Using Silviculture to Maintain and Enhance Grizzly Bear Habitat in Six Variants of the Prince George Forest Region

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Executive Summary

This project was initiated by the Habitat Branch of the Ministry of the Environment, Lands and Parks to identify silviculture opportunities in second growth stands to enhance grizzly forage in the Prince George Timber Supply Area.

Summarizing information from the Parsnip grizzly bear project and relating it to natural stand densities and gaps resulted in some striking correlations. Grizzly bears that live on the plateau have larger home ranges, and lower densities than mountain grizzly bears. These numbers correspond with the natural stand attributes of the SBSmk1 variant where stands have a stem exclusion stage, with large areas on the landscape with low or nonexistent forage for a long period, and where there are few gaps in natural stands. Plateau grizzly bears utilize wet alder swales and riparian areas as special habitats. Mountain grizzly bears have higher densities, much smaller home ranges and utilize the sub-alpine and alpine habitats in the summer. This corresponds to the natural stand attributes of the SBSwk1 mountain phase, SBSvk, ESSFwk1, wk2 and wc3 variants that do not have a stem exclusion stage, and have many natural gaps that support shrub and herbaceous forage species. The other habitat features that mountain bears utilize include avalanche chutes, wet meadows, subalpine meadows, seeps and alder swales. The SBSwk1 (plateau phase) is closest in character to the SBSmk1.

Using the habitat and natural stand dynamic information a series of silviculture guidelines have been developed. A mixture of silviculture systems is recommended, and in particular partial cutting silviculture systems to create gaps in the landscape and optimize light levels for forage species growth. At the harvesting and site preparation phases protection of coarse woody debris and retention of high stumps around gaps and on drier site series in the SBSmk1 is recommended for ant habitat, an alternative forage in poor berry years. Soils and shrub roots should be protected to reestablish forage species. For each variant on the southern aspects, reduced stocking and reduced maximum densities are recommended to promote forage species in the pioneer seral and young seral successional stages. Manual brushing is recommended on these aspects to ensure forage species are retained on site.

In any watershed a maximum level of brushing that occurs in a given year is established to allow for regrowth of grizzly forage species. Maintenance or creation of gaps in the forest canopy is recommended to provide forage throughout the rotation. For each variant, a minimum gap area and range of sizes of individual gaps has been identified. This number applies to any cutting permit in the variant, regardless of aspect. Existing natural gaps of special grizzly habitat are preferred locations to maintain gaps, however suggestions on other areas to locate gaps are outlined. In particular distance from roads and distance to other grizzly habitat have been identified. In the gaps where *Vaccinium* species occur trimming during manual brushing activities is recommended to maximize berry production.

The report provides an adaptive management framework for testing and refining the guidelines operationally. Areas where the guidelines could be clarified, including information on denning habitat and applications to other subzones are identified. A number of research

topics have been listed that would assist in refining the guidelines by increasing our understanding of particular habitat issues.

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1.0 Introduction

This project was initiated by the Habitat Branch, of the Ministry of the Environment, Lands and Parks (MOELP) to identify silviculture techniques to enhance grizzly bear (*Ursus arctos horribilis*) forage in second growth stands. The project involved adapting existing information from coastal British Columbia by Tony Hamilton, MOELP and others (Appendix 11, B.C. Min. of Forests 2000) to the Prince George Timber Supply Area (PGTSA). The objectives of the project were to:

- identify key components of grizzly bear habitat in second growth forests in PGTSA;
- identify which site series in the Sub-boreal Spruce (SBS) mk1, wk1 and vk and Engelmann Spruce-Subalpine Fir (ESSF) wk1, wk2 and wc3 biogeoclimatic ecosystem classification variants that are important for grizzly bear habitat;
- produce silviculture guidelines to enhance grizzly bear forage for the 6 subzones; and
- produce an adaptive management framework to implement guidelines by identifying stand selection and monitoring activities.

The SBSmk1, wk1 and vk along with the and ESSFwk1, wk2 and wc3 were the variants selected for production of grizzly bear forage guidelines in the Prince George Timber Supply Area, as they are areas with high grizzly populations[1]. The Forest Practices Code identifies the northern boreal mountains and the northern portion of the Sub-boreal Interior ecoprovinces as able to support healthy populations of grizzly bears (1999a). These biogeoclimatic variants typically support grizzly bears that live in Arctic river drainages, which do not produce salmon. Therefore, the vegetation portion of the Arctic river drainage bear's diet is much more important than for the Pacific river drainage grizzly bears.

Where harvesting is been undertaken, silviculture activities can be used to enhance vegetative forage opportunities for grizzly bears. Silviculture systems can be used to provide sites with characteristics of the range available in natural disturbance patterns. For example, pioneer seral stand planting numbers and patterns, can be used to establish future gaps. Site preparation and broadcast vegetation management treatments can be minimized to enhance forage in pioneer seral stands. In young seral stands, spacing treatments can be used to delay loss of light to the understory and to create canopy gaps. The intent of this report is to identify 1) ecosystem specific and 2) habitat specific silviculture activities at the stand level that will enhance grizzly bear forage and also maintain timber production.

2.0 Components of grizzly bear habitat

The following review of related literature focuses on aspects of grizzly bear forage in the central interior of British Columbia. Some of the information presented is taken from progress reports and observations made during the first two field seasons of the Parsnip Grizzly Project (PGP) (Mamo et al. 1999, Ross et al. 2000), an ongoing study of grizzly bear

[1] Personal communication with Dale Seip, Regional Wildlife Ecologist, Ministry of Forests January 26, 2001.

population, ecology and habitat selection. Other information has been collected from provincial documents and guidelines, and from other literature sources. Since the PGP study has only summarized two seasons of field data and in each of the two years there has been differences in forage species utilized the potential for other species been used for forage is high.

2.1 Grazing

Table 1 summarizes the forage species grizzly bears in the PGP study area typically feed on. Known forage species from other areas of British Columbia and the northwestern states that are also present in the subzones are summarized in Table 2. The PGP study divided grizzly bear habitat use into 3 seasons: spring summer and fall. The seasonal delineations were based on noticeable changes in bear forage behaviour. Annual climatic variations result in temporal variability in seasonal dates by as much as 30 days. Spring was defined as the period after den emergence when the bears were found grazing on early emergent vegetation and on south facing slopes where the forage was most available (approximately April 15 to June 15). In the PGP study summer was defined by the period when the bears used mainly cow parsnip (approximately June 15 to July 30). The fall season generally ranged from the initiation of berry season until den entry (usually August 1 to October 15).

Table 2. Grizzly bear forage species of the Parsnip Grizzly Project study area for 1998 and 1999 (Ross et al., 2000). Seasonal use intensity refers to the observed and expected use of a specific food item and how much effort bears put in to use the resource. These ratings are subjective, based on field observations.

			Seasonal Use intensity[1]		
Code	**Latin Name**	**Common Name**	**Spring**	**Summer**	**Fall**
Trees					
Abielas	Abies lasiocarpa	subalpine fir	Low		
Picegla	Picea glauca	white spruce	Low		
Shrubs			**Low**	**Low**	**High**
Amelaln	Amelanchier alnifolia	saskatoon		Medium	Medium
Arctuva	Arctostaphylos uva-ursi	kinnikinnik	Low		
Cornsto	Cornus stolonifera	red-osier dogwood			High
Empenig	Empetrum nigrum	crowberry	Low		Low
Loniinv	Lonicera involucrata	black twinberry		High	Low
Oplohor	Oploplanax horridus	devil's club	Low		Low
Oxycoxy	Oxycoccus oxycoccos	bog cranberry	Low		
Ribelac	Ribes lacustre	black gooseberry		Medium	Medium
Ribeoxy	Ribes oxyacanthoides	northern gooseberry		Low	Low
Rosaaci	Rosa acicularis	prickly rose	Low		Low
Rubuida	Rubus idaeus	red raspberry		Low	Low
Rubupar	Rubus parviflorus	thimblebery		Low	Low
Salix	Salix species.	willow	Low	Low	
Sambrac	Sambucus racemosa	red elderberry		Low	Low
Shepcan	Shepherdia canadensis	soopolallie			Medium
Sorbsco	Sorbus scopulina	western mountain-ash			Low
Sorbsit	Sorbus sitchensis	Sitka mountain-ash			Low
Vacccae	Vaccinium caespitosum	dwarf blueberry			Medium
Vaccmem	Vaccinium membranaceum	black huckleberry		Medium	High
Vaccova	Vaccinium ovalifolium	oval-leaved blueberry		Low	Medium
Vaccsco	Vaccinium scoparium	grouseberry			Low

Vaccvit	Vaccinium vitis-idaea	lingonberry			Low
Vibuedu	Viburnum edule	highbush-cranberry			High
Forbs			**Medium**	**Low**	**Low**
Angearg	Angelica arguta	white angelica		Low	
Aster	Aster species	asters		Low	Low
Astragal	Astragalus species	milk-vetch	Medium		Medium
Athyfil	Athyrium filix-femina	lady fern	Low		
Dryoexp	Dryopteris expansa	spiny wood fern	Low		
Epilang	Epilobium angustifolium	fireweed	High	Low	
Equiarv	Equisetum arvense	common horsetail	Medium	Medium	
Equipra	Equisetum pratense	meadow horsetail	Medium	Medium	
Erytgra	Erythronium grandiflorum	yellow glacier lily	High	High	Low
Fragvir	Fragaria virginiana	wild strawberry		Low	
Hedyalp	Hedysarum alpinum	alpine sweet-vetch	Medium		Medium
Hedybor	Hedysarum boreale	northern sweet-vetch	High	Low	High
Heralan	Heracleum lanatum	cow-parsnip	Low	High	Medium
Menytri	Menyanthes trifoliata	buckbean	Low		
Osmorhi	Osmorhiza species	sweet-cicelys	Low		High
Oxyrdig	Oxyria digyna	mountain sorrel		Low	Medium
Petasag	Petasites sagittatus	arrow-leaved coltsfoot	Low		
Rubupub	Rubus pubescens	trailing raspberry		Low	
Senetri	Senecio triangularis	arrow-leaved groundsel		Low	
Smilste	Smilacina stellata	star-flowered false Solomon's-seal	Low		
Strepamp	Streptopus amplexifolius	clasping twistedstalk	Low	Medium	Low
Taraoff	Taraxacum officinale	common dandelion	High	Low	
Trifrep	Trifolium repens	white clover	High	High	Low
Urtidio	Urtica dioica	stinging nettle	Medium	Low	
Valesit	Valeriana sitchensis	Sitka valerian		Medium	Low
Veravir	Veratrum viride	Indian hellebore	Low		
Gramminoids			**Medium**	**Low**	**Low**
Bromus	Bromus species	bromes	Low	Low	
Carex	Carex species	sedges	Low		
Desccae	Deschampsia caespitosa	tufted hairgrass	Low	Low	
Poa	Poa species	bluegrass species	Low		
Trisspi	Trisetum spicatum	spike trisetum	Low		
		oats[2]			High
Other food sources					
	Formicidae	ants		Medium	Medium
	Vespidae	wasps			Low
	carcasses	ungulate/bear	High	Low	Medium
	Alces alces	moose	High	Low	Low
	Rangifer tarandus	caribou	Medium	Low	
	Ursus arctos	grizzly bear		Low	
	Ursus americanus	black bear			Low
	Castomomus commersoni	common white sucker[2]	Low		
	Marmota species	marmots		Low	Medium
	Lemus sibericus			Low	Medium
		microtines			Medium
	gut piles[2]				

[1] Seasons defined in Section 2.1.
[2] Reports from public.

Table 2. Other species foraged by grizzly bears. (From LeFranc et al. 1987, Fuhr and Demarchi 1990, MacHutchon et al. 1993, Mattson 1997).

Latin Name	Common Name
Trees[1]	
Pinus contorta	lodgepole pine
Populus spp.	poplar or cottonwood
Pseudotuga menziesii	Douglas-fir
Picea glauca	white spruce
Shrubs	
Betula glandulosa	scrub birch
Corylus cornuta	beaked hazelnut
Prunus virginiana	choke cherry
Herbs	
Achillea millefolium	western yarrow
Allium species.	wild onion
Angelica genuflexa	kneeling angelica
Aralia nudicaulis	wild sarsaparilla
Cicuta douglasii	Douglas water-hemlock
Cirsium spp	Thistle
Claytonia spp.	western spring beauty
Lathyrus spp.	peavines
Lupinus spp.	lupines
Lysichiton americanum	skunk cabbage
Streptropus roseus	rosy twisted stalk
Tiarella trifoliata	three leaved foam flower
Grasses	
Calamagrostis spp.	reedgrasses
Fescuta spp.	fescues
Juncus spp.	rushes
Scirpus micrcarpus	small-leaved bulrush

[1] Bears will occasionally strip bark from a tree in the spring and scrape off the cambium layer.

During spring the bears most commonly observed activity was grazing of emerging vegetation, both in PGP and other in other studies (LeFranc et al., 1987, MacHutchon et al. 1993). In early spring the PGP study identified the following commonly used species as grasses, *Epilobium angustifolium, Taraxacum officinale, Equisetum* species, *Veratrum viride, Heracleum lanatum*. Catkins of different *Salix* species were also grazed for a short period in the spring. Grizzly bears in the mountains also made use of slopes where snow was receding to take advantage of succulent vegetation.

Grizzly bears foraging on cow parsnip is common in the PGP and other areas (LeFranc et al. 1987, MacHutchon et al. 1993). Cow parsnip is ubiquitous throughout the PGP study area and is the dominant plant species used by bears, with respect to plant volume and effort expended. Summer use usually focused on the consumption of the lower 10 to 15 cm of the stalk. In the PGP study cow parsnip feeding occurred under open canopies or under *Alnus* species canopies. In cutblocks, cow parsnip was usually more abundant in wetter and richer sites and feeding was often near forest edges.

During the late summer in the plateau (SBSwk1, SBSmk1) there are not many succulent species available for grazing (Ross et al. 2000). A strong preference was observed for *Streptopus amplexifolius*, which was abundant at low densities throughout the study area. Many other species were grazed at low intensities (see Table 1).

Fall, grazing activity noted in the PGP study area was low and generally focused on grasses and plants bearing seed pods. *Valeriana sitchensis* was also grazed in the mountainous (ESSFwk1, ESSFwk2) portion of the study area. There was a marked difference in fall grazing activity in the mountains between 1998 and 1999. In 1998 very little feeding on *Heracleum lanatum* was observed while in 1999 very high use was observed. This may be explained by very poor berry production in 1999. The bears seemed to have switched over to *Heracleum lanatum*, feeding mainly on formed seedpods and upper stems. Forage of *Oxyria digyna* was also observed at this time.

2.2 Root digging

Grizzly bears forage by digging for a variety of starchy plant roots, small mammals, and insects (Servheen 1983, Hamer and Herrero 1987, Hamer et al. 1991, Mattson 1997). Grizzly bears often use the roots of plants as a food source especially when no other forage is available (LeFranc et al. 1987, MacHutchon et al. 1993). Spring root digging in the mountains (ESSFwk1, ESSFwk2) in the PGP study focused on *Hedysarum boreale* roots and *Erythronium grandiflorum* corms (see Table 1). Excavations were usually on south facing slopes with well-developed soils. *Erythronium grandiflorum* corms were often excavated through the snow or in recently melted snow and digging for corms was observed throughout the summer and fall seasons. Digging for *Hedysarum* spp. was always observed in the spring or fall and was not recorded in the summer season. In the spring on the plateau (SBSmk1 and wk1) root digging was uncommon and focused on *Osmorhiza* species. Intensive excavations for *Osmorhiza* species was observed in late September in several cutblocks on the plateau. One grizzly bear and her two cubs were observed spending over two weeks excavating in two and three year old cutblocks. Several site investigations revealed several hectares of excavations where almost 100% of the available *Osmorhiza* species were excavated and consumed.

2.3 Berries

The PGP study observed grizzly bears eating twenty-six different berry species throughout the study area (see Table 1). Bears foraged on over-wintering berries such as *Arctostaphylos uva-ursi*, *Empetrum nigrum,* and *Oxycoccus oxycoccos* in early May, in association with other food sources. Almost no berries were observed in late spring and early summer in the study area. One of the first berries available in the Prince George TSA is *Lonicera involucrata* (Mamo et al.. 1999), which was abundant but seasonally short-lived in the study area. Other early summer berry feeding on the plateau focused on small south facing microsite berry patches often in cutblocks where berries developed earlier than surrounding areas. These small patches usually offered early *Amelanchier alnifolia*, *Rubus idaeus*, *Sambucus racemosa*, *Ribes* species, *Rubus parviflorus* and *Shepherdia canadensis,* sometimes weeks before they were abundant throughout the study area.

Vaccinium membranaceum was the most commonly used berry in the PGP study area. *Vaccinium ovalifolium*, *Vaccinium vitis-idaea*, *Vaccinium scoparium* were often found in association with these patches but not in great abundance. During 1998, heavy foraging of *Vaccinium membranaceum* patches occurred as early as July 1st and as late as September 14th in the mountains. The burned area around Hook Lake (SBS wk1), along the eastern boundary of the PGP study area attracted bears from as far as 20 km away due to the high *Vaccinium membranaceum* productivity. Very poor berry production in 1999 resulted in the grizzly bears switching over to herbaceous forage in particular *Heracleum lanatum.*

In the PGP study, late summer and fall berry consumption was most commonly *Cornus stolonifera*, *Rosa acicularis*, *Viburnum edule*, *Vaccinium membranaceum*, *Streptopus amplexifolius*, *Oplopanax horridus*, *Ribes* species and *Sorbus* species. For a complete list of fall berry use see Table 1.

Table 2 includes other berry species that are also know forage species that grow in these subzones but have not been recorded in the PGP study.

2.4 Ungulates and Rodents

Being opportunistic foragers, grizzly bears will consume ungulates if they are available (LeFranc et al. 1987, MacHutchon et al. 1993). Typically in much of the PGP study area grizzly bears in the interior plateau consume one or more moose annually. Winter weakened ungulates are usually taken in the spring or hunted in the fall. The PGP study observed little use of ungulates in the summer season.

Grizzly bears will also utilize rodents when they are available (LeFranc et al. 1987, MacHutchon et al. 1993, Ross et al. 2000). Most rodent use in the PGP occurred in mountainous habitat types.

2.5 Insects

Observations from the PGP indicate that both grizzly and black bears feed on ants in coarse woody debris and stumps. Casual observations noted that anting stumps in cutblocks were often burned and that anting was more frequent in drier portions of the cutblock. Frequency of observed anting behaviour was greater during the summer from early July to mid-August. Ant feeding is usually correlated to seasonal availability of other forage species (Swenson et al. 1999) particularly berries. A local researcher is interested in investigating the habitat of ants in the Prince George area[2].

Grizzly bears eat wasps when they are available (LeFranc et al. 1987, MacHutchon et al. 1993). . Of the two wasping sites in the PGP project, both were observed to be associated with wasp nests in slash piles in five and seven year old cutblocks. Wasping activity was rare and appeared to focus on ground nesting wasps.

[2] Personnal communication with Staffan Lindgren, Department Head of Biology, UNBC, March 22, 2001.

