
Lewes Marsh Caribou Lichen Research and Monitoring

Report on 2022/23 post-harvest assessments.

**Prepared for the Yukon Government
Forest Management Branch**

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August 2023**



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Summary.

Pine-lichen woodlands in the Lewes Marsh area south of Whitehorse have been studied over a ten-year period (2012-2022) to follow naturally occurring changes in the abundance of terrestrial lichen mats used by caribou as winter forage. Additionally, within experimental treatment plots the impacts of partial-cut harvesting carried out in winter 2014/15 and 2015/16 on frozen ground (one-third and two-third's level of canopy removal) on forest floor plant communities have been evaluated. Within undisturbed stands noticeable changes in plant community composition were seen over the 2012-2022 period. Terrestrial lichen mat cover declining by about a quarter overall, with an even larger decline (more than 60%) found in photoplot studies that focused on large lichen mats, a preferred winter food source for caribou. In contrast, the cover of feather moss mats increased over this same time period, by approximately 10%. The decline in the cover of large lichen mats was not observed in the partial-cut treatments, where lichen cover remained stable or even increased in cover while feather moss mat cover declined. The cover of dwarf shrub communities, such as lingonberry and crowberry, also showed a positive growth response to a more open canopy structure in the partial cuts. In the two-thirds removal treatment continued windfall of trees was observed after harvesting (between 2016 and 2022). The one-third harvest treatment removal may thus represent the "goldilocks" zone, where caribou habitat values are maintained and forest canopy structure remains stable. Continued monitoring of partial-cut harvesting plots for windfall events is recommended. These experimental results highlight the importance of maintaining a range of stand ages within landscapes, caribou habitat values in old pine-lichen woodlands at Lewes Marsh may already be in decline due to natural changes in plant community composition as stands age.

Introduction.

Factors Controlling the Growth and Development of Terrestrial Lichen Mats.

Terrestrial lichen mats, especially species such as *Cladonia mitis*, *C. rangiferina*, and *C. stellaris*, commonly referred to as reindeer mosses (although they are not a moss at all), are the preferred winter forage for woodland caribou in northern British Columbia and the southern Yukon. Lichens are unique among forage sources available to caribou in the winter period in that they accumulate high levels of sugars and polyols which provide an important energy source for caribou. Woodland caribou have a highly developed sense of smell for lichen mats buried under snow and have been shown to preferentially crater through snow to reach lichens.

Terrestrial forage lichens used by caribou are easily outcompeted by other vascular plants at the forest floor surface. They are typically most abundant in dry pine stands, where competing forest floor vegetation is limited by poor soils and summer drought. Terrestrial forage lichens reach their greatest abundance in 60–80-year-old pine stands, gradually declining in abundance in older stands as the canopy grows and the forest floor surface becomes increasingly shaded. In older pine stands the forest floor surface is increasingly dominated by feather moss mats, which slowly displace pre-existing lichen mats.

This sequence of stand successional development, where terrestrial lichens are most abundant within a defined “mid-seral” period after stand origin raises the question as to whether or not lichen abundance in older pine stands can be maintained (or even enhanced) by moderate levels of stand thinning. Can thinning of the canopy in older pine stands be used to shift the balance from conditions that favour feather-moss mat growth to conditions that instead favour terrestrial lichen mat growth? Forest floor plant communities can also be sensitive to changes in canopy cover. Dwarf shrub communities, plants such as bearberry or kinnikinnick

(*Arctostaphylos uva-ursi*) and crowberry (*Empetrum nigrum*), are known to show a positive growth response to increased light availability at the forest floor surface. Intensity of stand thinning may thus be an important factor to consider. Can a level of stand thinning be identified that favours lichen growth, while avoiding a growth response from dwarf shrub communities? Finally, the intensity and scale of any harvesting disturbance are important variables. If forest harvesting disturbs the forest floor there can be a strong colonization response from early-successional plants such as fireweed (*Chamaenerion angustifolium*), potentially displacing forest floor lichen mats.

