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Stars, Long Fingers, and Signals: A Study on Grass Species Diversity, Density, Frequency, and Veld Analysis at Ndarakwai Wildlife Ranch

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“Knowing trees, I understand the meaning of patience. Knowing grass, I can appreciate persistence.”

-Hal Borland

“I asked the waiter, 'Is this milk fresh?' He said, 'Lady, three hours ago it was grass.'”

-Phyllis Diller

Acknowledgements

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We must also express much gratitude to our askari Jeremiah, Head Wildlife Ranger Thomas, friends and cooks Joyce and Mary, reception manager Saba, driver and ambulance Olias, and all of the staff and askaris at Ndwarakwai who encouraged us and made us feel welcome with many a "karibu tena".

Abstract

This study was the first step to assessing veld quality and grass species diversity at Ndarakwai Wildlife Ranch in West Kilimanjaro, Tanzania in an effort to better inform management decisions that affect grasses and grazers. Our study was performed from April 5 to April 26, 2014. We utilized compass line quadrat method (n=600) in six sub-populations within three sample frames to achieve non-representative, random data set on richness, diversity, frequency, and density, with metadata from which we extrapolated veld indicators through secondary-source knowledge. Across all sample frames, we found 43 specimens: identified 29 to species, 7 to genus, and left 7 unidentified. Sample Frame A were sloped and non-sloped sub-populations. We found that sloped grass community had all healthy veld indicators. We recommend management leave the veld un-manipulated. Sample Frame B were Burn A, Burn B, and Non-burned sub-populations. Burned populations were statistically significantly dependent on region (p=0.0000, alpha=0.1), but were ecologically similar to their control. Burns more frequent than five year intervals would decrease high moribund plot frequency and fully reestablished communities. Sample Frame C were farmed and non-farmed sample populations. Farmed sample population exhibited the lowest density (19.48 +- s.d. 25.34) and most non-grass plots of all sample populations (17). We recommend an attempt at seeding the area, with efforts to help counter the effects of erosion in the region, such as rock terracing or mulching. Future studies are recommended to achieve a representative grass survey or to incorporate the effects of manipulations such as controlled burns and soil homogenization before any ecological restoration has started.

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Introduction

The Importance of Grass

"As a wildebeest walks along feeding it encounters different individual grass plants at different stages of growth, different genotypes of the same grass species, different grass species, and a mixture of grasses forbs and shrubs. It is presented with a number of options. Do I take a bite of this or not? Do I stay here or do I move? If I move, in what direction? How far should I move in this direction before I change direction? Should I stop here or are there more profitable areas ahead? The responses to some of these alternatives are probably, to a certain extent, genetically programmed, but many also undoubtedly may be learned to a considerable extent. How the herbivores respond to these alternatives is influenced by, and influences, the entire character or the Serengeti ecosystem."- S.J. McNaughton, Serengeti II

How all types of herbivores respond to vegetation variables is influenced by, and influences, entire grassland ecosystems across the world. Herbivores are not the only type of animal intertwined with grass species composition. Vegetation provides the base level of biomass upon which all trophic levels depend. Even humans, whether we like to believe it or not, are entirely dependent on vegetation and grass species availability for survival. Grasses were the first plants to be cultivated as food over ten thousand years ago and are still the largest source of food for humans worldwide. It is abundant, nutritious, easily cooked, and also used as fodder for livestock that eventually becomes food for humans (Van Oudtshoorn 2009). Grasses also prevent soil erosion, which affects the availability and quality of potable water and consequential health effects of polluted water. As important as grasses are to the global ecosystem, they are often overlooked and underappreciated, necessitating further research and understanding.

Grass Definition and Function

A grass is taxonomically defined as any species within the large family (*Gramineae* or *Poaceae*) of monocotyledonous plants having narrow leaves, hollow stems, and clusters of very small, usually wind-pollinated flowers. Grasses include many varieties of plants grown for food, fodder, and ground cover (Grass 2014). Grasses are often confused with sedges (*Cyperaceae* family) and reeds (*Restionaceae* family. However, sedges do not have a leaf sheath and their leaves are attached directly to the culm—a diagram of grass anatomy is provided in Appendix C. The culms of sedges are also angular, while grass culms are circular. Reeds can be distinguished from grasses because their leaves consist only of a leaf sheath that surrounds the culm. The grass family is the fifth largest plant family on earth with over 700 genera and 9700 species. About ten percent of the grass species worldwide can be found in southern and tropical Africa; the major genera of which are Eragrostis, Pentaschistis, Panicum, Sporobolus, Aristida, Digitaria, Stipagrotis, Setaria, Brachiaria, and Hyparrhenia (Van Oudtshoorn 2009). These species support the wide diversity and abundance of wildlife for which East Africa is famous.

Almost all animal species and food chains depend on grass because grass occurs across the world and is almost always edible. The groups of animals that depend most directly on grass for food are birds, insects, rodents, and grazers. There are many bird species, such as *Quelea* finches, the most common bird on earth with a population of over 1.5 billion in Africa alone, that solely eat grass seeds. Grass provides the only food source for seed-eating birds, and the birds play an integral role in seed dispersal. Insects use grass for both food and shelter. Disruption of these grassland ecosystems can cause a dangerous under or overabundance of insect species. Rodents consume grass seeds or the base of the plant where the most nutrients are stored. Grazers have the largest impact on grasslands and typically graze in large herds which makes spatially expansive impact.. Grazers remove old plant material, stimulate new growth, and provide nutrients in the form of manure. Although predators and decomposers are also ultimately dependent on grass species, it is primary consumers- specifically herbivores- that have the biggest causal relationship with grass species. Herbivores and grass species composition are highly interdependent.

Most grass species depend on grazing or ecological management to maintain a healthy growth cycle. The growth point of an individual grass is situated close to ground, which allows the majority of the plant to be defoliated and still have the ability to re-grow. Reserve nutrients are stored in the roots and culm base, which are used to support the individual until it is able to photosynthesize again. Once the individual grass is mature, it again builds a store of reserve nutrients. If leafy and flower material are not removed from the individual by grazing or burning, excess moribund material builds up and suffocates the plant. Overgrazing occurs when repeated defoliation exhausts the amount of reserve nutrients in an individual. The roots become weak and are unable to absorb water, so the plant dies. If overgrazing happens on a large scale, the food source for animals will quickly be depleted. It is vitally important for managers of national parks, private conservation areas, and ranched areas with large numbers of wildlife or cattle to understand how grazing can affect grass species.

Evaluating a Grassland

There are four main measures to evaluate a grassland: grazing value, ecological indicator status, succession stage, and perenniality. Several factors that can help conservation managers determine whether their area is providing valuable grazing material. By identifying grass species in the area, grazing value can be determined. Grazing value is defined as the quality and quantity of material from an individual available for grazing (Van Oudtshoorn 2009). The factors affecting grazing value are:

- Production: the amount of leaf material
- Palatability: general acceptance of grazers due to nutrient value and digestibility
- Nutrient value: the amount of nutrients in a grass, of which crude protein content is the most important aspect
- Growth vigor: capability for rapid regrowth of grazable material
- Digestibility: depends on fiber content of leaves, a higher fiber content= lower digestibility. Some plants contain silica particles that are indigestible.
- Habitat preference: a habitat may lend itself to higher leaf matter and nutrient content

A healthy mature grassland with many species of average to high grazing value will attract and be able to support a larger number of herbivores than a grassland which has a majority of low grazing value species (Van Oudtshoorn 2009).

Conditions of grasslands can also be evaluated by the ecological status of grass species in the area. Ecological status of a grass species refers to the group it is categorized in based on its reaction to different levels of grazing. The different ecological statuses that a grass species can be categorized in are:

- Decreaser: species that are abundant in a healthy veld, but decrease when the veld is overgrazed or undergrazed
- Increaser I: species that are abundant in underutilized veld. They are usually unpalatable, robust climax species that can grow without any defoliation
- Increaser II: species that are abundant in overgrazed veld. They increase due to disturbance of overgrazing and are mostly pioneer and subclimax species. They produce many seeds and can quickly establish on newly exposed ground.

- Increaser III: species that are commonly found in over grazed veld, but are usually unpalatable dense climax grasses. They are found in the overgrazed veld only because herbivores choose not to consume them. They are strong competitors and increase because the palatable grasses have become weakened through over grazing. Removing this group by normal grazing practices is difficult; however they will mostly suffocate during underutilization.
- Invasive: species that are not indigenous to an area. They are mostly pioneer plants and are difficult to eradicate. (Van Oudtshoorn 2009)

The abundance of grasses in each group can help management determine whether a veld is being grazed at a sustainable level or needs intervention to increase the quality and quantity of grasses.

The third measure of veld analysis to be used in this study is succession stage. Grass species fall into three categories of succession: pioneer, subclimax, and climax stage. Pioneer species are the first to colonize a substrate and can survive in less than ideal habitat. Their roots systems hold soil in place, reduce runoff, and increase nutrient intake in the soil. The changes in conditions made by pioneer grasses make an area suitable for subclimax grasses. Subclimax grasses survive in an area until it is colonized by climax species. Climax species out-compete most other species. It is not uncommon for there to be a small number of pioneer or subclimax grasses in a climax veld, but the majority of the grasses will be climax.

Finally, perenniality of grasses in an area can be used as an analysis tool. Perenniality describes the number of years and individual can survive without re-seeding. Grasses classified as perennials will live for five or more years without needing to re-seed. Annual grasses will re-seed every year. A high number of perennial grasses in an area indicate that there will be a healthy population for multiple years.

Significance of the Study

Evaluating grazing value, ecological indicator status, succession stage, and perenniality allows conservation managers to understand the strength and quality of grasslands. A thorough understanding of grasslands as a community and as a resource can lead to further analyses on biomass levels and carrying capacity. Specifically in Tanzania, where ecological tourism accounts for 20% of the GDP annually, it is vital for conservation managers in national parks and private reserves to understand the food source that supports wildlife that draws tourists from around the world (Matthews 2014).

Our study on grass species composition and veld analysis is specifically useful at the study site—a privately owned conservation area called Ndwarakwai Wildlife Ranch. The study presented in the report addresses how grass species density, diversity, and frequency vary between six subpopulations within Ndarakwai: a sloped area and adjacent flat plain, a formerly farmed area, two burned areas, and a control region that was neither farmed nor burned. The study was conducted from April 4th to April 26th of 2014. We chose to study grass species at Ndarakwai Wildlife Ranch in order to inform management so they may make more informed decisions concerning ecological management, as well as to provide a baseline for long-term continued research on grass species composition.

Study Site

Our study took place at Ndarakwai Wildlife Ranch in the Siha District of Western Kilimanjaro, Tanzania. The eleven-thousand acre property is located at the bottom of the northwestern slopes of Mount Kilimanjaro. The nearest large city, Arusha, is approximately seventy kilometers southwest from the ranch. Ndarakwai is also approximately thirty-five kilometers south of the Kenya-Tanzania border.

