Forests for Tomorrow Adaptive Management Initiative

Synthesis of Information on Selected Topics & Clarification of Key Uncertainties

EXCERPT:

Managing Snowshoe Hare Damage

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Managing Snowshoe Hare Damage

The Forests for Tomorrow (FFT) program was established by the BC Government in 2005 in response to the devastating impact of major fires and the mountain pine beetle (MPB) epidemic on the forest land base of the Province. The program is aimed at improving the future timber supply and protecting other forest values through the re-establishment of young forests on lands that would otherwise remain underproductive.

The mountain pine beetle epidemic had affected over 10 million hectares of forest land by 2008 and is expected to expand further. This loss in forest cover is unprecedented in both scale and complexity. Many forest types have been affected across a range of ecological conditions from the dry Chilcotin to moist sub-boreal and high elevation zones. These twin factors of scale and complexity have, in turn, created numerous uncertainties for forest managers. Adaptive management strategies have been proposed as one approach for dealing with these uncertainties.

An adaptive management workshop held on June 26, 2008 under the FFT program for key staff engaged in restoring forest cover to the mountain pine beetle area raised a range of uncertainties or questions from participants. This is one of the topics for which our team was asked to review and summarize information in the existing literature.

Executive Summary

Snowshoe hare (*Lepus americanus*) damage seedlings by clipping the leader and lateral shoots. As well, they gnaw bark in small patches near the base of the stem or on the lower branches. Feeding damage may occur higher on the tree in deep snow years. Smaller seedlings are highly susceptible to mortality from clipping at the root collar. Larger seedlings, sapling and young trees suffer deformity, reduced growth rate, and occasional mortality from girdling. Feeding damage may: limit regeneration of appropriate tree species in certain forest ecosystems; increase cost of achieving Free Growing Status; decrease net productive forested area; and, result in loss of mean annual increment.

Northern populations of snowshoe hares undergo cycles that range typically 9 to 11 years between population peaks, but populations in different geographic areas of BC seem to be at quite different levels (Quesnel higher than Prince George, for example).

Snowshoe hares require dense, brushy, usually coniferous cover for thermal and escape cover. Heavy cover 3 m above ground provides protection from avian predators, and heavy cover 1 m tall provides cover from terrestrial predators. A wide variety of habitat types are used if cover is available. In northern regions snowshoe hares occupy conifer and mixed forests in all stages of succession, but early successional (<30 years old) forests foster peak abundance. Dense conifer understories support higher hare densities than hardwood understories because the former provide superior thermal and hiding cover. However, broadleaf cover is important to snowshoe hares in some areas.

The quantity of hare browse is linked to both the number of hares using the area, and to the percentage of available cover (>0.5m high), with increasing browse as cover increases. Sometimes even at low populations, hares can focus on fertilized seedlings (which are highly preferred forage) and seriously damage new plantations.

Potential solutions for reducing damage by hares:

1) Identifying problem areas and times: Gain knowledge of how extensive and severe attacks are expected to be. Of most concern are areas of high hare numbers at times when populations are increasing or peaking.

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2) In areas of high hare numbers and peaking hare cycles clearcutting may be the best option. Delay underplanting until numbers drop, and time plantation establishment to occur during the low phase of the snowshoe hare population cycle.

3) Where populations are lower, and damage less severe or extensive, then there is more opportunity for underplanting dead pine stands, perhaps in combinations with some of the tools noted below.

Methods to reduce hare damage range from mechanical barriers, scent repellents, alternate food sources, and stand treatments to decrease the attractiveness of the stand to hares. Scent applications are not usually successful operationally, and mechanical barriers have a number of challenges (snow press, poor seedling form, clipping along edges of protector). Alternate food sources have been used successfully and are being tried experimentally in Prince George. Habitat management by removal of overstory and/or understory cover may be the best option. While thinning can reduce overhead cover it can also encourage denser growth of shrubs thus improving hare habitat, so subsequent brushing may be necessary. Other tools include using larger planting stock with a reduced fertilizer regime, and selection of tree species based on snowshoe hare preferences (*Abies*, Douglas-fir, hemlock and sometimes spruce seem less preferred than lodgepole pine). Ongoing local studies by Doyle, Deanna and Ransome should be followed closely.

