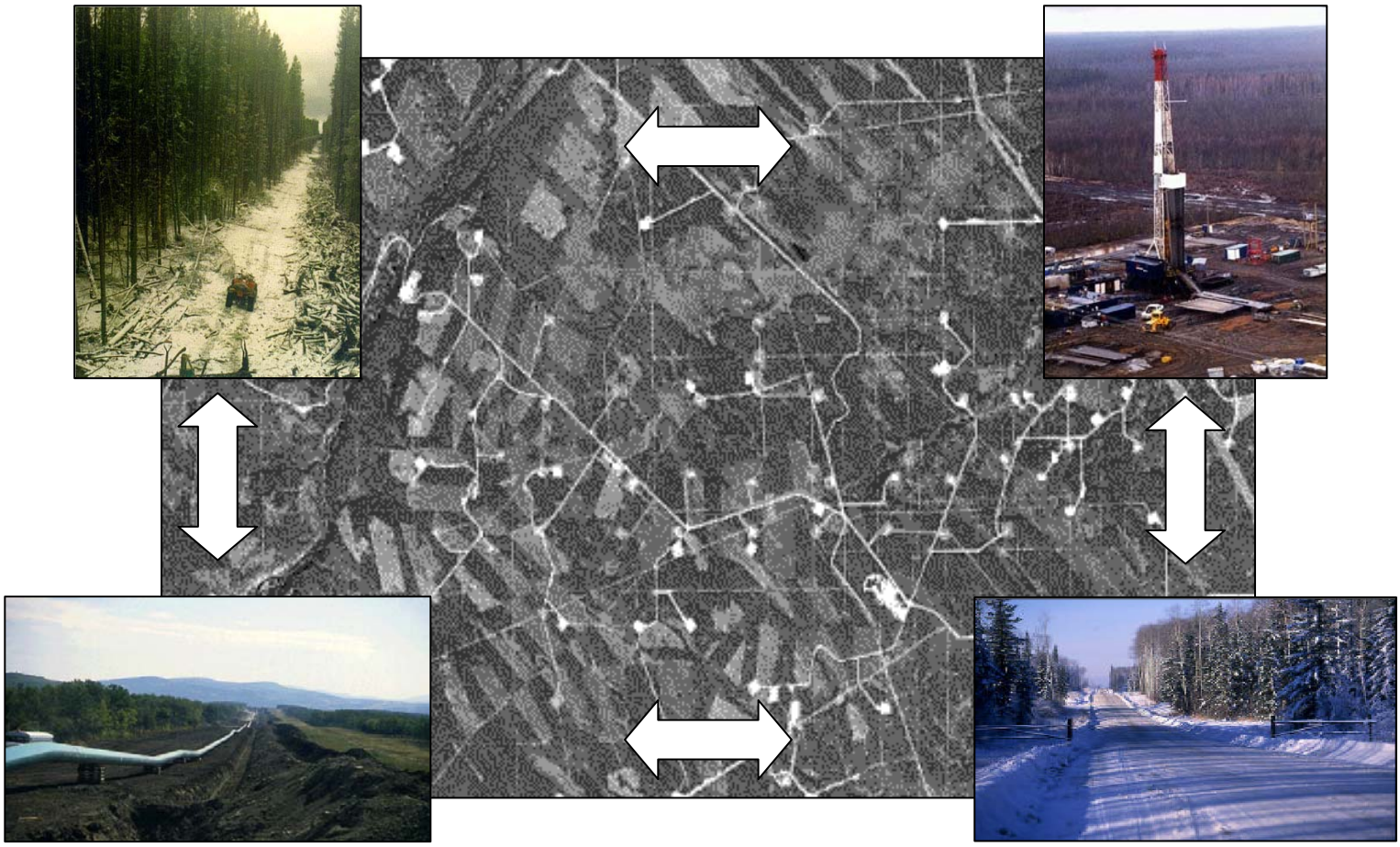
Forest Fragmentation – Effects of Oil and Gas Activities on Alberta Forests



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Centre Photo: Air photo of forested landscape exemplifying cumulative fragmentation impacts of petroleum and forestry activities.

Top Left Photo: Seismic line through mature boreal forest.

Bottom Left photo: Primary crude oil pipeline establishment

Bottom Right Photo: Oil and gas Road

Top Right Photo: Wellsite establishment

Disclaimer:
The intent of this research document is to provide an overview of the forest fragmentation that results from energy exploration and development in Alberta. This report was prepared based on the requirements set by Dr. Doucet for BUEC663.

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EXECUTIVE SUMMARY

Forest fragmentation is one of the most significant externalities associated with oil and gas exploration and development in the forested region of Alberta, Canada. This externality has negative social and ecological implications, and providing an overview of this issue will be the primary objective of this report. To achieve this objective, several key areas will be discussed: an overview of Alberta's economy with respect to the energy sector; a characterization of the boreal forests of northern Alberta; a description of the impacts of energy exploration and development; an explanation of the Alberta resource lease regime; and a discussion of the cumulative impacts associated with both the energy and forestry sectors.

Alberta's economy is currently the strongest in Canada. Although this is partially a function of economic development efforts of the provincial government, it is primarily the result of extensive energy deposits throughout most of Alberta. The energy sector is significant. It represents approximately 25 percent of the Alberta GDP, employs 17 percent of the provincial population, and represents 80 percent of the value of total provincial exports.

Not only is Alberta fortunate to have substantial oil and gas reserves, it also has a substantial forest resource that supports a sizable forest industry. Northern Alberta is carpeted with vast tracts of boreal forest that support vigorous ecosystems composed of diverse vegetation and wildlife. Unfortunately, the exploration and development of energy deposits requires access to the surface immediately above these reserves. Subsequently, considerable areas of forest are cleared to make way for equipment and infrastructure. This has significant social and environmental implications such as the clearing and fragmentation of the boreal forest.

