Survey of Endangered Plant Species in Fuji Grasslands

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Introduction

The amount of land area in Japan covered by grasslands has been decreasing over the past century. This is in part due to the decrease in uses for grass, which was once used for fodder, fertilizer, and thatch. Further, as the logging industry no longer plays such a prominent role in Japan's economy, forests continue to encroach beyond the confines of where they were planted 50 years ago. Japan has no areas where grasslands are the climax stage of succession, so human involvement is vital for the maintenance of these ecosystems. If left untouched, these lands would naturally develop into sun-tolerant woodlands with species of oak and beech, then into shade-tolerant forests (Watanabe 2016). "Satoyama" is the Japanese word for the types of natural areas near human settlements that experience constant human intervention in the form of mowing, coppicing, and other agricultural practices. Grasslands are one example of these important environments. As the amount of satoyama grasslands declines, species dependent on these ecosystems are disappearing.

Our research examines three grasslands at the northern foot of Mt. Fuji. The three grasslands are Motosukōgen, Nashigahara, and Nojirisōgen. There were three research groups so we could compare and contrast different parts of the grassland ecosystem. One group researched soil types and lava flows, the second researched grassland butterflies, focusing on those on the red list, and our group researched endangered plant species. We worked closely with Michihito Watanabe Sensei to conduct this research. He is a local ecologist from the Laboratory of Natural Science for the Coexistence of Humans and Nature. In his work, Watanabe created a guidebook that we referenced in the field to help identify endangered plant species. He also helped us in person to identify the plants that we were unsure of or were not currently flowering.

With the guidance of Watanabe Sensei, we chose to focus on how the presence of other plant species affects endangered species. Specifically, we looked at grasses, trees, saplings, shrubs, ferns, and overall biodiversity of other flowering species. By surveying plots in these three grasslands, we hoped to understand what types of habitats allow the rapidly disappearing grassland species to flourish. We also hoped to explore the relationship between human intervention and presence of endangered species.

Research Questions

1. How does historical land use influence the number of endangered species we see today?
2. Do grasslands close to high concentrations of trees or forests experience greater diversity or overall number of endangered species?
3. How might the percentage of grass affect the presence of endangered plant species?

Hypothesis:

1. We predict that the grassland that has the highest human influence contains the most endangered species.
2. If there are trees in or near the plots, then there will be higher numbers of endangered species. This may be due to succession, as grassland and forest overlap.
3. Areas with higher percentages of grass and/or ferns will also have higher numbers of endangered species. This is because higher percentages of grass indicate a flourishing grassland, the typical ecosystem of the endangered species we are studying.

Site Descriptions

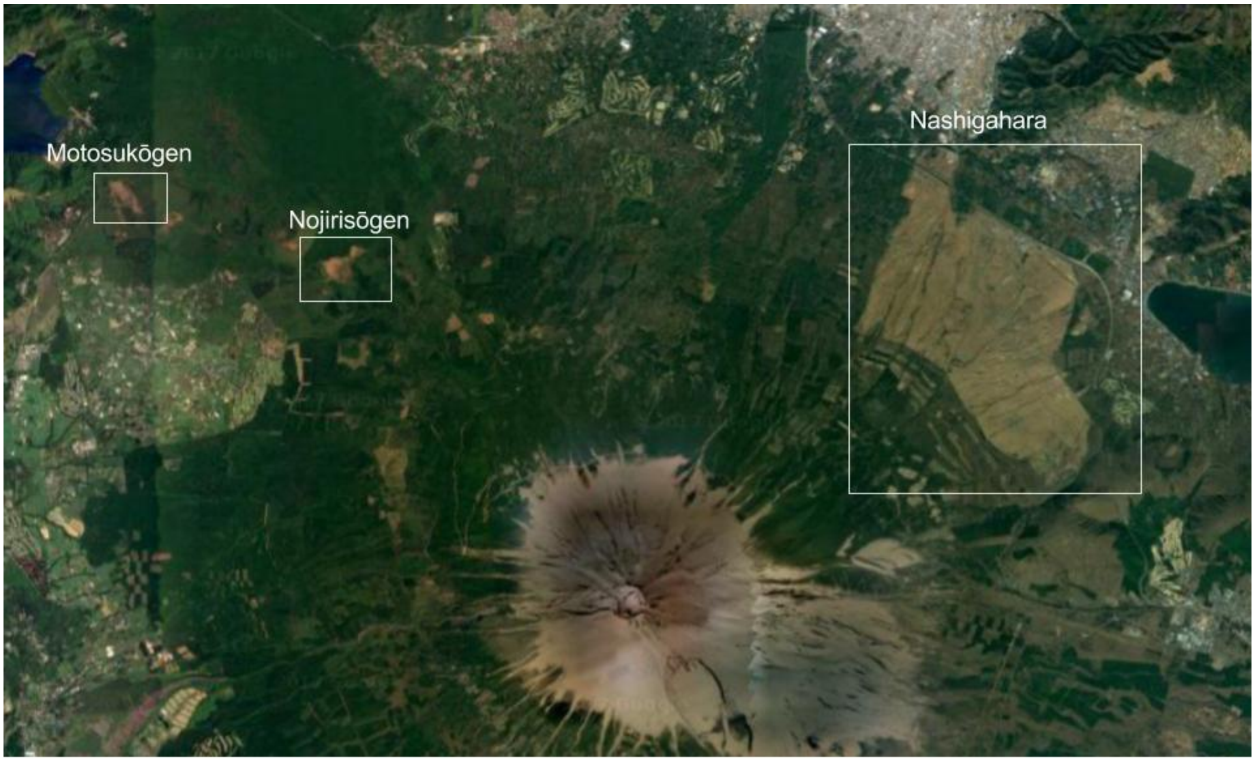

Fig 1. Above is an image introducing the three grasslands around Fuji.

The Motosukōgen lies on an old basaltic lava flow from the Fujinomiya stage of an eruption ocuring from around 15,000 to 6,000 BCE. The Motosukōgen has shrunk in size over the past several decades due to forest encroachment. However, a firebreak was created around 1970 that further defined one of the edges of this grassland. This firebreak still exists today. Throughout many years of planting and harvesting timber, the central portion of the Motosukōgen has remained the same. This grassland continues to undergo annual mowing.

The Nashigahara is geologically complex as it contains a mix of lava flows, slush flow deposits and several drainages. It is also the largest grassland at the foot Mt. Fuji. Two basaltic lava flows covered portions of these deposits about 1,000 years ago: the Hinokimarubi flow and the Takamarubi flow. The Nashigahara gently slopes to the north as it lies on the broad skirt of Mt. Fuji. Shallow ridges and valleys crisscross this grassland. These are due to lava flows and slush flow erosion. The Nashigahara has been maintained by the military since the early 20th century. It has expanded in size since then as it is still used as training grounds. The Nashigahara is burned yearly by iriai rights holders to maintain their agreement with the military. These iriai right holders are a part of communities who co-own common lands and exert their rights through traditional maintenance such as burning, mowing, and herb collecting (McKean, 1985).

