<u>Effects on Bilberry (*Vaccinium myrtillus*) height and percentage cover in relation to tree canopy cover.</u>

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Abstract:

The purpose of this research is to understand the relationship between light exposure and percentage cover of bilberry (*Vaccinium myrtillus* L.) Data was collected in three locations and data from two of those locations were analysed. The results showed significant relationships between light exposure and bilberry cover, light exposure and bilberry height and bilberry cover and bilberry height. It is determined that whilst there is small differences between the results obtained in this study and results obtained from previous studies - which may be due to the data being collected at a different time of the year - light exposure is important factor in the distribution and growth of bilberry.

Introduction:

Vaccinium myrtillus (known as common bilberry, blue whortleberry, or European blueberry) is an important forage source for herbivorous and omnivorous mammals such as bears (*Ursus arctos*) and voles (*Microtus* sp.), as well as being an important plant for invertebrate, birds, humans and moose (*Alces alces*). Understanding factors that affect its growth can give insight to forestry management, herbivore distribution or bilberry cultivation.

Bilberry is a deciduous, rhizomatous and herbaceous plant that is widely spread across acidic soils. It can be identified by its green conspicuously three angled stem, with two to three ranks of leaves and if mature, older woody shoots. The flowers are 4-6mm, have 5 small calyx segments, and a fused pink globose shaped corolla. The fruit are a purple-black berry (Ritchie, 1956). It grows in acidic, nutrient poor soils and can be found in temperate or subarctic regions.

In Norway, bilberry is commonly part of the ground flora occurring across forest with often a canopy cover of birch (*Betula pendula*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), and less often Rowan (*Sorbus* sp.) or Alder (*Alnus glutinosa*).
Bilberry is tolerant of *Pinus sylvestris* allelopathic toxins - hence it’s abundance across the pine forest floor.

Allelopathy is a natural biological process important in plant defence against herbivory competition. Biochemicals from the adult tree are produced in the needle and when dropped are released into the leaf litter below, these chemicals are known as allelochemicals. These influence germination, growth, survival and reproduction of other young seedlings and saplings. In doing so reducing competition from other species and increasing the chance of *Pinus sylvestris* saplings survival. It is widely used through species of plant, algae, coral and fungi. It can determine specie distribution and abundance in communities.

Bilberry is important for human consumption in wild and cultivated harvest for fresh eating or jams and dishes, also a well-known plant in much folklore and traditional medicines.

It’s an important foraging source for moose during the summer and autumn (Selås et al., 2010). Moose are an important economic income for game in Norway as well as problematic conflict for forestry as they browse young pine and spruce saplings rendering the adult tree inadequate for production value.

In application, this could help deter moose damage in forestry management.
Understanding how forest canopy affects bilberry growth and fecundity can give us insight to bilberry distribution, and how forestry management can affect that. A paper by Atlegrim and Sjoberg (1996) suggests that a ground cover and nutrient quality of bilberry is increased with selective felling over clear cutting. Bilberry bushes are important browsing source for moose during the summer and autumn. If moose are to follow bilberry distribution into forestry production areas, then understanding how we can change forest structure in management to increase or decrease bilberry growth may be of assistance when trying to deter moose.

The objective of this research is to get an understanding of the relationship between *Vaccinium myrtillus* and canopy cover. How does reduced or increased light exposure due to canopy density effect the growth and fecundity of *Vaccinium myrtillus*? Measuring bilberry height suggests vigour of growth, the flower and berry count can be used to assess the reproductive success, and percentage cover shows the competitive success of the plant by observing homogeneity of bilberry.

Methods:

We used the same sample plots as Hedmark University's research and study project based on moose and forestry. A study was carried in three locations: Ljørdalen, Gravberget and Plassen in eastern Norway. Each site has 2 sampling areas; one with experimental treatments (A) and one control (B). In each area 10-11 quadrats of 500 m x 500 m are laid out systematically with GIS. Each quadrat has an individual number, according to figure 1. Each quadrat has 16 sampling plots, 4 along each side with 100 m between them. The plots have a predetermined GPS position and can be located by using the Go To function on the GPS, or by maps. All plots are marked at the center of the plot with a white plastic pole where the GPS first shows < 5 m to the predetermined position (you may have to search a bit for the pole).