Most of the land in Alberta is publicly owned, therefore, access to the timber resource or energy deposits is granted through lease agreements between firms and the provincial government. This results in two sectors operating on the same landbase, clearing forests at uncoordinated rates. Their activities are not harmonized and the cumulative effect of both the energy and forestry sector is substantial forest fragmentation.

Forest fragmentation has a number of consequences to both flora and fauna. Measures such as integrated regional planning and low impact exploration are being tested for their ability to minimize forest fragmentation and are addressed in more detail in this report.

1.0 INTRODUCTION

Alberta (Figure 1) is endowed with vast wilderness areas that contribute to the spirit and culture of Albertans themselves. In addition, Alberta has a luxurious economic position strongly influenced by the energy sector. However, forest ecosystems and energy extraction activities wrestle with somewhat competing needs. A key externality associated with the oil and gas industry of Alberta is forest fragmentation. Forest fragmentation is the process of subdividing a continuous habitat type into smaller sections, which results in the loss of original habitat, reduction in the size of continuous forest, and an increase in forest isolation.[1]

Figure 1. Location of Alberta.

The forested area of Alberta, covering over 50% of the provincial area, has been converted from nearly completely intact in the early 1900s, to over 90% fragmented forested landscape in 2002.[2] In fact, land clearing for oil and gas activities accounts for more than double the land cleared for forestry each year.[3] As a result, forest fragmentation has become one of the most significant land management challenges within forested regions of Alberta. From an ecological perspective, this has far reaching implications on forest health, particularly for species relying on continuous forest habitat such as woodland caribou or song birds. In an attempt to address this issue, considerable resources have been dedicated to researching fragmentation impacts on forested ecosystems. In addition, 'next steps' initiatives, guidelines and policies are being developed and implemented.

1.1 Objectives

The primary objective of this study is to provide an overview of how oil and gas exploration and development contribute to the fragmentation of Alberta's forests. To achieve this objective, the following topics will be provided:

- **Overview of the Alberta economy with respect to the energy sector:** establish its economic importance
- **Description of the forested area:** demonstrate its ecological significance
- **Listing of oil and gas activities leading to forest fragmentation:** characterize the fragmentation issue
- **Explanation of the Alberta resource lease regime:** frame the cumulative impacts conundrum among various industries operating in Alberta
- **Discussion of cumulative impacts and the mechanisms to mitigate them**

2.0 BACKGROUND

2.1 Alberta Economy – Influence of the Energy Sector

Alberta currently enjoys one of the strongest provincial economies in Canada, which has increased at an average annual rate of 3.7% between 1993 and 2003.[4] This has translated into one of the fastest provincial population growth rates and the lowest unemployment rate in Canada.[5] Natural resources are important components of the Alberta economy, of which the energy sector

is king (Figure 2).[6] In 2003, the energy sector contributed over 23% of the province's total GDP, translating into a $40 billion industry.

With respect to employment, the oil and gas industry is also a significant player. Over 90,000 Albertans are employed by upstream oil and gas jobs,[7] and another 6,400 work directly in the petrochemicals industry.[8] The secondary economic benefits, such as industry support services, are significant throughout much of the province. Overall, there are 950 active oil and gas companies operating in the province.[9]

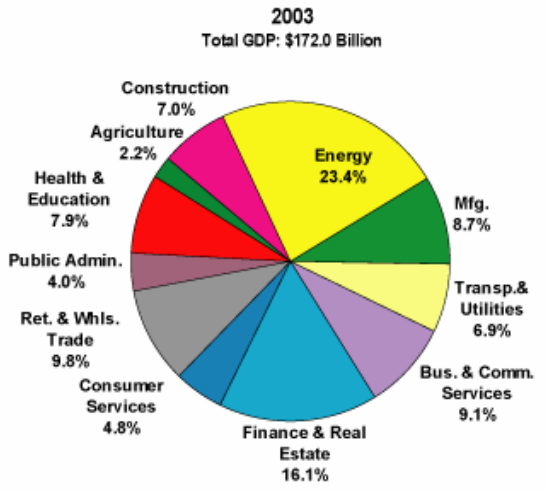


Figure 2. Alberta GDP by Sector, 2003.

2.2 Describing the Forested Area of Alberta

Alberta is dominated by forested landscapes (Figure 3).[10] Much of the forested area is provincially owned and has been coined the 'green zone' by provincial land managers. This is simply a jurisdictional classification that characterizes 'non-agricultural lands'. The green zone covers 53% of Alberta,[11] of which 84% is owned by the province, 9% by the federal government and 4% is privately owned.[12] The other 47% of Alberta is classified as 'white zone', much of which is private agricultural lands and urban areas.

The majority of the green zone is composed of boreal forest and foothills natural regions (Figure 2). The boreal forest extends across northern Canada, Europe, and Asia to form the world's largest forested ecosystem (Appendix 1). A mosaic of small forest types characterizes this region (i.e. coniferous and deciduous), and the forest ages are traditionally driven by natural disturbances (i.e. forest fires, insect and disease mortality). Forest stands rarely exceed 200 years of age, save riparian areas and/or north facing slopes. Although stands within the boreal forest are relatively young compared to other forested regions (e.g. temperate rainforests of North America), old age characteristics are plentiful throughout the region. This is due in part to residual patches left standing following forest fires, and the very nature of aspen and poplar trees, which exhibit old growth characteristics (e.g. large trunk diameter, disease, and rot in the stem), after only 80 years of growth. The heterogeneity of the forest age, shape, and species within the boreal forest natural region provides diverse habitat types for a broad range of biota. For example, this region is home to the most diverse population of migratory songbirds in North America.