Nojirisōgen lies on top of an old lava flow that erupted during the Subashiri B stage around 3,600 to 1,500 BCE. Due to past explosive eruptions of Mt. Fuji and Mt. Omuro, significant amounts of scoria have been deposited. The soil has also gone through weathering and erosion, allowing plants to colonize the space. The Nojirisōgen is flat with few slopes and dips. It has remained a grassland despite many years of non-maintenance and minor forest encroachment. After a period of disuse for fifty years, the grassland was recently burned again to maintain iriai rights.

Methods

We surveyed a total of ten plots in the three grasslands: five were in the Nashigahara, three in the Motosukōgen, and two in the Nojirisōgen. We began each survey by setting up a 10x10 meter plot in an area designated by Watanabe Sensei. We divided the plot into four quadrants. Each quadrant of the plot was surveyed by four individuals, while one person focused on general observations of the whole plot. The center point of the plot was measured and marked for the group of students studying soil. Photos and sketches of the plots were also included in our surveys as well.

To measure geological and ecological differences between grasslands, we used a survey created in the Fulcrum app to record data within each of the quadrants. Each survey recorded was for one quadrant. For general observations of the plot area, we looked at geologic maps and indicated whether or not the plot was on a lava flow, if the plot was on a swell or in a dip, was sloped or flat, and which direction the slope was facing, if applicable. We then indicated any outstanding perimeter observations like nearby endangered species, trees, or roads. The next step was to indicate tree species, the total number of trees, and other tree observations such as size or shade coverage. After identifying trees, we counted the number of shrub species and the total number of individual shrubs. For the next section of the survey, we indicated the estimated percentage of land covered by grasses and ferns, as well as the percentage of exposed or barren soil. We took note if the exposed soil had any important qualities (i.e. exposed lava flow, mounds of scoria, etc.).

To get a sense of overall plant diversity, we counted all angiosperm species in each of the 5 m x 5 m quadrants. We defined angiosperms as all flowering and leafy ground cover species that did not include grass, shrubs or trees.

The final part of our survey was dedicated to endangered species. First, we indicated whether or not endangered species were present in a plot. If they were, the number of individual plants and number of species were noted. For notes on endangered species, we recorded the names of the species found, the total number in the plot, how many of each species were found, and information about the location and the surroundings in which the endangered plant was found. Also photos were included for identification. It is important to note that some of the endangered species we saw were only identifiable because they were flowering during the time of our survey. There may be several plants we missed because Watanabe Sensei was not available to help us identify the non flowering endangered species at the time.

For data analysis, we averaged the percentiles of grass, ferns, and exposed soil for each plot, as well as a final average per grassland. For endangered species data, we added up the numbers of different species present in each grassland and the number of individual endangered plants found in each grassland. There are inconsistencies in the number of plots we surveyed in each grassland due to time constraints during our field work and Watanabe's varying directions in each location. Since the number of plots are different for the three grasslands, we normalized the data for tree, shrub, and endangered species totals by dividing the total number of plants by the number of plots surveyed in each grassland.

Results

Below are graphs of our results from the survey and trends on endangered species, maps supporting our findings on endangered species, as well as tables comparing the grasslands and endangered species totals.

In the tree and shrub section of our survey, we wanted to see how many were present in each plot. Trees offer shade to the plants surrounding them, potentially helping them to retain moisture.

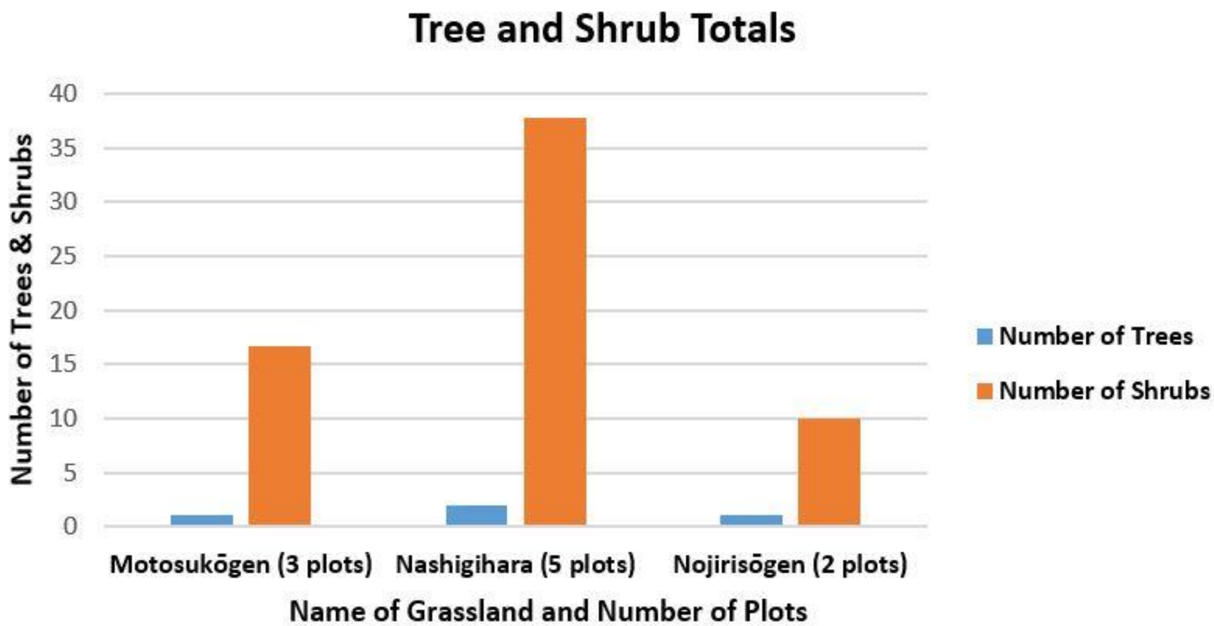

Fig. 2: Comparison of total number of individual trees and shrubs between all three grasslands.

The Nashigahara contains the most trees and shrubs per plot. Within the five plots that were surveyed, there were ten trees and 189 shrubs -- at least 75% more than the others. Motosukōgen comes in second with 50 shrubs and no trees. The Nojirisōgen has the fewest number of shrubs at 20, and just one tree.

