Extension Note – DRAFT Long All Zones

Soopolallie: Implications of logging, site and climatic factors on plant cover and berry abundance in British Columbia

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EXECUTIVE SUMMARY

1. Berry producing soopolallie plants occurred in cutblocks and other open sites as well as closed canopy forests from the IDF zone up to the ESSF and north to the BWBS zone; cover was generally fairly low. Site characteristics such aspect, slope angle and elevation influenced berry abundance with better berry production on warmer sites with nuances by zone. Management for berry production should focus on sites with the greatest potential to produce berries now and into the future with consideration for implications of climate change.

2. Soopolallie berry production was positively correlated with soopolallie plant cover. Management practices that focus on maintaining and/or enhancing soopolallie plant cover are recommended to provide for optimal berry production.

3. Soopolallie plants occurred in logged and unlogged sites and in sites with a range of canopy covers. Canopy cover was generally lower in logged sites. Average soopolallie cover was generally greater in unlogged sites, however**, berry abundance was generally greater in open logged sites**. Berry production generally declined as canopy cover increased presumably due to negative effects of shade and greater competition for resources associated with overtopping plants. Management practices should aim to maintain and/or enhance soopolallie plant cover by minimizing negative impacts on existing plants during logging and by maintaining open canopy areas over time.

4. Weather conditions in current and previous years influenced berry production; the timing of weather events has implications for flowering success and berry maturation. For example, exposure to freezing conditions when plants are not hardy can have negatively impacts, cold wet spring weather can reduce flowering success and hot dry conditions summers can limit berry development. Management should focus soopolallie protection and enhancement activities across a range of geographic areas to help ensure sufficient berry production in some areas every year – given the existing and/or expected variability in weather patterns now and into the future.

1. INTRODUCTION

2.1 Cultural Context

Soopolallie or soapberry (*Shepherdia canadensis*) has been highly valued by Indigenous Peoples across British Columbia and beyond (Canada, US) for generations. This culturally significant deciduous shrub is known to many different Nations, each with their own name for the plant and understanding of its characteristics and uses. These names often reflect key features such as the shrub's phenology, sensory traits, habitat preferences, seasonal timing and role as an ecological indicator (Turner, 2005; Turner & Reid, 2022). In some cases, names and place names refer directly to where the plant is found, such as "the place of soapberries" (Turner, 1980). The language reflects a longstanding relationship with the land and the plant's ecological patterns (Turner, 2005; Turner & Reid, 2022), including the uses by other species, such as the grizzly bear.

Also known as Canadian buffaloberry, soopolallie is closely tied to cultural practices such as ceremony, storytelling, and seasonal rhythms. In many regions, its flowering and fruiting serve as phenological cues, including indicators of salmon runs (Turner & Reid, 2022). The FirstVoices platform (https://www.firstvoices.com/) offers further insight into the diverse Indigenous names for soapberries and their uses across the province.

Soapberries continue to be a widely used and celebrated cultural food among both coastal, northern and interior First Peoples in British Columbia (Turner, 2005). Soapberries are a high-energy food source that is easily metabolized, rich in antioxidants and essential vitamins, and efficiently converted into fatty tissue (Turner, 2005). Relative to other temperate berry species, soapberries exhibit a higher soluble sugar concentration (Green & Low, 2013; Riedl et al., 2013). They contain saponins, a class of naturally occurring chemical compounds that allow the berries to be whipped into a frothy dessert commonly known as "Indian Ice-cream" (First Nations Health Authority, 2020). Traditional Ecological knowledge across Indigenous territories reveals generations of land-based understandings and stewardship practices that support soapberry health and growth. For centuries, many communities have known that soapberries thrive in open canopies and actively managed berry patches through practices such as pruning and cultural burning (Gottesfeld, 2011). Gottesfeld's (1993) research in the Gitxsan and Wet'suwet'en territories, for example, documented the use of light burns to enhance productivity, recognizing that several years might be needed for complete regrowth (cited in Deur & Turner, 2011). These place-based practices demonstrate the intricacies of Indigenous understandings of plant succession; forest dynamics and the reciprocal care grounded in ancestral knowledge.

In addition to its role as a food source and ecological indicator, soapberry holds cultural and spiritual significance. It has long been used in trade, weaving, and dyeing, and is respectfully acknowledged by communities in medicine (Turner, 2005; Marles et al., 2000). As with many culturally significant plants, the sharing of detailed medical knowledge is often subject to community protocols. Soapberries are also woven into oral histories (Turner, 2005), teaching and stories, frequently appearing alongside animal and plant relatives in Indigenous narrative across the region.

2.2 Management context

In BC protecting and enhancing plants of particular importance to Indigenous people and wildlife is an increasingly important management goal. There is much interest in increasing habitat suitability for grizzly bears (*Ursus arctos horribilis*), a species of special concern in British Columbia (COSEWIC 2012). *Shepherdia canadensis* berries (Figure 1) are often selected by grizzly bears in summer or early fall (McLellan and Hovey 1995, Nielsen et al. 2004, McClelland et al. 2020, Clarke 2022) when bears require considerable calories prior to hibernation (Nelson et al. 1983). Soopolallie is widespread in BC; it's ecological distribution is provided in the Biogeoclimatic Ecosystems Classification (BEC) Regional Field Guides (BECweb 2025). Here, we present the results of an analysis to examine how climatic conditions, site factors and forestry practices influence soopolallie plant cover and berry production and provide guidelines to maintain and enhance berry production based on this work, and that of others.

