WINTER MOOSE FORAGE

FOREST REGENERATION AND WILDLIFE ENHANCEMENT

Prepared by:
Don White, Echo Track Adventures

Yukon Environment

January 2010

WINTER MOOSE FORAGE
FOREST REGENERATION AND WILDLIFE ENHANCEMENT
Yukon Fish and Wildlife Branch
TRC-10-01

Acknowledgements

This work was done under contract to the Yukon Department of Environment. The views expressed herein are those of the author and are not necessarily those of Government of Yukon.

Copies available from:

Yukon Department of Environment
Fish and Wildlife Branch, V-5A
Box 2703, Whitehorse, Yukon Y1A 2C6
Phone (867) 667-5721, Fax (867) 393-6263
Email: environmentyukon@gov.yk.ca

Also available online at www.env.gov.yk.ca

Suggested citation:

WHITE, D. 2010. Winter moose forage: Forest regeneration and wildlife enhancement Yukon Fish and Wildlife Branch Report TRC-10-01.

Winter moose forage: Forest regeneration and wildlife enhancement

---

January 28, 2010

Report submitted by:

Don White
Echo Track Adventures
41 Boxwood Crescent
Whitehorse, Yukon Y1A 4X8
Email: don.white@live.ca
Phone: 867-633-5671
Cell: 867-333-9202

Submitted to:

Shawn Taylor
Southern Lakes Regional Biologist
Environment Yukon

Table of Contents

List of Figures

List of Tables

Introduction

Environment Yukon contracted Echo Track Adventures to complete a project entitled *winter moose forage: forest regeneration and wildlife enhancement*. The study centred on the Champagne and Aishihik Traditional Territory (CATT). We collected data within the CATT during four days of field work, including visits to a number of sites (old cutblocks, fires and one riparian area) to collect data on willow and buffaloberry.

This report summarizes our findings, including:

- information collected about winter moose forage enhancement;
- a key that describes natural willow species being browsed by moose found in past cutblocks;
- observations and discussion about results of past test planting of willow adjacent to the McIntosh subdivision;
- information on methods, results, limits, costs, cautions and policies collected through a literature search and telephone interviews with researchers in other jurisdictions; and
- options that could be used in Yukon.

An unusually long lasting spruce bark beetle (*Dendroctonus rufipennis*) infestation has killed mature white spruce (*Picea glauca*) over several hundred thousand hectares throughout the CATT. The absence of natural fire and thousands of hectares of dead boreal white spruce will continue to affect vegetation communities and moose forage development across the CATT.

Planning for moose winter forage enhancement would need to include input from the Champagne and Aishihik First Nations (CAFN). CAFN elders have described how land in their traditional territory used to be much more open. This change in vegetation could be related to the recent presence of Lake Alsek or could be related to fires that CAFN members used to set. Fires used to be set intentionally to improve wetland habitat for muskrat, and unintentionally when First Nations lit trees on fire to signal others that a moose had been killed (Lawrence Joe, pers. comm., 1983).

Yukon Forest Management Branch is focusing its harvest planning development options in areas of spruce beetle killed forest in the CATT south of Haines Junction east of the Haines Highway. The purpose of these harvests is to salvage usable timber and reduce wild land fuels and wildfire threats to Haines Junction. Hundreds of hectares of forest have been harvested in the CATT to date. Some of these areas have been planted with white spruce (1996 program). Staff of the Forest Management Branch test planted a site west of the McIntosh subdivision with rooted and non-rooted willow scions in 1999 (scions are shoot cuttings that can be planted to produce new individuals).

Climate change may also affect the future abundance and growth of willow in the CATT. Positive feedback mechanisms between shrubs, snow cover and increased soil warming may increase the amounts of willow present in the CATT which may benefit moose but may possibly be detrimental to caribou (Myers-Smith, 2007).

Although buffaloberry is not foraged by moose, we collected data on this species because we were interested in seeing the relationship between harvest, soapberry growth and potential effects on grizzly bear forage. When the buffaloberry data was collected, most of the berries produced by the female plants were already dropped or consumed. Female shrubs were only detected in a single subplot above Quill Creek.

Background

Improving moose forage opportunities in the CATT has a long history of discussion. In an undated memorandum addressed to five staff members of the Habitat Section of the Yukon Department of Renewable Resources, Len Mychasiw set an “inaugural meeting of the enhancement (fire) working group” for Friday November 25 -- possibly in 1994 (the year was not included in the memo). In June 1995 M. Vaartnou and Associates prepared a document entitled *A Critical Assessment of Methodology Proposed for Analysis of Moose Winter Forage Production After Fire.*

Some of the CATT is heavily influenced by the icefields in Kluane National Park and Reserve where natural fire is infrequent; this is known as a lightning shadow (Map 1). Only four fires larger than 300 hectares have been recorded in the CATT since 1980. The absence of natural fire is thought to be one of the reasons that the spruce bark beetle infestation was able to explode and affect such a large area of spruce forest (Garbutt, pers. comm., 2009).

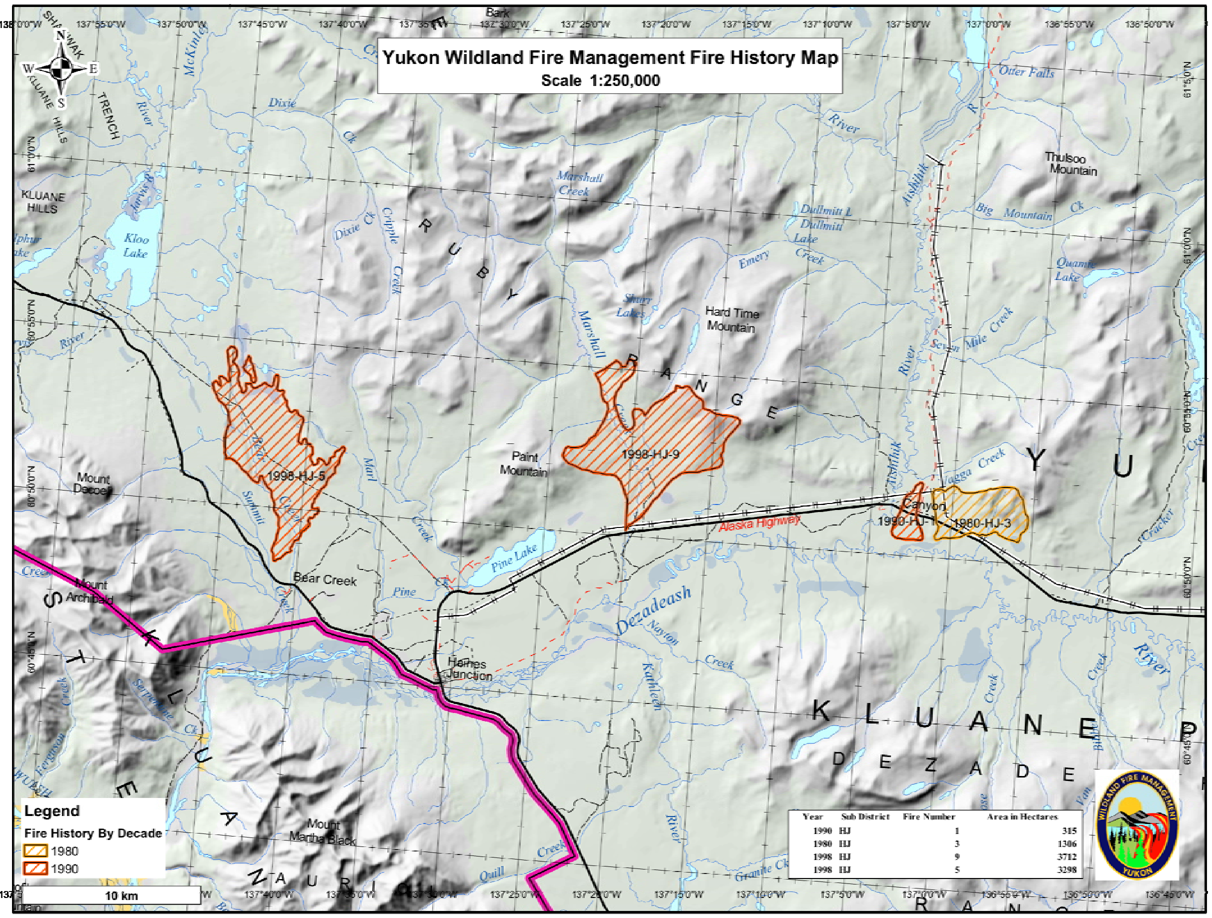

Figure 1. : Fire History Map of the Champagne and Aishihik Traditional Territory, 1980 through 2009.

A document entitled *Work Plan for Assessing Wildlife Habitat in Spruce Beetle Infestations* (undated) by Len Mychasiw of the Habitat Section of the Yukon Department of Renewable Resources references the initial outbreak of the spruce beetle infestation reported in the area in 1994:

> Forest renewal is of interest to habitat/wildlife management because optimal habitat requirements of some species are met by the young-seral plant communities which occur through post-fire biotic development. Species that tend to do well in early post-fire communities typically do so because coniferous mature forest is replaced by hardwoods. This seral-habitat relationship arises whenever possibilities for improving the situation for moose are considered and such considerations usually involve increases in the amount of moose forage in a given area. Spruce beetle infested areas are of interest in this context, as it is

possible that hardwood species will dominate early seral stages of the post infestation community.

Since 1994 the spruce beetle infestation has killed white spruce over an area of 400,000 hectares in the

CATT. White spruce (*Picea glauca* (Moench) Voss) is the only naturally occurring conifer found in contiguous stands in this part of Yukon (Garbutt et. al., 2006). Isolated individuals of lodgepole pine (*Pinus contorta* Dougl. ex Loud. spp. *latifolia* (Engelm.) Critchfield) have been recorded along the old Alaska Highway a few kilometres west of Champagne. It is found in pure and spruce co-dominant stands starting about 100 km to the east (Garbutt et. al., 2006). Cody (2000) reported a collection of alpine fir (*Abies lasciocarpa* (Hook.) Nutt.) near Haines Junction.

