also felled at regular intervals on some lines to test the effects of felled trees on reducing wolf movement efficiency and use of lines.

Plywood fences
Plywood fences were installed in numerous locations, typically when a seismic line intersected a main access route. The main objective of the fence installations included: reducing the visibility and access for predators and primary prey; protecting vegetation growth at the beginning of lines; and reducing human use of the lines.

Natural regeneration protection
Where significant regeneration had occurred on lines, regeneration was protected.

How did treatments vary along lines?

Intersection of cutlines with roads
Treatments applied at intersections with roads focused on discouraging predator use and discouraging public use of lines. Treatments were proposed for the first 200 metres of lines, except where longer treatments were warranted. A combination of site preparation, slash rollback, signage, tree falling, fencing, planting seedlings, and transplanting larger trees from the adjacent forest were considered.

Intersection of cutlines with cutlines
Treatments applied at these intersections were focused on reducing the value and use of intersections as movement corridors for predators. Proposed treatments were focused on treating the intersections, as well as the first 200 metres of lines in either direction from the intersection. Techniques proposed, in order of priority, included: site preparation, slash rollback, transplanting trees from the adjacent forest, planting of trees and alder and tree felling.

Lines between intersections
Treatments applied along the remaining length of lines were focused on establishing forest cover to fill in lines over time. Proposed treatments included site preparation to decompact soils and create microsites, and planting of trees and alder where appropriate.

Monitoring

The proposed monitoring program was both robust and extensive. However, it is not clear to what extent the monitoring was executed. Regardless, the effort and insights offered by the proposed monitoring program are very useful for future projects and thus are included here for reference:

- Aggregation of habitat patches
  - Measurable: Projected size distribution and habitat quality of contiguous patch sizes that would become re-established over time.
  - Method: GIS Analysis
- Effect of restoration techniques on wolf movement
  - Measurable: Sets of wolf tracks on treated versus untreated lines
  - Methods: Winter snow track counts on treated vs. untreated lines via aerial surveys
- Re-establishment of tree cover suitable for caribou habitat
  - Measurable: Survival and growth of trees
  - Methods: Monitoring of representative sample plots
- Public access use of restored lines
  - Measurable: Extent of public use of restored linear features.
  - Methods: Use of trail counts or strategically placed recording systems.
- Long term retention/sustainability of restoration
  - Measurable: Extent and source of industrial activity in restored areas.
  - Methods: Tracking of industrial activity in restoration pilot area
- Cost analysis of restoration planning and implementation.
  - Measurable: Cost of various components associated with planning
  - Methods: Analysis of costs associated with various components.

In addition to this proposed monitoring, Vinge and Lieffers (2013) conducted an informal assessment of previously treated lines 3-7 years after treatments were delivered. Some of their key findings from the monitoring program are captured verbatim here:

1. *There was relatively poor growth of planted spruce on the linear corridors of the Little Smokey Restoration efforts.*
2. *For planted seedlings, mounding was somewhat better than straight planting.*
3. *On upland sites of this natural subregion, mixing organic and mineral soils or mounding are likely to improve performance of planted seedlings. Rollback of slash also appears to be beneficial for the recruitment of trees and other vegetation on these sites.*
4. *At the current time, black spruce planting (especially large stock) may not be particularly effective on upland sites. Pine stock appeared to grow better.*
5. *There were some sites where soil compaction was an issue. These sites need to be identified with records of historic use of the lines and/or soil sampling. They likely should be deep ripped to reduce soil bulk density.*
6. *When making mounds, care must be taken to connect the mineral caps of mounds with the mineral soil below with a strip of mineral soil (hinge). On upland sites, seedlings may actually be planted on this hinge position. If seedlings are planted on top of the mounds, they probably should be planted deeper than the root collar in order to minimize effects of frost heaving or soil creep and penetrate the LFH layer below the mound.*

7. *Mounds on dry sites appear to trap water, thereby retaining this water on the site instead of allowing it to run off.*
8. *Mounding and slash placement appear to be a good treatment for both planted and natural regeneration.*
9. *Slash placement on lines appears to dissuade wildlife use of lines (preliminary observation). Lines that had no slash placement had game trails while lines that were mounded and/or had slash placement did not have game trails.*
10. *On organic sites mound generated elevated spots on the flat topography of seismic lines. Black spruce grew quite well on these elevated positions, thereby partially overcoming the problems of anaerobic soils of peatlands.*
11. *Some peatland sites had impeded drainage because of road construction that will prevent full success of restoration activities.*
12. *Reforestation of linear corridors will require that planners select different species, and different microsite treatment/selection within a relatively short distance of linear corridor. This level of planning and different treatments will be expensive, but likely needed if reforestation is to be successful.*
13. *Without exceptional effort and expertise, we recommend a simpler approach to tree regeneration on upland linear corridors that is likely to yield success. We suggest using natural regeneration systems. A combination of rollback of slash and topsoil and mechanical site preparation such as mounding would be a good general purpose treatment to achieve natural regeneration on most corridors.*
14. *We recommend formal study of two issues: does the combination of mechanical site preparation and slash rollback provide a consistently high level of success of regenerating forests on these lines. Secondly, do these treatments reduce the use of these lines by large mammals?*

Key References

Little Smoky Habitat Restoration Pilot: Implementation and Monitoring Plan. Prepared by Suncor Energy Inc. and ConocoPhillips Canada. May, 2005.

Little Smoky Caribou Habitat Restoration Pilot Project: 2006/2007 Field Work Plan. Prepared by Brian Coupal (Caribou Range Restoration Project), John Ward (Suncor Energy) and Jordan Kirk (Canadian Forest Products). January, 2006.

Vinge, T. and V. Lieffers. 2013. Evaluation of forest reclamation efforts on linear corridors of the Little Smokey. Unpublished report.

MEG Energy Christina Lake Regional Project (CLRP)

MEG Energy Corporation




Overview

The Christina Lake Regional Project (CLRP) is currently the focus of MEG Energy Corporation's *in situ* oil sands development. Comprised of ~ 21,200 ha of oil sands leases, the CLRP is a multi-phased project that uses steam assisted gravity drainage (SAGD) bitumen recovery technology; it currently has regulatory approvals in place to produce approximately 210,000 bpd.

In order to meet approval conditions, regulatory requirements and align with the Woodland Caribou Policy for Alberta, MEG has developed a woodland caribou mitigation and monitoring program and caribou habitat restoration plan. This plan includes a provision for maintaining and restoring caribou habitat. In line with the broad habitat management goals, in December 2013 MEG started an inventory of existing disturbances for nine townships within and surrounding the CLRP lease as a first step to identify habitat restoration opportunities. This inventory is being used to help determine potential linear restoration opportunities. Restoration treatments were initiated in winter 2014 (~ 2 km), which included mounding and planting, and tree-felling. In summer 2014, restoration treatments (i.e., seedling and shrub planting) were applied on ~ 72 km (34 ha) of linear features.