It is clear that the boreal forest is a mosaic of forest types that supports diverse vegetation and wildlife. Once a continuous tract of forest area, it is now being cleared and fragmented due to industrial development. The characteristics of this original forest type are important benchmarks that help assesses the effects of forest fragmentation.

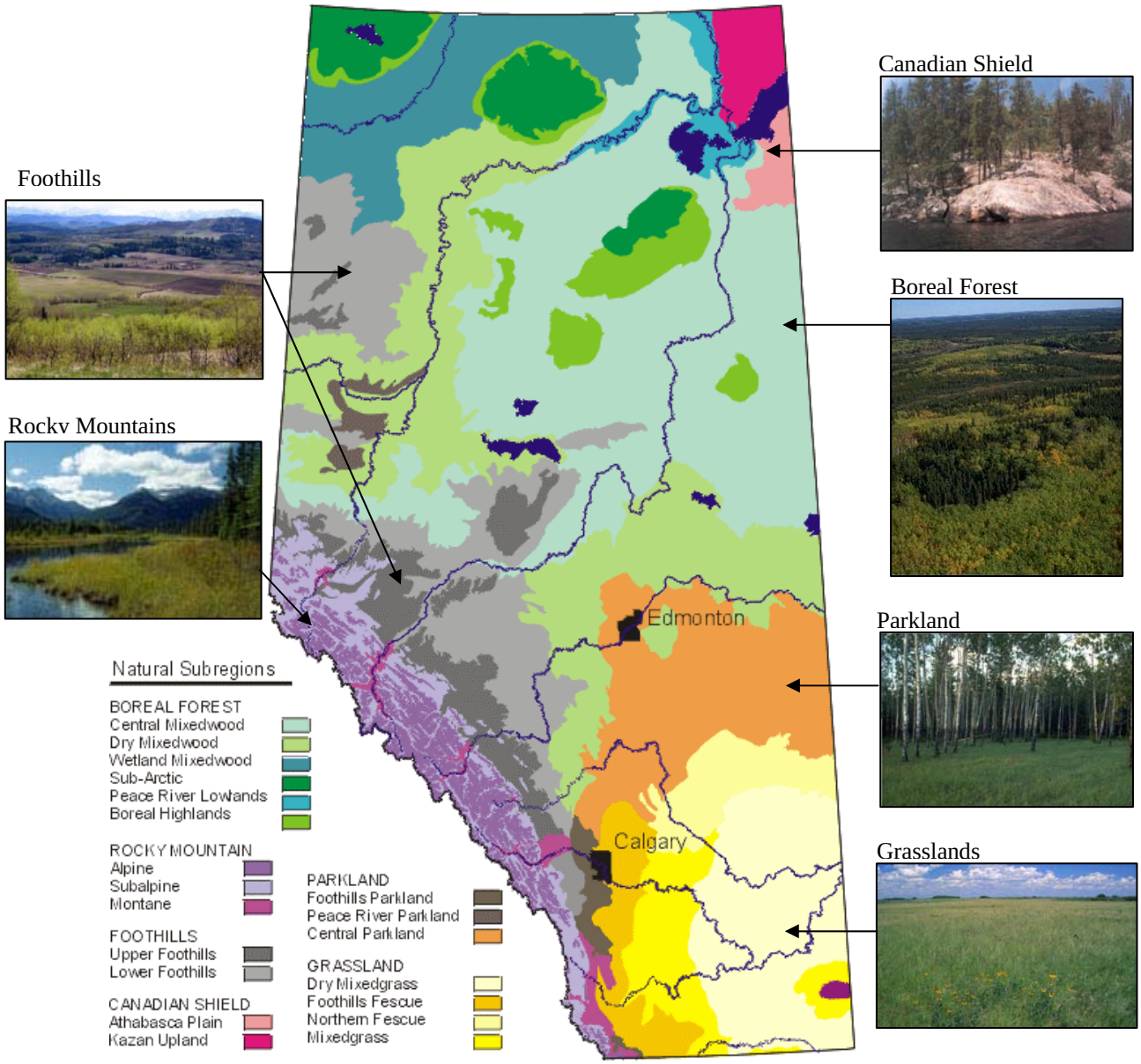


Figure 3. Natural Regions of Alberta.

3.0 ENERGY SECTOR ACTIVITIES CAUSING FOREST FRAGMENTATION

3.1 Primary Oil and Gas Activities

The oil industry and the gas industry have similar impacts on forest fragmentation. Each creates seismic lines, pipelines, wellsites, roads, and upgrading facilities to access and develop the energy resources. These activities all require the clearing of forest land.

3.1.1 Seismic Lines and Pipelines

To find subsurface oil and gas reserves, seismic information is collected from the surface to locate the deposits below the earth's surface. In order to collect the seismic data, access corridors are created through the forest to allow the movement of seismic equipment. Linear clearings, down to the soil, are cut through the forest (Figure 4). These linear clearings are commonly referred to as seismic lines, and represent the most significant footprint associated with oil and gas activities.

Figure 4. Seismic Line Establishment.