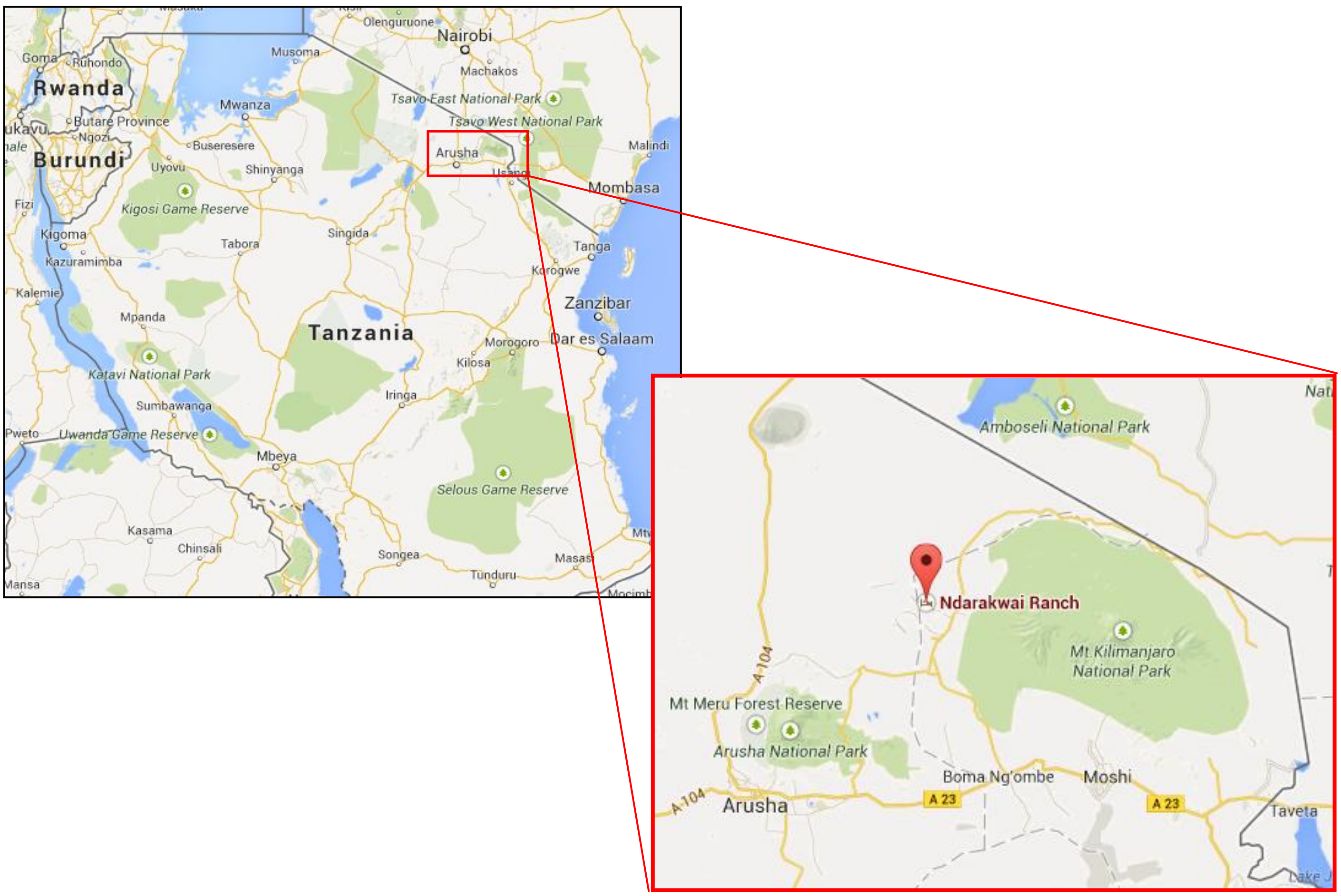

Figure 1. ***Study Site Location***. Google Earth, 2014

Ndarakwai Wildlife Ranch has a fascinating history and has undergone many transformations over the last century. The area was named by the Maasai people of Tanzania after the native cedar trees species Ndarakwa. During the mid-1900s, the area was farmed and ranched by German colonialists when the country was still known as Tanganyika. Before Britain took control of the colony, the area saw considerable fighting during WWI. Many German trenches can still be found on the property. Post-war, the area was again ranched, this time by British colonialists until the 1970s. Tanganyika gained independence in 1961; in 1975 several farms in the West Kilimanjaro region were nationalized including the area now known as Ndarakwai Wildlife Ranch. Nationalized control of the farm land unfortunately led to overgrazing, deforestation, and poaching until 1994. Conservation of the area became important for the first time in 1995 when Peter Jones, directing manager of the ranch, bought the property and decided to restore the health of the ranch and its ecosystem.

Ndarakwai is a dry savanna grassland ecosystem commonly referred to as bush land. The ecosystem is characterized by seasons based on rainfall. There are two dry seasons and two wet seasons in the dry savanna where Ndarakwai is located. The *masika*, long rains, last from mid-March to May followed by a dry cold season from May to October. The *mvuli*, short rains, last from November to January. The warm dry season follows from December to March. Rainfall greatly affects structure and productivity of vegetation. Dry savannas receive on average less than 600mm of rain annually (Gichohi 1996). Although the word dry implies that there is an insufficient amount of water, rainfall amounting to 500-700mm annually is ideal because it allows nutrients to collect in the soil.

The amount of rainfall Ndarakwai receives makes the ranch mostly open plains with some areas of more concentrated acacia and woody growth. Additionally the area has scattered granite and gneiss outcrops, called kopjes, due to past volcanic activity in the area. The kopjes as well as the large stream that runs through the ranch provide many microhabitats within the grassland. After nearly twenty years of rehabilitation, the ranch now conserves a wide variety of habitats that support more than 70 mammal and 350 bird species. It also protects seasonal elephant routes and provides a reprieve for animals such as eland, zebra, buffalo, and cheetah during the dry season. There are also many year-round residents such as kudu, Grants gazelle, warthogs, impala, wildebeest, and giraffe (Ndwarakwai Ranch 2014).

Within the many habitats at Ndarakwai, we chose to study three sample frames. The locations of our sample frames within Ndarakwai are detailed are detailed below. We chose these areas in order to gain a sufficient amount of information on grass species density, diversity, and frequency that will be useful to Ndarakwai management in future ecological manipulations of the ranch. The data gathered from the three sample frames will help provide a baseline for continued research on grass species.

Sample Frame A: Sloped/Non-sloped Sit Description

Sample Population: Sloped (picture above left)
GPS Coordinates of Baseline: start S 02’59’46.9” E 037’00’14.3”
end S 02’59’46.2” E 037’00’13.4”
Baseline: East to West, trail across top of mountain
Compass Line Aspect: north and south
Site Description: at an elevation of 1465m, scrubland, rocky soil with many pebbles on surface, south slope steeper than north side

Sample Pupulation: Non-sloped (pictured above right)
GPS Coordinates of Baseline: start S 02’59’57.8” E 037’00’20.2”
end S 02’59’57.6” E 037’00’137.8”
Baseline: East to West, along wildlife trail
Compass Line Aspect: south
Site Description: at base of sloped area, some scrub and bush along with many trees, more scrub towards east end of baseline, more pebbly than other areas, red soil

Sample Frame B: Burn A/ Burn B,/Non-burn Site Description

Sample Population:Burn A (no picture)
GPS Coordinates of Baseline:
start S 03’00’25.5” E 037’00’02.3”
end S 03’00’21.8” E 037’00’01.2”
Baseline:
Serengeti road near ranger house
Compass Line Aspect: east
Site Description:
light bush coverage and few trees, few dense clumps of grasses, utilized by Ndarakwai cows for grazing, baboons and ruminants spotted frequently, few more trees towards east end of line

Sample Population: Burn B (pictured above)
GPS Coordinates of Baseline: start S 02’59’16.8” E 036’59’55.3”
end S 02’59’10.7” E 036’59’52.8”
Baseline: east to west, starts near large acacia tree and termite mound
Compass Line Aspect: south
Site Description: open plain, minimal scrub, gently ungulates, few trees, patchy, northeast side of Pasaronga, cattle trough northwest of GPS start

Sample Population: Non-burned/Control (no piture)
GPS Coordinates of Baseline: start S 03’00’13.1” E 037’00’02.6”
end S 03’00’12.5” E 037’00’04.2”
Baseline: 100m line from east to west
Compass Line Aspect: south
Site Description: line started at large acacia tree, many dead trees and branches, noted trampling and grazing, small and large bushes, highly patchy, evidence of wildebeest, zebra, and impala in the area

Sample Frame C: Farmed/Non-farmed Site Description

Sample Frame: Farmed
GPS Coordinates of Baseline:
start S 03’00’27.4” E 036’59’03.9”
end S 03’00’30.0” E 036’59’04.1”
Baseline:
road, north to south
Compass Line Aspect: west
Site Description:
acacia grove, by road and river, many acacia trees of vary species, depression near road catches water, large washed out area with bare cracked soil and sparse ground coverage, farmed in the 1950s to early 1970s, no rock disturbances

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Sample Population: Non-burned/Control (no piture)
GPS Coordinates of Baseline: start S 03’00’13.1” E 037’00’02.6”
end S 03’00’12.5” E 037’00’04.2”
Baseline: 100m line from east to west
Compass Line Aspect: south
Site Description: line started at large acacia tree, many dead trees and branches, noted trampling and grazing, small and large bushes, highly patchy, evidence of wildebeest, zebra, and impala in the area

We chose to conduct our study at Ndarakwai Wildlife Ranch because ranch management identified a need for more information on grass species. The field is largely unexplored and the research we were able to provide in a short amount of time can be directly useful in the immediate future.

Methods

This study divided the grasses of Ndarakwai Wildlife Ranch in to three sample frames: A, B, and C. We used the quadrat method (n=600) with ten meter intervals between fifty meter compass lines that ran perpendicular to predetermined baselines to achieve a non-representative, random data set from 1m x 1m plots. Sample frame A was constituted of sloped (n=100) and non-sloped (n=100) subpopulations. Sample frame B was constituted of Burn A (n=100), Burn B (n=100), and Non-burned/Control (n=100) sub-populations. Sample frame C was constituted of farmed (n=100) and Non-Farmed/Control (n=100). "Control" for Sample frame B and C were data from the same site. The baselines for the sloped area, an area called Pasaronga, was a wildlife trail that ran across the top of the hill. The compass lines were on either side of the baseline, with an aspect alternating between north and south. For the non-sloped area adjacent to Pasaronga, we created a baseline running from East to West parallel to the base of the mountain. The compass line aspect was south only. The baselines of the other four areas were randomly selected. The number of plots per compass line was randomly selected between five and ten until we reached one hundred plots in each area over a span of three days.

After determining the baseline, we recorded meta data including: slope degree, aspect of baseline and compass line, GPS coordinates of the baseline, disturbances, descriptive soil data, and general habitat description. We then determined the compass line and outlined the $1m^2$ plots. Within each plot, we counted the number of individual inflorescences. Counting inflorescences gives us a better estimate of edible matter within the plot produced by a given species than counting individuals alone. After taking count of the inflorescences, we recorded the percent of ground covered within the plot, the percent of coverage that was non-grass species, and the percent of coverage that was moribund material. We then measured the height of five random mature, flowering grasses and averaged the data. These methods were appropriate because they allowed us to collect a semi-random non-representative survey of grass species in each designated zone to achieve maximum data collection in the time frame we were given.

Throughout the data collection process, we collected example specimens of each species to create vouchers -pressed, dried, and labeled specimens- in order to create a herbarium as evidence of the grass species we identified in the area. In order to identify the grass species collected, we used *Guide to Grasses of Southern Africa*, as there is no guide book available for grasses in East Africa because the field is largely unexplored. The diagrams we used to identify species can be found in Appendix C. Many of the grass species identified in the book have widespread habitats throughout tropical and East Africa. However, we were not able to identify every grass that we collected with the resources available. There are very few grass species experts in Tanzania and a centralized thorough catalog of the grass species in the region does not yet exist. With the resources available to us, we were able to gather 43 specimens, seven of which were identified by genus, and twenty-nine which were identified by species.

We utilized key-informant interviews with Head Ranger, Thomas, and Managing Director, Peter Jones, to analyze historical contexts of sub-populations. Chi-squared analysis, with an alpha value of 0.1, a common degree of certainty in ecological studies, in each sample-frame determined statistical dependence of richness between sub-populations and frequency between sub-populations. We avoided biases in the test by following statistician Jerrold H. Jar's set minimum of an average expected (6.0). Simpson's Index of Diversity in each sub-population showed us the relative species abundances and evenness of distribution. We used descriptive statistics to analyze density and metadata.

Results

Our study on grass species composition and veld analysis is specifically useful at the study site—a privately owned conservation area called Ndwarakwai Wildlife Ranch. The study presented in the report addresses how grass species density, diversity, and frequency vary between six subpopulations within Ndarakwai: a sloped area and adjacent flat plain, a formerly farmed area, two burned areas, and a control region that was neither farmed nor burned. We analyzed each region with chi-sqared test to establish statistical dependence, Simpson's Index of Diversity to better understand the region's relative abundance and species distribution, and descriptive statistics to graphically view density and metadata. The study was conducted from April 4th to April 26th of 2014. We chose to study grass species at Ndarakwai Wildlife Ranch in order to inform management so they may make more informed decisions concerning ecological management, as well as to provide a baseline for long-term continued research on grass species composition. The following results are broken up by sample frame.

Sample Frame A: Sloped/Non-sloped

Richness and Diversity: Sample frame A had a gamma richness of 30 species, with the sloped sample population's alpha richness 16—not counting unidentified/unknown species—and the non-sloped alpha diversity 19. In sloped, 25% (4/16) of species abundance exhibit 75% of sub-population richness. 32% (6/19) non-sloped species constitute 75% richness. *Schizachyrium (*)* exhibits the most richness is both areas: 55% (4464/ 5952) of total inflorescences in the sloped region and 38% (2605/6857) in non-sloped.

Individual plots range in diversity from 0-7 species abundance in sloped and 0-11 species abundance in non-sloped sub-populations, with an average of 3.740 +- 1.384 and 5.590 +-2.566 abundance respectively.