2.6 Soils, aspect and seasonal migrations

There has been little research equating grizzly bear habitat quality to soil quality. Although no detailed work on soils has been completed during the PGP, often, bears are observed feeding in areas with well-developed soils (Ross et al. 2000). Soils were often loamy with less than 30% coarse fragments on forage rich feeding sites, particularly on south facing slopes in the spring. Often root and corm digging was associated with soils with low coarse fragment (less than 30%) although some root digging associated with *Hedysarem* species was in areas with high (greater than 50%) coarse fragments.

Grizzly bears typically use south facing snow free areas in the early spring after den emergence (Servheen 1983, LeFranc et al. 1987, MacHutchon et al. 1993). The PGP analysis of spring aspect use revealed that over 52% of bear locations were on southerly facing slopes. As the snow recedes and more habitats become available aspect use becomes more varied but is still generally biased towards south facing slopes (MacHutchon et al. 1993, Ross et al. 2000). Other aspects were used variably in the spring. South to west facing slopes were most commonly used in the fall. Northeast facing slopes were also used more in the late fall which corresponds with den site selection aspect attributes.

Seasonal elevation migrations have often been observed in grizzly bears (Mace et al. 1997, MacHutchon et al. 1993, LeFranc et al. 1987, Servheen 1983) as well as a seasonal migration from mountainous to flatland habitat. In the PGP study area none of these seasonal migrations were observed (Ross et al. 2000) however four bears did move from the mountains to the plateau. These movements were most likely one way, typical of a dispersal movement. It appears that in the Prince George TSA grizzly bears that live in the mountains stay in the mountains and likewise on the plateau.

2.7 Special habitat types

Riparian habitats are areas that are hydrologically active with dense mesic understory vegetation in a usually timbered setting (Servheen 1983). Riparian habitats are important forage areas for grizzly bears (Servheen 1983, LeFranc et al. 1987, McLellan and Hovey 1995, Mattson 1997). Ross et al. (2000) observed grizzly bears using some riparian areas for foraging in the PGP study area. Riparian areas were used mostly in the spring for emerging *Sedges* and grass species. These areas also provided good late spring and summer growing areas for other forage including *Heracleum lanatum* and *Epilobium angustifolium*. Fall berry production was often very good along the edges of riparian areas.

Avalanche chutes are important habitat types for bear forage (Servheen 1983, Hamer and Herrero 1987, McLellan and Hovey 1995, Mattson 1997). Avalanche chutes usually occur at high elevations and are naturally open sites on steep slopes with forb and shrub dominated canopy (Servheen 1983). Ross et al. (2000) found that bears used avalanche chutes in the PGP study area, with the most extensive use occurring in the spring and summer.

Alder swales are important habitat areas for grizzly bears (Ross et al. 2000). In the mountainous portion of the PGP study area alder swales are usually associated with snow slides. These sites offer both visual cover and forage values for grizzly bears. In the spring as the snowmelts, these swales provide excellent growing conditions for early vegetation prior to the alder leaves fully emerging.

Forest openings are often used by grizzly bears (MacHutchon et al. 1993, LeFranc et al. 1987, Servheen 1983). Ross et al. (2000) found alder canopy openings, predominately in the SBSmk1 and SBSwk1, are important forage areas for grizzly bears. These alder patches are often retained after harvesting and provide excellent visual cover and travel corridors in cutblocks.

Wet meadows are also important habitat types for grizzly bears (Servheen 1983, Mattson 1997, Ross et al. 2000) especially in the spring when openings are used for grazing *Sedges* species and occasionally *Menyanthes trifoliata*, *Lysichiton americanum*, and *Potentilla palustrus*. Ross et al. (2000) observed grizzly bear beds on the edges of wet meadows, excavated to access cooler bedding areas in the heat of the summer. Seeps are an even wetter habitat type used by grizzly bears and sometimes associated with wet meadows. Seeps are perennially moist areas with shallow standing water (Servheen, 1983).

Subalpine shrub meadows are often important areas for grizzly bears (Servheen 1983, Ross et al. 2000) as they are dominated by forbs and shrubs interspersed with sparse or stunted *Abies* species. Usually these occur at high elevations with steep but undulating terrain. This is a common feature in parkland ESSF subzones.

MacHutchon et al. (1993) observed that coastal grizzly bears prefer valley-bottom flood plain habitat types. Ross et al. (2000) did not observe this preference for floodplain valley-bottom habitat by bears with some exceptions. There were brief periods, usually associated with *Lonicera* feeding when grizzly bears used floodplain habitats.

3.0 Gap summary

The locations of a number of the grizzly bears identified in the Parsnip Grizzly Bear Project were placed on orthophotos to determine relative number and size of gaps where grizzly bears were in mature forests. In an approximately 40 ha area around the bear location (radius of 350m), gaps in the forest canopy were identified and the size calculated. This information was sorted by subzone to identify the "gappiness" of stands that grizzly bears select for forage. It is not necessarily representative of the natural "gappiness" of mature forests in these variants. This is not a statistical representation as not all bear locations were placed on orthophotos due to the time available. Also, confirmation of GIS location of the grizzly bears is required, as the locations mapped included 2 sites well outside the TSA and 3 in streams or lakes. The intent of this initial look at the data was to provide a range of gap sizes associated with grizzly bear forage opportunities. Tables 3 and 4 below provide the results of this analysis.

In future analysis, other factors such as the time the bear spent in the area, the site series, and the age of the forest cover should be considered. The ESSFwk1 should be divided into plateau and mountain terrain to match the NDT types and the plateau and mountain grizzly bear habitats. The other bear locations not included, should also be sampled

Table 3. Range in number and size of individual gaps by variant

Subzone	# of different bears	# of records	maximum single gap size (ha)	minimum single gap size (ha)	average single gap size (ha)	maximum number of gaps/40 ha	minimum number of gaps/40 ha	average number of gaps /40 ha
ESSFwk1	no data							
ESSFwk2	19	45	0.018 - 8.7	0.001 - 3.112	0.008 - 4.382	65	3	24
ESSFwc3	no data							
SBSmk1	2	6	0.227 - 1.269	0.015 - 0.095	0.085 - .337	15	2	10
SBSwk1	7	26	0.159 - 16.884	0.008 - 0.31	0.078 - 3.04	33	4	13
SBSvk	10	8	0.236 - 2.34	0.01 - 0.187	0.085 - 0.625	57	7	24

Table 4. Total area of gaps per 40 ha by variant.

Subzone	maximum total gap size/ 40 ha	minimum total gap size/40ha	average total gap size/40ha
ESSFwk1	No data		
ESSFwk2	18.075	0.212	4.15
ESSFwc3	No data		
SBSmk1	2.881	0.532	1.47
SBSwk1	18.267	0.552	5.99
SBSvk	9.82	1.582	5.346

The mature forests stands selected by mountain grizzly bears (ESSFwk2, SBSvk) had more openings (average number of gaps is 24) with a greater diversity of sizes (0.01 ha to 4.38 ha) than the plateau grizzly bears. The plateau grizzly bears (SBSmk1) were in mature forest stands with fewer openings and the openings were much smaller (0.085 to 0.337 ha). See Appendix 1 for an example of the range in opening sizes. There is a trend in mature forests of number and size of gaps increasing as you move to variants with longer disturbance patterns and a landbase dominated by mature and old forests. This trend also corresponds with the natural stand dynamics outlined in Delong et al. (2001) that are described in the next Section.

4.0 Variants and site series where grizzly forage habitat can be maintained or enhanced at the stand scale.

4.1 Natural stands

In the first 100 years post-disturbance naturally established stands in the ESSFwk2, wc3 and SBSvk are much less dense than the fire origin SBSmk1 stands (DeLong and Massicotte 2001). In natural stands in the ESSFwk2, wc3 and SBSvk no stem exclusion stage was detected (Delong and Massicotte 2001). The stem exclusion stage occurs when densely regenerated stands have complete canopy closure. These closed canopies shade out understory vegetation and inter-tree competition results in mortality and small coarse woody debris. The lack of a stem exclusion phase in these variants is supported by the low proportions of CWD (<17.5 cm) present in the stands. In the SBSmk1 stand development has a stem exclusion phase (DeLong and Kessler 2000). This difference in natural stand densities in different variants occurs when stands are young. As stands age the difference in densities are reduced. In managed forests, rotation ages are 80-120 years. At these ages natural stand density is very different in the SBSmk1 variant than the other variants.

Natural stands that develop in the ESSFwk2, wc3 and SBSvk variants have slow rates of tree establishment that results in low density stands at maturity. The lower stand densities of mature forests in the ESSFwk2, wc3 and SBSvk variants result in gaps where shrubs and herbs grow. The stands in the ESSFwk2, wc3 variants are more open than in the SBSvk (Delong and Massicotte 2001). The moist climate of these variants also contributes to well-developed shrub and herb layers. Table 5 shows the average stand densities of mature and older stands in these variants.

Table 5. Average stand densities (stems >7.5 cm) in naturally established stands by variant.

Variant	**Mature stands (71-140 years)**	**Old stands (>140 years)**	**Main canopy**[3]
SBSmk1 [1]	1,910 sph	984 sph	
SBSvk [2]	811 sph	617 sph	<400 sph
ESSFwk2, wc3 [2]	542 sph	558 sph	<400 sph

1 Delong 1997.
2 Delong and Massicotte 2001.
3 A-2 layer (co-dominants), no A-1 layer present (Luttmerding et al 1990).

Figure 1 and 2 provide visual images of stand densities at maturity. Note the gappiness of the stands in these images also corresponds with the information presented in Section 3. Canopy cover in mature natural stands on mesic sites (devils club site association) ranged from 20-22% (Delong and Massicotte 2001). These levels of canopy cover are common in the wet variants as devil's club site association is extensive in ESSFwk2, wc3 and SBSvk variants.

In the ESSFwk2, wc3 and SBSvk, snag densities are low between 50 –100 years (Delong and Masicotte 2001). The snag densities are higher in all stand age classes in the ESSFwk2 and wc3 than for the SBSvk. Delong et al. (2000) found spruce more prominent in larger diameter classes and subalpine fir more prominent in the smaller diameter classes, in mature stands in the ESSFwk2 and wc3. Less spruce was present in the old stands than the mature stands. This corresponds with Lewis and Lindgren's (2000) model of biotic disturbance where spruce beetle will remove a portion of older, larger diameter spruce in mature stands. Over long timeframes, the result is heterogeneous spruce and subalpine fir stands and the stand susceptibility to beetle decreases. Root disease and other mortality agents act selectively on subalpine fir to allow spruce to increase in dominance. These natural processes that kill off single trees and groups of trees continuously create gaps in the stands.

Figure 1. An open stand in the SBSvk.[3]

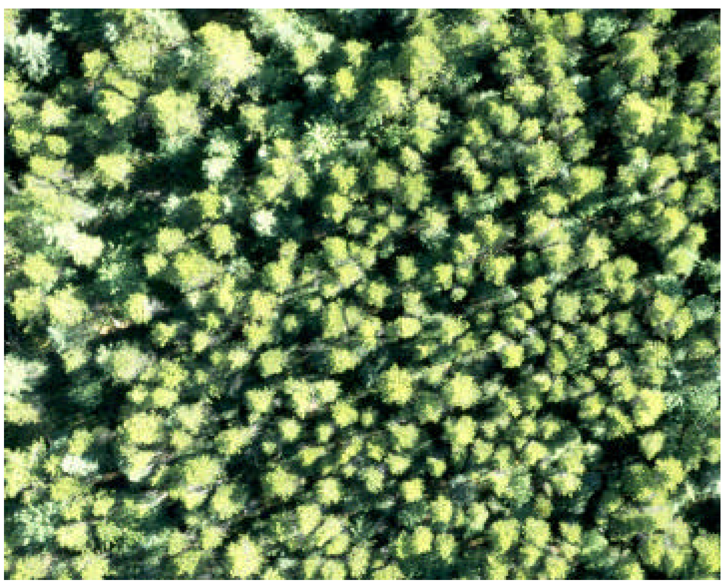

Figure 2. A stand in the SBSmk1.[4]

A summary of the forest cover used by timber supply analysis shows distinct differences in age class distribution in these variants that also corresponds to their natural disturbance types (NDT) (Appendix 2). The SBSmk1 (NDT 3) and SBSwk1 (NDT3- plateau, NDT2 mountain) variants have forested area in all age classes, in part due to a longer harvesting history, while the SBSvk (NDT2), ESSFwk1, wk2 and wc3 (NDT1) have predominantly old forests (age classes 8 and 9) and a shorter harvesting history. In the SBSvk and ESSFwk1 only a small

[3] Photo by Craig DeLong
[4] Photo by Staffan Lindgren

portion of the forested area is NSR or age class 1. This age class distribution reflects the level of natural historical disturbance. The SBSmk1 has a 100 year average disturbance return period while the mean average disturbance period in the ESSF variants is 350 years (Forest Practices Code 1995a). The large area in mature and old forests in the ESSF zone (Appendix 2), and the long average disturbance period corresponds to size of grizzly bear habitat and grizzly bear densities. That is smaller ranges and greater bear densities occur in variants that are dominated by mature and old forests. This issue has been identified in the Forest Practices Code (1999b) where stratification of habitat by natural disturbance type is essential because of the strong relationship between natural disturbance regiment and grizzly bear habitat value.

Grizzly bears on the plateau (SBSmk1) have larger home ranges, lower densities and concentrated use in riparian corridors and along roads (Section 2). This corresponds with the natural stand attributes of the SBSmk1 where stands have a stem exclusion stage. Large areas in this subzone have low or nonexistent forage for a long period (> 60 years), and there are fewer gaps in natural stands (Section 3). The riparian travel corridors[5] are adjacent to the wetter site series. Both of these habitat types support many forage species. Plateau grizzly bears utilize wet alder swales and riparian areas special habitat sites (Section 2.7).

Mountain grizzly bears have higher densities, much smaller home ranges and utilize the sub-alpine and alpine habitats in the summer (Section 2). This corresponds to the natural stand attributes of the SBSvk, ESSF wk1, wk2 and wc3, which don't go through a stem exclusion stage and have many natural gaps (Section 3) which support shrub and herbaceous forage species. The other habitat features that mountain bears utilize include avalanche chutes, wet meadows, subalpine meadows, seeps and alder swales.

In the SBSmk1 stand replacing fires are more common than in wetter SBS and ESSF variants, where the fire return period is 500 up to 1000 years (Lewis and Lindgren 2000). Shorter fire return periods would result in more areas with stumps for ant habitat. But ants are also common in old logs and stumps in mature stands[6]. Forest management will impact the stumps available to ants by increasing the number. However, with mechanization of harvesting, the stumps left are almost flush to the ground, unlike the taller stumps left after wildfires.

4.2 Managed Stands

Harvesting creates pioneer seral stands (Luttmerding et al. 1990), with full sunlight supporting the development of herbs and shrubs, and with changes in species composition. These areas are then reforested. Managed stand establishment in these variants is at much higher stocking densities than in natural stands. Figure 3 shows total tree density in the ESSFwk2; compared to mature natural stand densities of ~600sph the majority of managed stands in this variant have densities over 1000 stems per hectare (sph).

[5] Personal communication with Dale Seip, Regional Wildlife Ecologist, Ministry of Forests January 26, 2001.
[6] Personal communication with Staffan Lindgren, Department Head of Biology, UNBC, March 22, 2001.

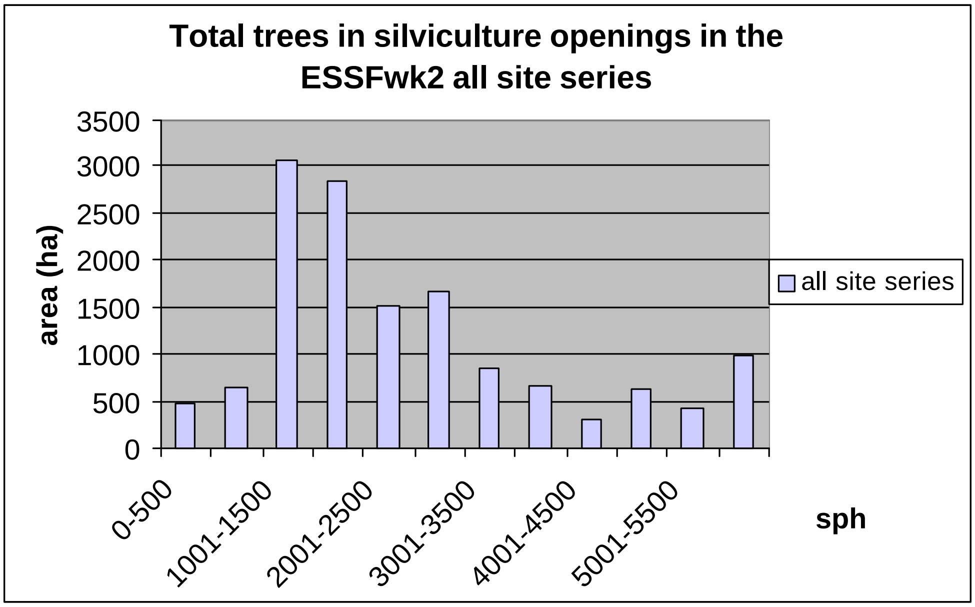

Figure 3. Total trees in managed stands in the ESSFwk2[7].

The trend of higher densities in managed stands occurs in all the subzones and in most of the site series (See Appendix 3). In the SBSmk1, natural stand densities are higher so managed stand densities are much closer to natural stand densities (Figure 4).

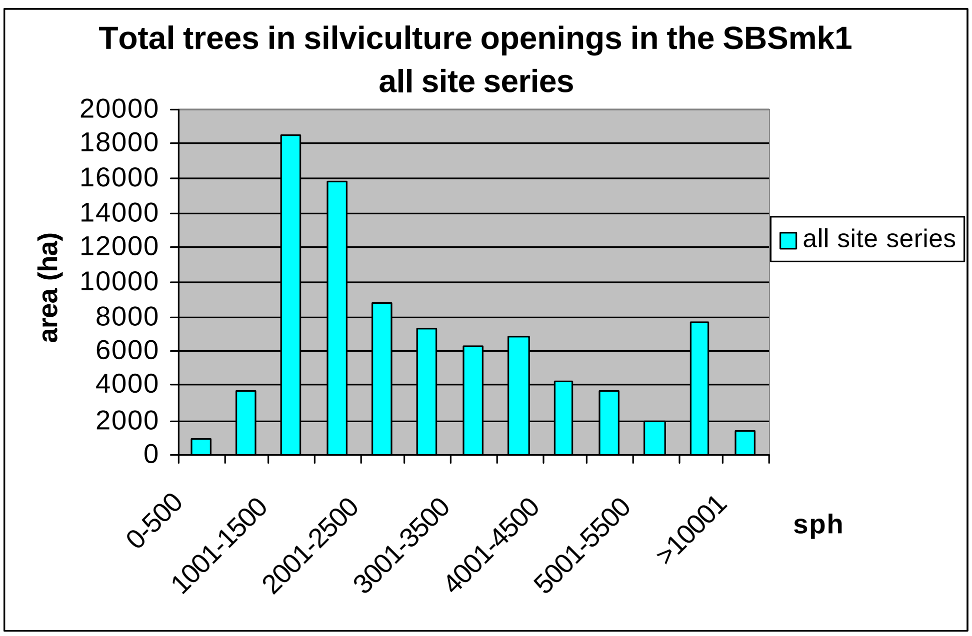

Figure 4. Total trees in managed stands in the SBSmk1[8].

