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Forest Management and Planning for Grizzly Bears

Applying science-based management tools in multiple stages of forest harvest planning

Prepared for
Forest Resource Improvement Association of Alberta (FRIAA)

Final Report
Edson Forest Products, fRI Research Grizzly Bear Program

November 13, 2019

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About the Authors

fRI Research is a unique community of Partners joined by a common concern for the welfare of the land, its resources, and the people who value and use them. fRI Research connects managers and researchers to effectively collaborate in achieving the our vision and mission.

The fRI Research Grizzly Bear Program was created in 1998 to provide knowledge and planning tools to land and resource managers to ensure the long-term conservation of grizzly bears in Alberta. Key to its efforts are sound scientific field research, practical results, and a large-scale or "landscape level" approach toward grizzly bear conservation.

Learn more at FRIresearch.ca/program/grizzly-bear-program

West Fraser is a diversified North American wood products company with 45 manufacturing facilities in Western Canada and the southern United States. West Fraser is the largest forest products manufacturer in Alberta directly employing 2,300 people across 10 communities. West Fraser manufactures lumber, plywood, pulp, energy, and other specialty wood products and sustainably manages over 4-million hectares of third-party certified forest lands in the province.

West Fraser has supported grizzly bear monitoring and research programs in Alberta for many years. These activities have included collaring programs, population estimates, biophysical habitat needs, and participation in the Alberta grizzly bear Recovery Plan process. Much of this work has occurred through partnership with fRI Research.

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Any opinions expressed in this report are those of the authors, and do not necessarily reflect those of the organizations for which they work, fRI Research, or West Fraser.

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REPORT SUMMARY

In Alberta's Rocky Mountain Foothills, grizzly bear habitat is frequently altered through natural resource extraction activities which can alter landscape composition, configuration, and security for wildlife species.

Using a priori knowledge of grizzly bear habitat requirements, a forest harvest scenario was "hand-crafted" by professional foresters with input and guidance from biologists, with the aim of minimizing negative impacts on grizzly bear habitat, while minimizing human-caused mortality risk, within operational limits. A separate forest harvest scenario was also drafted in a "business as usual approach" (BAU) through the use of Stanley and Woodstock forest management modeling software, incorporating different road access and cutblock designs. Research biologists from the fRI Research Grizzly Bear Program then examined the impacts of these different harvest scenarios on habitat availability and security using existing grizzly bear modeling tools that had been developed using 22 years of research findings.

The Habitat State tool incorporates both habitat quality (as measured by resource selection function (RSF) models) and habitat security (as measured by mortality risk models) into a single value, and can quantify changes to this value across a given study area with the proposed anthropogenic development. Habitat state values increased with both the proposed Business as Usual and the Grizzly Bear plan (increases of 58.67% and 42.67% respectively). With the addition of access controls to the Grizzly Bear plan, restricting motorized access by the public, habitat state values increased 45.33%. The observed increase in habitat quality (RSF), regardless of harvest scenario, was not unexpected as prior research has demonstrated that forest harvesting is known to provide a diverse array of food resources for grizzly bears, particularly roots and tubers, herbaceous materials, and ants. Clear differences in habitat security were observed between different harvest scenarios, with all scenarios resulting in increased risk, but the addition of access controls to the Grizzly Bear plan succeeded in the aim of minimizing the increase in human-caused mortality risk. Ultimately, the BAU plan resulted in a net positive change in Habitat State, greater than that observed in the GB Plan, due to the spatial arrangement of smaller harvest areas and larger road network creating significantly more edge habitat. This large increase in habitat quality outweighed the accompanying increase in mortality risk, when the two components are equally weighted in the Habitat State Tool. This finding highlighted the importance of incorporating more edge habitat in the GB Plan, which featured a get in/get out approach focused on harvesting large (if not all) forest patches along a minimal road network.

Minimizing existing and anticipated motorized access in grizzly bear habitat has been identified as a high priority activity for provincial recovery of this species, since areas with higher road densities are associated with an increased risk of human-caused mortalities. While the Business as Usual plan resulted in an 18.87% increase in open road densities, incorporating access control measures in the Grizzly Bear plan resulted in an increase of only 2.12%. Effectively, since forest harvesting does improve grizzly bear habitats, this plan is a means to manage for road density over the long-term, which is arguably the most important element to support long term grizzly bear conservation in the Alberta Foothills.

ACKNOWLEDGEMENTS

Thank you to the fRI Research GIS staff, current and past, specifically Julie Duval and Dan Wismer, for the development and ongoing support and updates of the GB tools package.

Thanks to Byron Vriend, Timber Supply Analyst with West Fraser for generating the spatial harvest sequences for the scenarios tested. Thanks to Aaron Jones, Management Forester with West Fraser, for insights provided in the development of this study. Thanks also to Jody McCready, Resource Analyst with West Fraser, who provided information and resolution on the technical challenges encountered when running the Grizzly Bear GIS tools.

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INTRODUCTION

Decades of research has shown that grizzly bears benefit from a forest matrix with a variety of seral stages. Young regenerating forests contain critical bear foods such as berries, ants, ungulates, green herbaceous vegetation, and roots (Martin 1983, Zager et al. 1983, Nielsen et al. 2004*b*). Adjacent stands of older seral stages also provide thermal cover, resting sites, and hiding cover (Ordiz et al. 2011, Cristescu et al. 2013). In the foothills of west central Alberta, this matrix of forest ages is created through ongoing natural resource extraction activities, including modern commercial timber harvesting which aims to maintain (in perpetuity) a variety of seral stages across the landscape through natural disturbance emulation (Hinton Wood Products Natural Disturbance Strategy, 2014).

These same natural resource management activities also rely on the creation of new road access, which has been shown to be related to a reduction in grizzly bear survival (Boulanger and Stenhouse 2014). With increased road access into previously remote landscapes, there is a corresponding increase in human-caused grizzly bear mortality, the primary source of death for grizzly bears (Benn and Herrero 2002, Nielsen et al. 2004*a*).

Forest harvesting activities effect future grizzly bear habitat through changes in landscape composition, configuration, and security (Nielsen et al. 2004*b*). Previously, measuring the potential effects of forest harvesting on grizzly bear habitat was carried out by the Government of Alberta (GOA) after the forest company completed and submitted their spatial harvest sequence (SHS) plans along with an assessment of potential effects on grizzly bears and other values. It was not an iterative process in an adaptive planning process, but rather a last check that examines the effects of forest harvesting to grizzly bear habitat after the harvesting plans have been finalized. More recently, there have been changes in the forest management planning process to address non-timber values before forest companies submit harvest plans. By shifting assessments to earlier in the planning process, companies can incorporate habitat needs at the onset of harvest planning, thereby reducing uncertainty in plan approvals. Early examination of effects on habitat allow managers to adjust plans at the early stages of planning to maximize positive effects on habitat and minimize negative effects.

Edson Forest Products (EFP), a division of West Fraser Mills Ltd., took this one step further. Rather than simply evaluating harvest plans for quality, quantity and perpetuity of grizzly bear habitat, EFP devised a harvest plan that was intelligently designed with *a priori* knowledge about grizzly bear habitat needs to mitigate risk to bears. The end result was a compartment-level harvest and road entry plan. This handcrafted “grizzly bear” plan was designed to minimize new road development, identify options for road access controls, and maximize young seral forests.

In this case study, two scenarios of road and harvest were assessed using science-based grizzly bear planning tools. One scenario represents a business as usual case where roads and harvest areas are driven by processes that would typically be used by the company considering an array of values with no one value being weighted higher than the others. The second scenario represents a “grizzly bear friendly” plan, incorporating considerations from fRI Research’s grizzly biologists and forest planners alike, which elevated the importance of grizzly bear habitat outcomes over all other values considered, but was still within the bounds of operational feasibility.