Goals and Objectives

The goals of habitat restoration in the CLRP lease are to reduce the residual effects of existing linear disturbances on caribou habitat. The objectives for treating linear footprints in the 2013/2014 study area are three-fold:

1) Habitat restoration: Revegetation of the historic footprint to achieve establishment, survival and growth of woody plant species in the short-term, such that natural forest vegetation communities will regenerate over the long-term.
2) Access control: Human access can prevent or slow the growth of vegetation along disturbed areas. Thus a main objective of treatments is to establish effective human access control over the short-term along segments of linear features within the study area. A secondary objective of access control treatments would be to minimize or reduce travel by predators along linear disturbances.
3) Line-of-sight blocking: Reduce lines-of-sight for predators and produce hiding cover for caribou along linear corridors within the study area by using a combination of long term

techniques (e.g., enhanced revegetation by planting seedlings), and measures that may be more effective in the short to medium-term (e.g., hinging trees across corridors).

Location

Located in the Regional Municipality of Wood Buffalo and in the southern Athabasca oil sands region, the CLRP is located 150 kilometres south of Fort McMurray and 20 kilometres northeast of Conklin; the lease overlaps with a portion of the East Side Athabasca caribou range (ESAR).

Site description

The majority (approximately 55%) of CLRP is wetland habitat, and peatlands (i.e., bogs and fens) are the predominant wetlands type. Terrestrial vegetation, including both coniferous (e.g., black spruce) and deciduous (e.g., aspen) trees encompass almost 30% of the CLRP area. Old growth forests are limited, accounting for only 2% of the vegetation.

Treatments

How were lines selected for treatment?

The overall habitat management strategy for MEG is to maintain current levels of undisturbed caribou habitat within the CLRP lease. However, in order to meet on-lease operational growth requirements, restoration efforts to offset project effects on caribou habitat will extend broadly to include priority restoration areas within the ESAR caribou range, i.e., Christina caribou priority restoration areas. Thus, the main focus of restoration efforts will be within priority restoration areas to the east of the CLRP lease area. Those areas were selected because they contain numerous abandoned disturbances that provide considerable restoration opportunity and, as priority restoration areas, they are likely to have the most pronounced positive effect on caribou and caribou habitat. Also, most of the priority restoration areas are non-bitumen bearing lands with low oil and gas development potential, so have low potential for future disturbance from the energy sector.

MEG is still in the process of developing annual reclamation and restoration plans. The focal areas for caribou habitat restoration are Township 78-4-W4M and the north half of Township 77-4-W4M. This 9,324 ha area is located immediately northeast of the CLRP lease area and overlaps with the ESAR range.

Lines for the initial pilot were chosen based on ease of logistics, proximity for monitoring and limited potential for future development. A linear disturbance inventory was also conducted to determine the amount of re-vegetation on various lines through aerial imagery collected in fall 2013. Reconnaissance flights were flown in December 2013 to collect site level information to guide restoration treatments to be implemented in winter.

The anthropogenic footprint in the selected area totalled 830 ha, including well sites, seismic lines and pipelines. Based on the treatable areas at candidate restoration locations, a total of 65.4 km (39 ha) of linear features were identified as suitable treatment areas. Seventy six (76) potential locations were identified for implementation of access control or line-of-sight blocking measures.

Site preparation and planting

Pilots have been designed to trial logistics, equipment and types of treatment (hinging, mounding and planting). For the winter pilot project in 2014, the main treatments used were tree-felling; mounding was used as a line blocking technique as well as providing suitable sites for planting black spruce seedlings. Planting of seedlings was done by hand, on and off the mounds at a rate of 2200 stems/ha

In summer 2014, restoration treatments were conducted on ~ 72 km (34 ha) of linear features. Depending on ecosite characteristics, the summer planting comprised a diversity of tree and shrub species including: jack pine, white spruce, black spruce, trembling aspen, white birch, blueberry, willow, and green alder.

Full lines or partial line treatment

Partial line treatment was used on both pilots so far and is planned for future application alongside full line treatment where feasible.

Monitoring

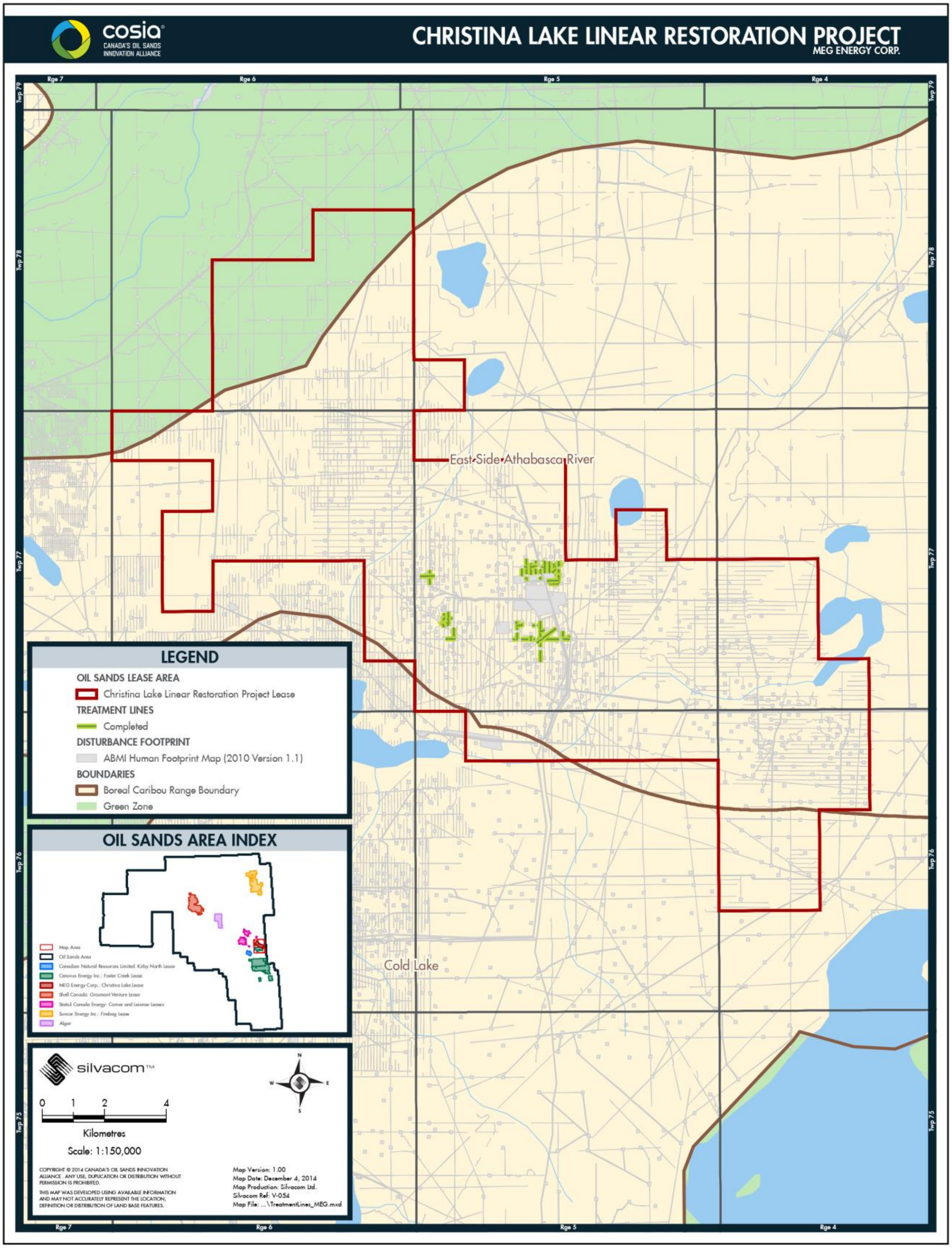
In early June, 30 remote cameras were deployed at locations where wildlife trails (identified from aerial imagery and LiDar) intersected candidate treatment areas, to collect baseline information about wildlife occurrence along the linear features. Camera monitoring will continue after the treatments have been applied to determine relative impacts of various line treatments on wildlife.