In managed stands there is also a significant species shift. Total stocking of spruce is two times that of spruce in natural stands (Delong et al. 2000). With higher densities in second

[7] ISIS data compiled March 2001 for stands <80 years in the ESSFwk2.
[8] ISIS data compiled March 2001 for stands< 80 years in the SBSmk1.

growth stands crown closure will occur earlier. The forage species are suppressed by closing canopies (see Section 4.3) and the level of available forage is reduced. This post-logging successional pattern contrasts with the gap-phase dynamics of old-growth forests, in which tree, herb, and shrub seedling regenerate continuously and form a conspicuous vegetative stratum.

The increase in harvest levels above natural disturbance levels will result in more of the landbase carrying second growth stands. The combined change in age class distribution and amount of stands with closed canopies will impact the mountain grizzly bears the most due to their smaller home ranges. In the SBSmk1 harvest levels are closer to natural disturbance patterns and the existing even age class structure (see Appendix 2) will continue to provide pioneer seral stands for grizzly forage across the landscape.

4.3 Forage species and light levels

Different successional stages of a forest provide different levels of shrubs and herbs for grizzly bear forage due to variations in light and moisture availability. This Section briefly summaries studies that identify available light effects on growth and berry production of species identified as high forage value in Table 1. Many studies have shown light plays a dominant role in controlling understorey composition (Leiffers 1994, Minore 1984, Alaback and Tappeiner 1991) and managing the canopy can change available light to the understory. Knowledge of how light levels effect grizzly bear forage species will assist in planning silviculture treatments that can enhance these species. Some grizzly bear food species increase with increasing light levels (canopy removal) (e.g. raspberry, fireweed and black twinberry) but other species decline (e.g. devil's club). For some species there is no evidence that they respond to increased light levels (e.g. skunk cabbage and mountain ash). The following information is a summary of light level and growth and berry production for forage species that are ranked high in seasonal use (Table 1).

Black huckleberry (*Vaccinium membranaceum*)

Burton (1998) found thtat for black huckleberry, optimal growth (standing crop, new shoot weight, current growth and current annual growth) occurs between 75-90% full sunlight. Fully open conditions (>90%) did not have the greatest growth but were not detrimental to growth and berry production of black huckleberry (Burton 1998). However an array of evidence indicates that some degree of partial shading provides the optimal environment for these plants (Minore 1984). Minore (1984) reduced overstory shading in closed second growth stands without altering understory density of black huckleberry and obtained a significant increase in fruit production. Burton (1998) found fruit production (fruit density and total dry weight) was strongly related to light levels for black huckleberry, but even more influenced by moisture regime. For a related species, Alaback and Tappeiner (1990) found it took four years before *Vaccinium ovalifolium* produced fruit in new canopy openings in second growth stands. Black huckleberry has high levels of fruit production, Burton (1998) noted it was one of the highest fruit producers of five berry species sampled.

Seasonal weather conditions are of greater importance than local site conditions in determining annual levels of berry production (Burton, 1998). Reductions in fruit production in *Vaccinium* species occur at moderate levels of moisture stress in summer and high duff temperatures. (Moola et al. 1998). In the Prince George area in dry summers, berry production is better in shaded areas and on moister sites, while in wet summers berry production is better on larger openings and dry sites[9]. Sunny summers appear to have greater berry production than cloudy summers[10]. This forage species can be enhanced in young plantations and maintained in gaps and with partial cutting systems. In the northwestern United States, fertilization (with and without nitrogen) has been shown to increase blueberry yields (Burton et al. 2000).

In the ICHmc1 and mc2 high quality-black huckleberry habitat is found between 930-1050m elevation; slopes 16-28% and south facing; with subalpine fir as the leading species. Moderate-quality habitat is found between 863-1140m; and includes NW slopes (Burton et al., 2000). South facing slopes are the aspect that grizzly bears favour (Section 2.6).

Black twinberry (*Lonicera involucrata*)

Black twinberry increases with harvesting disturbances very quickly on wet sites, and more slowly on mesic and drier sites (Haeussler et al. 1990). Black twinberry persists or increases in abundance in pioneer and young seral forests (Beaudry et al. 1999). This forage species can be enhanced in young plantations and maintained in gaps and with partial cutting systems.

Cow parsnip (*Heracleum lanatum*)

Cow parsnip often occurs on seepage sites or soils with fluctuating groundwater tables. Cow parsnip cover can increase in pioneer and young seral stages. In mature aspen stands in the ESSF zone, cow parsnip increases in abundance (Beaudry et al. 1999). This species can be maintained in young plantations, gaps through protection of deciduous and riparian habitats.

Fireweed (*Epilobium angustifolium*)

Fireweed is associated with pioneering stages of succession and most often occurs on open ground and invades rapidly after fires. Fireweed does not compete where vegetation is already well established (Haeussler et al. 1990). Fireweed is weakly related to transmitted light in the understorey of boreal aspen stands (Leiffers and Stadt 1993). It is not present at 10% full sunlight, but as light levels increase, the height and cover of fireweed increases (Leiffers and Stadt 1993). This forage species can be enhanced in young plantations.

Highbush-cranberry (*Viburnum edule*)

Highbush-cranberry production on the coast, appears to improve following light disturbance or clearcutting, though north of Prince George studies suggest clearcutting does not promote rapid reestablishment of this species (Haeussler et al. 1990). Highbush-cranberry persists in pioneer seral stages (Beaudry et al. 1999). This forage species can be maintained in gaps and with partial cutting systems.

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[9] Personal communication with Craig DeLong, Regional Ecologist, Ministry of Forests, March 9, 2001

[10] Personal communication with Phil Burton, Plant Ecologist, Symbiosis Research and Restoration, March 13, 2001.

In the ICHmc1 and mc2 the best habitat for highbush-cranberry is found on 520-650m elevation; slopes 10-32%; flat sites or sites with S facing slopes; dominated by subalpine fir or western hemlock (Burton et al. 2000). South facing slopes are the aspect that grizzly bears favour (Section 2.6).

Sweet cicely's (*Osmorhiza* spp.)

These species persist or increase in the pioneer seral stage (Beaudry et al. 1999). This forage species can be enhanced in young plantations and maintained in gaps using partial cutting systems.

Red-osier dogwood (*Cornus stolonifera*)

Optimal growth (of standing crop, new shoot weight, current growth and current annual growth) of red-osier dogwood occurs between 73-85% full light (Burton 1998). Fully open conditions (>90%) did not have the greatest growth but were not detrimental to growth and berry production. Burton (1998) found fruit production was not strongly related to light but was more influenced by moisture regime. Red-osier dogwood may increase in abundance in pioneer and young seral forests, and persist in deciduous, mature seral forests (Beaudry et al. 1999). This forage species can be maintained in young plantations, gaps and with partial cutting systems.

Soopolallie (*Sheperdia canadensis*)

This species has medium use (Table 1) but is included as it is representative of use on drier sites. Optimal growth (of standing crop, new shoot weight, current growth and current annual growth) of soopolallie occurs between 37-68% full sunlight. Fully open conditions (>90%) were detrimental to growth and berry production (Burton, 1998).

Black huckleberry and soopolallie had the highest fruit productivity of five berry species sampled (Burton 1998). Burton (1998) found fruit production (fruit density and total dry weight) was strongly related to light levels and sugar content both which increased with increasing light. Soopolallie had more berries on mesic and wet sites in the ICHmc than dry sites. But soopolallie does not respond well to competition on mesic and wet sites (Haeussler et al. 1990).

The best habitat for soopolallie in the ICHmc subzone is found at low (450-520m) elevation (some at 800-1100m); slopes 7-19%; and associated with lodgepole pine stands. The most extensive berry gathering areas by First Nations people are found in old, uncut forests but current picking is concentrated in clearcuts 6-17 years of age (Burton et al. 2000).

4.4 Site Series

In the biogeoclimatic variants studied, all of the site series at maturity have plants that grizzly bears use for forage (See Appendix 4). The ecosystems in the ESSF and wetter SBS variants generally have higher cover in the climax forest of grizzly bear medium and high use forage species. The higher cover of forage species corresponds to the lower density natural stands in these subzones. In climax forests in the SBSmk on moist and wetter sites, there are more moderate and high use forage species. Some species grow only in certain biogeoclimatic subzones and variants. Appendix 4 to summarizes which species are available to grizzly bears by variant and site series. *Cornus stolonifera*, *Rosa acicularis*, *Sheperdia canadensis*, *Viburnum edule*, and *Arctosostaphylos uva-ursi* and are rare to uncommon in the ESSF variants and *Vaccinium ovalifolium, Petasites sagittatus, Senencio triangularis, Valeriana sitchensis*, *Veratrum viride* (except SBSvk) are rare to uncommon in the SBS variants. Also, the extent a species appears in different site series represents it tolerance to variation in moisture and nutrient regimes.

To identify which plants will potentially occur in pioneer seral stage on the site series, information was compiled from the site identification field guides (DeLong 1996, DeLong et al. 1993, 1994), the Northern Plant Indicator Guide (Beaudry et al. 1999) and Autecology of common plants in British Columbia (Haeussler et al. 1990). Species that increase or persist in occurrence in the pioneer seral stage were identified. Due to different successional pathways depending on original vegetation, type and intensity of disturbance and subsequent management activities, the degree to which these species will dominate on pioneer sites will vary from site to site. The species listed in Appendix 4 are species that are likely to grow in pioneer seral stands of the site series.

Site series where more of the medium and high intensity forage species occurred were considered most important for grizzly forage management. The site series that had 3 or more medium or high intensity forage species in the pioneer seral stage are identified in Table 6. When these site series occur on south facing aspects (S, SE, SW)(Sections 2.6) then silviculture activities that enhancing forage opportunities will be the most beneficial.

Table 6. Site series with three or more medium and high intensity grizzly bear forage species in pioneer stands.

Variant	**Site Series**
SBSmk1	04 , 05 , 06, 07, 08, 09a, 09b
SBSwk1	01, 03, 04, 05, 06, 07, 08, 09, 10
SBSvk	All except 09
ESSFwk1	All except 08
ESSFwk2	All except 31
ESSFwc3	All except 02

There are other sites that are not classified in the Biogeoclimatic ecosystem classification system which are also important sites when planning harvesting and silviculture activities that are sensitive to grizzly bear habitat. These special habitat sites are identified in Section 2.7 and include alder swales, (which corresponds to the wet alder complex (Newton and Comeau 1990)), wet meadows, seeps, riparian zones, avalanche tracks, and aspen/cow parsnip communities. Only in the SBSvk and ESSFwk1 are alder swales recognized as a seral climax ecosystem and classified as a site series/site association. This site association should also be recognized in the ESSFwk2 and ESSFwc3 variants where alder gaps are a distinct part of the landscape and important grizzly bear forage sites.

The drier ecosystems in the SBSmk1 are important for ground and soil ant and wasp nests. Ant nests in stumps and coarse woody debris have not been correlated with site factors.

The SBSwk1 is similar to the SBSmk1, though generally has more forage species on wetter sites and has slightly more natural gaps in mature forests.

5.0 Draft guidelines by subzone for second growth stands.

These guidelines are meant to supplement other available planning tools. In particular because grizzly bears are creatures of the landscape, it is as necessary to manage for the spatial configuration of habitat as it is to manage for habitat per se. Loss of habitat capability means both loss of food and an increase in intraspecific interaction as more bears become confined to less habitat (MacHutchon et al. 1993). Landscape level planning for grizzly bear habitat is critical in maintaining grizzly bear populations. Other documents (Forest Practices Code 1999b) provide ways to incorporate grizzly bear habitat at the landscape level. This document outlines stand level strategies for 6 variants in the Prince George Timber Supply Area.

5.1 Silviculture systems

Partial-cutting silvicultural systems which create gaps that provide a range of moisture and nutrient conditions would optimize forage in subzones where grizzly bears have small home ranges (ESSFwk1, wk2, wc3, SBSvk and mountain phase of SBSwk1) (see Section 5.6). Partial cutting silviculture systems in these variants are also closer to disturbance sizes created naturally. Gaps are purposely created with partial cutting silviculture systems. Gaps created in multistoried, mature stands are more effective in enhancing shrub growth than gaps in even-aged stands (Van Pelt and Franklin 2000). Burton et al. (2000) suggests silvicultural systems that provide 60% full sunlight for a minimum of 20 years on 75% of the area to optimize berry production. Gap sizes to produce this level of sunlight can be calculated, Coates and Burton (1997) predict that gaps 30-75m in mature ICHmc2 forests will be dominated by light levels between 50-75% full sunlight.

Shelterwood systems also promote more shade-tolerant and moisture requiring shrubs and vascular plants (Hannerz and Hanell 1993). The mix of silviculture systems proposed in the Biodiversity Guidebook (Forest Practices Code 1995a) for these variants includes smaller dispersed clear cuts, some dispersed partial cuts and a few large aggregated harvest units while maintaining forests in a connected network.

Harvesting practices that enhance berry species in managed stands include careful winter logging with understory protection, to minimize damage to root systems of berry producing shrubs (Burton et al. 2000) and retention of security cover (MacHutchon et al. 1993). Careful logging should also protect coarse woody debris to minimize damage to ant habitat (see Section 5.7). If possible coarse woody debris should be undamaged and left in its original location.

Forage areas are used more often if there is security cover or darkness (MacHutchon et al. 1993). The availability of security and thermal cover may be important variables that influence the use of clearcuts (MacHutchon et al. 1993, Zager and Jonkel 1983). Security cover reduces displacement of grizzly bears as a result of human activity in managed stands and near roads.

Security cover should be provided adjacent to special grizzly habitat. At the silviculture prescription stage (SP) a strip of forest habitat should be retained on the edges of all special grizzly habitats (Zager and Jonkel 1983, MacHutchon et al. 1993). At the stand management prescription stage (SMP) on older blocks where there is no retention of forest cover, maintenance of brush species and no spacing is recommended (see Section 5.4). The retention of tree and brush species should minimize visibility. In the long term, these areas will probably become forested habitat that have some level of continual canopy retention.

Buffers of forested habitat should also be maintained along travel corridors. On the plateau (SBSmk1, wk1 and ESSFwk1 plateau phase) travel routes follow riparian zones. These forested strips may also be part of the riparian reserves (Forest Practices Code 1995b). In the higher elevation one way travel usually occurs along avalanche chutes, snow chutes and between cutting units (Zager and Jonkel 1983).

Landscape level and stand level planning should be designed so grizzly bear habitat that is protected, maintained or enhanced are connected to other grizzly bear habitats.

5.2 Roads

Increased human access to grizzly bear habitat has been the number one contributor to declines in grizzly bear populations throughout North America (McLellan 1990) so road access and road density cannot be overlooked in managing grizzly forage. Bunnell (1997) found grizzly bears in southeastern BC, northern Idaho and northwest Washington avoided open roads, but did not avoid restricted roads if adjacent habitat was preferred. In his study, grizzly bears did not avoid clearcuts and young forests after controlling for the effects of open roads. Traffic volume on roads did not determine whether a road is avoided or not, rather it depended on the type of human activity. (Bunnell 1997). Bears reacted more strongly to people on foot than in vehicles (more common on open roads). Avoidance of areas > 100m (LeFranc et al. 1987) to >250m (Bunnell 1997) from roads has been recorded. Bears avoided open roads and were shot on or near open roads. Just as bears can be habituated with food source locations, they also learn to stay away from active roads. One of the largest effects of forestry on bear populations and habitat use is human recreational use of forestry roads.

Planning of new harvesting in grizzly habitat should minimize roads and place roads far as possible from unique grizzly habitat features. Man induced mortality associated with forestry roads may contribute more to grizzly population declines than habitat alteration. (Archibald 1983). Planning of gap locations for grizzly bear forage enhancement should be located away from roads (see Section 5.6). Silviculture activities in second growth stands should retain vegetation along roadsides to minimize visibility (see Sections 5.4, 5,5). Roads should be deactivated and rehabilitated to a standard that excludes hunter and recreation access. Rehabilitation can include grass and legume seeding, which will create an additional forage source for grizzly bears in the spring. Grass seeding should be minimized near active roads, to reduce human interactions with grizzly bears. Deactivation may be one of the most important factors in maintaining grizzly habitat.

5.3 Site preparation

Site preparation activities should minimize disturbance to rootstocks, but can be used to enhance re-growth of forage species. Ground disturbance and uprooting of many of the shrub forage species during site preparation should be minimized, as it will reduce rootstocks for re-growth and establishment of these species. In *Vaccinium* species, reproduction from seed is low. Most re-establishment of *Vaccinium* species comes from sprouting of buds at the base of surviving stumps or underground rhizomes. (Moola et al. 1998). Soopolallie, black huckleberry, red-osier dogwood, devil's club and thimbleberry recover quicker from disturbance when the rootstock is not damaged (Burton 1998).

Scarification produces grasses, sedges and clover. Zager and Jonkel (1983) recommend no more than 20% of an area be scarified as many of the shrubs used for food decline. Current site degradation guidelines have established acceptable levels of scarification and can be used to introduce a percentage of pioneer seral species that spread by seeding, while maintaining shrub species.

Light impact broadcast burns can enhance berry species in managed stands. First Nations People used low intensity burning at regular intervals to halt encroaching vegetation on *Vaccinium* and *Shepherdia* berry patches and to burn off old woody bushes, allowing the growth of new shoots. Berries returned within 2 to 3 years after burning (Burton et al. 2000). Burning stimulates resprouting of plants and development of younger shoots. The age of shoots has been shown to affect the amount of berry production (Bunnell 1989). Other studies report that burning increases regrowth and berry production for *Shepherdia canadensis* (Mattson 1997; Burton 1998), *Vaccinium* spp (Moola et al. 1998, Bunnell 1989, Burton 1998, Haeussler et al. 1990), *Cornus stolonifera* (Burton 1998, Haeussler et al. 1990), *Loincera involucrata* (Haeussler et al. 1990), *Oplopanax horridus* (Burton 1998), and *Viburnum edule* (Haeussler et al. 1990). Light broadcast burns should be considered as a grizzly forage enhancement tool. Area in which historic fires have occurred and now support high shrub cover are often used by grizzly bears in the PGP study (Ross et al. 2000).

During site preparation coarse woody debris must be maintained on-site to provide ant habitat (see Section 5.7). If possible coarse woody debris should be undamaged and left in its original location. If slash piling occurs, ensure a portion of the large pieces (>30cm dbh) is distributed throughout the opening. On northeast aspects coarse woody debris should be maintained for denning.