Balsam poplar (*Populus balsamifera* Mill.) and trembling aspen (*Populus tremuloides* Michx.) are the only deciduous trees found in stands in the CATT. Paper birch (*Betula papyrifera* Marsh.) and Alaska birch (*B. neoalaskana* Sarg.) are scattered in the CATT, but neither black spruce (*Picea mariana* (Mill.) B.S.P.) nor larch (*Larix laricina* (Du Roi) K. Koch var. *alaskensis* (Wight) Raup) has been recorded in the CATT.

The future vegetative complex that develops from this beetle-killed forest will impact all wildlife species that live in or migrate to the area. Furthermore, climate change is expected to impact vegetative communities within the CATT (Myers-Smith, 2007). Researchers remain uncertain how these impacts will influence moose forage.

Methods

We collected information for this report using three methods: literature review, personal interviews and field study. Environment Yukon staff provided literature citations and the author conducted the literature search. Staff also provided an initial list of interviewees which was augmented throughout the interview process.

We conducted field study in two parts. The author spent two days in the CATT in August 2009 to become familiar with the species of willow found in older harvest blocks, natural meadows and willow thickets (Bruce Bennett, Wildlife Viewing Biologist at Environment Yukon, identified collected samples). We collected number, crown cover and height data of willow (*Salix* spp.) and buffaloberry (*Shepherdia canadensis*) over an additional two days in September 2009 (Map 2). Appendix 1 contains a summary list and description (willow key) of the species found. Appendix 2 contains observed heights, densities and crown cover data of willow and buffaloberry.

We sampled a total of 11 areas using a cluster of four circular subplots, each having a radius of 11.3 metres and an area of 400m². A total of 11 plots in 4 habitat types were sampled in order to assess the relative availability of moose browse. We sampled 3 burns, 2 cutblocks, 1 riparian and 5 forest plots (controls). Because of the small number of samples in some habitat types, we must be cautious in our interpretations of the observed habitat associations.

At each location we arbitrarily selected a plot centre within the unit (cut block, burn, riparian area or control) and measured the subplots 25 metres in each cardinal direction from this centre point (Figure 1). In each subplot we describe average *Salix* spp. and *Shepherdia canadensis* availability, using two variables, 'percent-cover' and 'number of stems'. In addition, we measured the average height of both the tallest and shortest *Salix* spp. in order to describe the physical structure of the *Salix* spp. community.

Willows were identified to genus and we include photographs in digital form on disk appended to the report.

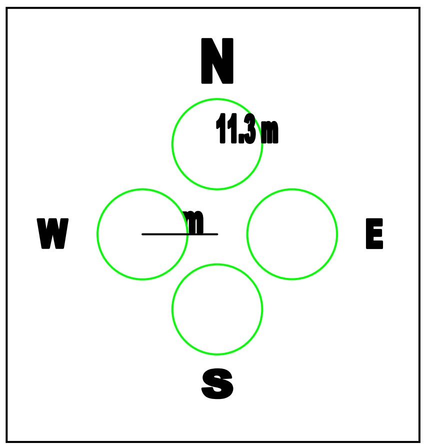

Figure 2. Cluster plot configuration and dimensions.

Results

Our findings from the literature review and interviews were similar. We also interviewed several of the authors of cited articles who provided additional practical recommendations.

Fire is a natural part of the boreal ecosystem. At a landscape scale, prescribed fire is the most cost-effective tool to effect change for moose winter forage. Not only can it effect positive change for wildlife foraging opportunities, it can also help reduce fuel loading and assist in the protection of communities, recreation areas and infrastructure (Paragi and Haagstrom 2005: Rodgers, Marshall, Haagstrom pers. comm. 2009).

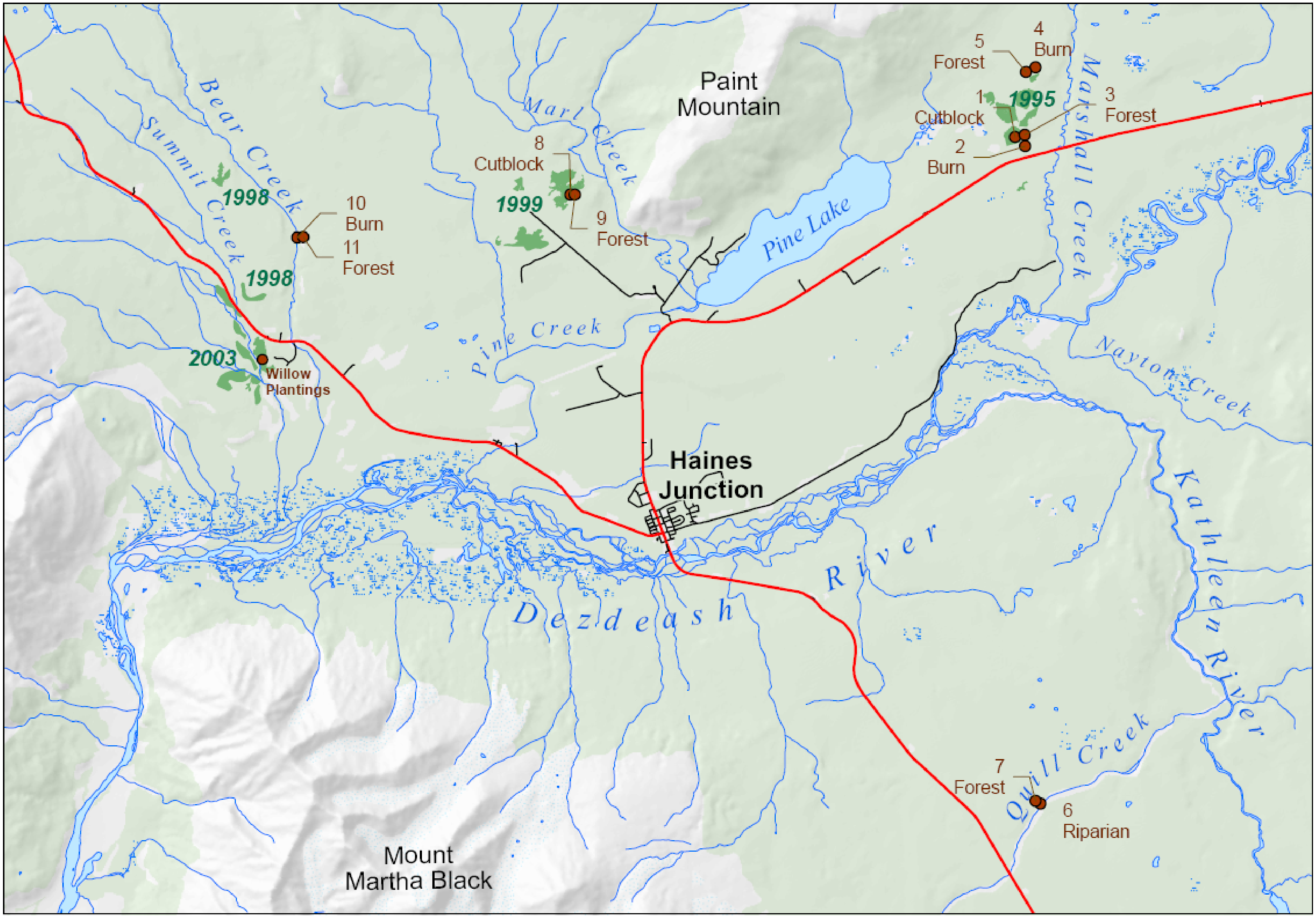

Figure 3. Recent harvest activity, sample plot locations, and willow test planting site in the CATT.

> *"In the big picture you need fire."*
>
> Marshall (pers. comm. 2009)

Prescribed fire is a management tool, but wildfire may also produce serendipitous results. Haagstrom (pers. comm., 2009) lamented the inability of his team to treat an area of the Tanana Flats by prescribed fire during the 1990's until a wildfire burned a large portion of the area in 2004. The results were not exactly what were desired but the wildfire did create new moose foraging opportunities. Rick Marshall (B.C. Ministry of Environment) stated that burning over a large area is the best method, but he pointed out that subsequent use by moose may be delayed (pers. comm. 2009).

Art Rodgers (Centre of Northern Forest Ecosystem Research) observed that in northern Ontario it took about ten years following disturbance for sufficient volume and height of forage to attract moose. Moose would browse for a further 20 to 30 years before the site transitioned to caribou use (pers. comm. 2009). Rodgers noted that production of useful forage was not the issue; key factors were distance from cover (both thermal and visual) and awareness in the population of a new food source.

The Canadian Forest Service (CFS) Forest Health Unit in Victoria, B.C., studied impacts of the spruce bark beetle (*Dendroctonus rufipennis*) in the CATT at 27 forest assessment plots in the Shakwak Trench from 2000 to 2003. They found white spruce in the CATT had densely clustered, fine branchlets that continue to shade the ground years after needles have dropped. This shade continues to keep the root zone cool, affecting any vegetation growing within the shadow. Low root zone temperature is one of the critical impediments to shoot growth in Yukon (Garbutt et al. 2006). Until the dead canopy breaks up and falls to the ground – which can take decades in this region – or is removed by other means (harvesting, prescribed fire, wildfire or wind), reoccupation of the site by trees or shrubs will be compromised.

According to Rod Garbutt, initial measurements and observations indicate no discernable improvement in the number or growth of willow in spruce stands killed by the spruce bark beetle (pers. comm., 2009).

A warming climate in the CATT is expected to affect permafrost, and forest fire frequency and intensity, and shift ecosystem boundaries (Myers-Smith, 2007). If these altered conditions occur, researchers expect animal foraging behaviour to be affected. An increase in biomass of woody shrubs, such as willow (benefitting from root zone warming), may enhance foraging opportunities for moose while reducing caribou habitat.

In a comparison of recent (1989) and historic (1947-48) aerial photographs in Southwest Yukon, researchers reported significant changes in the spruce-shrub tundra transition. Increased growth of individual trees was most common, increased population density of trees at treeline was less common, and expansion of the distribution of trees was least common {upslope migration, sic.} (Danby and Hik, 2007).