Vegetative monitoring has been initiated.

Planning + Logistical Challenges

Some of the key challenges incurred during the winter pilot program were:

- fencing method did not work and was not supported by the local wildlife officer;
- black spruce seedling stock was difficult to handle and plant in extreme cold;
- hoe operator training/experience was lacking; and
- effective tree hinging was difficult to do under winter snow conditions.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East Side Athabasca River
Cold Lake
LEGEND
OIL SANDS LEASE AREA
Christina Lake Linear Restoration Project Lease
TREATMENT LINES
Completed
DISTURBANCE FOOTPRINT
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Shell Grosmont Caribou Habitat Restoration

Shell Canada Ltd.

Overview

Shell Canada Ltd. acquired the Grosmont lease property in 2006. Shell`s short term objective is to test proprietary in situ technology and verify bitumen resources in the Grosmont carbonate formation; its long term objective is to design and construct a commercial in situ heavy oil project.

Although final reclamation of in situ operations will take decades to complete, an initial focus for Shell was to implement its land strategy through the Grosmont Project by revegetating legacy linear disturbances (e.g. cutlines, seismic lines) that have not re-grown on their own and occur within the West Side Athabasca caribou range (WSAR). Shell implemented the Landscape Ecological Assessment and Planning (LEAP) process to select a strategy for treating eligible seismic lines within the Grosmont lease that was focused on combined caribou habitat and late seral stage stand restoration. Field work for the restoration pilot project was completed in winter 2014.

Goals and Objectives

The goal of the restoration project was to restore historic seismic lines to a vegetated condition similar to adjacent forests, as well as reducing the ease of access for both humans and wildlife. Success will be to show that habitat restoration is a feasible and useful landscape management tool that will:

- contribute towards Shell's long-term goal of Net Neutral Footprint;
- reduce the risk to caribou from disturbance to habitat through restoration of current footprint; and
- contribute towards long-term habitat restoration of caribou ranges.

Location

The Grosmont lease property is situated on the far-west side of the Athabasca oil sands region - approximately 140 km west of Ft. McMurray, and approximately 400 km north of Edmonton.

How was the site selected?

The pilot area for caribou habitat restoration was selected within the south east region of the Grosmont lease, where there was generally good ground access.

Site description

The Grosmont lease falls within the Boreal Mixewood ecological area and covers ~ 126,900 ha of boreal forest, and the pilot area is ~8,000 ha.

Treatments

How were lines selected for treatment?

The restoration plan for the Grosmont lease used the Landscape Ecological Assessment and Planning (LEAP) framework, which is a four-part process to develop a comprehensive strategic to tactical plan for the landscape where:

1. the current landbase was benchmarked;
2. the forest ecosystem was modelled to establish feasible options for a future landscape (i.e, footprint growth and reclamation scenarios);
3. based on a preferred scenario, a tactical plan was developed, verified, approved and implemented; and
4. a monitoring program for key indicators was designed and applied.

Based on the LEAP process, 13 management scenarios were compared for treating 548 ha (914 km) of eligible seismic lines within the lease. The selected strategy was focused on combined caribou habitat and late seral stage stand restoration (40 km per year) and operationalized into a tactical plan by creating a 5-phase operational plan that considered access requirements and operational efficiencies.

Helicopter reconnaissance and ground surveys of the pilot area were conducted to measure and confirm biophysical attributes of linear features (and adjacent habitats), and determine ease of ground access and other logistical considerations. A detailed treatment was prescribed for each segment of the legacy lines using multiple site characteristics derived from the Alberta Vegetation Inventory and the ground surveys.

Depending on the state of natural revegetation, two general reclamation treatments were applied to segments of legacy lines within the pilot area.

- *Site preparation and planting:* Areas without sufficient natural regeneration and adjacent forest cover were identified for site preparation and planting with the addition of coarse woody material (CWM) where possible and beneficial.
- *Natural regeneration protection:* Segments of treatment lines with sufficient natural regeneration densities or open lowland conditions were protected with additional CWM applications where feasible.

How did treatments vary along lines?

Treatments varied along lines based on key site characteristics:

- Ecosite (tree/shrub vegetation characteristics, nutrient regime, moisture regime)
- Presence or absence of existing natural regeneration
- The condition of existing natural regeneration (species, average height, relative abundance)
- Estimated sunlight conditions

- Soil organic layer depth
- Estimated line of sight distance
- Presence or absence of CWM operational sources
- Evidence of frequent wildlife use
- Likelihood of use by industrial/recreational users

Additional site-specific considerations for field crews implementing reclamation treatments on seismic lines are summarized in Table 1.

Table 1. Summary of treatment actions and options recommended by Alberta Environment and Sustainable Resource Development (AESRD; T. Vinge, personal communication) for Shell Grosmont Caribou Habitat Restoration Project.

Site Preparation & Planting				
Treatment Actions	Treatment Options			
Site Preparation	None	Light Surface	Mounding	
Mounding Density	400	800	Other	
Planting Density	2/mound	3/mound	4/mound	1200 stems/ha (no mounding)
CWM Treatment	None	Lowland: 0-50m^3	Upland: 50-75m^3	Upland: 75-100m^3
Planted Species	Black Spruce	Jack Pine	White Spruce	

Natural Regeneration Protection				
Treatment Actions	Treatment Options			
Site Preparation	None			
Mounding Density	None			
Planting Density	None			
CWM Treatment	None	Lowland: 0-50m^3	Upland: 50-75m^3	Upland: 75-100m^3
Planted Species	None			

Monitoring

Effectiveness monitoring

Effectiveness monitoring was focussed on evaluating regrowth characteristics on treated lines by recording vegetative condition on a sample of lines before and after restoration work. To achieve this, 20 monitoring plots on a sample of treatment lines were established in February 2014 before the restoration treatments. The methodology to establish vegetative conditions on seismic lines comprised of standardized photographs (i.e., line-of-site and 360 degree panoramas) followed by detailed vegetation and coarse woody material surveys. Future data collection at these sample sites will be used to evaluate post-treatment line conditions.