The Issue

Snowshoe hare (*Lepus americanus* L.) damage seedlings by clipping the leader and lateral shoots. As well, they gnaw bark in small patches near the base of the stem or on the lower branches. Feeding damage may occur higher in deep snow years. The stem of trees less than 60 mm diameter at the root collar is occasionally girdled. Smaller seedlings are highly susceptible to mortality from clipping at the root collar. Larger seedlings suffer deformity, reduced growth rate, and occasional mortality from girdling. High-risk stands occur in areas near clearcuts with young seedlings, and high-density, second growth, pole-size lodgepole pine (*Pinus contorta)* stands with a dense brushy understory. Newly planted seedlings or trees that have recently been fertilized are most attractive. In terms of conservation and sustainability of temperate forests, feeding damage may: limit survival and growth of appropriate tree species in certain forest ecosystems; add costs to reforest these stands in time for Free Growing Status; decrease net productive forested area; and, result in loss of mean annual increment. There is more specific concern that in MPB-killed stands in the Northern Interior Forest Region (NIFR) underplanted seedlings may experience significant damage from snowshoe hares and this will limit the ability to re-establish forest cover quickly.

Young lodgepole pine that are not covered by snow are very susceptible to damage. Most damage occurs within several years of planting and follows a very regular 9 to 11-year population cycle. Ellsworth (2008) reported hares preferred lodgepole pine branches over all other conifers in the winter. In his trials, lodgepole pine was the most nutritious conifer, and it had the highest protein and energy content of all the species tested. In fact, hare consumption of browse in the field and in the laboratory directly reflected the amount of protein contained in the plant species. The two species with the lowest protein and energy values, hemlock and grand fir, were almost entirely avoided in the field, and in the lab they would only resort to feeding on these species when they had consumed all other browse species. It is possible hares can change the course of succession by altering stand composition.

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Basic Biology

Northern populations of snowshoe hares undergo cycles that range from 7 to 17 years between population peaks Sullivan (1995). The average time between peaks is approximately 10 years but ranges between 9 and 11 years (Keith 1963, 1990 in Sullivan 1995). The period of abundance usually lasts for 2 to 5 years followed by a population decline to lower numbers or local scarcity. Concentrations of abundance tend to be scattered. Populations across North America do not peak simultaneously in all areas, although there is a great deal of synchronicity in northern latitudes. From 1931 to 1948 the cycle was synchronized within 1 or 2 years over most of Canada and Alaska, despite differences in predators and food supplies. The next anticipated peak in abundance of hares is 2009-2011.

Snowshoe hares utilize different areas of their home range at different times of the year in relation to food availability Watson et al. (1999). Hares switch from a diet of mainly woody browse during the winter to a diet of forbs, grasses, and leaves during the summer. They are adapted to feed within a small vertical band of vegetation 0-1.5 m high. During the winter, as snow accumulates, snowshoe hares utilize higher branches of trees and shrubs. After many years of heavy and consistent browsing, a browse line becomes established below which edible twigs no longer grow. Snowshoe hares seldom, if ever, dig in the snow for food.

Snowshoe hares require dense, brushy, usually coniferous cover. Thermal and escape cover (both provided by low vegetation) are important, especially for young snowshoe hares. Heavy cover 3 m above ground provides protection from avian predators, and heavy cover 1 m tall provides cover from terrestrial predators. Overwinter survival of snowshoe hares increases with increased cover. Visibility in good snowshoe hare habitat ranges from 2 percent at 5 m distance to 0 percent at 20 m. Travel cover is slightly more open, ranging from 14.7 percent visibility at 5 m to 2.6 percent at 20 m Sullivan (1995).