Wildlife managers in Ontario and British Columbia are relying more on coordinating activities with forest managers for the enhancement of moose forage. In jurisdictions where thousands of hectares of forest are harvested annually, this is the most cost-effective approach. Ontario produced *Timber Management Guidelines for the Provision of Moose Habitat* in 1988 which states: *The purpose of the guidelines is to assist resource managers in maintaining or creating through timber management the diversity of age classes and species of vegetation that provide habitat for moose.*

These guidelines acknowledge that moose range over the entire forest using specific habitat components throughout the area. They recognize that there are seasonal uses of specific habitats (i.e. winter foraging, calving, etc.). The guidelines also acknowledge that moose require habitat that also provides for thermal cover in winter, visual cover, maximum distance to visual cover, maximum and optimal opening sizes, and the differences across eco-regions or geographic regions. The advantage to wildlife managers of such a system is the continuing addition of early seral shrub stages to the landscapes while maintaining adequate mature forests adjacent to the harvested blocks for cover.

Field Observation Summaries

Salix spp. Availability

Based on percent-cover estimates Salix spp. availability was greatest in riparian and burned habitats, 13.3 and 8.5% respectively (Fig. 2). However, we should be cautious in this interpretation as variability in the three burned plots was extremely high (range= 1.75-19.5%) and our estimate for riparian habitats was based on only one sample. Average percent cover of Salix spp. was lowest in cutblocks (3.3%) and forest (1.6%) habitats.

While percent cover of Salix spp. is high in riparian habitats, the number of stems (53/400m2) is comparatively low (Fig. 3). Burned habitats exhibit the greatest availability when expressed in terms of number of stems (274.4/400m2), but again, the variability among the three burned plots is very high (range=32-588/400m2). The lowest number of stems was observed in forest (29.6/400m2) and cutblock (33.9/400m2) habitats.

Shepherdia canadensis Availability

Shepherdia canadensis exhibited a different availability pattern than *Salix* spp. The highest percent-cover (7.6%) and number-of-stem (45.2/400m2) estimates were observed in forest habitats whereas all other habitats had similarly low availability (Fig.4 and Fig. 5). Again, caution should be used in interpreting this pattern as the variability among forest plots was high.

Salix spp. Height

The average maximum height of *Salix* spp. was greatest in forest habitats (3.9m) but was similar in burned (2.2m), cutblock (2.1m) and riparian (1.6m) habitats (Fig. 6). The average minimum height of *Salix* spp. was again greatest in forest habitats (2.7m) and was similarly low among the remaining three habitat types.

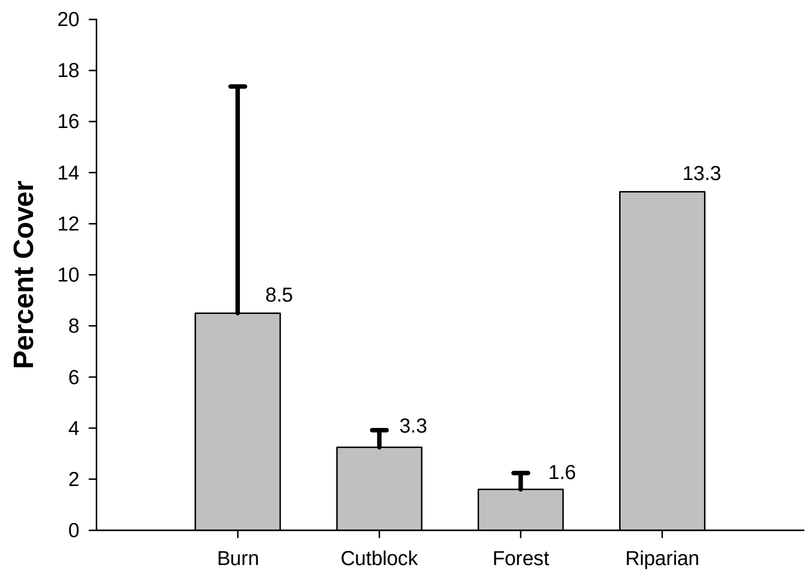

Figure 4. Average percent cover of Salix spp. by habitat type. (n= 3 for burn; n=2 for cutblocks; n=5 for forest; n=1 for riparian).

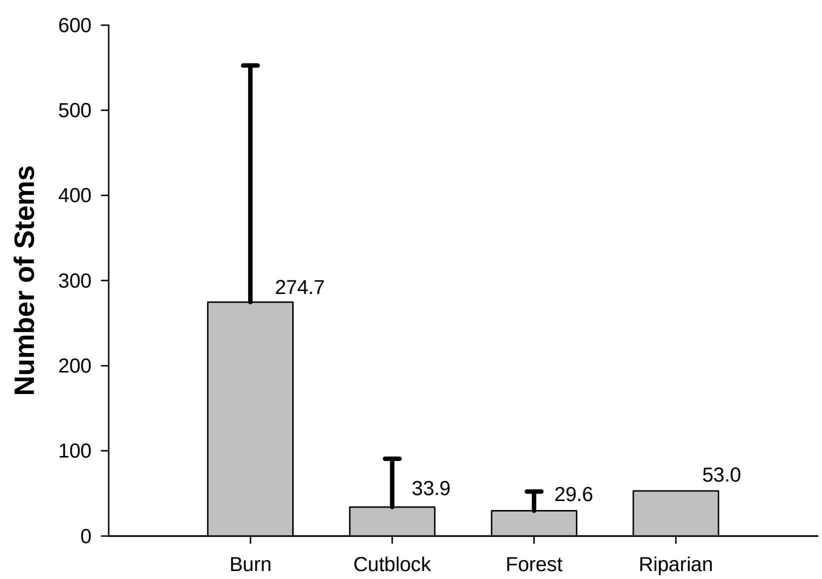

Figure 5. Average number of Salix spp. stems by habitat. (n= 3 for burn; n=2 for cutblocks; n=5 for forest; n=1 for riparian).

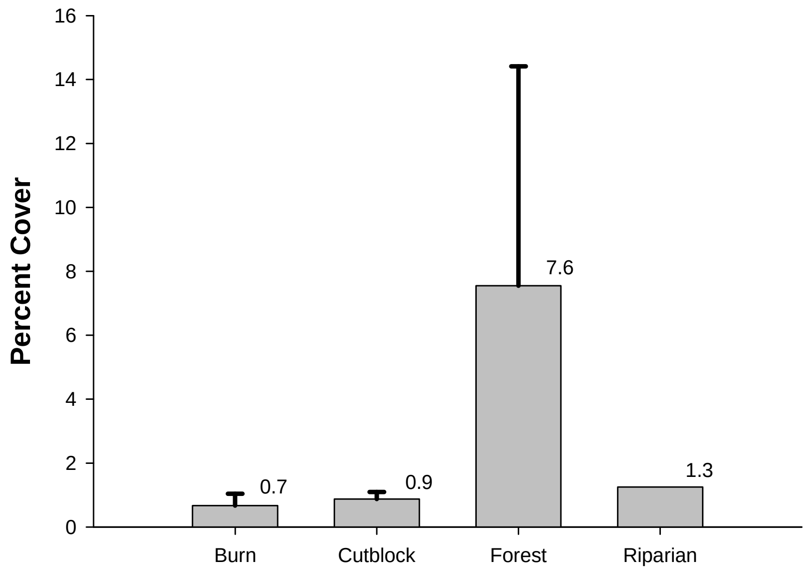

Figure 6. Average percent cover of Shepherdia canadensis by habitat. (n= 3 for burn; n=2 for cutblocks; n=5 for forest; n=1 for riparian).

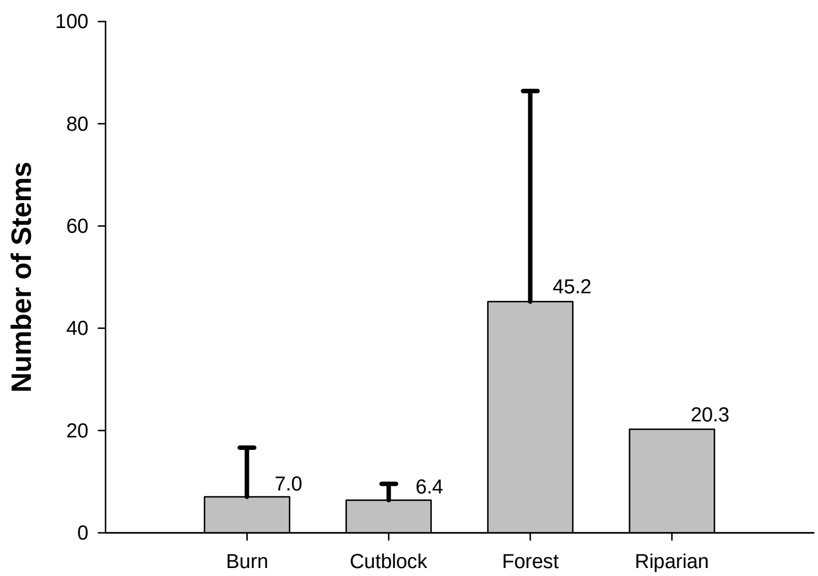

Figure 7. Average number of Shepherdia canadensis stems by habitat. (n= 3 for burn; n=2 for cutblocks; n=5 for forest; n=1 for riparian).

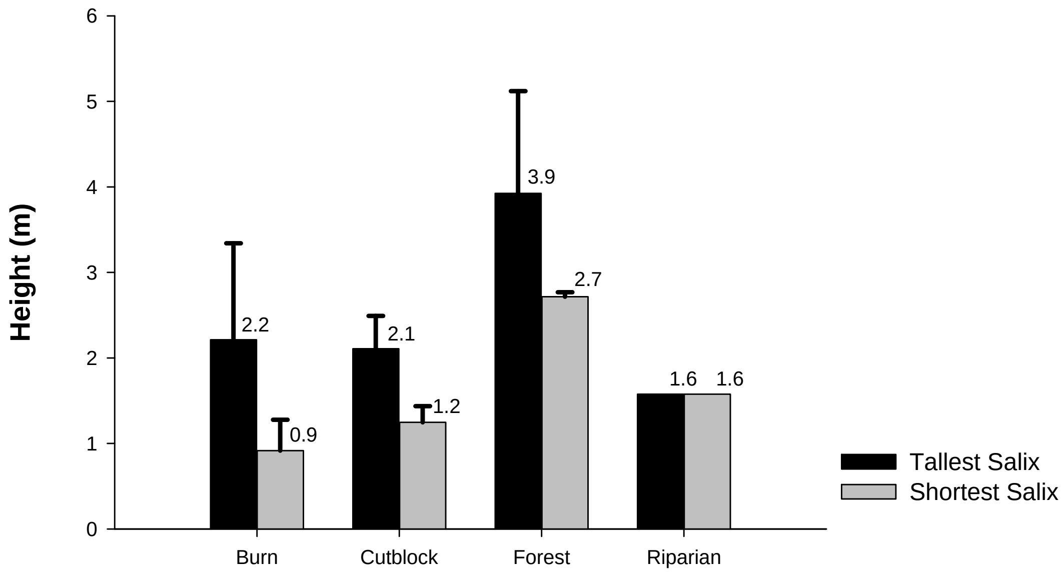

Figure 8. Average height of the tallest and shortest Salix spp. by habitat. (n= 3 for burn; n=2 for cutblocks; n=5 for forest; n=1 for riparian).