5.4 Stocking and spacing

Studies have shown that thinning increases shrubs and herbs in second growth stands, though the effects do not last the life of the stand. Increased low shrubs and ferns was reported in 40 to 70 year old Douglas-fir stands, but very low spacing densities also had invasion by exotics (Thysell and Carey 2000). Alaback and Herman (1988) found biomass shifted from over 70%

moss in control to almost 90% shrubs in an extreme thinning treatment. Herb abundance was greatest in the light treatment and the control. However by 33 years biomass returned to control levels in shrubs and herbs in sites with conifer seed-in. Thinning does not appear to fundamentally change the pattern of understory succession, but rather prolong the shrub stages and reduce the duration of the depauperate understory stage (Alaback and Herman 1988). Pruning can be used to extend the gains in forage production from thinning (Thysell and Carey 2000).

Thinning reduces coarse woody debris production and delays the recruitment of snags, especially with wide spacing (Greenough and Kurz 1996). Planning a thinning treatment is a trade-off between forage production and availability of long-term snags and coarse woody debris.

On southern aspects and in the site series identified in Section 4.4 lower stand densities are recommended to provide grizzly bear forage in the pioneer and young seral stands. A variety of spacing densities should be prescribed ranging between the minimum and maximum densities in Table 7. Lower densities will provide forage longer, while higher densities will contribute to security cover, long-term snags and coarse woody debris. In maturing seral and older stands forage will be available in the gaps created (Section 5.6) and in special habitats that have been maintained.

Table 7. Recommended establishment to free growing stocking standards for grizzly bear habitat management objectives.

Subzone	**Site Association**	**Free growing stocking standards (stems/ha)[a]**		
		Target	**Minimum[b]**	**Maximum[c]**
SBSmk1	04, 05, 06, 07, 08	600	400	1000
SBSmk1	09a, 09b	400	300	700
SBSwk1	01, 03, 04, 05, 06, 07, 08	600	400	1000
SBSwk1	09, 10	400	300	700
SBSvk	01, 02, 03, 04, 05, 07	600	400	800
SBSvk	06, 10	500	400	800
SBSvk	08	400[d]	200[d]	800
ESSFwk1	02, 06, 07	500	300	600
	01, 03, 04, 05,	500	300	600
ESSFwk2	01, 02, 03, 04, 05,	500	300	600
	06	500	300	600
ESSFwc3	01	500	300	600
ESSFwc3	03	400[d]	200[d]	600

a - does not include mappable gaps.
b - minimum for preferred and acceptable species.
c - if it exceeds maximum density set in the prescription at free growing these guidelines recommend spacing back to this stocking level.
d - no change from existing standards.

Reduced inter-tree spacing can create clumpiness in the stand without planting trees in clusters. Reduced minimum inter-tree spacing is used in the Lillooet Forest District in grizzly bear habitat (Templeton, 2000). Reducing the inter-tree spacing tolerance will also encourage planters to use preferred microsites. Another way for silviculture surveys to encourage clumpiness is to increase the "m" value in silviculture surveys. Larger plot sizes are another option. In the caribou habitat, in the Prince George Forest District, an "m" value of 10 and a minimum intertree spacing of 0.8m are used to maintain clumpiness[11]. It is recommended that these numbers be used on areas planted for grizzly bear forage. An advantage of having a forest with clumpy but continual cover ensures monitoring of planting can be done within the existing silviculture surveys. Another advantage of having a forest with clumpy but continual cover is that visibility is reduced. Reduced visibility will increase the security value of the area. Continual cover occurs naturally in these variants, see Figures 1 and 2.

Species mixtures should be promoted. Burton et al. (2000) found that high quality habitat for berry-producing shrubs are associated with subalpine fir. This may be due to increased light levels under subalpine fir canopies compared to spruce canopies. Klinka et al. (1996) found canopy cover in second growth stands (35 years old) for western red cedar, western hemlock, amabalis fir and grand fir stands was less than <50%, while Douglas-fir, and Sitka spruce stands had 70-80% cover. Species mixtures are encouraged in the Prince George District (1998) and identified as a way to contribute to biodiversity during juvenile spacing (Park and McCulloch 1993).

Prince George District (1998) guidelines for silviculture treatments in backlog areas are appropriate for enhancing grizzly bear forage. The guidelines recommend no spacing for 10m adjacent to roads and S4 and S6 streams. These reserves will provide security cover for bears. The guidelines also recommend maintaining 10% of the total area untreated, for biodiversity. If the riparian and road buffers do not meet the 10% retention then leave other areas unspaced. For grizzly bear habitat other unspaced area for all the variants should be concentrated on the drier site series, to maximize forage production on wetter site series.

The guidelines for maintaining biodiversity during juvenile spacing (Park and McCulloch 1993) identify both landscape and stand techniques that would enhance grizzly bear habitat. At the stand level the guidelines that apply to grizzly forage management in particular are:

- Retaining woody forage species, which when taller than 3m can be cut or slashed to promote coppicing and improve browse.
- Avoid creating large continuous piles of slash.
- Provide an unspaced buffer strip along roads (similar to the Prince George District, 1998)
- A variety of stocking levels. For grizzly forage they should range between the minimum and maximum stocking standards.
- Along any body of water use patchy spacing. This is opposite to these guidelines for grizzly bear forage where a no-treatment zone along riparian areas is recommended to provide security cover.

[11] Personal communication with Bob Richards, Silviculturist, Prince George Forest District, March 9, 2001.

Spacing activities should be timed outside peak foraging periods for that type of vegetation (LeFranc et al. 1987). Spacing programs in the mountain variants should occur in the summer when grizzly bears are in the subalpine and alpine habitats or in the winter. On the plateau spacing in winter will avoid bear foraging.

In conjunction with spacing, trees on the edge of maintained and created gaps could be pruned (Section 5.6). Pruning would increase light into the gaps and the adjacent understory.

Long term impacts of lower stand densities include a potential reduction in long term timber supply. This reduction will be offset by larger piece sizes. Planting costs will be reduced since fewer trees will be used. Planting success may improve with an increased focus on microsite planting. These cost savings will be offset by spacing costs, since spacing will be required for most stands on southern aspects, as most managed stands well above suggested targets (See Figure 1 and Appendix 3).

5.5 Brushing

Timing, intensity and method of brush treatments can be chosen to minimize impacts on grizzly forage species while achieving silviculture objectives. Single applications of glyphosate reduce brush species coverage but generally in 2-5 years species recover to original cover percents. Glyphosate severely injures *Epilobium angustifolium* but the plant is not effectively killed and reductions in cover are not long lasting (2-3 years) (Haeussler et al. 1990). Herbicides have limited effects on *Vaccinium membranaceum* and *Viburnum edule*, cause light to moderate injury to *Vaccinium ovalifolium* and cause severe injury to *Lonicera involucrata* (Haeussler et al. 1990). Fruit production may recover in part within 2-3 years after foliar applications (Zager and Jonkel 1983). Hamilton et al. (1991) recommends application rates no higher than required to meet silvicultural obligations, and spot treatments to avoid bear forage species not competing directly with crop trees. This recommendation also applies to the variants in this report.

Manual brushing usually results in much quicker recovery of brush species and can also be used to rejuvenate berry producing species. In commercial blueberry patches the practice of pruning blueberry fields by fire or mowing increases fruit yields. These practices effectively remove older, less productive stems while stimulating the development of taller, branched shoots with more reproductive buds (Moola et al. 1998). Burton et al. (2000) recommends pruning only senescing and malformed or diseased stems and branches to maximize berry production. In Ontario, one application of glyphosate or a brushsaw treatment did not reduce berry production *Vaccinium myrtilloides* (Moola et al. 1998).

Current trends in brushing to increased use of manual methods and selective brushing are helping to increase grizzly forage (Hoyles 2001). Canadian Forest Products Ltd. (Canfor), Prince George Division is mainly brushing in SBS zone, with some brush treatments in ESSF zone, due to historical harvesting patterns[12]. Canfor uses manual and chemical methods, with

[12] Personal communication with Steve Jenvey, FRBC Forester, Canadian Forest Products Ltd, Prince George Division, March 13, 2001.

increased use of manual treatments and ground chemical applications to meet biodiversity objectives.

Brushing can be used in high grizzly bear forage areas. It is recommended that a brushing program does not treat all blocks in one year within a particular watershed. A brushing program must ensure forage is maintained in a watershed and allow time for recovery in treated openings. A maximum of 30% of all blocks, 3 to 20 years old, in a watershed should be brushed in any one year. A minimum four year time lag between brush treatments should be used for brush recovery. Brushing plans should also consider spatial arrangement of openings and avoid concentrating brushing in one area. Sensitive brushing programs are especially important in the ESSFwk1, wk2, wk3, SBSvk and SBSwk1 mountain phase where grizzly bear home ranges are smaller so the impact of a brushing program is much larger.

When brushing is scheduled in the variants and site series identified in Section 4.4 and on southern aspects, manual brushing should be prescribed with cutting down to ground level confined to plants competing directly with crop trees. The areas between crop trees should be trimmed back by cutting senescing, malformed and diseased stems and branches to maximize young regrowth and berry production. Brush should be retained along roadsides to minimize visibility. On other aspects, selective brushing treatments, manual brushing treatments and single herbicide treatments (aerial or ground) are acceptable. In backlog (pre-1987) silviculture treatments the Prince George District Manager (1998) recommends in riparian management zones to maintain existing vegetation complexes as much as possible by creating microsites for establishment and release of crop trees. For grizzly bear forage in riparian areas trimming of *Vaccinium* species not competing with crop trees should also occur to enhance berry production.

In gaps (Section 5.6) that have a minimum 20% cover of *Vaccinium* species, trimming of all shrubs should be undertaken concurrently with scheduled manual brush treatments. Cutting senescing, malformed and diseased stems and branches to maximize young regrowth and berry production.

The timing of brushing treatments should be outside peak foraging periods of grizzly bears to minimize disturbance (LeFranc et al. 1987). Brush programs in the mountainous variants should occur in the summer when grizzly bears are in the subalpine and alpine habitats. On the plateau timing cannot avoid bear foraging as it occurs throughout the spring, summer and fall.

5.6 Gap sizes

In forest stands gaps are used by grizzly bears for foraging. In natural stands gaps are present in all variants with more gaps in the ESSFwk1, wk2, wc3, SBSvk, and mountian phase of the SBSwk1 and fewer gaps in the SBSmk1, SBSwk1plateau phase. (see Section 3). The protection of existing gaps and creation of gaps in managed stands is a good tool for enhancing grizzly forage. Gaps will provide forage throughout the life of a stand. In particular gaps will provide forage during the critical stand exclusion stage of managed stands. Alaback and Herman (1988) found the best understory development will likely occur when pockets of viable understory clones are maintained throughout the forest development cycle. They recommend maintenance of canopy gaps to create a more productive and diverse understory than that which will result from one-time precommercial thinnings, because of the diverse microclimates created by gaps.

Another difference in managed stands is they have a single canopy compared to the multistoried canopies in mature and old natural stands. The natural stands of the ESSFwk1, wk2, wc3 and SBSvk variants have continually open canopies since they do not have a stem exclusion phase. A horizontally homogeneity of a tree canopy reduces light to understory herbs and shrubs more than multistoried canopies (horizontal and vertical) (Van Pelt and Franklin 2000). Gaps will increase light to the understory lost due to the single storied nature of managed stands. Van Pelt and Franklin (2000) support the increase in light to the understory in stands at high latitude and high canopies as they found light penetrates at relatively low angles, reducing the significance of the canopy gap to the point of ground directly beneath it.

Canopy gaps create a range of light conditions within and around a gap opening depending on sun angle, gap diameter, tree height and sky condition. (Leiffers et al. 1999). Studies have shown for some grizzly bear forage species that a range of light and moisture conditions will enhance growth and berry production (see Section 4.3). Shade tolerant species will grow well in small gaps while shade intolerant species will occur on the north edge of the gap under the canopy on the north edge (Canham et al. 1994). In a gap there are many edge effects and their magnitude and significance are not constant but vary with each of the factors affecting the silvicultural decision and with the characteristics of the stand itself. No single gap size will give the maximum value for all factors so a range of sizes is required (Bradshaw 1991). Variety in gap size and site series the gaps are located in may also help offset climatic conditions that affect berry production (see Section 4.3).

Canopy gaps also need to be established in the pioneer stage, while forage species are present. Studies have found that gaps created in closed second growth stands have slow species establishment. In managed stands it may take 30-100 years or more for understory plants to recolonize these forests because of low light levels and subsequent stress to seedlings (Alaback and Herman 1988). In windfall gaps in mature forests, Alaback and Tappeiner (1991) found that *Vaccinium ovalifolium* took 3-4 years before shoot growth was released. In second growth stands (after stem exclusion occurred) in windfall gaps, herbs were not successful colonizers because of poor seed dispersal (Alaback and Tappeiner 1991). A late successional stand is relatively resistant to reinvasion of shade-intolerant species, unless disturbances create large openings (Canham et al. 1994).

There needs to be a sufficient amount of forage to make it worthwhile for the grizzly bear to expend the effort to utilize the gaps. The amount of forage available is a combination of number of gaps, gap size, distance between gaps and adjacent forage opportunities. Forage species as identified in Section 1 must be present in the gaps. Grizzly bears can learn to exploit newly available food sources, and once grizzly bears are accustomed to finding sufficient food in an area they become habituated to using the area (Forest Practices Code 1999a). Permanent gap locations will ensure long-term grizzly bear use of an area for forage.

Gaps created at the pioneer seral stage should be larger than gaps found in mature forests. In second growth stands tree canopies will encroach on the gap and subsequent natural regeneration will reduce gap sizes over time. Also larger gaps will increase light into adjacent understory and to some extent providing the diffuse light found in older forests (Van Pelt and Franklin 2000).

Retention of natural gaps to provide for other forest attributes is recognized in the Forest Practices Code of BC Act Section1 (1) retroactive to September 1, 1999. It states that areas of non-commercial forest cover of 4 ha or less may be excluded from the 'net area to be reforested' if that is indicated in a silviculture prescription. This capability to protect non-commercial cover fits well with these guidelines to protect gaps for grizzly forage. The Prince George Forest District (2001) has further interpreted the Forest Practices Code amendment. This District requires that determination of gaps occurs at the silviculture prescription stage, indicating in the text and on maps the areas and the distinction as to whether they are included in the net area to be reforested or not. These guidelines recommend that gaps should also be determined at the stand management stage in existing openings in grizzly bear forage. The alder swales (<4ha) are very difficult to reforest in these subzones and most licencees are unsuccessful at this[13], so retention of these areas should not be difficult to achieve.

The Prince George District Manager Policy on stand level biodiversity and wildlife tree management (1999) also allows for retention of potential grizzly forage areas. This policy allows up to 0.25 ha NCBr and NP brush forest cover types can be included in Wildlife tree patches, but can only be up to 50% of the patch.

Gaps can be purposely created during stand establishment or during stand management phases or with partial cutting silviculture systems. This Section discusses retention and creation of gaps in the stand establishment and stand management phases.

The data collected from the stands selected by grizzly bears for forage has been used to develop a recommended minimum area and size range of gaps by variant, for all second growth stands, regardless of aspect (Table 8).

Table 8. Recommended minimum area and size range of gaps by variant.

Variant	**Size range of gaps**	**Total area in gaps per 40 ha**
SBSmk1	0.1 – 1.5 ha	2 ha
SBSwk1	0.1 – 2.0 ha	4 ha
SBSvk	0.01[1] – 2.5 ha	7 ha
ESSFwk1	0.01 – 2.5 ha	7 ha
ESSFwk2	0.01 – 4.0 ha	10 ha
ESSFwc3	0.01 – 4.0 ha	10 ha

[1] these smaller gaps can be maintained or created for forage but 0.1ha is a recommended minimum gap size due to mapping constraints.

[13] Personal communication with Bob Richards, Silviculturist, Prince George Forest District, March, 9,2001.

These guidelines can be applied over a cutting permit to provide flexibility in retaining natural gaps. However the guidelines can also be applied on a block by block basis if required.

In both silviculture prescriptions and stand management prescriptions a series of steps should be undertaken to ensure sufficient gaps exist.

1. Initially existing gaps should be identified and mapped. The gaps will require mapping to smaller than the current 1 ha scale used in silviculture reporting. In the Prince George Forest District Manager Policy (2001) subsequent surveys are required to maintain the mapscale used. The gaps should include high value grizzly habitats identified in Section 2; wet alder swales, aspen communities with cow parsnip understory, and riparian areas of ladyfern and other forage species, open *Vaccinium* complexes, etc. Only gaps containing greater than 20% cover of all grizzly bear forage species (assessed at the field reconnaissance stage) should contribute to the total gap requirement.

2. The total area of the natural gaps should be calculated to see if it meets or exceeds the guidelines. If a cutting permit contains more than 1 variant and no one variant is dominant then an average of the total gap size should be used. Any standing trees in these gaps for a silviculture prescription must be excluded from harvest and will contribute to stand biodiversity. For stand management prescriptions planted trees in the gaps must be assessed to ensure they will not reach crown closure. Reduction in the numbers of trees in the gaps is required if the gap will not be maintained for the rotation length. A few (~10sph) should be retained for biodiversity.

3. If additional gaps are required either
   a) enlarge the size of existing gaps;
   b) create gaps in areas where >20% cover of any grizzly forage species is present;
   c) at the SP stage protect areas with >20% cover of any grizzly forage species is present with little conifer overstory (<20% crown closure);
   d) create gaps in site series where there is a good potential for forage species to establish. (refer to Appendix 4, DeLong et al. 1993, 1994, Delong 1996, Beaudry et al. 1999, Haeussler et al. 1990)

Location of additional gaps or natural gaps that are enlarged must consider the impact of road location on grizzly bear forage and the location of other grizzly bear forage habitat. If possible, gaps should be created greater than 250 m from roads (see Section 5.2). Try to cluster the additional gaps or enlarge natural gaps. For example new gaps should be created within 500 m of other gaps and within 500 m of existing special grizzly bear forage habitat (riparian areas, avalanche tracks, wet meadows, alder swales, aspen with cow parsnip) so that the energy to access the gaps in minimized and gaps are more easily located initially. The existing grizzly bear habitat will also have retained mature timber for security cover (Section 5.1) and this cover will be used by grizzlies foraging in the gaps.

Creation of gaps will impact long term forest level planning and AAC calculations, which assume full site occupancy in managed stands. Creating gaps is contrary to full site occupancy. However the gaps will provide more light to trees on the gap edge resulting in slightly larger piece sizes. Gaps may contribute to earlier free growing stands due to less onerous stocking requirements. Gaps will contribute to biodiversity goals. These factors must be considered when calculating the impact on forest level planning and annual allowable cut calculations (AAC).

5.7 Ant habitat

Ant habitat needs to be maintained through silvicultural activities, to ensure ants are available in poor berry years and when other forage is not sufficient. Ant habitat includes stumps, coarse woody debris, vegetation nests on the ground and coarse textured soils. Ants are found in all stand ages.[14]

Stumps
Minimum height guidelines should be applied to cutting permits on south aspects (S, SW, SE) in the SBSmk1, wk1 and plateau ESSFwk1 variants where historical reliance on anting by bears was probably higher than in the wetter variants. In these areas on mesic and drier sites a minimum 0.5 m stump, with a minimum basal diameter of 17.5 cm, should be retained on at least 200 sph of trees harvested. Species other than spruce are preferred for retention due to the potential for spruce beetle buildup in spruce stumps.