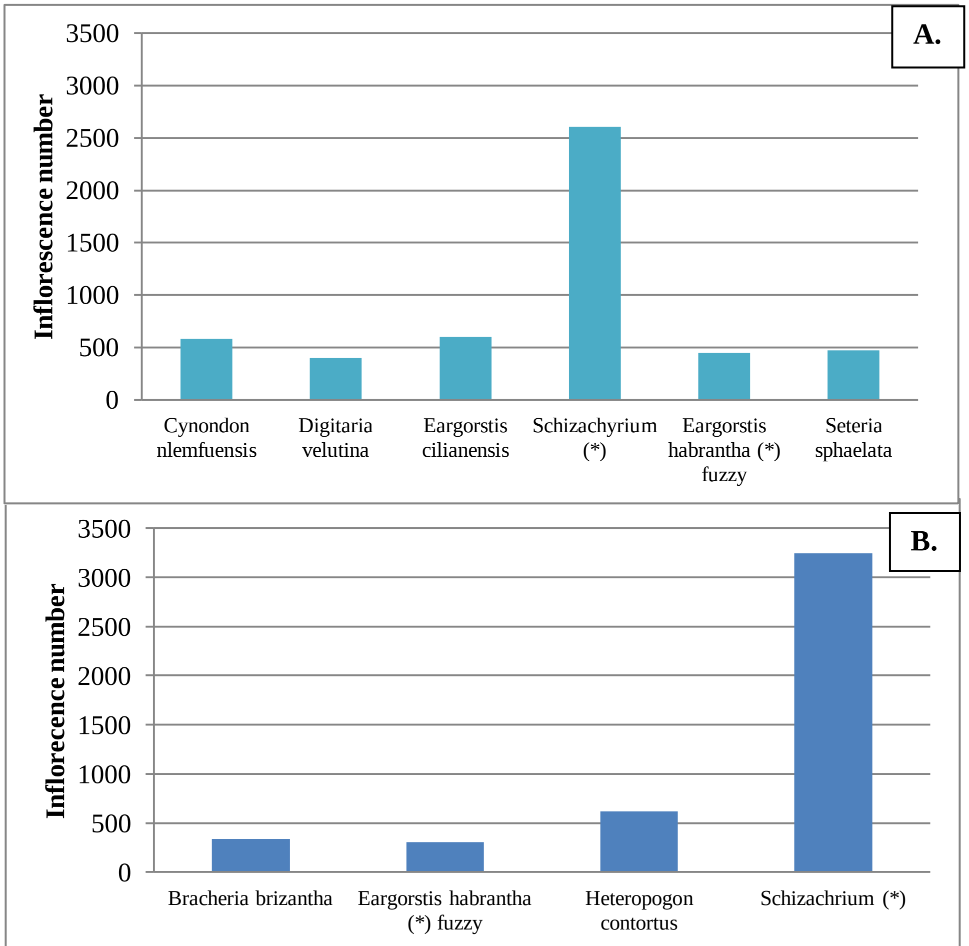


Figure 2.Grass Species Distribution of Top 75% (n=5952; n=6857) of Total Richness in Sloped (A) an Non-Sloped (B) Sub-Populations of Ndarakwai Wildlife Ranch. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Simpson's Diversity Index of sloped was D=0.678, showing slightly above average abundance and even distribution of species in the region, whereas non-sloped index was D=0.180. Sample frame A richness demonstrates a significant statistical dependence on sub-population (p=0.000E+0, alpha=0.1). Such a low p-value is valid because the average expected value (192.59+-s.d.487.83) is greater than 6, which, according to statistician Jerrold H. Jar, prevents major bias in the chi-squared test.

Frequency: Frequency of species' presence in plots shows a significant statistical dependence by sub-population (p=1.71531E-95; alpha=0.1). *Schizachyrium (*)*, the most rich, is also the most frequent, appearing in 70% of sloped and 74% of non-sloped plots. *Eragrostris habrantha (*) fuzzy* was both rich and frequent (top 75% of total richness and in more than 40% of plots) in both subpopulations. Most species in sloped (13) and non-sloped (15) sub populations were not in more than 40 of the respective 100 plots

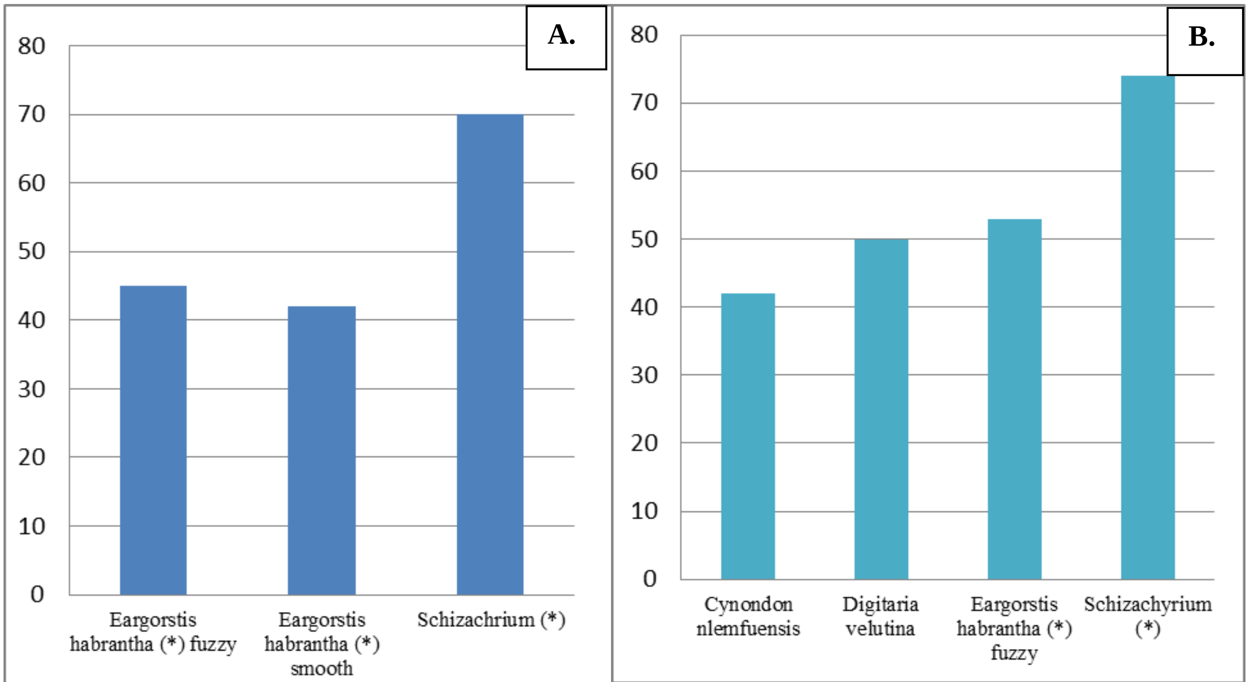


Figure 3. Distribution of Species' Top Frequency (>40%, n=100 plots) for Sloped (A) and Non-Sloped (B) Sub-Populations at Ndarakwai Wildlife Ranch. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Density: Average non-slope density is greater than that of the slope region (76.27+-s.d 35.37; 55.99+-s.d 29.79). Maximum density peaked at 152 in the non-slope region and 123 on the slope. Both regions shared a minimum density of 0 inflorescences per plot. We observed major variation in density patterns in the non-slope: oscillation between dense, moribund patches, and thin coverage with rock disturbances

Metadata: Sloped region was more concentrated with rocks that covered at least 10% of individual plot area and with evidence of grazing. Zebra and elephant dung onstituted the most common form of grazing evidence we observed in both regions. Both regions exhibited a high percentage of plots with moribund material: 27% (27/100) in the sloped region and 33% (33/100) in non-sloped. Non-grass plots were negligible: only1/100 in sloped, 4/100 in non-sloped..

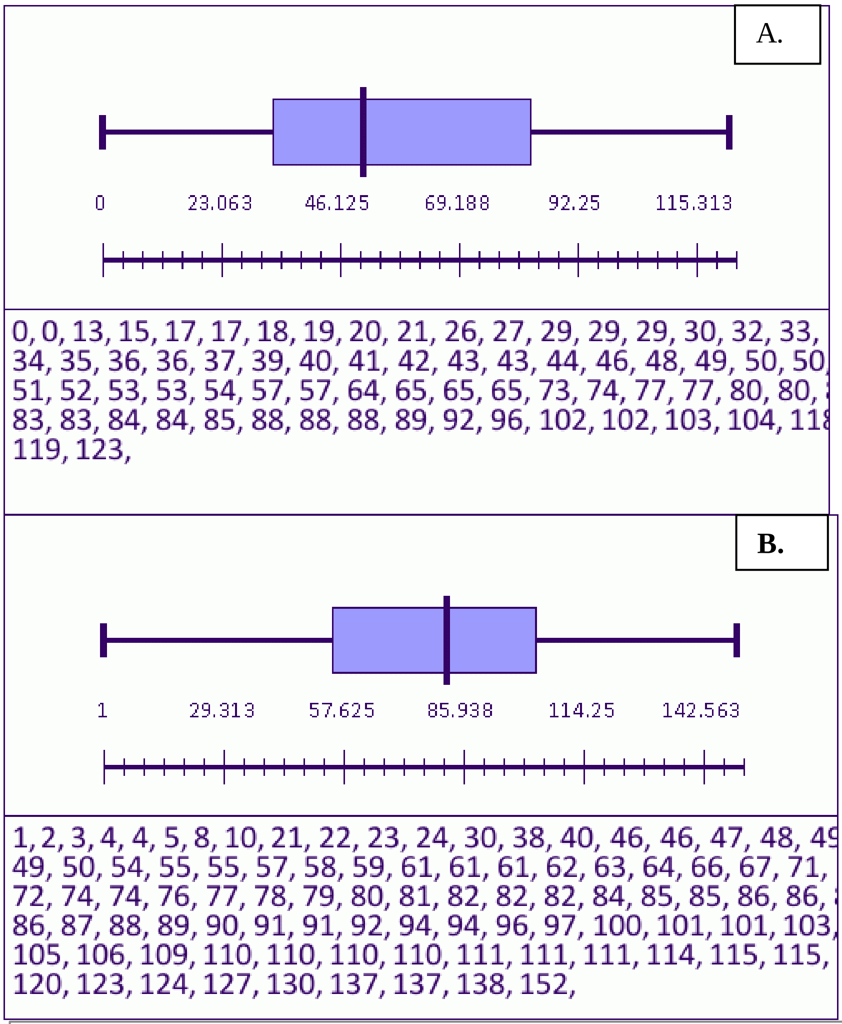


Figure 4. Plot Densities Box and Whiskers for Sloped (A) and Non-Sloped Sub-Populations at Ndarakwai Wildlife Ranch. Data was collected in each sub-population using random compass line quadrat method (n=100) from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

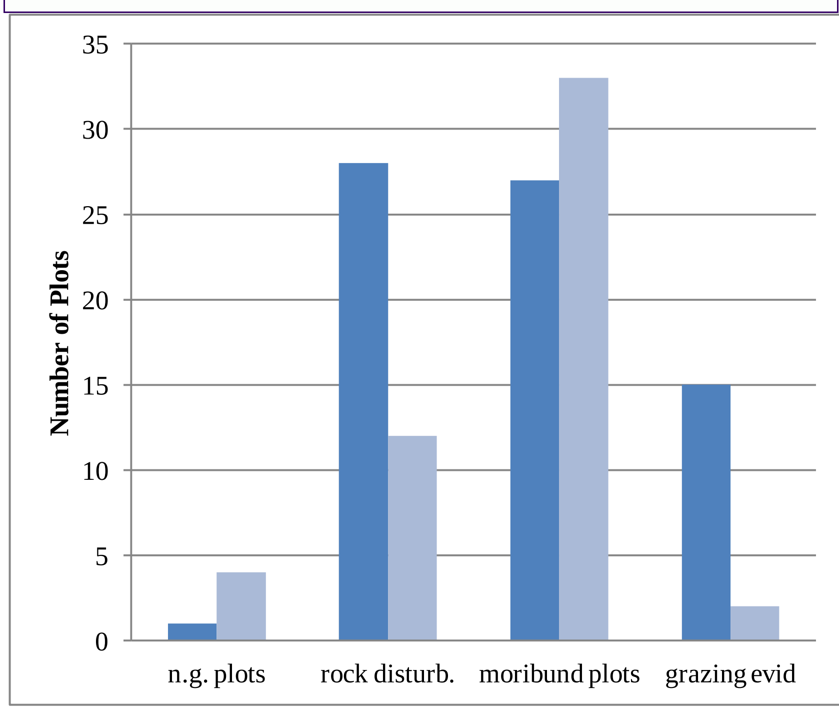


Figure 5. Metadata Expressed in Number of Plots in Sloped (dark blue) and Non-Sloped (light blue) Sub-Populations at Ndarakwai Wildlife Ranch. Non-grass plots include those with ground coverage solely by non-grasses such as sedges and reed as well as plots with no coverage. Rock disturbance is defined as plots with a stone or stones covering more than estimated 10% of plot area. Any moribund material within a plot was counted as a binary. Grazing evidence includes trampling, tracks, scat, or any animal spoor. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