Discussion

Similar to findings from the literature, the densest willow stands were observed in riparian and burned habitats. This may suggest that the best and most practical opportunities for increasing large scale willow availability may lie with enhancement burns. The limited number of cutblocks that were observed in this review was from relatively recent harvesting. Willow growth may be expected to increase over time since harvest. Different silvicultural treatments such as different scarification and planting treatments may also likely affect the regrowth of willow in cutblocks. The scope of harvest also leaves relatively little opportunity to influence moose numbers on a large scale.

The observation of relatively low amounts of buffaloberry in cutblocks may also reflect time since harvest. The female berries of this shrub, which are important as grizzly bear forage, are also known to positively respond to increased amount of edge. While the interior of cutblocks may not support good soapberry growth, the edges of the blocks that were not sampled may provide more abundant soapberry growth.

Best management practices within winter range areas must recognize the large differences in climate, forest productivity and snow depths in different parts of the region (Keystone, 2006). Winter snow depth in excess of 80 centimetres appears to be a limiting factor affecting moose foraging success – it is the difference between energy expended to forage and energy gained from feeding (Rogers, Marshall pers. comm. 2009). Moose are typically excluded from high elevation habitats by deep snow in winter, but those areas can provide important summer range and calving habitat (Keystone, 2006). Moose typically prefer mosaics of seral stages offering both cover and browse (Proulx, 2006).

A report titled *Identification and Management of Moose Winter Habitat in the Cariboo Region: Literature Review and Mapping Pilot Study* by Keystone Wildlife Research Ltd. for the B.C. Ministry of Environment in Williams Lake offered several guiding principles pertaining to moose. These principles originated from the Ungulate Winter Range Technical Advisory Team (2005):

- Energy balance is the primary factor in determining overwinter survival. Maximizing availability of preferred forage and minimizing energy loss due to movement should be the main goal of moose winter range management.
- There is an inverse relationship between rooted forage and forest canopy cover.
- Snow is intercepted by the forest canopy and decreases in depth on the ground with increasing canopy density.
- Moose use traditional winter ranges, and occupancy must guide the identifying of winter ranges.
- Movement in deep snow can be energetically expensive. Minimizing movement costs must be considered in identifying and managing moose winter range.

Several jurisdictions state that for wildlife management purposes cutblocks should average no more than 100 ha in size but should be in a range of sizes, of irregular shape, with buffers between cuts and with scattered islands of trees within the cutblocks. This limit allows for visual and thermal cover to be within a short distance of forage (Keystone, 2006; Ministry of Natural Resources, Ontario, 1988).

In the CATT, to date harvest blocks have been less than 100 ha in size and meet the other general requirements noted above (Map 2).

In Southeast Yukon *Salix arbusculoides*, *S. alaxensis*, *S. bebbiana*, *Cornus stolonifera*, and *Betula papyrifera* were observed, initially, to be the species likely to contribute the greatest forage biomass to moose winter diets (Florkiewicz, 1991). This information comes from an interim report, and subsequent data from follow-up research may have shifted the results. Of interest, *Cornus stolonifera* has not been reported in the CATT, while *Betula papyrifera* has not been reported in any significant amount. However, all willow species reported from Southeast Yukon are found in the CATT.

Alaskan birch (*B. neoalaskana*) has evolved to discourage browsing by snowshoe hare, so the palatability between this species and another paper birch (*B. neoalaskana*) to moose may differ (B. Bennett, *pers.com.,* 2010). Identification of these two species during this review was restricted to genus.

Wetlands can provide aquatic forage in the ice- and snow-free periods but are often sites of large shrub complexes that provide important winter forage. Regardless, moose will be found where foraging opportunities exist.

Moose Habitat Enhancement Options

> *Enhancement techniques that are effective, affordable, and socially acceptable must be developed to optimize use of limited funding and address often conflicting public concerns over wildlife and associated land management practices.* Paragi and Haagstrom, 2005

Fire

Several wildfires have been recorded within the CATT in recent years (Map 1). Due to the influence of the St. Elias Mountain Range and its lightning shadow effect, wildfire is less of a disturbance factor in the Shakwak Trench then elsewhere in the boreal forest (Garbutt et. al., 2006).

The oldest fire, in 1980, burned at the junction of the Aishihik Road and the Alaska Highway. In 1990 a smaller fire burned at Canyon. These fires occurred prior to the outbreak of the spruce beetle infestation (Table 1).

In spring 1998, a large wildfire ignited in the McIntosh valley. This fire burned for several months and threatened the town of Haines Junction. Later that same summer, a second fire ignited east of Marshall Creek and burned into the northeast area harvested in 1995. A small fire burned a portion of the harvest block in the area west of Marshall Creek adjacent to the highway in 1995 – this small fire is not included on the map.

> *Fire is a natural force throughout Yukon's forest environment. Lightning or man-caused fires are the primary mechanism of forest renewal and have created a mosaic of forest communities on the landscape, representing a diverse mix of forest cover-types, differing as to age class and species composition. The edge effect and diversity created by the mosaic provides habitats for forest-dwelling wildlife species.*
> (PRESCRIBED FIRE POLICY. PRESFIRE.POL/LM/j)

We visited the 1995 and 1998 fires to observe the impacts of fire on moose forage in the CATT.

Table 1. Fire history in the Champagne and Aishihik Traditional Territory from 1980 through 2009 (data provided by Yukon Wildland Fire Management).

Year	Sub-District	Fire Number	Size in Hectares
1980	Haines Junction	3	1,306
1990	Haines Junction	1	315
1998	Haines Junction	5	3,298
1998	Haines Junction	9	3,712

The abundant *Salix alaxensis* and *S. arbusculoides* of river floodplains contain few fine fuels to carry fire and tend not to burn well. However, in areas where there is a mix of fine fuels, it is possible to rejuvenate these species (Haagstrom, pers. comm. 2009).

Response of *Salix pulchra* to low-severity prescribed fire or wildfire should be evaluated. Spring burns can be conducted safely and cost-effectively in willow habitats when the ground beneath is still snow covered or wet (Paragi and Haagstrom, 2005). In these areas fire kills surface biomass above the snow but the root collars remain viable and respond with the production of vigorous new shoots.

A number of recommendations resulted following the Red Ridge burn trials south of Whitehorse:

- Further investigate the use of fall burning as a possible treatment: what measures need to be taken to implement a fall burn?
- Induce a secondary burn a few years following initial burn, depending on fuel availability.
- Conduct a burn later in the spring or into the early summer to generate a fire with higher intensity and severity.

(Watterreus and Alexander, 1996)

This study was undertaken to improve winter Dall's sheep (*Ovis dalli*) habitat, but these observations are applicable when fire is used to enhance moose habitat. Willows respond to damage by sprouting from dormant buds on branches, stems and at the root collar. In order to improve forage by fire this damage must be more inclusive of the surface vegetative mass. Complete removal of surface cover will expose suitable seedbed surface – soil, ash, thinned and moist duff layer.

Site location and fine fuel density should suggest the best season for conducting a prescribed burn. However, fire use requires coordination and cooperation between government departments, public education, and understanding of social concerns over smoke and potential breakout of the fire. These can be limiting factors.

In many Yukon locations trembling aspen (*Populus tremuloides*) is a dominant post-fire species. Generally, if aspen are found in a mature spruce stand, that stand will convert to aspen following fire. If aspen is present it will sprout from root suckers following the removal of the conifer canopy as a result root zone heating. The question is: How important to moose in the CATT is aspen as a forage species? If aspen is not important as moose forage, subsequent burns may be required to reduce its content.

Mechanical

Mechanical enhancement of moose habitat can be done a number of ways.

Bulldozer:	shearing
	crushing
	scraping
Excavator:	scraping (using bucket blade)
	scarifying (using scarifying blade)
	chopping (using hydro-axing power head)
Manual:	brushing (using a swing saw)
	felling (using a power saw)

Habitat enhancement for moose is most commonly done in conjunction with post-harvest silvicultural treatments (Ministry of Natural Resources, Ontario 1988; Rodgers, Marshall, Harestad pers. comm. 2009). In fact, most of the literature and personal conversations on this subject point to the close relationship between forest management agencies and wildlife managers when machines are used to enhance forage for moose. (See subsection: Silviculture Treatments)

Shearing and crushing by caterpillar tractors are the most common methods of forage enhancement for moose carried out in Alaska. According to articles written by and conversations with Dale Haggstrom (Alaska Department of Fish and Game), special forage enhancement work was conducted in floodplains and willow flats using mostly D8 or equivalent machines.

Willow species generally rebound naturally from fire or mechanical disturbance by growing new shoots from buds that rest dormant at the root collar or along branches. Given willow's natural ability to sprout vigorous new whips, wildlife managers have conducted a number of studies on the timing and methodologies to be employed.

Timing of the work is in the fall and winter following the onset of winter dormancy (anytime after mid-August). Workers mark specified tracts and pass the equipment over the area with the cutting blade of the machine about 35 cm (a foot) above the ground. This approach tends to shear, break or hinge the stems at that height and leads to the development of new stems the following spring. Air temperature is selected to maximize the shearing effect while minimizing possible equipment hydraulic failures. Preferred operating temperatures are near to or slightly above freezing range of 32° to 40° F (0° to 5° C). Haggstrom pointed out that while colder temperatures resulted in more effective shearing and crushing, negative impacts from equipment failures and malfunctions (time delays, reduced equipment and human performance, increased cost) tended to outweigh the improved shearing performance.