After surveyors have plotted a route, trees are removed and the line is de-rooted using bulldozers. Trees are not typically salvaged for lumber or pulp; rather, they are usually piled along the side of the seismic line and left, because the cost to move the cut timber to mills is prohibitively expensive. Seismic lines vary in length but typically extend for several kilometres (several miles) in a perfectly straight line. Conventional seismic lines measure between 6 m and 9 m (i.e. 19.7' to 29.5') across. Seismic line spacing generally depends on the level of geophysical information required and the nature of the subsurface structures. A conventional seismic program would typically establish several parallel seismic lines 400^{+} meters apart (1312^{+}'), but in areas of intense surveying, seismic lines can be spaced less than 100 meters (328') apart.

After the energy firms have finished using the seismic lines, they are seeded with an industrial, non-native blend of grass species, but they are not replanted with native tree seedlings. Approximately, 30% of seismic lines are eventually re-cleared for regenerating forest for subsequent exploration, while others are upgraded to roads. In addition, natural re-vegetation is often slowed as a result of significant all terrain vehicle (ATV) activity and to a lesser extent snowmobile activity as seismic lines become popular access routes for recreational ATVers and hunters.

Figure 5. Pipeline right-of-way.

Pipelines (Figure 5) are major petroleum transportation systems that have functionally similar fragmentation impacts as seismic lines with two primary exceptions. First, pipelines are actively managed to prevent tree regeneration for pipeline maintenance purposes. Second, pipelines are significantly wider than seismic lines, measuring approximately 50 m (164') wide.

3.1.2 Wellsites and Upgrading Facilities

Once economically viable oil or gas reserves are identified, wellsites (Figure 6) are established to extract the resource. Similar to seismic lines, wellsites are cleared of trees and levelled by bulldozers, seeded with industrial grass species and left to re-vegetate naturally upon site abandonment with no soil rehabilitation. Wellsites typically cover an area of one hectare (2.47 acres).

Figure 6. Clearing for a wellsite.

Upgrading facilities, such as natural gas sweetening facilities are also present within the forested landscape of Alberta. However, these facilities are comparatively insignificant contributors of forest fragmentation because one facility fed by an extensive network of pipelines can handle large volumes of product, thereby minimizing the number of facilities needed. These facilities, generally cover several hectares of area, and are usually established adjacent to existing roadways.

3.1.3 Roads

Roads are a significant and permanent footprint associated with oil and gas activities, because each wellsite requires vehicle access. Once they are established, roads are rarely decommissioned since there is a chance that the energy firm may return to re-activate the well, the public now uses the road and/or the cost of road deactivation and reclamation is too expensive. Road grades range from unmanaged trails (Figure 7) to paved right-of-ways.

Figure 7. Forestry road (unmanaged haul road).

Seismic Fast Facts:[13,14]

- 31,000 mi of seismic lines are approved for the green zone annually
- 870,000 mi of seismic lines existed in the green zone as of 1995 (more than three times the distance to the moon).

Pipeline Fast Facts:

- 183,000mi of pipelines as of 2000

Wellsite Fast Facts:

- 103,806 operating wells as of 2000
- 11,898 wells were drilled in 2000 alone

Facilities Fast Facts:

- Over 659 gas plants in Alberta, most of which are in the green zone

3.4 Quantifying the Distribution of Oil and Gas Activity

Oil and gas activity exists throughout most of Alberta to varying degrees. What differs is the density of these linear features on the landscape, as a function of oil gas extraction potential. Density and distribution of linear features and wellsites have considerable overlap, as depicted in Figure 8 and Figure 9, respectively. [17,18] In addition, the rate of change is also a function of the price for the underlying asset (Figure 10).[19] As would be expected, the rate of development is positively correlated with increasing oil and gas prices.

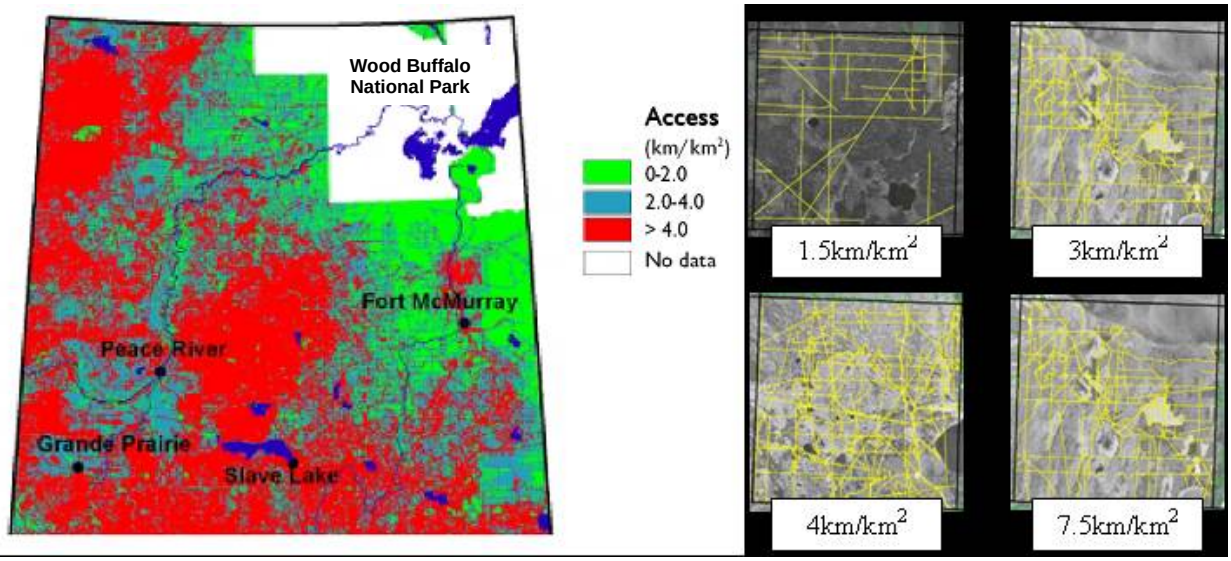


Figure 8. Access density (km/km^2) in northern Alberta as of 2000, including seismic lines and trails.