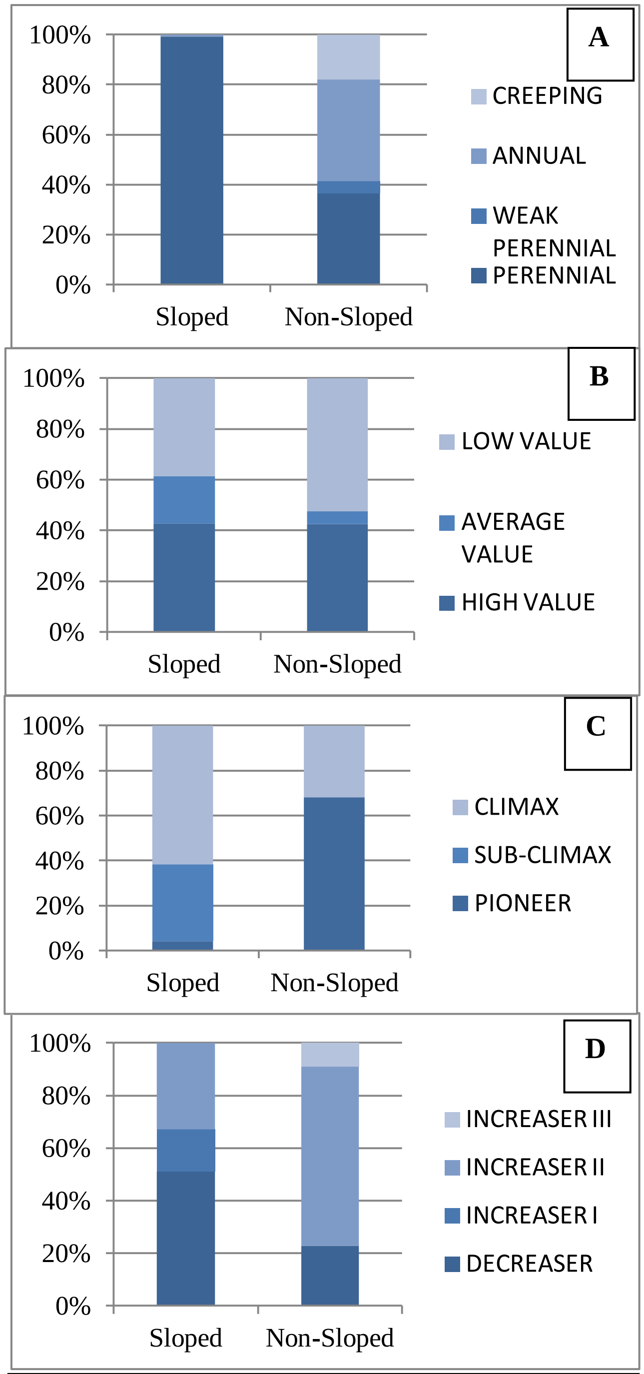
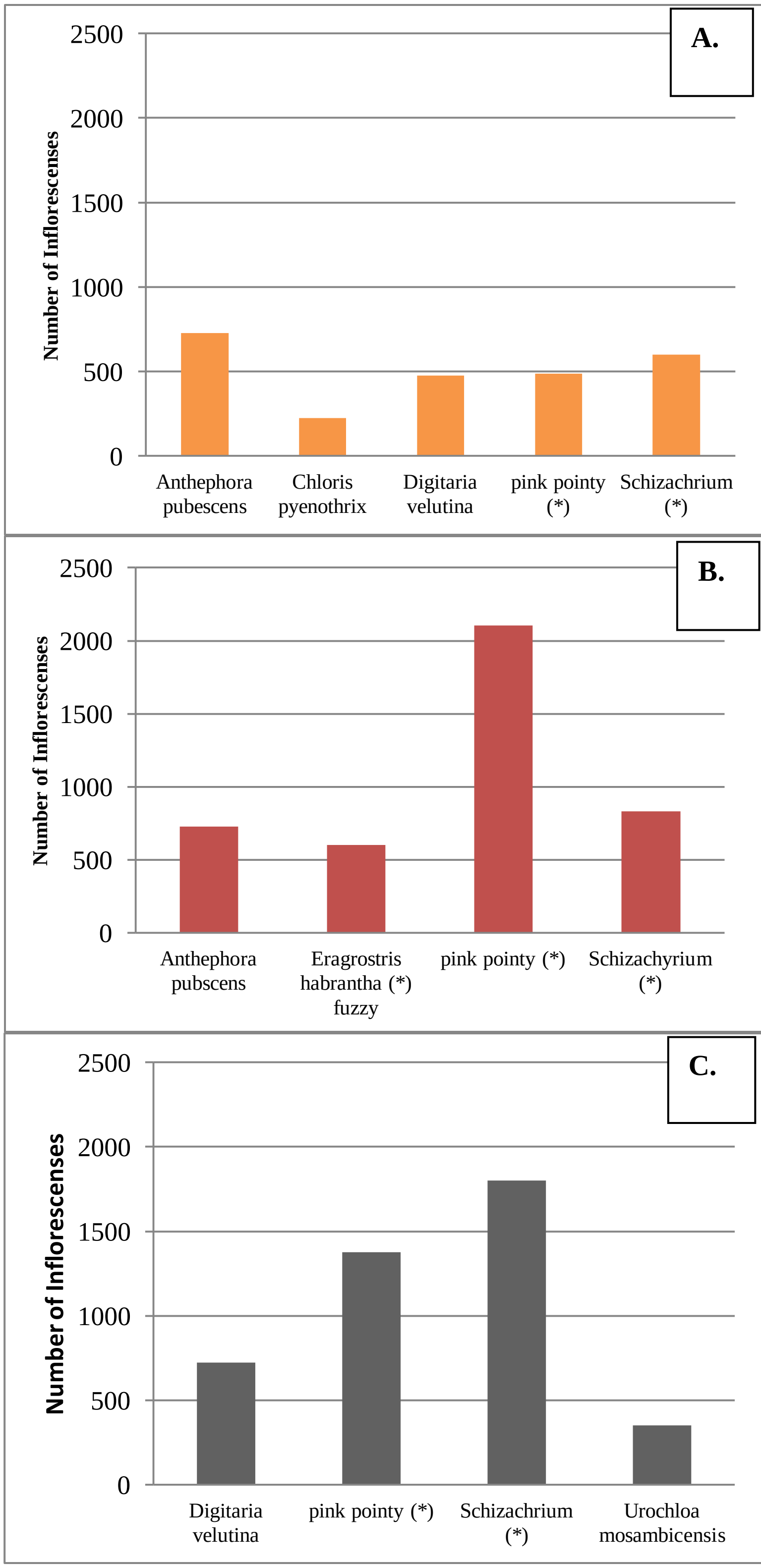


Figure 6. Perennial Type (A), Grazing Value (B), Succession Stage (C) and Status Indicator (D)Species Proportions for Sloped and Non-Sloped Sub-Populations of Ndarakwai Wildlife Ranch. Data was collected in each sub-population using random compass line quadrat method (n=100) from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Species compositions in sloped and non-sloped sub-populations have different implications for veld conditions in their respective regions. Using secondary source information from *Guide to Grasses of Southern Africa*, we compiled relative percentages of total inflorescences for fully identified species and their perennial types, grazing values, succession stages, and status indicators. Sloped region is nearly 100% perennial individuals (2596/2614) whereas non-sloped region has a more even distribution with 41% (1681/4118) annual grasses and 36% (1498/4118) of individuals perennial. Grazing value is composed relatively evenly in both regions: 43% (773/1812) high value and 39% (698/1812) low value in sloped; 43% (1409/3305) high value 42% (1736/3305) low value in non-sloped. Most inflorescences in the sloped region are climax stage, 62% (1108/1794) and decreasers, 51% (1083/2124). Non-slope is 68% (2466/3618) pioneer stage and 68% (2479/3631) increaser II.

Sample Frame B: Burned/Non-burned



Richness and Diversity: The sample frame that compares burning management areas has a gamma richness of 27 species. Burn A had an alpha richness of 19 and a Simpson's Index of Diversity value of D=0.950. Richness of species exhibited a statistically significant dependence on place compared to other regions (Burn/A/BurnB: p=0.0000E+0, alpha=0.10; BA/NB: p=0.0000E+0, alpha=0.10). Burn B sub-population has an alpha richness of 17 and Simpson's Diversity Index of D=0.78455. Burn B richness was significantly statistically different than Burn A and Non-Burned sub-populations (BurnB/Non-burned: p=0.0000E+0, alpha=0.10). Non-Burned population has an alpha richness of 21 and a Simpson's Diversity Index of D=0.799.

Figure 7.Grass Species Distribution of Top 75% (n=5952; n=6857) of Total Richness in Burn A (A), Burn B (B), and Non-Burned (C) Sub-Populations of Ndarakwai Wildlife Ranch. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

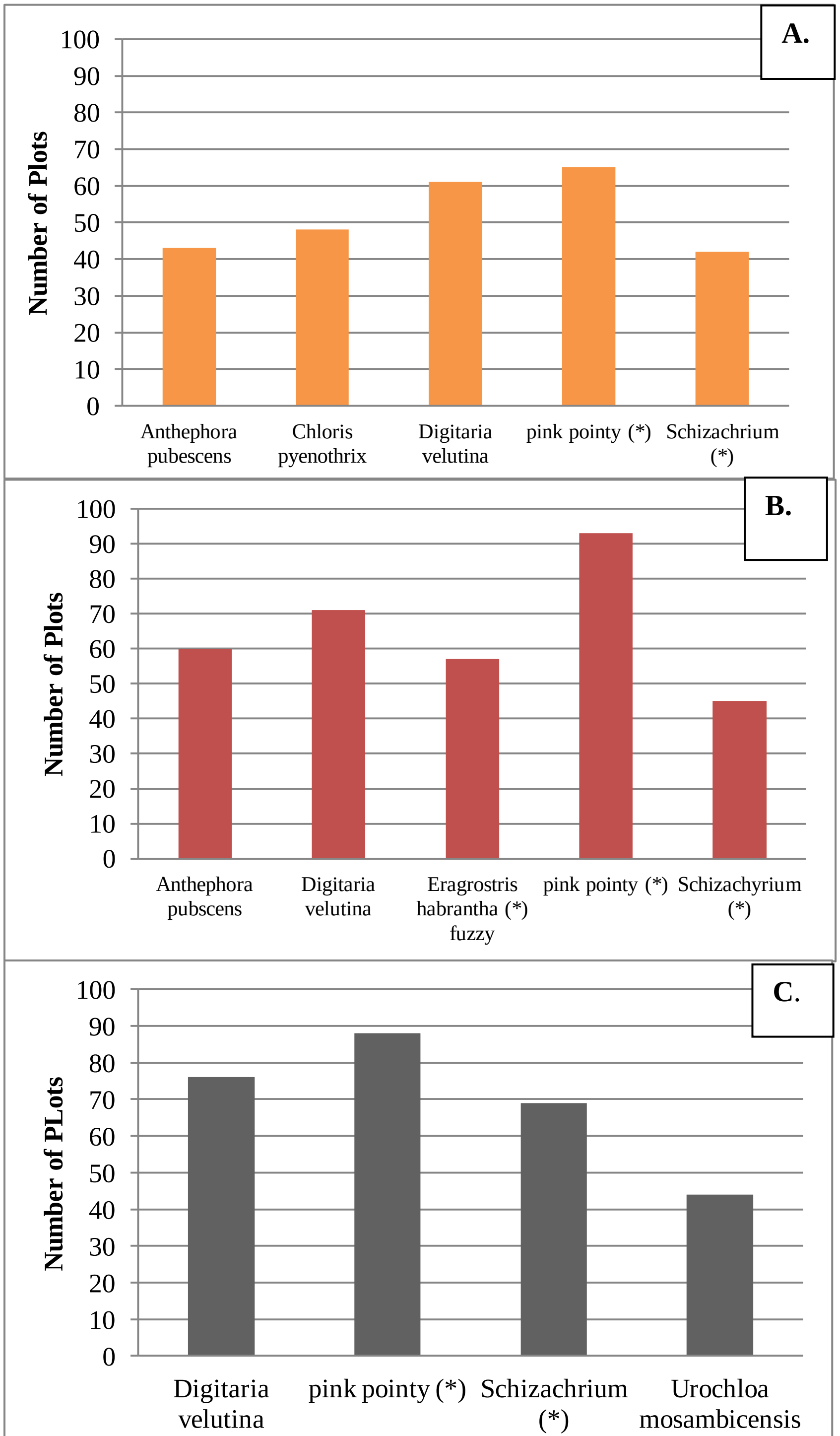
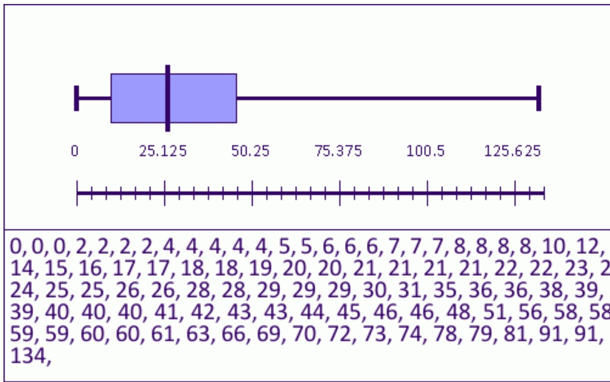