Soopolallie is an upright, shade-tolerant, early to mid seral, drought and frost tolerant, deciduous, nitrogen fixing, dioecious shrub that grows to several m in height; female plants have small red berries that grow in clumps called sprays. It occurs predominantly in boreal and other cool temperate climates in very dry to moderately dry conditions, often on sandy, rocky, or gravelly nutrient poor soils (Lamb 2015, Klinkenberg 2021). In BC, it is typically found in interior valleys on open mesic to dry sites

Figure 1 Soopolallie (*Shepherdia canadensis*) berries and leaves. Photo credit: Garth Mowat.

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2. METHODS

Soopolallie cover (%) and plot-level predictor variables were collected from 343 plots across BC in 2016, 2017, 2018 and 2022 (Figure 2) using standard ecological methods (British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment 2010). Berry abundance (berries/100 m^2) was collected using methods described in the more detailed Soopolallie Research Report (Chandler et al. 2025 draft). Predictor variables included site variables[1] (canopy cover[2], elevation, latitude, longitude, slope and aspect), site history (unlogged or various silviculture systems including clearcut and clearcut with reserves), and modelled climate data for the current year as well as the two preceding years. "Unlogged" sites could include meadows, bogs, shrublands and old or mature unlogged forests. These data were downloaded from the ClimateBC database (Wang et al. 2016, ClimateBC.ca).

Sampling occurred in locations with bear foods and was not targeted at sites where bear foods (i.e. berries) were not expected to be found. The study does not represent a comprehensive provincial assessment, as sampling intensity varied by BEC subzone variants and many variants were not sampled. Relationships described as significant had *p* values of <0.05. Further details regarding sampling and analysis methods and results are found in Chandler et al. 2025 Research Report "*Shepherdia canadensis* (soopolallie): Implications of logging, site and climatic factors on plant cover and berry abundance in British Columbia".

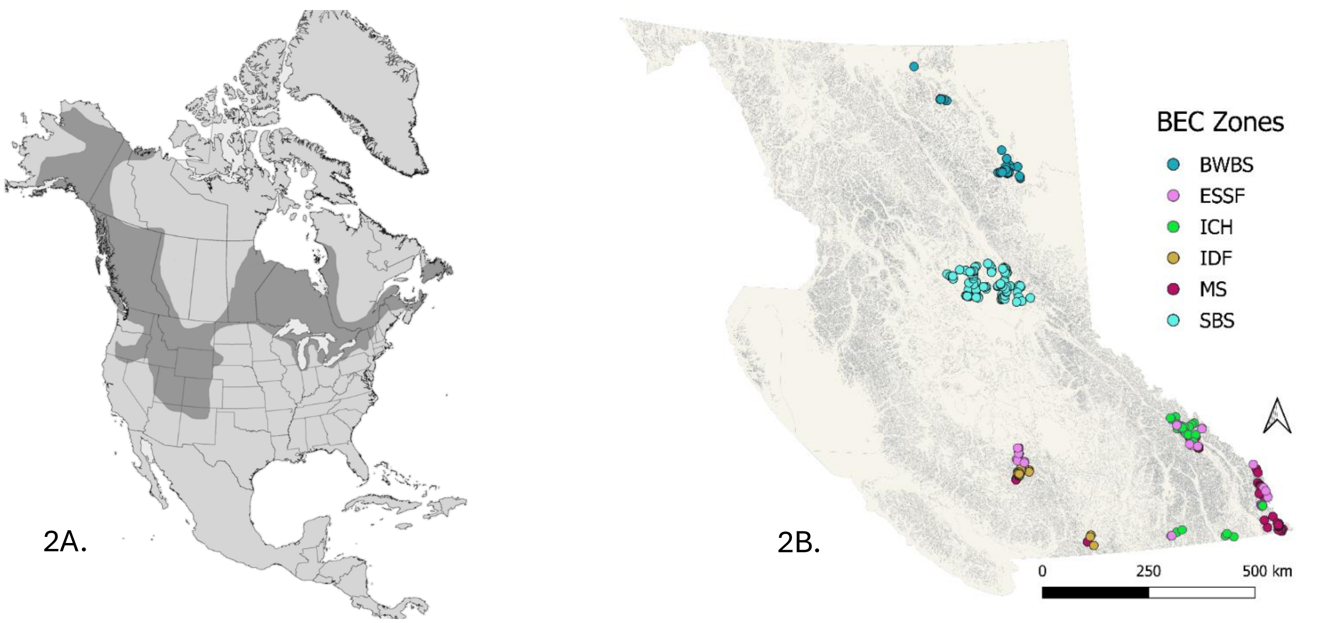

Figure 2 A) Distribution of soopolallie (*Shepherdia canadensis*) across North America[3]; and B) sample sites located in six Biogeoclimatic zones across British Columbia, Canada. Elevation is represented in gray with areas of higher elevations showing darker shading.