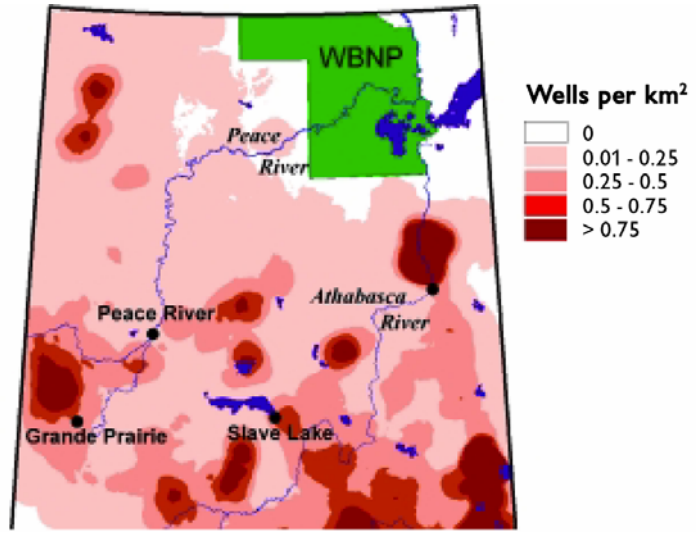


Figure 9. Wellsite density in northern Alberta as of 2000.

3.5 Quantifying the Rate of Increase for Oil and Gas Activity

Not only is the extent of oil and gas proliferation across the forested landscape impressive, so too is the rate at which it has increased. Oil and gas exploration essentially took root in the 1950s. From 1970 to 1990, the number of wells in Alberta increase approximately 100% every five years, and has increased at a rate of over 200% every five years since (Figure 11).[21]

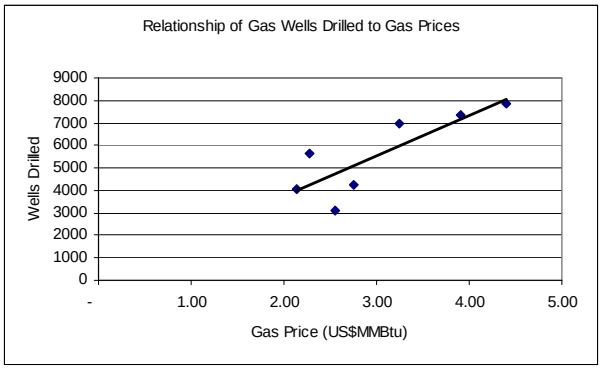


Figure 10. Wellsite establishment as a function of gas prices (1996-2002).[20]

Although the landscape has changed dramatically from virtually pristine to somewhat fragmented in less than 50 years, the future projections appear even more foreboding. Given historic rates of industrial expansion, it is expected that linear corridors will increase four times over the next 20 to 30 years.[22]

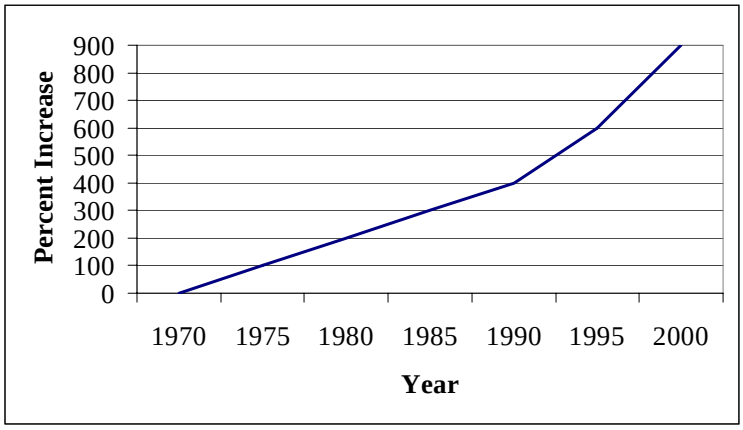


Figure 11. Cumulative increase in the number of Wells in Alberta.

4.0 RESOURCE ALLOCATION MECHANISMS AND LEGISLATION

To understand why the natural resource industries (i.e. oil, gas and forestry) clear such vast tracts of forest requires an understanding of land ownership. Natural resources are publicly owned in Canada. However, the Crown in Right of Alberta took control of managing Alberta's natural resources in the early 1900's. This empowered the provincial government to not only exploit natural resources for profit, but also to regulate their use for non-economic, societal benefits on behalf of the people of Alberta.[23] Subsequently, there is relatively little private land in the forested landscape, and the development of natural resources on public land operates via lease agreements between the firm and the provincial government.

The leases issued by the provincial government are for either surface or mineral rights (Figure 12). Surface leases are typically granted to forestry firms for the right to the standing or cut timber, whereas subsurface or mineral rights are granted to energy firms to explore and produce oil and gas. The surface owner's Title is subject to the mineral owners' right to enter the land in order to develop the energy reserves. This overriding approach to land rights is premised on the assumption that harvesting the oil and gas is in the general public's best interest.[24]