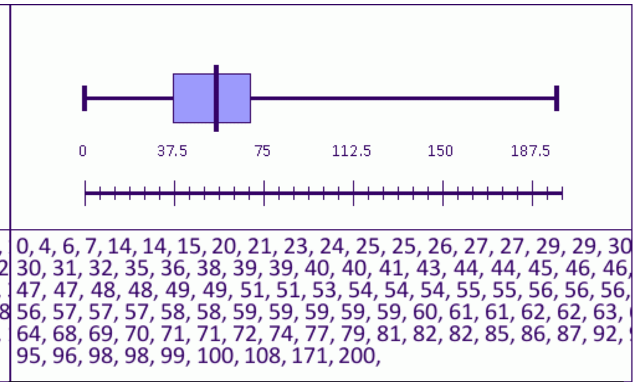
Figure 8. Distribution of Species' Top Frequency (>40%, n=100 plots) for Burn A (A), Burn B (B) and Non-Burned (C) Sub-Populations at Ndarakwai Wildlife Ranch. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Frequency:

All sub-populations' species frequencies were statistically dependent on sub-population (BurnA/Burn B: p=1.4668E-20, alpha=0.1; Burn A/Non-Burned: p=1.218E-11, alpha=0.1; Burn B/Non-Burned: p=3.42E-58, alpha=0.1). Only *Digitaria velutina*, in Burn B was frequent but not in the top 75% richness of the sub-population. All other species that were present in 40% of plots, also comprised the top 75% inflorescence richness of their sub-population.

Density: Burn A overall density was 3,248 inflorescences in 100 m^2 with an average density per plot of 33.23+- s.d. 27.18. Burn B overall density was 6,463 inflorescences in 100m^2 with an average density per plot of 55.67+- s.d. 30.31. Non-Burned overall density was 5,505 inflorescences in 100m^2 with an average density of 55.16+- s.d.38.08.





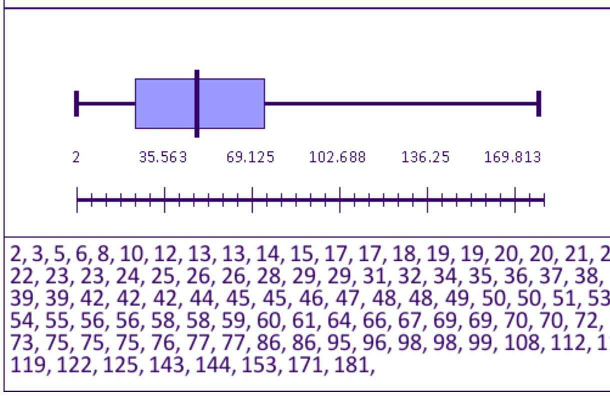


Figure 9. ***Plot Densities Box and Whiskers for Burn A (A) Burn B (B) and Non-Burned (C) Sub-Populations at Ndarakwai Wildlife Ranch.*** Data was collected in each sub-population using random compass line quadrat method (n=100) from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania

Metadata:

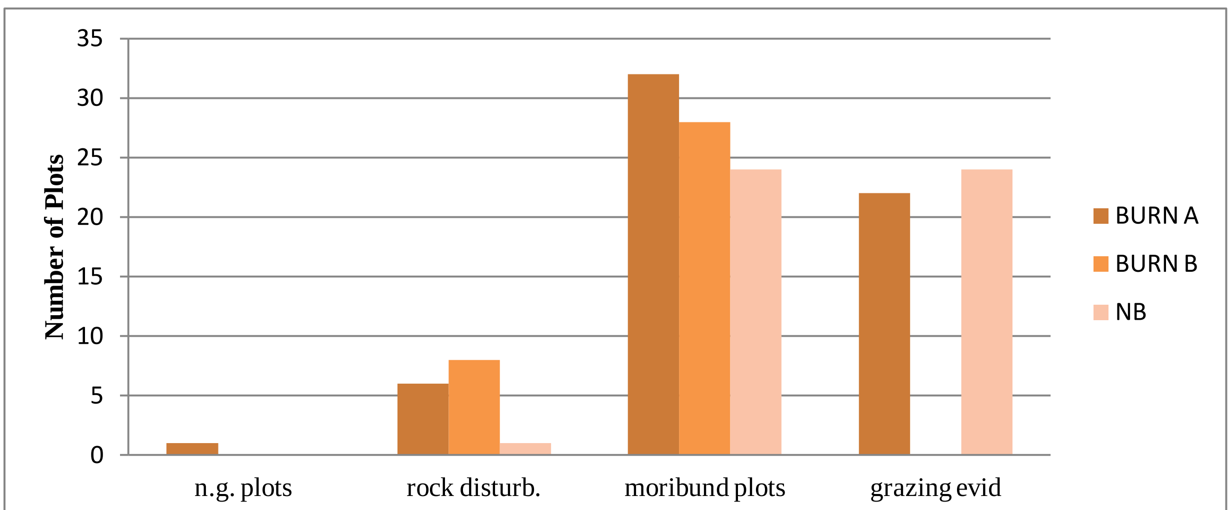


Figure 10: Metadata Expressed In Number of Plots in Burn A, Burn B, and Non-Burned Sub-Populations at Ndarakwai Wildlife Ranch. Non-grass plots include those with ground coverage solely by non-grasses such as sedges and reed as well as plots with no coverage. Rock disturbance is defined as plots with a stone or stones covering more than estimated 10% of plot area. Any moribund material within a plot was counted as a binary. Grazing evidence includes trampling, tracks, scat, or any animal spoor. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

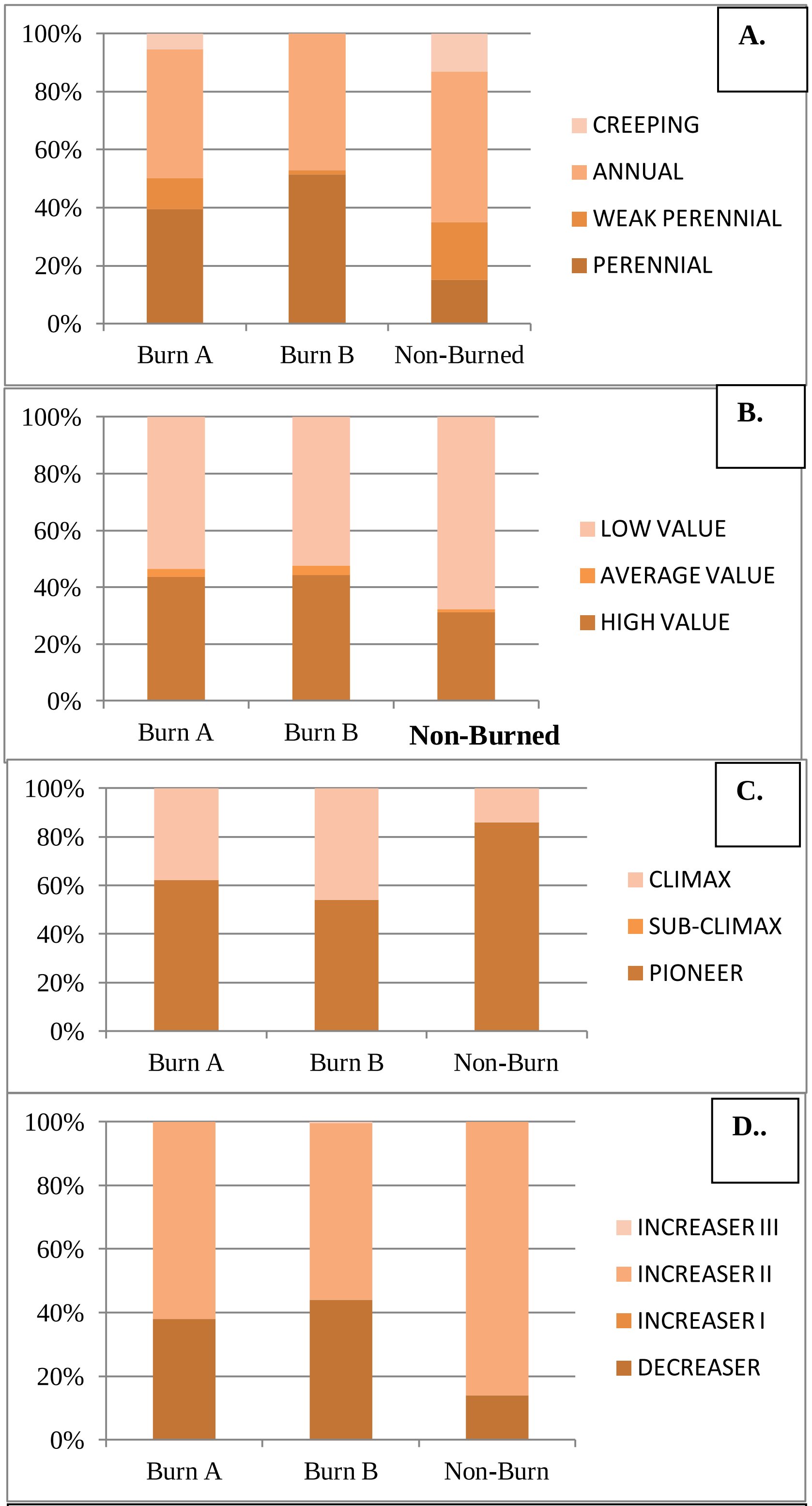


Figure 11. Perennial Type (A), Grazing Value (B), Succession Stage (C) and Status Indicator (D)Species Proportion for Burn A, Burn B, and Non-Burn Sub-Populations of Ndarakwai Wildlife Ranch. Data was collected in each sub-population using random compass line quadrat method (n=100) from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Only the Burn B sub-population exhibited any non-grass plots, with only 1/100 without grass inflorescences, and no regions had more than 10% rock disturbed plots. All regions, however, had over 20% moribund plots (Figure 10). Non-burned sub population had the highest percentage of annual grasses, with 52% (919/1765), while Burn B was dominated by 63% (1596/2516) perennial grasses and Burn A showed a relatively even spread. All sub-populations were dominated by low grazing value grasses, pioneer species, and increaser II conditions.

Sample Frame C: Farmed/Non-farmed

Diversity: This sample frame had a gamma richness of 25, with the farmed sample population exhibiting an alpha richness of 16 and the non-farmed region showing 21 species. The Simpson's Diversity Index was D=0.873 for farmed and D=0.799 for non-farmed. The richness for sample frame C is statistically dependent on sub-population (p=0.0000E+0, alpha=0.1). Farmed total richness was less than half of the inflorescences of non-farmed (1821/5505).