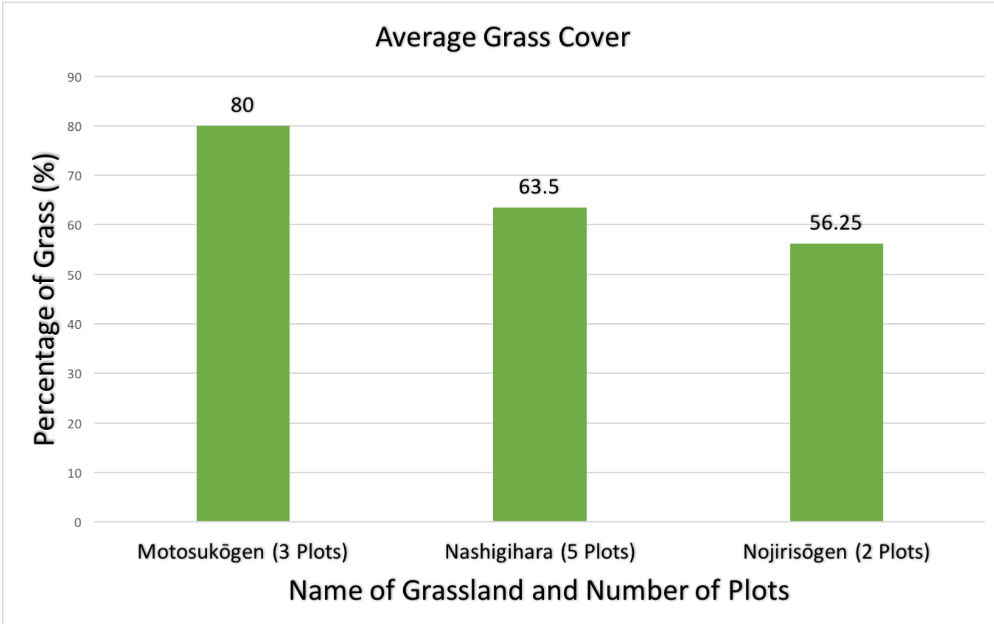

Fig. 3: Comparison of the average percentage of grass cover between all three grasslands.

The grass percentage was an important component within our plots from each grassland. To make this graph, we took the total amount of grass in each grassland and divided it by the number of plots surveyed to normalize the data. The plots within the Motosukōgen had the largest percent of surveyed space covered by grass. There is only a 7.25% difference in grass coverage between the Nashigahara and Nojirisōgen.

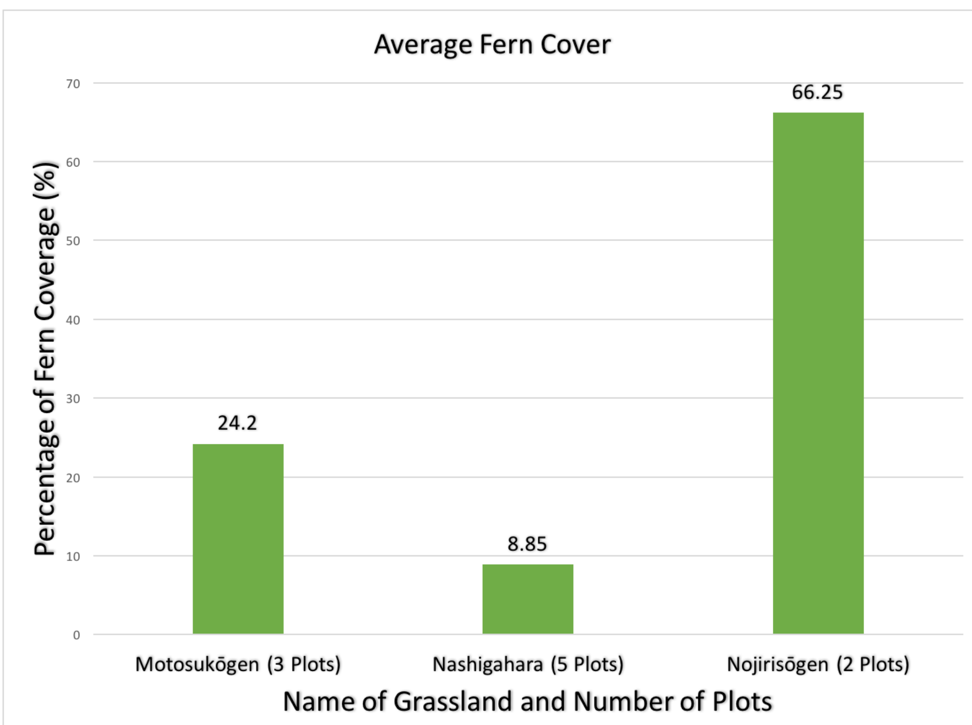

Fig. 4: Comparison of the average percentage of fern coverage between the three grasslands.

Fern coverage was also a noticeable component of the plots. We chose to include this in the survey because it was one of the most abundant plants in some of our plot areas. Similar to trees, ferns can play a role in helping the surrounding areas to retain moisture as well. It is clear that the Nojirisōgen has the most fern coverage by far, leading by 42.05%. Although both the Motosukōgen and Nashigahara have considerably less fern cover, lack of ferns is most evident in the Nashigahara at only 8.85% of coverage.

Another characteristic we surveyed was the percentage of exposed soil. This was done in order to keep track of how much barren soil and rocks were present in our plots. Noting the exposed soil also helped to give us a better overview of the landscape of our entire plot.

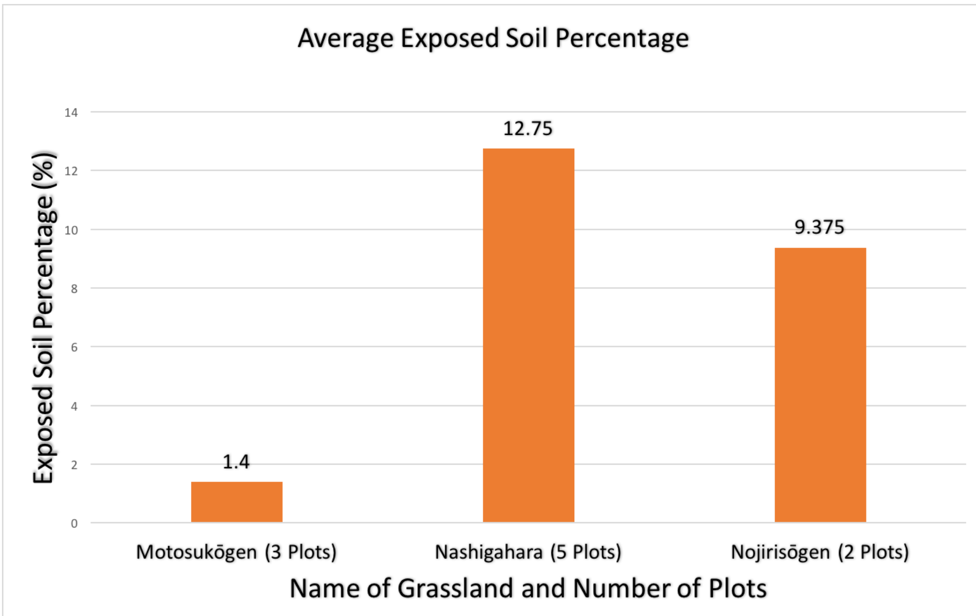

Fig. 5: Comparison of the average percentage of exposed soil between all three grasslands.