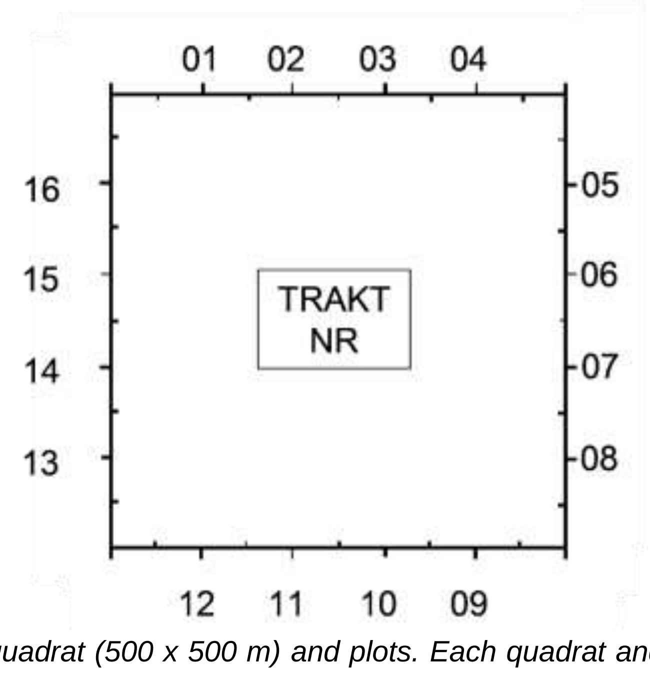

Figure 1: Sampling quadrat (500 x 500 m) and plots. Each quadrat and plot have a specific number i.e. L-A1-01(site-quadrat-plot)

Sampling plots were circular with the identified point on the GPS as center and a radius of 5.64m; the radius was measured with a marked rope. For each quadrat, there was one registration form, which was inputted in the KoBoCollect app. Once at the white pole (marking the plot center) the measured length of rope was attached to the pole with the looped end. The compass direction was then measured with the rope stretched outwards at four points: north, east, south and west. At the outer point of the circle where the rope reaches (to avoid trampling from students collecting data from the same sample plots) a pole was placed marking the bottom of a 1m square transect. With a rope marked at 1m intervals a square was made to the right of this point.

A canopy cover reading using a spherical densitometer was then calculated facing away from the central point; measured at elbow height with a quadrat mirror making sure the bubble was aligned in the center of the circle. Bilberry percentage cover was estimated and number of flowers/buds were counted. Within each corner of the 1m quadrat the bilberry plant closest to each corner was measured in height in cm with a ruler. It was then noted whether it had been browsed in; winter, showing signs of moose twig browsing last winter; spring, showing signs of mammal browsing this spring; and by insects, showing signs of insect herbivory this spring i.e. holes/bites on the leaves. This was then repeated in each cardinal direction (north, east, south, and west) using a compass or GPS as aid. Stage of leaf development was also recorded as either none, early or full. A picture of each sample plot was captured as evidence of leaf development. Any recent logging activity or other things that have happened since 2015 should be recorded. Water or snow percentage cover was also recorded for example if a bog or river was present.
Only the data collected at Ljørdalen and Gravberget were used. To analyse the results non-parametric correlation spearman's rank was used.

Results:

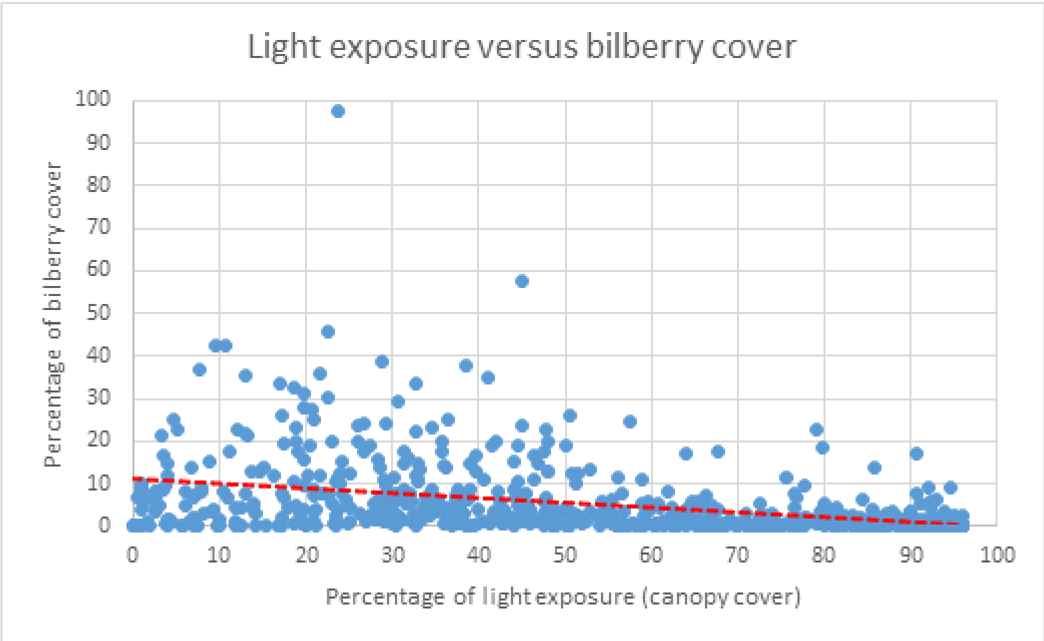

Figure 2: Percentage of light exposure in relation to the percentage of bilberry cover

This first analysis of light exposure versus average bilberry cover shows a small but significant negative relationship between bilberry and light exposure ($r = -0.497$, $p < 0.001$). The red dotted line determines the correlation of -0.497.

Figure 2 shows that the amount of bilberry cover decreases as the amount of light exposure increases. Apart from the 2 exceptions, the first showing 97.75% bilberry at 23.75% cover; the second one shows 57.5% bilberry for 45% cover. We can also notice a general cloud of data set between 0 and 40% canopy cover, concentrated in the 20-40% bilberry cover area.

The majority of the dots are found in the 0-10% bilberry cover clade of data. The general tendency of the data is decreasing.

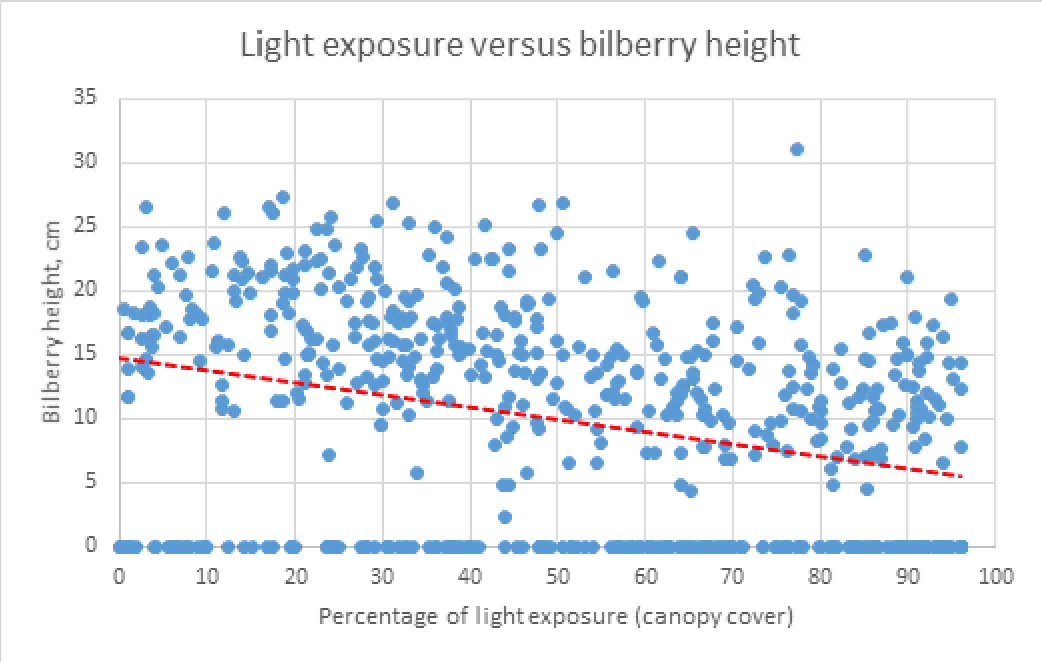

Figure 3: Average bilberry height in relation to percentage of light exposure

Figure 3 shows a stronger correlation between canopy cover and height of bilberry plants. Analysis shows a significant negative relationship between bilberry height and canopy cover ($r = -0.362$, $p<0.001$). The global trend is decreasing in this graph. The red line shows the correlation of -0.362.