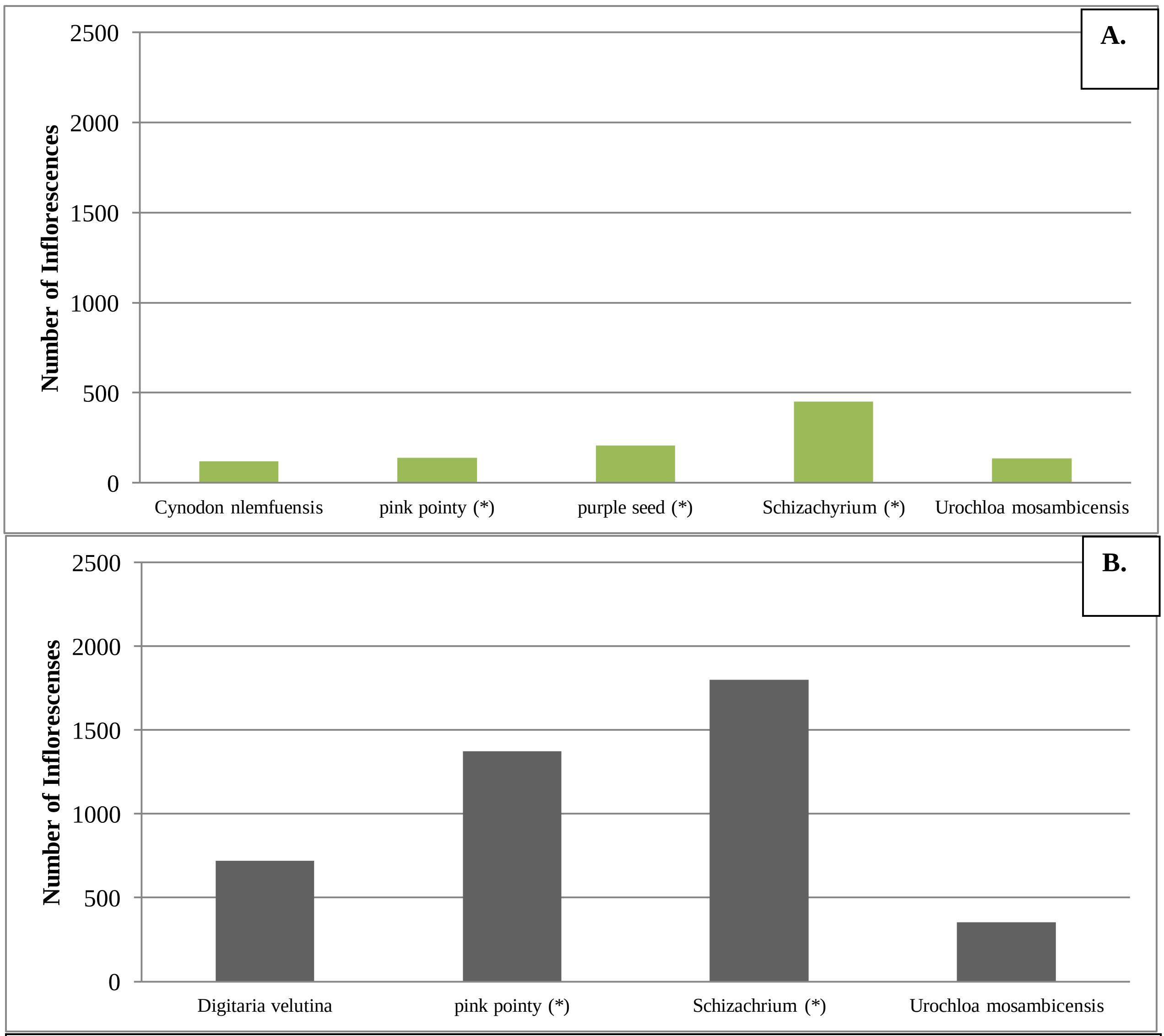


Figure 12. Grass Species Distribution of Top 75% (n=5952; n=6857) of Total Richness in Sloped (A) and Non-Sloped (B) Sub-Populations of Ndarakwai Wildlife Ranch. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Frequency: Frequency of species is statistically dependent on sub-population (p=3.2084E-25, alpha=0.1). No species in the farmed region were present in more than 30% of plots and so did not qualify for a top frequency comparison. The low frequency may be attributed to the high number of non-grass and bare plots in the region (Figure 15). For non-farmed region, all species whose richness made up 75% of total inflorescence counts was also most frequent

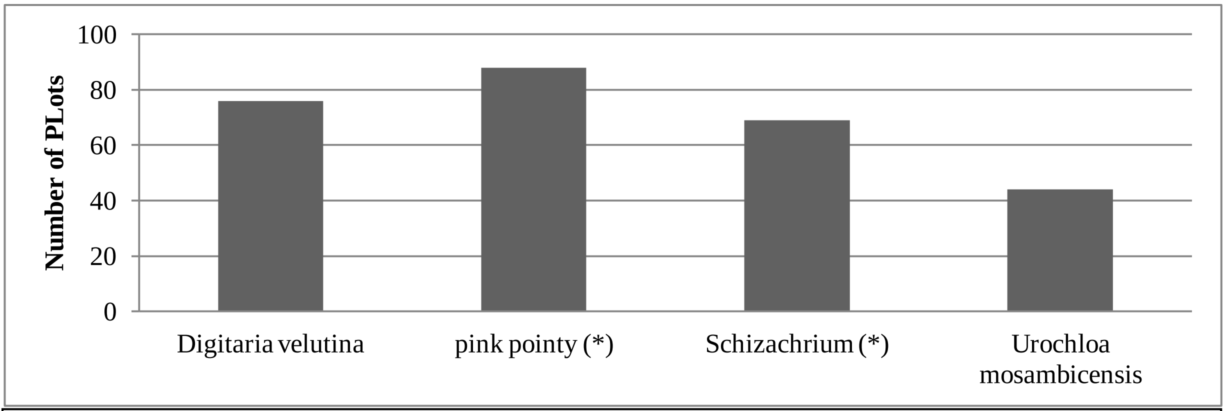


Figure 13. Distribution of Species' Top Frequency (>40%, n=100 plots) for Non-Farmed Sub-Populations at Ndarakwai Wildlife Ranch. There were no species in the Farmed sub-population that demonstrated a top frequency qualification. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Density: Farmed sub-population was the least dense of any population in all sample frames, with two quartiles between 0-10 inflorescences and a density average of 19.48 +- s.d. 25.34. Non-farmed had a more typical density distribution, with no non-grass plots and more evenly distributed quartiles and an average of 55.16 +- s.d. 38.08.

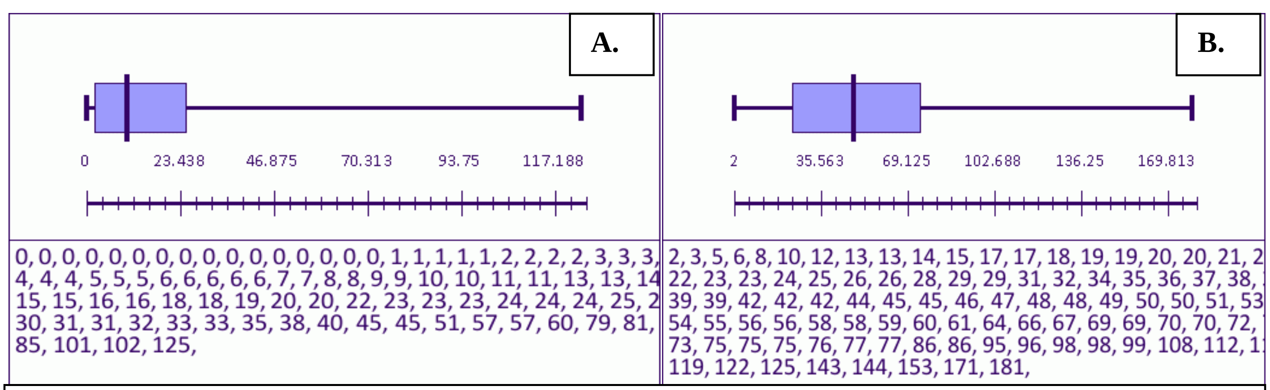


Figure 14.** **Plot Densities Box and Whiskers for Farmed (A) and Non-Farmed (B) Sub-Populations at Ndarakwai Wildlife Ranch. Data was collected in each sub-population using random compass line quadrat method (n=100) from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

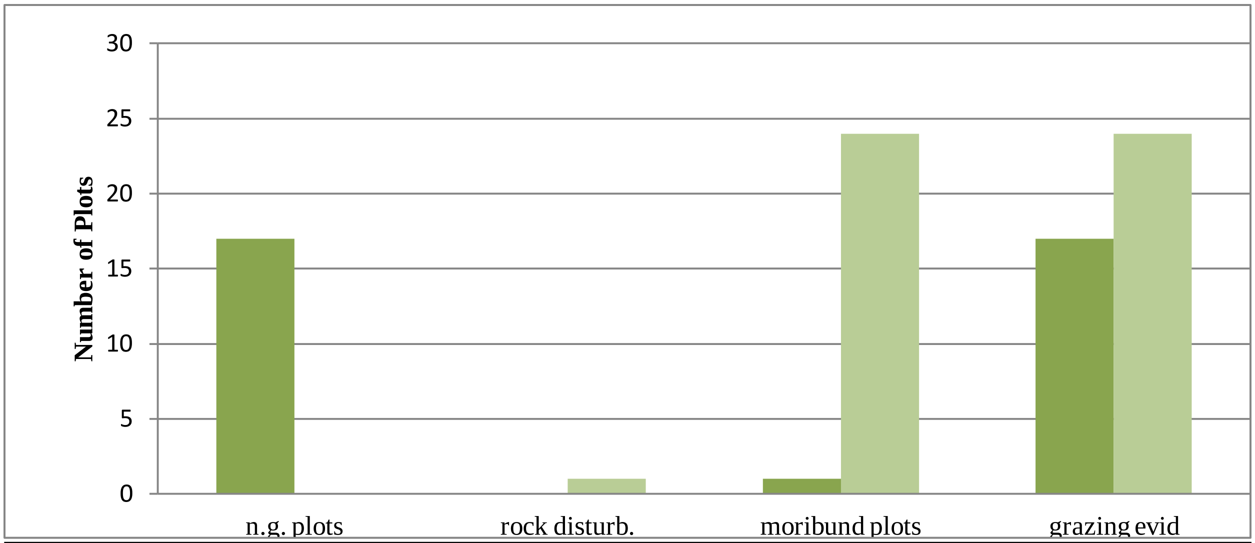


Figure 15. Metadata Expressed In Number of Plots Farmed (dark green) and Non-Farmed (light green) Sub-Populations at Ndarakwai Wildlife Ranch. Non-grass plots include those with ground coverage solely by non-grasses such as sedges and reed as well as plots with no coverage. Rock disturbance is defined as plots with a stone or stones covering more than estimated 10% of plot area. Any moribund material within a plot was counted as a binary. Grazing evidence includes trampling, tracks, scat, or any animal spoor. Data was collected using compass line quadrat method from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

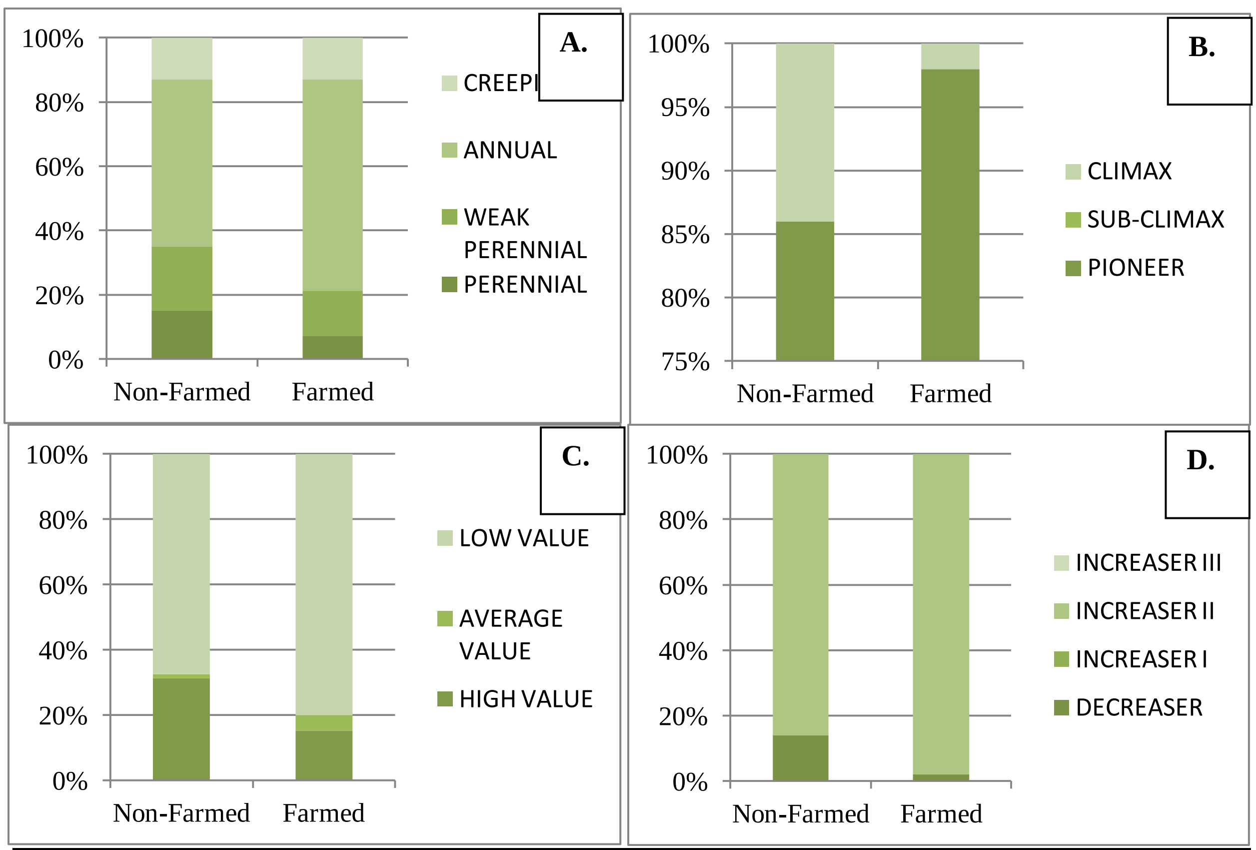


Figure 16. Perennial Type (A), Grazing Value (B), Succession Stage (C) and Status Indicator (D)Species Proportion for Burn A, Burn B, and Non-Burn Sub-Populations of Ndarakwai Wildlife Ranch. Data was collected in each sub-population using random compass line quadrat method (n=100) from 5-25 April, 2014 in West Kilimanjaro region, Northern Tanzania.