These questions are particularly important within the range of the Carcross caribou herd in the Southern Lakes Region in south central Yukon Territory (and a portion of adjacent British Columbia). Much of the winter range of the Carcross caribou herd falls in close proximity to local communities, where factors such as linear developments (e.g. roads), residential use, recreational activities, and local timber harvesting have all had a past influence on pine stands. Many of the best lichen-producing habitats for this herd fall within this zone of human influence, leading to concerns that access to winter forage lichens may ultimately become a limiting factor for this herd. In response to these issues the Yukon Government initiated a program of research aimed at identifying how forest harvesting practices can minimize their impacts on terrestrial forage lichens in the winter range. Their research trial examines the impact of different levels of canopy thinning on forest floor plants and lichens within a replicated partial-cut harvesting trial. The trial, located in the Lewes Marsh area south of Whitehorse, allows the examination of how partial-cut harvesting influences terrestrial lichen mats in a pine-lichen woodland. This can potentially provide guidance for local communities on both the status of these pine-lichen woodlands and their response to different levels of forest harvesting.



Figure 1. Top: View of the forest floor within the Lewes marsh site (control plots) showing clumps of *Cladina mitis* forage lichens, interspersed within a mosaic of feather-moss mats, dwarf shrubs, and forest floor litter. Lower left: Photoplot showing *Cladina* lichen clumps embedded within feather moss mats. Lower right: Infiltration of lichen thalli by feather moss fronds at the boundary between species.

Experimental Design

The design and layout of the sampling lines within treatment units was carried out in conjunction with FMB personnel in summer 2012 based on an assessment of the availability of suitable habitat within the Lewes Marsh area. The intent of the harvesting prescriptions was to create stands with dispersed retention of the existing tree canopy at two different levels of openness. Over time, the result will be a two-storied or multi-storied stand. Two levels of retention were implemented:

- High retention – one-third basal area removal using a mark-to-cut single-tree selection system, with trees marked for removal.
- Low retention – two-thirds basal area removal using a mark-to-leave single-tree selection system, with trees marked for retention.

Nine experimental treatment units, each 3 ha in size, were laid out (see outline of treatment units in Fig. 2). The treatment units were set out in three blocks, each block containing three treatment units. The blocks were separated from each other by a 100 m buffer. Within each block, each treatment unit was randomly assigned to one of the three treatments. Within individual treatment units three 100-m sampling lines were placed, these centered along the long axis of each unit and placed 10 to 15 m apart, referred to as lines 1 through 27 (sampling line 1 being the western-most line in treatment unit one and sampling line 27 being the eastern-most line in treatment unit nine). Along each of the 27 sampling lines, plots were established at 10-m intervals. Each plot was composed of two adjacent 1 m² quadrats and one 144-cm line intercept transect (Figure 2). Harvesting was conducted in winter 2014/15 and 2015/16 on frozen ground. Hand-falling was used, with debris from topping and delimiting trees left at stump-side. No site preparation or planting was conducted after harvesting.