Crushing is similar to shearing, however the blade is kept higher or removed and the weight of the machine snaps the stem clusters at root nodes as the tracks roll over. This approach may require a greater number of passes over an area to ensure that adequate breakage is achieved. If the ground is not frozen, resulting soil compaction may produce other problems that can negate improvement to forage in the area (Marshall pers. comm. 2009).

A potential approach to improve crushing is to use a Marden Brush-Crusher towed behind a large machine. The Marden Brush-Crusher is a heavy, sharply ridged cylinder designed to roll over logging or natural debris to break it into shorter sections.

Foresters used excavators in a forest site preparation trial in the Watson Lake area in 1994. This trial compared the site preparation costs of straight blading using a D8 Cat and excavator mounding. The cost per unit of area prepared by the excavator was double that of the straight blading, until temperatures dropped below minus 20° C when the costs tripled.

Yukon or B.C. highways offices can provide cost estimates for brushing with an excavator fitted with a brush cutting head. This method is used to control brush encroachment on highway shoulders and rights-of-way. For sensitive riparian shoreline sites, an excavator would be more environmentally sensitive than a bulldozer because only the cutting head gets near to the stream edge while the machine tracks stay back. However, the distance would depend on the type and size of excavator and the length of the machines goose-neck. This consideration becomes more important when salmon streams are involved.

Finally, hand brushing using swing saws or power saws can achieve the desired results in environmentally sensitive areas. Though this method may be relatively expensive, it can be used effectively in areas where Land Use Permits may be difficult to obtain because of environmental sensitivity. Yukon's Forest Management Branch used modified swing-saw equipment in a power hand-mounding trial in 1994 in the Watson Lake area. Production rates were far below that of either straight blading or excavator mounding, but costs were comparable. While heavy equipment or hand clearing both cost $500 per hectare, machine clearing produced about five hectares per day while hand clearing with a four person crew cleared about one hectare per day. The benefit of manual power slashing is that using crews of people allows for a variety of configurations in deployment.

Brush cutting differs from shearing, crushing and hinging because the plants are sawn cleanly to remove the top. Brush cutting is being used to replace herbicide treatment. Although Scouler's willow appear to compensate for brush cutting by producing large compensatory shoots they are low in digestibility in the long term and lower in tannin content in the short term relative to shoots of uncut willows. There is not sufficient data to portray the full range of morphological and chemical changes that occur throughout the shrub community (Rea and Gillingham, 2007). This noted increase in compensatory shoot size was pointed out as a general observation by Bruce Bennett, Wildlife Viewing Biologist at Environment Yukon, when he was identifying willow collected in the CATT.

During the late 1980s to mid-90s, a joint Canada-B.C. Forest Research Development Agreement (FRDA) funded research in the forest sector in British Columbia. They encountered many problems, from the outbreak of the mountain pine beetle (*Dendroctonus ponderosa*), to the number of small projects that were being attempted and monitored, to the general feeling of inadequacy. According to Marshall and Steventon, they were barely scratching the surface to complete research on selected sites while the quantity and extent of habitat enhancement by the logging industry through normal post-harvest silviculture operations far exceeded anything that was being done under what amounted to a make-work program (pers. comm. 2009). Marshall said, "Our ability to do anything significant was so remote that we decided to can it," (pers. comm. 2009).

The time and expense to perform mechanical treatment of large areas is prohibitive. Without a steady source of funding, Haagstrom stated that operations in Alaska would cease (pers. comm. 2009).

Silvicultural Treatments

Moose forage enhancement in Ontario and British Columbia appears to be tied to post-harvest silviculture. In these jurisdictions thousands of hectares of forest are harvested annually. Although replacement of commercial forest species is the priority of forest regeneration, forage species (including *Salix* spp., *Cornus stollonifera, Populus* spp. and others) occur as normal seral development takes place. In some jurisdictions forest and wildlife managers enjoy an enviable relationship that allows for the enhancement of all targeted species (Ministry of Natural Resources, Ontario, 1988).

Silvicultural treatment includes the use of heavy equipment to prepare planting and seeding beds, prescribed fire to reduce post-harvest biomass, fertilizer to enhance nutrient levels, sowing of seed and planting of seedlings. It also includes subsequent reduction or removal of competing vegetation by brushing, thinning and application of herbicides. In some jurisdictions herbicides have been replaced by the grazing of sheep or goats "although this latter has proved less environmentally acceptable than first thought" (Lindsey, pers. comm. 1995).

In Yukon, the Forest Management Branch has experimented with the use of various types of equipment. The branch used different equipment types at an industrial scale in harvested pine sites. They conducted post-operation analysis for the production of suitable planting or seeding beds and the germination and growth of conifers. Follow-up data collection noted the presence of shrub components but only in a cursory manner. Staff kept photo records of site preparation operations, planting programs and subsequent survival and establishment surveys that may be available electronically from the Forest Management Branch. All harvest blocks had discrete unit numbers based on geographic location.

A limited assessment of current forage (willows) in the Marshall Creek and west Pine Lake harvest programs were conducted as part of this project. (See Appendix 2 and the locations on Map 2)

Revegetation

Our research indicated that little work has been done on habitat enhancement through seeding, planting or the use of scions. Some species are more adept at rooting and are selected for this purpose in bioengineering (Dave Polster, 2008). Collet, in *Willows of Interior Alaska*, comments on the ease or difficulty of rooting cuttings and the best time for the collection of cuttings. Some species (*Salix. bebbiana*, *S. glauca*, and *S. scouleriana*) are to be avoided while others have been used for a variety of revegetation purposes (*Salix. alaxensis*, *S. arbusculoides*, and *S. barclayi*).

Polster offers this advice when considering revegetating with seed:

- Observe the details associated with the establishment of the species.
- Do seedlings establish in the moose prints or the damp surface?
- Are willow seedlings found around the margins of puddles?
- Do pioneer species occupy old wheel ruts on a disturbed site?

Knowing what a species needs to establish – its micro-environmental requirements – will make subsequent forage enhancement operations more successful. Many species require rough surfaces with many micro-sites in which wind-dispersed seed may lodge and germinate. Others may need to land in puddles where there is sufficient water and mud required for germination and growth (Polster, 2008).

Seed collection must coincide with the ripening and dispersal of seed. Willow seed generally has a short time when it is viable between dispersal (collection) and germination. A low germination rate can result if too much time lapses between collection and sowing. Collection for sowing in a greenhouse would offer the greatest rate of success if the time between collection and sowing could be kept to an absolute minimum (local growing).

Collection of seed-loaded catkins that are mature in June would be most effective as long as the collected catkins could be hand-dispersed in the desired area soon after collection. This is less seed-thrifty but is also less time consuming and potentially cheaper to implement. Seed matures for dispersal later in the summer or early fall may be safely over-wintered in frozen storage for early spring sowing.

Researchers at the Prairie Farm Rehabilitation Administration (PFRA) nursery and research facility in Indian Head, Saskatchewan have used under-pot heating to stimulate root development in scions of many deciduous species. Scions are collected after the onset of dormancy in the fall, sown in pots placed on heating pads and grown in the early spring when the air temperature is sufficiently low to maintain shoot dormancy. Roots develop with soil temperatures of 10^{o}C, while shoots do not. By the time the ambient air temperatures are sufficient to allow for bud burst and shoot development, the scion has a root system in place.

This system could have potential use in Yukon if a commercial facility had the equipment or if the Department was able to access greenhouse space for limited production. Although there are a number of potential Yukon growers, chances are that none are currently equipped to produce rooted scions this way. As the Forest Management Branch experienced when contracting work under the Canada/Yukon Economic Development Agreement, Forest Development, 1992-1996, the lack of long-term contracts with local growers offers them little incentive to acquire the required equipment, such as under-pot heating mats. Note that this under-pot heating method may overcome the natural limitations of some species to root from cuttings with or without the use of rooting hormone.

Straight planting of scions is hit-and-miss. Some species do not root well. Others will only root well if placed in suitable medium (e.g. moist loam). All species need to be collected during dormancy. A list of potential species is presented in Table 2 below.

Table 2. Willow species and their relative scion rooting ability as noted by Dominique M. Collet in Willows of Interior Alaska.

Species	Roots Well	Does Not Root Well
Salix alaxensis	x	
Salix arbusculoides	x	
Salix barclayi	x	
Salix bebbiana		x
Salix glauca		x
Salix pulchra	x	
Salix scouleriana		x

To root successfully, a single live bud must be placed into the ground in a suitable environment for the species. Adventitious roots develop at the buried bud node. A single live bud needs to be available above the ground level from which the aerial portion of the plant will develop. There is no advantage to have greater numbers of buds above the ground level, but there may be an advantage to have more than one below ground to increase potential development of roots. Onsite testing needs to be done to assess the most effective and efficient manner in which to sow scions.

While employed by Yukon Forest Management Branch, the author, Don White, was involved in a project with students from St. Elias School in Haines Junction collecting willow whips from ditches in the community in October 1998. Whips were stored outside the Forest Management Branch greenhouse beneath snow cover until March 1999. Staff cut whips to 20 cm lengths, dipped the lower (root) end in rooting hormone over the excision and lower bud(s) and placed the treated scions in commercially prepared soil medium in Spencer-Lemaire containers. Staff watered and monitored the scions daily. By the end of June when planting took place, only about 15% of the cuttings had produced roots of any amount and fewer had adequate root balls available for normal planting.

While Polster prefers to use larger diameter scion material (greater than 2 cm diameter) for bioengineering, smaller scions (0.5cm to 1.0cm) were found to be more effective for rooting when tested by Yukon Forest Management Branch in the Haines Junction area (Polster, pers. comm., 2008). The trials out-planted by the Branch in 1999 in the Macintosh subdivision west of Haines Junction had no success with scions that were greater than 1.0 cm in diameter regardless of the site in which they were planted. They observed better success in scions that were less than a centimetre in diameter.