In all subzones where gaps are maintained or created, stumps of the same dimensions should be retained around all gaps for a distance of 20 m. Any trees stubbed to create wildlife tree habitat can also contribute to the stumps retained

Coarse woody debris
Coarse woody debris should be maintained onsite. In particular large logs or pieces of logs should be left intact during harvesting and other silviculture activities. It is preferable to maintain a piece of at least 30 cm diameter, 17.5 cm in length, as larger piece sizes are probably required for carpenter ant nests[15]. This coarse woody debris may also provide habitat for the rodents and other small mammals that grizzly bears forage on. More information is required to look at small mammal habitat.

6.0 Adaptive management framework for second growth stands

Step 1 Select Appropriate Stands

- Mixed species stands (more representative of current practices).
- Southern aspects, as a minimum compare plateau and mountain variants.
- Stands 10-40 years old, prior to crown closure so forage species are present.
- Density > 2000 sph.

[14] Personal communication with Staffan Lindgren, Department Head of Biology, UNBC, March 22, 2001.
[15] Personal communication with Staffan Lindgren, Department Head of Biology, UNBC, March 22, 2001.

Step 2 Apply Treatments

- Space to 400 to 700 stems-per-hectare; a range between the minimum and maximum stocking standards recommended.
- Create gaps 0.1 to 2.0 hectares in size.
- Trim some of the not crop-tree competing shrub species, compare to *Vaccinium* regrowth.
- Minimum 5 ha areas.
- Treat at least 3 areas with same treatment, in different openings but on the same site series.

Step 3 Monitor

- Habitat Use – record scat, tracks and feeding activities.
- Berry Production – follow Burton 1998.
- Forage Growth – use line intersect samples (Chambers and Brown, 1983). For shrub growth follow Burton 1998 to distinguish between old stem and new stem growth.
- Growth and Yield – use small fixed radius plots (B.C. Ministry of Forests 1997).
- Coarse woody debris and stumps – use line intercept sampling (B.C. Ministry of Forests 1997).
- Sample over a number of years to look at change over time.
- Plan statistical analysis prior to collecting the data.

Step 4 Analysis and Incorporation of Results

- Analyze the results in consideration of the original objectives of enhancing grizzly forage.
- Refine the grizzly forage guidelines proposed here, with the results of the analysis.

7.0 Recommendations for further studies

The following suggestions came from identifying information that would help to refine the foraging guidelines and from interviews with a few local researchers involved in ecology and wildlife programs. The suggestions are not presented in order of priority and do not represent an analysis of information gaps and research requirements.

1) Determine and compare patterns of clumpiness and gappiness in stands that develop after wildfires and managed stands. For example a retrospective study of the managed stands in Hungary Creek area. Variables to consider comparing include crown closure, stocking densities, grizzly forage species development, and conifer growth.
2) Determine which gap sizes in immature stands produce optimal light levels for forage species, for the rotation.
3) Determine how the density and pattern of spacing regimes in immature stands affect light levels. Variables should include crown closure, species mixture and variant. Does subalpine fir have lower canopy cover than spruce?
4) Estimate of minimum level of forage that a grizzly bear will access, this should look at gap sizes, number of gaps, adjacency to other forage and security habitat.

5) Define characteristics of ant habitat by quantifying the habitat (e.g. by ant species, tree species, decay class, piece size, stump, coarse woody debris, soil types, stand age, interaction with fire).
6) Define characteristics of small mammal habitat. Small mammals are a food source not discussed in these guidelines.
7) Summarize qualities associated with grizzly bear denning sites (e.g. habitat features, size of undisturbed area).

8.0 Proposed activities

Some activities that were identified when this project was initiated but not included in this project are presented in this section.

When the guidelines are approved by the Ministry of the Environment the guidelines and the rationale for developing them should be presented to foresters managing the landscape. Some organized opportunities currently exist. To aid in presentations a visual image of the stand similar to the images in Park and McCulloch (1993) should be produced to show the different elements in the guidelines. Presenting this information at a Prince George District Steering Committee meeting would introduce the information to the major licenses including the small business program. If approval of the guidelines is completed by late May 2001, a presentation at the July 10/11 2001, Northern Silviculture Committee/ Northern Interior Vegetation Management Associations meeting on Management in the wetter SBS and ESSF subzones could be scheduled.

Areas for adaptive management trials could be identified. This would include contacting licencees to identify openings in their spacing and brushing programs. Integrated Silviculture Information System (ISIS) summaries could also be used to identify potential locations. The ISIS summaries have already been compiled for these subzones and are held by the senior author. The large database compiled from the identified openings would require sorting to find openings that fit the criteria in the guidelines, be spread among licenses and have spacing treatments that are scheduled for the near future.

Areas of known grizzly bear habitat and threatened grizzly bear populations (landscape level) could be mapped. Information from Section 2, Local Resource Management Plans (LRMP's), biogeoclimatic mapping and a known resident adult female grizzly could be used. Identifying areas of forage shortfall (using TSA data to identify low levels of age class1, overmature forest over time) could refine these maps. Another approach may be to conduct core area analysis for female grizzlies.

Since research on ants, small mammal and denning habitat characteristics will take time, compilation of existing information on small mammal habitat, and denning habitat and development of guidelines could be undertaken.

The gap information presented here could be refined by including other factors in the database such as the time the bear spent in the area, the site series, and age of the forest cover. The remaining bear locations should be included in the gap summaries. The total sample should be categorized by habitat type (open habitat, mature forest with gaps, immature forests, mature forest adjacent to special habitat types). Gap information for the ESSFwk1 should be divided into plateau and mountain terrain to match the NDT types and the plateau and mountain grizzly bear habitats.

Guidelines for other areas in the Prince George Timber Supply Area or Prince George Region could be developed. Grizzly bear habitat potential determined from habitat mapping assign the Interior Cedar Hemlock (ICH), Boreal White and Black Spruce (BWBS) and Alpine Tundra (AT) biogeoclimatic zones in the PGTSA as high; moderate to high and low to moderate habitat potential respectively (Fuhr and Demarchi 1990). The drier variants of the SBS zone range from low to high for grizzly bear habitat. The other biogeoclimatic zones in the PGTSA have not had grizzly bear studies to look at habitat use[16]. However the information on grizzly bear forage species, important site features (Section 2) and an understanding of natural stand dynamics could be used to identify site series in other subzones where grizzly bear forage could be enhanced.

[16] Personal communication with Doug Herd, Wildlife Biologist, Ministry of Environment, lands and Parks, March 26, 2001.

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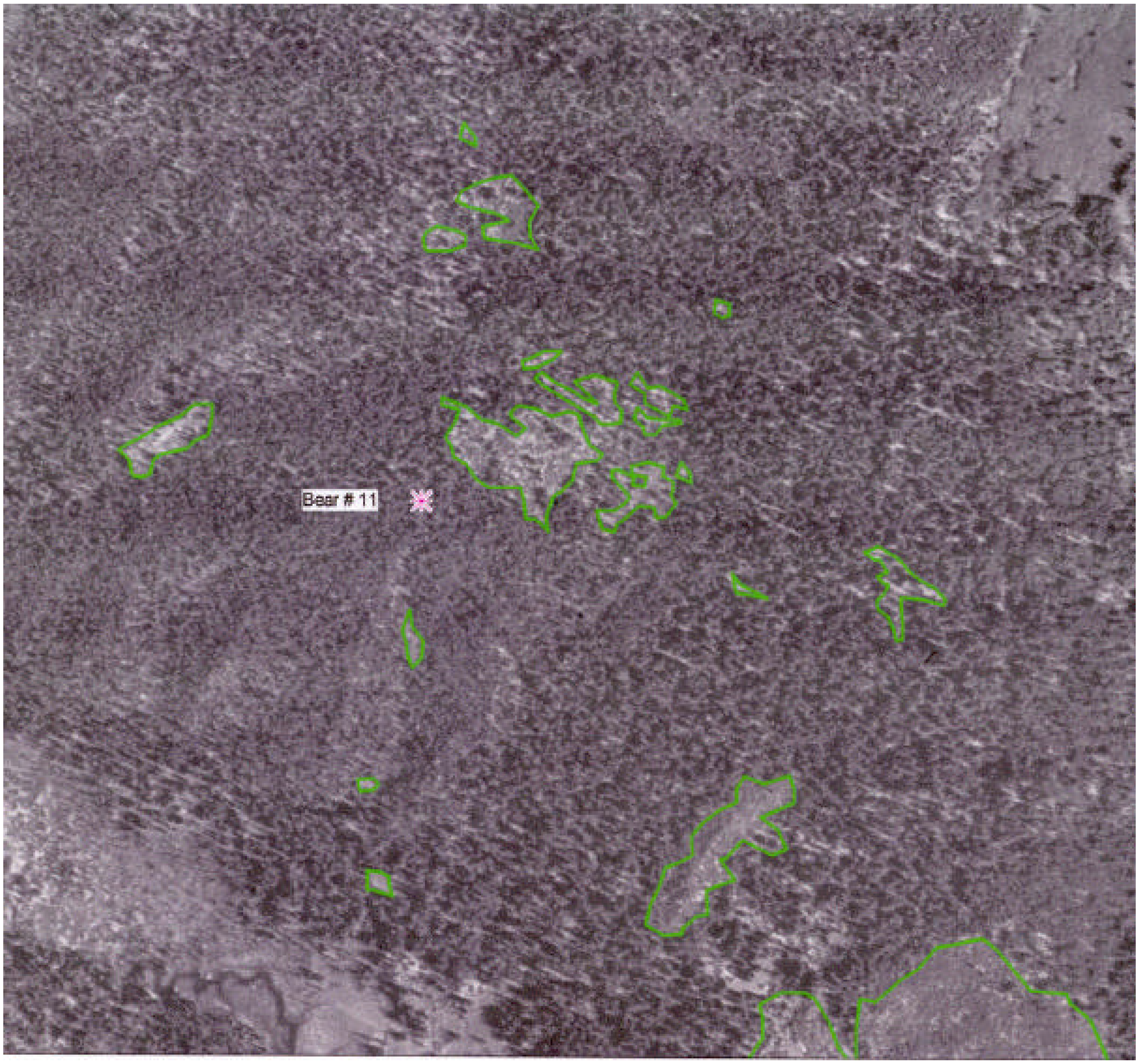
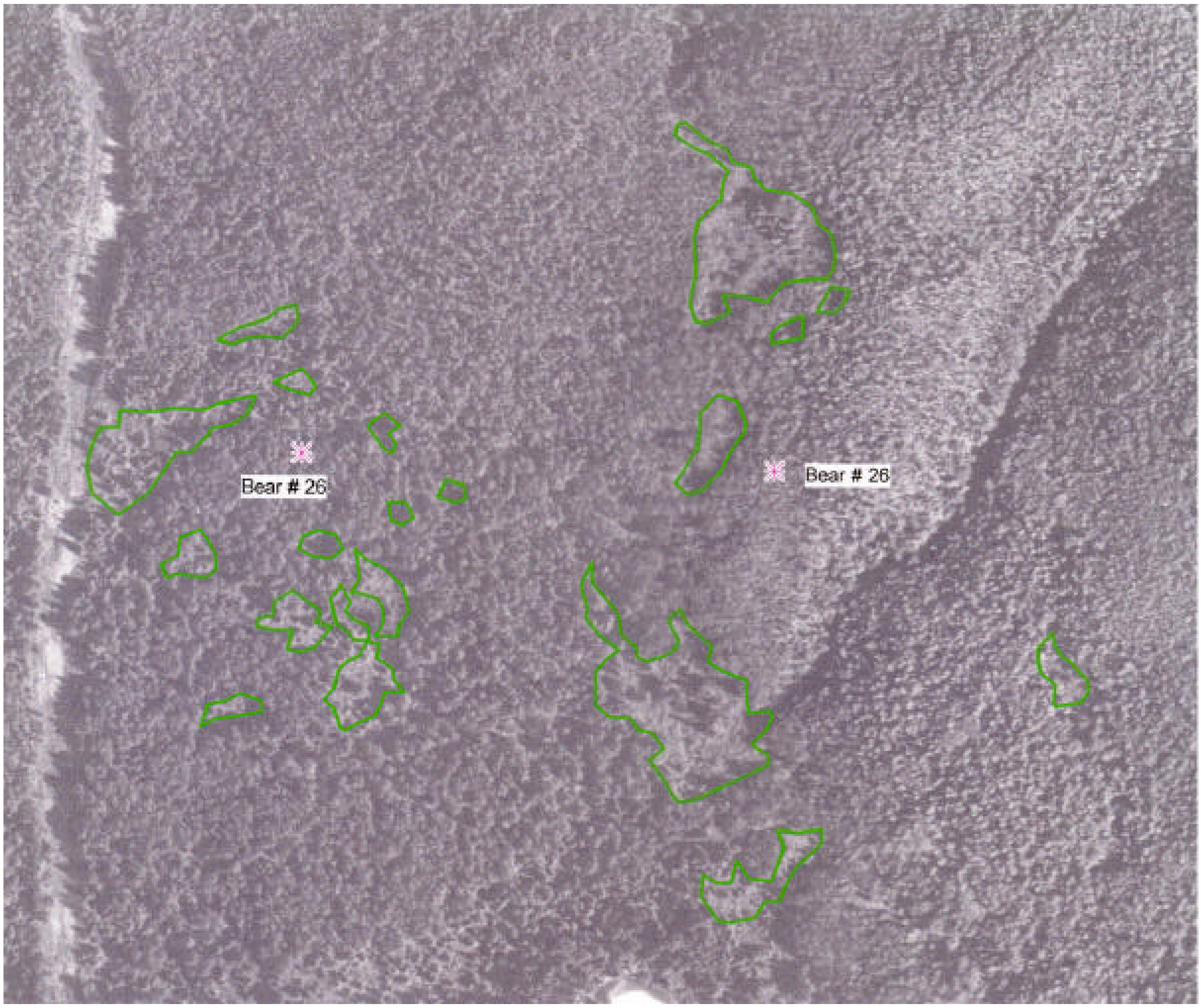
Appendix 1

Gap images



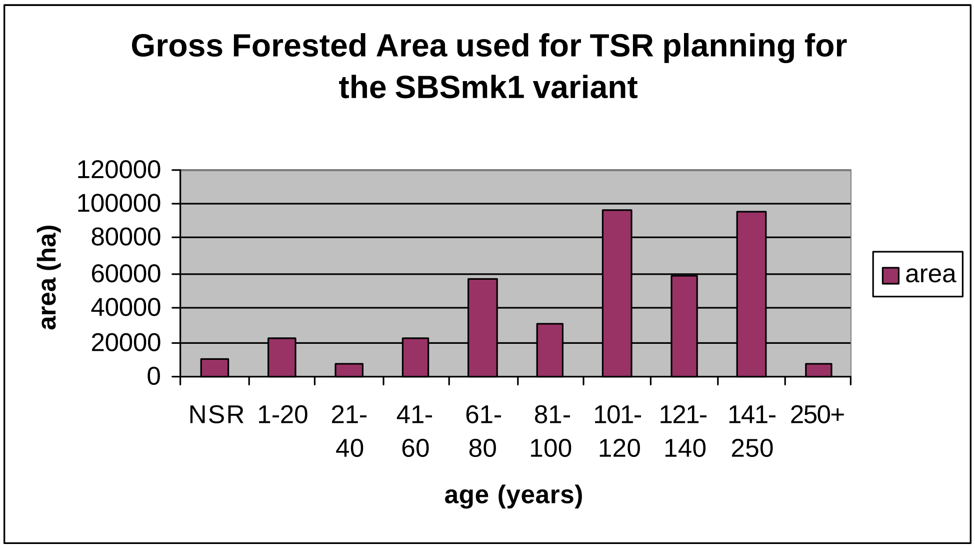
An example of a typical gap configuration in the ESSFwk1. Scale 1:5000

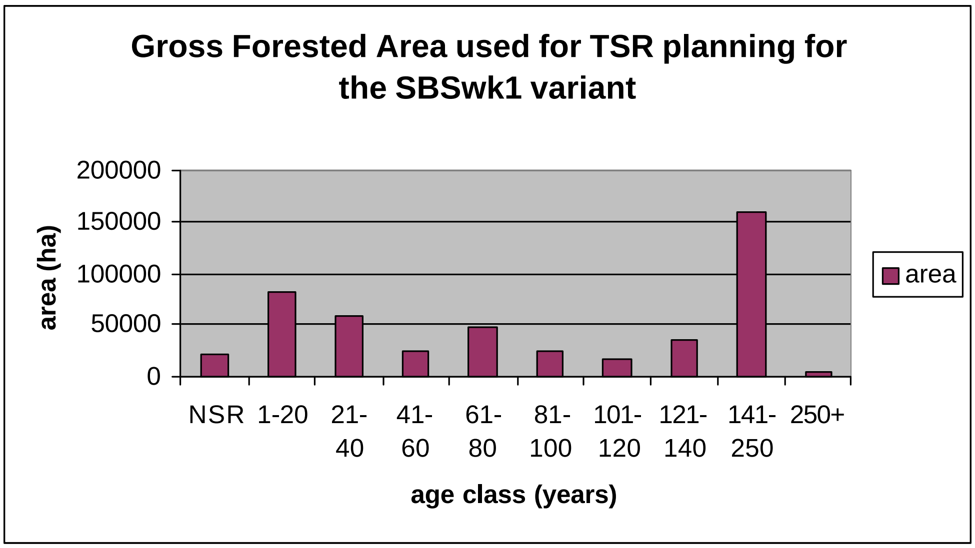


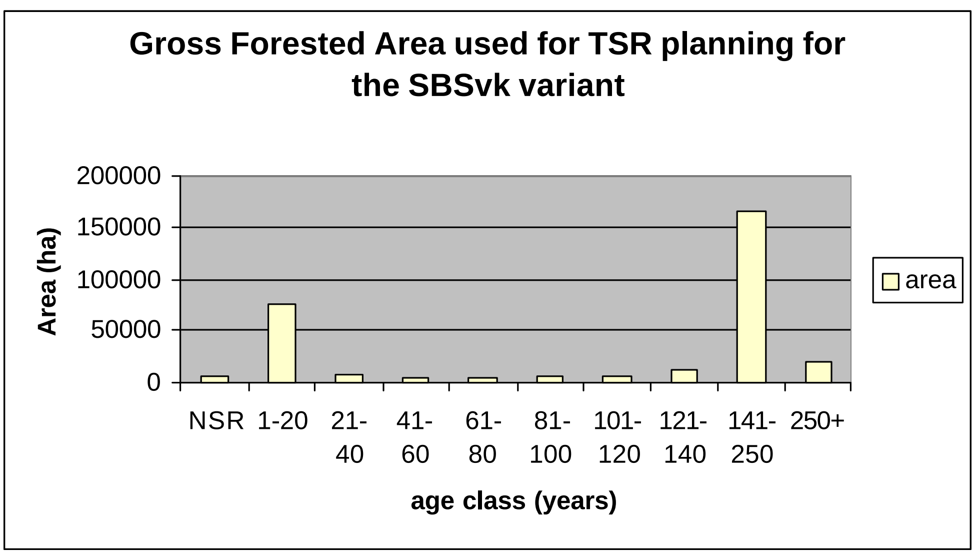
An example of a typical gap configuration in the SBSmk1. Scale 1:5000