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[1] Site data included BEC unit, canopy cover, % slope, aspect (azimuth), elevation, and whether the site had been logged or not. Azimuth values were converted to "folded aspect" such that the sites that receive comparable solar radiation (heatload) have comparable aspect values (See McCune, 2007).

2 Percent canopy cover refers to the amount of cover of other vegetation (typically trees and tall shrubs) that overtop ground level vegetation.

3 Shepherdia canadensis North American distribution map from Virginia Tech Dendrology Fact Sheet.

3. RESULTS

The relationships between soopolallie cover and berry abundance and ecological and site conditions and site history observed in this study are described in this section.

3.1 Location of study sites

Berry producing soopolallie plants occurred in a wide range of ecological conditions in BC from recent cutblocks and other open sites to closed canopy forests in the valley bottom IDF zone up to the mountain top ESSF zone and north to BWBS zone (Figure 2). Soopolallie was sampled in 353 plots; it was recorded in >6 plots per zone in the MS, IDF, ICH, SBS, ESSF and BWBS BEC zones and <7 sites per zone in other sampled zones (Table 1).

3.2 Relationship between soopolallie berry abundance and plant cover

Soopolallie plant cover was quite low in almost all sampled sites; mean cover in a zone was less than or equal to 10% (Table 1). Soopolallie berry production was positively correlated with soopolallie plant cover (r=0.34). Highest correlations were between cover and berry abundance in unlogged plots in the IDF (r=0.79) and the ESSF and (r=0.65); and lowest correlations were in logged plots in the ESSF (r=0.15) and the SBS (r=0.24).

Soopolallie berry abundance ranged up to 49,655 berries/100m^2 where species cover was ≥10%. There were more berries (p<0.001) where plant cover was ≥7% (5264 berries/100m^2, n=83) vs where cover was <7% (1890 berries/100m^2, n=270) (Figure 3).

3.3 Relationship between canopy cover and logging

Canopy cover was significantly higher (p<0.001) in unlogged plots sites ($\bar{x}$=33%, n=240) compared to logged plots ($\bar{x}$=6%, n=113) (Figure 4).

Canopy cover in logged sites did not exceed 30% and exceeded 15 % in only 10 plots; in unlogged sites it was up to 80% and 51% of the plots had ≥30% canopy cover.

3.4 Relationship between soopolallie cover, BEC zone, logging history and canopy cover

Soopolallie plants occurred in logged and unlogged sites, in sites with a range of canopy cover.

Soopolallie cover up to 13% was found in logged sites and up to 31% in unlogged sites. Median soopolallie cover was 3.5% in all zones (Figure 5A); mean cover was greater (p<0.001) in unlogged sites ($\bar{x}$=5.5%, n=240) vs logged sites ($\bar{x}$=3.7%, n=113).

Soopolallie cover was greater (p=0.035) in sites with >20% canopy cover ($\bar{x}$=5.5%, n=173 vs in sites with ≤20% canopy cover ($\bar{x}$=4.4, n=180) (Figure 5B).

3.5 Relationship between berry abundance and logging history and canopy cover.

Median berry abundance is less than about 3000/100m^2 in any zone/logging history combination (Figure 6A). Half the plots (i.e. 170/339) had a berry abundance of >1000 berries/100m^2; about two thirds of these (i.e. 113/170) were in unlogged plots.

Berry abundance was generally greater (p=0.014) in logged sites ($\bar{x}$=3920 berries/100m^2, n=113) vs unlogged sites ($\bar{x}$=2100 berries/100m^2, n=240). Open sites with <20% canopy cover had greater berry abundance (p<0.001) ($\bar{x}$=3622 berries/100m^2, n=180) vs sites with >20% canopy cover ($\bar{x}$=1707 berries/100m^2, n=173) (Figure 6B.)

3.6 Influence of logging, canopy cover and weather conditions on soopolallie cover and berry abundance by zone

Weather conditions in current and previous years influenced berry production; the timing of weather events has implications for flowering success and berry maturation.

3.6.1 BWBS Zone

In the BWBS, all plots were in the BWBSmk subzone and only a single plot was logged. Berry abundance increased with soopolallie cover (r=0.56) and with slope (r=0.45; maximum slope of 33%), with no significant correlations with other predictor variables. was greater where canopy cover was <=35% (mean # berries/100m^2=2207, n=30) vs where it was >35% (mean=886, n=30). There were more berries (p=0.002; mean=1945 berries/100m^2 vs mean=859 berries/100m^2) and greater plant cover (p=0.035; mean=4.5% vs mean=2.7%) where April maximum temperature was 8°C or higher (n=38) vs lower (n=22) (i.e. warmer spring conditions).

3.6.2 SBS Zone

In the SBS, 67% of the plots were not logged. Plots were in the SBSdw3 (n=19), mk1 (n=66), wk1 (10), wk2 (n=7) and wk3 (n=5) subzone variants. Berry abundance was positively correlated with soopolallie cover in plots that were not logged (r=0.48) and weakly positively correlated in plots that were logged (r=0.24). Soopolallie cover was significantly higher (p<0.001 in unlogged sites ($\bar{x}$=6.3%, n=72) compared to logged sites ($\bar{x}$=2.2%, n=35)

Higher berry abundance (p=0.031) occurred in unlogged plots that had up to 25% canopy cover ($\bar{x}$=3924 berries/100m^2, n=35) compared to unlogged plots with canopy cover >25% ($\bar{x}$=1659 berries/100m^2, n=37).

