2019–2020 ANNUAL REPORT

fRI Research
Informing Land & Resource Management

Written by Ben Williamson | Art by BubbleUp Marketing

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MESSAGE FROM JESSE KIRILLO, PRESIDENT

2019 started like any other year and fRI Research and our programs were charging ahead. As the year progressed it was clear there were storm clouds on the horizon. Thankfully, I believe our programs and people are prepared for the challenges ahead. We have made extraordinary strides tackling the hard issues set forward in our 5-year strategy which will help us through the challenging economic times coming in 2020 and beyond.

At our core, fRI Research is a dedicated group of people who are determined to keep finding solutions and answers for our partners. In 2019, we have disseminated that information in papers, reports, quick notes, conferences, and many other ways. I encourage everyone to keep any eye out for all these results.

With the commitment and resolve everyone at fRI Research has shown over the years, I am confident we will continue to be the organization our partners look to for answers about our natural world or how our anthropogenic influences can be minimized.

MESSAGE FROM RYAN TEW, GENERAL MANAGER

Each year, the annual report gives me the opportunity to look back and see how we are measuring up to the strategic direction set by our Board of Directors. I find this to be a tremendous way to focus on our highlights and our challenges. Overall, I am very satisfied that we remain on track to meet our partners' needs and help them answer their land and resource management questions.

We are pleased to welcome Millar Western as a new shareholder and member of the Board of Directors. Their continued investments into fRI Research's programs and associations, now at the Shareholder level, is greatly appreciated. This level of support along with the other shareholders (all listed on page 6) is critical to the continued success of fRI Research.

Congratulations to our Grizzly Bear Program on being a 2019 finalist for an Emerald Award, and thanks to the Canadian Association of Petroleum Producers for supporting this nomination. This recognition is a result of the excellent work of the program's staff under the leadership of Gordon Stenhouse, and the program partners, for the past 23 years.

I continue to learn more about fRI Research's programs and associations through my involvement on activity teams and association membership groups. I appreciate the willingness of Program Leads and their activity teams to answer my questions and to help me better understand their operations and needs.

Lastly, I am very proud of how all our staff are handling the pressures and changing directions surrounding the pandemic. Good business continuity planning is allowing staff to continue their work and ensure that our partners' past, current, and future investments in fRI Research are secure.

Jim LeLacheur *1955–2020*

The second president of this organization broadened the scope of our research to help address mountain pine beetle and new industrial pressures on the landscape. Our condolences to all who knew and worked with Jim.

2019–2020 BOARD OF DIRECTORS

Jesse Kirillo (Board President), Repsol Oil & Gas Canada Inc.

Bruce Mayer (Board Chair), Forestry Division, Alberta Agriculture and Forestry

Erica Sivell (Treasurer), Hinton Wood Products, a Division of West Fraser Mills

Mark Boulton, Suncor Energy

Steve Blanton, Manning Forest Products, a division of West Fraser Mills

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Shawn Cardiff, Jasper National Park, Parks Canada

Wendy Crosina, Canadian Timberlands, Weyerhaeuser Company

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Julienne Morissette, Northern Forestry Centre, Canadian Forest Service

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Travis Ripley, Policy and Planning Division, Alberta Environment and Parks

Jon Taszlikowicz, Alberta Fibre, Canadian Forest Products

Laura Trout, Hinton Wood Products, a division of West Fraser Mills

PARTNERS

Partnerships are the foundation of fRI Research. They identify and analyze issues, assemble resources, and integrate research into land and resource management. Without our partners' commitment, we would not be the strong, effective source of knowledge and tools that we are today. fRI Research offers flexible and inclusive ways of partnering that we group into the three broad categories below, though many partners find more than one role for themselves.

Shareholders

fRI Research shareholders provide stable core funding and in-kind contributions to support the overall operation of the entire organization. In 2019-2020 shareholders are: Alberta Agriculture and Forestry; Jasper National Park, Parks Canada; Norbord; Repsol Oil & Gas Canada*; Suncor Energy*; Hinton Wood Products, a division of West Fraser Mills; Canfor Corporation; and Weyerhaeuser Company.

*Companies are shareholders through the Foothills Energy Partners

Program and Association Partners

These partners provide funding or in-kind contributions to directly support our programs and associations. Many of these partners are also responsible for land, resource, or forest management, and are interested in using fRI Research knowledge and tools in their operations.

Alberta Indigenous Relations
Alberta Agriculture and Forestry
Alberta Biodiversity Monitoring Institute
Alberta Conservation Association
Alberta Energy Regulator
Alberta Environment and Parks
Alberta Fish and Game Association
Alberta Forest Products Association
Alberta Innovates
Alberta Labour
Alberta Newsprint Company
Alberta-Pacific Forest Industries
Alberta Upstream Petroleum Research Fund
Apache Canada
Arctos Ecological Consulting
Aseniwuche Winewak Nation of Canada
Bandaloop Landscape-Ecosystem Services
BC Oil and Gas Research and Innovation Society
Bighorn Wildlife
Borealis Ecology Wildlife Research
Canadian Association of Petroleum Producers
Canadian Institute of Forestry
Canadian Natural Resources Limited
Canadian Wildlife Health Cooperative
Canlin Resources Partnership
Cardinal Energy
Cenovus Energy

Chevron Canada Resources
CST Canada Coal
Colleges and Institutes Canada
County of Grande Prairie No. 1
Denali National Park
Devon Energy Corporation
Ducks Unlimited Canada
Encana Corporation
Environment and Climate Change Canada
Fisheries and Oceans Canada
Followit Sweden AB.
Foothills Forest Products
FORCORP
Forest Products Association of Canada
Forest Protection
Forest Resource Improvement Association of Canada
Forest Resource Improvement Association of Alberta
Forest Stewardship Council
Forsite Consultants
Fuse Consulting
Golder Associates
Government of British Columbia: Ministry of Environment; Ministry of Forests, Lands, and Natural Resource Operations
Government of Northwest Territories: Ministry of Environment and Natural Resources
Government of Saskatchewan: Ministry of Environment
Greenlink Forestry
Habitat Conservation Trust Foundation
Hammerhead Resources
Husky Energy
Integrated Ecological Research
Jupiter Resources
Lehigh Hanson
Louisiana-Pacific Corporation
Mercer Peace River Pulp
Modern Resources
Métis Settlements General Council
Mistik Management
Mitacs
Natural Sciences and Engineering Council of Canada
Natural Resources Canada, Canadian Forest Service
Northland Forest Products
Norwegian University of Life Sciences
Norwegian Institute of Bioeconomy Research
Outlier Resources
Paramount Resources
Pembina Pipeline Corporation
Peregrine Helicopters
Petroleum Technology Alliance Canada
Project Learning Tree Canada
Saskatoon Forestry Farm Park & Zoo
Scandinavian Brown Bear Research Project
Seven Generations Energy
Shell Canada
Spray Lake Sawmills
Stone RV Sales and Service
Strath Resources
Sustainable Forestry Initiative
Swan River First Nation
TAQA North
Tangle Creek
Teck Resources Limited (Cardinal River Operations)
TerrainWorks
Tidewater Midstream
Timberworks
Tolko Industries
TORC Oil and Gas
Tourmaline Oil Corp.
Town of Hinton
TransCanada Corporation
TRIA-Net
Trout Unlimited Canada
United States Department of Agriculture
University of Alberta
University of British Columbia
University of Calgary
Université Laval
University of Oslo
University of Saskatchewan
University of Victoria
Vanderwell Contractors *1971)
Washington State University
West Fraser Mills divisions: Alberta Plywood, Blue Ridge Lumber, Edson Forest Products, High Prairie Forest Products, Manning Forest Products, North Central Woodlands, Sundre Forest Products
Woodland Operations Learning Foundation
XTO Energy
Yellowhead County

Alignment Partners

These partners provide informal support for fRI Research, and align with our vision and goals.

Alberta Chamber of Resources
Alberta Forest Genetic Resources Council
Alberta Professional Planners Institute
Alberta Riparian Habitat Management Society
Alberta Society of Professional Biologists
Association of Alberta Forest Management Professionals
Banff National Park
British Columbia Institute of Technology
Brock University
Carleton University
Council of Forest Industries
Ember Research Services
Forest History Association of Alberta
Forest Products Association of Canada
FP Innovations
Hinton and District Chamber of Commerce
Hinton Fish and Game Association
Inside Education
International Model Forest Network
McCarthy Tétrault LLP
Municipality of Jasper
NAIT Boreal Research Institute
Nature Conservancy of Canada
NatureServe Canada
Northern Rockies Museum of Culture and Heritage
Peter J. Murphy Forest Consulting
Silvacom
St'at'imc Government Services
University of Guelph
University of Montana
University of New Brunswick
University of Waterloo
Vilhelmina Model Forest
Watershed Alliances and Councils: Athabasca, Beaver River, Bow River, Lesser Slave, Milk River, Mighty Peace, North Saskatchewan, Oldman, Red Deer River, South East Alberta
Western University
Wildlife Habitat Canada
Wilfrid Laurier University

A NEW WAY TO STUDY BEARS

An hour west of Sundre, dry ice was always in the back of Dr. Abbey Wilson's mind. Out in that wild and beautiful country, it is the only way to keep her cooler full of grizzly bear skin frozen to -80°C.

Wilson had driven from her University of Saskatchewan lab to join the bear capture crew for a field season. For a few weeks, the team was based in a remote camp in the outskirts of Banff National Park, setting up traps and flying over the foothills in search of grizzly bears to dart, collar, and sample.