Some of the data shows that there are no plants no matter what the canopy cover is, however the majority of the data is concentrated between 5-25% clade. For example, for 30% light exposure, a plant grows at 14.45cm. An exception to look at can be a plant of 31.1cm at 77% light exposure.

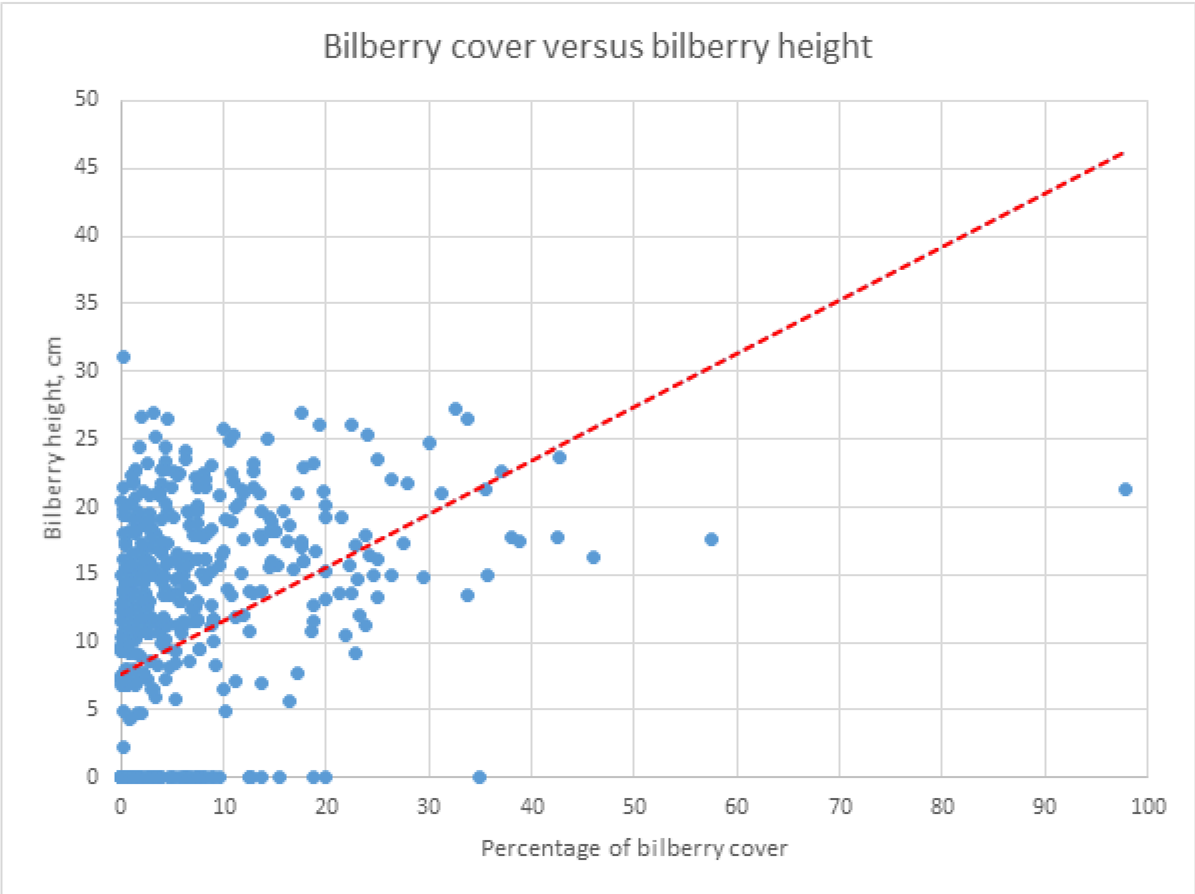

Figure 4: Bilberry height in relation to percentage of bilberry cover

Examination of the data shown in Figure 4 reveals a positive relationship between height of the bilberry and percentage of bilberry cover ($r=0.610$, $p<0.001$). Most of the data is focused between 5-25 cm and 0-20% bilberry cover, although some exceptions show a plant of 21 cm at 97% bilberry cover, 17.6cm at 57% bilberry cover.
When doing a non-parametric t-test testing height of the bilberry against site, MWU= 49467, $p= 0.231$; when testing canopy cover against site, MWU= 54717.5, $p= 0.298$.

