IMPACTS OF BRUSH THATCHING AS A CONTROL MECHANISM FOR “NATIVE INVASIVE” SPECIES, HAY SCENTED FERN

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Abstract

This study examines the influences of the clearing practice known as thatching on the plant *Dennstaedtia punctilobula* or Hay Scented Fern. The purpose of the practice is to reduce deer browsing and allow for greater biodiversity to develop in intentionally cleared lands, as is the case in the area which the study was conducted- the Hogback Conservation Area. As lands were being cleared on the old ski resort, it was found that Hay scented fern, despite being a native species, would outcompete new species and dominate the freshly opened landscape, thus countering the organizations goal of increasing species diversity. My study examined the impact of thatching on the fern's biomass after 2 years of growth had occurred. The results supported my hypothesis in that yes, the fern did show a significant decrease in biomass in areas where thatching was employed, although further study is required to assess what the exact process for the biomass limitation is.

Introduction

The dominating effect of the native plant *Dennstaedtia punctilobula* or Hay Scented Fern is extremely well documented (Horsley and Marquis 1983, Cretaz and Kelty 2002) and is particularly damaging in efforts by conservationists to restore forests, especially in the Northeastern United States, cases found in both PA and MA. Because of this high level of success, the fern has been coined as a "Native invasive", defined as a species that both spreads in a space as well as has negative impacts on the naturally occurring populations in that space, although unlike our common definition of invasive species, happens to naturally occur in the region that it is impacting (Alpert, Bone, Holzapfel 2000).

*T*he fern is a homosporous, leptosporangiate fern whose naturally occurring range is all along the Eastern Seaboard of the US and Canada [See figure 1] (Hammen 1993). It grows in large roughly elliptical patches, and its optimal growing season is mid-April through to mid-July. This early season growth is essential to the fern's success in response to disturbance, likely due to the large fraction of biomass stored in the underground rhizome, which allows for early season production of large fronds, which can create a understory canopy of up to 60 cm in height, shading out many other species that would also be attempting to establish (Hammen 1993, Cretaz and Kelty 2002). This success can be attributed to a few factors, but one that is notable in the context of this study is their incidence with human disturbance, especially clearing of over story trees (George and Bazzaz 1999). There are many theories about how ferns become dominant over all other species in these scenarios, but the most influential is without a doubt the presence of the fern in the area to begin with- "advance regeneration" being a term thrown around to describe the phenomena (George and Bazzaz 1999).

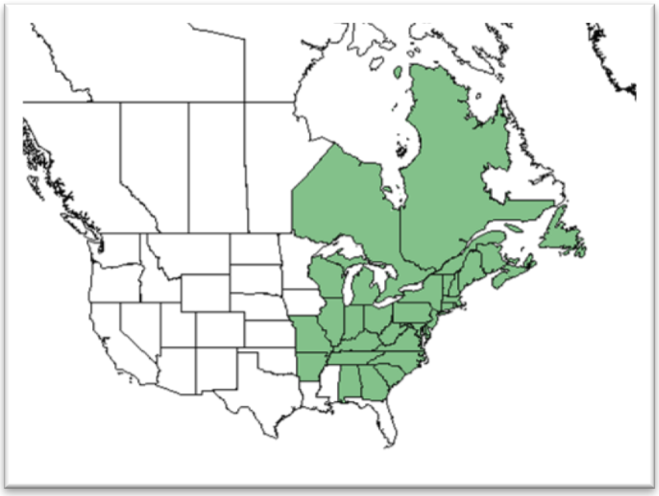

Figure 1- Native Range of Hay Scented Fern

Another prevailing theory revolving around the fern is its success as dependent on the over-browsing of other understory seedlings by white tailed deer and other smaller mammals in the progression of early successional communities (Cretaz and Kelty 2002). Building off of this theory, forms of management have been developed that don't rely on damaging practices like yearly mowing (Cretaz and Kelty 2006), or pesticide use (Horsley et al 2003). Instead, as areas are cleared, leaving a layer or "mat" of brush known as thatching prevents large browsers, like deer, from grazing down young saplings. In addition, it may also prevent Hayscented fern from establishing itself so dominantly in the community, as the shading canopy it creates will not be as dense and impermeable to light.

The ultimate impact of thatching is the question I sought to answer in this piece, both in its impact on plant diversity and its impact on Hayscented fern, measurable by dried biomass. I predicted that there would be a significant decrease in the above ground biomass of the Fern in areas of thatching, which would be reflected as an increased level of biodiversity and species evenness. The ultimate goal of this research is to influence the restoration efforts at Hogback, the location of the study, as well as other areas working to establish early successional communities.