Using a tools package custom built by fRI Research staff in ArcGIS, the two forest harvest scenarios were evaluated to determine the effects of proposed roads and harvest areas on grizzly habitat quality and availability (as measured by resource selection function models) and habitat security (as measured by mortality risk models). Resource selection function (RSF) models predict the relative probability of bear occurrence, which is used as a surrogate for the abundance and distribution of various habitat resources required by grizzly bears (Nielsen et al. 2002). Habitat security is represented by the mortality risk model (Nielsen et al. 2004*a*), which predicts the relative probability of human-caused grizzly bear mortality as a function of landscape variables. The habitat states tool, built by staff from the fRI Research GIS team, combines the RSF model with the mortality risk model to identify areas of population sink (good-quality but high-risk habitat) and population source (good-quality and low-risk habitat). Additionally, the custom built road density tool identifies the effect of proposed roads on road density values across the grizzly bear watershed unit, as prior research has demonstrated strong spatial gradients in grizzly bear survival and population trend based upon open road density calculations. Using these two tools, the two forest harvest scenarios were compared to one another, and to current landscape conditions.

Objectives

The primary goal of this collaborative project between the fRI Research Grizzly Bear Program and the Edson Forest Products forest management planning department was to test the efficacy and practicality of applying science-based grizzly bear tools at the beginning of a forest harvest planning process, allowing the science behind these tools to drive harvesting scenarios and identify operational constraints that conflict with grizzly bear needs up front. In addition to evaluating this approach, communicating the results of this test case was a primary aim of this project. Objectives were:

1. Evaluate and rank different forest harvest scenarios to determine the effects on habitat supply and security, with emphasis placed on reducing human-caused grizzly bear mortality.
2. Communicate the outcomes of this test case to forest managers across grizzly bear range in Alberta to highlight practices beneficial to grizzly bear habitat conservation, efficacy of analysis tool use, practicalities and economics.

Study Area

This project was conducted within an operational compartment (Sundance 2; 11,340 ha) on the Edson Forest Products Forest Management Agreement (FMA). This area is commonly referred to as the Chungo because it borders Chungo Creek – a large headwater channel of the Blackstone River drainage. The Chungo is located west of the Forestry Trunk Road and is bordered by the Blackstone River to the south, the Brazeau River to the north, and Weyerhaeuser Edson FMA to the east (Figure 1).

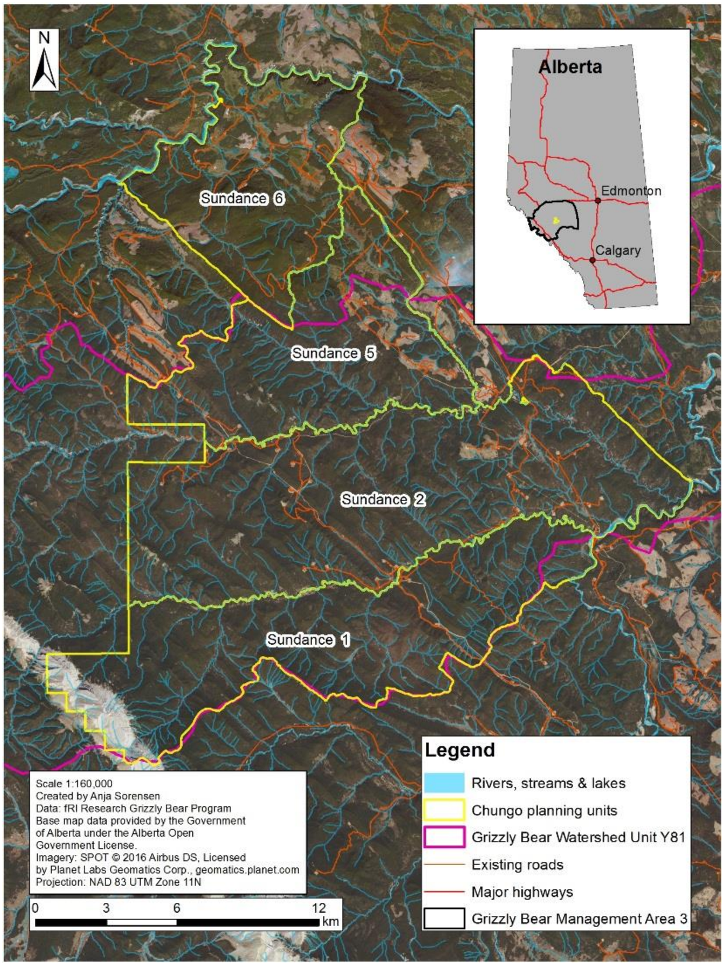

Figure 1. Chungo study area located in the foothills of west-central Alberta. Analysis for this project focused on the Sundance 2 compartment.

The area is part of the Chungo Creek Integrated Land Management plan (ILM). The ILM plan was created in 2002 by representatives of the forest and energy sector whose companies have interests in this area. The aim was to reduce the impacts associated with industrial roads by strategically co-planning potential routes for main trunk road access in this area. By working together, companies were able to consider factors that may not be considered during planning by individual companies.

The Chungo Creek area contains abundant renewable and non-renewable resources that are relatively under-developed with regard to industrial activity. This area has had a very low level of forest management activity in the past and makes up a significant portion of Edson Forest Products tenure and therefore, to properly manage the forested land, future access development was required.

Analysis for this project focused on the compartment Sundance 2, which falls entirely within core grizzly bear habitat, designated by the Alberta government in 2008 based on habitat quality and security, and is located within Bear Management Area 3 (Yellowhead).

METHODS

Using existing grizzly bear models and planning tools, staff from West Fraser forest management planning department and the fRI Research Grizzly Bear Program examined the effects of different harvest approaches on grizzly bear habitat and mortality risk, and identified site-specific management practices which mitigate impacts to grizzly bear habitat.

HARVEST PLANNING

Two scenarios for forest harvest were drafted for the Sundance 2 compartment; a "Business as Usual" (BAU) plan, and a "Grizzly Bear" (GB) plan, each incorporating different road access and harvest areas based on spatial harvest sequencing. Though harvest/road designs differed in each plan, both plans had to incorporate typical landbase constraints including: subjective deletions from the timber harvesting landbase; inaccessible terrain (i.e. steep slopes); ground conditions, especially the inclusion of harvestable areas accessible during the wet and dry seasons; limitations in road placement due to slope, ground conditions, fish-bearing watercourses, and other constraints.

The BAU plan was generated automatically through the use of timber supply modeling software (Stanley and Woodstock), while the GB plan was "hand-crafted" by professional foresters with input and guidance from the biologists with the fRI Research Grizzly Bear Program. In the end, the designed GB plan was a selection of all merchantable forest stands within the bounds of what is permitted by the Alberta Planning Standard and accessible from the road corridor design. This allowed for a "get in/get out" approach which was deemed important for the mitigation and management of grizzly bear mortality risk over time.

In reality, operational grounds and road corridor locations were significantly bound by the terrain of the area and operational feasibility. This area occurs within the Upper Foothills and Subalpine natural subregions; characterized by steep slopes and rugged terrain. Therefore, the GB plan represents the best possible attempt to fully utilize *a priori* knowledge to mitigate grizzly bear mortality and increase grizzly bear habitat supply but does include some trade-offs with operational limitations.

The characteristics and attributes of these two scenarios are shown in Table 1. Also included in Table 1 is a third scenario describing the Grizzly Bear plan with the proposed road access controls.