Two decades of practice has made the team efficient, but bear capture will probably never be routine, exactly. For Wilson, a post-doc specializing in the biomarkers that indicate a bear's health and reproductive status, this was an opportunity to meet the animals she studies from afar.

As soon as the tranquilizer dart hit the grizzly bear, the clock started. While one technician watched the animal's vital signs to make sure they didn't drop dangerously or indicate that the bear was waking up, the others worked together to measure and weigh it, fit it with a GPS collar, and collect samples. These include a small draw of blood, plucking a bit of hair, and taking a skin biopsy.

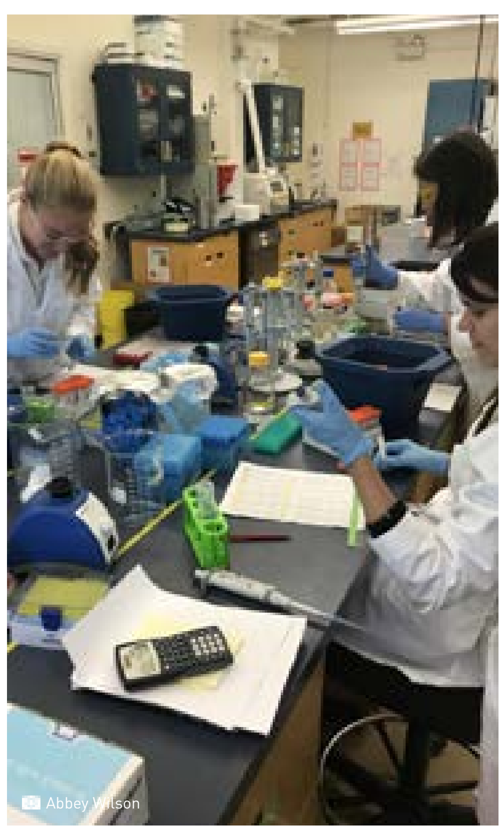
The collar will tell us about the bear's home range, denning, habitat needs, predation behaviour, and more. We will learn about its kinship, and the demographics of the entire population, by comparing its DNA to the hundreds of other individual bears we have detected over the years. But Wilson and her colleagues at the Universities of Saskatchewan and Victoria believe there are many more answers hidden in these samples.

Similar to how doctors can check the levels of certain molecules from a biopsy or blood test to understand a patient's health, Wilson is figuring out what the molecules in a bear's skin and hair can tell us. For years, the Grizzly Bear Program and its lab partners have been fine-tuning a procedure of collecting hair and extracting a few important hormones.

Abbey Wilson

Congratulations to UBC's Dr. Nicolas Coops, who shares forestry's top honour, the 2020 Marcus Wallenberg Prize, with colleagues in Australia and the US. Coops is a frequent collaborator with fRI Research, lending his remote sensing expertise to many projects, notably the projects on pages 8 and 16. King Carl Gustaf XVI of Sweden will award the prize in October.

Abbey Wilson



Abbey Wilson

The first is cortisol, which is related to the animal's stress levels. By comparing hundreds of hair samples collected in different years, the group found that cortisol levels have been trending down. This might indicate less nutritive stress. In other words, bears are having an easier time finding enough to eat.

The other molecules measured in hair are three sex hormones: estradiol, progesterone, and testosterone. Male and female bears make all three, but in different proportions. The levels also depend on what stage of development the bear is in, and whether a female is pregnant. While still a work in progress, the group is now able to predict, with decent accuracy, the age class and sex of a bear. Building this kind of

demographic picture really helps with population monitoring, especially if you can get an idea of the number of pregnant females.

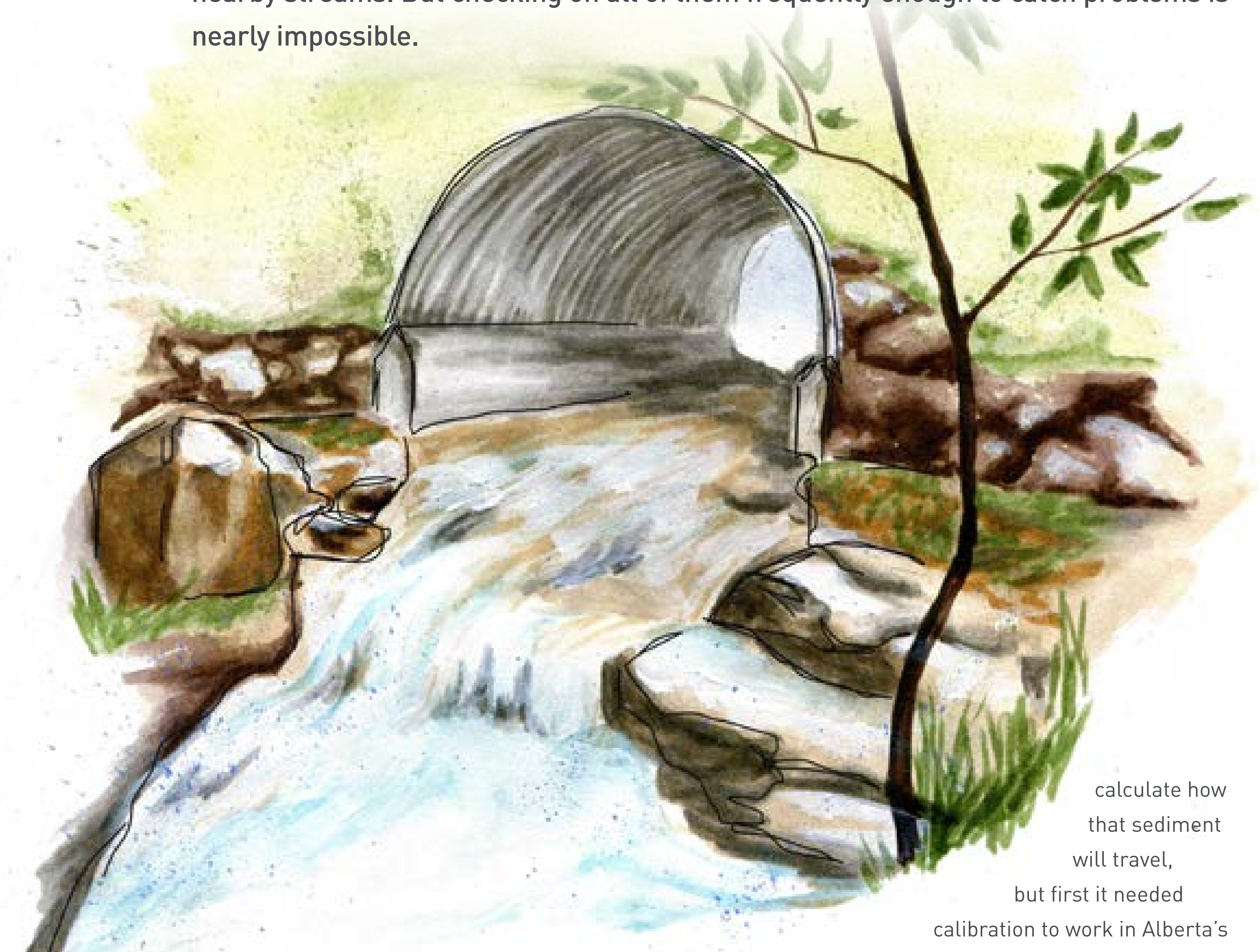
Those hair hormones are great biomarkers, but they aren't the only ones. Wilson's focus is developing a procedure to use different proteins from skin samples to learn even more. When the field season was over, they shipped the samples off to Saskatoon for the first processing step. It was an unpleasant mixture of tedium and extreme cold as Wilson and her lab partner crushed over 100 frozen samples into powder. Once that was done, Wilson and the samples drove west to the University of Victoria to figure out how to extract the proteins.

The team cast a wide net and were able to identify over 700 different proteins in the grizzly bear skin. Wilson then systematically pared the list down to 19 proteins that are well-established indicators of metabolism, reproduction, and stress. For the next month, Wilson and two other scientists tested out ten different procedures, based on ones that work for proteins in humans and mice, to try to figure out how to get the most protein out of less than a gram of sample. Eventually, they worked out a method that has the sensitivity to detect enough protein even from the tiny discs of skin that biologists collect.

Just inventing a procedure and working out all the bugs, from capture to storage to extraction to analysis, was the primary goal for this stage. The team is already using the Grizzly Bear Program's long-term archive of grizzly bear samples to answer specific questions about how things like parks, roads, and forestry are affecting of grizzly bears. By combining the protein data with the hourly locations of grizzly bears fitted with GPS collars, the team can use the new ability to uncover the relationships between landscape, especially human disturbances, and health. Wilson and her colleagues broke the trail; the Grizzly Bear Program and its collaborators are eager to take the next steps.

MUDDY WATERS

The spiderweb of dirt and gravel roads among Alberta's foothills have tens of thousands of culverts, drains, ditches, and bridges. Some are well maintained, but others may be eroding so heavily that they are causing major problems for fish in nearby streams. But checking on all of them frequently enough to catch problems is nearly impossible.



The good news is a new tool called Netmap is up and running and has identified which are the most likely problem sections of road. Now government, road owners, and volunteer organizations can target their efforts to the places that need the most attention.

The tool, originally developed by TerrainWorks for the US Forest Service, predicts the risk of fine particles of sand and silt—anything that you can get your boot stuck in when wet—making their way from a road down to a stream. It uses the contours of the landscape and information about ditches and drains to calculate how that sediment will travel, but first it needed calibration to work in Alberta's complex landscape.