Implementation Monitoring

An experienced Silvacom representative was on site to ensure winter planting protocols and site prescriptions were being followed. The Silvacom representative was responsible for verifying the planted sites within the pilot area, ensuring seedlings were being planted and stored correctly, CWM was being dispersed appropriately and mounding targets were being met.

Quality control plots were randomly selected along treatment lines. Mound quality, length, width and height (cm), the number of trees planted, and CWM transects were recorded at each plot. Results of the surveys were communicated directly to operators and field supervisors so that any adjustments could be made in a timely fashion. Daily reports of activities, weather conditions and quality control checks were compiled and submitted as part of a weekly summary report to Shell.

Results to date

A total of 18 potential treatment lines were identified in the pilot area, with line segments totalling to 51.5 km (or 31.3 ha). Field work for the pilot project was done in February and March 2014, during which over 15,000 trees were planted and over 32 km of linear footprint treated. An additional 15 km that was ground verified was left untreated due to road use restrictions. Of the legacy lines receiving treatment, ~59% (19.4 km; 11.4 ha) were subjected to site preparation and planting, whereas ~36% (11.9 km; 7.1 ha) of the lines received natural regeneration protection. A small portion, ~3% (1.1 km; 0.5 ha) of lines were scarified and treated with CWM, and the remaining 2% (0.5 km; 0.3 ha) were site prepared and planted without CWM.

Working with Auger & Sons operators, a new mound technique was tested where a long linear mound was created spanning the width of the line. Multiple trees (5-9) were then planted on each mound. Spacing was modified to achieve the target tree densities. Operators indicated that this mound configuration required less digging and was more efficient in areas where a higher mound density was prescribed (800 mounds/ha). It is unclear at this time how successful this treatment will be in restoring habitat.

Examples of bar mounding.

"Leap Frog" application of CWM

A second configuration was piloted that involved "leap frog" treatments where 100 metres of line were treated followed by 100 metres of line left untreated. This pattern was repeated for the length of the line.

Planning + Logistical Challenges

Stakeholder engagement

Consultation with First Nations and trappers was conducted by Shell. Consultation with the Bigstone Cree Nation (BCN) Government Industry Relations (GIR) office was conducted initially to provide information on the restoration project being planned. A follow-up meeting was held to provide an update on the restoration project, including reclamation activity both underway and planned; BCN GIR indicated support for the project especially due to the sensitive nature of the caribou population within their traditional territory.

Detailed information and maps were provided to a local trapper, whose trap line was within one of two areas proposed for the restoration; they did not express any concerns with respect to either area or elements of the project.

Regulatory approval and timelines

Before proceeding with implementation, program approval was required from the Government of Alberta and local stakeholders. Silvacom compiled a regulatory approval document for the pilot area that included:

- Application for Linear Restoration
- Temporary Field Authorization
- Consultative Notation

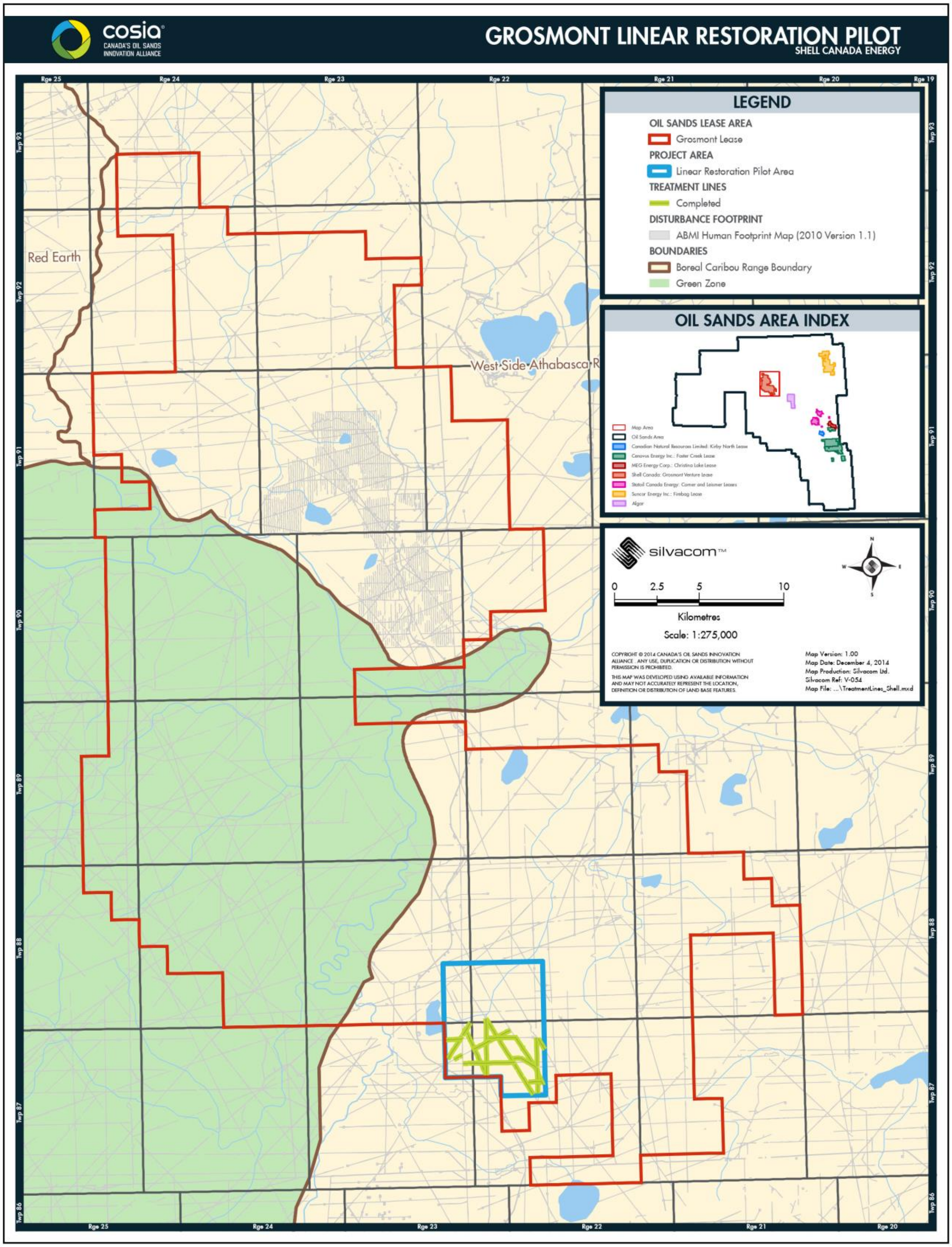
A separate Caribou Protection Plan was submitted to AESRD in October 2013 by Shell. Temporary access was granted by Alberta Energy Regulator (AER) in January 2014. Access Access to treatment areas was based on existing linear features, subjected to a check on disposition.