Table 1. Attributes of three proposed forest harvest scenarios

	Business as Usual (BAU) Plan	Grizzly Bear (GB) Plan	GB Plan with Road Access Controls
Block design approach	Timber supply modeling with typical optimizations (e.g. volume) and constraints (e.g. stand age) as per the Alberta Planning Standard. Any area within the compartment that was	Two large aggregated harvest areas were chosen based on a combination of timber attributes (i.e. eligibility) and predicted habitat attributes for grizzly bears (e.g. maximized	Harvest areas are the same as in the GB Plan. Note also, harvest scheduling of these areas was chosen based on ability to restrict public access (i.e. stream crossings that could be

	eligible for harvest could have been selected by the model. Forest planners allowed the model to choose harvest areas at random.	Primary Habitat, and combined Primary + Secondary Habitat , and distance from roads).	pulled when not in use or optimal gate locations).
Harvest area	916 ha	1629 ha In a "get in/get out" approach, the GB plan has more total harvestable area. All eligible forest stands off the road corridor must be harvested during the life of the road.	1629 ha In a "get in/get out" approach, the GB plan has more total harvestable area. All eligible forest stands off the road corridor must be harvested during the life of the road.
Permanent road corridor approach	An approximation of road corridors needed to access the spatial harvest sequence.	Aggregated harvest areas were planned to occur immediately adjacent to one major corridor and planned temporary spur roads, reducing the total length of new road needed. Note, temporary spur roads are not assessed in this analysis as they will be built on an as needed basis and will be in place for 3 years or less. The intent of using spur roads with the main permanent corridor is to achieve spatial separation of harvest areas from the permanent road.	As in the GB plan but including 4-5 major road access control points. Three control points are permanent gates along the new permanent road. The remainder of the control points will be used in association with the temporal harvest sequence and will be customized to road construction phases and/or harvesting or reforestation activities.
Road length (existing)	76.13 Km		
New road length (planned)	49.25 km	25.43 km	20.13 km closed to public, 5.30 km open Total road length is the same as the GB plan (25.43 Km); however, the main corridor will be gated (3 locations) effectively eliminating

			public access on 79% of the corridor. Additional access controls are planned for temporary spur roads during active operations.
Permanent road access controls	None*	None*	4-5 pre-determined locations, primarily restricted by gates.
Temporary road access controls (lifespan <3 years)	As per Operating Ground Rules, prompt reclamation following harvest activity.	As per Operating Ground Rules, prompt reclamation following harvest activity.	As per Operating Ground Rules, prompt reclamation following harvest activity and use of access controls during active operations (e.g. pull crossings between operation phases).
Sequence and harvest schedule	Although any SHS area could be accessed at any time, all would be harvested within a 10 year period. Roads created would be maintained beyond 10 years because future SHS polygons will eventually be created as part of the next Forest Management Plan. Some roads in this scenario could be reclaimed and re-opened multiple times to access SHS areas depending on how they are selected.	Both aggregates to be harvested within 10 years; however, harvesting of the most distant aggregate (from the Forestry Trunk Road) would occur first and road roll back would occur following forest harvesting and reforestation commitments resulting in a gradual reduction of the road length over 10-30 years. Future spatial harvest sequences would not occur off the road corridor because all eligible forest stands (with planned full rotation retention) would be removed in one pass.	As in the GB plan with road access controls put in place when roads are not in use for forestry activities. Roads would have an initial access control of gates with possible crossing removal as further access controls.
	Figure 2	Figure 3	Figure 4

*Permanent road development requires approval from Alberta Environment and Parks (AEP). Road disposition approvals from AEP often require some use of public access controls.

Both scenarios tested are pre-layout plans, meaning that changes may be made when forest planners interpret the spatial simulation of the scenario and begin constructing on-the-ground plans. Of particular importance, the placement of in-block and between-block retention not designed until the layout stage can have impacts on final results of modelling. To amplify the effect of retention practices for grizzly bear habitat quality and mortality risk mitigation, forest planners were trained on the use of the sightability tool developed by the fRI Research Grizzly Bear biologists.

One component of habitat security is sightability: the visibility of the landscape from adjacent roads, as determined by terrain and forest cover. The assumption is that increased sightability into areas such as an exposed cutblock increases the risk of human-caused grizzly bear mortalities. Using LiDAR (Light Detection and Ranging) remote sensing data, the sightability tool calculates the proportion of natural openings and cutover area visible from the roadside. Users are able to model the effects of various proposed harvest designs on the post-harvest roadside viewsheds. The Sightability tool can also model the reduction of visibility with increasing time since harvest and the regeneration of new trees, including customization options for regeneration density and height.

After the aggregate harvest area perimeters were designed, and log processing areas along the permanent access and temporary in-block roads were identified, forest planners utilized the sightability tool to aid in the placement of stand retention across the blocks. Testing different orientations and sizes of stand retention in the harvest areas, forest planners were able to identify locations for future retention that reduced the overall visibility into the harvest area from permanent road access corridors while meeting operational harvest considerations.

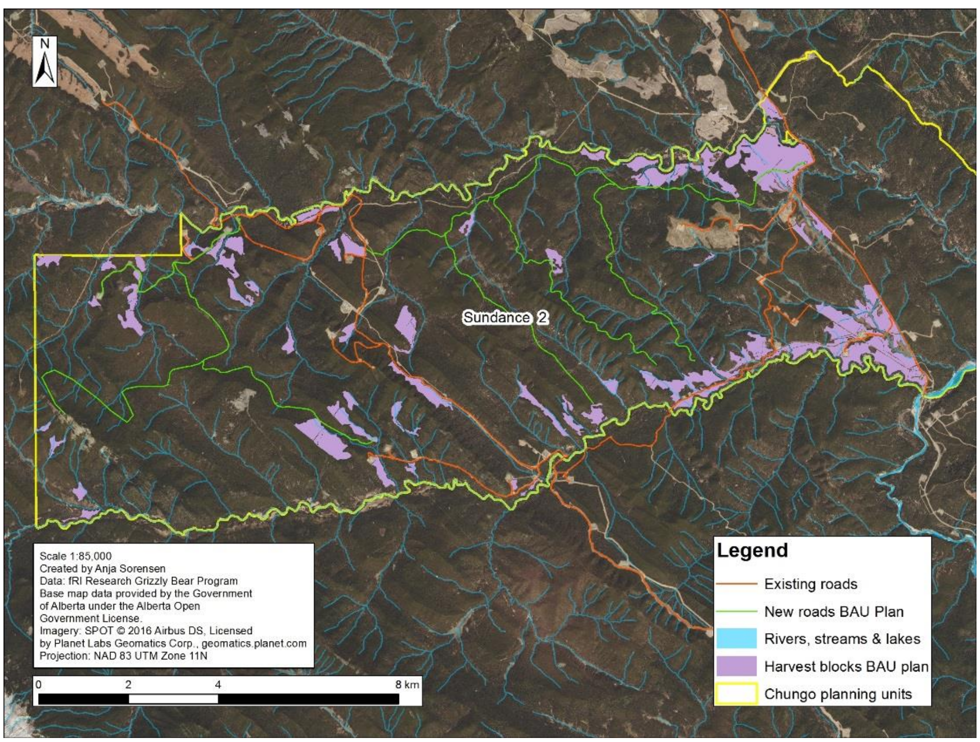

Figure 2. Proposed forest harvest scenario following a Business As Usual approach, including cut blocks, existing roads, and new roads in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