Overall, in these cool and warm SBS subzones, higher soopolallie cover and berry abundance were found in unlogged plots.

3.6.3 MS Zone

In the MS zone, 55% (37/67) of the plots were not logged. Plots were in the MSdc1(8), dk (17), dm2 (1), dw (35) and xv (6) subzone variants. Berry abundance was moderately positively correlated with soopolallie plant cover (r=0.37). Berry abundance was greater in logged vs unlogged plots (p=0.035; n=64) while no difference in plant cover was found with logging.

3.6.4 IDF Zone

In the IDF, 70% (16/23) of plots had not been logged. Plots were in the IDFdc (17) dk2 (3) and xc (3) subzone variants. Soopolallie cover was weakly positively correlated with canopy cover in plots that had not been logged (r=0.32) and that had higher precipitation in August of the current year (r=0.29). Generally, plant cover was greater where there had been moister weather conditions.

Berry abundance was strongly positively correlated with soopolallie plant cover in plots that had not been logged (r=0.85) and moderately positively correlated in logged plots (r=0.49). Abundance increased with elevation (r=0.70) in logged plots and was greater where there had been cooler spring temperatures.

3.6.5 ICH Zone

In the ICH, 50% of the 52 plots were logged. Plots were found in the ICHdm (1), dw1 (3), mk4 (12), mk5 (1), mw1 (20), and mw5 (1) subzone variants. Soopolallie cover was slightly lower in logged plots (r=-0.28) and positively correlated with average and minimum winter temperatures (r=0.28 to 0.31) and negatively correlated with degree days below zero in the winter (r=-0.31), indicating that cover was higher where conditions were not as cold. Berry abundance was weakly positively correlated with soopolallie cover (r=0.39) and was somewhat higher in logged plots (r=0.34). Berry productivity decreased with increasing canopy cover (r=-0.45), with fewer berries (*p*=0.002) under canopy cover ≥20% ($\bar{x}$=594 berries/100m2, *n*=22 vs $\bar{x}$=3936 berries/100m2, *n*=30). Abundance was higher in plots that had experienced moister weather conditions (r=0.3 to 0.4) and where there had been more snow the previous January ($\bar{x}$=4058 berries/100m2, *n*=25 vs $\bar{x}$=1099 berries/100m2, *n*=27).

3.6.6 ESSF Zone

Of the 32 plots in the ESSF zone, 62% were not logged. Plots occurred in the ESSFxv (3), xc (5), dk1 (4), dk2 (6), dv2 (6), mh (2) and mm (6) subzone variants. Soopolallie cover was positively correlated with indicators of moist cool winter and moist spring climatic conditions (r=0.50 to 0.59, respectively), and higher summer humidity (r=0.40). Berry abundance was positively correlated with soopolallie plant cover (r=0.52), May climatic moisture index the previous year (r=0.46), and relative humidity 2 years prior (r=0.58). Berry abundance was also negatively correlated with indicators of higher maximum winter temperatures in February (r=-0.49) and January (r=-0.41), and May climatic moisture deficit of the previous year (r=-0.48).

4. DISCUSSION

4.1 Introduction

Our study included sites from a wide range of BEC zones that had a range of disturbance histories (e.g. logging and site preparation methods) and were sampled in a range of years. We found that factors associated with these conditions (e.g. climatic conditions in different areas, weather conditions in different years) varied and were important determinants of plant cover and berry abundance. This should be kept in mind when comparing our results to those from other studies which were done in specific locations characterised by particular climatic regimes, site factors, harvesting regimes and recent weather conditions – and are thus not necessarily comparable to our results.

4.2 Relationship between soopolallie cover and berry abundance

We found an overall a positive correlation between soopolallie cover and berry abundance. (Knight (1999) reported a similar relationship. However, we found that sites that had the greatest plant cover didn't necessarily provide the greatest berry abundance. Soopolallie cover was usually best correlated to site factors like canopy cover, aspect, and slope, whereas berry abundance was best correlated with climatic conditions. It is difficult to distinguish influences of canopy cover vs. those associated with logging as logging results in reduced canopy cover for at time. Because berry abundance varies so much year to year using soopolallie cover as a metric to identify best sites to manage for abundance is reasonable.

Site conditions (Lamb 2015), climatic conditions in current and past years (Knight 1999, Krebs et al. 2009, McLellan 2023) and availability of pollinators (Lin et al. 2015) are known to affect berry production. Lin et al. (2015) found parent plant density affected pollinator behaviour and hence berry abundance. Denny et al. (2018) reported that soopolallie fruit density was a function of environmental and demographic factors such as local canopy cover (Hamer 1996, Nielsen et al. 2004b).

4.3 Influence of climatic and weather conditions on soopolallie cover and berry abundance

Suitable conditions for berry production existed across a wide range of BEC zones and ecological conditions. Mean cover was highest in the IDF, the warmest and driest zone; colder wetter zones (e.g. BWBS, ICH) appear less favourable for cover and berry production (See the UBC subzone variant climate analysis).