Access

An existing road from the town of Wabasca was used to access the pilot area. Access was limited in the summer months due to wet conditions. Ground access was achieved in winter by using an existing road and with agreement and consent from the disposition holder – Perpetual Energy Operating Corp. To gain access to the far south east portion of the pilot area some historic seismic selected for treatment were frozen in for vehicle and equipment passage.

Equipment

Frozen ground conditions were required for winter field operations. For the pilot area two excavators were used during site preparation and planting. A refrigeration unit (reefer) was also required on-site to store and maintain black spruce seedlings at a constant environmental temperature prior to being planted in mounds.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CANADA'S OIL SANDS INNOVATION ALLIANCE

Statoil Kai Kos Dehseh Caribou Pilot Project

Statoil Canada

Overview

The current focus of Statoil Canada Ltd.'s (Statoil) Kai Kos Dehseh (KKD) caribou pilot project has been on development of wildlife monitoring techniques and potential mitigations to manage human and predator use of linear features. This report focuses on a small scale woody material trial that was installed in an attempt to restrict wolf and human use of linear features. Through the pilot project, heavy applications of woody material were placed at intersections of linear features and wildlife response to the treatments were monitored using remote cameras. Study results have indicated that heavy application of course woody material is an effective technique for reducing use of linear features by wolves and humans.

Goals and Objectives

The goal of the project is to develop mitigation and monitoring strategies for linear features and human footprints that maintain spatial separation between caribou and their predators. Specific objectives for field research on linear features were:

- develop and test methods for using camera traps to monitor animal use on linear features across space and time;
- monitor animal use rates (humans, white-tailed deer, and wolves) and their interactions on linear features; and
- test whether spreading 200 m3/ha of coarse woody material is an effective mitigation for reducing predator use along linear features.

Location

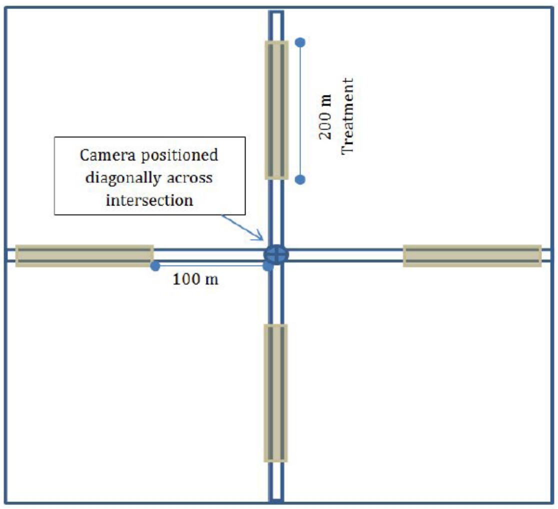
The study area was located south of Fort McMurray and northwest of Conklin in the KKD lease near the headwaters of the Christina River and overlapped the range of the East Side of the Athabasca River caribou herd.

Site description

The study area is characterized by expansive peatlands and undulating upland forests. Nearly all of the study area is managed for bitumen extraction and timber harvesting. Alberta-Pacific Forest Industries Inc. is the primary forestry company operating in the area and Statoil is the largest oil lease holder within the area.

Treatments

A trial was established using woody material rollback to discourage active use of linear features by wolves. Four sites were selected for log roll-back treatments based on high likelihood of use by wolves and were located at intersections of multiple linear features. At each treatment site, logs were spread over a 200 meter length of the linear feature with an application rate of 200 m^3/ha. A remote camera was placed so that the field of view was oriented diagonally across the intersection.



Treatment design

Line blocking treatments of heavy woody material application

Monitoring

As part of a broader monitoring effort, a total of 63 monitoring sites (including the four log roll-back treatment sites) were selected within Statoil's KKD project leases for placement of remote cameras. The monitoring sites covered a diverse range of linear features including:

- permanent roads
- winter roads
- aboveground pipelines
- belowground pipelines
- 2D seismic lines
- 3D seismic lines

Remote cameras were placed in locations that would maximize deer, human and wolf detections. The following criteria were used to select candidate sites for cameras:

- areas were preferred habitats for wolves, based on a wolf resource selection probability function (RSPF) model developed from wolf habitat use data collected in the study area by Wasser et al. (2011);
- areas had been historically used by wolves; and
- intersections of multiple linear features.

Remote cameras were placed at each of the 63 monitoring sites in August 2011 (n=27) and February 2012 (n=36) to monitor human and animal occurrences under different types of environmental conditions and characteristics of the right-of-ways. Aggregated data across all camera monitoring stations for 15 months resulted in ~13,000 monitoring days and ~254,000 pictures. Additional images have been collected over the course of 2013 and 2014.

Results to date

Key results from the camera monitoring study were:

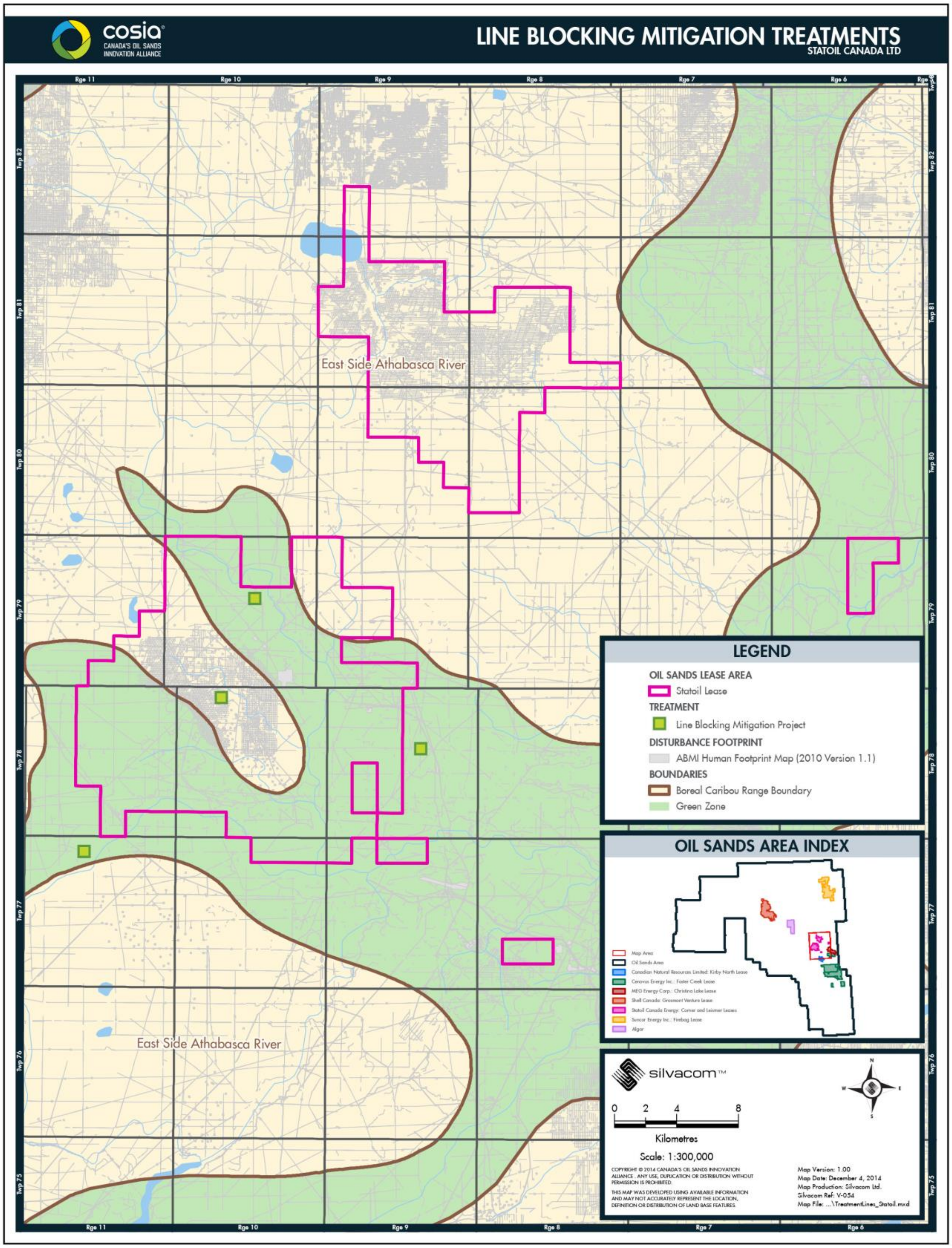
- Animal use on linear features is suppressed when daily traffic volumes exceed 10 to 30 vehicles per day.
- Linear feature use by white-tailed deer, wolves, moose and black bears is significantly higher within 0-5 km of major river valleys.
- Three-dimensional seismic lines have a weak effect on animal use compared to other linear feature types, unless they have packed snow in winter.
- Linear features containing a line-blocking treatment altered animal use; humans, wolves and black bears used treated sites less than untreated sites whereas moose and deer used treated sites more than untreated sites. The line-blocking treatments essentially reduced human use of linear features to zero. Line-blocking treatments significantly reduced wolf use year round (> 50%), indicating that this mitigation is effective.

Key References

Wasser, S. K., J. L. Keim, M. L. Taper, and S. R. Lele. 2011. The influences of wolf predation, habitat loss, and human activity on caribou and moose in the Alberta oil sands. Frontiers in Ecology and Evolution 9:546–551.

DeWitt, P. and J. Keim. 2013. Kai Kos Dehseh Project 2012 Winter Tracking Technical Report: Monitoring Predator-Prey Interactions. Draft Report submitted to Statoil Ltd. July 2013. Matrix Solutions Inc., Edmonton, AB.

Keim. J., J. Fitzpatrick, P. DeWitt, T. Shopik, and S. Lele. 2013. Kai Kos Dehseh Project 2012 Wildlife Camera Monitoring Technical Report. Draft Report submitted to Statoil Ltd. March 2013. Matrix Solutions Inc., Edmonton, AB.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Twp 81
Twp 80
Twp 79
Twp 78
Twp 77
Twp 76
Twp 75
East Side Athabasca River
East Side Athabasca River
LEGEND
OIL SANDS LEASE AREA
Statoil Lease
TREATMENT
Line Blocking Mitigation Project
DISTURBANCE FOOTPRINT
ABMI Human Footprint Map (2010 Version 1.1)
BOUNDARIES
Boreal Caribou Range Boundary
Green Zone
OIL SANDS AREA INDEX
Map Area
Oil Sands Area
Canadian Natural Resources Limited: Kirby North Lease
Cenovus Energy Inc.: Foster Creek Lease
MEG Energy Corp.: Christina Lake Lease
Shell Canada: Grosmont Venture Lease
Statoil Canada Energy: Corner and Leismer Leases
Suncor Energy Inc.: Firebag Lease
Algar
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Kilometres
Scale: 1:300,000
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Map Version: 1.00
Map Date: December 4, 2014
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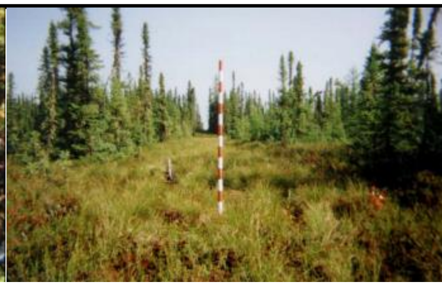
CANADA'S OIL SANDS INNOVATION ALLIANCE

Suncor Firebag Seismic Line Reclamation

Suncor Energy Inc.

Overview

In 2000, Suncor Energy Inc. announced its first *in situ* steam assisted gravity drainage (SAGD) oilsands project – the Firebag Oil Sands Projects (Firebag Project). Seismic exploration was a key part of the initial phase of the Firebag Project to define the spatial characteristics of the bitumen reservoir. The seismic exploration area covered about 38,000 ha. As part of its application, Suncor committed to and initiated a seismic line reclamation study in August 2000. The 6-year study was intended to assess alternative techniques for reclaiming seismic lines compared to standard reclamation practices and evaluate options for accelerating seismic line forest regeneration to help mitigate environmental effects.

The study was based on seven seismic line areas with variable site conditions ranging from well drained uplands to poorly drained wetlands. Control and transplant plots were located in each area, where control plots were left for natural regeneration. In comparison, transplant plots were planted with small 'vegetation islands' that comprised of small trees (black spruce or tamarack saplings) or shrubs collected from adjacent stands, or alternatively nursery stock plugs of black spruce or willow.

Growth of naturally regenerating trees and shrubs on upland seismic line sites with mulch application was poor. Regenerating vegetation on transitional wetlands sites had the highest density and diversity, whereas growth and vigor of trees and shrubs on wetlands sites was very low due to the high water table. The use of tree islands was found not to be effective or efficient. Marginal results of the black spruce vegetation island transplants and the effort involved in locating, removing and planting appropriate stock, suggested that this method was not well suited for use in reclaiming seismic lines. Performance of transplanted black spruce and willow plugs was best in upland sites. Excess soil moisture was the probable cause for high mortality rates and poorer performance of transplanted black spruce and willow plugs in wetland and transitional wetland sites.