The highest degree of success was achieved by planting pre-rooted scions. About 50 percent of the non-rooted scions had produced a tissue callus over the severed end in the soil; according to theory, they should have been able to produce roots after planting at the site. The remaining 35 percent were likely dead. As a result of this project, planted willows grow in a harvested block next to the McIntosh subdivision west of Haines Junction. When the author visited and photographed the site, he observed that moose had been browsing the planted willow.

Figure 9. Rooted willow scions 12 years after planting.

Conclusions

Of the four moose habitat enhancement options considered within this report, only fire presents a practical opportunity for large-scale winter moose forage improvement. This technique does come with real challenges related to cost, public perception and community risk; these are not the purview of this report, and would require further investigation.

In jurisdictions where large-scale forest harvest operations exist, wildlife managers are normally confident that forage and habitat requirements may be met over the long term by coordinating silvicultural practices with wildlife management concerns. The removal of forest trees cycles habitat through early seral stages: site preparation or prescribed fire provides seedbed. Harvesting damages shrub species but they in turn sprout vigorous new shoots.

The boreal forest industries in the Yukon and Alaska are too limited in scope to significantly affect moose numbers over the long term. However, opportunities to research whether silvicultural techniques are consistent with maintaining winter moose forage and affecting local moose numbers should be explored. Similarly, mechanical treatments and revegetation of willow through direct planting are tools that are too labour intensive to be practical on a meaningful scale for moose. The detailed techniques to increase success of willow plantings provided here will be more beneficial to specific site remediation needs associated with soil erosion reduction.

If habitat enhancements other than silviculture, such as burning are chosen as methods to increase Yukon moose numbers, sustained basic funding will be required. For example, Alaska has given wildlife managers an annual budget dedicated to improving forage for moose and other ungulates. Selection of appropriate enhancement sites would need to be coordinated between government and First Nations. The planning and execution of moose habitat enhancements would best be integrated among various government bodies (including wildlife, fire and forest managers) and Yukon First Nations. Communication and education in advance of planned operations would also be a large requirement of a successful program. This is largely related to public apprehension related to fire escape and the threat that it could pose to communities.

Appendix 3 presents a checklist for each enhancement option.

References

ARGUS, GEORGE W. 2000. A Guide to the identification of willows in Alaska, the Yukon Territory and adjacent regions. Workshop on willow identification. June 2000.. 138 pp.

CODY, W.J. 2000. Flora of the Yukon Territory, second edition. NRC-CNRC NRC Research Press, Ottawa 2000. ISBN 0-660-18110-X. 213-230pp.

COLLET, D.M. 2004. Willows of Interior Alaska. US Fish and Wildlife Service. 111pp.

DANBY, RYAN K., AND HIK, DAVID S. Evidence of Recent Treeline Dynamics in Southwest Yukon from Aerial Photographs. Arctic, Vol 60, No. 4 (December 2007) P. 411 - 420

FLORKIEWICZ, R. 1991. Moose and Caribou Habitat Use Relative to Logging in the Liard River Basin, Southeastern Yukon. Interim Report: May 1991. Project 12.2 (Presented to Wildlife Habitat Canada). May 1991. 25pp.

FOOTE, M.J. 1983. Classification, description, and dynamics of plant communities after fire in the taiga of interior Alaska. Res. Pap. PNW-307. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 108 p.

GARBUTT, R. ET. AL. 2006. Spruce Beetle and the Forest of the Southwest Yukon. Natural Resources Canada, Canadian Forest Service, Information Report: BC-X-406. 2006. 68pp.

GOVERNMENT OF ONTARIO, MINISTRY OF NATURAL RESOURCES, 1988. Timber Management Guidelines for the Provision of Moose Habitat. February 1988, Wildlife Branch. ISBN 0-7729-3532-7. 33pp.

GOVERNMENT OF YUKON, FISH AND WILDLIFE BRANCH. 1995. The Use of Prescribed Fire in Habitat Management a Policy Framework (draft 4). Prescribed Fire Policy, Presfire.Pol/LM/j June 1, 1995. 8pp.

KEYSTONE WILDLIFE RESEARCH LTD. 2006. Identification and Management of Moose Winter Habitat in the Cariboo Region: Literature Review and Mapping Pilot Study. For BC Ministry of Environment, Williams Lake. March 2006. 47pp

MCKELL, C.M., BLAISDELL, J.P., AND GOODWIN, J.R., TECHNICAL EDITORS. 1972. Woodland Shrubs – Their Biology and Utilization, an International Symposium, Utah State University, Logan, Utah. July 1971. Selected Articles. USDA Forest Service General Technical Report Int-1 1972.

MYERS-SMITH, I. 2007. Shrub Line advance in Alpine Tundra of the Kluane Region: Mechanisms of Expansion and Ecosystem Impacts. InfoNorth, Arctic Vol. 60 No. 4 (December 2007). 447-451pp.

PARAGI, T.F. AND HAAGSTROM, D.A. 2005. Identifying and Evaluating Techniques for Wildlife Habitat Management in Interior Alaska. Alaska Department of Fish and Game. September 2005. 35pp.

PARAGI, T.F. AND HAAGSTROM, D.A. et. al 2009. Identifying and evaluating techniques for wildlife enhancement in Interior: Project No. 5.10 – Habitat Enhancement FY09 Final Performance Report. Alaska Department of Fish and Game, Division of Wildlife Conservation. June 2009. 29pp.

POLSTER, DAVID 2008. Natural Processes: The Application of Natural Systems for the Reclamation of Drastically Disturbed Sites. 2008. 10pp.

PROULX, G. 2006. Moose, Furbearers and Woodpeckers Winter Habitat Use in TFL 30. For Canadian Forest Products Ltd., Prince George, BC. March 2006. 22pp.

PROULX, G. 2007. Moose, Furbearers and Woodpeckers: Winter Habitat Use in TFL 30. For Canadian Forest Products Ltd., Prince George, BC. March 2007. 28pp.

REA, R.V. AND GILLINGHAM, M.P. 2007. Initial Effects of Brush Cutting and Shoot Removal on Willow Browse Quality. Rangeland Ecology and Management 60(6) November 2007. 556-573 pp.

REISENHOOVER, K.L. 1989. Composition and quality of moose diets in interior Alaska. Journal of Wildlife

Management. 53(3): 568-577.

VAARTNOU, M. 1995. A Critical Assessment of Methodology Proposed for Analysis of Moose Winter Forage Production After Fire. Prepared for the Habitat Section Yukon Department of Renewable Resources. June 1995. 13pp.

VAN DAMME, L. ET AL. 2003. The development and application of a decision support system for sustainable forest management on the Boreal Plain. J. Environ. Eng. Sci. 2: S23-S34(2003) doi: 10.1139/S03-031 2003 NRC Canada.

WATTERREUS, M. AND S.A. ALEXANDER. 1996. The Effects of Prescribed Fire on Vegetation on the South Slope of Red Ridge, Southwest Yukon, Progress Report, May 1996, Yukon Renewable Resources, Fish and Wildlife Branch, PR-96-2. 22pp.

Sources Interviewed

GARBUTT, R., PERS. COMM. R.G. FOREST PEST SOLUTIONS, 2334 Terrace Road, Shawnigan Lake, B.C. V0R 2W1.

HAGGSTROM, DALE A., PERS. COMM. Fire and Habitat Management Coordinator, Alaska Department of Fish and Game, Division of Wildlife Conservation. dale.haggstrom@alaska.gov

HARESTAD, DR. ALTON, PERS. COMM. Simon Fraser University, Retired. College of Applied Biology, RPBio, Wildlife, Biodiversity, Forestry.

JOE, LAWRENCE, PERS. COMM. Director; Heritage, Lands, Resources. Champagne and Aishihik First Nation, Haines Junction, Yukon. ljoe@cafn.ca

LINDSEY, STEVE, PERS. COMM. District Manager, BC Ministry of Forests and Range, Ft. Nelson.

MARSHALL, RICK, PERS. COMM. Senior Wildlife Biologist, BC Ministry of Environment, Smithers. Rick.W.Marshall@gov.bc.ca

POLSTER, DAVID, PERS. COMM., 2008. Polster Environmental Services Ltd., 5953 Deuchars Drive, Duncan, BC V9L 1L5, d.polster@telus.net

ROGERS, ART, PERS. COMM. Research Scientist, Northern Mammal Ecology, Centre of Northern Forest Ecosystem Research, Thunder Bay, Ontario. art.rodgers@ontario.ca

STEVENTON, DOUG, PERS. COMM. Research Wildlife Biologist, BC Ministry of Environment, Smithers. Doug.Steventon@gov.bc.ca

The following were contacted but were unable to provide direct assistance. Several recommended others who did provide information included in the report. Regardless, I thank them all for their assistance and feedback.

ELLIOTT, JOHN, PERS. COMM. Research Scientist, Ecopathology, Canadian Wildlife Service, Delta, BC. john.elliott@ec.gc.ca

MURRAY, DENNIS, PERS. COMM. Canada Research Chair in Terrestrial Ecology & Associate Professor, Trent University, Peterborough, Ontario. dennis.murray@trentu.ca

RITCHIE, CHRIS, PERS. COMM. Mountain Pine Beetle Response Manager, Prince George, BC. Chris.Ritchie@gov.bc.ca

EDIE, ALAN, PERS. COMM. Consultant, Smithers, BC.

HATTER, IAN, PERS. COMM. Manager, Wildlife Management Section, Fish and Wildlife, Wildlife Management Section, Victoria, BC. Ian.Hatter@gov.bc.ca

APPENDIX 1

Key of willows found in the CATT, August 2009

Salix alaxensis (Andersson) Coville spp. ***alaxensis*** -- Felt-leaf Willow  	-- A robust shrub up to 10 m tall. Also known as “felt-leaf willow”. Underside of leaves are densely felty contrasting to greenish upperside. It appears that there are two sub species found in Yukon: spp *alaxensis* on which the branchlets are densely covered with white-yellow wooly hairs and leaf petioles are often swollen, and spp. *Longistylis* on which the branchlets are coated with a fine white waxy powder. -- Moose are very fond of felt-leaf willows. -- Felt-leaf willow is a favorite for riverbanks restoration because it roots readily from cuttings. -- **Habitat**: forms dense stands on gravel bars of fast- flowing rivers (Quill Creek south of Haines Junction), and in association with other willows in wetlands, alpine meadows and young forests.
Salix arbusculoides Andersson -- Little-tree Willow	-- A shrub or small tree 1 – 6 m tall. Branches are thin, flexible. Leaves are long and narrow (3 to 6 times longer than wide). Leaves have short white or reddish hairs oriented towards the leaf tip. Leaf margins are finely toothed. -- Moose browse this willow. -- This species is recommended for revegetation projects using the dormant cuttings method.