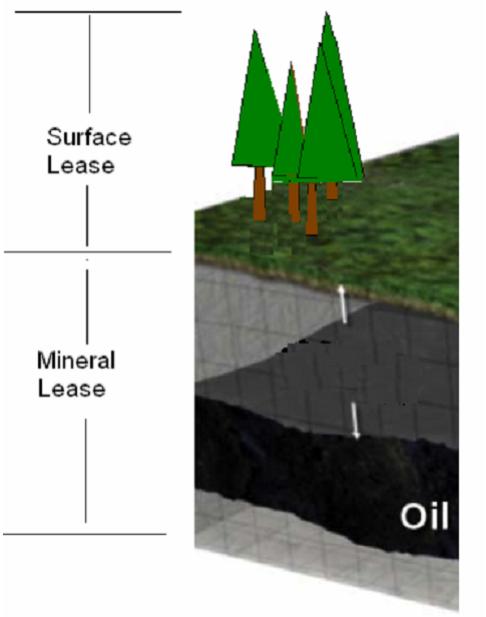


Figure 12. Surface and Sub-Surface Leases

Hence, the forestry sector cannot deny the energy sector entry onto its landbase for the exploration and extraction of oil or gas. Further, the forestry firm has little say in where the energy firms construct their exploration or extraction infrastructure. The effect of these two conditions is further magnified by the disconnect between the provincial departments that approve forestry and energy activities. Neither branch consults the other when issuing approvals, subsequently, there is a high probability that development activities will overlap and accelerate the rate of forest clearing.

The competitiveness of the oil and gas industry in addition to the existing lease regime compounds the forest fragmentation issue. Leases are auctioned to interested parties, which can lead to large numbers of firms operating in a small area (Figure 13). The end result is a congestion of activity with independent planning that leads to excessive forest clearing.

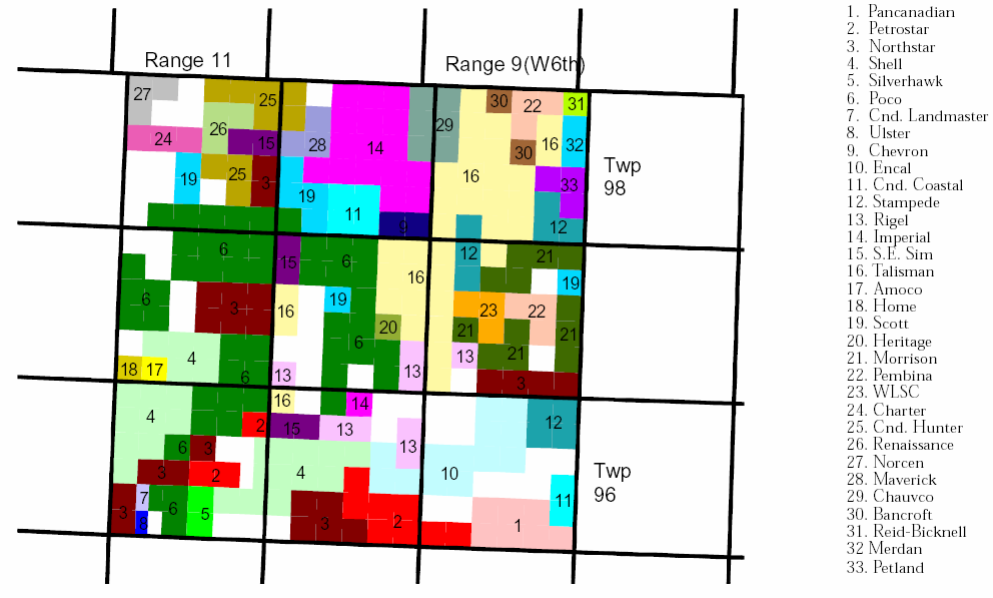


Figure 13. Typical oil and gas lease distribution in Alberta.

5.0 CUMULATIVE IMPACTS

5.1 Additive Impacts of Petroleum and Forestry Industries

Formally defined, cumulative impacts are the "changes to the environment that are caused by an action in combination with other past, present, and future human actions."[25] In the case of Alberta's boreal forests, this is predominantly the additive impacts of oil and gas development and forestry operations (Figure 14). Both the energy and forestry sectors denude vast areas of forest annually and produce substantial ecological impacts.

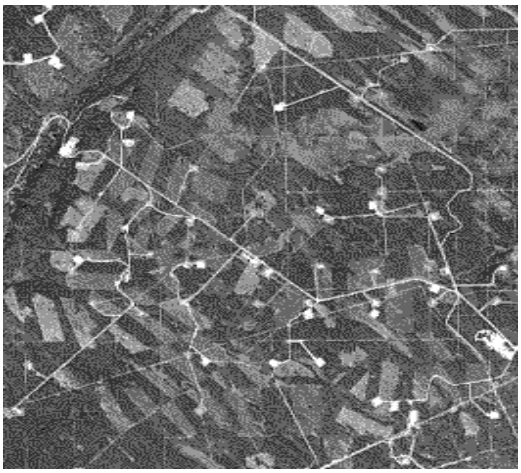


Figure 14. Aerial photo depicting cumulative effects and fragmentation.

The reason the impacts of both sectors is additive and not overlapping is because the planning standards and time horizons for each sector are quite different. The standards and time horizon for forestry are detailed and long-term, whereas for energy, the standards are vague and short term. For example, before logging can take place, a forestry firm must complete a three-year planning process that involves local stakeholders, the government and the energy sector. These long-term plans are intended to incorporate the plans of the energy sector. However, due to the short planning horizon of the energy sector, which is largely a function of the price of oil or gas, energy firms provide little input into the planning process because in most cases the energy firms activities will be either completed or changed in the immediate future. In the case of the energy firm, its planning horizon is quite short and rather than spend time meeting with the forestry firms it secures government approval and begins its exploration or development projects.