A wide variety of habitat types are used if cover is available. In northern regions snowshoe hares occupy conifer and mixed forests in all stages of succession, but early successional forests foster peak abundance. Dense conifer understories support higher hare densities than broadleaf understories because the former provide superior thermal and hiding cover (Watson et al. 1999). However, broadleaf cover is important to snowshoe hares in some areas. Dense stands of immature hardwoods were the preferred habitat of snowshoe hares in Alberta (Watson et al. 1999). In Alberta, the highest densities of hares during a low population period were in thickets of small black spruce and alder at the edges of bogs, in patches of beaked hazel, and in areas of dense trembling aspen and willow in all seasons (Watson et al. 1999). In mixedwood forests in Alberta, snowshoe hares were in young broadleaf dominated stands consisting of trees less than 20 cm diameter at breast height (DBH at 1.3 m), with high grass cover (during summer only) and high shrub/sapling and willow densities throughout the year. The pattern of habitat use by snowshoe hares is based primarily on understory density not on species composition (Watson et al. 1999), however, species composition may influence population density.

Effects of Forestry Practices

Several studies have examined impacts of forestry treatments on hare populations and on damage to crop trees. We note only those conducted in BC or close to BC.

Thinning of the overstory has been reported to both increase and decrease hare numbers. Ausband and Baty (2005) assessed snowshoe hare habitat use during winter on two precommercial thinning treatments in sapling stands (approximately 18 years old) in

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northwestern Montana. One treatment type retained 0.2-ha patches of unthinned saplings, representing 8% of the total stand area, and the second retained 0.8-ha patches of unthinned saplings, representing 35% of the stand area. Snowshoe hare habitat use was also estimated within a nearby control sapling stand and mature conifer stands. Snow tracking and fecal pellet counts were used to estimate hare use before and after thinning treatments were applied. There was no conclusive trend in hare use of sapling stands after thinning, but use within the control stand and adjacent mature stands suggested there was considerable movement of hares to nearby untreated stands after thinning. Hares used retention patches regardless of size, even though large retention patches were four times larger than small retention patches. Because hares demonstrated an affinity for dense patches of residual forest, any retention of untreated saplings may be beneficial for hares during winter (and potentially damaging to susceptible crop seedlings and saplings). Hare use within thinned portions of the stand and unthinned remnant blocks suggests that over the winter hares may also benefit from a connectivity of dense cover. Results from other studies also suggest connectivity of dense cover may benefit hares (Ausband and Baty 2005).

Sullivan and Sullivan (1988), in a study located near Prince George BC, noted that population density and recruitment of snowshoe hares increased significantly in thinned stands of lodgepole pine during the first winter but declined thereafter. Their study focused on lodgepole pine stands (mixed with broadleaves and spruce) that started with stocking of 30000 to 40000 stems per ha and were spaced to 2300 stems in 1979. Grids of live traps and plots to monitor damage to crop trees were set up and monitored from March 1979 to November 1983. Trees were on average 540 cm tall. The study took place in the late stages of the hare abundance cycle when populations were high. After thinning, hare abundance on the treatments increased while those on controls decreased, presumably due to hares being attracted to increased food and cover provided by fallen pine stems. The peak only lasted a year or two before both thinned and control abundances began to decline. Crop tree damage increased in the controls from 35% in 1979 to 57% in 1980 and 69% in 1981, then decreased in 1982 and dropped again in 1983 to 23%. In the thinned stands crop tree damage decreased to 3% when hares were using the fallen pine as forage and cover, but jumped to 75% over the winter of 1980-81 when that food source dried up. After that, damage reduced to 18% due to declining hare populations and deep snow in the thinned stand. Further decreases to 14 percent occurred in the last year of study. Thinning overstocked lodgepole pine had little or no effect on reproduction or survival of snowshoe hares but reduced average body weights. Note that Sullivan and Sullivan (1988) did not include replicates of sampling grids, so their results are not as conclusive as they could be. The increased damage coincided with the increase, peak and decline phases of hare cycle. Supplemental food does not seems to stop the cyclic hare decline, so alternate food sources could be used as means of deflecting hare damage from crop trees. Sullivan et al. (2006) report results of a long term study on effects of thinning and fertilization on hare populations that confirm the trends in earlier studies. Hares benefit from fertilized stands and dense stands, with peak densities in unthinned stands or stands thinned to only 2000 stems. Stands thinned to 100, 500 and 250 stems had lower hare numbers (fertilization did not improve habitat significantly). In another study Sullivan (1994) noted that in areas dominated by conifers, herbicide treatment also did not reduce cover or forage to an extent that affected hare populations.