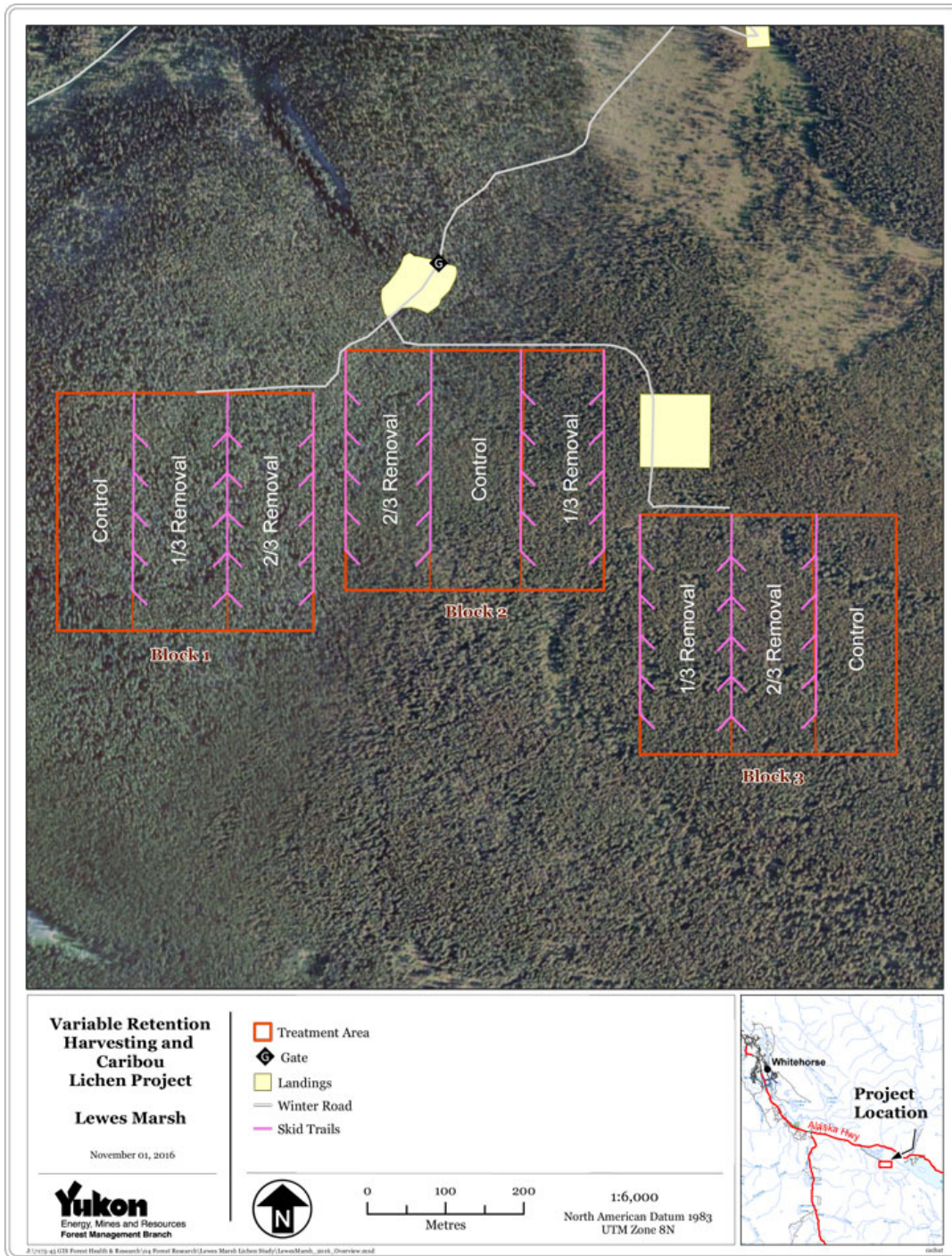


Figure 2. Location and layout of the treatment units and level of harvest removal (one-third basal area removal, two-thirds basal area removal, and control) at the Lewes Marsh study area.

The primary method for assessing the abundance of forest floor plant communities, including caribou forage lichens and feather-moss mats was the use of permanent plots along which line-intercept measurements were taken (Fig. 3 and 4). This provides a highly repeatable approach which allows for the assessment of changes in forest floor cover down to a 0.5 cm scale.

Lichen cover was also measured using permanent photoplots centred on existing large lichen clumps (see Fig. 1). These measurements were complemented by visual cover estimates of forbs and litterfall within 0.5 x 0.5 m quadrats. (Fig. 3). Changes in the abundance of shrub and tree regeneration within the trials were assessed using point-quarter sampling, where a tape was run from each sampling point in four quarters to the nearest tree or shrub.