5.1.1 Land Clearing

Increased road construction results from the duplication of road networks. For instance, an energy firm may plan a road right-of-way unknowingly in close proximity to a planned forestry road right-of-way. Although this seems absurd, it results from the disparity in planning horizons whereby neither party knew the others intentions of road construction. The end result is that the roads are constructed before either party recognizes the outcome and two roads bisect a forest area where only one was required.

Over-harvesting is a function of greater than expected seismic and pipeline activity and slower forest growth rates on seismic lines. Forestry firms calculate their annual harvest based on the rate of forest growth and the available forest area. This annual harvest is approved for five years by the provincial regulator. If the area of forest cleared by the energy sector is greater than predicted during this five-year period, the amount of forest clearing by both sectors is not sustainable since the forest will be depleted rather than sustained over the long-term.

In addition, forest regeneration on seismic lines is much slower than that of a cut-block or natural forest condition. The reason for this reduced growth is twofold. First, bulldozing down to the

mineral soil horizon removes many of the needed nutrients to facilitate tree seedling growth. Second, recreational and industrial use of seismic lines slows forest regeneration and persists long after the seismic lines original use.

5.2 Ecological Implications of Fragmentation

Cumulative impacts of energy and forestry sector activities are producing negative ecological impacts. Three ecological impacts have been identified, mainly with respect to changes in species composition. First, the abundance and diversity of species dependant upon older aged forests has decreased and the abundance of species that inhabit younger aged forest has increased. Second, the abundance and diversity of species dependant upon continuous has decreased and the abundance and diversity of species that inhabit fragmented forests has increased. Third, there has been an increase in the number of exotic and human-tolerant species at the expense of native and human-avoiding species.

5.2.1 Old Versus Young Forest Species Specialists

One of the most apparent changes across the green zone of Alberta is a decrease in average forest age. This is largely driven by forestry harvesting practices, where harvest plans target older-aged stands and regenerating stands succession patterns are truncated. When these harvesting activities are combined with those of the energy sector, the proportion of older stand types decreases dramatically.

The degree to which the forested landscape is changing has spurred considerable ecological research and biodiversity monitoring. Results have shown that species adapted to younger forest types are oftentimes thriving, while those specializing in older aged forests are generally struggling.[26] The degree to which species are adapted to young versus old aged forests often drives the extent to which their populations are being affected. Since species diversity increases as forest age increase, a reduction in the older forests has net negative impacts on species diversity and abundance.

5.2.2 Continuous Versus Fragmented Forest Species Specialists

Linear clearings also have a major influence on species diversity and distribution within the forested landscape. These clearings dramatically increase in the amount of “edge” within forested areas. Forestry cut-blocks create a substantial amount of edge forest particularly when numerous small cutblocks are used instead of fewer large cut-blocks. This harvesting practice combined with seismic lines creates a substantially higher proportion of edge in the boreal forest. Not only is rate of edge creation higher, the edge condition persists longer because seismic lines are not required to be reforested. Subsequently, there is a substantial lag in reforestation and once the seedlings are established their growth rate is much slower than those in cut-blocks or under regenerating under natural conditions.[28] Like young versus old species specialists, edge specialists benefit in the existing landscape at the expense of species that rely on large tracts of continuous forest. The Woodland Caribou, now on the verge of being extirpated in Alberta, is the signature example of a species suffering from forest fragmentation. This species avoids forest edges to avoid predation, so when linear corridors increase accessibility for edge species like their primary predator, the wolf, they are placed in a significant disadvantage.

5.2.3 Exotic and Human-Tolerant Species Versus Native and Human-Avoiding Species

Exotic species are now present within the forested landscape as a result of forest fragmentation. The most obvious form of exotic species introduction occurs from active planning of non-native grass species on seismic lines, pipelines and roadsides. These species are selected for their ability to quickly reclaim bare soil. However, they out-compete the native grass species, are difficult to control once they have established, and often include non-target species due to 'unclean' seed mixes. Furthermore, non-native plant species are inadvertently planted from seeds attached to ATVs and other vehicles.

Furthermore, certain species are well adapted to the presence of humans. This is most apparent among fauna, where those species that tolerate human presence fill niches left vacant by those that avoid humans. In addition, some of these species aggressively remove and marginalize native species. A classic example of this is the range expansion of the brown cowbird. This species is expanding its range northward into the forested landscape and parasitizes nests with its own eggs at great cost to native songbirds.

5.3 Mechanisms to Mitigate Cumulative Effects

Before means to mitigate the cumulative effects are presented, it is important to distinguish the drivers for each sectors forest clearing activities. The forestry sector depends on timber as the primary input into the commodities it produces, whereas the energy sector views the timber as an obstacle to be overcome to develop the oil and gas reserves. Therefore, processes to mitigate forest fragmentation that capitalize on this difference should be successful. At the macro level, one process currently proposed to both sectors and the regulator is an integrated resource management plan at the regional level.

5.3.1 Macro Level

Integrated resource management planning at the regional level is expected to provide cost savings, sustainable harvest levels, and minimize the environmental impacts. Cost savings are expected from harmonizing the construction of roads among industrial sectors and minimize the administration and planning for many regional authorities. The sustainable harvest levels would result from a one-window timber harvest forecast that incorporates all of the forest clearing activities in the region and the ecological targets into the approved rate of harvest. Finally, the negative impacts on the environment would be minimized, because of the harmonized access development and incorporation of environmental targets (e.g. proportion of old growth) into the rate of forest clearing. For these reasons, integrated resource management planning will ultimately result in less forest clearing and fragmentation.

5.3.2 Micro Level

At the micro level, a number of industry specific measures to minimize forest fragmentation are underway. Forestry firms are using existing seismic lines where possible to access their timber. For example, they will use the area already cleared to build their road rather than clear a new right-of-way. Energy firms are using low impact seismic measures such as hand cut lines (one meter wide) and winding lines (reduce the line of sight) to minimize the cost of clearing trees and ultimately reduce the extent of fragmentation (Figure 15).

