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LiDAR study in Horn River Basin

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The BC Oil and Gas Commission, the University of Victoria, and the Science and Community Environmental Knowledge (SCEK) Fund have joined forces on a study that could have a number of applications for oil and gas industry operations in the Horn River Basin.

The study, which began in 2009, employed a pair of remote sensing technologies as well as aerial photography to produce detailed maps of a 700 square kilometre area in the Horn River Basin. The data obtained through the study can provide the Commission and companies working in the region a variety of information about vegetation and water and aggregate resources, as well as the environmental impacts of energy sector activity.

The two main technologies used in the study were light detection and ranging, commonly known as LiDAR, and an imaging spectrometer used for hyperspectral imaging. They are mounted on an airplane, constantly recording data as the craft flies over the study area.

"The LiDAR that we use," said Olaf Niemann of the geography department at the University of Victoria, "it's what we refer to as a discrete multiple return system. So, it's a four return system. In other words, for each laser – for each pulse of laser light that goes out – we record up to four returns. And those returns are a function of what the structure of the ground cover looks like. So, if we have a wide open area, we typically get one return. And if we have enough openings in the canopy, it will go all the way down to the bottom. So, the first return will be from the top of the canopy. The last return will be from the ground. And then there'll be two [returns] in between."

The data obtained by the LiDAR system allows them to distinguish the ground from other elements of the landscape, which is largely vegetation in the Horn River Basin. It then enables them to construct an elevation model that is far more accurate than the TRIM elevation model used by the province.

"It's a provincial generated system or data set," Neimann said of the TRIM model. "And it has an accuracy of plus or minus ten metres, horizontal accuracy and vertical accuracy. And ours is plus or minus two metres horizontal accuracy and about twenty-five centimetres vertical accuracy. So, we can get an extremely detailed elevation model with that."

Subtracting that accurate ground height from the height of vegetation provides a canopy height model for the forest. The LiDAR data also enables them to recognize gaps in the canopy and the mass of the canopy, which can help discern between old growth and new growth. Hyperspectral imaging offers additional detail in terms of the tree species that make up the forest and the health of those trees, including the effects of pathogens, forest pests, and water related stress.

"Typically," said Niemann, "we say that the laser gives us the form and the hyperspectral gives us the functioning. So, the hyperspectral is a very detailed spectral measurement where we get 490 channels to define the electromagnetic spectrum between about 400 nanometres and 2500 nanometres."

"Human vision," he added, "is active between 500 and 700 nanometres."

So, hyperspectral imaging not only sees the visible spectrum, but also extends slightly into the shorter wavelengths of the blue part of the spectrum and deep into the infrared part of the spectrum.

"When we combine them," Niemann continued, "we get a very, very powerful tool."

Howard Madill, Director of Stewardship with the Commission, described the potential applications of the study in terms of strategic, tactical and operational levels. The strategic applications are yet to be determined, but Madill did have some insight into the tactical and operational uses of the data.

"At the tactical level," he said, "it gives you some pretty good indications of things like where the wetlands are, percentage of wetlands in the area, soil wetness index, that may be useful to help determine the effects of oil and gas activity on things like draw down on water … We want to make sure that we're managing the water properly."

"It also gives you a pretty good tool to help classify vegetation," Madill continued. "So, then you can probably do some tactical analysis. Is there specific vegetation or ecosystem types being more or less impacted by oil and gas activities?"

"That area up there is fairly flat in a lot of areas, and there's these sort of fens and bogs," he added. "And when you're out in the field, it's actually fairly difficult to tell where the flow is from Area A to Area B, because it's all these fens and bogs mixed up. And combining these two technologies gives you a picture that you can interpret some of that from, which might have some operational implications for how you route roads and how you want to provide for drainage through fens and things like that."

Scott Wagner, Nexen's Environment Team Lead for Shale Gas, is hopeful that the LiDAR study can provide valuable information about the natural regeneration of cut lines and other disturbances – such as those made during 3D seismic programs – and other issues related to declining caribou populations in northeast British Columbia. Disturbances of that nature have given wolves easier access to caribou, causing a detrimental change in that predator-prey relationship.

Wagner believes that the detailed habitat mapping that has been done through the LiDAR study will fit hand-in-hand with a SCEK funded caribou monitoring study that began this February.

(See February's edition of the Pipeline News North, "Caribou.Caribou- Part 2"; http://www.pipelinenewsnorth.ca/article/20110227/PIPELINE0118/302279992/-1/pipeline0118/caribou-caribou-part2).

"We'll see how caribou and predators are actually using the landscape in relation to those linear disturbances," said Wagner, noting that the combination of data from both studies can lead to site specific solutions for these types of environmental problems.

"When [we] combine the caribou work and the predator work and the mapping stuff," he continued, "what we're hoping to achieve is some specific, effective mitigation that allows oil and gas, at a given pace, to continue to develop, while at the same time protecting caribou in the long term."

Particular areas of interest for the caribou monitoring study are caribou calving sites and the areas where young caribou spend the first few weeks of their lives. The LiDAR study should provide a better sense of habitat characteristics associated with calving sites, which could help the industry design better caribou management plans.

"Maybe there is some comparison or some parallel parameters that you find across the landscape [where calving is occurring]," said Wagner. "So, then you can start adding buffers or protective mitigation measures around those specific areas.

"What we have now is really coarse, broad scale mapping, and we have these wildlife habitat areas and ungulate winter ranges that are huge," he continued. "And they can't be no-go zones, because it sterilizes significant portions of land, especially in northeast B.C.. So, if you can get finer scale mapping you can start to focus in on the possible pathways for decline in those specific areas. Maybe it's a calving area. Maybe it's a rutting area or whatever it might be. Then you can start developing effective and efficient mitigation specific to those decline pathways in those areas."

The study also has practical applications for the day-to-day operations of the oil and gas industry in the region.

"We also did some work on finding aggregates," Niemann explained. "So, we looked at the geomorphology as expressed by the bare earth model. We can map, for example, moraines versus dune fields, shorelines. And we can look at the vegetation structure that's on top of it. So, certainly, up north, better drained areas tend to have different types of vegetation on them … They tend to be taller. They tend to be primarily deciduous in there. And as you get wetter, the vegetation changes to more coniferous and the spacing of the trees starts to increase as well. All this we can pick up quite nicely from the LiDAR data and the hyperspectral combined."

Wagner believes this will take a lot of the guesswork out of locating gravel required for roads and lease sites.

"It's just simply the fine scale topography," he said, "and you can kind of see the landform characteristics that would be more likely to have gravel."

The Commission originally approached Niemann and the University of Victoria about conducting a LiDAR study in the Horn River Basin because of what they had heard about similar work that the university had done with Canfor. Initially, the Commission was mainly interested in mapping bodies of water in the region.

"They wanted depth," said Niemann, "but the water up in that area is just too opaque. There [are] just too many tannins in the water. It's too brown. We don't get any depth penetration at all for the light."

According to Madill, there have been numerous LiDAR projects in the past, but this was the first one designed to use both LiDAR and hyperspectral imaging to examine such a large area.

"It's pretty cool stuff," he said. "And now that we've got it, we're trying to figure out how to make best use of it in an oil and gas context. And if we need to continue down this path or not."

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