In a study dealing directly with underplanting and showshoe hare, Doyle (2007) assessed the effects of removal of cover on hare damage. The study took place in the Skeena-Stikine and Kalum Forest Districts where approximately 40,000 ha of lodgepole pine plantations had been attacked to varying degrees by *Dothistroma*, resulting in a high loss and/or severe reduction in the growth of the young trees in close to 10% of that area. Subsequent underplanting of

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different species within the most severely impacted stands has resulted in very high loss of these seedlings as a result of browsing, with the snowshoe hare believed to be the main species damaging the seedlings. In addition to the pine, other commercial tree species (planted and natural regeneration) are also present in the plantations.

Rather than clearcutting the entire plantation, selective pine removal trials were established to determine if the removal of these trees alone would result in higher survival of underplanted seedling trees, and to determine if, or when, the rate of browsing damage decreased in relation to the distance to a non-harvested edge. The MoF established trials (removal of various amounts of dead and dying pine) in four separate locations, to establish if the removal of cover and forage plants for potential browsers, would result in an increase in the survival of under planted seedlings. Three seedlings species were planted in 2006; sub-alpine fir, western hemlock and interior spruce, and the study looked both at the impact of cover and distance to edge on the rates of browsing damage to these seedlings.

To confirm that hares were the main species browsing the seedling trees, seedlings were examined to identify species specific browsing attributes. In addition, fecal pellet quadrats were established to identify the species and relative density of herbivores using the trial areas. Vegetation type, percentage coverage and distance from forested cover were also measured to establish if these impacted the level of browsing on the seedlings. After the first year of monitoring, 35% of all seedlings were browsed throughout the trial areas (cleared and adjacent control areas combined). On three of the four trial sites most of the browsing was done by hares, while at a fourth site cattle were responsible. Browsing damage impacted ~90% of all seedling spruce under planted within the un-cleared (control) *Dothistroma* impacted stand, and approximately 40% of all hemlock, and 30% of all the sub-alpine fir. Hares preferentially browsed spruce, while cattle were the main species damaging (browsing and/or trampling) the fir. Overall, 35% of all seedlings (962) planted were damaged by browsing, with spruce approximately three times as likely to be browsed by hares (42%), than western hemlock (14%) or sub-alpine fir (8%) seedlings. Cattle primarily damaged sub-alpine fir with 27% of all seedlings damaged, followed by 8 % of spruce seedlings.)

Clearing of the dying/dead *Dothistroma* trees significantly reduced browsing damage by >50%, in all areas except where the cattle were present. In addition, the probability of browsing declined with distance from cover. At the site with cattle the probability of browse/trampling damage increased the further the seedling was from the uncleared forest edge. Within cleared areas the quantity of hare browse was significantly linked to both the number of hares using the area, and to the percentage of available cover (>0.5m high), with increasing browse as cover increased.

Importance of Hares

Although snowshoes hare forage on conifers during winter, they are valuable components of the ecosystem. Hare are relied upon by many species as a source of food. Great horned owls (*Bubo virginianus*), coyotes (*Canis latrans*), fishers (*Martes pennanti*), and Canada lynx (*Lynx canadensis*) are just a few of the species that prey heavily upon hares. In particular, the Canada lynx, which is federally listed in the United States as a threatened species, preys almost exclusively on snowshoe hares, and lynx populations can be negatively affected by decreases in the hare population (Ausband and Baty 2005). Forest management practices and, in particular, precommercial thinning treatments in coniferous sapling stands and subsequent effects on snowshoe hare abundance have been a recent area of concern since the listing of the lynx.

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Only thinning below 2000 (or maybe even 1000) stems per ha seem to reduce habitat quality for hare for any significant period of time (Sullivan et al. 2006/07).

Potential Solutions – Reducing Damage by Hares

1) Identifying problem areas and times: The first step in managing hares is to gain knowledge of how extensive and severe attacks are expected to be. Two factors govern the level of expected attack: hare populations, and stand condition. At high population and in stands with good cover, underplanting is not recommended, unless various techniques to protect seedlings are employed. At low populations and low cover, underplanting is more likely successful. At intermediate condition (moderate populations, or suboptimal habitats, then underplanting could be considered, but again one or more of the techniques below would need to be implemented to help improve conifer survival. The effectiveness of different tools, at various times of the hare cycle, remains uncertain and should be addressed by applied research/adaptive management.