Discussion:

The aim of the research was to study the effect of canopy cover against the bilberry cover percentage. It is important to understand the habitat and environmental requirements for bilberry (*Vaccinium myrtillus* L.) both scientifically (Atlegrim & Sjöberg, 1996), economically (Miina et al. 2010), and culturally (Ghirardini et al. 2007; Miina et al. 2010). Many environmental factors affect bilberry, such as pollution (Zvereva & Kozlov, 2005), snow cover (Ritchie, 1956), and light exposure (Atlegrim & Sjöberg, 1996). According to Raatikainen et al. (1984), the highest berry yields are found in mature conifer stands with the canopy coverage between 10% and 50%. Compared with our results we found that the highest yields were between 0%-50%. This difference of 10% could be due to the difference in time between studies and bilberry may have adapted to grow in lower light conditions, it could have been due to the surrounding vegetation and competition from other species alternatively, it could be due to the study being at a different time of year. From the results, it shows that with increased light exposure the bilberry cover decreases, therefore dense forest opposed to open spaces would be the most ideal habitat. There may be multiple reasons for this: bilberry roots are generally shallow (Flower-Ellis, 1971); significantly more sunlight may dry out the humus layer in areas of increased canopy and the water balance of the bilberry could be affected. With increased sunlight exposure, water availability for bilberry therefore could be significantly less, leading to increased mortality, reduced photosynthesis and growth. The results of our study support the conclusion of Atlegrim & Sjöberg (1996) that an increased light exposure decreases bilberry cover. Also, the more canopy cover the higher the plant would grow. On the other hand the open habitat may increase the risk of frost damage to the bilberry. The snow cover, which protects the bilberry from low temperatures, disappears earlier in areas of minimal canopy cover than in the forest (Atlegrim & Sjöberg, 1996). Again another reason for limited bilberry cover in areas with less canopy cover could be due to competition, as many grasses thrive in exposed sunlight which could out compete bilberry. Our results can aid in decision making for silvicultural practises within the boreal forest and other areas with bilberry. Understanding how light exposure impacts the growth, distribution and cover of bilberry is vital for making these informed decisions.

Many animals depend on Bilberry as an important food source including Moose (*Alces alces*), Roe Deer (*Capreolus capreolus*), Brown bears (*Ursus arctos*) and many species of game bird. For logging companies and forest management it is extremely important to take into account bilberry cover as areas with increased bilberry availability and quality, might influence the ecology of many herbivores in the boreal coniferous habitats (Atlegrim, O. and Sjöberg, K., 1996). A study undertaken by Storch (1993) showed Capercaillie (*Tetrao urogallus*) selected large areas of old forest with moderate canopy cover of about 50%, and a well-developed field layer with high proportions of bilberry *Vaccinium myrtillus.* The study demonstrated that bilberry is the major determinant of the selection of habitat by Capercaillie in landscapes with sparse and fragmentary cover of ericaceous shrubs, such as central Europe. From this study it is important to see that many other animals may rely on bilberry as heavily as Capercaillie and therefore understand where they are is significant for purposes such as logging as to not disrupt too many habitats and to see where else could be more appropriate to log.

Bilberry is among the economically most important wild berry species in several European countries where it is collected for both household consumption and sale (Mina *et al.* 2010).

Understanding bilberry can lead to many benefits for example ecological, economic and cultural. From this paper we can gather that areas of increased canopy cover provides larger bilberry cover, this indicates the location of where to harvest bilberry, where a significant number of animals could be grazing which helps with conservation efforts, and it provides logging company with vital information that forests can still be utilised without having to clear cut, that selective felling would be ideal.

Conclusion:

Bilberry is an important plant not only to the animals that require it as a part of their diet, but also to humans for reasons such as maintenance of the boreal forest, but also for consumption purposes. Our results clearly show that light exposure is an important factor in determining where the plants will grow, which supports the work and evidence provided by previous reports on bilberry.

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