Gathering the data to tune Netmap took a lot of hard days from the Water Program field crew. They criss-crossed the rolling western flank of the province, one team in the southern watersheds west of Calgary, and another up north in the Athabasca and Peace headwaters.


Michael Wagner

This coverage was necessary to make sure that the model can work well for the whole province and will be effort well-spent when it comes to protecting the health of our watersheds.

Sand and silt in a stream may not strike everyone as an obvious problem, but too much of it is a serious issue. A poorly designed road without proper ditches and drains can dump far more sediment into nearby water courses than they can handle. The result is that insects living in the river bed are buried and can't support the rest of the food chain, murky water can choke the gills of fish, and it will be much harder for female fish to find clean gravel beds in which to lay their eggs.

The obvious artificial sources of sediment are right where a road crosses a stream. If the crossing is a bridge, it might literally be as simple as holes in the deck letting through sand. Another likely culprit is the bank where the bridge is anchored, if it hasn't ben reinforced with things like rocks and vegetation. If the crossing has a culvert that hasn't been maintained, is too small, deformed, or partly buried, the stream will often force its way through by another path, eroding the banks, sweeping through ditches, or even rushing over the road, and picking up sediment that way.

But the Water Program has also found that even roads some distance from a crossing can be shedding sediment into nearby streams. These places are generally at steep sections of wide roads, perhaps where the road cuts into a slope. Being able to automatically find and flag these areas for attention means we know where a small number of really effective drains will make all the difference for bull trout, for example. In fact, Netmap predicts that by focusing on just 15–20% of all the unpaved road segments, we could address 90% of the sedimentation problems.

As well as government regulators, the Water Program is also sharing the Netmap results with Watershed Councils, which are grassroots organizations that care for the rivers sustaining their communities. This summer, volunteers will be able to head out to the priority sections and document their condition, plant willows to reinforce banks, and do some maintenance on ditches and drains.

The Netmap team will also be busy, gathering more data to upgrade the tool. Right now, it reports which sections of road are likely to be causing sediment problems. After the next stage is completed, it will tell us the amount of sediment that a road segment will add to streams before and after it is fixed. Early in 2020, the team got word of a cause to celebrate: the Netmap project has been named a finalist for the Shared Footprint Award by Alberta's Emerald Foundation. While the main reward is to improve water quality, empower volunteer groups, and contribute to the field of hydrology, this acknowledgement is a nice boost for the team.

LODGEPOLE UNDERGROUND

When mountain pine beetle destroys a stand of trees, the impacts run deep. Belowground, a community of animals, bacteria, and fungi are profoundly changed by the death of the giants supplying the soil biome with carbon.

In the years after the mountain pine beetle breached the Rockies north of Jasper, Dr. Justine Karst's group began taking soil samples along the leading edge of the infestation, collecting from a range of different sites. They showed that widespread death of lodgepole pine affects hundreds of fungal species, especially those with a particularly intimate connection to the trees.

Underground, these fungi form a vast mesh of living threads woven through the soil and the pine's roots. The fungi pass up minerals and water and are repaid with sugar made by the tree. Without their hosts, the symbiotic fungi fade, replaced by decomposers working on the roots of dead trees.

Seedlings feel the loss of their underground partner. Even when any shading shrubs are cleared from an area struck by the insect, planted seedlings do not fare as well there as in nearby stands that were not disturbed by the beetle. Similarly, in growth chambers and rooftop greenhouses at the University of Alberta, Karst's team found that fewer seedlings survive, and they grow slower when planted in sterilized soil. Adding a scoop of soil from healthy lodgepole pine stands restored their growth and survival; a scoop from beetle-attacked stands did not.

Forest companies are searching for ways to restore the tree-fungus relationship in attacked stands after salvaging the dead timber. The seedlings in their tiny pots can be rescued, but can the same be done in an acre of forest?

"It was time to test it," says Karst. "We said, let's do the field trials and put this to rest."

For this Mountain Pine Beetle Ecology Program project, they grew 2580 lodgepole pine from seed, in sterilized

soil, for six months. Some got regular forest soil, some got soil from a beetle-attacked area, and some got nothing extra. That June, 722 seedlings headed west into the rolling foothills, to be planted at 15 different places that mountain pine beetle had been. After two summers, and again after a third summer, the team returned to see how many made it and how they had grown.

Their survival and growth, the ultimate measures of success, were not obviously better for the seedlings that got the dose of their native, undisturbed soil. Although the previous steps had clearly supported the idea that pine seedlings grow better in soil with their usual underground community, the results are not entirely surprising to Karst. The seedlings were planted with just a few millilitres of soil and fungus clinging to their roots. It's easy to imagine that this amount is simply overwhelmed by the dynamics in the ground, which have been going on their own course since the beetle attack.

Karst's group is still analyzing the data after the third year to see if there is at least a subtle difference in growth or survival between the seedlings. They are also gleaning new insights into the fungal communities in the seedling's roots and the symphony of chemicals that the communities create. A major pattern is that, over and over, they are finding that the texture of the soil is a big factor. Soils with a lot of sand, compared with loamy soils containing more silt, tend to have different water content, different amounts of nutrients, and support different communities of bacteria, fungi and insects, all of which affect how well the trees grow.

At least now forest companies know it will take more than a few scoops of the right soil to restore the underground community after mountain pine beetle attack, and Karst's lab has many new fungal threads to pull on to unravel these underground mysteries.

THE SHAPE OF A FOREST FIRE

Even as recently as a century ago, the dominant force shaping the western Canadian landscape was wildfire. The frequency, size, and severity of fires determined the balance of old and new forest, the plant communities that would come to dominate different regions, and therefore the wildlife that could find a niche. Recognizing this, forest companies generally use historical fire patterns as a guide when planning their harvesting and reforestation.

The first step in understanding fire patterns is to map them, but until recently, this was mainly done by flying over recent burns and comparing the new landscape with aerial photographs from before the fire. Over the years, the Healthy Landscapes Program used this method to piece together the most comprehensive database of 129 historical fires in Alberta and Saskatchewan.

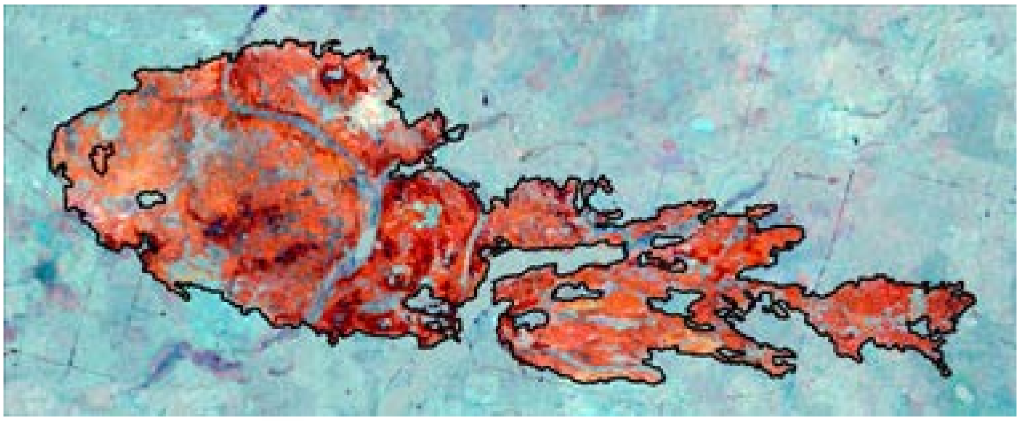
But the Canadian boreal is big—too big for aerial photography to scale up enough to answer the deeper questions about why fires burn the way they do. Time for new methods and new partnerships. The Healthy Landscapes Program teamed up with the renowned Integrated Remote Sensing Studio at UBC to figure out how to use the growing abundance of satellite imagery.

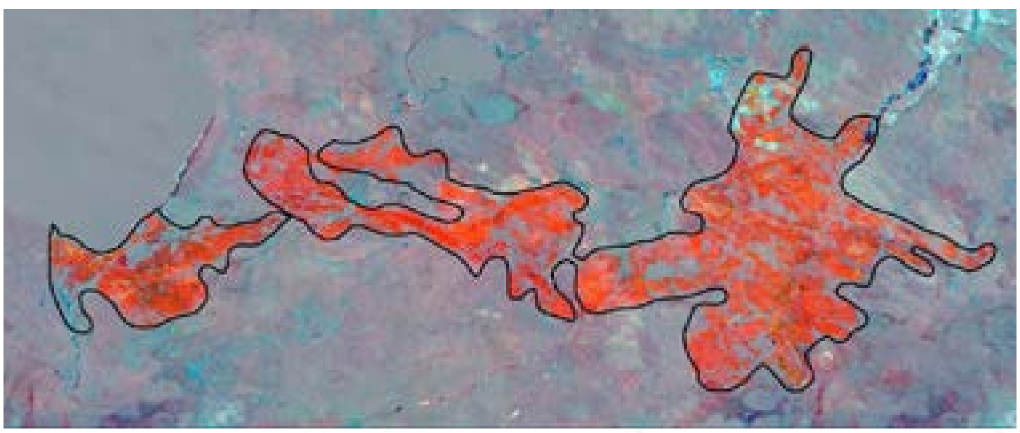
In 1972, the US Geological Survey and NASA began launching satellites to continuously observe Earth, and in 2008, the USGS made all the images freely available. However, just having images is not enough to create a catalogue of fires across the boreal. How do you prove that, say, a pixel with a particular shade of dark brown is definitely a patch of burned trees without flying out to hundreds of remote test plots? Dr. Ignacio San-Miguel Sánchez's task was to find a cost-effective way to calibrate the Landsat imagery, and unlock a new way to study fire patterns at a scale that wasn't possible just 15 years ago.