	-- **Habitat**: stream banks and lakeshores, openings in boreal forest, muskegs, treed bogs, and sedge fens.
Salix bebbiana Sarg. -- Bebb's Willow  	-- Upright shrub or tree to 10 m tall. Many-branched from the base, lateral branches often inserted at right angles to the stem; upper surface of leaves indented with impressed veins (look quilted), underside whitish, long wavy hairs on both surfaces; stipules fall of during summer. -- Browsed by moose. Shrubs become scraggly-knotty looking. -- New leaves on browsed branches can be very large with little likeness to usual canopy leaves. -- **Habitat**: riparian and upland white spruce forests, wet lowland thickets, prairie margins, dry south-facing slopes, disturbed areas.
Salix lanata L. spp**. richardsonii** (Hook.) Skvortsov	-- Shrub 0.5 to 4.0 m or more high; branches reddish brown, pubescent; branchlets densely white-lanate. -- Leaves eleptic; upper and lower surface glaucous; stipules often large, linear to ovate, glandular serrulate to irregularly toothed. -- **Habitat**: gravelly lakeshores and

 	riverbanks, wet meadows, and in thickets on mountain slopes.
Salix glauca L. -- Gray-leaf Willow  	-- Shrub 0.3 – 6 m tall. Stem bark with translucent layer often peeling off; branchlets hairy; leaf upper surface dark green while underside is densely white hairy; leaf tip more or less pointed; margins smooth; yellowish petiole 2 -15 mm long; male catkin remains on stem. *Salix glauca* is highly variable. Three varieties are recognized in North America. Relevant to the CATT are *S. glauca* var. *acutifolia*, var. *stipulata* and var. *villosa*. (Refer to the George W. Angus guide dated June 2000.) -- Winter cuttings do not root well, not recommended for revegetation projects. -- Used moderately by moose in some areas (Reisenhoover 1989) and avoided in others (Foote 1983) -- **Habitat**: river floodplains and terraces, alpine tundra, edge of

	boreal forest, disturbed sites.
Salix planifolia Pursh spp. ***planifolia*** -- Tea-leaf Willow, Plane-leaf willow  	-- Low to tall shrubs 0.15 – 3 m tall, erect or decumbent. Branches flexible at base. Branchlets yellow-brown, red-brown, or dark brownish. Leaves narrowly oblong (more than three times long as wide). *Salix planifolia* spp. *Pulchra* var. *pulchra* leaves frequently marescent; linear stipules 3-15 mm or more long, often persisting 2-4 years. *Salix planifolia* spp. *pulchra* var. *yukonensis* differning from var. *pulchra* in having branches glabrescent with patches of indumentums; branchlets usually densely white-gray villous; mature leaves usually pubescent on midrib; petioles persistently villous-tomentose. -- **Habitat**: willow-dwarf birch thickets in fens and lake/stream edges, treed bogs, openings in white spruce forests.
Salix pseudomonticola C.R.Ball -- Park Willow, False Mountain Willow 	-- Upright shrub 1 – 6 m tall; branches dark reddish brown to yellow-brown, glossy; young leaves reddish, mature leaves green above and pale beneath, hairs white or rust coloured; leaves rounded at base, pointed at tip, margin finely toothed. Catkins appear before leaves. -- **Habitat**: thicket-forming on alluvial riverbanks, floodplains, spruce muskegs and poplar forests.

	
Salix pseudomyrsinites Andersson -- Tall Blueberry Willow  	-- Erect shrub 0.6 – 7 m tall; branches flexible at base, grayish brown to dark reddish brown, glaborate; branchlets yellow-brown or yellow-green usually densely white-villous, becoming sparsely pubescent or glaborous. Leaves widest in last third of length, narrower at base and tip, margins not smooth; immature leaves reddish and villous; upper midrib pubescent with white or rusty hairs; lower side glossy and pale green. Catkins appear with leaves on leafy branchlets. -- **Habitat**: in thickets on shores of lakes and streams, wetlands, muskegs, fens, marl bogs, dwarf birch thickets and prairie margins. Is often an early successional species on rivers.

Salix pulchra Cham. – Diamond-leaf Willow  	-- Low to tall shrub 1 – 4.5 m tall. Branches flexible at base. Branchlets brownish. Stems glossy. Leaves diamond shaped, tip pointed, margins smooth, hairless, shiny green above, pale green to whitish below. *Salix pulchra* var. *yukonensis* C.K. Schneider characterized by densely hairy stems. -- A main source of moose browse where found. -- Recommended for revegetation projects using dormant cuttings method. -- **Habitat**: sub-alpine thickets, forms more or less dense thickets with other willows in wetlands bordering lakes and rivers and in moist sites above treeline.
Salix scouleriana Barratt ex Hook. – Scouler's Willow, Mountain Willow 	-- Tall shrub or small tree to 20 m tall, several trunks up to 60 cm in diameter. Branches flexible at base, dark reddish brown to yellow-brown, glossy, pubescent. Branchlets yellow-green to yellow-brown, densely pubescent. Leaves large to 8 cm long, smooth margins; narrow at base, widest about one third of length from tip, narrowing to tip; young leaves covered with white straight hair that sheds on mature leaves revealing short flat white or reddish- brown hair on the underside. Catkins are short and among first to develop in spring; shed early after seed dispersal. -- Winter cuttings do not root well and are not recommended for

	revegetation projects. -- "Moose are fond of lush *S. scouleriana* suckers. Moose feed on foliage and strip bark in winter (Weixelman et. Al. 1998). Post-fire upland habitats recolonized by abundant fast growing shoots of the "fire willow" *S. scouleriana*, support the highest densities of moose in Alaska." (Dominique M. Collet 2004.) -- **Habitat**: well-drained not too densely wooded slopes or riverbanks. Colonizes disturbed and burned habitat. Isolated individuals survive longer in maturing forest. Very common at forest margins and along roadways. Fairly ubiquitous.

Other non-willow species, which were referenced as being used as forage by moose, included *Populus tremuloides* Michx. (trembling aspen), *Cornus stolonifera* Michx. (red-osier dogwood), and *Betula* spp. In Yukon aspen and varieties of birch are ubiquitous while the dogwood is rare if found in the southwest. Of these three, the dogwood roots well from cuttings and can be grown from seed with relative ease. It is the most preferred by moose of the three species. Aspen and birch rebound well from root suckers (aspen) and root collar buds (birch – all species) following fire and mechanical disturbance.

APPENDIX 2

Plot data on willow and buffaloberry collected from 11 plots in four habitat types in the CATT, September 2009.

DATE:	29-09-09	<u>LOCALE:</u> 1st cut block, Marshall Creek					
CO-ORDINATES:							
60° 50.275' N		137° 21.000' W					
SLOPE:	5%	ASPECT:	SSE				
CREW:	DW,MO,LL,OB ,ML	TIME:	9:35 AM				
PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00001	E	< 2	9	1.05	~ 2	20	0.53
	N	<1	7	*1.8	<1	5	0.49
				1.4			
	W	2	32	*1.44	<1	7	0.53
				~1.15			
	S	4	60	3.9	<1	12	0.83
				0.95			
				0.42			

* identified as *S. arbusculoides*, ~ identified as *S. bebbiana*. There were many young *Populus tremuloides* in the plot. The cut block was planted to *Picea glauca* in July of 1996.

DATE:	29-09-09	LOCALE: Burn adjacent to 1st Marshall Creek cut block					
CO-ORDINATES:							
60^{o} 50.151' N		137^{o} 20.743' W					
SLOPE:	5%	ASPECT:	SSW				
CREW:	DW,MO,LL,OB ,ML	TIME:	11:15 AM				
PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00002	E	10	147	2.10	<1	15	0.88
				1.26			
	S	40	1322	1.88	<1	22	0.70
				0.38			
	W	25	809	1.45	<1	24	0.68
				0.40			
	N	~3	74	1.42	<1	17	0.89
				0.65			

Greatest number of *salix* in sub-plot E were below browse height in the 0.38 metre height cohort. This also put them below the upper surface of much of the dead fall and fire kill trees.

DATE:	29-09-09	<u>LOCALE:</u> Natural forest adjacent to Marshall Creek cut block.

CO-ORDINATES:	
60^{o} 50.302' N	137^{o} 20.740' W

SLOPE:	0%-10%	ASPECT:	Varied

CREW:	DW,MO,LL,OB ,ML	TIME:	9:35 AM

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00003	E	0	0	0	<1	6	0.27
	S	<1	1	4.37	<1	1	0.38
	W	0	0	0	<1	8	0.5
	N	0	0	0	<1	14	0.47

The single willow found in the plot was into the tree canopy. Other large willow in the area exhibited the same tall growth. There were no willow seedlings seen under this mature spruce forest canopy. The plot was located on a series of small esker-like serpentine ridges.

DATE:	29-09-09	LOCALE: Small eastern most cut block and Marshall Creek wildfire.

CO-ORDINATES:	
60° 51.186' N	137° 20.419' W

SLOPE:	2%	ASPECT:	SSE

CREW:	DW,MO,LL,OB ,ML	TIME:	

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00004	N	2	270	0.50	0	0	0.00
	E	5	55	0.89	<1	2	0.46
	S	7	420	1.01	<1	2	0.86
	W	3	71	0.33	<1	1	0.41
				1.42			

This area was harvested as part of the original program. It was planted to white spruce in 1996. The area was subsequently burned by a wildfire that started on the power line east of Marshall Creek. The planted spruce were totally destroyed in this area. Windthrow of fire-killed stems has occurred. In-fill by *Picea glauca, Salix* spp., *Sheperdia canadensis, Arctostaphylos uva-ursi,* a variety of native grasses and forbs has occurred since. The area is presently being harvested for fuel-wood.