Goals and Objectives

The objectives of Suncor's seismic line reclamation study were to:

- assess the effects of applying residual wood chips to seismic lines on the growth, survival and diversity of regenerating vegetation;

- assess the effectiveness of transplanting vegetation islands and planting nursery stock tree plugs on seismic lines and across a wide range of ecological conditions for accelerating forest regeneration;
- compare the effectiveness of an interventionist approach to revegetating seismic lines to that of natural regeneration; and
- provide recommendations for implementing a cost-effective seismic line regeneration program within a reasonable timeframe that meets the goals of reducing habitat fragmentation and limiting lines-of-sight.

Location

The Firebag Project is located approximately 65 km northeast of Fort McMurray. The project area occurs within a matrix of wetlands dominated by wooded fens and uplands commonly composed of stands represented by black spruce and jack pine trees.

Treatments

Seven seismic line areas (i.e., study sites) within the Firebag Lease were designated to evaluate seismic line reclamation methods. Surface conditions were either slash free or contained various amounts of tree chips. Soil conditions among sites ranged between well drained uplands to very poorly drained wetlands. At each of the study sites, three types of plots were established including:

- vegetation plots in an adjacent undisturbed forest area to document baseline conditions;
- control plots[3] on the seismic line to assess the rate of natural regeneration; and
- transplant plots within the seismic line for transplanting vegetation islands[4] (black spruce or tamarack saplings, or common shrubs) and planting tree plugs – with species, i.e., black spruce or willow, suited for the particular conditions of the site).

Seismic lines were either cleared by bulldozer (with slash rolled to the side) or cleared by mulching and leaving the residual chips on the line. Since the study was initiated in the summer of 2000, it was assumed that study plots occurred on lines cleared in winter 1996/1997. Thus, surface conditions at the study sites were either slash free or contained various amounts of tree chips. Soil conditions among sites ranged between well-drained uplands to very poorly-drained wetlands. Mean width of seismic lines at study plots was 4.8 m (n = 26, range 3.8 – 6.7 m).

[3] Control and transplant plots along seismic lines were about 10 m long by 4 to 8 m wide.
[4] *Vegetation islands were removed by hand shovel from adjacent forested areas and transplanted into the appropriate plot in locations with the least amount of competing vegetation. Preference was given to black spruce saplings if appropriate sized stems existed in the adjacent stand, otherwise, tamarack, Labrador tea, or blueberry were selected. The islands were marked with brass pins and numbered aluminum tags. Results from the 2001 survey indicated that the ratio between the size of the root ball and above-ground biomass appeared to be a factor in transplantation success. Therefore, larger root balls and smaller seedlings were preferred. Transplanted vegetation islands in 2003 were approximately 30 to 40 cm in diameter and 15 to 20 cm deep.*

Monitoring

Monitoring of study plots was focussed on growth, survival, vigor and height of vegetation along control and reclaimed sections of seismic lines.

- In the initial years that plots were established, species composition and cover data were collected in each adjacent, control and transplant plot. Vigour and height of each transplant were assessed and measured each year to track health, survival and rates of growth. In 2003, natural regeneration height measurements were added to the field protocol so that yearly comparisons in growth rates could be made.
- Tallies and height measurements of naturally regenerating shrubs and trees were initiated in the 2003 field program. Only those species with the potential to reach a height of one metre were included in the tally; therefore, species such as Labrador tea were excluded from the regeneration assessment.
- In 2005, vegetation visual obstruction was measured using a slightly modified methodology using a Robel pole. The amount of increment markings on the Robel pole that vegetation obscured was measured and observations were taken from two sides of the pole at a distance of 4 m, and 1 m above the ground. Lines-of-sight along the length of the seismic line were also estimated (into distance clasess) and readings taken 1 m above the ground.

Results

A summary of detailed key results is provided in Table 1. With respect to natural regeneration, results showed that transitional wetlands sites had the highest density and diversity of vegetation, whereas growth and vigor of trees and shrubs on wetland sites was very low due to the high water table. Growth of naturally regenerating trees and shrubs on upland sites with mulch application was also poor.

Based on results of transplant plots, the use of tree islands was not considered to be effective or efficient. Marginal results of the black spruce vegetation island transplants and the effort involved in locating, removing and planting appropriate stock, suggested that this method was not well suited for use in reclaiming seismic lines. Performance of transplanted black spruce and willow plugs was best in upland sites, with 80% and 65% survival after three years. Excess soil moisture was the probable cause for high mortality rates and poorer performance of transplanted black spruce and willow plugs in wetland and transitional wetland sites.

Table 1. Key findings of Suncor's Firebag seismic line reclamation study

Site type	Treatment	Key findings
Uplands	Black spruce vegetation islands	▪ survival rate was relatively high (76%) but tree condition was fair to poor after five years ▪ long-term survival of transplanted black spruce may be more favourable for smaller individuals where a greater percentage of the root system is retained during the transplant process ▪ for those transplants that survived, height increases were marginal

	Black spruce & willow plugs	▪ the survival rate of black spruce and willow plugs on upland sites was relatively high after three years which was comparable to survival rate of vegetation islands ▪ vigour of black spruce plugs was less than fair; willow plugs were between fair and good ▪ mean black spruce plug height increased more than 60% in three years while willow increased more than 100% over the same period ▪ a portion of the willow stems were browsed
	Natural regeneration – unmulched sites	▪ regeneration recruitment was very low; the reasons were unclear but micro-site condition may be a significant factor in recruitment success ▪ natural regeneration results from the unmulched sites was confounded by extraneous factors – winter road use that may have compacted soils and reduced tree and shrub development – slash piles along the side of the seismic line enhanced stem densities and appeared to be influenced by available organic matter and better sunlight condition
	Natural regeneration – mulched sites	▪ mulch application may have created a poor environment for growth and/or establishment of seedlings ▪ soils in the Firebag area were considered to be nutrient-poor, which may have contributed to low recruitment rates in mulched upland plots.
Transitional Wetlands	Black spruce vegetation islands	▪ survival rate of black spruce vegetation island transplants after two years was 78% ▪ tree condition of transplants were fair over this same time period ▪ height growth of black spruce transplants was negligible
	Black spruce plugs	▪ survival rate of black spruce plugs after three years was 48% ▪ tree condition was on average fair after the same time period ▪ excess soil moisture was the probable cause of mortality for most black spruce plugs as they tended to be located in excessively wet micro-sites ▪ height growth of the surviving plugs increased 64% over three years
	Willow plugs	▪ willow plugs had a very low survival rate - only 18% remained after three years ▪ excess soil moisture was the probable cause of mortality for most willow plugs as they tended to be located in excessively wet micro-sites ▪ condition of the surviving willow plugs were good ▪ height growth of surviving willow plugs increased more than 100% over three years
	Natural regeneration – unmulched sites	▪ densities and diversity of tree and shrub species were good, particularly green alder, willow and paper birch ▪ lines-of-sight was at least partially obstructed by growth of these species