There were BEC zone-specific nuances. In the ICH on logged sites, and in the MS, which is a fairly dry and cool zone, warmer aspects with moister environments appear to provide better conditions for berry abundance. Climatic conditions in parts of the MS are similar to the IDF, although the MS is generally cooler and moister. In the SBS plant cover was higher where conditions were cooler, whereas berry abundance was higher where there had been warmer spring conditions (i.e. circa above 0 ^{0}C) and drier November conditions. In the cold climate of the BWBS, the more open canopy sites had higher berry abundance, possibly because open sites offer warmer conditions, greater light availability and deeper snowpacks. Deeper snowpack may provide greater frost protection and conditions favourable to soopolallie berry production.

Our results are consistent with others in recognizing the importance of climatic conditions in the current and preceding year on berry abundance and plant cover. Soopolallie is a very widely distributed species found in mesic to dry sites in the lowland and steppe and to subalpine and boreal; its is common throughout BC, elsewhere in Canada and in parts of the USA (Fig 2A, Walkup 1991, Klinkenberg 2021). It is characteristic of montane (Wilkinson 1990) and temperate and boreal forests (LaRoi and Hnatiuk 1980). In the Kootenays, Lamb (2015) found soopolallie was most likely to occur in areas where the mean annual precipitation and canopy cover were the lowest. In the

Yukon where soopolallie is quite abundant its berry production was strongly positively correlated with previous July rainfall (Krebs et al. 2009), indicating berry production is sensitive to climatic conditions in previous summers. Knight (1999) reported that berry biomass was influenced by weather patterns. Having sufficient snowfall, sufficiently warm winter temperatures to avoid freezing damage and sufficient summer rain, especially in drier regions, appears important.

4.4 Influence of canopy cover and disturbance history on soopolallie cover and berry abundance

Our results are consistent with others who observed that soopolallie is well adapted to open canopy environments (McLellan 2018, Bateman and Nielson 2020, Nielson et al. 2004**,** Clarke 2022) and that open sites support better berry production (Burton 2006,1998, Bateman and Nielson 2020, Burton et al. 2000, Clarke 2022).

We found plots that had not been logged had at least 20% more canopy cover than logged plots in all zones. Because of the considerable reduction in canopy cover from logging, it is difficult to separate the implications of canopy cover per se from those associated with logging.

Overall, our results are consistent with studies that found soopolallie is tolerant of timber harvesting insofar as it can resprout after disturbance and is adapted to open areas (Schryer et al. 2011). We could not evaluate the implications of site preparation treatments per se. In a previous study (Souliere et al. 2020) found that in the Alberta foothills, soopolallie was more likely to occur in harvested areas than in mature forest and that fruit production was greater in disturbed stands vs mature forests and peaked in young stands (circa 20 year) compared with younger (5 year) and older age (60 year) classes. Logging can reduce soopolallie abundance when mechanical site preparation is involved; harvesting alone was not observed to reduce the occurrence of soopolallie without this intervention in some areas (Nielson et al 2004). In southeast BC, no difference in plant abundance was noted in logged sites vs mature forest however scarification in logged sites reduced the number of soopolallie bushes (Knight 1999, Souliere et al. 2020, Nielson et al. 2004).

We could not determine implications of burning per se, although it is likely that some or many logged areas had been burned. Burning was reported to be positive for soopolallie plants and berry production (Hamer et al. 1983, Noble 1985, Walkup 1991). Soopolallie occurrence was positively correlated with time since fire in the BC mountain parks (McLellan 2018). Soopolallie can be negatively impacted by severe fires that destroy root systems and impact its regrowth, and it may take many years for plants to recover (Zager et al. 1983). However, prescribed burning may be a useful tool to maintain open canopies and reduce competition from other species (Clarke 2022). Berry abundance can be high for many decades after a wildfire (McLellan, B. pers. comm. 20025).

4.5 Implications of ecological factors on soopolallie cover and berry abundance

Our results are generally consistent with other studies that observed soopolallie cover and berry abundance is affected by environmental conditions corresponding to BEC unit and elevation, aspect and slope. Other studies found soopolallie was adapted to warm, sloping sites and influenced by factors associated with elevation (Lamb 2015, Ferguson and Byrne 2016 and Nielson et al. 2004, Klinkenberg 2020 BC). In the Pacific Northwest, Ferguson and Byrne (2016) found soopolallie was most likely to occur on warm aspects. In another study, buffaloberries were found to ripen first on south-facing aspects, but to dry up sooner than on other aspects (Hamer 1996). Other studies captured some nuances that we have not presented fully here. For example, Nielson et al. (2004) reported the probability of occurrence decreased with elevation between 1050 to 1500 m and increased with an increase in slope aspect index, an indicator of site warmness. Lastly, the probability of soopolallie occurring increased somewhat as global radiation and % slope increased in the Kootenays; it was more likely to occur on mid slope or valley bottom sites and where soils have a higher coarse fraction, less sand, and low organic C and higher pH (Lamb 2015).

The impacts of slope on soopolallie cover and berry abundance varied by BEC zone. We found soopolallie plant cover was greater on steeper slopes in the BWBS and weakly negatively correlated with slope angle in the ESSF and ICH. The relationship varied on logged vs unlogged sites; notably, in the ESSF cover was strongly negatively correlated with slope angle on unlogged sites and not correlated on logged sites. Berry productivity was weakly positively correlated with slope angle in most zones.