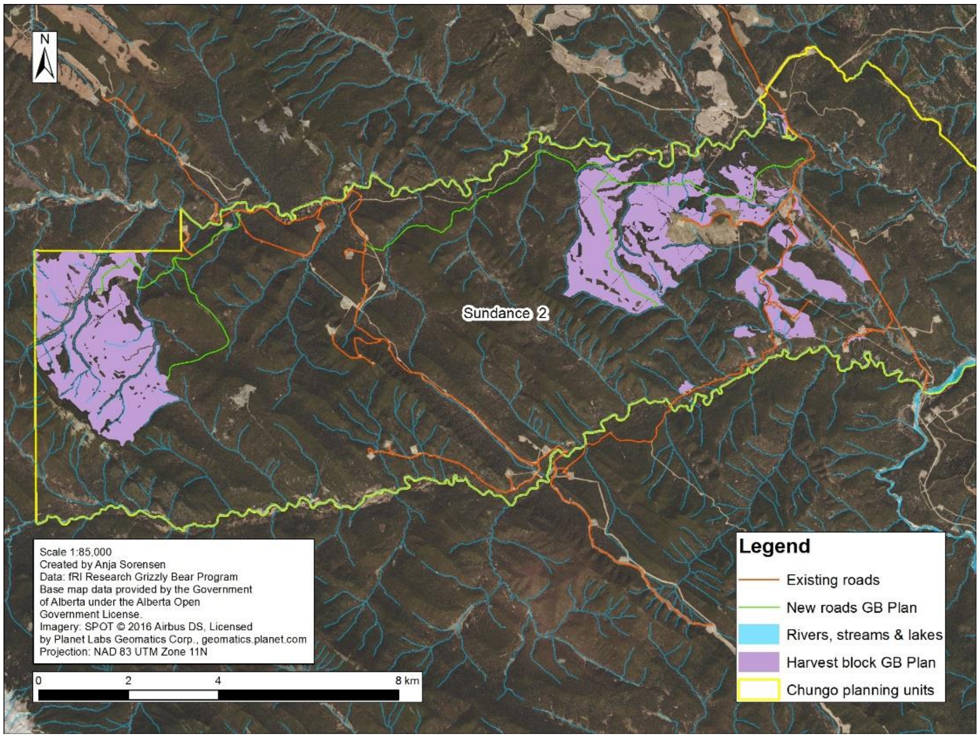

Figure 3. Proposed forest harvest scenario following a Grizzly Bear centric approach, including cut blocks, existing roads, and new roads in the Sundance 2 compartment in the Chungo study area of west-central Alberta.

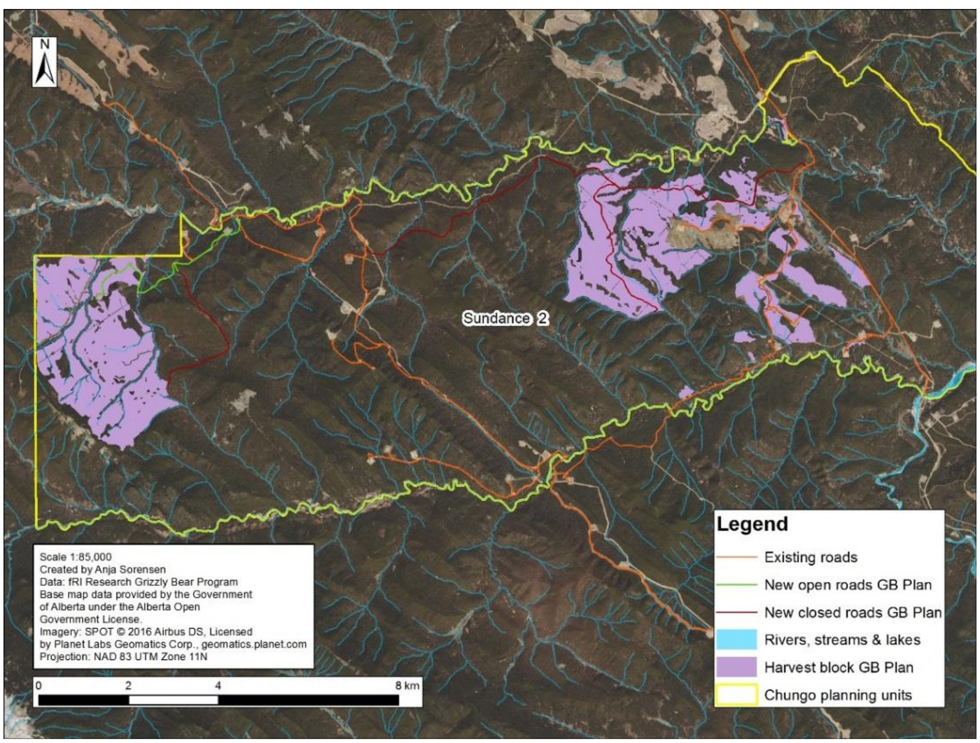

Figure 4. Proposed forest harvest scenario following a Grizzly Bear centric approach, including cut blocks, existing roads, and new roads with access management (roads closed or open to public access) in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

Grizzly Bear Tools

Both the BAU plan (915.9 ha harvested) and the GB plan (1,629.0 ha harvested) were evaluated in relation to their effects on grizzly bear habitat quality, availability, and security, compared to the current landscape conditions. Tools to measure these changes currently exist as part of the GBTools package for ArcGIS, developed by fRI Research staff and collaborators. An outline of these tools follows:

Habitat States Tool

The habitat state tool incorporates two important components to grizzly bear conservation: habitat quality and availability (as measured by resource selection function models) and habitat security (as measured by mortality risk models).

Resource selection function (RSF models) models predict the relative probability of bear occurrence, classified into 10 ordinal bins (Nielsen et al. 2002). Bear occurrence, or occupancy, is used as a surrogate for the abundance and distribution of various habitat resources including food, water, denning sites, and thermal cover. These models are based on regression analysis of at least 2 years of grizzly bear location data collected by GPS radio collars, combined with six basic landscape variables: landcover type (eight broad vegetation classes (McDermid 2005)), canopy cover, conifer/deciduous mix, streams, regenerating forest mask, and Compound Topographic Index (a measure of soil wetness). Models have been developed for three seasons (spring, summer and fall), and for six population units (Livingstone, Castle, Clearwater, Yellowhead, Grande Cache, and Swan Hills), based on differences in resource use seasonally and between regional population groups.

Habitat security is represented by the mortality risk model (Nielsen et al. 2004*a*), which predicts the relative probability of human-caused mortality as a function of landscape variables including terrain, proximity to roads and trails, and regional land-use. The model is based on multivariate logistic regression analysis of 297 anthropogenic grizzly bear mortalities that occurred within the Central Rockies Ecosystem between 1971 and 2002. The model is derived from six base inputs: landcover, terrain ruggedness, and proximity to roads and trails, White Zone (agricultural areas), streams, and protected areas.

The habitat states model (Nielsen et al. 2006), combines the RSF model with the mortality risk model to distinguish areas of population sink (good-quality but high-risk habitat) from good-quality, low-risk areas that serve as a population source (Figure 5). The relative proportion of population sources and sinks within a defined area can serve as a baseline measure of overall habitat quality.

The habitat state tool classifies current landscape conditions using the RSF and mortality risk models, in addition to predicting changes to these surfaces with proposed anthropogenic features (roads, cut blocks, pipelines, etc) and adjusting the combined habitat state value for each pixel. The output of this tool is a raster surface for each proposed development scenario, with each pixel representing one of five categories (Figure 5). The habitat states model has also been reclassified from categorical values to ordinal classes so that a mean value can be calculated across the area of interest. This tool also provides managers with the option to forecast the impact of new anthropogenic features on habitat state over time. When the forecast age is left at 0, as was done in this analysis, the RSF is based on typical forest conditions 5 years post-harvest. Otherwise, a value up to 40 can be entered and the script will project canopy closure values as a function of cutblock age.

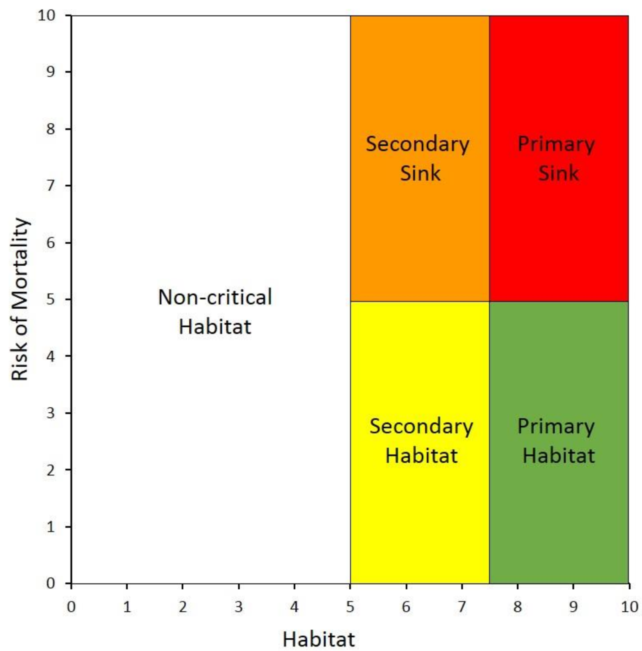

Figure 5. Habitat State categories, based on the combined values of habitat quality (as calculated by resource selection function models) and the risk of human-caused grizzly bear mortality.