Although the adoption of these practices is slow and not industry-wide, the benefits are clear. Less forest is cleared or fragmented for exploration, development and infrastructure. For example, hand-cut seismic lines established in a grid over a section of forest are nearly un-detectable in the field because little timber has been cleared and the tree canopies of the remaining forest covers the one meter strip. In summary, these simple techniques in combination with integrated regional planning are a good start towards minimizing the industrial footprint left in the forest.

Heli-assist seismic

Low impact seismic

Hand-cut seismic

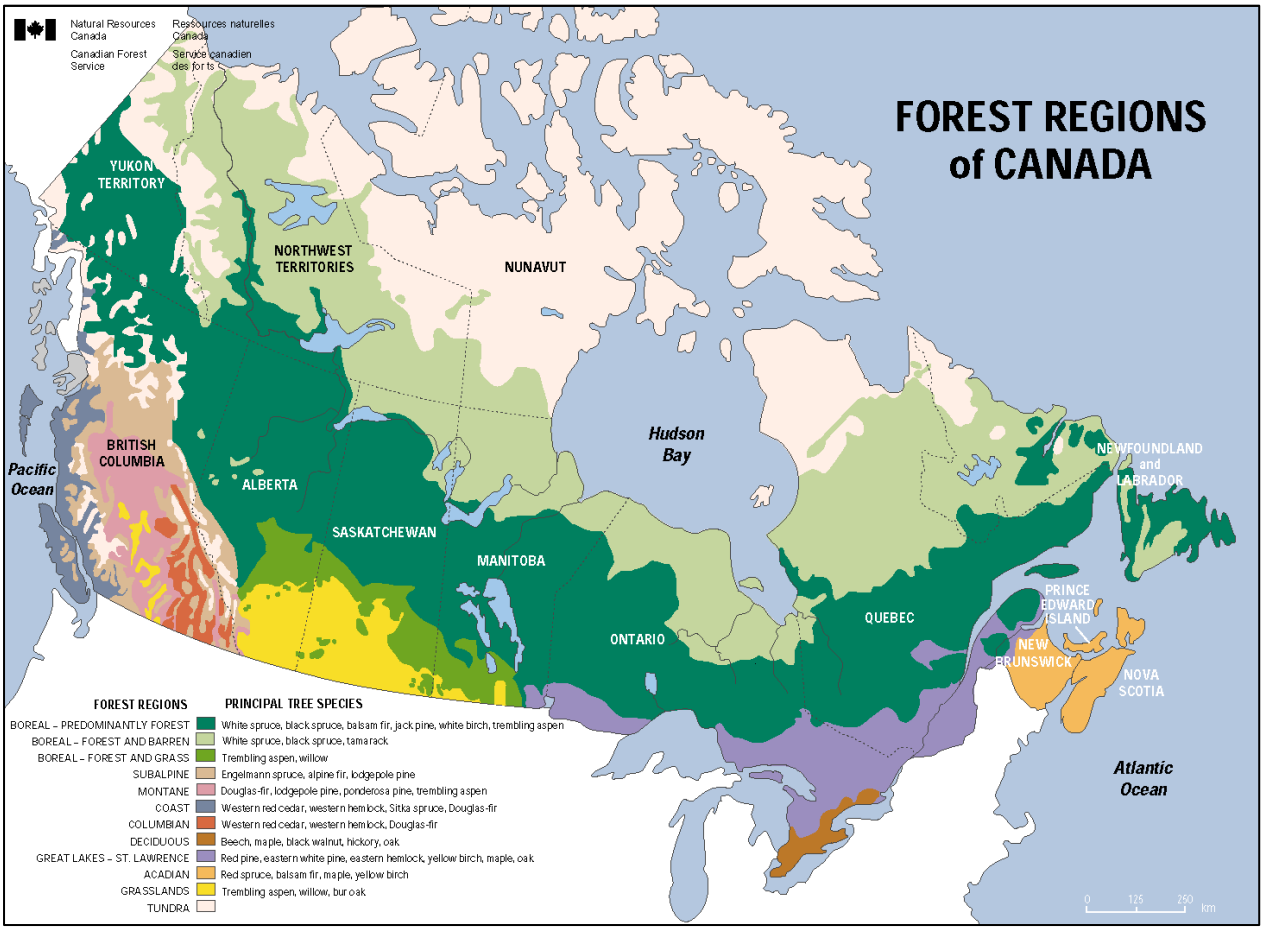
Figure 15. Modern seismic techniques designed to reduce fragmentation

6.0 CONCLUSIONS

Alberta's economic prosperity is a function of the wealth of natural resources within its boarders. The sale of oil and gas to markets worldwide and the taxation of the firms that produce it contribute significantly to Alberta's GDP. However, the wealth created by the exploration and development of oil and gas reserves should not overshadow the economic and ecological importance of the forest that is cleared to access it. Alberta has vast forests that support a respectable forest industry and a diverse ecosystem of vegetation and wildlife. The externality of combining the activities of both the energy and forestry sector is the fragmentation of the forest. Forest fragmentation has considerable short and long-term consequences on wildlife habitat and forest composition but the means to mitigate the effects are promising and under development.

7.0 APPENDICIES

Appendix 1. Forest Regions of Canada.



Source:
Natural Resources Canada. Forest Regions of Canada. http://www.cfl.scf.rncan.gc.ca/ecosys/images/classif/forestreg_e.gif. Accessed January 21, 2005.

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