		▪ favourable moisture conditions, no vehicle traffic and minimal surface disturbance during line clearing are believed to be key factors contributing to the positive growth seen in this site type
Wetlands	Black spruce vegetation islands	▪ after five years, nearly 80% of all black spruce transplants died, and of those that survived, height growth was marginal ▪ all eight tamarack vegetation islands died after two growing seasons
	Black spruce plugs	▪ over a three year period 85% of the black spruce plugs died ▪ slightly better survival rates occurred when vegetation islands and plugs were planted in elevated micro-site locations ▪ saturated soil is most likely factor contributing to poor performance of black spruce plugs ▪ equipment movement through one site also contributed to mortality of planted stock and natural vegetation

Recommendations

The following recommendations were made to encourage or enhance vegetation regrowth and reduction of lines-of-sight on existing seismic lines in Suncor's Firebag lease area:

- to encourage natural regeneration regrowth, restrict access on seismic lines by piling slash at entry points;
- to reduce lines-of-sight in the short-term, build up slash piles at various intervals along seismic lines where sufficient slash material exists;
- to reduce lines-of-sight in the long-term, consider planting clusters of nursery plugs on the long and straight seismic lines; clusters should be placed every few hundred metres and in upland or transitional wetland sites types;
- black spruce, jack pine and willow plugs would be most suited for upland sites;
- black spruce, willow and balsam poplar plugs would be suitable for transitional wetlands; and
- no planting is recommended for wetlands.

Key References

Golder Associates. 2006. Report on Firebag Project 2005 Seismic Line Reclamation Study – Annual Report. Golder Assocates Ltd., Calgary, AB. 37 pp. + Appendices

Gulley, J. Z. 2006. Seismic Line Reclamation: The Suncor Firebag Steam-Assisted Gravity Drainage (SAGD) Project. Unpublished M.Sc. Thesis, Royal Roads University, Victoria, BC. 74 pp.

Overview

Alberta's Provincial Woodland Caribou Policy recognizes caribou conservation and recovery as a shared government, public and private sector responsibility. Resource-based industries in Alberta recognize that, among habitat-based actions within our sphere of influence, reduction of future industrial footprint and coordinated restoration of existing industrial footprint are the actions most likely to benefit caribou. The long-term benefits of these actions will be greatest if they are (i) focused on areas with high value for caribou, and (ii) coordinated over whole caribou ranges. This necessitates collaboration among multiple operators and industry sectors on a shared landscape at a scale larger than individual dispositions and operating areas.

A group of companies from the oil sands, pipeline and forestry sectors are collaborating with the Government of Alberta to implement such a program in the Cold Lake and East Side Athabasca River (ESAR) boreal caribou ranges of east-central Alberta. This collaborative program is a multi-pronged strategy comprised of 4 pillars: (i) research on caribou, predators and their habitats, (ii) coordinated footprint management, (iii) site-specific assessment of wildlife and vegetation responses to reclamation treatments on linear features, and (iv) broad-scaled and active adaptive management study design (treatment vs control) across large areas. The 5-year program will support the Government of Alberta in its efforts to develop and implement caribou range and action plans under SARA.[5]

Goals and Objectives

The goal of the RICC is to coordinate research, integrated land management and active, science-based adaptive management to contribute to caribou conservation and habitat recovery in the geographic scope of interest while maintaining an economically viable resource industry.
There are four main objectives:

1) Coordinate functional restoration of disturbance in priority areas of the geographic scope of interest.
2) Coordinate land use planning and industrial activity across companies and across sectors to minimize future disturbance across the geographic scope of interest.
3) Support and lead scientific research on caribou ecology and on caribou-predator-landscape relationships to identify priority issues and/or priority areas.
4) Support and lead investigative trials on functional restoration methods and wildlife responses to assess the effectiveness of treatments, and to make recommendations for broader implementation.

[5] Saxena, A., M. Cody, A. Higgins, E. Dzus, D. Hervieux, and R. Serrouya. 2014. Regional industry caribou collaboration program. Paper presented at 15th North American Caribou Workshop, Whitehorse, YK.

Location

The geographic scope of the RICC is defined by the Cold Lake Caribou Range, the East Side Athabasca Range (ESAR), and contiguous portions of the boreal forest to the east, which encompass parts of the Saskatchewan Boreal Plain Caribou Range. The concept of area of assessment will be considered in geographic scope, and will be defined as the range boundaries plus 20 km buffer of adjacent matrix habitat as informed by emerging research.

The geographic scope was selected based on operating areas of participating companies and the large landscape scale that is necessary to incorporate the individual caribou range as the management unit within which to establish, evaluate, and achieve meaningful caribou habitat and population actions.

Collaboration

RICC participants will work together, commit to participation, exhibit leadership, build and maintain relationships and share information.

RICC participation is limited to participants with:

- Industrial activities on caribou ranges within the geographic scope of interest; or
- broad corporate or project-specific commitments to restore caribou habitat in caribou ranges

Service providers (i.e., academia, consultants, etc.) provide scientific and research oversight, subject matter expertise, project implementation, program administration and/or management functions as required.

Planning and Coordination

The RICC is supported by an overseeing Steering Committee, a Program Manager, a Technical Advisory Committee, a Communications Sub-Committee, and/or other sub-committees deemed necessary by the Steering Committee.

Projects

Contributing projects are those that are proposed, planned, led and managed by RICC Participants, and that are within the scope defined by the Participants.

Contributing projects are:

- sponsored and managed by a RICC Participant;
- funded by a RICC Participant, either solely or in partnership with multiple funders (including other RICC Participants);
- reviewed and authorized by the Steering Committee;
- aligned with the Mission, Goal, Objectives and Scope of the RICC; and
- beneficial, or reasonably likely to be beneficial, or to determine whether benefit exists to caribou or landscapes within the geographic area of interest
- Contributing Projects are managed by the project proponent.

Key References

Regional Industry Caribou Collaboration (RICC). 2014. Program Charter. Revision No. 10: October 15, 2014

Key Contributors

Devon Energy Corporation, Cenovus Energy Inc., Canadian Natural Resources Limited (CNRL), MEG Energy, Imperial Oil Limited, Alberta-Pacific Forest Industries Inc. (Al-Pac), TransCanada Pipelines, Alberta Environment & Sustainable Resource Development (AESRD), Alberta Biodiversity Monitoring Institute (ABMI), Alberta Innovates Technology Futures (AITF).