The Motosukōgen has a significantly smaller percentage of exposed soil, with an average of only 1.4%. This may be due to the fact that the Motosukōgen lies on top of the oldest lava flow. It has had the most time to weather and for biomass to accumulate. The Nashigahara leads in exposed soil percentage at 12.75% while the Nojirisōgen iss at 9.375%.

The following figures depict our findings on the totals and different species types that we discovered in our plots. This is where we focused a majority of our research, in conjunction with the work Watanabe Sensei has done thus far regarding endangered species in the Fuji grasslands.

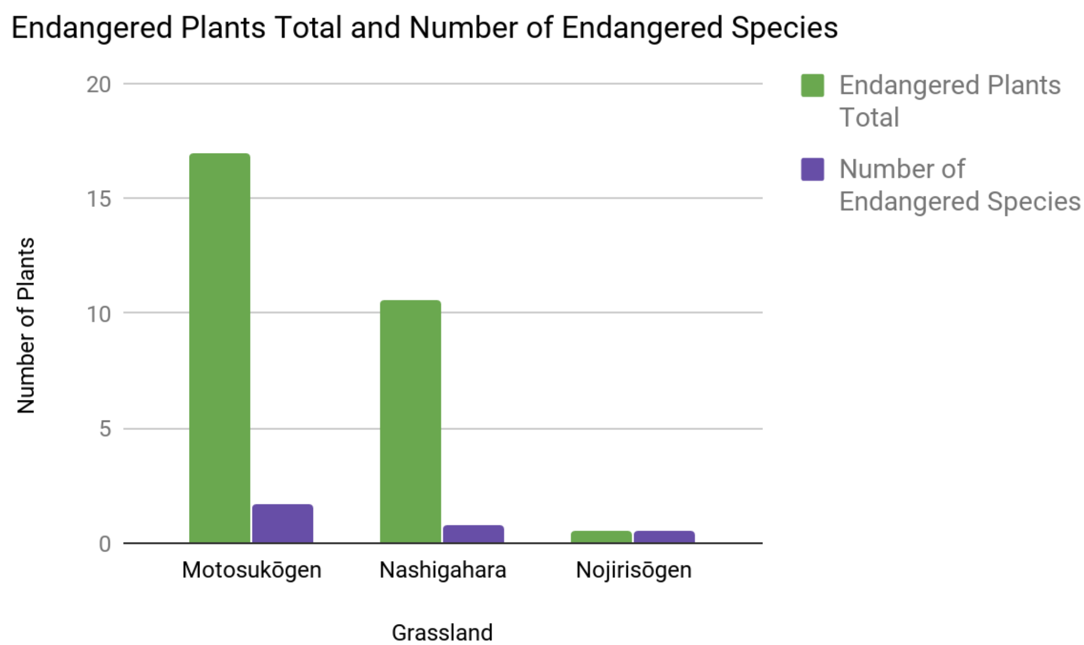

Fig. 6: Comparison of the number of individual endangered plants and number of different species found in all three grasslands.

Although relatively close, the Motosukōgen has more endangered species than the Nashigahara but the Nashigahara has a greater number of individual endangered plants. The number of endangered plants and species is drastically lower in the Nojirisōgen.

This map was created to provide a visual distinction between the plots that we surveyed from three different grasslands and the total number of endangered plants that we found. The triangle shape stays the same for each plot surveyed. The color gradient represents the change in number of endangered plants found. Red is the least endangered plants, and blue is the most endangered plants found per plot.

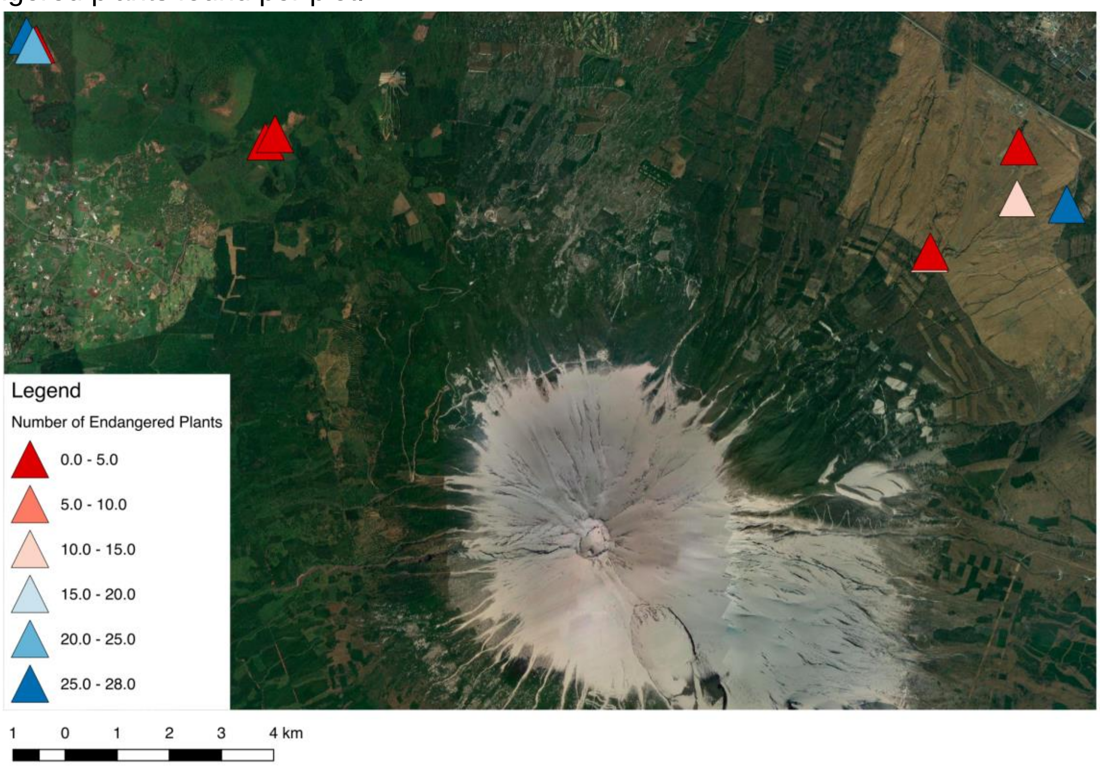

Fig. 7: The number of endangered plants in each plot.