DATE:	29-09-09	<u>LOCALE:</u> Native forest west of plot 00004

CO-ORDINATES:	
60° 51.128' N	137° 20.676' W

SLOPE:	2%	ASPECT:	S

CREW:	DW,MO,LL,OB ,ML	TIME:	3:37 PM

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00005	N	<1	6	4.82	0	0	0
				0.23			
	E	<1	1	0.98	<1	8	0.38
	S	<1	1	0.98	<1	7	0.30
	W	<1	9	10.00	0	0	0
				0.03			

This control plot was removed form the disturbance plot by several hundred metres due to deadfall and the encroachment of the fire in the area. The surrounding clearing and burn areas are being actively harvested for fuel-wood. The plot appears to have been put into one of the plots established as part of the spruce beetle (*Dendroctonus rufipennis*) studies conducted by Forestry Canada.

DATE:	30-09-09	LOCALE: Quill Creek riparian/flood channel south of Haines Junction.

CO-ORDINATES:	
60° 41.494' N	137° 20.681' W

SLOPE:	1%	ASPECT:	S

CREW:	DW,LL,OB,ML	TIME:	9:35 AM

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00006	W	5	14	1.50	2	26	0.80
	S	10	38	1.95	0	0	0.00
	E	30	142	1.03	1	24	0.75
	N	8	18	1.83	2	31	0.52

This area is browsed by moose. The main species of willow found was *Salix alaxensis*. The site shows evidence of ice scouring which has damaged some willow and stimulated sprouting of new twigs. The site is adjacent to the access road leading into the present harvest sites.

DATE:	30-09-09	LOCALE: Bench above Quill Creek north of the access road.

CO-ORDINATES:	
60° 41.526' N	137° 20.806' W

SLOPE:	undulating	ASPECT:	E

CREW:	DW,LL,OB,ML	TIME:	

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00007	E	7	25	4.70	60	238	0.80
				2.39			
	N	4	14	10.00	5	130	0.60
	W	3	8	8.20	15	190	0.70
	S	2	9	6.80	60	282	1.10

There was minimal evidence of browsing in this control plot. The area has large aspen and large spruce beetle killed spruce. Of note is sub-plot S where a third of the *Sheperdia canadensis* retained berries. These were the first shrubs that had any evidence of fruit observed in the plots.

DATE:	30-09-09	LOCALE: Dakwa-Kada cut block west of Pine Lake

CO-ORDINATES:		
60^o 49.624' N		137^o 32.912' W

SLOPE:	2%	ASPECT:	N

CREW:	DW,LL,OB, ML	TIME:	

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00008	N	12	61	3.80	0	0	0.00
				1.60			
	W	2	37	1.32	<1	5	0.35
	S	2	50	2.00	<1	2	0.40
				0.80			
	E	1	15	1.20	0	0	0.00

This plot was located in one of the smaller openings created in the harvest program west of Pine Lake. Some browsing was observed.

DATE:	30-09-09	LOCALE: Native forest adjacent to the opening in which plot 00008 is located.

CO-ORDINATES:	
$60^{o}49.619'$ N	137^{o} $32.799'$ W

SLOPE:	2%	ASPECT:	N

CREW:	DW,LL,OB, ML	TIME:	

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00009	E	2	222	0.50	<1	1	0.35
	N	<1	4	0.20	<1	1	0.20
	W	<1	7	3.50	<1	1	0.27
				0.10			
	S	<1	243	1.75	<1	4	0.40
				0.10			

Dense thickets of spruce interspersed with small openings characterize this patch of native forest. The spruce beetle had attacked few of the white spruce at the time of plot establishment. The two large willow recorded may have been *S. pulcra*. The low willow remains unidentified.

DATE:	30-09-09	LOCALE: McIntosh Creek wildfire: creek valley below an escarpment.

CO-ORDINATES:	
60° 49.111' N	137° 40.237' W

SLOPE:	5%	ASPECT:	S

CREW:	DW, LL,OB, ML	TIME:	

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00010	W	3	20	11.30	0	0	0.00
				1.00			
	S	<1	14	1.45	0	0	0.00
	N	2	83	1.53	0	0	0.00
	E	<1	11	1.60	<1	1	0.75

Access to the plot was made following an trail from near McIntosh Lodge and a cat trail (fire access) to the escarpment edge. Huge aspen and very large spruce beetle and fire killed white spruce were found in the plot. A small water creek flowed through the plot. High bush cranberry were plentiful and had been browsed but species uncertain. Large alder were more common than willow.

DATE:	30-09-09	LOCALE: Native forest on the escarpment above McIntosh Creek, north of the cat trail.

CO-ORDINATES:	
60° 49.121' N	137° 40.070' W

SLOPE:	1%	ASPECT:	W

CREW:	DW,LL,OB, ML	TIME:	4:15:00 PM

PLOT	SUB-PLOT	ALL WILLOWS			*Sheperdia canadensis*		
		% COVER	#	HT (m) median	% COVER	#	HT (m) median
00011	E	<1	17	4.00	0	0	0.00
				1.75			
	N	~2	12	1.70	<1	13	1.75
	W	<1	4	10.00	0	0	0.00
	S	2	8	6.00	0	0	0.00

This plot had patches of dense thickets mixed with small openings. It had been hit with chemical fire retardant (trees remain stained). There was limited deadfall.

APPENDIX 3

Checklists: For Moose Forage Enhancement Options

Prescribed Fire Checklist

1. Determine the objective of the prescribed burn:

    - provide a large scale map of the area to be burned,
    - describe the vegetation and debris to be burned,
    - state whether the ground surface fuels or aerial fuels are to be targeted,
    - describe the desired results of the burn (amount of exposed mineral soil, percent of surface vegetation to be removed or killed, etc.),
    - suggest the season or time of year for the burning to take place.

2. Following normal policy procedures for prescribed fire,

    - provide a map of the location of control points and back up locations,
    - develop the prescription in consultation with wildlife managers,
    - present the plan to representatives of the first nations government and cooperating departments to review,
    - present the plan to the public through public forums and the media,
    - be prepared to modify the plan as urged or requested by the public for reasons of smoke, potential for the loss of property, etc., and
    - prepare YESSA document for screening.

3. Set target date(s) and project suspension date,

    - target dates will be based on weather norms that would achieve the desired results of the agreed to prescription,
    - the suspension date will be that date by which the fire needs to have been ignited in order for the desired results to be achieved while leaving Fire Management the leeway necessary to meet it's main obligations of protection,
    - suspension may be for a season (for example, spring to fall) or until the following year.

4. Communication and education planning must be a part of the process to ensure that the public is properly and continually informed until the operation is complete.

5. Monitoring plans for pre-burn, burn, and post-burn periods are required. Monitoring is necessary to be able to learn properly from the activity.

- photographic documentation is essential in all phases,
- video documentation is necessary during the burn phase,
- properly positioned sensors should be mandatory,
- public observers from the first nation and the general populace should be present to observe and provide "gut feel" feed back on any operation but especially on larger projects or projects near communities.

Machine Clearing Or Crushing Operations Checklist

1. Plan six to eight months in advance at the minimum.

2. Determine the size of equipment required for the operation and its support,

- use the minimum sized equipment needed to achieve the desired results,
- remember the need for support equipment, fuel, staging site(s) and so on.

3. Obtain a Land Use Permit,

- Land Use Regulations, permit requirements and application forms are available through the Yukon Government web site,
- support may be obtained by phone or in person at the Land Use office.

4. The land use permit application requires a map of the operation site,

- boundaries of the operation will need to be flagged, marked or electronically located to ensure the operation does not trespass,
- minimum distances from stream edges, high water marks, sensitive areas and so on are required to be maintained,
- using existing accesses is preferred,
- seasonal shut-downs may be enforced.

5. The program will be subject to a YESSA review with the potential of restrictions being enforced on the project.

6. When contracting out work select operators with experience in the climate that they will be working in,

- design contracts to be area based, that is price per hectare completed not hours worked.

- include time out delays for weather, equipment failure, and personnel,

- require on-site spares (hydraulic hoses, couplings, etc. that break or fail frequently in cold weather).

7. Be aware of the potential increase to costs incurred with extreme cold, deep snow, poor choice in equipment or equipment type, and possible need for repairing any excessive environmental disturbance.

8. Plan to use heavy equipment after the ground has frozen sufficiently to support the equipment if work is to be conducted in sensitive areas.

9. Where "hinging" is the desired result operations must be conducted in frost free periods (late fall) but care to limit soil compaction needs to be exercised.

10. Hand tool operations, often seen as being more environmentally acceptable and socially supportable, may not require a land use permit but they may still be required to be YESSA reviewed,

- tend to be "make work" projects,

- have the potential to configure smaller programs and environmentally sensitive sites,

Silvicultural Treatments Checklist

1. Communicate with staff of the Forest Management Branch.
2. Become familiar with the policies and manuals of the branch.
3. Accompany forestry staff on planning and layout field trips,

- learn first hand what is growing in the areas being selected for harvest,
- determine forage species present,
- note the condition of shrubs,
- assess forage options.

4. Coordinate forage development options with forestry staff when they are developing post-harvest silviculture plans.
5. Develop post-harvest monitoring strategies.

Revegetation And Planting Options Checklist

1. Determine species to be used.

2. Prepare contract(s) for seed and scion collection, seedling or cutting production, and seeding or planting on a piece-unit basis.

3. Collect seed or scion material in season.

4. Prepare contract for site preparation, if required, in conjunction with Forest Management staff.

5. Prepare contract for hand or machine seeding.

6. Prepare contract for planting in conjunction with forestry staff especially if there is to be a conflict with timing of planting programs.

7. Planting of callused cuttings will be different from planting rooted cutting or willow seedlings which should be reflected in the wording of the contract(s), price per unit planted and expected results.

8. Guidelines will need to be developed to obtain highest survival rates possible in rooted and not-rooted cuttings.

9. Planting assessment procedures (similar to Establishment and Free-to-Grow surveys) need to be developed to monitor success or failure of programs or species.