Road Density Tools

Demographic models have predicted that grizzly bear populations would likely increase at open road densities of <=0.6km/km^2, but females with young cubs are particularly vulnerable and would likely decrease at open road densities greater than 0.75km/km^2 (Boulanger and Stenhouse 2014). As such, the Alberta Grizzly Bear Recovery Plan (2016) recommends open road density thresholds of 0.6km/km^2 in grizzly bear watershed units (GBWU) occurring within the Core Zone, and 0.75km/km^2 in the Secondary Zone.

The road density tools are meant to inform users of current conditions, and the impact of constructing new roads on the local road density threshold, in a two-step process. First, the current state of road density within a user's area of interest is calculated. Secondly, projected scenarios can add or remove roads from the previous run and re-calculate densities for comparison.

The Calculate Current Road Density tool identifies the GBWU that the user's identified area of interest fall within. Roads intersecting the GBWU of interest are selected, and road density is generated by dividing the total length (km) of roads by the respective GBWU area (km^2). Secondly, the Calculate Road Density Scenario tool allows the user to add or remove roads from a previous Calculate Current Road Density output. This tool is useful for planning road construction or restoration projects. Once roads have been removed or added, densities are re-calculated and compared against current conditions. The Calculate Road Density Scenario tool is designed to run only after a current road density output has been generated.

Workshopping the GBTools

Evaluating the efficacy and applicability of the GBtools package in a forest planning scenario was a primary objective of this project. To examine how forest planners could incorporate these tools into their planning process, fRI Research hosted a workshop on February 22, 2017 to introduce planners to the applications of GBTools. Staff from the fRI Research Grizzly Bear Program and GIS team presented to thirteen West Fraser forest planners and GIS staff. Following a demonstration outlining the use of the tools, planners had the opportunity to work through practice exercises in ArcGIS. Written surveys were collected anonymously from participants following the workshop, seeking feedback on the applicability of the tools, suggestions to improve the tools demonstrated, and ideas for additional tools which could be developed to incorporate grizzly bear requirements into forest management planning.

Results

The effects of the Grizzly Bear (GB) and Business As Usual (BAU) plans to grizzly bear habitat quality, availability, and security, were evaluated and compared to the current landscape conditions. As expected grizzly bear habitat quality (as measured by resource selection function models) was found to increase with both harvest plans. With the GB plan, the mean RSF value within the Sundance 2 compartment increased by 21.01% (Figure 6), while an increase of 27.72% was observed with the BAU plan (Figure 7). Human-caused grizzly bear mortality risk models predicted an increase in risk with both the GB plan (17.02%) and the BAU plan (26.24%), compared to current landscape conditions (Figures 8 and 9, respectively). With the addition of effective access control measures to the GB plan, such as gates to restrict public vehicular access, mortality risk increased from the current conditions (15.6%, Figure 10), but the increase in mortality risk was lowest in this scenario compared to the increase in risk seen in the BAU plan or in the GB plan without access control.

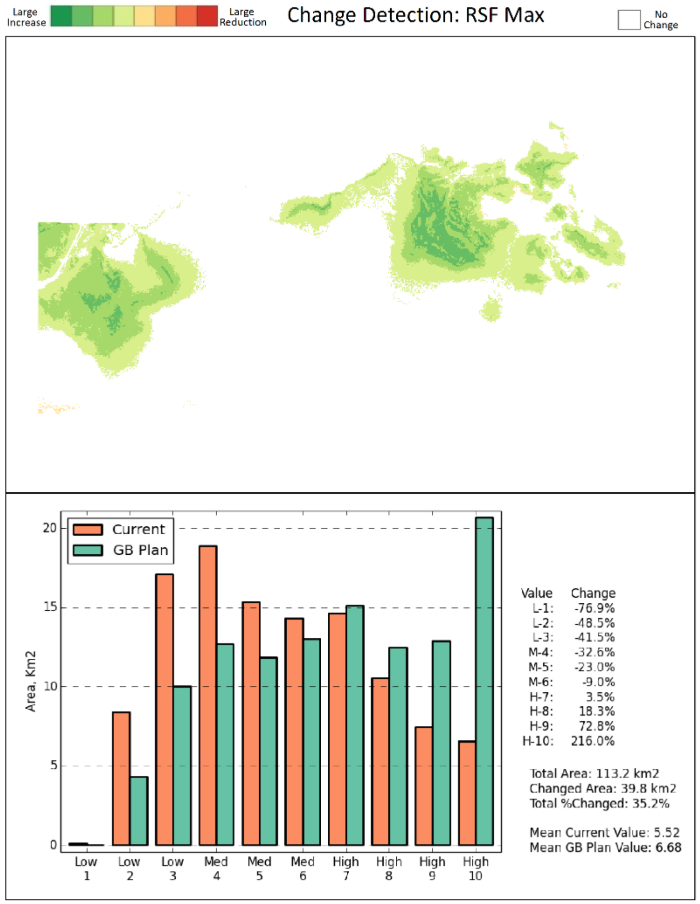

Figure 6. Projected changes to grizzly bear habitat quality, as measured by resource selection function (RSF) models, with the proposed Grizzly Bear (GB) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

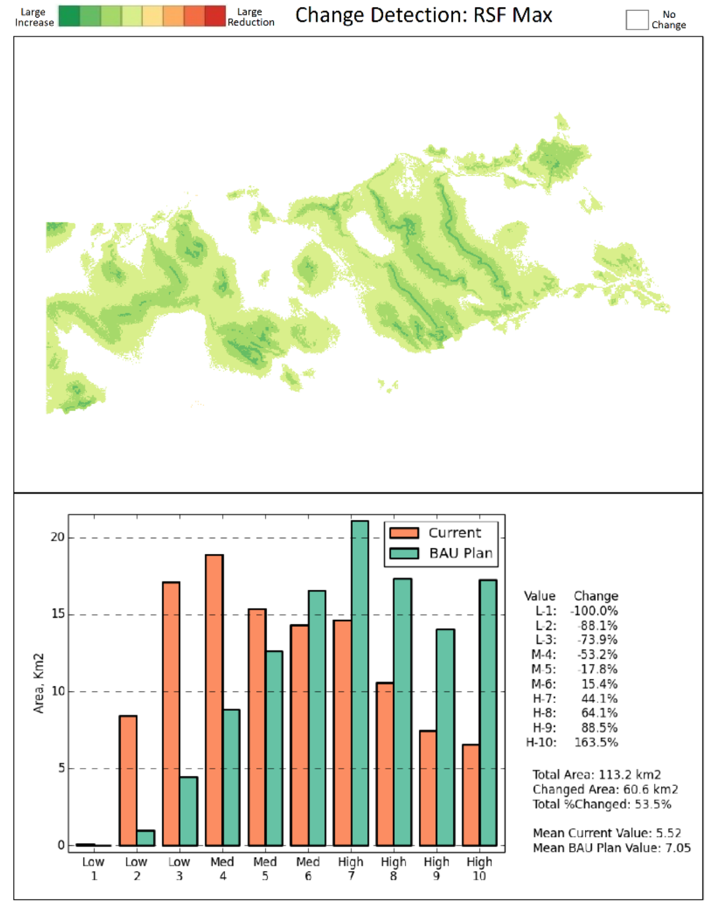

Figure 7. Projected changes to grizzly bear habitat quality, as measured by resource selection function (RSF) models, with the proposed Business As Usual (BAU) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