The plot with the most endangered plants was in the Motosukōgen with 28 endangered plants and shows the brightest red color. The plot with the least was from the Nojirisōgen with one endangered plant and is represented with the darkest blue.

This map was created to show the number of plots and the number of endangered species found in each plot. Like the map above, the shape stays the same. The color gradient represents blue as the most endangered species, and red as the least number of endangered species found per plot,

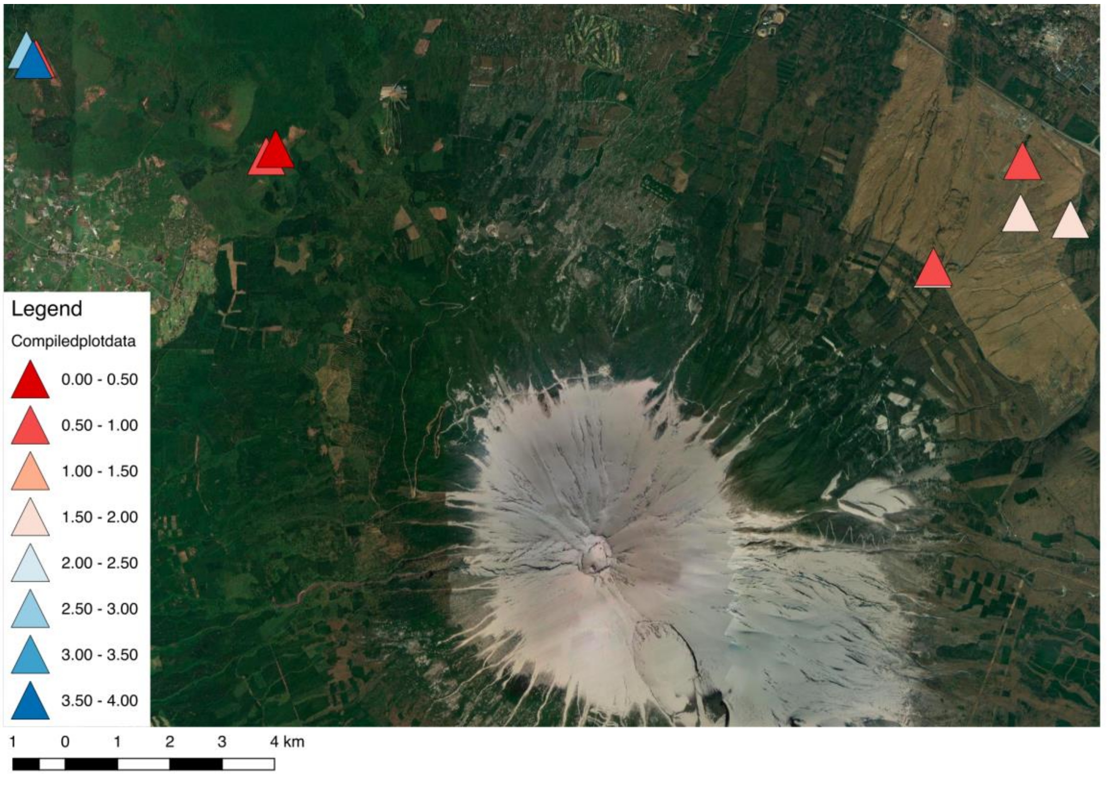

Fig 8: The total number of endangered species in each plot.

The grassland with the fewest number of different endangered species was the Nojirisōgen and is represented in the darkest blue color. The grassland with the greatest number of different endangered species was the Motoskōgen and is represented with the brightest red color.

The tables below show the different species discovered in each grassland. It is interesting to note that several species only appeared in two grasslands, while some were only found in one. There was not a single endangered species that was discovered in all three grasslands.

	Grassland		
Species	**Motosukōgen** **(**3 plots = 30m^2)	**Nashigahara** (5 plots = 50m^2)	**Nojirisōgen** (2 plots = 20m^2)
Basobu	**11**		
Mizu-chidori	**5**	**1**	
Suzusaiko	**10**	**29**	
Kasenso	**4**	**33**	
Funabaraso	**2**		
Murasaki		**6**	
Sanshobara			**1**

Table 1: Distribution of Endangered Species Plants in the Three Grasslands.

Basobu and funabaraso were only present in the plots we surveyed in Motosukōgen, murasaki was only found in the Nashigahara, and sanshobara was only found in Nojirisōgen. The species mizu-chidori, suzusaiko, and kasenso were present in both the Motosukōgen and Nashigahara.

	Grassland		
Species	**Motosukōgen** (3 Plots = $30m^2$)	**Nashigahara** (5 plots = $50m^2$)	**Nojirisōgen** (2 plots = $20m^2$)
Basobu	3.67		
Mizuchidori	1.67	0.2	
Suzusaiko	3.33	5.8	
Kasenso	1.33	6.6	
Funabaraso	0.67		
Murasaki		1.2	
Sanshobara			0.5

Table 2: Number of endangered species in the three grasslands.

The area surveyed varies per grassland, therefore the data is normalized according to number of plots surveyed. By doing this, we are able to roughly compare abundance of endangered species across the three grasslands. It appears that some species show up more or only in certain grasslands.

We looked at two specific factors when analyzing the presence of endangered species: grass and fern coverage. The percentage of land covered by these plants was thought to possibly affect the types and totals of endangered species we discovered in each plot.