2) Reducing seedling damage: Reducing or eliminating seedling destruction by hares is a prerequisite to successful forest renewal in many forests at various periods. Solutions to hare damage range from mechanical barriers and scent repellents to alternate food sources and stand treatments to decrease the attractiveness of the stand to hares. Costs of these treatments depend on several factors, which should be explored while evaluating their utility.

Mechanical barriers: Zimmerling and Zimmerling (1998) examined the effectiveness of a mechanical barrier, a tubular, polyethylene/polypropylene mesh seedling protection device used to reduce overwinter feeding damage by snowshoe hares and meadow voles (*Microtus pennsylvanicus*) on spring planted, plug stock (1 + 0) lodgepole pine. Seedlings fitted with the seedling protection devices had significantly lower levels of feeding damage (3 and 9%) than control seedlings (25 and 41%) respectively on two study sites. Most of the feeding damage to treated seedlings was the clipping of the terminal leader or laterals that were not protected by the protection device. In two instances, a vole tunnelled under the seedling protection device to damage the stem of the treated seedling. This physical barrier can be effective in reducing feeding damage by small mammals on lodgepole pine.

Scent compounds: Certain mustelid scent compounds have suppressed feeding by snowshoe hares Sullivan and Crump (1984), presumably because of a predator-induced "fear response" in the prey species. Sullivan et al. (1985) reported that several predator odor preparations reduced feeding on coniferous tree seedlings by hares. Of the urines tested, red fox produced the most effective short-term suppression of feeding (Sullivan et al 1985).

Sullvan and Crump (1984) investigated the influence of the volatile constituents of red fox *(Vulpes vulpes)* urine in suppressing feeding by snowshoe hares on coniferous tree seedlings. Pen and field bioassays indicated that the odor of fox urine and its principal component, 3-methyl-3- butenyl methyl sulfide, had a negative effect on feeding behavior of hares. The other sulfur-containing compounds, 2-phenylethyl methyl sulfide and 3- methylbutyl methyl sulfide, as well as six other constituents, were not effective. Synthetic urine mixtures composed of eight and nine volatile constituents, respectively, did not suppress feeding in pen bioassays. Pen bioassays clearly demonstrated that 3-methyl-3-butenyl methyl sulphide was the functional compound responsible for altering hare feeding behavior.

Sullivan and Crump (1986) conducted spring field trials of red fox urine odours at Tabor Mountain, 25 km southeast of Prince George, B.C., during April to June 1984. The study area was in the Sub Boreal Spruce biogeoclimatic zone, overgrown with deciduous brush species, mainly willow *(Salix* spp.) and Sitka alder *(Alnus sinuata),* with some aspen *(Populus*

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tremuloides), black cottonwood *(P. trichocarpa),* and paper birch *(Betula papyrifera);* and had experienced coniferous plantation failure because of feeding damage by snowshoe hares. The hare population cycle peaked in this area in 1980-1981 but the peak was much more of a plateau than that described elsewhere. Although field results were not as outstanding as those obtained with certain mustelid scent-gland compounds Sullivan and Crump (1984), suppression of feeding in the presence of real urine and 3-methyl-3- butenyl methyl sulfide was still highly significant when compared with a control. This study and that of Sullivan and Crump (1984) demonstrated the potential of mammalian-predator semiochemicals for use as area repellents to protect forest and agricultural crops.

Habitat management: Control of snowshoe hares by habitat management basically involves removal of overstory and/or understory cover. Silvicultural practices can be modified to reduce snowshoe hare use of an area by reducing brushy areas that attract snowshoe hares. While thinning can reduce overhead cover it can also encourage denser growth of shrubs thus improving hare habitat (second-growth stands with dense brushy understories and high sapling densities are optimum snowshoe hare habitat). Hence the effectiveness of removing live or dead overstory to reduce hares will in part depend on the response of understory shrubs. Larger blocks of open areas may reduce hare damage since most damage is found at edges of openings close to cover.