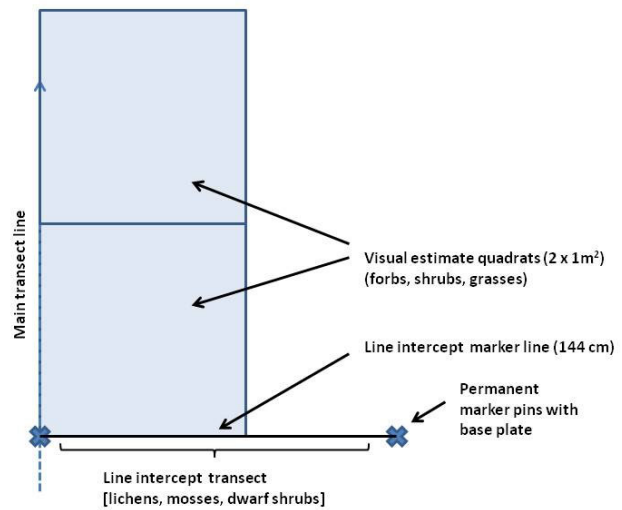


Figure 3. Layout of line intercept transect and visual estimate quadrats at each plot.

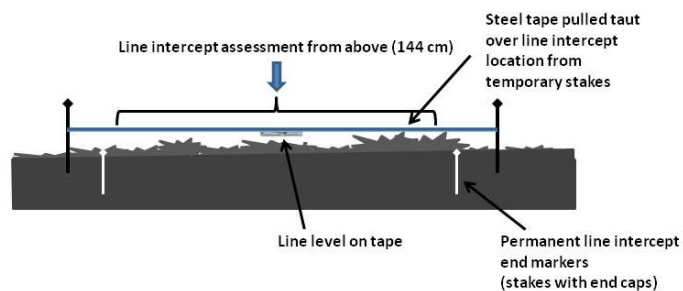


Figure 4. Placement of line intercept tape during assessments of ground cover.

Canopy openness was assessed using fisheye photographs (Figure 5), taking pictures of the sky from the center of each plot with a fisheye lens that had a 180° coverage (to stand horizons). These measurements provided a highly accurate means of measuring canopy cover. Analysis was conducted with Gap Light Analyzer (Simon Fraser University).