The influence of aspect on soopolallie cover and berry abundance varied by BEC zone. In the ESSF, berry abundance was greater on the warmer aspects in unlogged sites but lower on logged sites. In the ICH, berry abundance was greater on warmer aspects in logged sites but had no strong correlation with aspect in unlogged sites; this was also true for plant cover in the MS. In cooler zones, conditions provided on warmer aspects appear to be beneficial; this is consistent with soopolallie being adapted to warm dry conditions.

The influence of elevation on soopolallie cover and berry abundance varied by BEC zone. In the IDF, we observed that cover and berry abundance increased with elevation in logged sites. These sites appeared to provide better conditions for both metrics perhaps because conditions in lower elevation sites were too dry and warm particularly on exposed logged sites, despite the species being generally adapted to warm conditions. Cover increased slightly with elevation in unlogged sites in the SBS, while in the ICH cover decreased with elevation. However, a number of factors including climatic conditions, and the mix of other plant species which vary by BEC zone make differentiating the nature of the relationship with elevation complicated. Furthermore, our study did not account for the role of elevation on population dynamics due to sexual dimorphism such as recruitment, or on intersexual phenological differences, for example, the length of growing season, flowering synchrony, and the number of flower buds per inflorescence (Lewis, 1990).

4.6 Considerations and Caveats

Soopolallie cover was relatively low (<7%) in most (79%; *n*=261) sampled sites making it difficult to determine the influence of predictor variables.

The weather in the years in which sampling was done (i.e. 2016 to 2020), and the some of the preceding years were significantly different from normal conditions. Specifically, in 2015 and 2016, weather was warmer province-wide, 2018 was drier and warmer in the north, and 2020 was generally wetter and cooler (See the <u>BC Climate Anomaly app</u>). Year to year variation in berry abundance as a consequence of weather conditions limits interpretations of the influence of other predictor variables. Sampling in some zones was restricted to one of these years (i.e. SBS only in 2016, BWBS only in 2017, IDF only in 2020).

In addition, sampling was not done across the whole range of sites where the plant occurs which limits interpretation of results. For example, sampling occurred in 3/11 IDF subzones and primarily the dc, with a few dk and xc sites, in 5/8 MS subzones and primarily the MSdw and dk with some dc and xv sites, in 6/12 ICH subzones, primarily the mk and mw, 1/5 BWBS subzone i.e. only the mk, 3/14 SBS subzones - mostly the mk and some dw and wk and 6/17 ESSF subzones with relatively even sampling in the dk, dv, mh, mm, xc and xv. In summary, for example in the IDF sampling was only done in very dry and dry subzones and in the SBS only in warm and cool subzones. Similarly, in the ESSF no sampling was done in wet or very wet subzones.

5. CONCLUSIONS

1. Although many factors influence berry production, berry abundance was positively correlated with soopolallie cover in most zones.
2. Suitable conditions for the plant and berry production existed across a wide range of BEC zones and ecological conditions
3. Soopolallie is well adapted to open environments and berry production is typically greater under lower canopy cover.
4. Berry producing soopolallie plants were found across a wide range of BEC zones – from the IDF north to the BWBS and from valley bottoms up to the ESSF zone. However, soopolallie appeared better adapted to dry continental climates (e.g. IDF, MS), colder wetter areas appeared less favourable (e.g. ESSF).
5. Soopolallie cover and berry abundance varied by site factors including elevation, aspect and slope; influence varied by BEC unit. Inclined sites with warmer aspects appeared more favourable.
6. Soopolallie is adapted to sites with sufficient snowfall and warm enough winter temperatures to avoid winter freezing damage, and with sufficient summer rain in drier regions to avoid desiccation.
7. Climatic conditions in the current and preceding years have implications for berry abundance and plant cover. Current year berry production can be negatively impacted by severe winter conditions and dry summer conditions in current and previous years.
8. Soopolallie is generally tolerant of timber harvesting and burning although it can be negatively impacted by site preparation treatments like severe burning, scarification, and brushing that damages plants; it can take several decades to recover to pre-disturbance levels after severe disturbance.

6. MANAGEMENT RECOMMENDATIONS

Managers are encouraged to try a variety of forest management regimes (e.g. harvesting, site preparation and stand tending regimes) in different areas to allow for the determination of implications of alternatives and selection of best practices for soopolallie berry production.

Considerations to maintain or enhance soopolallie plants and berry production on logged sites include:

1. In order to determine good candidate areas for soopolallie management, consult BEC field guides and other BEC resources relevant to the area to help identify ecosystems and sites that support higher soopolallie cover in the forested stages (See BECweb). This information, along with an understanding of the likely response of the species in timber harvested sites, can help managers identify good candidate areas to focus management attention.
2. Our results suggest that suitable sites can be found in zones ranging from the IDF to the ESSF and BWBS including the SBS, ICH and MS. However, our study was not a comprehensive survey of all BEC units in the province. Prioritize management activities in BEC units that will likely provide the warm and dry conditions that soopolallie is best adapted to, bearing in mind the potential implications of climate change on climatic conditions (See BECweb, ClimateBC and bioclimatic envelope modelling | CFCG).
3. In areas best suited for soopolallie, maintain existing plants to the extent possible and provide suitable site conditions (e.g. open canopies) to enhance soopolallie growth and berry production by considering the following:

   3.1 At the landscape level:

   a) Schedule harvesting activities to allow for a range of age classes of open canopy sites in good soopolallie sites over time.
   b) Leave forested buffers that will likely be less productive for berries along roads to provide screening cover for bears using the new openings.