Metadata: Farmed sub-population demonstrated the most non-grass plots of any sub-population (17) in this study as well as the fewest rock disturbances (0). The region was dominated by 66% annual grasses (626/952), 98% pioneer (880/898), 80% low value (719/898), and 98% increaser II (880/898) grasses. Despite the differences in metadata, in which Non-farmed demonstraited no non-grass plots and high numbers of moribund plots, the two regions shared common veld indicators. Non-farmed was composed mostly of annual grasses, pioneer species, low grazing value, and increaser II (Figure 16).

Discussion

Sample Frame A: Sloped/Non-sloped

Our observations of diversity's abundance and richness dependence on sub-population and high number of site-specific species indicates a difference in nutrient options for grazers in Sloped and Non-sloped sub-populations. Utilization of these different nutrient groups may explain why grazers at Ndarakwai climb the slopes despite the metabolic cost. Demonstrated higher veld palatability, compared to the non-sloped region, also indicates incentive for grazers to expend energy to reach the summit area. This observed trend is congruent with known effects of leaching on sloped regions. Water runoff from the top of slopes pools at the base region, diluting and removing nutrients from the soil. In order for grazers to access those missing nutrients, they must reach the non-leached zones at the top of the slope. Calculated Simpson's Diversity Indices for each sub-population show that sloped had a more evenly distributed richness than non-sloped, which, despite a greater species abundance, has richness concentrated mostly in Schizachyrium (* (See Figure 2).. Many ecologists correlate a high index result with a healthy, stable community. Although the association is not confirmed, our contextualized results support the praxis.

Our frequency results for the sloped region were dependent on area, and are again congruent with a healthy veld: a mix of rich and frequent with purely frequent species suggests an even distribution that still allows room for new species to grow among common grasses (See Figure 3). Non-sloped region, however, had a direct correlation between rich and frequent species. Sloped region is less dense on average than the non-sloped region. Demonstrated higher concentration of rock disturbances and less moribund evidence indicate that the lower density of the slope may be due to soil contributors that inhibit growth of leafy species prone to moribund, such as Anthephora pubescens or Setaria sphacelata both of which were present in the non-sloped region (See Figure 5, Appendix).

Veld indicators confirm our findings of a healthy veld at the summit and slope of Pasaronga. Nearly entirely composed of perennial species and mostly at climax stage, we can assert that the community has been or will continue to be at a stable abundance for more than five years (See Figure 6). Its decreaser status is the ultimate healthy veld indicator: the region is neither over nor under grazed. However, the community health will decrease if over-utilized or neglected. We recommend leaving the veld without manipulation. A repeated study in future years will enlighten whether the community has taken any abuse over the interval years.

Sample Frame B: Burned/Non-burned

Statistically, diversity richness and frequency are significantly dependent on region, but we observed few species that were site-specific between non-burned and burned regions. Densities were relatively high, with Burn B exhibiting the highest. All three regions demonstrated high numbers of moribund plots (See Figure 9, 10). All calculated Simpson's Diversity Indices were high and indicate stable community. All regions' frequency was dependent on region and were evenly spread. *Digitaria velutina* in Burn B was the only species in any sub-population that was frequent but not rich (See Figure 7, 8). Combined with density findings, the direct correlation indicates a veld made up of leafy species with high ground coverage that does not allow the introduction on new species. These results are inconsistent with normal expectations of burned regions, which would predict lower abundance, lower, density, few moribund plots, and a lower diversity index than the non-burned region. Time and rehabilitation are possible explanation for the similarities of the region within their historically different contexts. Our veld information follows the pattern of similarity due to rehabilitation. All sites had similar proportions of pioneer grasses, were dominated by low value grazing, and were made up of a majority of increaser II species (See Figure 11).. However, the higher proportions of decreaser grass in Burned regions than non-burn indicates that the veld may have been in a better condition in the past, but with over grazing or under-utilization has pressured and destroyed the decreaser species. The surprisingly high proportion of pioneer grasses in the non-burned region may be due to natural cycling effects of nutrient levels. However, none of our results contextualize this finding.

Our results do not indicate long-term veld benefit from burning. More data and another study are necessary to define short-term differences between non-burned areas. We recommend that management burn more frequently than five year intervals to counter the effects of rehabilitation and underutilization.

Sample Frame C: Farmed/Non-farmed

Our metadata and site description showed stark contrast between the farmed and non-farmed sub-populations, observations that our diversity, frequency, and density results confirmed. The two sites were significantly dependent on place, alpha richness values were significantly different, farmed had only half the total richness of non-farmed, and no species were qualified as frequent. Our results are consistent with the effects of over farming: no rock disturbances, fine soil aside, the low richness and diversity are possible results of nutrient depletion and soil homogenization through tilling, poorly rotated crops, and long-term use.

However, results for farmed and non-farmed regions are surprisingly similar when we assess veld condition proportion (See Figure 16). Both regions were dominated by annual grasses, low grazing value, and increaser II. The highlighted difference is the almost exclusive pioneer population of the farmed area, which indicates a constant introduction and death of pioneers since the cessation of farming practices thirty years ago. Unlike the cycling of the non-farmed area, which allows about a quarter of the region to be at climax stage, the farmed area has not succeeded beyond climax. We recommend management to attempt seeding in the farmed region. Such an undertaking would require water absorption measures like adding rock terracing and mulch, but is worthwhile to help move the veld to a healthier condition.

Limitations, Biases, and Recommendations

Methodological Biases

- Limited time frame
- Counting inflorescences is not the most accurate method to establish ground coverage, often confused with density, because it does not account for leaf material
- Because baselines were determined to be near roads or trails, we often collected data in areas that are highly trafficked
- Limited secondary sources and expert knowledge of East African grass species and identification
- The study was conducted early in the rain season; some individuals were not fully mature making it difficult or impossible to identify younger individuals

Observational Biases

- Inexperience in grass species identification led to possible misidentifications throughout the study, especially in the beginning

Improvements

The study could have been improved by increasing the number of plots surveyed in each sample population to ideally achieve a representative survey of Ndarakwai Wildlife Ranch, totaling 10% of the 11,000 acre property. While not feasible during the twenty day time frame of the SIT Independent Study Project period, such an undertaking would more fully inform Ndarakwai management practices. GPS coordinates could have been recorded for each individual plot to provide the most accurate location data. More structured interviews with key informants such as management and rangers would have been helpful to establish better historical context and current usage patterns of each sample population.

Recommendations for Future Studies

There are multiple options for future studies on grass species at Ndarakwai Wildlife Ranch. Our study is the first step in providing management with a workable database to use for making future decisions on grassland management. The first option would be to conduct a similar survey with a higher number of plots, ideally totaling 10% of the ranch property for a representative study. Or a study could have a more narrowly focused study question to assess grass species composition more fully in one sample population, such as focusing entirely on a burned area. Lastly, we recommend studies that introduce manipulations such as controlled grazing, burning, or soil homogenization by farming to look at contemporary changes to manipulated and un-manipulated zones in the same usage area. Studies on manipulations will help management to understand the effects of current strategies to maintain or improve veld conditions.

<u>Conclusion</u>

After collecting data on the grass species diversity, density, and frequency at Ndarakwai Wildlife Ranch, we were able to evaluate the condition of the grasslands we surveyed by analyzing grazing value, ecological indicator status, succession stage, and perenniality. Among the sample populations we found that sloped grass community was dependent on area, had many site-specific species, and had all healthy veld indicators. We recommend management leave the veld un-manipulated. A future study of indicator species in the region will assess over or under-utilization of the veld in the interim years. Burned regions were statistically significantly dependent on region, but were ecologically similar. We recommend that management gather more data on the effects of recent burns, and burn more frequently than five year intervals because of high moribund plot frequency and fully reestablished communities. Farmed sample population exhibited the lowest density and most non-grass plots of all sample populations. We recommend an attempt at seeding the area, with efforts to help counter the effects of erosion in the region, such as rock terracing or mulching.

Although the amount of data collected was not a significant portion of the sample population, any information regarding grass species in East Africa is extremely useful because currently there is no formal academic compilation of grass species in the region. By cataloging grasses in the sample population we have gathered information useful to not only Ndarakwai Ranch management, but to grass species literature in general. The herbarium we have compiled is evidence of the species we have identified, making it possible to have experts confirm the findings and creating a reference for future grass studies in East Africa. Increased research in the field is highly necessary because grass is a food source for millions of people as well as animals. Without proper attention to grasses, both food sources and ecological tourism could be put in jeopardy.

We chose to undertake the study at Ndarakwai specifically because its management has the resources and intent to continue researching grass species composition and veld manipulation. By increasing the area surveyed and employing manipulations such as planned burning or controlled grazing, the ranch has the potential to be a leader in the grass science and veld management field. Too often grass is an afterthought; it is taken for granted as a basic tenant of the ecosystem. Its complexity and importance are not substantially recognized in scientific literature. We hope that our study serves as a small stepping stone in the effort to gain a comprehensive survey and understanding of grasses in East Africa.

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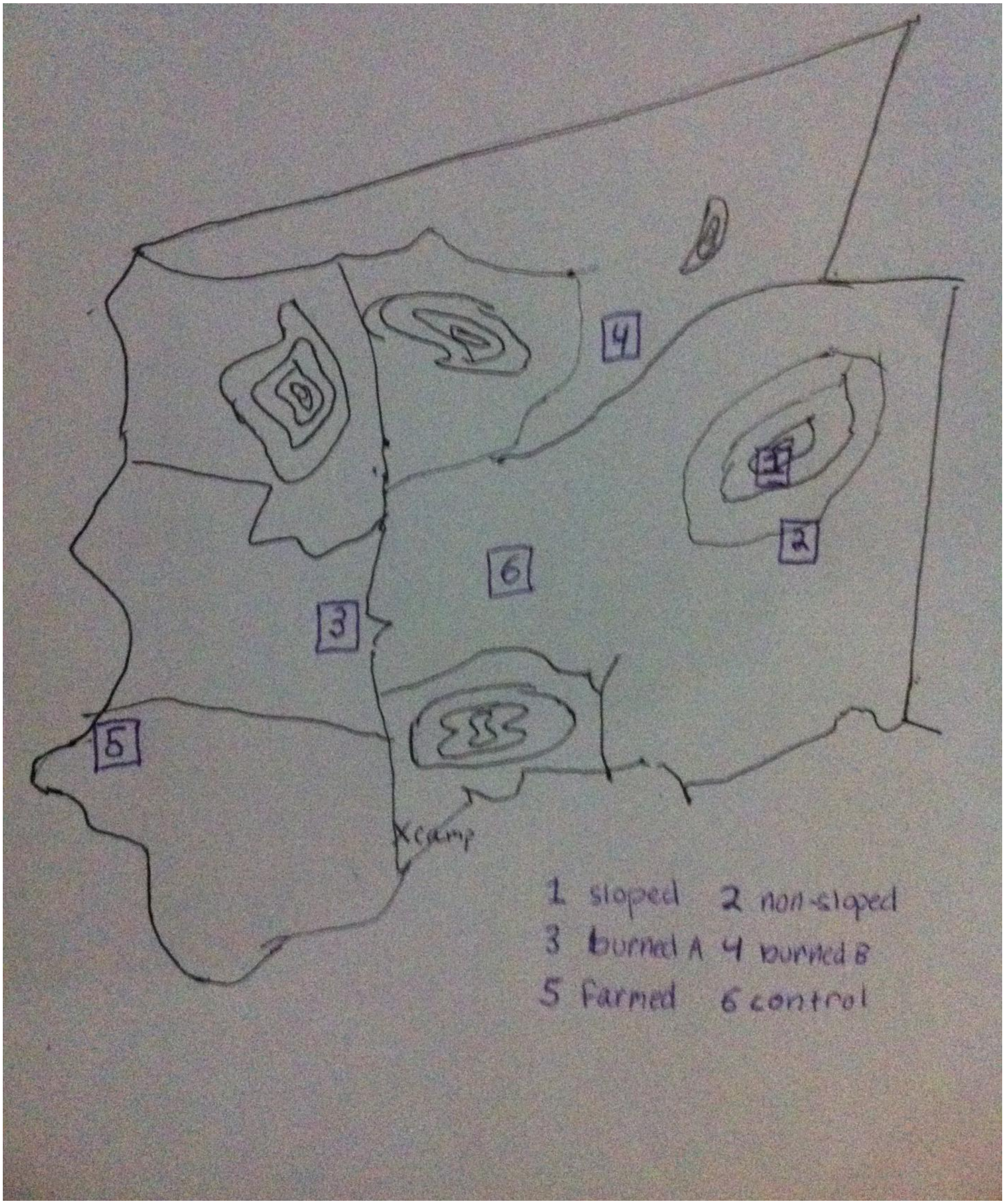
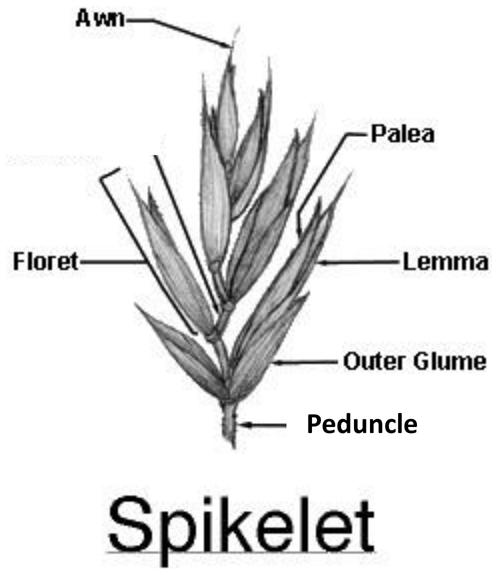
Appendices