Methods

Research was conducted at Hogback Mountain, in Marlboro VT. The study focused on the effects of an ecological restoration project being conducted at this closed ski area, where the decision to re-clear the slopes after 30 years of growth was prompted by a desire to allow for study of early forest succession and allow for winter low impact recreation. The trail that was the focus of the study was cleared between the years of 2013 and 2014, reaching about halfway down the mountain, approximately 600ft [figure 2]. It is about 75% exposed to sunlight, courtesy of large bordering trees. 25% of the visible growth is Red Maple, leaving the remaining 75% to fern and small shrub growth. The prominent species are as mentioned, Red Maple, Wild Raspberry, Virginia Creeper, Hayscented Fern, White Avens, Interrupted Fern, Fringed-Black Bindweed and Steeplebush. The slope is largely south facing, although it grades to the SW slightly. The coordinates are 42.849791, -72.798678.

Of the 6 study sites, 3 were chosen at locations where thatching of cleared brush occurred, while the other 3 were where the ground was cleared fully, and easily accessed. The sites will follow a staggered pattern down the slope, dependent on where the thatched sites are, as it was only being experimentally used towards the end of the clearing process (in 2014). See Figure 2 for exact locations.

The plots were 1 m^2 in size, and were marked by wickets once measured out. Once a site had been established and marked, the second step was to assess the species present in the plot, as well as their density within the plot (aside from the Hayscented Fern).

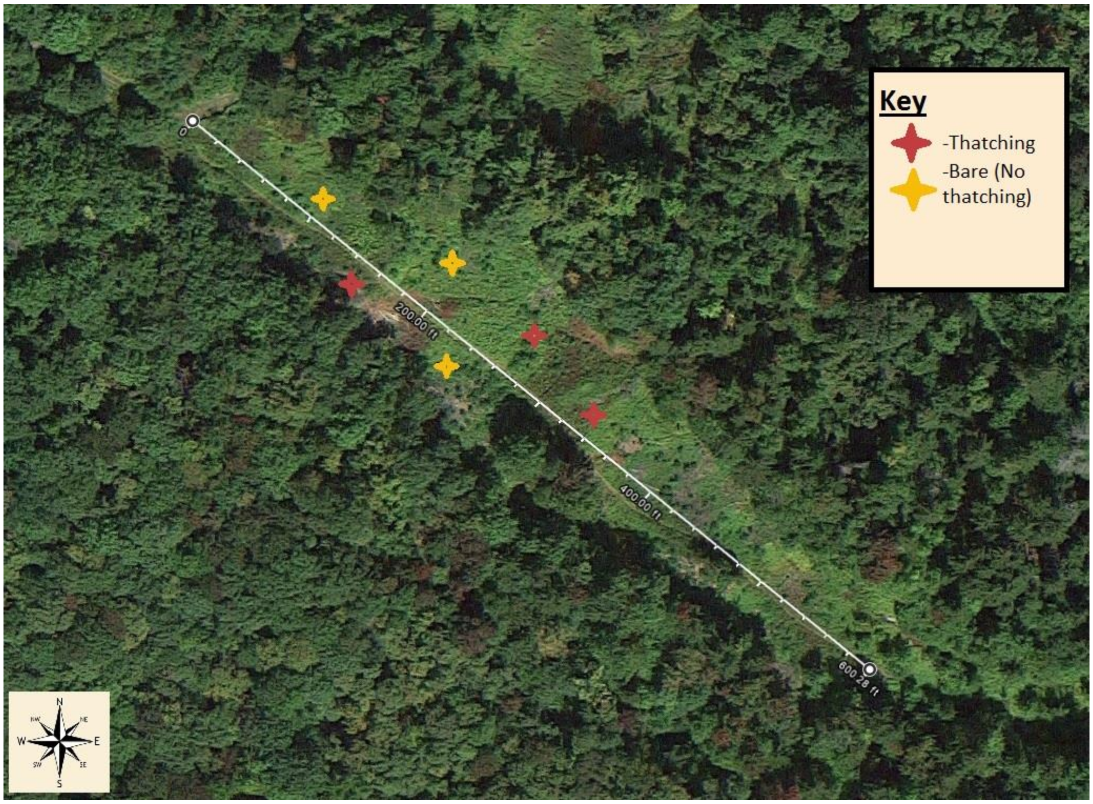

Figure 2-Study site locations at Hogback

Next, a soil sample was collected using a soil core sampler, to be examined in lab for its pH, soil water content, organic matter content, litter depth (this includes the thatching), nutrient availability (Phosphorus, Nitrogen, and Potassium) and percentage of exposed soil. The sample was taken 10 cm deep into the substrate, and bagged and labeled. The final procedure was to clip each of the Hayscented Fern fronds rooted in the quadrat at a height of 3 cm above the soil using garden shears, and collect them in plastic bags to be massed in lab with a hanging spring scale.