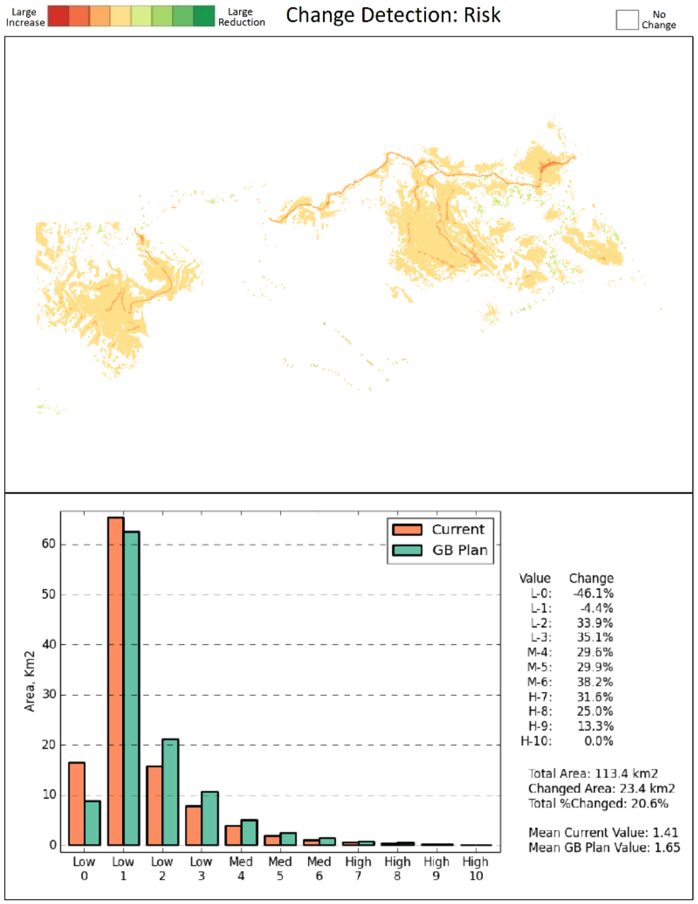

Figure 8. Projected changes to grizzly bear mortality risk, as measured by human caused grizzly bear mortality risk models, with the proposed Grizzly Bear (GB) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

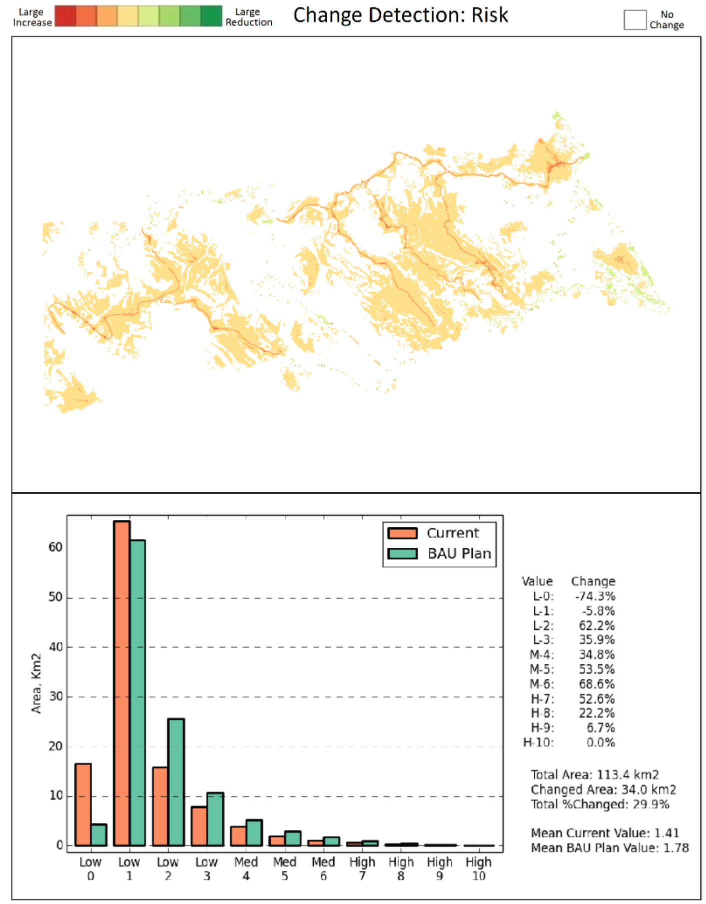

Figure 9. Projected changes to grizzly bear mortality risk, as measured by human caused grizzly bear mortality risk models, with the proposed Business As Usual (BAU) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

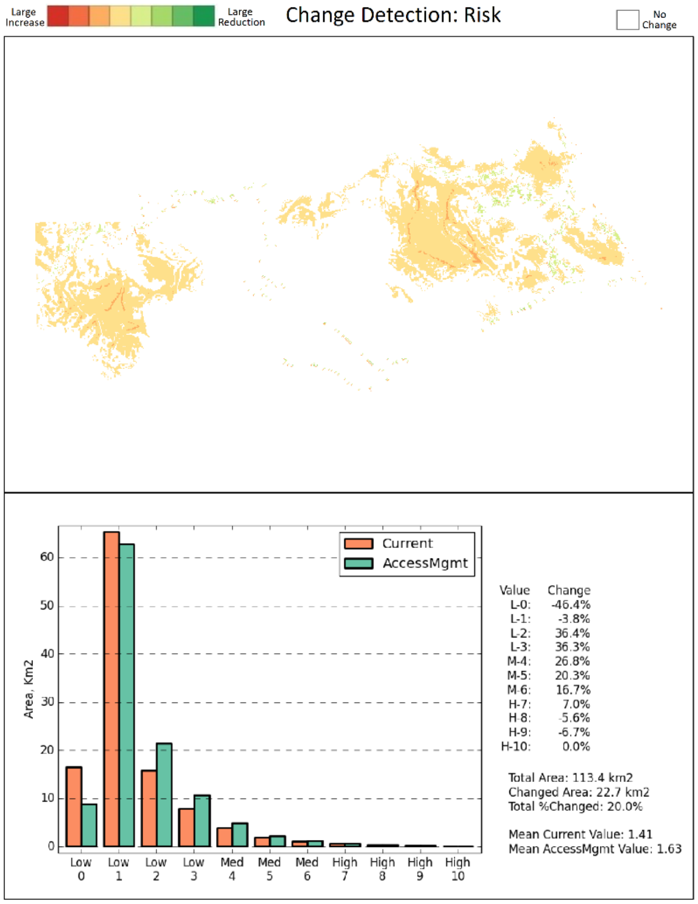

Figure 10. Projected changes to grizzly bear mortality risk, as measured by human caused grizzly bear mortality risk models, with the addition of access control measures to the Grizzly Bear (GB) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

The Habitat State tool incorporates both habitat quality (as measured by resource selection function models) and habitat security (as measured by mortality risk models) into a single value. In order to calculate the mean habitat state value across an area of interest, the habitat states model can reclassify categorical values to ordinal classes (primary sink=-2, secondary sink=-1, non-critical habitat=0, secondary habitat=1, primary habitat=2). Currently, the habitat state value averaged across the Sundance 2 compartment is 0.75. When modeling the effects of the GB plan, average habitat state value increased 42.67% to a value of 1.07 (Figure 11). When examining landscape changes with the BAU plan, average habitat state value increased 58.67% to a value of 1.19 (Figure 12). Finally, when modelling the effects of the GB plan with access control measures put in place on new roads, habitat state was found to increase 45.33% from current conditions, resulting in a final value of 1.09 averaged across the Sundance 2 compartment (Figure 13).