The key was to match up the Healthy Landscapes Program's reference database of wildfires with the Landsat imagery. The photos are high resolution and taken within five years of the fire. In addition, all 129 fires were chosen, in part, because they were allowed to burn out naturally and no one had yet gone there to alter the landscape by salvage logging. After San-Miguel had met and overcome many technical challenges, from unifying the scientific terminology of fire patterns to dealing with clouds in the satellite imagery, he had added over 500 new fires across 2.5 million hectares of the boreal.

Quadrupling the number of wildfires for analysis allowed San-Miguel and his colleagues to look for the connections between how the fires burnt and factors like climate, fuel, the shape of the landscape, and more. The goal was to see whether we could explain why fires burn the way they do. The team focused on three characteristics of fire patterns: how complicated the burned area's shape is, how "patchy" the burned areas are, and how much vegetation survived within a burned patch.

The first thing San-Miguel saw in the data was just how variable wildfires are. So





much depends on what the weather was like during the fire that this unpredictability was the dominant factor for the set of 507 boreal fires. However, San-Miguel's model could predict a smaller, but still significant amount of variation.

What he found was that when there was young forest present because of a recent disturbance, fires tended to have a greater number of small burned patches scattered around an area instead of a few big patches. Drought and bodies of water also tended to spread a fire out, leaving corridors between burned patches. Another finding confirmed something that is already well established in the fire research community: the amount of fuel controls the spread and intensity of fires, which in turn controls the patchiness. Dense forest, for example, burns intensely, likely leaving a big burned patch without many remnants inside.

The model turned up other interesting associations. To take just one example, elevation seems to be important for wetlands to act as fire breaks, or, during drought years, fire wicks. But this is just the start of what will be possible with this new trove of wildfires to study. Forest companies can use these examples to bring their harvesting patterns closer to wildfire patterns, and researchers can build on this beginning to expand our understanding of fire behaviour.

KristaMorrow

CARIBOU PATROL: SEASON 8

Alberta's southern mountain caribou herds take refuge in the alpine every summer and return to the shelter of the boreal forest to survive the winters. The annual migrations are a vulnerable time in general, but one herd, the A La Peche, has an extra hazard. Highway 40 North, a major industrial corridor, runs straight through their range and must be crossed by the herd twice per year, in the spring and fall. In one particularly bad year in the early 90s, just over one in ten caribou from that herd perished on that road. Something had to be done.

The Caribou Patrol Program was established by the Aseniwuche Winewak Nation of Canada in 2012 and supported by the Foothills Landscape Management Forum with the mission of preventing any more caribou deaths by vehicles. The Patrol is accomplishing this by focusing on two groups: the caribou and the drivers.

Year-round, the Caribou Patrol does educational outreach to inform Albertans about the threatened status of caribou in Alberta, and the need to slow down where caribou are likely to be migrating. They have teamed up with Jasper National Park at festivals across the province, produced educational material for teachers to use in their classrooms, and even done live shows with Alberta Parks. Along highway 40, the Patrol have worked with Alberta Transportation to include a hazard icon on the 511 map, as well as erect highly visible, billboard-sized signs to alert drivers during the migration.

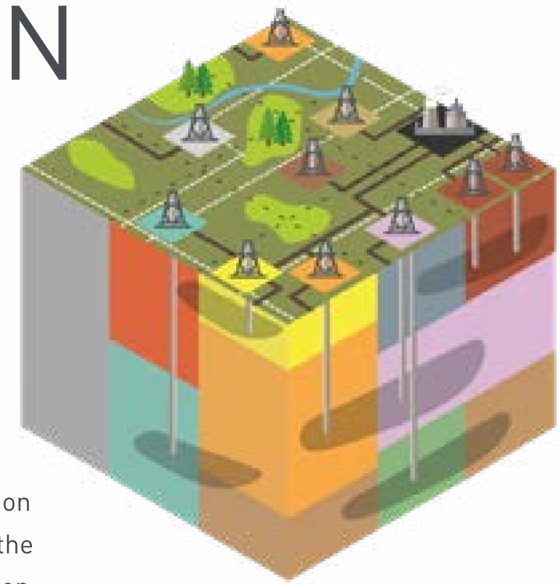
But of course, the Caribou Patrol is best known for the thousands of kilometers they cover. The patrols, based out of Grande Cache, can respond to sightings reported on the cariboupatrol.ca website and Facebook group or by calling 1-877-CPHWY40, as well as take near-daily scheduled trips during caribou migrations. In 2019, they recorded 266 caribou sightings. For some of these, the patrollers simply put on their hazard lights to raise the attention of other drivers. But in 90 instances, the team acted to either push them back if it wasn't safe to cross, or else helped them cross when traffic was clear or stopped.

Kevin Gedling

The techniques that Caribou Patrol uses are those of stockmanship, an ancient practice for controlling herds of animals such as cattle in a low-stress way. By changing their position and distance, patrollers were able to successfully deter or help 200 caribou cross the highway, with a 100% success rate. While no caribou has ever been struck by a vehicle while the Patrol is out, unfortunately there were still two fatalities last year, the deadliest year for the herd in a decade. This is a sad reminder of how vital the Aseniwuche Winewak Nation's efforts are.

COMMITTED TO COLLABORATION

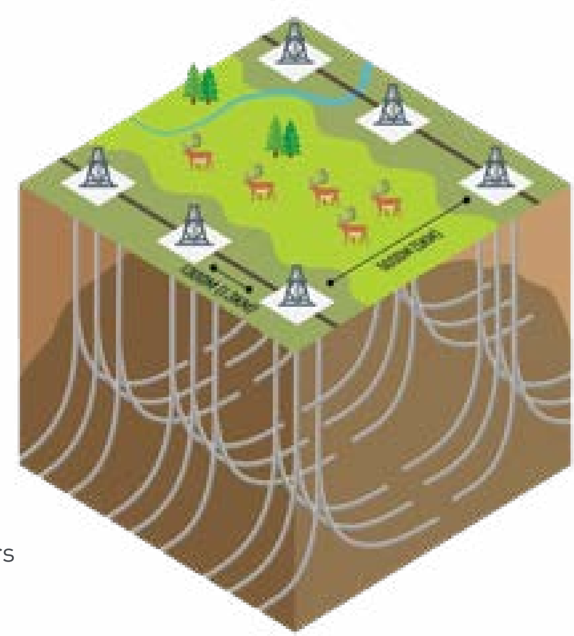
The Foothills Landscape Management Forum is a cross-industry group pioneering a collaborative approach to reduce the footprint of their activities. That approach, called integrated land management, requires companies to work together, right from the start, on the management plans they must get approved by the provincial government.



The Forum had previously shown the effectiveness of integrated land management in a pilot study. By deploying new oil and gas extraction technology and planning roads together, the group found that they could have the same amount of activity while creating only a fraction of the roads. Shrinking the amount of disturbance is critical for Alberta's caribou herds to recover.

Building on this success, the Forum held a workshop with government in June to identify the next needed steps, such as further field verification of the pilot study, removal of implementation barriers, and most importantly, working with the province to put this new approach to use. The membership was also adamant about the benefits of working together on their planning to ensure everyone has the access they need with a lighter impact on the environment.

In addition to working with the government, the membership is also keen to continue their partnership with the Aseniwuche Winewak Nation of Canada on the Caribou Patrol Program and the Traditional Land Use Study. This study, described in last year's Annual Report, maps and records the culturally important sites in the AWN's traditional territory. It's so important to the community to preserve these places while the Elders can still go and mark them, and land users can plan for their protection.



The Foothills Landscape Management Forum continues to grow and now counts the following organizations among its membership:

ANC Timber
Aseniwuche Winewak Nation of Canada
Athabasca Oil Corporation
Canadian Natural Resources
Canadian Forest Products
Cenovus
Ontiv (formerly Encana)
Foothills Forest Products
Hinton Wood Products, a division of West Fraser Mills
Jupiter Resources
Millar Western
Seven Generations Energy
STRATH Resources
Tourmaline Oil
Weyerhaeuser Canada
XTO Energy

THE LONG-TERM EFFECT OF HERBICIDE IN FORESTRY

The little pine and spruce seedlings, compared to the likes of willows, alder, and tall grass, are slow and steady growers. In the shade of their quicker rivals, the conifers often need a head start. Forest companies, which are obliged to regrow the timber that they cut, have a few ways to do this: pulling up grasses, sawing off willow stems, breaking and bending young aspen. They can even use heavy equipment to overturn the top layer of soil before planting. But for at least the last two decades in Alberta, the most common method has been herbicide.

"Immediately after spraying, the effects are extremely dramatic. You have a field of little green seedlings and everything else is brown. It's something only a forester could love," says Milo Mihajlovich who, along with biologist John Nash, led a new study on herbicide effects.

The quick results are one reason why it has come to be used more often than not when a company regrows conifers after a harvest. Closely related to that is the cost. Spraying an area from a helicopter is several times cheaper than repeatedly sending out crews with brush saws.

Still, herbicide is not a panacea, says Mihajlovich. Companies already opt not to spray, for example, on poorer sites without as much competing vegetation, where indigenous communities raise concerns, or areas which are important winter food for moose. Another concern is the long-term impacts on forest diversity, but there haven't been any studies looking at local species.