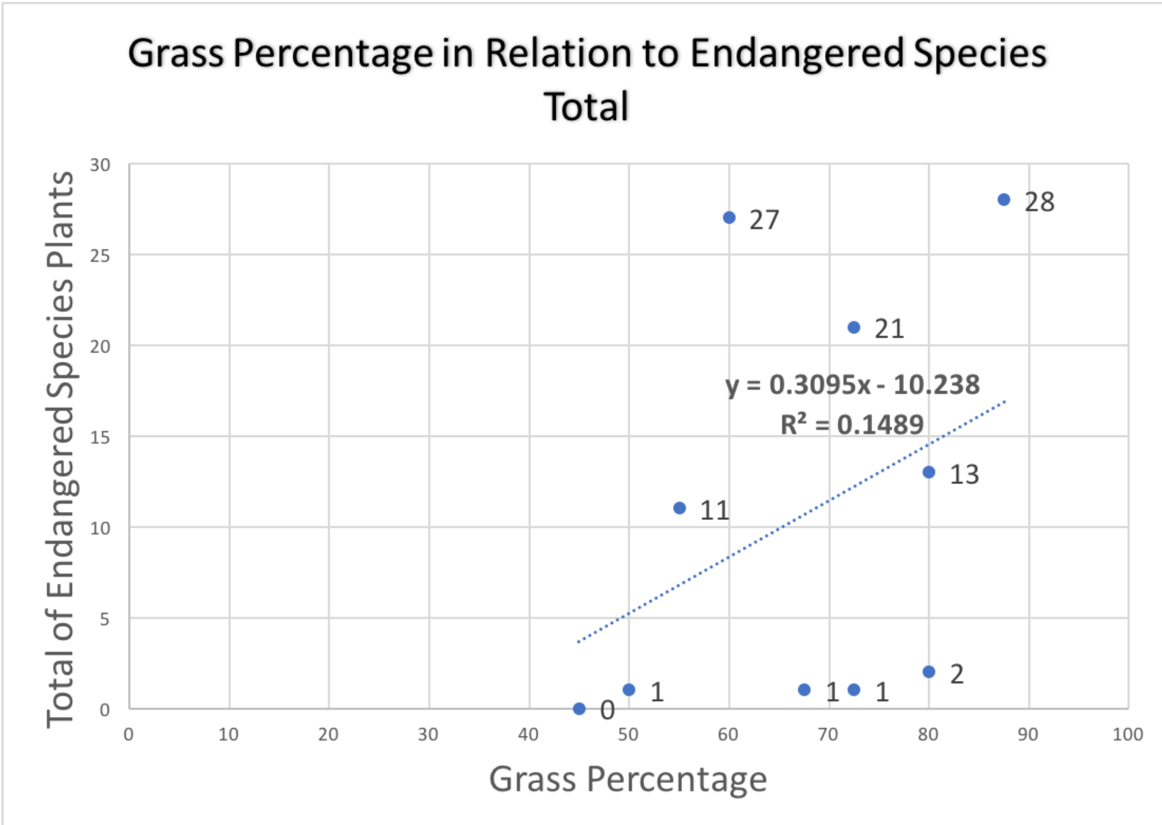

Fig. 9: The scatter plot above shows the grass percentage of each surveyed plot in relation to the total number of endangered species discovered in the respective plots.

As we can see from the line of best fit, the R^2 value is 0.1489. This means that approximately 15% (R^2 x 100) of the variation in *y* (endangered species total) is accounted for by the variation in predictor *x* (grass percentage). This is not a strong relationship, but as the grass percentage increases, we do see a slight increase in the total number of endangered species found in each plot. We learned from Watanabe Sensei that the presence of grass is important for the survival of endangered species which is why we chose to look at this specific variable. Grass is also an important indicator of a flourishing grassland, the ideal ecosystem for the endangered species to survive.

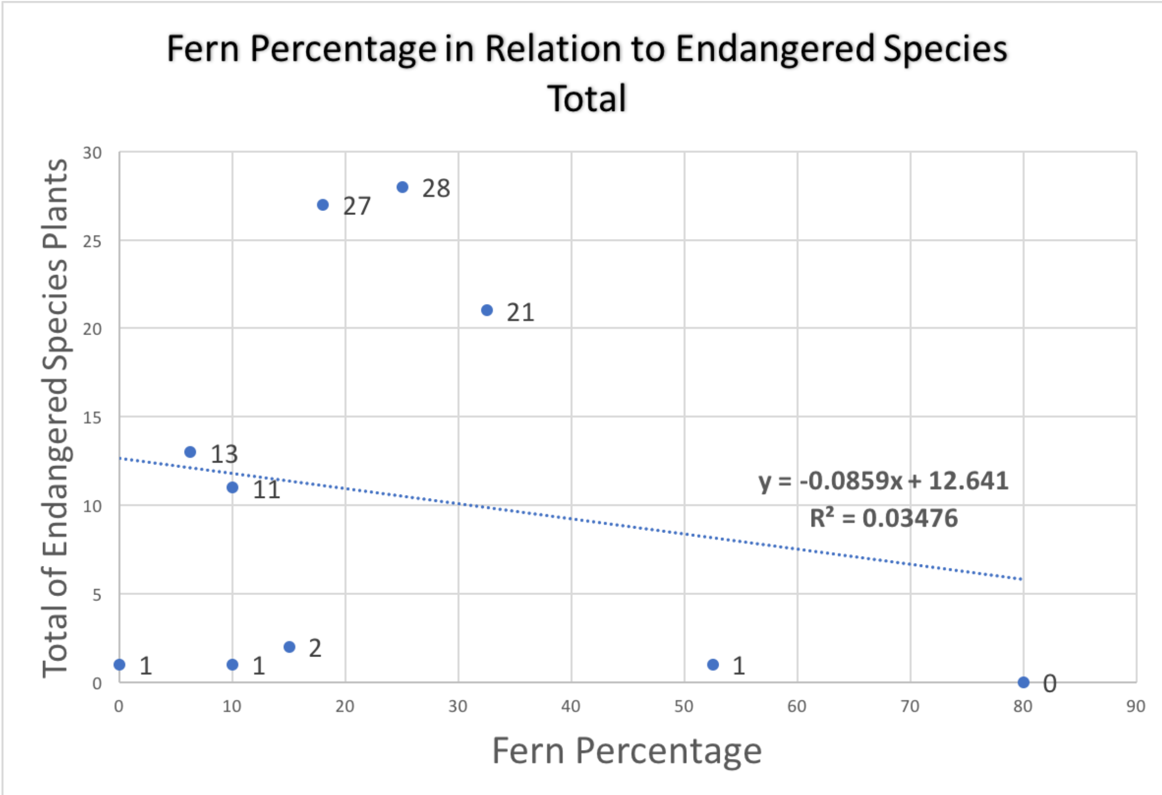

Fig. 10: The scatter plot above shows the fern percentage of each surveyed plot in relation to the total number of endangered species discovered in the respective plots.

During our fieldwork in each grassland, ferns appeared to play a potential role in the presence of endangered species. We noticed that the one plot that did not have any endangered plants was also the plot with the highest fern percentage. However, the R^2 value of the line of best fit for the scatter plot is 0.03476. This means that only 3% (R^2 x 100) of the variation in *y* (endangered species total) is accounted for by the variation in predictor *x* (fern percentage). This is an extremely minimal relationship so we cannot say that ferns affected the presence of endangered species in the plots we surveyed.

The three plot sketches below exhibit the range of plant coverage and geologic formations. What is particularly interesting is the difference between grass and fern coverage between

Nojirisōgen and Nashigahara (Fig 3, Fig 4). Further, the Motosukōgen firebreak zone had trails and exposed soil, yet had the most total number of endangered plants (Fig 6).