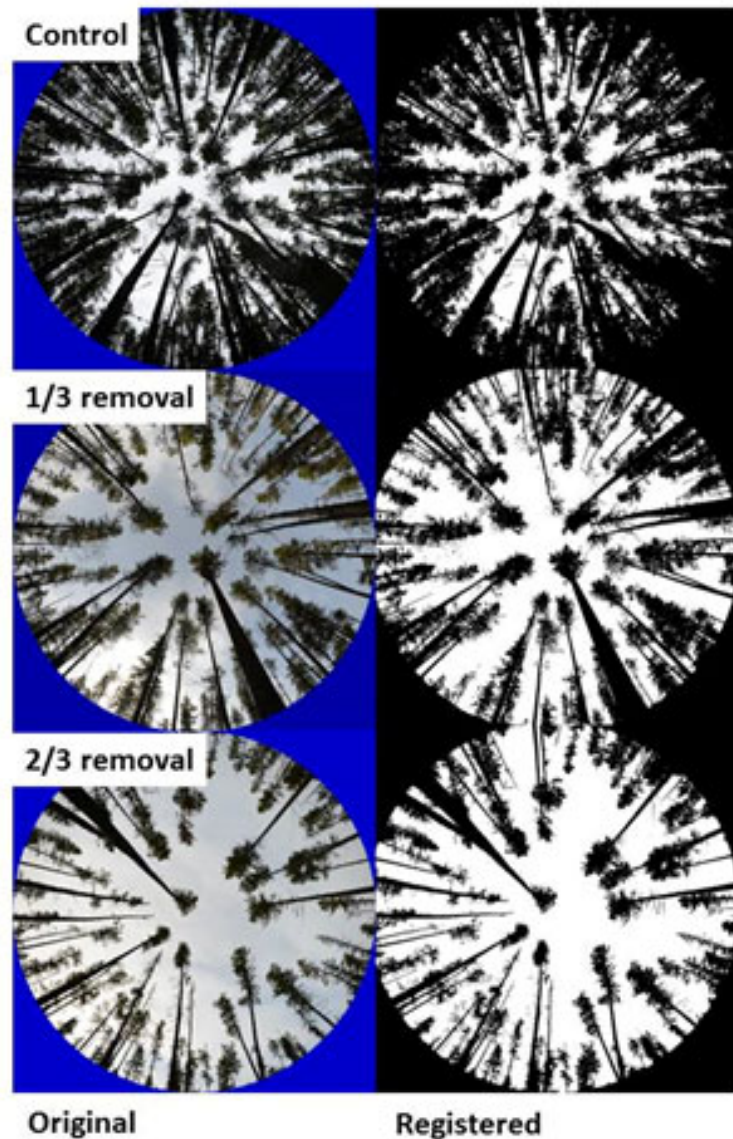
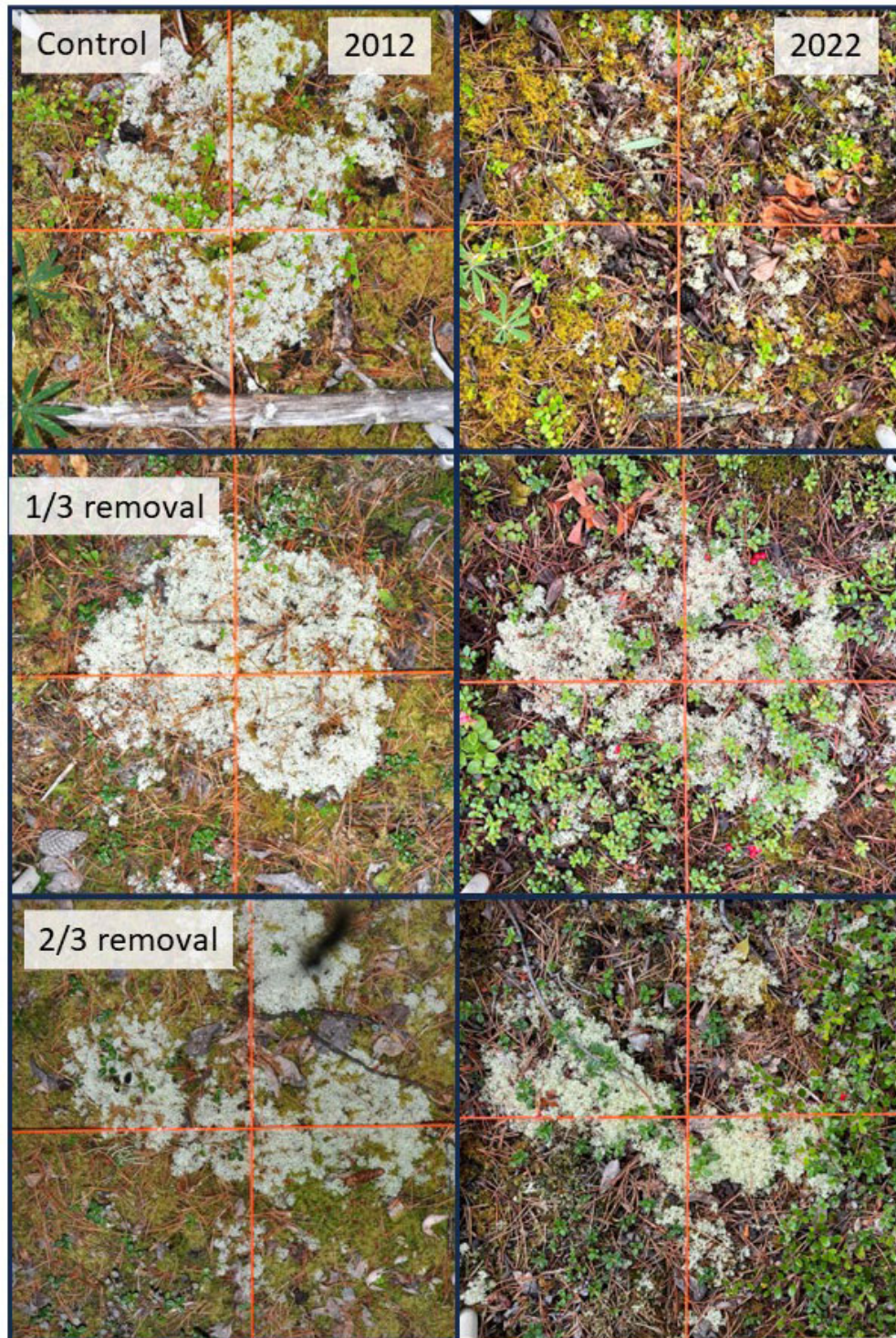