To address this, the Forest Growth Organization of Western Canada asked Nash and Mihajlovich to find out how plant diversity differs between sprayed and un-sprayed stands.

Their study revisits some of the earliest stands to be sprayed in Alberta, which only adopted the practice in the 1990s, much later than other provinces. The researchers surveyed the plant communities in ten sites, comparing the parts that were sprayed with the ones that weren't.

In the first growing season after spraying, "it looks like we've created a monoculture," says Mihajlovich. "But very quickly thereafter, there's a lot of recovery. The herbs emerge. We see fireweed, raspberries, blueberries. Within three years, we see a fairly active community growing up, including willow, aspen, and balsam."

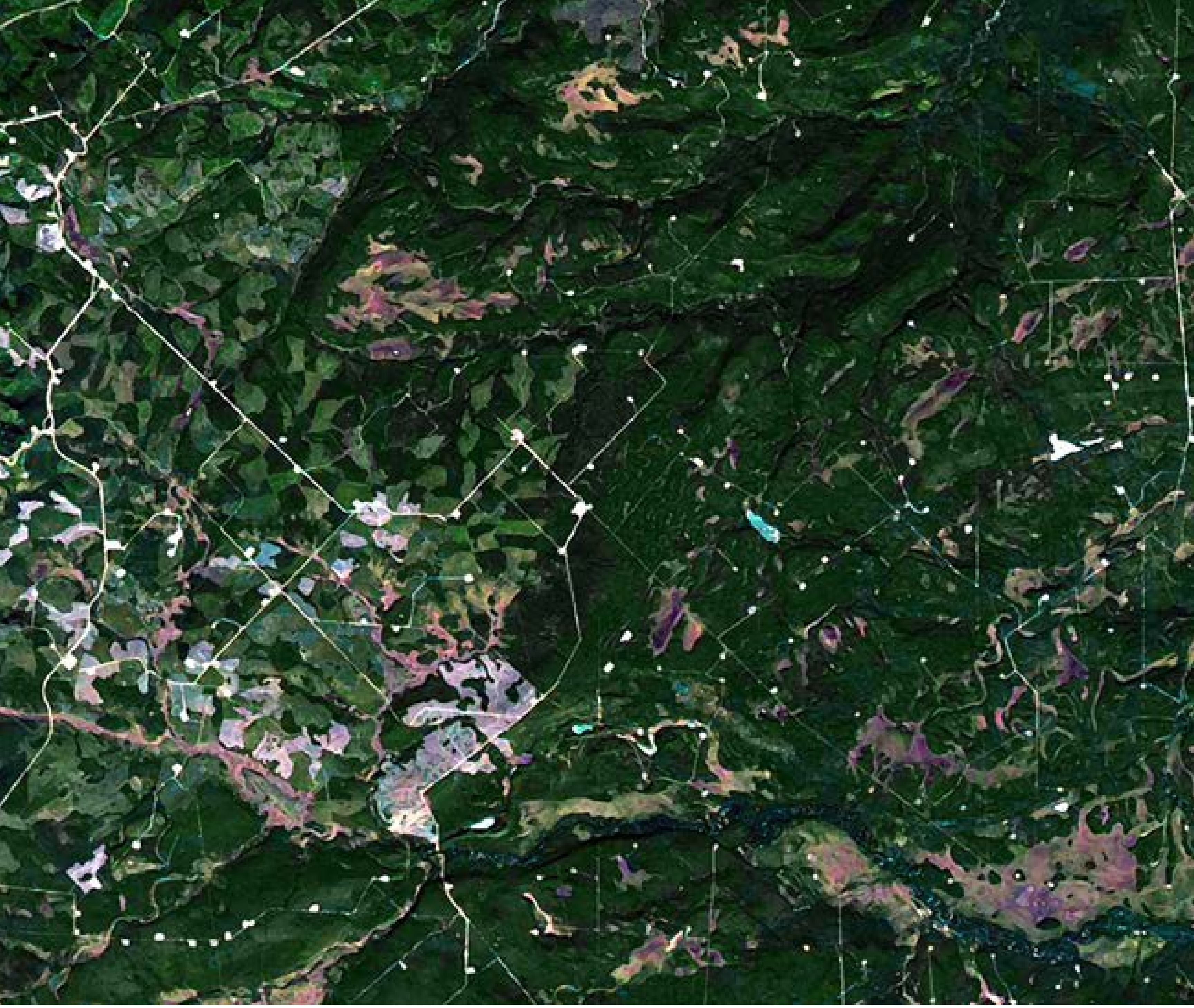
This delay is enough for the pine and spruce seedlings to get established and

grow enough to stake out their place in the sun. But we know from previous research that the effect of herbicide is more than to just postpone the regrowth of the same mix of species. The understory takes a different path and there are real changes in how the community develops. Usually, the amount of willow and poplar in sprayed sites is never as much as in unsprayed. On the other hand, some sites that are sprayed develop a richer understory, particularly in sites that have a reed grass commonly called Calamagrostis that would otherwise overrun everything else.

Mihajlovich suspected they would find, after 25 years, that the sprayed and unsprayed areas have converged. "We all have our perceptions, but no one has ever gone out to quantitatively compare biodiversity after 25 years. That's what makes this study so interesting. We really didn't know."

The counts are done. They are writing up the results now. It isn't what they expected. "What we're seeing is that we have more diversity in treated than untreated," says Mihajlovich. "Candidly, I was very pleasantly surprised by that." In fact, he was so surprised at the result of using classic measures of biodiversity that he asked Nash to use some more current metrics. The results remain the same; the portions of the cutblocks treated with herbicide 20 or more years ago exhibit more diversity than the untreated portions of the same blocks.

This won't be the end to the conversation around herbicides in forestry. What's important to Mihajlovich and the forest industry is that we're looking at a mix of forest values and thinking long-term.

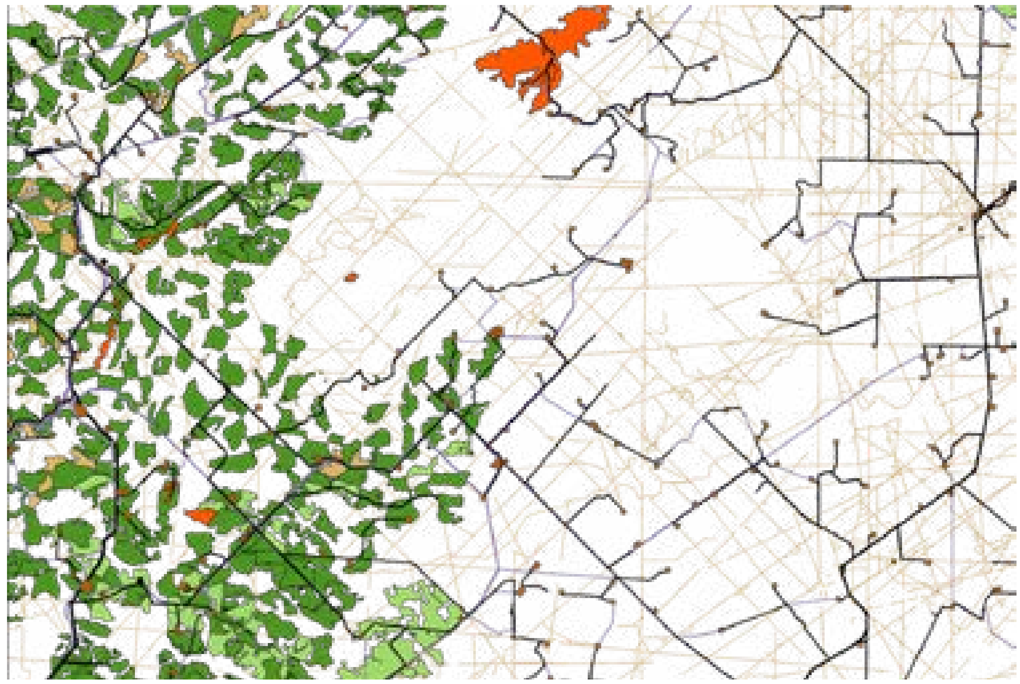


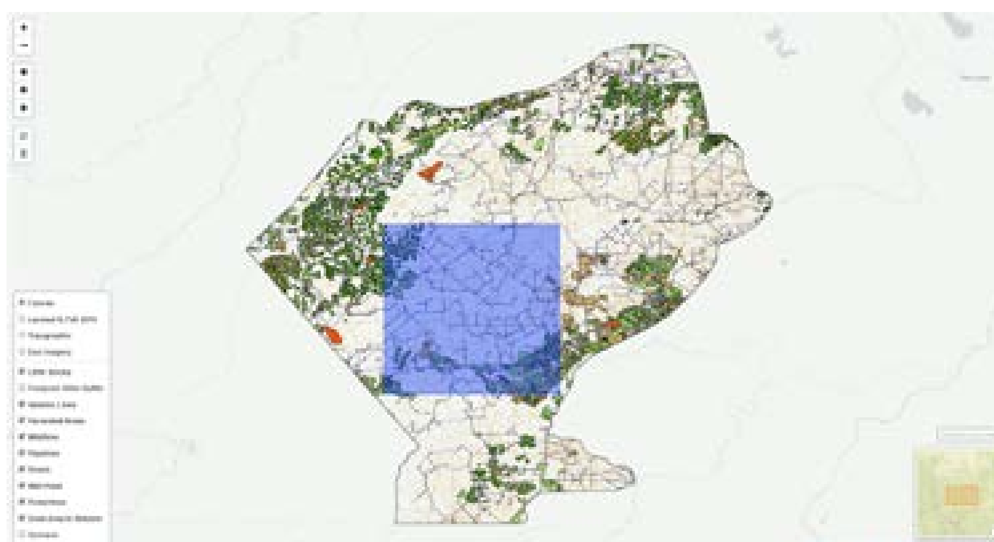
SHIPPING NEW TOOLS AND BOOSTING PROGRAM EFFICIENCY

The small but mighty GIS Program has released new tools for researchers and partners on top of improving all our programs' efficiency and reducing their data management costs. Led by Julie Duval, the team has also continued to deliver on the meat and potatoes of GIS work: performing large scale data extraction and cleaning, and building robust, efficient databases.