My data was collected in late October in the morning, before 11 am, on two days, the 19th and the 20th. This was not the optimal time to perform my study however, which I will explain in my Discussion.

The dependent variables measured here are varied and comprehensive. They include the biodiversity within the plots, and the biomass of the Hayscented Ferns present in the plots. The independent variables are primarily soil composition and features, as well as whether the site was thatched or not.

In the lab I tested each soil sample using the Rapitest soil testing kit from Luster Leaf, the procedure for which is as follows:

pH TEST:

(Take a soil sample from about 4" below the surface.)

1. Remove cap from one of the the green capped tubes.
 Remove the green capsules.
2. Fill tube with soil to the first line.
3. Carefully open a green capsule and pour powder into the tube.
4. Add water (preferably distilled) to the fourth line.
5. Cap tube and shake thoroughly.
6. Allow soil to settle and color to develop for about a minute.
7. Compare color of solution to the pH color chart.
 Repeat for remaining capsules.

NITROGEN, PHOSPHORUS & POTASH TESTS:

(Take a soil sample from about 4" below the surface. Fill a clean jar or can with 1 part soil and 5 parts water. Thoroughly shake or stir the soil and water together for at least one minute and then allow the mixture to settle out for at least 10 minutes.)

1. Remove the cap from the tube. Remove colored capsules.
 (Please note that the color of the capsules should match the color of the tube cap.) Fill the tube to the fourth line with liquid from your soil mixture. Avoid disturbing the sediment.
2. Carefully separate the two halves of one of the capsules.
 Pour the powder into the tube.
3. Cap the tube and shake thoroughly.
 Allow color to develop for about 10 minutes.

4. Compare color of solution to the appropriate portion of the plant food color chart. For best results allow daylight, not direct sunlight, to illuminate the solution. Note your results.

To support my data, and further examine it, I ran unpaired t tests on the data collected relating to whether or not thatching took place and fern biomass, as well as an one directional ANOVA test, to establish how strong of a correlation I can find. However, eventually I figured out that an unpaired t-test is the same thing as an unweighted ANOVA, so eventually I started to use this test as well, to double check my findings. I will also display the data about biodiversity in some form that makes sense, depending on how many species I can identify and compare.

Results.

My findings indicated first and foremost a negative correlation between the aboveground biomass of the ferns and the incidence of brush thatching. This was found by running an unpaired t test, with group A being fern biomass in unthatched areas, and group B being the fern biomass of thatched samples (see Table 1 for raw data). The experimental p value was 0.0383, which is considered statistically significant as p is less than 0.05, and a t value of 3.0426 and df of 4. This data is supported anecdotally by the observations I took in the field, noting that the ferns were significantly less dense when thatching was present. The average biomass of the ferns in thatched regions was 161.67 g/m^2 (SD: 20.21) and in unthatched was 221.67 g/m^2 (SD: 27.54).

The next factor I examined for its influence was the biodiversity in the experimental and control plots. I found, as predicted, a higher amount of biodiversity in the thatched sites, with fewer numbers of species in the control sites as well as reduced species evenness (Table 1). The species I found in the control sites were as follows: White Avens (Geum canadense), Interrupted Fern (Osmunda claytoniana) and a small, hardy grass I could not identify. In the experimental sites, I found both White Avens and fronds of Interrupted Fern, in addition to Virginia Creeper (Parthenocissus quinquefolia) and small sprouts of the tree Quaking Aspen (Populus tremuloides). As I said, each of these species was not only found in my experimental plots, but found in greater number and with increased species evenness. However, for all sites, hay scented fern was by far the most dominate species (Table 1).

Thatching had another interesting influence on the amount of exposed soil in the plots. In the experimental plots, the average amount of exposed soil was 3.3% (SD: 2.89), as opposed to the control group's average of 10% (SD: 10.0) (See Table 1 for Raw Data). However, when analyzed via an unpaired t test, the data proved statistically inconclusive P= 0.3295, t=1.1094, and df=4.