Figure 5. Representative canopy fisheye images for control (top), one-third basal area removal (middle), and two-thirds basal area removal (bottom) treatments. The original colour image is shown on the left, with the contrasting black and white (registered) image for digital gap light analysis shown on the right.

Results and Discussion.

Canopy openness in the unlogged parts of the Lewes Marsh stand (in control sites) remained relatively unchanged from 2012 through 2022, with average canopy openness ranging from 34% in 2012 to 39% in 2016. In the one-third and two-thirds partial cutting treatments these values increased to 50 and 61% canopy openness respectively in 2022. The greater light availability at the forest floor surface in the partial cuts had a major impact on plant communities, especially on the previously widespread feather-moss mat communities. Cover of bryophytes declined by almost half in both partial-cut treatments, reflecting the preference of feather mosses for cooler shaded environments. Photoplot images show this change clearly. Previously continuous surface feather-moss mats have now been largely replaced by forest floor litter (organic soils or pine needles) (Fig. 6). In contrast, in the control plot growth of feather-moss mats has continued unabated, covering both surface litter (see changes in moss cover over stick in lower part of image in Fig. 6) and substantially covering previously intact lichen clumps. The loss of large lichen clumps in the control plots over this ten-year period was substantial, averaging over 60% in permanent plot markers. In contrast, large lichen clumps in the partial cuts showed only small declines or even increases in their surface area (Fig. 6). These findings highlight our understanding of changes in forest floor plant communities with time after stand origin and natural replacement of one plant community with another as stands age. The changes in the abundance of large lichen mats at the Lewes Marsh control sites are likely indicative of changes in the broader southern Yukon landscape, at least in mesic-trending sites, on north-facing aspects or on sites with silty soils, where feather-moss mats dominate in older stands.

Figure 6. Photographs of permanent lichen plots from control, one-third, and two-thirds removal treatments in 2012 (preharvest) and 2022 (six years post-harvest).



Other forest floor plants also increased in abundance in response to greater canopy openness in the partial-cuts, especially dwarf shrub communities - at Lewes Marsh these consisting primarily of kinnikinnick or bear berry (*Arctostaphylos uva-ursi*) and cranberries or lingonberries (*Vaccinium vitis-idaea*) (Fig. 7). Further monitoring will be required to determine whether this increase in dwarf shrub communities will displace terrestrial forage lichens.



Figure 7. Dwarf shrubs such as lingonberry showed a strong positive growth response to the greater openness of the canopy in the partial cuts at Lewes Marsh.

Previous research on woodland caribou foraging strategies reinforces our understanding of the importance of scattered large lichen mats in pine-lichen woodlands, with caribou known to preferentially crater through snow to reach large lichen mats in the winter period. Thus, although overall lichen cover at Lewes Marsh shows a trend of gradual decline as stands age, the accelerated loss of large lichen mats over the past decade has major implications for caribou winter forage values in old pine-lichen woodlands within the southern Yukon. Ultimately, maintaining caribou habitat will depend on maintaining a continued supply of younger stands, between 60 and 80 years in age, an age where terrestrial lichen mats reach their greatest abundance.