In the previous year, the GIS Program created their first suite of cloud-based GIS tools, the Caribou Webtools, which allowed land use planners to see how adding and restoring things like roads, seismic lines, and cutblocks will affect the habitat quality of caribou and their predators. Building on the successful launch of the Webtools, and taking what he learned, GIS Analyst Dan Wismer got to work with the Caribou Program on another project that has been long requested.

The Caribou Habitat Disturbance tool is the next step forward for speed and ease of use. The previous Webtools hosted all the GIS data and performed the calculations online so that users didn't need to figure any of that out themselves. All they had to do was make and upload a "shapefile" to specify the area they are interested in. The new tool uses some new tricks, so it doesn't even require a shapefile or any knowledge of GIS software at all.





The goal is to give a sense of the situation in the caribou range with the most industrial activity in Alberta. Caribou require large tracts of undisturbed habitat—a widely cited federal target suggests 65% of their range—but in the Little Smoky range, only 1% is undisturbed. In choosing which industrial features to restore, government and industry will have to be strategic.

To play around with scenarios, you just click and drag an area on a map to define where you want to make a change. Then you check the types of disturbance you are restoring and hit run. In a few seconds the map updates and a graph shows you what the new level of disturbance is.

Another new capacity of the GIS Program is to take advantage of the Google Earth Engine to outsource some really heavy computation to Google's servers. This lets us do remote sensing analysis much faster without crushing our network and local computers. The platform has the entire Landsat archives, the free-to-use satellite images of Earth. There will be many images of the study area over time, but unfortunately, the most recent snaps might happen to have a lot of cloud cover. We might have to go back a long way before you find one where your study area is completely clear, with no white wisps to throw off your analysis.

The solution is to make a composite of recent images, using just the clear bits from and combining them into one perfect image. By writing a script, Wismer had Google's incredible computing power sort through every image of the study area and pick the very best one, pixel by pixel.

Shipping tools to partners and adding new abilities is certainly exciting news. But it's important not to take for granted that these come in addition to the routine excellence the GIS Program delivers on data management and analysis. The team's most valuable contribution is how they make everyone else at fRI Research more effective.

A NEW PROTOCOL FOR WETLAND ROAD CROSSINGS

The Foothills Stream Crossing Partnership has completed over 20,000 crossing inspections and made hundreds of repairs to bridges and culverts. This has restored access to over 500 kilometers of streams in western Alberta for fish and reduced the amount of sediment that makes its way from road to river. These are important gains for the province's headwaters and cold water fish species like rainbow trout, but the improvements have been confined to the steep slopes of the foothills.

A little way downstream, where the land flattens, the streams fan out into bogs and fens, and the watercourses slow, there are still roads and the same issues of blocked channels and excess sediment. But the signs, symptoms, and solutions are very different, and the Partnership is learning how to help there too.

They got started by joining forces with Duck Unlimited Canada, FPInnovations, and environmental consultants Fuse and Circle T to review the best science, talk to companies about their best practices, and create a plan. In 2019, the group published the main things they learned.

The first thing they discovered is that there are research gaps in the scientific literature, and even larger knowledge gaps within industry because much of the published research has not yet been synthesized and incorporated into the organizations' training. They recommend, therefore, creating a short course for companies about wetland systems in the boreal and how to monitor wetland crossings.

Whereas a road might cross a stream at just one obvious point, the watercourses in wetlands aren't confined to a single obvious channel. Much of the flow of water happens below the surface, at a depth that varies throughout the year.

Adam Sprott

Adam Sprott

Adam Sprott

Such problems might be too few culverts, the culverts being too small, or even that they aren't in line with the underground flow of water. Because these issues take place out of view, inspectors will have to look for indirect signs of their effects.

These can include signs of the road or culverts breaking down, or changes in the vegetation around the roads. For example, if, after a road is built, trees start dying on one side and flourishing on the other, that is a strong indication that the road is blocking water flow, causing flooding on the first side and a general drying out on the second.

Another main recommendation of the group is to consider the type of wetland when building, inspecting, and maintaining roads. Peatlands, in particular bogs, are usually somewhat acidic and so their soil and water chemistry can be seriously altered if the road is deteriorating, because that sediment tends to be basic. The water table in wetlands with mineral soils, like marshes and swamps, can go up and down a lot from season to season. Because of this, if culverts aren't large enough or installed at the correct depth, it could cause water to pool on one side of the road.

The Stream Crossing Partnership is working to put these recommendations into practice by updating their database so it can accept this new class of crossing, expanding their inspection protocol to include wetlands, and start training inspectors. Wetland crossings come with a whole host of new challenges, from less clear legislation to logistical issues, such as roads that are winter-access only. But taking on these challenges will be well worth it if the Partnership can fix and avert damage to Alberta's boreal wetlands.

2019–2020 Membership of the Foothills Stream Crossing Partnership:

Athabasca Oil
Baytex Energy
Canfor
Canlin Energy
Cardinal Energy
Cenovus Energy
Chevron Canada
Hammerhead Resources
Husky Energy
Jupiter Resources
Kicking Horse Oil
Millar Western
Modern Resources
Outlier Energy
Paramount Resources
Petrus Resources
Peyto Exploration and Development
Repsol Oil and Gas
SemCAMS Midstream
Seven Generations Energy
Strath Resources
Tangle Creek Energy
Taqa North
Tidewater Midstream
Torc Oil and Gas
West Fraser: Hinton
West Fraser Mills: Slave Lake
West Fraser Mills: Blue Ridge
Weyerhaeuser


Adam Sprott


Adam Sprott


Adam Sprott

CONSIDERING CARIBOU IN THE BEETLE BATTLE

There is a struggle in western Alberta that has pit the provincial government, the forest industry, and Canadian scientists against a tiny but implacable beetle about the size of a grain of rice. For over a decade, the humans have been resisting the eastward spread of mountain pine beetle: by helicopter surveys to scout for new infestations, ground crews that find, cut, and burn infected trees, and strategic forest harvesting. Newly published research by the Caribou Program examines the collateral damage to caribou habitat.

Caribou are old-growth forest specialists. The herds in Alberta require large tracts of undisturbed habitat to thrive—something they have not had for decades, as roads, seismic lines, and pipelines have increasingly carved up their home ranges. The result is that populations have dwindled, in many cases to near-extirpation levels. Now comes a new pressure on the landscape. The old pine forests that are rich in lichen and other key caribou foods are also the most susceptible to mountain pine beetle, raising the question of what this disturbance, and strategies to control the disturbance, will mean for threatened caribou.

The program dispatched field crews to caribou ranges throughout west-central and northwestern Alberta to look for differences in the amount of lichen between undisturbed pine forest, mountain pine beetle–attacked stands, and forest patches that had recently burned or seen control efforts. For 20% of sites, the team helicoptered into, so they could reach even extremely remote parts of caribou ranges. The crews reached the other 80% of the sites by driving lonely gravel roads, slogging through the deep mud of all-terrain vehicle tracks, and walking the rest of the way to their pre-assigned sites.

The beetle-kill sites that they investigated were mostly in the red attack stage, so named because the dead pine trees have dried out enough that their needles have turned a rust-red colour and begun dropping to the forest floor. The impact of the insect attack was still ongoing. A bit more sun, rain, and snow could make it through the canopy, changing the conditions for the flora below. At that point, the team did not see a significant difference between the amount of lichen in the red-attack trees compared to the undisturbed forest, but it would be interesting to see if that changes as the dead pine really start to topple. In BC, for example, the

slow-growing lichen declined only 10–15 years after mountain pine beetle killed the stand.

We also found that caribou food was also similar where the province used the single tree cut and burn strategy to kill beetles still in a tree before they can reproduce and escape. Since they do this work on foot and in the winter, the disturbance to the ground is relatively minor. The burned and harvested areas told a different story. Such strategies could be used to try to either head off the beetle by removing vulnerable lodgepole pine before it can become fuel for further spread, or to "mop up" stands that have been hit hard and might still harbour beetles in the survivors. These more drastic approaches do result in serious loss of lichen.

At least in the short and medium term, we saw that the options of just leaving beetle-killed trees and single-tree control efforts leave the most food for caribou. But if lichen in Alberta responds like it did in BC, then reducing the amount of lodgepole pine mortality could save more caribou food in the long run. For the harvest and burn strategies, then, the question for caribou is whether the short- and medium-term loss of food is worth the potential long-term benefit of saving more old growth pine habitat. This will partly depend on how effective those methods are at controlling the beetle. More research is needed, but some modeling (see page 30) suggests that it is far less effective than single tree cut and burn. Combined with the Caribou Program's findings that this strategy is also less costly for caribou in the first decade, and it seems to strike a good balance of maintaining caribou food now and protecting habitat later.