Reduced intensity of feeding has been noted by Sullivan in "open" plantation habitats compared with overgrown habitat. In a habitat manipulation study, Sullivan and Moses (1986) reported a dramatically reduced abundance of hares in a scarified habitat, but the amount of feeding damage to planted coniferous trees was still unacceptable. Sullivan (1994) in the SBS documented that use of herbicide to remove vegetation may reduce forage and cover for a few years, but, particularly in areas with high proportion of young (25 year old) conifer trees, herbicides did not have significant impacts on numbers of hares.

In her review Sullivan (1995) noted that in aspen-birch stands reduction of coniferous cover in cutover areas reduces use by snowshoe hares. Snowshoe hare damage is probably reduced where slash and brush are disposed of by burning. In quaking aspen (*Populus tremuloides*) stands in Alberta, intensive regeneration and periodic removal of competing brush promotes fast early growth and reduces snowshoe hare damage.

Other solutions: Possibly the most pragmatic recommendations include timing conifer plantation establishment during the low phase of the snowshoe hare population cycle, using larger planting stock with a reduced fertilizer regime, and selection of tree species based on snowshoe hare preferences.

The possibility of raising Douglas-fir stock or non-fertilized pine that is less palatable to snowshoe hares has been discussed. Douglas-fir is browsed in some areas, but to a much lesser extent than pine. Spruce may be less palatable than Douglas-fir, but results seem to vary geographically (spruce have been heavily browsed in Smithers area, Doyle pers. comm.). Douglas-fir may be browsed by ungulates so deciding if it is the best alternative also depends on ungulate pressures in the area.

Supplemental food does not seem to stop cyclic hare decline, so alternate food sources could be used as means of deflecting hare damage from crop trees.

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Summary

Because hare populations are expected to peak in the next few years, underplanting may result in particularly low survival. Clearcutting may be the best option in areas of heavy attack. In areas where underplanting is desirable and some damage is expected but not prohibitive, potential solutions include planting trees that are less palatable to hares, or planting stock of palatable trees on sites with a sparse cover to support hares (Doyle 2007). As well, there is the possibility of removing various amounts of dead overstory to reduce cover for hares (provided a flush of shrubs is not expected in response). Protective barriers around trees or chemical deterrents may have to be considered as the only potential way to ensure planting success. Two studies that are underway should be followed closely to help guide the next few years of treatments. 1) Currently Hanna and Doyle have established tree shelter trials (in *Dothistroma* attacked pine stands) to determine if this prevents browsing. (See Danskin 2007). Sullivan (pers. comm.), however, reported that Plantskydd has not been effective. 2) As well, Ransome (Sullivan et al 2006/07; Ransome and Sullivan 2007/08) is examining the effectiveness of removing shrub cover to reduce hare damage. Ransome's proposed study is outlined in Appendix 1. There will also likely be work soon to explore effects of removing dead pine overstory on hare numbers and damage.

This seems an opportune time to conduct field surveys to identify the spatial location of low risk and high risk stand conditions so that post 2011 an underplanting program can be implemented in low risk areas. Higher risk areas could be targeted for overstory removal in various amounts in concert with various tools to limit damage.

Key Uncertainties

Although hares will preferentially feed on planted seedlings even when at low populations, most damage is in areas where populations are high. Identifying population levels seems important, particularly as levels seem to vary place to place in relatively short distances. It may be that pellet counts in stands to be planted are the only way to get a sense of local hare populations

In areas of high hare numbers the options are to avoid underplanting until numbers are lower, or treat stands to reduce damage. Treatment options are areas of uncertainty. How well will alternate food sources work, how well will brushing work under a canopy? Would partial removal of the canopy be beneficial? What are the possibilities for planting larger stock? Less well fertilized stock? Alternate species of seedlings? Many options are worth testing.

Short-Term Learning

All these treatments are suitable for short-term research that will provide information to adapt practices over the next few years. With appropriate controls and replication, useful means of treatment can be assessed.