   3.2 At the stand level:

   a) Use PEM/TEM maps of site series where available to identify candidate sites. Or, map areas of higher soopolallie cover, or selection by bears, using the soopolallie mapping available on the BC Data Warehouse (Clarke, 2022).
   b) Assess areas pre-harvest to determine the extent and distribution of soopolallie plants and determine the best options to protect existing plants.
   c) Schedule timber harvesting for times when the sites have sufficient snow cover to minimize damage to plants.
   d) Plan timber harvesting to promote established soopolallie patches.
   e) Implement timber harvesting practices like partial cutting or staggered logging that will create multi-age, patchy stands or mosaics.
   f) Minimize severe site disturbance from log skidding or scarification to minimize damage to plants.
   g) Consider prescribed fire or mechanical brushing to promote resprouting of older plants and reduce competition from other brush species. Burning can also enhance the release of nutrients in the soil.

h) Reduce timber stocking standards to reduce future canopy cover and promote the growth of soopolallie.
i) Plant tree seedlings in groups or clusters and leave open areas to encourage the growth and yield of soopolallie.
j) Avoid widespread chemical or manual brushing of soopolallie plants; any brushing treatments should focus on removing vegetation that would compete with soopolallie.
k) Consider thinning and pruning older stands to maintain open berry patches.
l) Avoid management practices that accelerate canopy cover development such as spacing and fertilization.
m) Consider how access may affect how bears are able to use the resources in the block post-harvest (Proctor et al. 2018, 2020). The simplest way to ensure access is to deactivate in-block roads after silviculture work is done.

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TABLES AND FIGURES

	Logged and Not Logged				Logged				Not Logged			
BEC Zone	*n*	Canopy Cover	Species Cover	Abundance	*n*	Canopy Cover	Species Cover	Abundance	*n*	Canopy Cover	Species Cover	Abundance
BWBS	60	35	4	1546	1	0	2	2830	59	36	4	1525
ESSF	32	22	5	1415	12	8	4	1544	20	31	6	1338
ICH	52	21	4	2522	26	6	3	3992	26	35	5	1052
IDF	25	35	9	4153	8	11	6	5485	17	46	10	3526
MH	3	0	10	2283	0	0	0	0	3	0	10	2283
MS	67	20	5	4854	30	8	5	7959	37	30	5	2336
SBPS	1	0	4	2	1	0	4	2	0	0	0	0
SBS	107	20	5	2187	35	2	2	1007	72	29	6	2760
SWB	6	31	3	1366	0	0	0	0	6	31	3	1366

Table 1. Canopy cover (%), soopolallie species cover (%) and berry abundance (#/100m^2) from logged and unlogged sites (value=mean value per zone, *n*=number of sites sampled/zone).

Figure 3. Soopolallie berry abundance[4] vs soopolallie cover in all plots (n=336)[5].

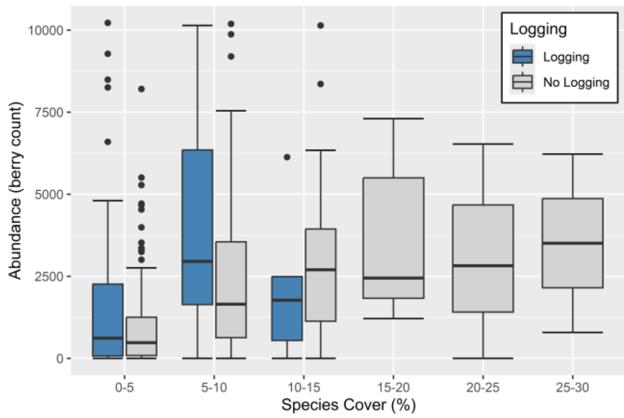
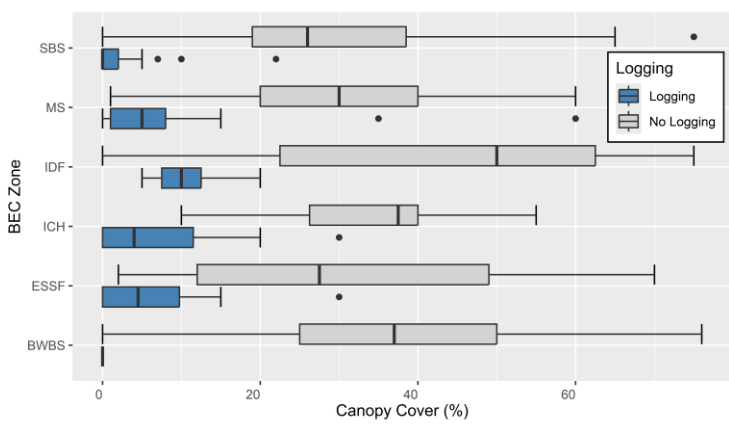


Figure 4. Canopy cover by BEC zone (n=339).