This study focused on food, however there are other impacts to think about too. Fires and large harvests could reduce cover from predators. Some disturbances could draw in predators, or require new roads, which cause further problems for caribou. Managing for mountain pine beetle is about reducing the damage it does on more than just timber volumes. Studies like this one will help the province and industry balance more boreal forest values.

SOMETHING FOR ALL LAND USE PLANNERS

The Alberta Land-use Knowledge Network continues in its mission to provide resources for Albertans planning land use activities. This includes everyone from town and county officials preparing for their regional land-use plan, right down to individual landowners looking for information on how to live and work more sustainably. It does this through two companion websites.

The landusekn.ca site was started back in 2011, and now catalogues thousands of articles, videos, and other resources of interest to a very broad audience, from urban agriculture to water use to species at risk. Because the topic is so broad, the Knowledge Network has focused on three keys to hosting a useful library: curate only reliable, practical resources; archive and organize them precisely; and provide powerful, user-friendly search tools.

Best practices for land-use continue to evolve as science and technology advance, and the Land-use Knowledge Network has kept pace in more ways than just adding more resources to the collection. In 2017, it released a short online course about the regional plans and legislation governing land use in Alberta.

Then in 2018, the network launched landusehub.ca which focuses specifically on serving practitioners with the datasets and summaries they need at their fingertips to implement their own regional plans. There are now 95 datasets on air, water, wildlife, industry, population, and more. The site also features articles synthesising information on timely topics. In the past year, there has been a roundup of regional land-use plans across the country, municipal waste management, Public Land Use Zones.

Finally, the Alberta Land-use Knowledge Network has provided ways for practitioners to share their experiences with each other through a discussion forum, social media, and a regular newsletter. Better land-use planning benefits all Albertans, and the knowledge network is contributing in every way it can.

FINDING THE BEST WAYS TO MANAGE MOUNTAIN PINE BEETLE

Since the mountain pine beetle first breached the Rocky Mountains, the government of Alberta has spent around $500M to try to slow the spread and save potentially millions of acres of lodgepole pine. Out of the urgent need to find out if this is money well spent—and which strategies are working best—Dr. Allan Carroll's Forest Insect Disturbance Ecology lab at UBC developed a model called MPBspread for the Mountain Pine Beetle Ecology Program that predicts how infestations hop from one pine stand to the next.

Since its release, the model continues to predict the spread with good accuracy, based on climate and landscape factors. Government and industry can use MPBspread to get a sense of what could have been by re-running it with different beetle control strategies.

"It has a bunch of levers that we can pull to assess efforts," says Carroll. These include the three pillars of the provincial response: detection, cutting and burning individual trees before they can seed larger local outbreaks, and clearcutting entire beetle-attacked stands.

Overall, the model shows that the province's efforts have greatly reduced the damage to Alberta's pine forests, to the tune of 500,000 hectares over the last ten years, and another million hectares over the next two decades. One clear conclusion is that single tree removal, while expensive, is far and away the most effective way to slow the spread. By contrast, the other strategy of mopping up in and around stands that already have high mountain pine beetle mortality does little to reduce future beetle-kill.

The trade off between the effectiveness of single tree treatment and its cost naturally begs the question of what the optimal level of effort is. Eventually, provincial surveys will find fewer and fewer beetle-infested trees until the money spent is greater than the value of the timber saved. In 2017, the MPBspread team began expanding the model and were able to answer this question too, by identifying a cost-benefit sweet spot. The model suggests that if the province cut back on control efforts by as much as 30%, it would sacrifice only a relatively small area to the beetle. One thing that absolutely cannot be reduced, however, are efforts to detect the beetle.

"The success of any strategy depends on finding the problem," says Carroll. It won't be easy. Flying over the forest and searching the areas around red trees (those killed by the beetle long enough ago that their needles have dried out and turned red) looking for green-attack trees (doomed pine that host a beetle brood but are still green) is very labour intensive. Carroll figures that the aerial surveys probably catch no more than seven out of every ten infected trees. "If that could be improved by additional surveys or better methods, it would really help," says Carroll.

While the first set of questions that MPBspread was designed to answer were about the amount of control efforts, the enhancements allowed the UBC lab to explore different ways to apply the control efforts. For example, one suggestion was to use the clearcut control strategy to cut off the beetle's eastward advance, like a giant fire break. Unfortunately, no, says Carroll. "We found that the pine forest is just too connected to be broken up and reduce the risk of spread."

Another alternative treatment strategy that they modeled is "back-treating". The province is currently targeting the leading edge of the mountain pine beetle with its control efforts to slow the spread. But according to one theory, the western areas already heavily colonised by beetle are acting as sources of new spread and the province should focus on knocking beetle populations down there. This also turns out to be a dead end: the current slow-the-spread strategy beats back-treating by 25%, though back-treating is still much better than doing nothing at all. The likely reason is that mountain pine beetle swarms only rarely take flight at just the right time to catch a strong wind east; most beetles only make it a few trees over in the same stand.

A final strategy, proposed by several Alberta forest companies, is for the industry to augment the government's efforts by adjusting their own harvesting. The idea is to cut the most vulnerable stands first to remove the trees that would be the best fuel for further insect spread. Carroll's team has now run those scenarios with MPBspread and will be ready to share the results in 2020.

Hanging over all these predictions is climate change, what Carroll calls, "the big unknown." Warmer years mean that fewer beetles die in the winter and the larger swarms will march east faster. Depending on control efforts and the temperatures in the next few winters, it means the difference between the beetle reaching Saskatchewan by 2021 or 2026.

Acknowledging the uncertainties of climate and the reality that mountain pine beetle is here to stay may discourage some, but what Carroll and his colleagues have shown is that the fate of Alberta's forest isn't written yet. Control efforts are slowing the spread and saving an untold number of trees. Though the beetle will be a permanent constraint, says Carroll, "we can minimize its impact."

INTO THE WILD

By some combination of fortune and genetics, one pine or spruce will stand above their neighbours. Whether it grew fastest or first, or because it handled a drought year or any other test, that tree prevailed. And like gardeners selecting for the largest pumpkin or sweetest snap pea variety, foresters bring seeds or cuttings from the best trees back to their orchards. These are bred with each other to improve the seeds the companies use to replant. Each Tree Improvement program has their own tree families that seem to grow better than the average wild variant. For more than 30 years in Alberta, selective breeding programs have also been working on other traits like drought tolerance, protection from disease and insect attack, and more recently, resilience to climate change

Now six forest industry companies, Isabella Point Forestry, the Government of Alberta, and researchers from the University of Alberta are cooperating on a large trial out in the wild. At 150 sites throughout Alberta's foothills, the group has planted seedlings from both wild stock and their seed improvement orchards to compare how they do in real world conditions. Out there, the improved seedlings, alongside their wild cousins, will have to contend with more competition from other plants and nibbling wildlife.

This Forest Growth Organization of Western Canada project is called the Realized Gains Trials, and the main purpose is to see how improvements in the orchard translate to an operational reforestation setting. Seedlings from one parent tree might grow, say, 3% faster than those of another parent in the orchard, but how will they grow on the landscape? This experiment will help government and industry better understand how to use the natural variation of the forest to keep pace with a changing climate.

A secondary goal is to pick up effects that aren't obvious in the more controlled research trials that companies do to identify promising seed stock. For example, if a tree is putting more energy

into growth at the expense of defense, it may look like a winner, but be too susceptible to disease and insects in the wild. Because the Realized Gains Trials will last for many years, the experiment will have decades to reveal which seedlings survive and how well they rise to environmental challenges.

The initial wave of seedlings went in the ground in 2019, but the group doesn't expect to see a trend until the 2030s. For such an investment of time and effort—not to mention much of their most promising seed stock—the group wants the experiment to be as robust and reliable as possible. To that end, they worked together to set standards for how everyone was going to manage their sites.

For example, the group wanted to capture effects in realistic reforestation situations, so they used the typical site preparations that they normally would to make an area plantable. To make sure that every set of wild and improved seedlings at a site are comparable, each particular site had to be as uniform as possible and had to get the same reforestation treatments for both wild and improved seedlings.

By enlisting the help of the university on the design, measurements and analysis of the trial, the forest companies can be confident in the quality of the study. By working with the Alberta government, they can expect that the results will inform the province's reviews of their forest management plans. By working together, the industry gets answers for wet and dry areas, sites rich and poor in nutrients, and forests with mixedwoods and pure tree species. And the forest could become more suited to the changes and challenges this century is bringing.

HOW TO COUNT GRIZZLY BEARS

In science, some questions can be tough to answer because of the physical difficulties of collecting the data. Some are tough because the methods that have been invented so far just aren't up for the job. Finding out how many grizzly bears live in Alberta is hard for both reasons. Throughout its 22-year history, the Grizzly Bear Program has been working toward an answer, and along the way, we have been improving the tools and pioneering new methods. Within a year, we will have the most accurate estimate yet for how big the population is and more information on which way it is trending. The result will be a landmark in grizzly bear conservation, but the impact of the improved methods might be even greater.

Since the early days of the program, our team has fitted grizzly bears with GPS tracking collars. Live capture is still the only way to answer some questions (see page 8), but it would be too hard on the bears—to say nothing of the researchers—to scale it up enough to use for a population count. So, starting in 2004, we turned to non-invasive methods to build toward a population count. The trick is to find the bits of DNA that grizzly bears leave behind: their hair and scat. By sequencing the DNA, we can identify individual bears, and by looking at how often we detect the same bears compared to new ones, we can estimate the total population in a given area.