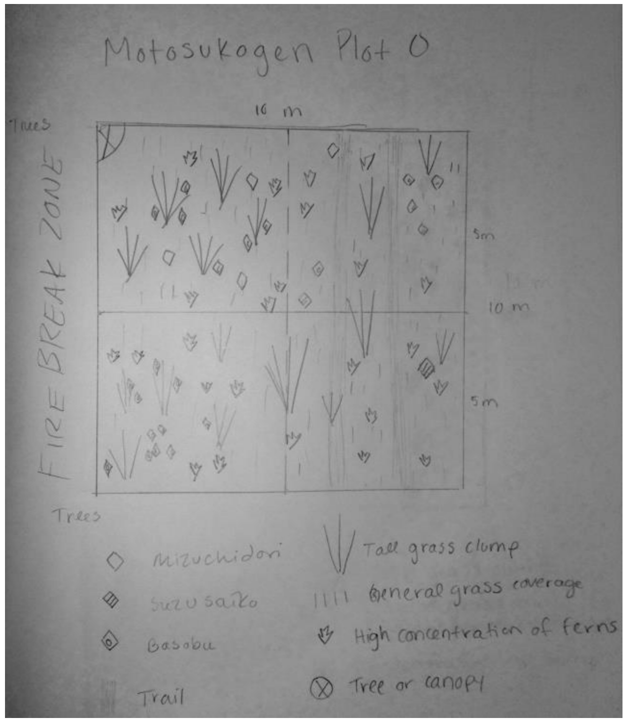

Fig. 11: A sketch of Motosukōgen Plot 0 and legend.

Motosukōgen Plot 0 had the the most total number of endangered plants and three different species. Note firebreak zone to left and trees in perimeter. Further, forest canopy covered the upper left quadrant.

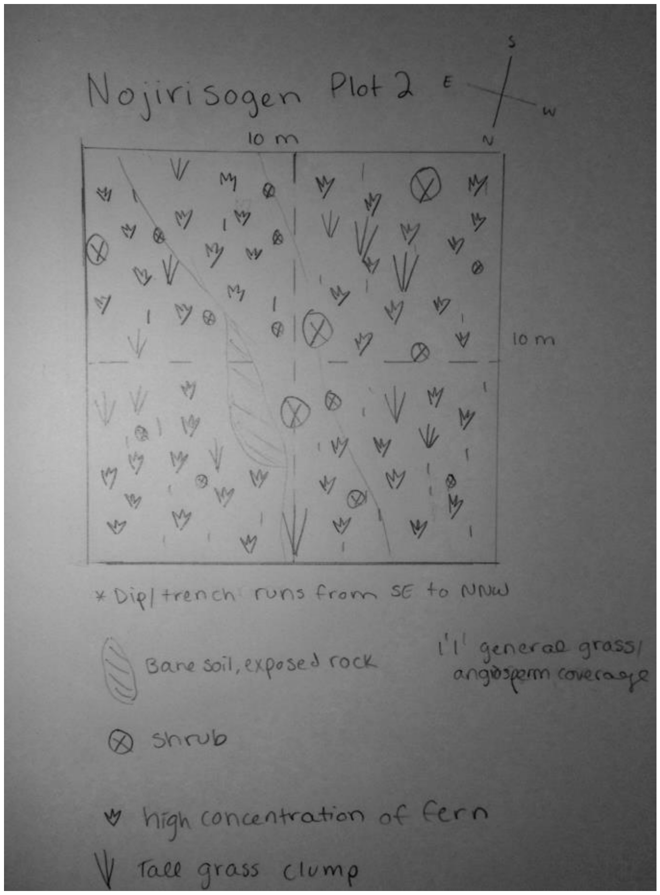

Fig. 12: A sketch of Nojirisōgen Plot 2. Note high concentration of ferns.

The second plot in the Nojirisōgen was the only plot in which no endangered species were found. The plot was covered by high concentrations of ferns, with some low grass and few clumps of much taller grass. The plot also had a trench in the center with exposed lava rock.

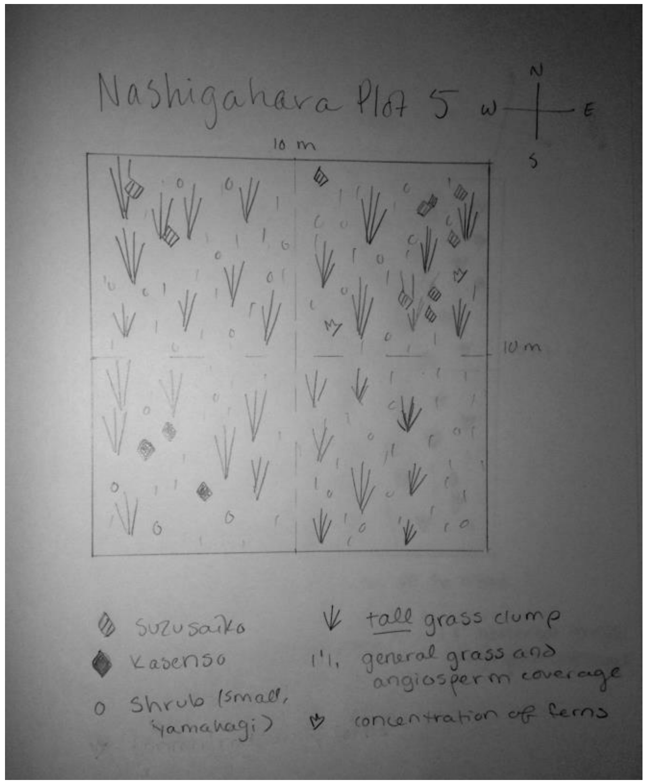

Fig. 13: A sketch of Nashigahara Plot 5. Note high percentage covered by tall grass.

Nashigahara Plot 5 had two different endangered plant species, and thirteen total plants. This plot was selected because the number of endangered plants found was in between extremes found in other plots. Another noticeable characteristic is that this plot had the second highest percentage of grass coverage of all plots surveyed.

Discussion

In this section, we hope to raise interesting points regarding potential trends. In order to do this, we used the findings from the soil and butterfly groups as well as our overall data to highlight trends and direction for further research. However, it is crucial to note that due to limited variation and randomization of plots surveyed from each grassland, we cannot reach any definitive conclusions from our current data.