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Appendix 1: Ongoing studies in FFT areas

Ransome et al. are continuing a local study in the Northern Interior Forest Region near Prince George. Presently, they are monitoring hare populations and damage under a variety of overstory conditions with the intent to gain information on where hare populations are in their cycle. Since FFT are active in both merchantable and non-merchantable stands, the study is looking at both overstory conditions. On some of these monitored sites, treatments such as supplying alternate food sources, brushing understory, or trying less fertilized stock, will be implemented (and the monitoring information used as baselines. They are addressing 3 objectives:

(1) Install a network of monitoring sites and monitor vole and hare populations in representative MPB-killed non-merchantable lodgepole pine stands in the NIFR. Relate vole numbers to stand conditions, and potential for feeding damage to plantations. Monitor relative habitat use by snowshoe hares at the NIFR network of MPB-killed stands. Monitoring sites are located near Dunkley, Prince George, and Vanderhoof in the Prince George and Vanderhoof Forest Districts.

(2) Install a network of monitoring sites and monitor habitat use by hares in representative MPB-killed merchantable lodgepole pine stands, in the NIFR. Monitoring sites are located near Quesnel, Fort Fraser, and Fort St. James in the Quensel Forest District, Vanderhoof Forest District, and Fort St. James Forest District, respectively.

(3) Monitor the survival of seedlings planted in MPB non-merchantable stands. Monitoring sites for the survival trials are located between Quesnel and Prince George in the Prince George Forest District.

Ransome et al.'s Results and Management Recommendations for 2007/2008

Objective 1: Live trapping of voles and snowshoe hares was initiated in 2006 and was conducted from May to September in 2006 and 2007. Similarly, pellet plots for snowshoe hares were examined on all sites in 2006 and 2007.

- There appeared to be an increase in meadow voles in MPB-killed non-merchantable stands from 2006 to 2007.
- Abundance of red-back voles appeared similar in MPB-killed non-merchantable stands from 2006 to 2007. However, their numbers appear to be building to peak populations in non-pine mature forests.
- Abundance of hares appeared similar in 2006 and 2007 for Dunkley. However, there were more hares captured in 2007 than 2006 in Prince George and Vanderhoof. Similarly, there was a two-fold increase in number of pellets encountered in the pellet pots from 2006 to 2007 for Prince George and Vanderhoof. Although the data only represents two years of monitoring, the use of MPB-killed non-merchantable stands by hares is increasing.

Objective 2: Pellet plots for snowshoe hares were established and cleared in 2007.

- Abundance and habitat use of MPB-killed merchantable stands was greater in Quesnel than Fort Fraser or Fort St. James.
- One merchantable stand had approximately the same use by snowshoe hares as did the unthinned control (optimal habitat).

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Objective 3: Four sites were monitored for clipping by snowshoe hares and voles on freshly planted seedlings in the NIFR. Sites were planted in mid to late July 2007 and assessed for damage the first week of August.

- Block 93G043-524 suffered a high level (36%) of damage within a few weeks after planting.
- Block 93G043-524 suffered lower levels of damage (6%) than the previous block. Remaining blocks suffered low damage (< 1%).
- 95% of the seedlings were clipped by snowshoe hare and 5% by voles.

Ransome et al.'s Recommendations for the 2008-2009 Monitoring Period

Management Recommendations: As both hares and meadow voles appear to be increasing in MPB-killed non-merchantable stands:

(1) Continue interacting with FFT operational staff in NIFR of the Ministry of Forests and Range; annual report to FFT; and include an additional extension event (e.g. field tour September 2008, SISCO/NSC).

(2) Continue monitoring of vole populations in MPB-killed non-merchantable stands, salvage clearcuts, and uncut forest stands.

(3) Continue monitoring snowshoe hare populations and relative habitat use by hares in MPB-killed stands (both non-merchantable and merchantable stands) and live unthinned control stands.

(4) Assess whether abundance of voles and hares is related to percent cover and/or volume of vegetation. If there is a relationship between these species and the vegetation, this information can be used to predict which sites are most susceptible to damage.

(5) Plant those MPB-killed non-merchantable stands, not currently planted, that are being monitored for damaging agents, in order to:

- Superimpose a survival trial on these stands, similar to that currently being conducted for Objective 3 (above).
- Superimpose damage-reduction techniques on the current design to determine their effectiveness in reducing damage to planted seedlings.

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