Developing these methods puts the Grizzly Bear Program on the cutting

edge. With each population survey, we improve our techniques and work with lab partners in North America and Europe to get the maximum amount of scientific information from every sample. Until recently, that was pretty limited for bear scat. Digested food doesn't have any bear DNA. But as the food passes through the bear's gut, some of the cells lining the intestines hitch a ride, and those cells do contain the animal's genome. Still, scat provides a relatively poor source of DNA compared to a tuft of hair, which usually has many cells in the follicle at the base of every strand.

For that reason, hair is still the most reliable and accurate way to study populations for grizzly bears and many other species. In one of our recent population surveys, our lab partners were able to identify the individual bear in every single hair sample we sent them. Our scat projects only get that level of precision from 14–21% of samples. Other projects see better rates, but still not as good as from hair.

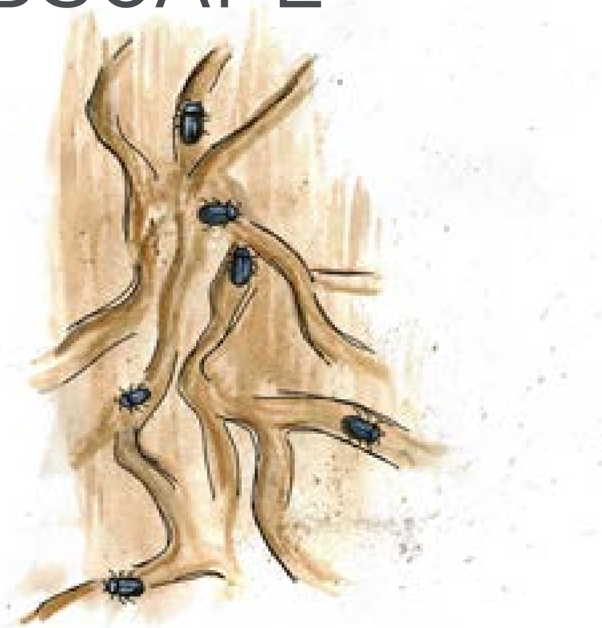
If it sounds like there must be a catch, there is: cost. In 2018 the Grizzly Bear Program hired over 20 field technicians to set up, check, and take down some 400 hair snag sites in three of the seven regions that grizzly bears call home in Alberta. This involved bushwhacking with tools and material to set up a scent lure surrounded by a string of barbed wire. Bears curious about the stench have to climb over or under the wire, leaving tufts of hair for us to pick up.

Collecting scat, on the other hand, is more a matter of chance. When researchers—or citizen scientists—happen on a specimen, we scoop it. While far less labour intensive, it's difficult to use that by itself to get an estimate for population size, but it can identify additional individuals and show whether the species is living in an area. Never content, the Grizzly Bear Program also trialed a new method of scat collection in 2018. During the population study, a field crew systematically drove along gravel roads in the same area where hair crews were working. Their haul for the season was DNA samples from 183 piles of bear scat. Because of the low success rate for identifying individual bears from scat, it was not enough to get an accurate population estimate on its own, but it cost much less, and when combined with the hair data, it made the final estimate more precise. Setting up scent lures to collect hair is far less invasive than catching and sedating grizzly bears, but it could temporarily have some impact on bear habitat and behaviour. Our scat collection method doesn't even have that modest disturbance, since bears are already attracted to roads in the spring and early summer when ditches are lined with delicious clover and dandelion.

By comparing scat and hair sampling in the same area, we learned the strengths and weaknesses of each method. It was easier and cheaper to collect scat, but the lab costs to extract DNA are a bit higher. Overall, the scat method turned out to be 30% cheaper than hair. If you need a solid population estimate for an area, hair collection is still the way to go, but you could consider augmenting that with some scat collection for more robust results. On the other hand, if you want to know where grizzly bears are within an area, scat could be sufficient and cost effective, and there is still a lot of room to improve it as a method.

When Alberta finally has a robust, up-to-date grizzly bear population count, our team will be thrilled. But another proud part of the Grizzly Bear Program's legacy will be leaving the tools of science considerably sharper than when we first picked them up.

LANDWEB REVEALS WESTERN CANADA'S PRE-INDUSTRIAL LANDSCAPE



Landweb has launched. The visionary modeling tool brings together climate, wildfire, forest growth and succession, and mountain pine beetle spread to let us better understand a key concept in ecology: natural range of variation. This refers to the types and ages of vegetation that there would have been before industrialization. The theory is that by staying within an area's natural range of variation, the ecosystem will be able to provide habitat for the native species of wildlife, and be resilient to disturbances like climate change and insect invasion.

In 2014, the Healthy Landscapes Program took on the immense challenge of modeling the pre-industrial range of variation across the entire western Canadian Boreal. The team, led by Dr. David Andison, would need to draw on the best science from several disciplines. The standard approach is to make a model specifically designed to answer a question. But when new data and new questions inevitably arise, researchers often have to completely overhaul the original model or start from scratch.

Andison and the program partners decided to build for the long term and break out of the cycle of single-use models. They teamed up with Drs. Eliot McIntire and Alex Chubaty to develop a modular platform that can accept new data and integrate additional models when new questions come up. For example, determining the pre-industrial habitat of caribou, or predicting how mountain pine beetle might bring the landscape closer to or further from its natural range of variation.

The result is Landweb, a suite of flexible models that use peer-reviewed components and public and propriety datasets to show the natural range of variation. Users can get results for the individual tenures of forest companies, or a particular ecotype, or any other region. Until now, no one has been able to do this on the scale of 125 million hectares—the western Canadian Boreal.

Overwhelmingly, what Landweb reveals is the profound effect of a century of fire suppression. Since the early 1900s, the provinces have been extraordinarily successful at preventing and extinguishing wildfires. This has saved lives, homes, and a tremendous amount of timber supply. But it has come with a cost. Many areas are beyond their natural range of variation, long overdue for a regenerating fire. In these places, there is now far more forest older than 80 and much less forest less than 40 years old.

This pattern is particularly pronounced where there isn't much forestry, such as wetter places dominated by black spruce. But even in areas with industrial disturbances such as forest harvesting, roads, seismic lines, and oil and gas wells, there is still less young forest today, and more old growth, than there used to be when fires swept through more often. The shift probably helps some wildlife that prefer mature forests, however not all disturbance is equal. Though there may be more total old growth forest, the roads, seismic lines, and pipelines slicing those patches up are responsible for the decline of the province's caribou herds, which require intact tracts of mature forest.

Landweb, in revealing how different the natural range of variation is from today's landscape, reinforces what has become a fairly well-known paradox: that decades of fire suppression have raised the risks of larger, more intense fires. The abundance of old forest is also more vulnerable to insect invasion and climate change. These are important issues, and Landweb's flexibility will make it easier for partners to explore them in the future, without having to build a new model from the ground up.

WE HAVE WRESTLED EVEN MORE LIVE DEER

What's good for deer is generally bad for caribou. Their habitat needs are quite different and having a lot of extra deer hanging around in caribou ranges invites predators. Ecologists call this apparent competition—caribou and deer aren't really competing for the same food and habitat, but the presence of one is bad for the population of the other because of their shared predators. This relationship gave the Caribou Program and its forestry partners the idea that if companies can do their harvesting in a way that is less helpful for deer, then harvested areas in caribou ranges might draw fewer predators.

To test this theory, we would need to monitor which animals use cutblocks, and we'd need to track deer specifically. Watching cutblocks was relatively straightforward, if a lot of work. For three summers, we drove to dozens of cutblocks and set up camera traps to photograph anything that moves. But keeping tabs on deer is a much bigger challenge, and one that hasn't been done in these caribou ranges before.

The team got to work capturing white-tailed and mule deer and fitting them with GPS collars. After discovering that the plan of net-gunning deer from a helicopter had a fatal flaw (trees), the Caribou Program switched to baited Clover traps. There was a steep learning curve. In the first season the team learned how to build the cages, the most irresistible recipe of hay and alfalfa for bait, which crew members were most allergic to hay and alfalfa, how to position the bait and the traps, and which hockey pads to wear when it came time to jump into the trap, wrestle the deer down, and put on the collar.

In addition to learning all that, the crew also learned to accept loss; a discouraging proportion of captured deer only sent us a few months' of location data before being eaten by predators. Still, by the end of the year, we had hourly locations from three male and three female white-tailed deer in the A La Peche caribou range. And we had proof that this method worked.

This past year, we applied those lessons and went after deer further north, in the Redrock-Prairie Creek range. The deer capture part went great. The team collared 14, including a couple of mule deer for the first time. The not so easy part was surviving the winter just outside the Kakwa Wildland, in a remote camp built for three seasons. Frozen water and

fuel lines and the exquisite experience of using the outhouse in -42°C built a lot of character, probably.

As the deer move around this year, sending us data about what kind of habitat they spend their time in, we'll retrieve the last batch of camera trap pictures and collect some information about vegetation in the cutblocks. Next winter, in lieu of tackling deer, the Caribou Program will be wrestling with R code and spatial analysis to determine how deer respond to different forestry practices.

Having this unique dataset of deer locations will allow the program to work on other questions about deer populations themselves. Deer are important for the ecology of an area and as hosts of chronic wasting disease, the ungulate version of mad cow disease.

It has opened up a new way to learn about how animals use a busy boreal landscape.

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