Soil factors were also well presented by these samples. Notably, pH showed some correlation with the biomass of individual sites- the lower the pH, the greater mass of ferns (see figure _)(Table 1 and 2). This was assessed using linear regression, and I additionally found the correlation coefficient (r)= -0.63897552124379, which indicates that the data has a fairly strong negative correlation (as it approaches -1). However, if you compare the pH's themselves for the control and the experimental sites (figure 4), the difference between them is not statistically representable. The mean pH of the control sites was slightly more acidic, at 5.33 (SD: 0.577), compared to the experimental sites mean of 6.33 (SD: 0.289). P= 0.0550, t= 2.6833. All the soils tested were on the acidic side, pH's ranging from 6.5 to 5 (Table 2).

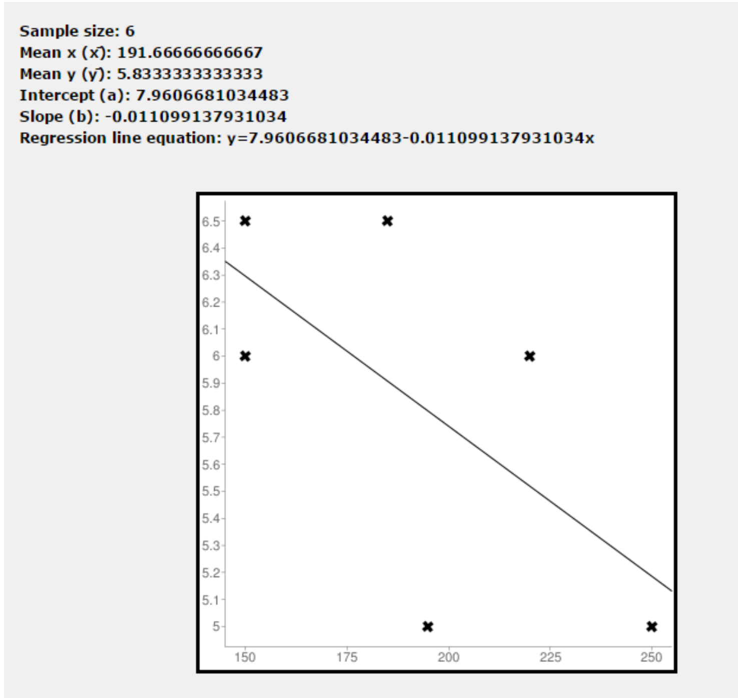

Figure 3 Impact of pH on Fern Biomass

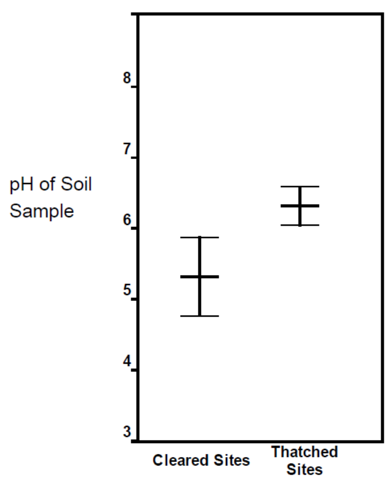

Figure 4- pH of soil in Control and Experimental Sites

Several other soil factors were recorded, however as I'll discuss further in the next section, they were not easily quantified, and therefore, not supported statistically. This being said, there was an observed heightened level of Phosphorus and Potassium in thatched soils. Nitrogen was also present in higher levels in the experimental plots as opposed to the controls, however, it was much less noticeable compared to the Phosphorus and Potassium (Table 2).

Discussion.

My key finding in this study was the correlation between the control method of thatching and reduced Hay Scented Fern Biomass. I also found a correlation between increased biodiversity in both species richness and evenness to thatching when comparing compositions of the plots for the two treatments. Somewhat counterintuitively, a correlation was found between the higher density fern patches found in the control group, and a greater amount of soil being exposed on the surface of the ground. In addition, a small but questionable correlation was found between pH and higher fern biomass, however, when the pH's were averaged for each group and compared, the correlation was much weaker, in fact, and it was inconclusive.