The scatter plot depicting the grass percentage and total number of endangered species for each plot has an R^2 value for the line of best fit of 0.1489 (see Fig. 9). This value is close to 0, meaning that there is not a high dependency of endangered species totals on grass percentage. Our scatter plot indicates that overall there is not a significant relationship between increasing grass percentage and endangered species totals within each surveyed plot. There is a slight increase, but not enough to determine a strong connection between the two variables. We also created a scatter plot looking at the same thing except with fern percentage (see Fig 10). Little to no relationship was discovered between the percentage of ferns and the presence of endangered species. Both these findings disprove our initial hypothesis that areas with higher percentages of grass and ferns will also contain more endangered species. However, our results are only true for our surveyed plots, so it is possible that a relationship between grass, ferns, and endangered species could still exist in each grassland as a whole.

Encroachment of forest into grassland could be due to the decreased usage of common lands. Human influence is key for the preservation of grasslands. After surveying the three grasslands, we deduced the possibility of a correlation between land use and the presence of endangered species. This is evidenced by the difference between land use history of the three grasslands. Regular mowing and burning of the Nojirisōgen has subsided since the 1960s, and forests have begun to take over. The most recent mowing of the Nojirisōgen was two years ago, and was the only mowing within the last 50 years. The two plots in the Nojirisōgen surveyed had very few endangered species (Fig 5, Fig 8). However, it was the only grassland in which the endangered shrub sanshobara was found. On the other hand, the Motosukōgen has continued to be mowed annually and people with iriai rights harvest herbs from the grassland. Interestingly, the firebreak zone of the Motosukōgen (Plot 0) had the most endangered species plants. Near this plot were piles of dead grass and a trail. Clearly, this land has seen human visitors. Two endangered species were found exclusively in the Motosukōgen: basobu and funabaraso (Table 1). It appears that the Nashigahara is particularly favored by the species suzusaiko and kasenso, and perhaps murasaki (Table 1).

As forests have been encroaching along with the decline in human intervention, we chose to look more closely at the number of trees in or near a plot. If a plot was near the edge of a forest or had a few trees nearby, we noted this in our surveys. Three of our plots were located far away from large numbers of trees, while others were in close proximity to forests. Plot 2 of the Motosukōgen, located in the center of the grassland, Plot 1 of the Nashigahara, and Plot 1 of the Nojirisōgen were distinct from other plots, as they were much more distant from large numbers of trees. Nojirisōgen had small trees present, but could not be categorized as near forest. These plots had some of the fewest numbers of endangered species plants. On the other hand, Plot 4 in the Nashigahara had ten oak saplings within it, and larger oaks on the perimeter of the plot. This plot had the second largest number of endangered species. The firebreak zone of the Motosukōgen in Plot 0 (Fig 11), as well as Plot 2, were very near trees as well. These had 28 and 21 endangered plants, respectively (Fig 6). The most endangered plants that were found in all of the grasslands was the plot in the Motosukōgen with the 28 endangered plants. (Fig 7). Interestingly, the only plot where we found no endangered species was Plot 2 of the Nojirisōgen (Fig 12). This plot had the highest fern coverage and was near a large collection of oaks (Fig 3). There was such a difference in landscape in this plot that no clear conclusion can be drawn, but as the space between grasslands and forests are ecotones, a correlation between the presence of trees and numbers of endangered species would be interesting to look further into.

The presence or absence of lava flows was another variable to consider. Three of our plots in the Nashigahara (Plots 3, 4, and 5) were directly on top of lava flows. Our plots in the Nojirisōgen and Motosukōgen were on top of much older lava flows. In the Nashigahara, Hinokimarubi E and Takamarubi A/B erupted about 1,000 years ago. Although Plot 4 on Takamarubi A was especially rich in endangered plants, our plots on Takamarubi B and Hinokimarubi E did not display notably higher amounts of endangered species than areas off of recent lava flows. All three of these lava flows are of similar age and we surveyed only one 10 m x 10 m plot on each, so conclusions cannot be certain. With regards to the grasslands as a whole, correlations cannot be drawn between the age of a lava flow and the amount of endangered species present. Although the greatest number of endangered species were found on top of the oldest lava flow (15,000 to 6,000 BC) at the Motosukōgen, the smallest number of endangered species was found above the second oldest flow (3,600 to 1,500 BC) at the Nojirisōgen. Conversely, the second greatest number of endangered species was found atop the most recent lava flows at the Nashigahara. Soil type and the density of soil could be responsible for these variations, but the presence or age of lava flows at our different sites do not point to any clear conclusions.

To find further trends we looked at data collected by the soil researchers. The apparent concentration of endangered species in areas that experience more human involvement (Nashigahara and Motosukōgen) could also be related to the humic content of the soil. According to research done by the soil group, the Nashigahara and Motosukōgen had thick surface layers, rich in organic material. This could be due to prolonged human intervention on a large time scale, in the forms of mowing and burning.

We also looked at data from the butterfly research group who found that the Nashigahara had the highest number of different and endangered species of butterflies. The endangered plant total was also the highest in the five plots we surveyed in Nashigahara. The higher amounts of butterfly and plant totals could be due to the fact that the Nahsigahara is heavily maintained. Although this is a trend we found, we are unable to find a clear connection between the presence of butterfly species and endangered plants. This is due to the fact that the butterflies do not strictly depend on endangered species to survive. On the other hand, both endangered species and endangered butterflies have a connection through their unique habitat. The niche for endangered plants and butterflies has been decreasing. It is unclear to Watanabe why the habitats have declined over recent years.

If we were to continue this research we would want to look more in-depth at geological aspects of the plots, grass identification, and the potential relationship between plants and butterfly species. We would hope to do this in more controlled conditions. This would mean knowing the exact survey areas within the grasslands beforehand and randomizing where we place our plots. We could also survey more plots of a smaller scale, in order to focus our identification. For the butterfly species, we would want to know their specific habitats and food sources in order to identify potential relationships.

In summary, the three grasslands surrounding Mount Fuji have historical, geological, and ecological land differences that contribute to the presence or absence of endangered species today. Plots created in areas with a longer history of land use had more endangered species. For example, the Motosukōgen was the only plot with a fire break (which is heavily maintained) and it had the most endangered plants in any of the plots we surveyed. Nojirisōgen has not been continually maintained until the last few years. In Nojirisōgen, we surveyed the smallest number of plots. The plots contained only one endangered species and had the lowest average grass percentage. We surveyed the largest number of plots in the Nashigahara, a grassland that has been heavily maintained for military use. These five plots had the most shrubs and trees as well as the most endangered species. Although there was some apparent connections in our raw data regarding grass percentage, fern percentage, and higher endangered species total, the scatter plots we analyzed showed a minimal relationship between those two variables. According to our data, it appears that human intervention is not only needed for the grasslands to prosper, but also for the endangered plants within them to survive.

Acknowledgements

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