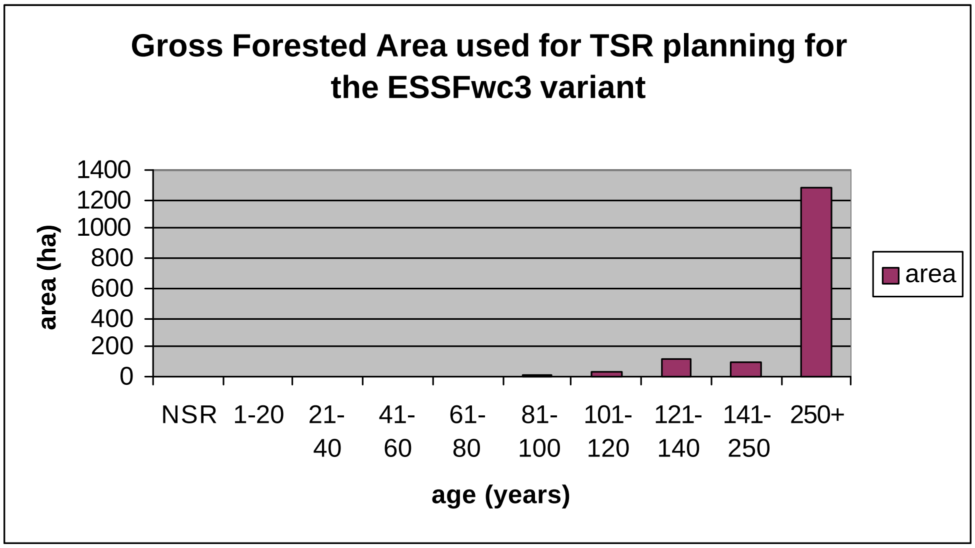
Appendix 2

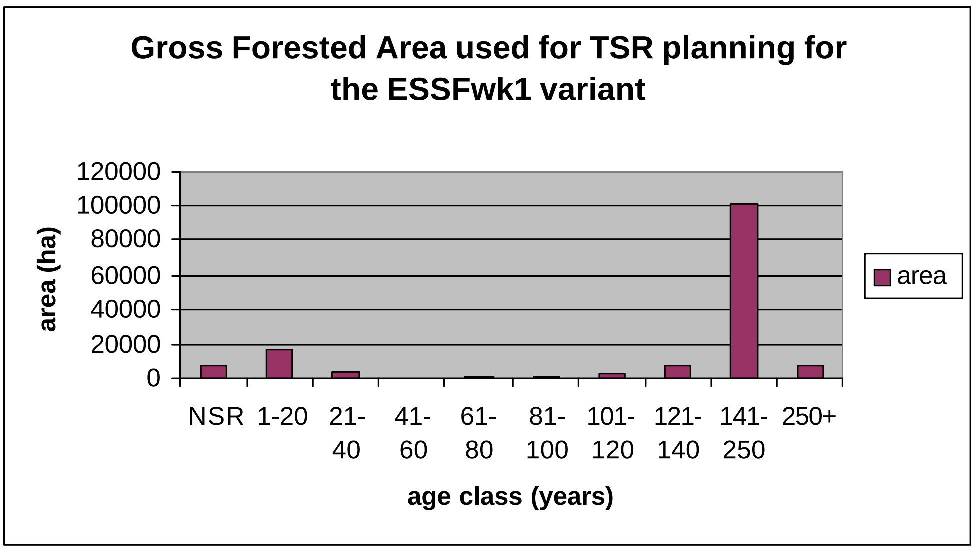
Forest cover summary by age class and variant

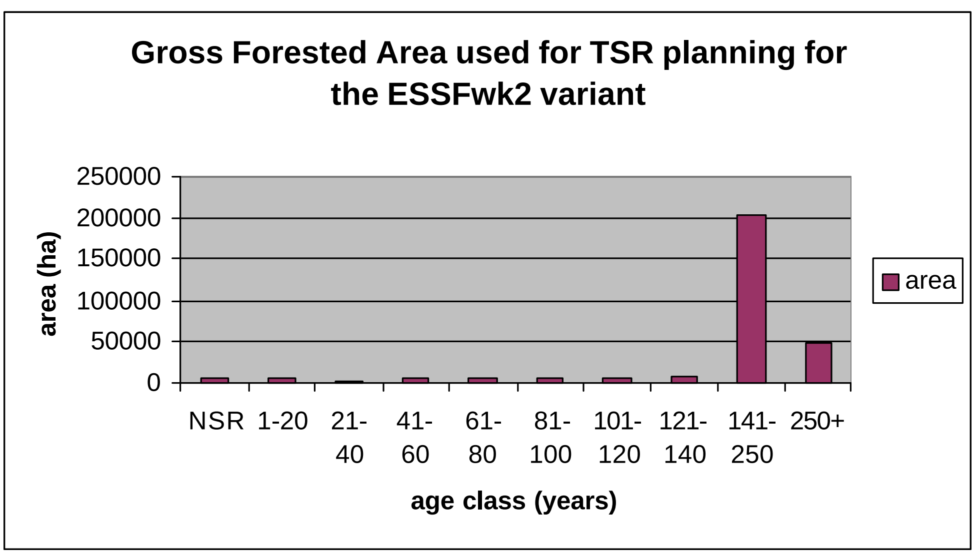

Gross Forested Area used for TSR planning for the SBSmk1 variant
area (ha)
120000
100000
80000
60000
40000
20000
0
NSR
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
250+
age (years)
area


Gross Forested Area used for TSR planning for the SBSwk1 variant
area (ha)
200000
150000
100000
50000
0
NSR
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
250+
age class (years)
area


Gross Forested Area used for TSR planning for the SBSvk variant
Area (ha)
200000
150000
100000
50000
0
NSR
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
250+
age class (years)
area

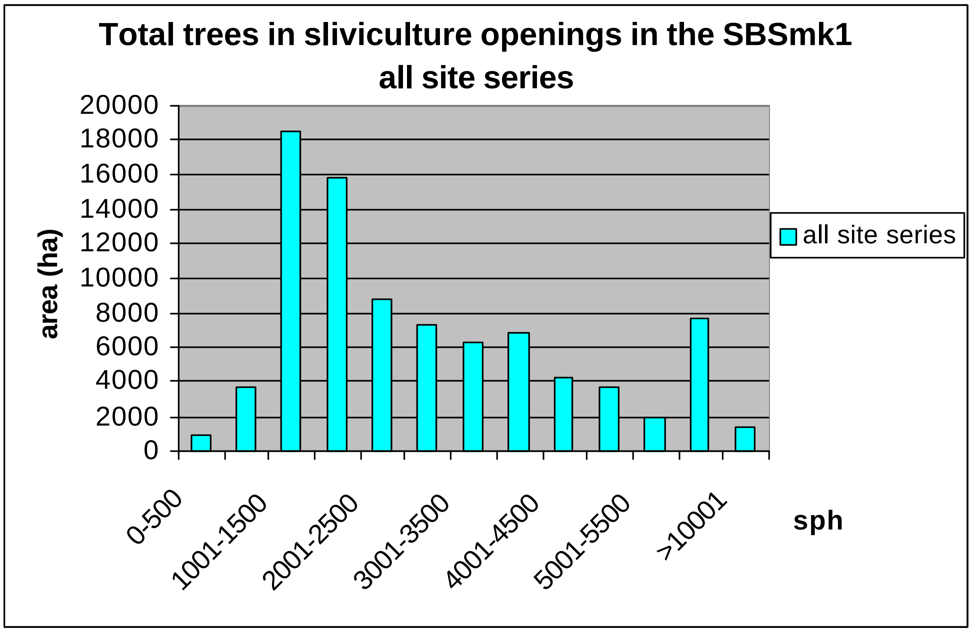

Gross Forested Area used for TSR planning for the ESSFwc3 variant
area (ha)
1400
1200
1000
800
600
400
200
0
NSR
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
250+
area
age (years)

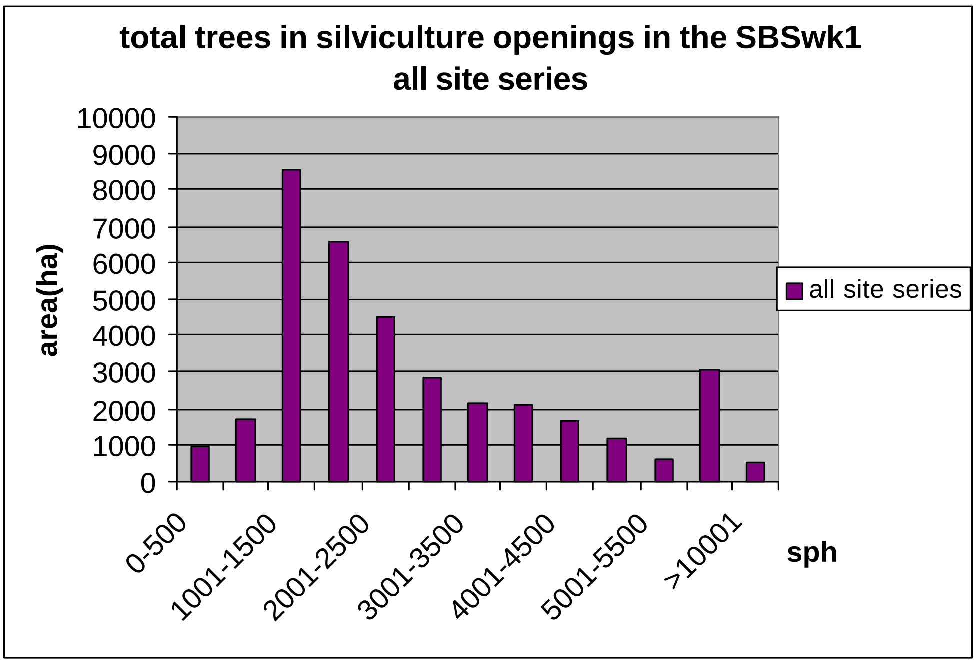

Gross Forested Area used for TSR planning for the ESSFwk1 variant
area (ha)
120000
100000
80000
60000
40000
20000
0
NSR
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
250+
area
age class (years)

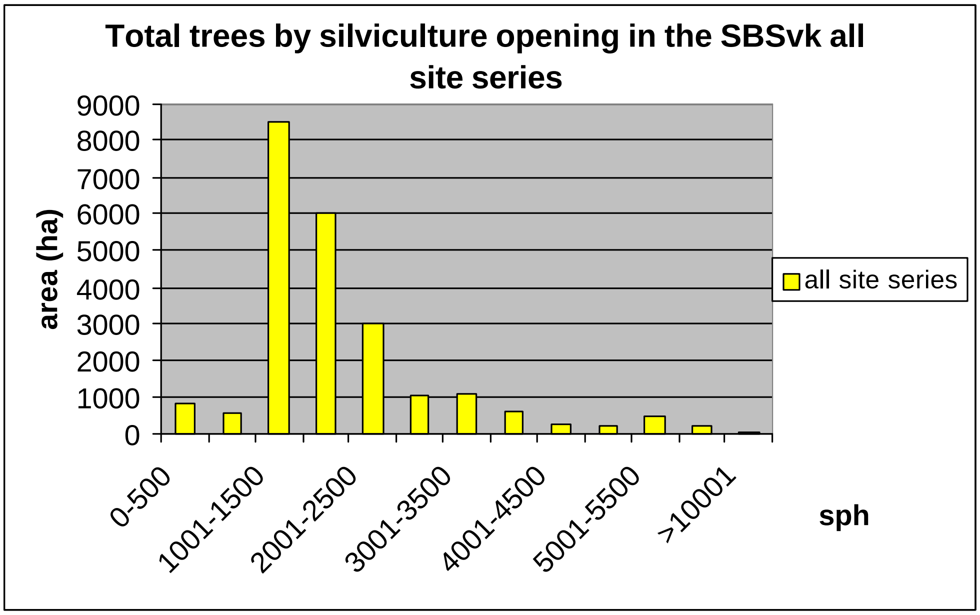

Gross Forested Area used for TSR planning for the ESSFwk2 variant
area (ha)
250000
200000
150000
100000
50000
0
NSR
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
250+
area
age class (years)

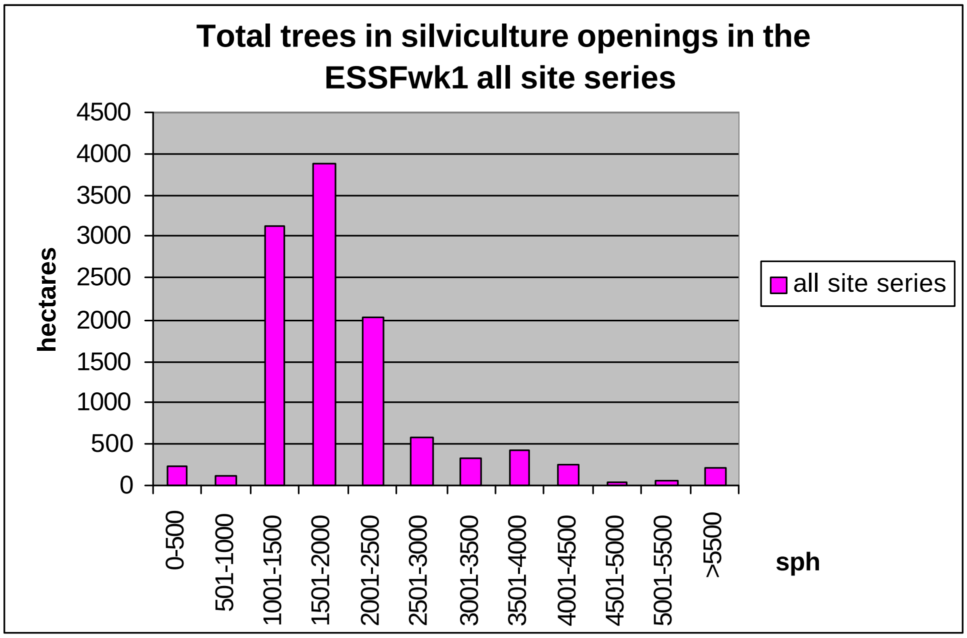
Appendix 3

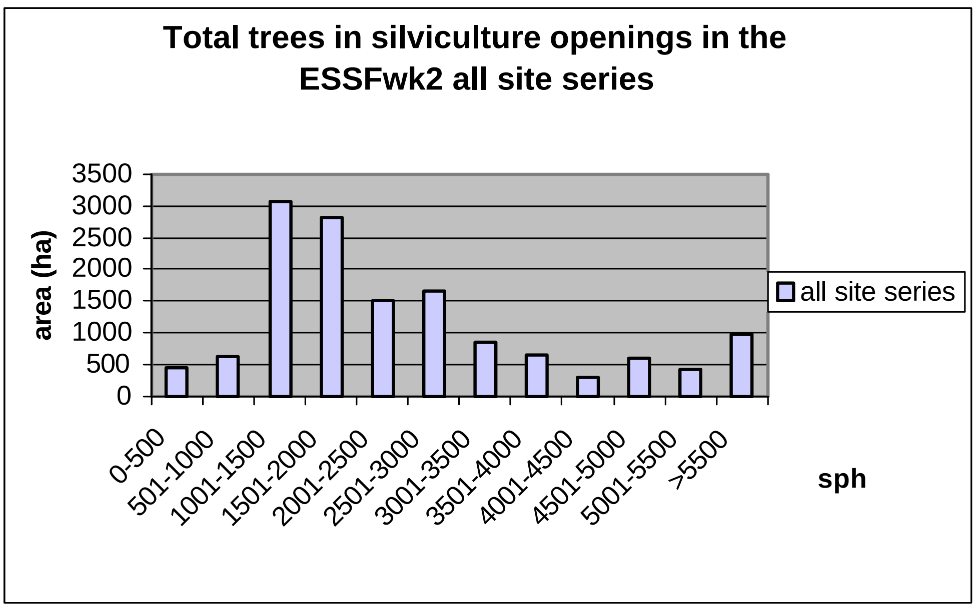
Summary of Silviculture Openings by Variant

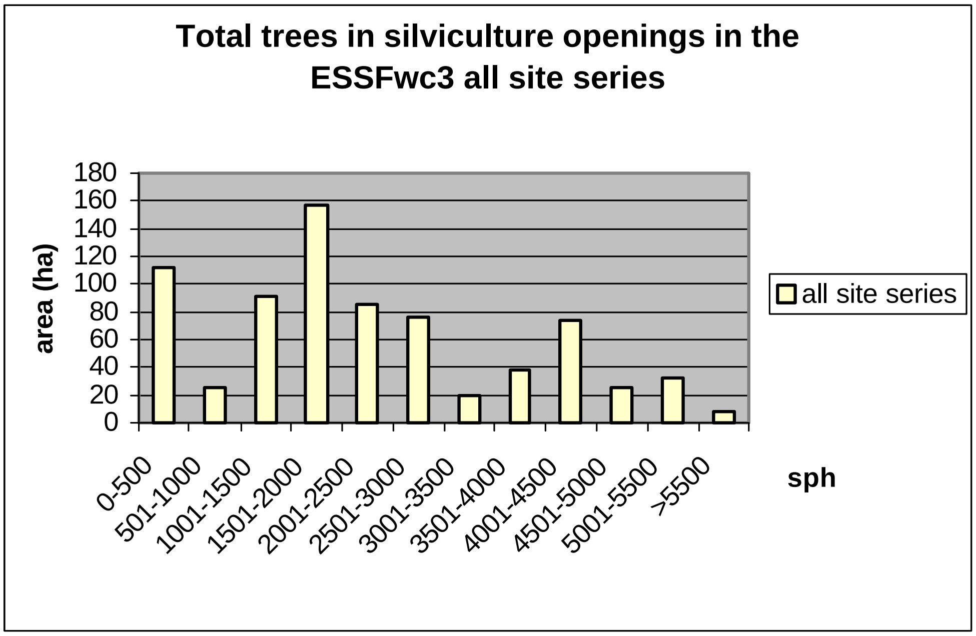

Total trees in sliviculture openings in the SBSmk1
all site series
area (ha)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0-500
1001-1500
2001-2500
3001-3500
4001-4500
5001-5500
>10001
sph
all site series