Figure 8. Wind-throw of retained trees was evident in some areas within the two-thirds basal area removal treatment units at Lewes Marsh.

In localized sites where soil was disturbed, for instance, along skid trails, some resprouting of willows was observed, although willow cover did not change significantly across the larger stand. The abundance of early-seral shrubs such as willows is a factor that can potentially impact caribou winter habitat values by attracting moose and associated predators such as wolves. Conducting the harvest on frozen soils in the winter was valuable in minimizing these impacts.

Sporadic moose pellets were seen throughout the stand, reflected in the abundance the curious yellow moose

dung moss (*Splachnum luteum*), a plant which grows specifically on decaying moose dung (Fig. 9).



Figure 9. The yellow moosedung moss grows in clumps atop decaying moose pellets at Lewes Marsh, its spores spread from one dung patch to another by small flies.

Finally, an important consideration when evaluating the impacts of partial-cutting harvesting is the long-term stability of retained trees in the stand. Previous studies have suggested that removal of more than one-third of the canopy in lichen woodlands can lead to greater susceptibility to wind-throw. This was not monitored as a specific parameter at Lewes Marsh, however, canopy openness in the two-thirds removal treatment continued to increase from 2016 (immediate post-harvest) to 2022.



Figure 9. Resprouting of willows was observed within some areas of the partial-cut treatment units, especially in sites with disturbed ground.

Selected publications with additional information on caribou and pine-lichen woodlands:

Boudreault, C., S. Zouaoui, P. Drapeau, Y. Bergeron, and S. Stevenson. 2013. Canopy openings created by partial cutting increase growth rates and maintain the cover of three *Cladonia* species in the Canadian boreal forest. *Forest Ecology and Management* 304: 473-481.

Coxson, D.S. 2015. Using Partial-cut Harvesting to Conserve Terrestrial Lichens in Managed Landscapes. *Canadian Wildlife Biology and Management* Vol. 4: 150-162.

Coxson, D. S., and J. Marsh. 2001. Lichen chronosequences (post-fire and post-harvest) in lodgepole pine (*Pinus contorta*) forests of northern-interior British Columbia. *Canadian Journal of Botany*. 79: 1449-1464.

Florkiewicz, R., R. Maraj, T. Hegel and M. Waterreus. 2007. The effects of human land use on the winter habitat of the recovering Carcross woodland caribou herd in suburban Yukon Territory, Canada. *Rangifer Special Issue* 17:181-197.

Haughian, S. R., and P. J. Burton. 2015. Microhabitat associations of lichens, feathermosses, and vascular plants in a caribou winter range, and their implications for understory development. *Botany* 93: 221-231.

Johnson, C. J., K. L. Parker, and D. C. Heard. 2000. Foraging across a variable landscape: behavioral decisions made by woodland caribou at multiple spatial scales. *Oecologia* 127: 590-602.

Maikawa, E. and K. A. Kershaw. 1976. Studies on lichen-dominated systems. XIX. The postfire recovery sequence of black spruce – lichen woodland in the Abitau Lake Region, N.W.T. *Canadian Journal of Botany* 54: 2679-2687.

- McNay, R.S. 2011. Silviculture options for use in ranges designated for the conservation of northern caribou in British Columbia. *BC Journal of Ecosystems and Management* 12(2):55-73.
- Racey, G.D., K. Abraham, W.R. Darby, H.R. Timmerman, and Q. Day. 1991. Can woodland caribou and the forest industry coexist: the Ontario scene. *Rangifer Special Issue* 7:108-115.
- Stevenson, S.K., and D.S. Coxson. 2015. Can partial-cut harvesting be used to manage terrestrial lichen habitat? A review of recent evidence. *Rangifer Vol* 35: 11-25.
- Sulyma, R. and D.S. Coxson. 2001. Microsite displacement of terrestrial lichens by feather moss mats in late seral pine-lichen woodlands of north-central British Columbia. *The Bryologist* 104:505-516.