[4] The boxes contain the middle 50% of the data points; the bisecting line shows the median value. Most of the remaining data falls within the range of the lines or "whiskers" except for outliers which are represented as dots.

[4] Plots where the berry abundance was exceptionally high (i.e. the 5% with greatest values) were removed from the graphic. All plots were used in the analysis.

Figure 5 A. Soopolallie plant species cover by BEC zone (*n*=339).

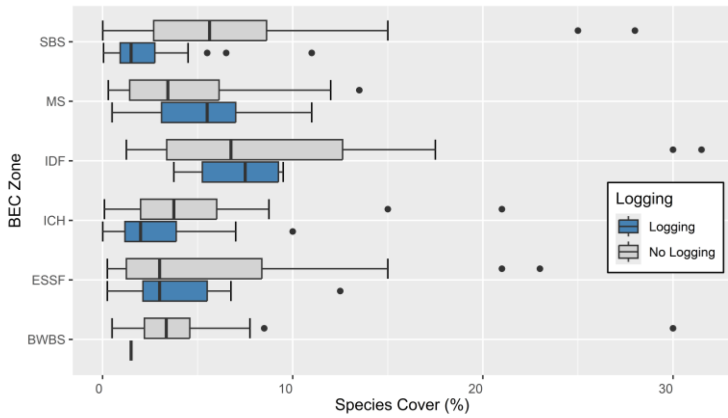
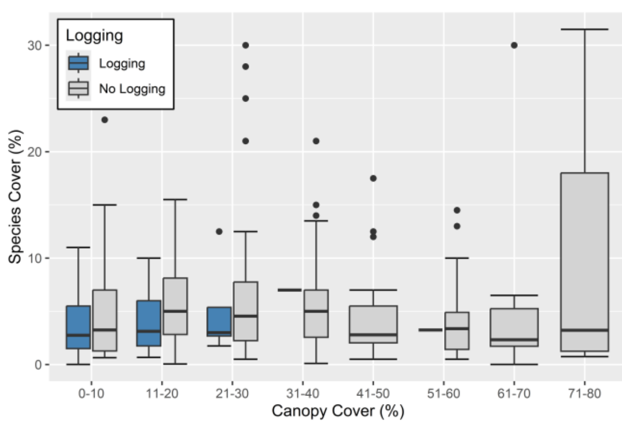


Figure 5 B. Soopolallie plant species cover[6] vs canopy cover in all plots (*n*=353)[7].



[6] Plots where the berry abundance was exceptionally high (i.e. the 5% with greatest values) were removed from the graphic. All plots were used in the analysis.

Figure 6 A. Soopolallie berry abundance by BEC zone (*n*=322)[8].

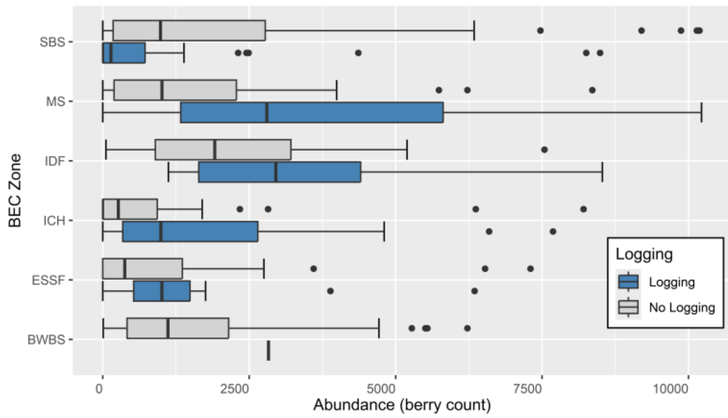
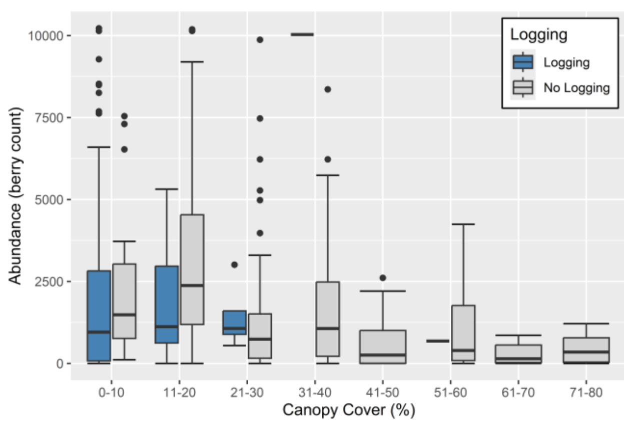


Figure 6 B. Soopolallie berry abundance[9] vs canopy cover in all plots (*n*=336)[10].



[8] Zones with less than 6 sites were excluded.

[9] The boxes contain the middle 50% of the data points; the bisecting line shows the median value. Most of the remaining data falls within the range of the lines or "whiskers" except for outliers which are represented as dots.

[10] Plots where the berry abundance was exceptionally high (i.e. the 5% with greatest values) were removed from the graphic. All plots were used in the analysis.