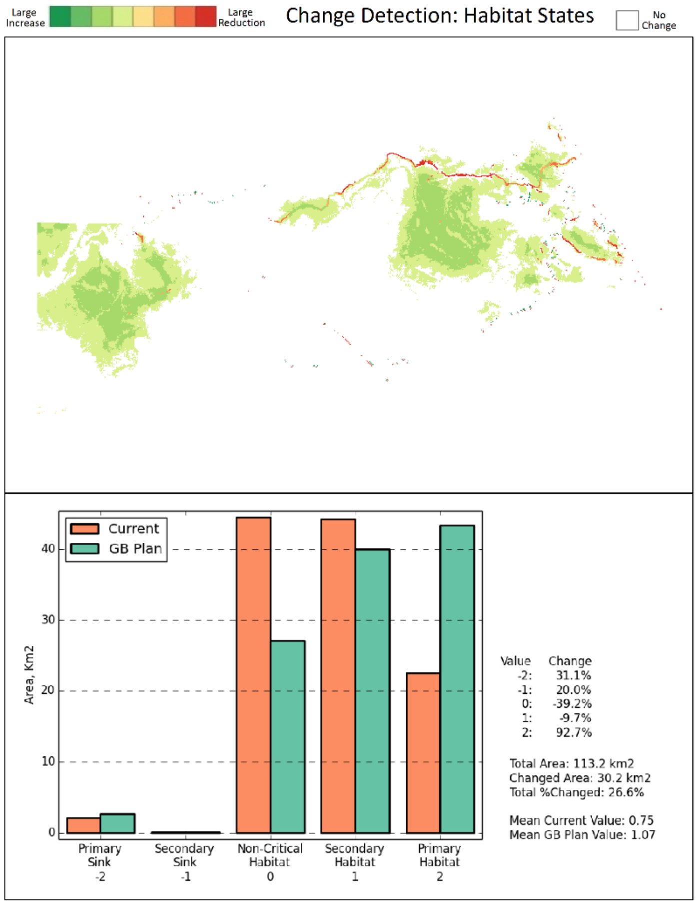

Figure 11. Projected changes to grizzly bear habitat state with the proposed Grizzly Bear (GB) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

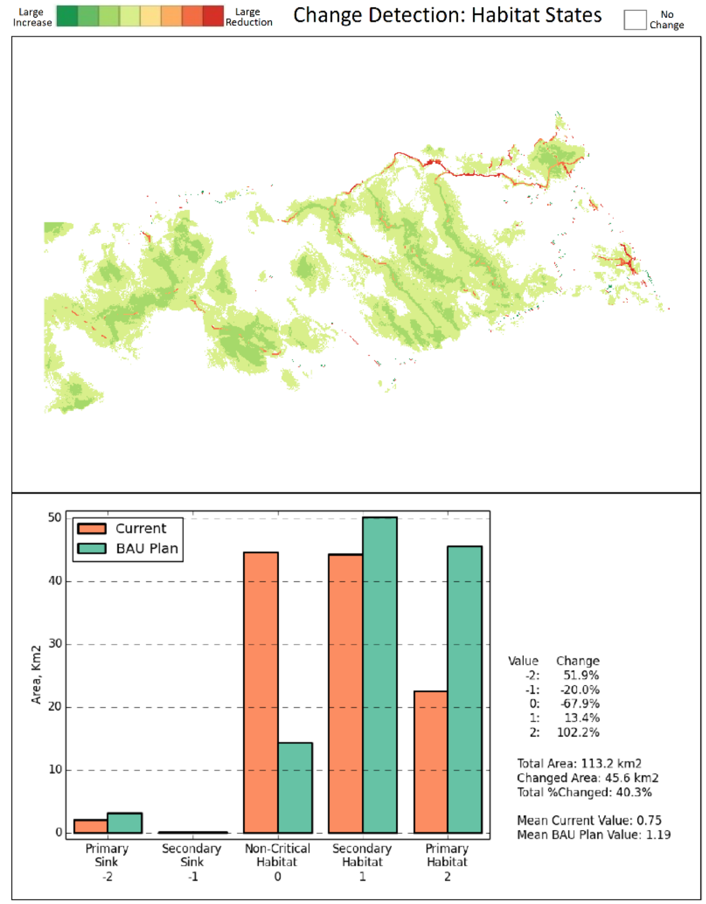

Figure 12. Projected changes to grizzly bear habitat state with the proposed Business As Usual (BAU) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

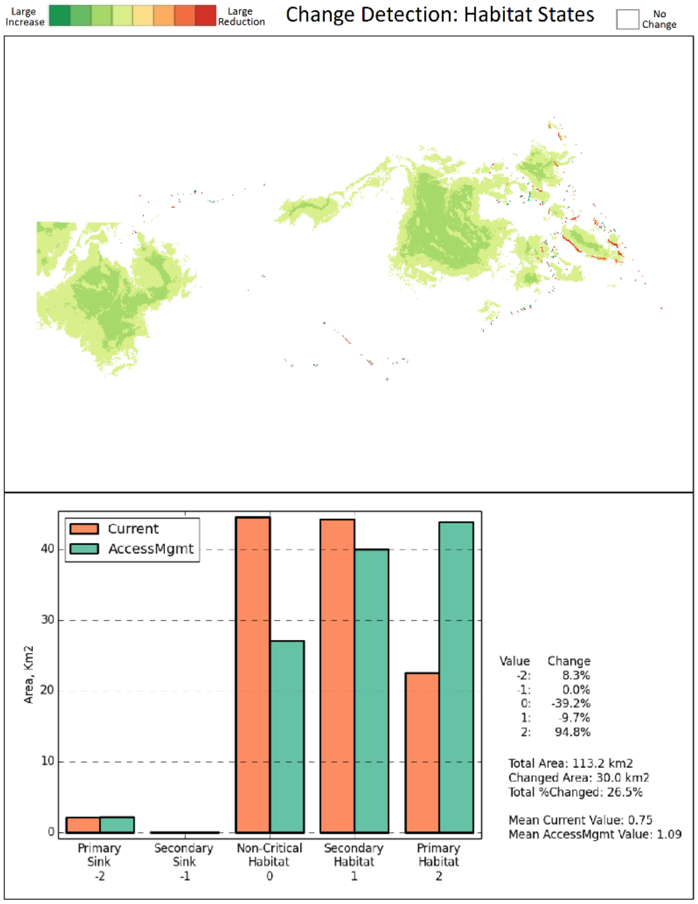

Figure 13. Projected changes to grizzly bear habitat state with the addition of access control measures to the Grizzly Bear (GB) plan for forest harvesting in the Sundance 2 compartment of the Chungo study area in west-central Alberta.

As the Sundance 2 compartment is located within Core grizzly bear habitat, the Alberta Grizzly Bear Recovery Plan (2016) recommends the open road density threshold of 0.6 km/km^2 across the GBWU. Currently GBWU Y81, in which the compartment is located, has an open road density of 0.424 km/km^2. Proposed new roads in the GB plan would increase that open road density 9.91%, to 0.466 km/km^2. Additional roads proposed in the BAU plan would increase open road densities in GBWU Y81 by 18.87%, resulting in a final value of 0.504 km/km^2. By incorporating additional access control measures in the GB plan, such as gates, increases in open road densities could be further managed. If effective gates restrict highway vehicle access, and roads are considered closed to the general public, the limited length of open roads required in this plan would result in a final open road density value of 0.433 km/km^2, a 2.12% increase from current conditions.

Discussion

This planning exercise proved to be a valuable learning opportunity for staff of both West Fraser and the fRI Research Grizzly Bear Program. As a result of this process, West Fraser forestry staff had a heightened awareness of incorporating conservation opportunities for grizzly bears, and other wildlife, in forest planning. Additionally, staff at fRI Research gained a greater understanding of the challenges of forest harvest planning, end user application of research findings with the GB Tools application and the complexity of managing for multiple ecosystem values and operating costs.

This collaborative project demonstrates that forest harvest areas can create high quality grizzly bear habitat through the addition of young seral forest and the negative effects of roads on grizzly bear habitat security can be effectively managed when measures are taken in the early stages of forest harvest planning. The GB plan, with additional access control measures to restrict public access, resulted in only a minimal increase in open road densities within GBWU Y81. By aggregating harvest areas in the GB plan, a greater area of primary habitat was achieved with fewer access roads required.