The correlation between thatching and reduced fern biomass came as no surprise to me, and supported my ultimate hypothesis, and supports the idea of using thatching as a control mechanism. Nyman & Engelman advised in their 2006 study that they could only bolster the populations of seedlings by reducing the total amount of deer browsing in an area, a challenging concept to take on in any northeast region. They did not consider the impact of exclusion methods however, which I recommend for further study on this topic. Rather, they found that by either chemically (glyophosphate) or manually (mowing) thinning the number of ferns, the seedling populations were benefitted, while the density of hay scented fern fronds reduced as years went on. Cretaz & Kelty found a similar influence in their work, with manual thinning by hand harvesting of ferns, an admittedly much lower impact practice, but not nearly as efficient for large scale ecological remediation. Ultimately, I support the concept of brush thatching, as it will not only limit deer browsing as we hypothesize, but also allow for the nutrients locked in the brush/trees that are being harvested in a swath of land to be returned to the soil and continue to cycle through the environment. I am more inclined to say that the higher levels of nutrients we see in the thatched sites are related to the thatching its self, as opposed to the density of the ferns themselves, as it has been shown in other studies that Hay Scented Fern had no impact on Phosphorus or Nitrogen levels in the soil in a time scale of two years (the amount of time that the study sites have been cleared for) (Horsley 1993).

My entire study was negatively impacted by one primary problem in my experimental design, a problem that any student in this sort of rushed semester timescale will encounter- having a small, statistically questionable sample size. With only 6 sites analyzed, it is hard to adamantly support (and accurately support) any of my hypotheses. However, the above mentioned correlation between thatching and reduced fern biomass was found to be statistically representable, which I was somewhat surprised and very pleased to find out. While other points in my data were statistically held up, none of them were linked directly to the incidence of thatching, at least in a way that was statistically representable.

Other factors that may have negatively impacted my study are fairly varied across both my experimental design and other factors that were beyond my control. As far as places that my design fell through, the method I used to clear each quadrat of ferns was to clip all the stems within my 1*1m plot. Instead of this, I should have followed a protocol more similar to the protocol given by the Oregon State Biology Dept, and taken any ferns who's fronds fell into the quadrat- but only as much of them as was present in it. This way is a better representation of the biomass present in the area. Another shortfall of my design was the depth of my soil core. While experimentally, I stated that the sample was to be 10 cm in depth, I should have taken samples at a depth of about 15-20 cm, in order to get a better perspective of the soil horizons I was working with. These are the issues I would address I were repeating this study myself, at the same time and place.

Larger failures of the study mostly are concerned with the time of year that my study took place. For starters, Hay Scented Fern's are at their peak productivity in June-July (Hammen 1993), so in order to get a better look at their actual biomass, harvesting would have to take place then on the largest, most active plants. In addition, competing species would be at their most prominent at that time of year, most notably, maple seedlings, one of the species the ferns outcompete the most. These species would be much better represented in my species richness findings at that time of year. My final issue with the study as it was done is the inability to truly quantify whether thatching works because of true deer browsing exclusion, or if there is another, unknown factor at play, perhaps some sort of nutrient balance problem, helped along by the decomposing/protective branches lying over the ground. These are all the potential routes I could see this study going in, for the future.

Ultimately, this study provides an effective and easy conservation method that I believe should continue to be employed in Hogback and locations striving for Early Successional habitats but are struggling with this "native invasive". The technique has a low ecological impact (unlike mowing, or spraying with chemicals), is cost efficient, and ultimately, helps the land that is being cleared through nutrient cycling, in well documented ways. As far as stating directly what about thatching causes the ferns to occur in lower densities, I can only hypothesize for now, and further studies will be needed to assess the exact causation. The correlation between incidence of thatching and decreased fern biomass is unmistakable from my data, however, and therefore, I make a recommendation for the employment of the process.

Acknowledgments

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Appendix

Tables

Table 1

Raw Data

	Control			**Experimental**		
Site	B1	B2	B3	T1	T2	T3
Depth of thatching	N/A	N/A	N/A	Apx. 2 ft	Apx. 2 ft	Apx. 1 ft
Other plant species present	White Avens, Small Hardy Grass (Unidentified)	Interrupted Fern	White Avens	Interrupted Fern, White Avens	Virginia Creeper, Interrupted Fern	Quaking Aspen, Virginia Creeper, White Avens
Mass of Hay Scented	220 g/m²	250 g/m²	195 g/m²	150 g/m²	185 g/m²	150 g/m²

Ferns						

Table 2

Soil Features

	Control			**Experimental**		
Site	B1	B2	B3	T1	T2	T3
Soil Nitrogen Content	Moderate/ Low	Moderate/ High	Moderate	Moderate	Moderate/ High	Moderate/ High
Soil Phosphorus Content	Low	Low	Moderate/ Low	Moderate/ High	High	High
Soil Potassium Content	Moderate	Moderate	Moderate	High	High	Moderate/ High
Soil pH	6	5	5	6.5	6.5	6
Exposed Soil	10%	20%	0%	0%	5%	5%