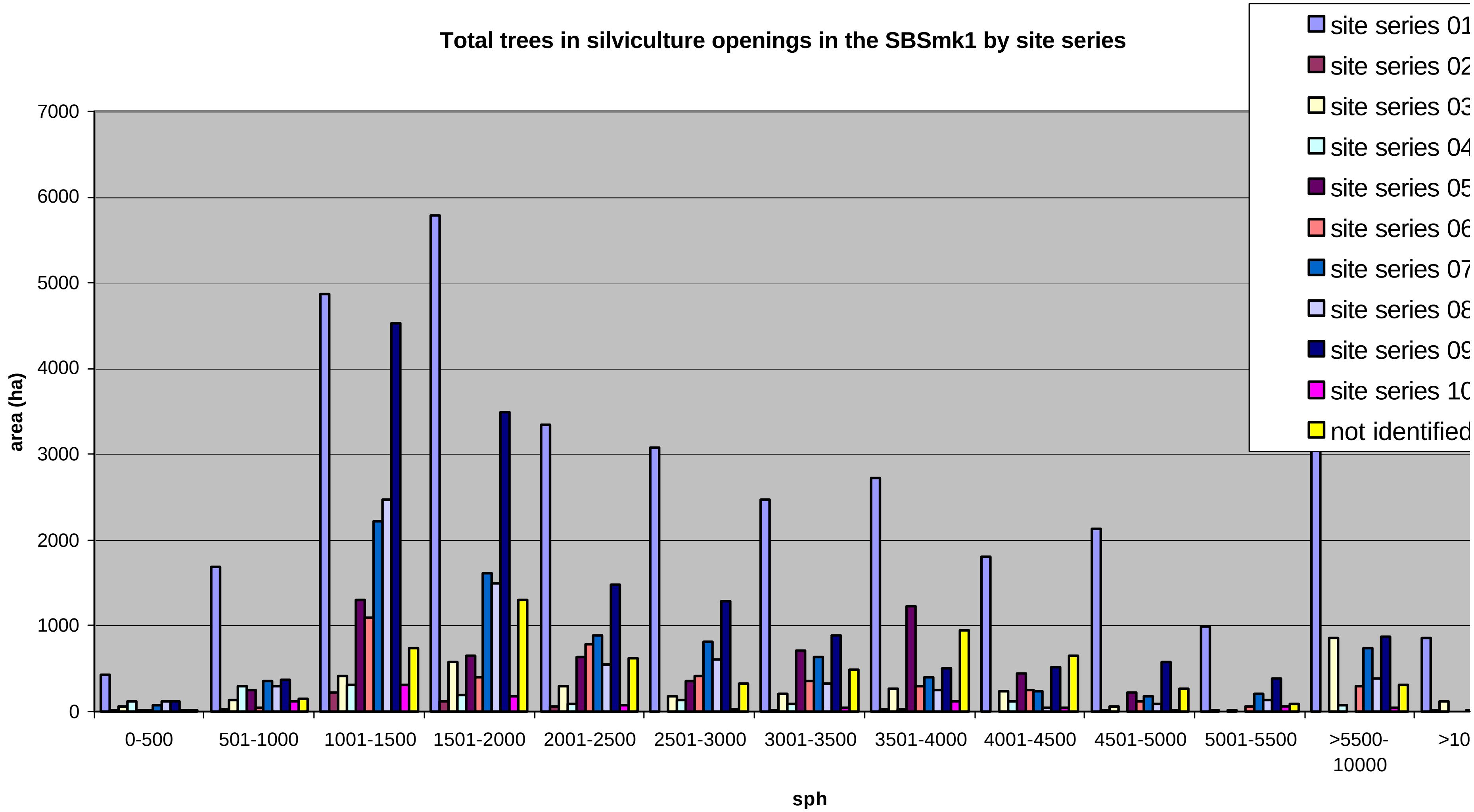

total trees in silviculture openings in the SBSwk1
all site series
area(ha)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0-500
1001-1500
2001-2500
3001-3500
4001-4500
5001-5500
>10001
sph
all site series

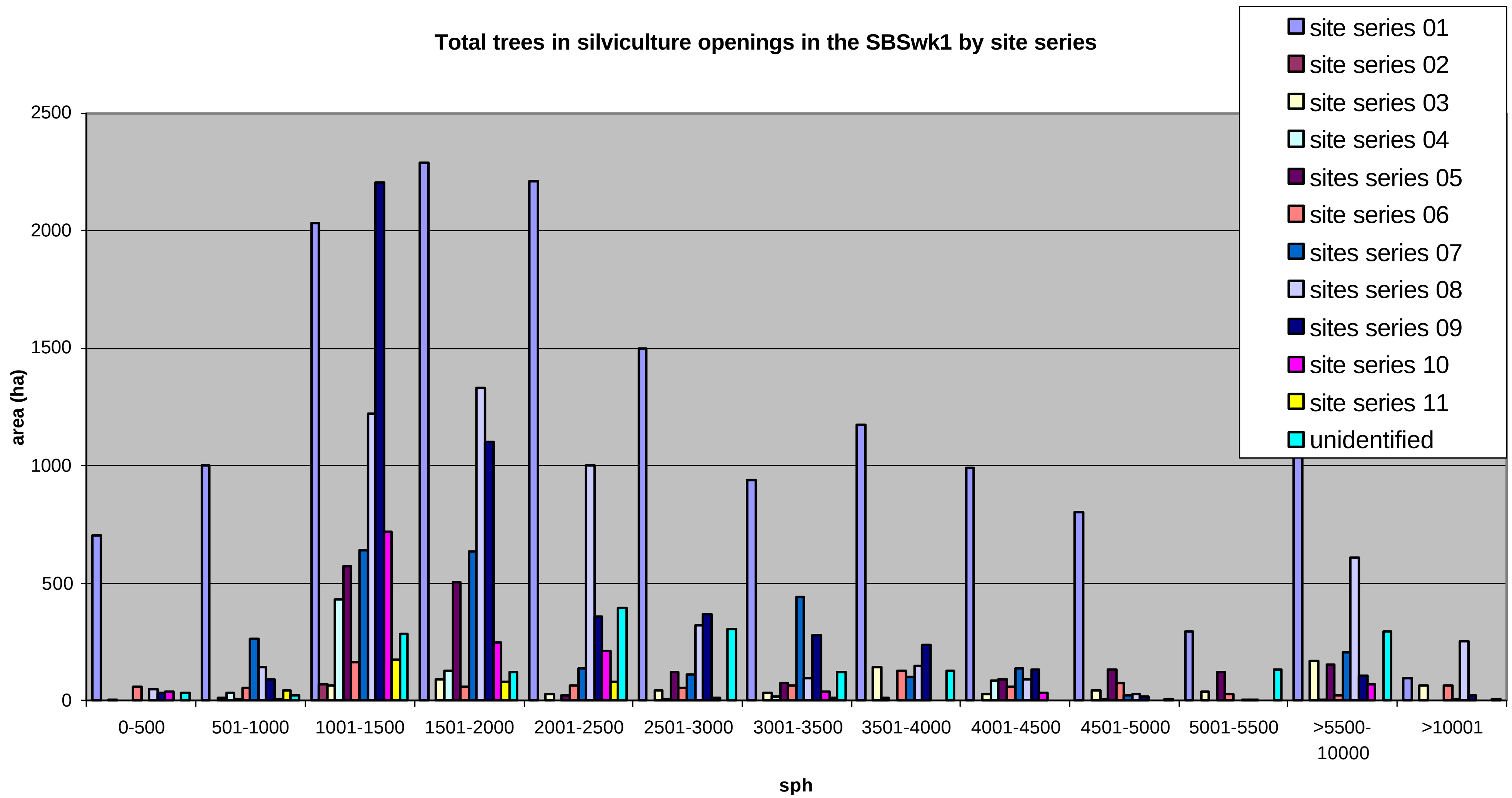

Total trees by silviculture opening in the SBSvk all site series
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
area (ha)
0-500
1001-1500
2001-2500
3001-3500
4001-4500
5001-5500
>10001
sph
all site series

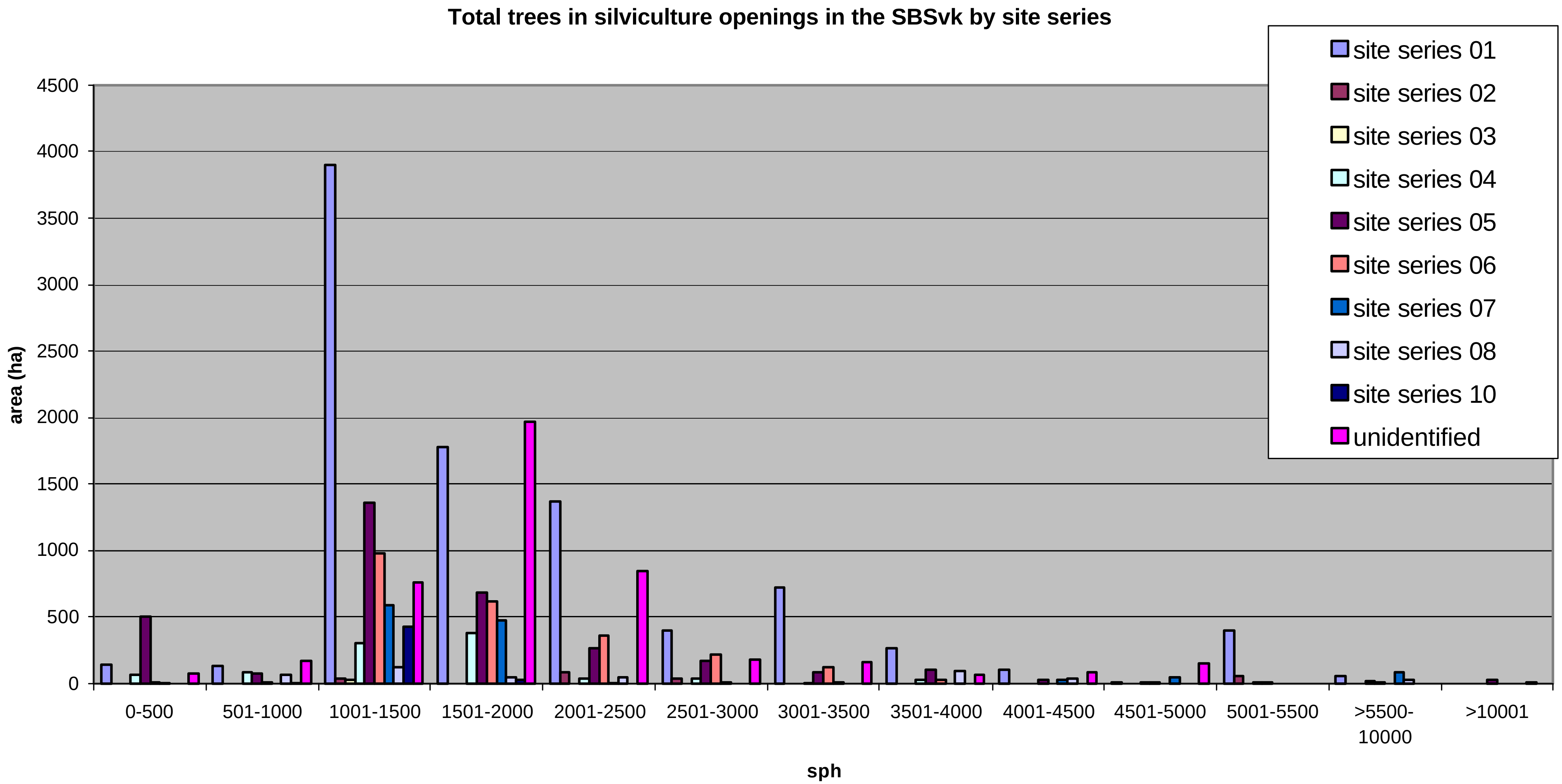

Total trees in silviculture openings in the ESSFwk1 all site series
hectares
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500
sph
all site series

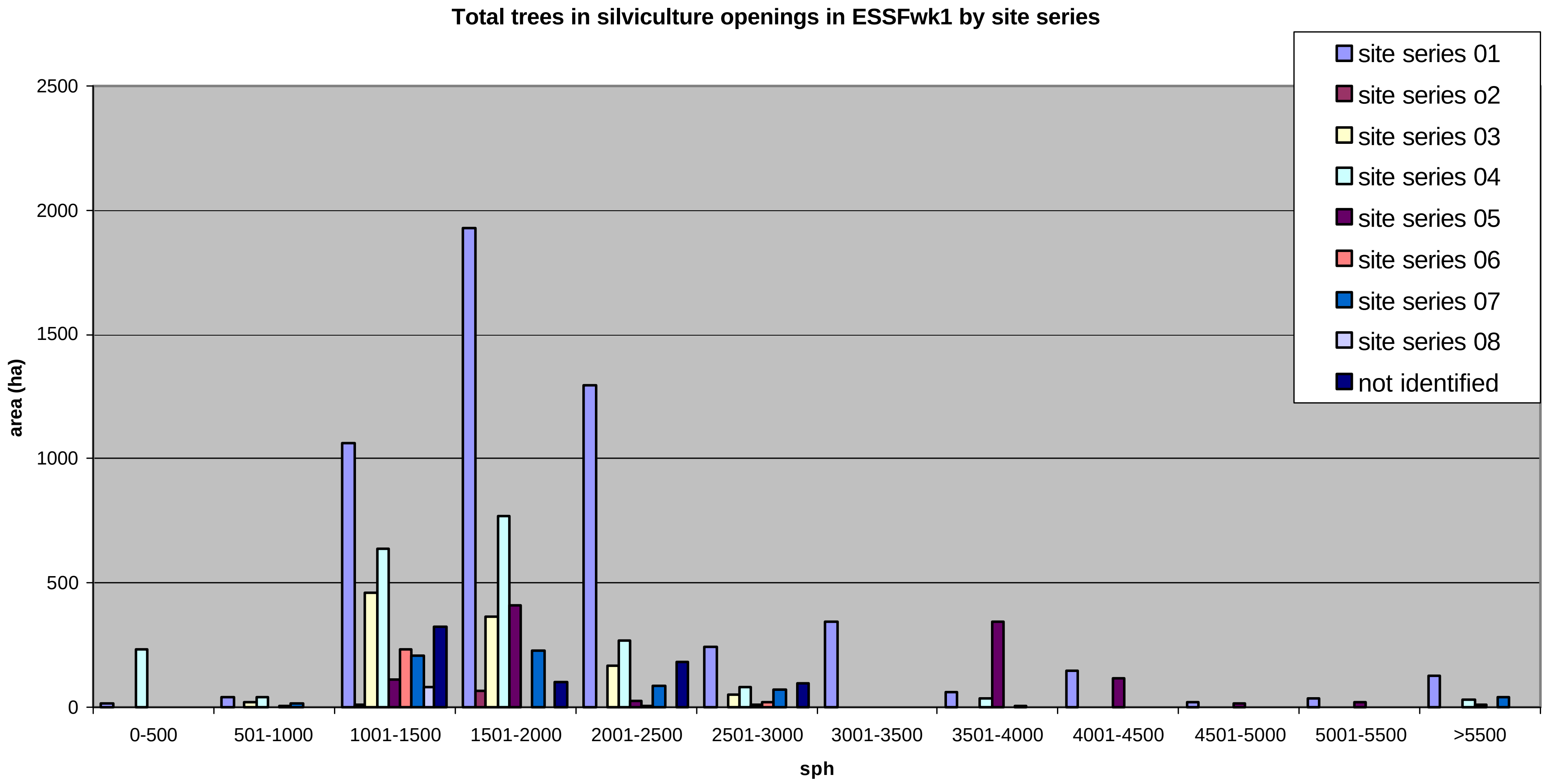

Total trees in silviculture openings in the ESSFwk2 all site series
area (ha)
3500
3000
2500
2000
1500
1000
500
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500
sph
all site series

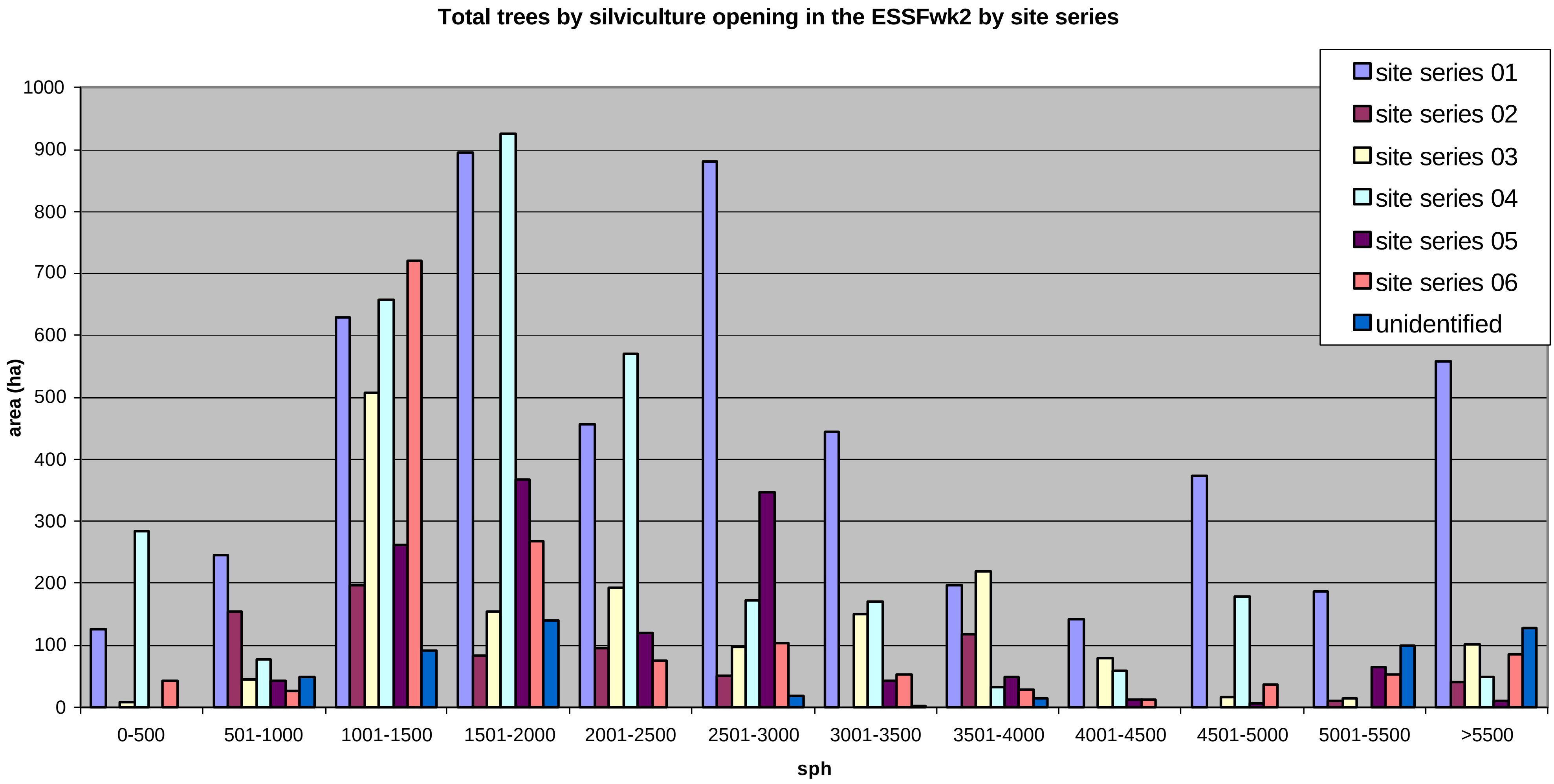

Total trees in silviculture openings in the ESSFwc3 all site series
180
160
140
120
100
80
60
40
20
0
area (ha)
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500
sph
all site series