Interestingly, the BAU plan resulted in a greater habitat state value, with a greater total combined area of Primary Habitat and Secondary Habitat, when compared to the GB plan. This is likely because the spatial arrangement, smaller harvest area size, and larger road network of the BAU Plan created significantly more edge habitat, which heavily contributed to increases in grizzly bear habitat quality (as measured by RSF models). Recent work by the fRI Research Grizzly Bear Program (Larsen et al. 2019) demonstrated the value of edge habitat, with important bear foods such as blueberry (*Vaccinium*) species and horsetail found to be positively associated with forest edges, likely due to understory disturbance coupled with alterations to light regimes. These findings correspond with previous research showing strong selection of edge habitats by female grizzly bears in the spring and fall (Stewart et al. 2013). In addition to increased food supply, grizzly bears may also select for forest edges for security and resting cover (Cristescu et al. 2013), or to manage their thermal requirements (Pigeon et al. 2016). While this edge habitat associated with the proposed road network in the BAU Plan also results in a significant increase in mortality risk, the habitat state tool weighs the two components of RSF and mortality risk equally when creating a single value. The large increase in RSF outweighs the corresponding increase in mortality risk, resulting in a net positive change in habitat state. This finding highlighted the need for a higher perimeter to area ratio (edge) in the GB Plan. The reduced road network in this plan succeeded in managing road densities, but came at the cost of reduced edge habitat. Planning foresters should focus on create more edge habitat in the GB Plan as the aggregated harvest areas are planned on the ground through increased dispersed and aggregated retention, as well as irregular block boundaries.

Outcomes and Learnings

Improvements and enhancements to the GBTools package for ArcGIS for future integration with forest planning were identified during this project and many of these have already be completed by the fRI GIS staff. Staff from both groups recognized the level of technical expertise needed for running tools and interpreting results, and the requirement for significant in-house training to ensure proficiency in both. Even with training, ongoing technical support was required by forest planning staff. Additionally, periodic tool upgrades do take place which requires ongoing technical support and communication between the two groups. Important modifications were made to the mortality risk modelling tool as a direct result of this project, allowing the model to account for road closures and access controls. Additional changes to the GBTools package that could be considered in future upgrades could also include:

- Habitat State Tool
    - Ability to replace base satellite-derived data with finer resolution forest inventory data
    - Ability to account for wider variety of forest conditions such as fire-origin versus harvest origin stands, stand structure retention post-disturbance, ecosite productivity, alternative growth and yield curves, etc.
    - Refinement of age classes used to assign habitat state such that a continuous age variable could be used reflecting a gradual change in habitat state, rather than an abrupt change from "sink" to "source"
    - Ability to automate the removal and reforestation of trails (completed)
    - Evaluation and validation of the mortality risk coefficient associated with static features such as watercourses.
- Sightability Tool
    - A more user-friendly interface
    - Development of a data dictionary
    - Reversal of the sightability assignment such that segments of the road can be identified and/or ranked based on sightability rather than the assignment of the harvest area polygon. This reversal would allow foresters a chance to identify visibility of the block from the highest risk segments of the road and plan block design at these key locations.

The GB plan had pros and cons for operational forestry. On the pro side, using "get in/get out" approach accesses most (if not all) available forest stands along a road corridor, allowing for a larger patch size; that is contiguous areas of Primary Habitat. Large patches resulted in more temporary in-block roads (considered to be impassable by on highway vehicles following reclamation and reforestation) in lieu of permanent roads. In modern ecosystem-based forestry, larger patches of single aged stands are thought to be more consistent with natural disturbance patterns. This is particularly true for lodgepole pine (*Pinus contorta*) in the foothills region of Alberta where stand-replacing fires dominate the landscapes' disturbance regime. Historically, two pass harvest practices have created small patches of young seral forest and there is therefore an imbalance towards smaller patch sizes of young seral forests on the landscape today. An aggregated harvest footprint shifts this balance closer to what would be expected under strictly natural disturbance patterns.

Road maintenance cost savings are also expected with the GB Plan following the proposed "get in/get out" approach. Traditional two pass harvest systems would require roads to remain in place such that both first and second pass harvesting events could occur. Although the schedule of first and second pass may vary, it could mean timelines of >50 years. During this time period, regular access is required for both reforestation and forest harvest planning activities which in turn require the roads to be maintained. In the GB plan, roads are expected to be deactivated when the final reforestation requirements are achieved; typically, 14 years post-harvest.

A BAU plan that does not aggregate harvest could result in the requirement for more roads and multiple entries to an area to access forested stands adjacent to prior harvest areas until harvest activities are completed for a compartment. It is likely that some roads could remain in place for a long duration and while some portions of roads could be reclaimed or deactivated, they would be re-opened for use, possibly multiple times adding significant costs for reclamation, re-construction, and maintenance. A “get in/get out” approach reduces the amount of time that a portion of a road network is required to be in use.

Temporary roads were not addressed in this case study as they are reclaimed after a short duration of use, less than three years if not much shorter (avg. <1 year) and are reforested as part of the harvest area with no requirement for long term access. Company specific best management practices for temporary roads will be used as part of any plan scenario. These include:

- Minimize total distance of temporary roads needed
- Access controls such as berms or pulled river/stream crossings when not in use
- Full reclamation when use is complete, except under specified requests during consultation with registered fur management area stakeholders and Indigenous peoples
- Utilization of terrain (where possible) to limit line of sight

It should also be noted that while the GB plan has the intent to harvest the most distant areas first and then work outward toward the main Truck Road, there are many phases of planning and construction that can limit the ability to work from a back to front scenario including approvals, construction and gravel constraints, watercourse crossings installations, seasons of operations and limitations by not having existing access in place. As such, some harvest areas may be planned for harvest as roads are being developed and may not be deferred until the entire road is constructed.

In addition, Forest Harvest Plans (particularly those in steep terrain and in large patches) can require years to develop on the ground. Therefore, West Fraser began sending planning foresters to the Chungo area to do block design and harvest planning where existing access was already available and where it was being created as the road construction occurred. On the ground planning advanced along the road corridor as the road was being constructed until access to the most distant area was reached. To balance trade-offs, the GB plan was designed to have two harvesting aggregates; one at the back end of the planned roads and one at the front end. Operationally, the front-end block will be accessed first until such time that the back-end block is made accessible by way of road construction. Once this is achieved, harvest operations will focus on the back-end aggregate as intended. The front-end aggregate will continue to be available for harvest to allow for weather and seasonal constraints that may periodically limit access to the back-end. This case study identified opportunities to make adjustments to the harvest boundary designs based on some of the findings of the scenarios both around length of time that some roads will be required and how delaying some harvest area or additions and placement of stand retention areas could influence habitat supply and contribute to reductions in mortality risk immediately, and throughout the regeneration phase.

Ultimately, the GB plan will require fewer permanent roads at any one time than the business as usual plan as there will be areas that do not require continuous road access. This is a win-win scenario as it decreases the total road density of the grizzly bear watershed unit thereby increases security (reduced human caused mortality) for grizzly bears and it results in fewer total kilometers requiring maintenance at any one time. Effectively, this plan is a means to manage for road density over the long-term, which is arguably the most important factor related to forest management in the context of grizzly bear conservation in the Alberta Foothills.

Summary & Conclusions

The findings of this collaborative project between West Fraser and the fRI Research Grizzly Bear Program suggest that forest harvest design strategies can maximize grizzly bear habitat quality, specifically food abundance, while minimizing human access. Habitat security can be effectively maintained by reducing the number of permanent roads implemented in forest harvest plans and incorporating measures to restrict public access on those roads which are required. As previous research has shown, forest harvesting can improve grizzly bear habitat by converting large tracts of old growth stands into a matrix of seral stages, including younger stands with a diverse array of important food resources for grizzly bears. This exercise also highlighted the importance of incorporating edge when considering grizzly bear habitat needs in the forest harvest planning process. This can be achieved through practices such as increasing perimeter-to-edge ratio for clear-cut shapes and retention patches, while still maintaining a minimal road network.

This project demonstrates that by assessing harvesting effects on non-timber values, such as wildlife habitat, earlier in the planning process, managers can adjust plans to maximize positive effects on habitat and minimize negative effects. This type of shift and reconsideration of traditional planning processes across the various industries in Alberta's Rocky Mountain Foothills could prove to be a critical step in ensuring the coexistence of natural resource extraction and grizzly bears across the landscape.

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