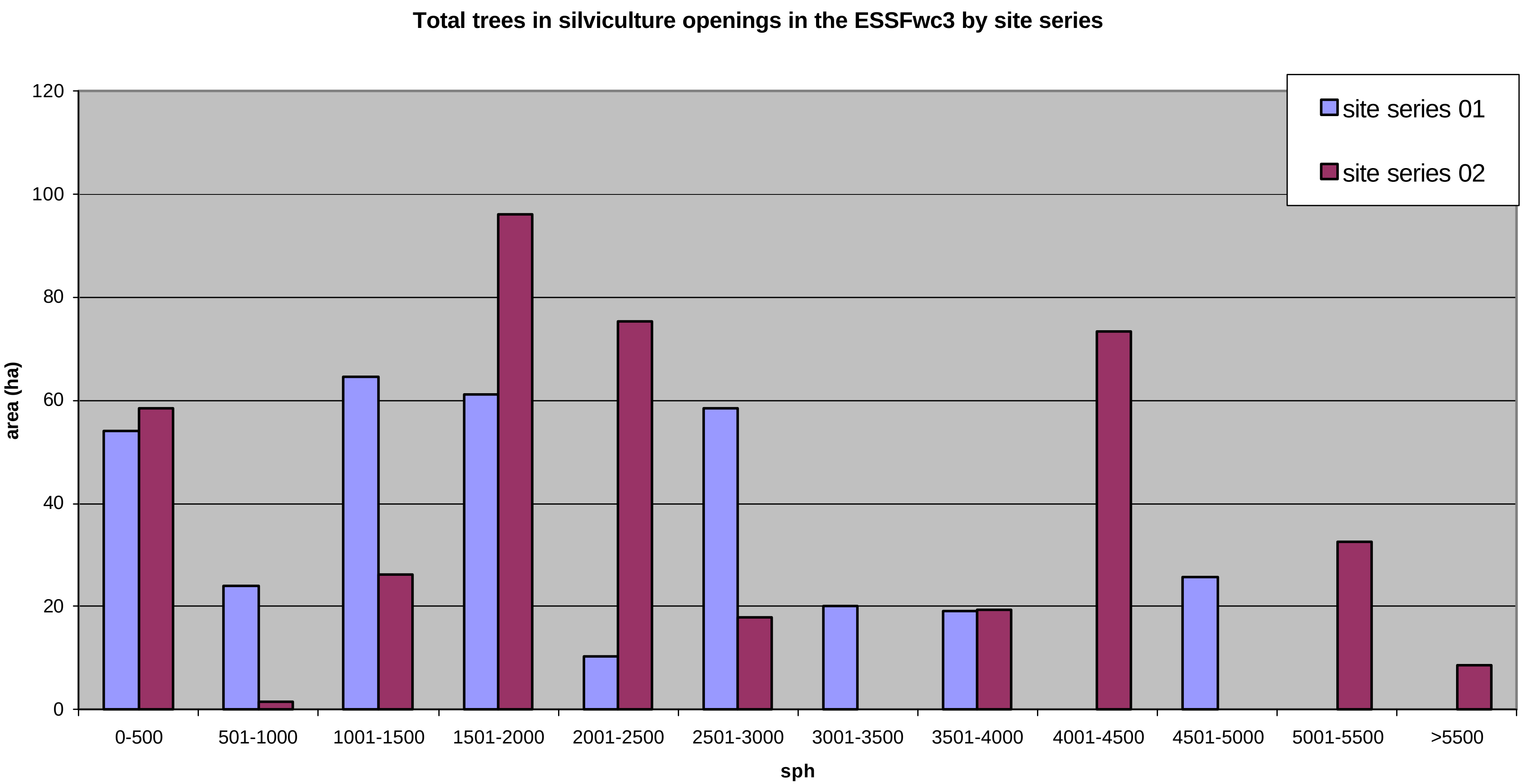

Total trees in silviculture openings in the SBSmk1 by site series
area (ha)
7000
6000
5000
4000
3000
2000
1000
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500-10000
sph
site series 01
site series 02
site series 03
site series 04
site series 05
site series 06
site series 07
site series 08
site series 09
site series 10
not identified


Total trees in silviculture openings in the SBSwk1 by site series
area (ha)
2500
2000
1500
1000
500
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500-10000
>10001
sph
site series 01
site series 02
site series 03
site series 04
sites series 05
site series 06
sites series 07
sites series 08
sites series 09
site series 10
site series 11
unidentified


Total trees in silviculture openings in the SBSvk by site series
area (ha)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500-10000
>10001
sph
site series 01
site series 02
site series 03
site series 04
site series 05
site series 06
site series 07
site series 08
site series 10
unidentified


Total trees in silviculture openings in ESSFwk1 by site series
area (ha)
2500
2000
1500
1000
500
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500
sph
site series 01
site series o2
site series 03
site series 04
site series 05
site series 06
site series 07
site series 08
not identified


Total trees by silviculture opening in the ESSFwk2 by site series
area (ha)
1000
900
800
700
600
500
400
300
200
100
0
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500
sph
site series 01
site series 02
site series 03
site series 04
site series 05
site series 06
unidentified


Total trees in silviculture openings in the ESSFwc3 by site series
area (ha)
0
20
40
60
80
100
120
0-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
4001-4500
4501-5000
5001-5500
>5500
sph
site series 01
site series 02

Appendix 4

Grizzly Bear forage species in climax and pioneer seral site series

Table 1 Forage plants in three SBS variants[1]

SBSmk1	SBSmk1 pioneer seral[2]	SBSwk1	SBSwk1 seral	SBSvk	SBSvk seral
01 -Rubupar[3] -VACCMEM -LONIINV -Rosaaci -RIBELAC -Sorbsco -VIBUEDU	moderate -EPILANG -Rubupar -LONIINV -Rosaaci	01 -LONIINV -RIBELAC -VACCMEM -Rubupar -VIBUEDU (-Oplohor)	Moderate to high -LONIINV -Rubupar -EPILANG -VIBUEDU -RIBELAC -VACCMEM	01 -Oplohor -RIBELAC -Rubupar -VACCMEM -LONIINV -VACCOVA (-VIBUEDU) -Dryoexp -Athyfil -Veravir -STREAMP	very high -Rubupar -Rubuida -Athyfil -EPILANG -LONIINV -RIBELAC -VACCMEM -VACCOVA -VIBUEDU -Veravir
02 uncommon -SHEPCAN -Rosaaci -AMELALN -VACCCAE (-Arctuva) (-Astecon) (-Prunpen)	low -SHEPCAN -Rosaaci -AMELALN -Aster	02 rare -VACCMEM (-EPILANG) (-VACCCAE)	Low -EPILANG -VACCCAE	02 uncommon -VACCMEM -AMELALN -Rosaaci -Sorbsco -LONIINV -VACCCAE -EPILANG -Smilste	low -EPILANG -AMELALN -Rosaaci -Sorbsco -LONIINV -Vaccae -Smilste
03 -Rosaaci -SHEPCAN -Arctuva -VACCCAE	Low -Rosaaci -SHEPCAN -Arctuva -VACCCAE	03 -VACCMEM -Sorbsco -Rosaaci -AMELALN -VACCCAE	Low -EPILANG -Rosaaci -AMELALN -VACCMEM -Sorbsco -VACCCAE	03 -Rubupar -CORNSTO -RIBELAC -VIBUEDU -VACCMEM -Oplohor -STREAMP -Rubupub	low -Rubupar -CORNSTO -RIBELAC -VIBUEDU -VACCMEM
04 uncommon -VACCMEM -Rosaaci -VIBUEDU -AMELALN	Low -VACCMEM -Rosaaci -VIBUEDU -AMELALN	04 uncommon S or W aspects -AMELALN -VACCMEM -Rubupar -RIBELAC -Rosaaci -VIBUEDU	Low -EPILANG -AMELALN -Rubupar -Rosaaci -VACCMEM -RIBELAC -VIBUEDU	04 uncommon -VACCMEM -VACCOVA (-Rubupar) (-Oplohor) (-Dryoexp)	high -Rubupar -Rubuida -Athyfil -EPILANG -VACCOVA -VACCMEM
05 -VACCMEM -Rosaaci -LONIINV -AMELALN -Rubupar -SHEPCAN	low -Rosaaci -LONIINV -VACCMEM -AMELA LN -Rubupar -SHEPCAN	05 -VACCMEM -Rubupar -Sorbsco -RIBELAC -Rosaaci -VIBUEDU -LONIINV -EPILANG	moderate -LONIINV -Rupupar -EPILANG -Rosaaci -VACCMEM -Sorbsco -RIBELAC -VIBUEDU	05 -Oplohor -RIBELAC -LONIINV -Rubupar - Sambrac -VACCOVA -VACCMEM -Rubuida -Athyfil -Dryoexp -Strepto -Veravir -EQUISYL	extreme -LONIINV -Rubupar -EPILANG -Sambrac -Rubuida -Veravir -EPILANG -RIBELAC -VACCOVA -VACCMEM -Veravir -EQUISYL

SBSmk1	SBSmk1 pioneer seral[2]	SBSwk1	SBSwk1 seral	SBSvk	SBSvk seral
06 -VACCMEM -LONIINV -Rosaaci -AMELALN -Sorbsco -VACCCAE -EPILANG	low -Rosaaci -LONIINV -AMELALN -VACCMEM -Sorbsco -VACCCAE	06 uncommon -LONIINV -Alnus -VIBUEDU -Rosaaci -RIBELAC (-Rubupar) -Athyfil	Moderate -LONIINV -Rubupar -EPILANG -Alnus -VIBUEDU -Athyfil	06 -LONIINV -RIBELAC -VIBUEDU -Oplohor -VACCOVA -Rosaaci -Athyfil -Dryoexp -EQUISET -STREAMP (-Lysiame)	high -EPILANG -Rubupar -LONIINV -Rosaaci -RIBELAC -VIBUEDU -VACCOVA -Athyfil -EQUISET
07 –RIBELAC -VIBUEDU -LONIINV -VACCMEM -Oplohor -Rubupar -STREAMP	moderate -LONIINV -Rubupar -EPILANG -RIBELAC -VIBUEDU -VACCMEM -	07 -LONIINV -Rubupar -VIBUEDU -RIBELAC (-VACCMEM) -STREAMP -EQUISET -Athyfil -Dryoexp	moderate to high -LONIINV -Rubupar -EPILANG -VIBUEDU -RIBELAC -EQUISET -Athyfil	07 -RIBELAC - LONIINV -Oplohor -Rubupar -CORNSTO -Sambrac -VIBUEDU -Athyfil -Streptos -EQUISET	Very high -Rubupar -EPILANG -Athyfil -LONIINV -RIBELAC -CORNSTO -Sambrac -VIBUEDU -Athyfil -EQUISET
08 -Oplohor -RIBELAC -Viduedu -LONIINV -Rubupar -Sorbsco -Athyfil	high -LONIINV -Rubupar -EPILANG -RIBELAC -VIBUEDU -Sorbsco -Athyfil	08 -Oplohor -Rubupar -RIBELAC -LONIINV -VACCOVA -VACCMEM -VIBUEDU -Rubuida -Dryoexp -Athyfil -STREAMP	very high -LONIINV -Rupapar -EPILANG -Athyfil -Rubuida -RIBELAC -VACCOVA -VACCMEM -VIBUEDU	08 uncommon -VACCMEM (-VACCOVA) (-Carex) (-Oxycoxy) (-EQUISET) (-Lysiame)	-VACCMEM (-VACCOVA) (-Carex) (-EQUISET)
09a -LONIINV -CORNSTO -Rosaaci -VIBUEDU -RIBELAC -EQUISET -Rubupar -OSMOCHI	high -LONIINV -EPILANG -Rosaaci -VIBUEDU -Rubupar -CORNSTO -RIBELAC -EQUISET -OSMOCHI	09 -RIBELAC -LONIINV -VIBUEDU -Oplohor -Rubuida -CORNSTO (-Alnus) (-Sambrac) -EQUISET -Dryoexp -Athyfil -STREAMP	high -LONIINV -EPILANG -VIBUEDU -Rubuida -Sambrac -RIBELAC -CORNSTO -Alnus -EQUISET -Athyfil	09 rare -VACCMEM (-VACCCAE)	Low -VACCMEM (-VACCCAE)
09b-uncommon -LONIINV -RIBELAC -Rosaaci -Alnus -CORNSTO -VIBUEDU -EQUISET -STREAMP	high -LONIINV -EPILANG -Rosaaci -RIBELAC -Alnus -CORNSTO -VIBUEDU -EQUISET	10 uncommon -Oplohor -CORNSTO -LONIINV -Vibudeu -RIBELAC -Rubupar -Alnus -Athyfil -EQUISET -Dryoexp	very high -EPILANG -Rubupar -Athyfil -LONIINV -CORNSTO -VIBUEDU -RIBELAC -Alnus -Athyfil -EQUISET	10 uncommon -Alnus -VACCOVA -Oplohor -VACCMEM -Lysiame -Athyfil -EQUISET -VALESIT -Dryoexp	-Alnus -VACCOVA -VACCMEM -Athyfil -EQUISET -VALESIT

SBSmk1	SBSmk1 pioneer seral	SBSwk1	SBSwk1 seral	SBSvk	SBSvk seral
10 -Salix -Alnus -LONIINV -Carex -EQUISET -Oxycoxy	-Salix -Alnus -LONIINV -Carex -EQUISET	11 -LONIINV -EQUISET -Carex (-Menytri)	-LONIINV -EQUISET -Carex	11 rare -Alnus -RIBELAC -Rubupar -Athyfil -Dryoexp -STREAMP	-Alnus -RIBELAC -Rubupar -Athyfil
		12 uncommon -SHEPCAN -VACCCAE (-Arctuva)	Low -SHEPCAN -VACCCAE (-Arctuva)		

[1] Species listed in order of occurrence as indicated in the field guides (DeLong 1996, DeLong et al. 1993). Codes as per Table 1.
[2] Pioneer seral stage, information from field guides (DeLong 1996, DeLong et al. 1993) and Beaudry et al 1999 (where species increase or persists in occurrence).
[3] Uppercase is a species with medium or high forage usage.

Table 2 Forage plants in three ESSF variants[1]

ESSF wk1	ESSFwk1 seral[2]	ESSF wk2	ESSFwk2 seral	ESSF wc3	ESSF wc3 seral
01 -VACCMEM[3] -RIBELAC -VACCOVA -Rubupar -Veravir -VALESIT -Smilste	high -Rubupar -EPILANG -Veravir -RIBELAC -VACCOVA -VACCMEM -VALESIT -Smilste	01 -VACCMEM -VACCOVA -RIBELAC (-Rubupar) -Dryoexp (-Veravir)	high -Rubupar -EPILANG -VACCMEM -VACCOVA -RIBELAC -Veravir	01 -VACCMEM -VACCOVA (-RIBELAC) (-Sorbsit) -Veravir -VALESIT -Dryoexp	high -VALESIT -VACCMEM -VACCOVA (-RIBELAC) (-Sorbsit) -Veravir
02 rare -VACCMEM[3] -AMELALN	Low -AMELALN -VACCMEM	02 -S aspects, upper slopes -VACCMEM -Rubupar -Sorbsco (-VACCOVA) (-Dryoexp)	Low to moderate -EPILANG -Rubupar -VACCMEM -Sorbsco (-VACCOVA)	02 -upper slopes -VACCMEM (-Sorbsit) -Rubuped	Low-medium -VACCMEM (-Sorbsit)
03 -VACCMEM -RIBELAC -VACCOVA -Veravir (-VALESIT)	Low -VACCMEM -RIBELAC -VACCOVA -Veravir (-VALESIT)	03 -RIBELAC -Rubupar -VACCMEM -Rubuida -LONIINV -STREAMP -Athyfil -EPILANG	high -Rubupar -EPILANG -Athyfil -Rubuida -LONIINV -RIBELAC -VACCMEM	03 -VACCMEM -RIBELAC -VACCOVA -VALESIT -Senetri -Veravir (-EPILANG)	high -VALESIT -RIBELAC -VACCOVA -VACCMEM -Senetri -Veravir -EPILANG
04 -LONIINV -RIBELAC -VACCMEM -VACCOVA -Rubupar -VALESIT -Veravir -Strepto -EPILANG -Athyfil -Dryoexp	high -Rubupar -EPILANG -Athyfil -LONIINV -RIBELAC -VACCMEM -VACCOVA -VALESIT -Veravir	04 -Oplohor -VACCMEM -VACCOVA (-Rubupar) -Dryoexp -Veravir (-Athyfil)	very high -Athyfil -Rubupar -EPILANG -VACCMEM -VACCOVA -Veravir	03 wet phase[4] (similar to ESSFwk1/06) -VACCOVA -EQUISET -VALESIT -Senetri -HERALAN -Athyfil -Veravir	high -VALESIT -EQUISET -VACCOVA -Senetri -HERALAN -Athyfil -Veravir

ESSF wk1	ESSFwk1 seral	ESSF wk2	ESSFwk2 seral	ESSF wc3	ESSF wc3 seral
05 -Oplohor -Rubupar -RIBELAC -VACCMEM -Sambrac -VACCOVA -Athyfil -Veravir -Strepto -Dryoexp -Valersit	Very high -Athyfil -EPILANG -Rubupar -RIBELAC -Sambrac -VACCOVA -VACCMEM -Veravir -Valersit	05 -VACCMEM -Rubupar -Sambrac (-Oplohor) -Athyfil -Dryoexp -Veravir -VALESIT (-EQUISET)	Very high -Athyfil -EPILANG -Rubupar -Sambrac -VACCMEM -Veravir -VALESIT (-EQUISET)		
06 rare -VACCMEM -LONIINV -RIBELAC -Salix -EQUISET -Carex -	high -EPILANG -VALESIT -LONIINV -RIBELAC -Salix -VACCMEM -EQUISET -Carex	06 uncommon -VACCMEM -LONIINV (-RIBELAC) -EQUISET -Dryoexp (-VALESIT)	high -EPILANG -VALESIT - LONIINV -EQUISET -VACCMEM (-RIBELAC) (-VALESIT)		
07 -LONIINV -RIBELAC -VACCMEM -VACCOVA -Rubupar -Athyfil -VALESIT -EQUISET -	very high -Athyfil -Rubupar -EPILANG -LONIINV -RIBELAC -VACCMEM -VACCOVA -VALESIT -EQUISET	31 uncommon -Salix -EQUISET -Carex	-Salix -EQUISET -Carex		
08 rare -LONIINV -Salix -Carex -EQUISET -Senetri	-LONIINV -Salix -Carex -EQUISET -Senetri				
09 rare -Alnus -RIBELAC -Rubupar -Athyfil -Dryexp -STREAMP	-Alnus -RIBELAC -Rubupar -Athyfil				

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[3] Uppercase is a species with medium or high forage usage.
[4] In the ESSFwc3 few site series have been described, an additional phase for one of the site series has been identified in other fieldwork (Beaudry 1999) and included here.