Appendix A—Map of Ndarakwai



Appendix B—Grass Anatomy Diagram



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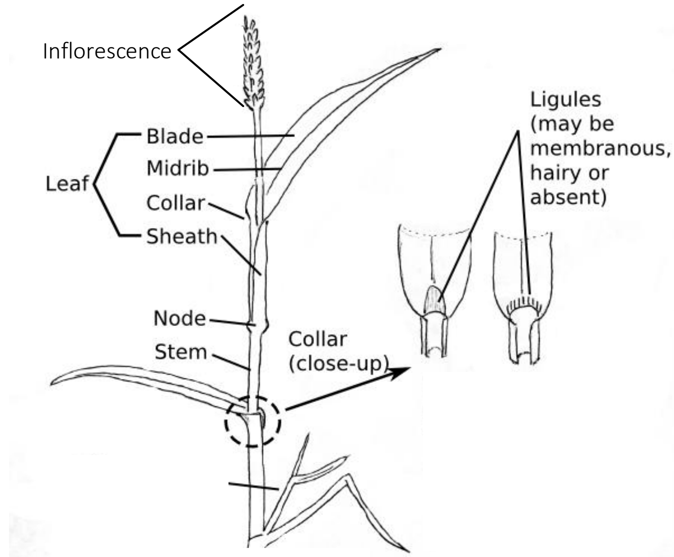

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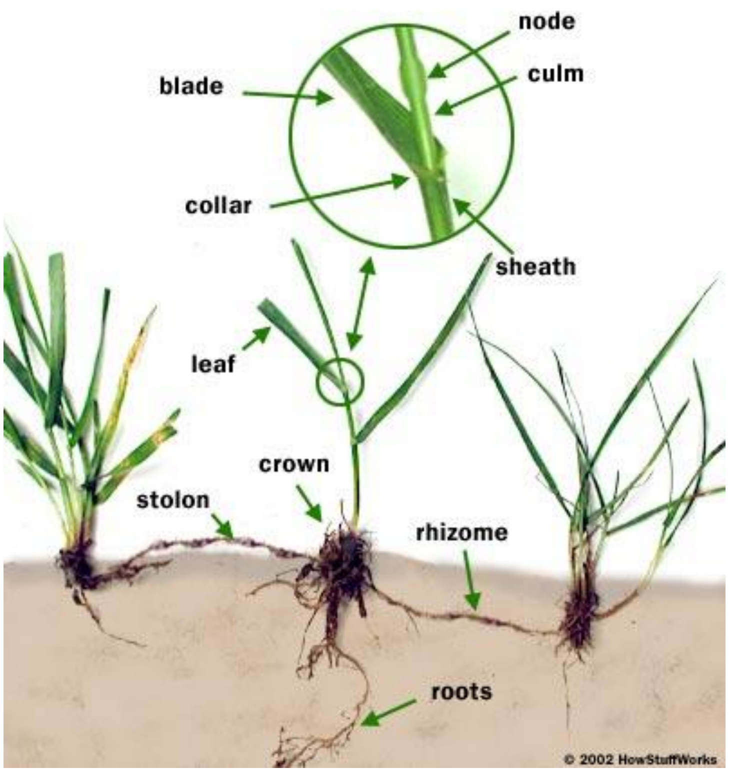


HowStuffWorks.com 2002

Appendix C—Total List of Species with Veld Information

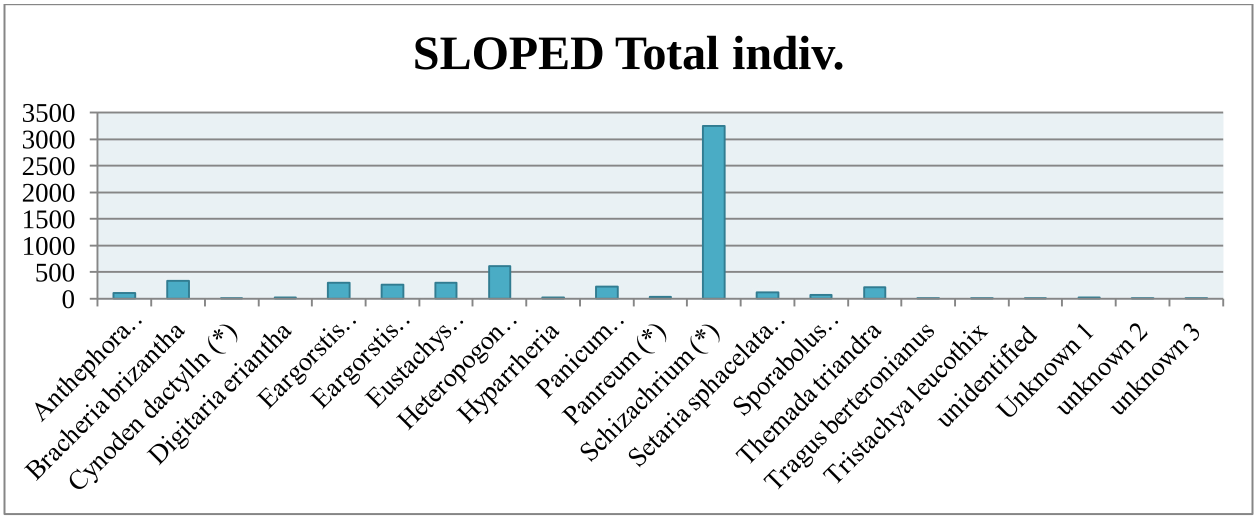
TOTAL	*Perenniality*	*Grazing Value*	*Plant Succession*	*Grazing Status*
SPECIES				
Anthephora pubescens	Perennial tufted	High value	Climax	Decreaser
Bothriochloa Insculpta	*	*	*	*
Brachiaria (*) dark pink pointy				
Brachiaria brizantha	Perennial tufted	Average value	Climax	Increaser I
Brachiaria deflexa	*	*	*	*
Brachiaria humidicola	*	*	*	*
Brachiaria (*) perpendicular	*	*	*	*
Brachiaria xantholeuca	Creeping	High value	Climax	Decreaser
Chloris pycenothrix	Annual tufted	Low value	Pioneer	Increaser II
Cynodon dactylon	*	*	*	*
Cynodon (*) unknown	Creeping	High value	Pioneer	Increaser II
Cynoden nlemfuensis	Creeping	High value	Pioneer	Increaser II
Dactyloctenium aegyptium	Annual tufted	Average value	Pioneer	Increaser II
Dactyloctenium giganteum	Annual tufted	High value	Pioneer	Increaser II
Dichanthium annulatum	Perennial tufted	High value	Climax, sub-climax	Decreaser
Digitaria (*) brown	*	*	*	*
Digitaria eriantha	Perennial tufted	High value	Climax	Decreaser
Digitaria velutina	Annual tufted	Low value	Pioneer, sub-climax	Increaser II
Eragrostris cilianensis	Annual tufted	Low value	Pioneer	Increaser II
Eragrostris cilianensis (*) thick	Annual tufted	Low value	Pioneer	Increaser II
Eragrostris habrantha (*) fuzzy	Perennial tufted			
Eragrostris habrantha (*) smooth	Perennial tufted			
Enneapogon scoparius	Perennial tufted	Low value	Climax	Increaser III
Eustachys paspaloides	Perennial tufted	High value	Climax	Decreaser
green seeds, purple culms (*)	*	*	*	*
Heteropogon contortus	Perennial tufted	Low value	Sub-climax	Increaser II
Hyparrheria				
light pink tree (*)	*	*	*	*
lobster tail (*)	*	*	*	*
octopus (*)	*	*	*	*
Panicum dregeanum (*)	Perennial tufted			

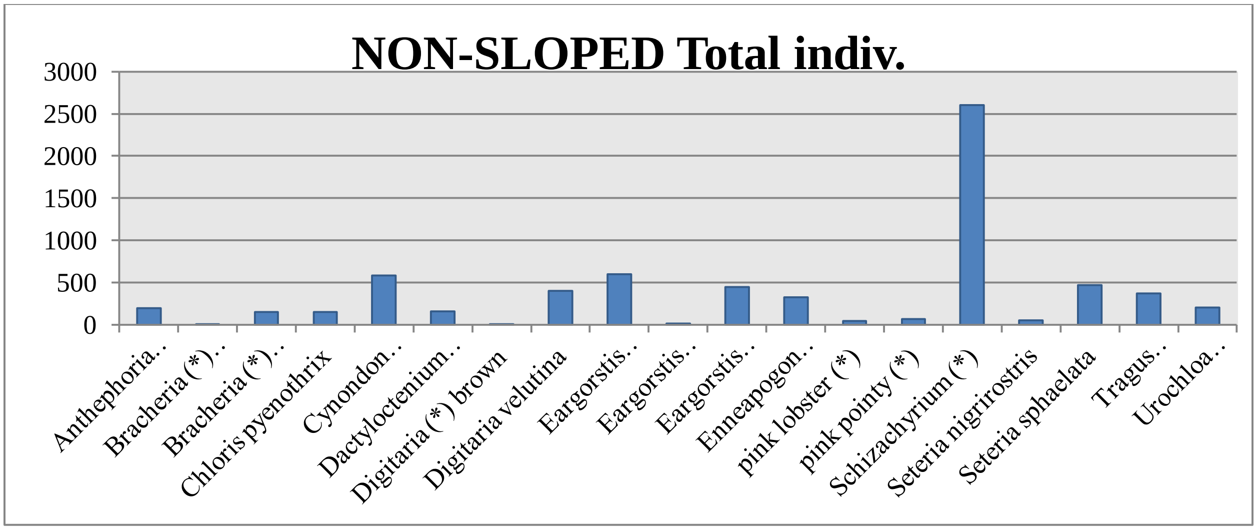
Panicum (*)	*	*	*	*
pink floppy (*)	*	*	*	*
purple paintbrush (*)	*	*	*	*
purple seed (*)	*	*	*	*
Schizachrium (*)	*	*	*	*
Setaria sphacelata	Perennial tufted	High value	Climax	Decreaser
Setaria nigrirostris	Perennial tufted			
Sporabolus pyamidalis	Perennial tufted	Low value	Sub-climax	Increaser II
Themada triandra	Perennial tufted	High value	Climax	Decreaser
Tragus berteronianus	Annual tufted	Low value	Pioneer	Increaser II
Tristachya leucothix	Perennial tufted	Average value	Climax	Increaser I
Urochloa mosambicensis	Weak Perennial	Low value	Pioneer	Increraser II

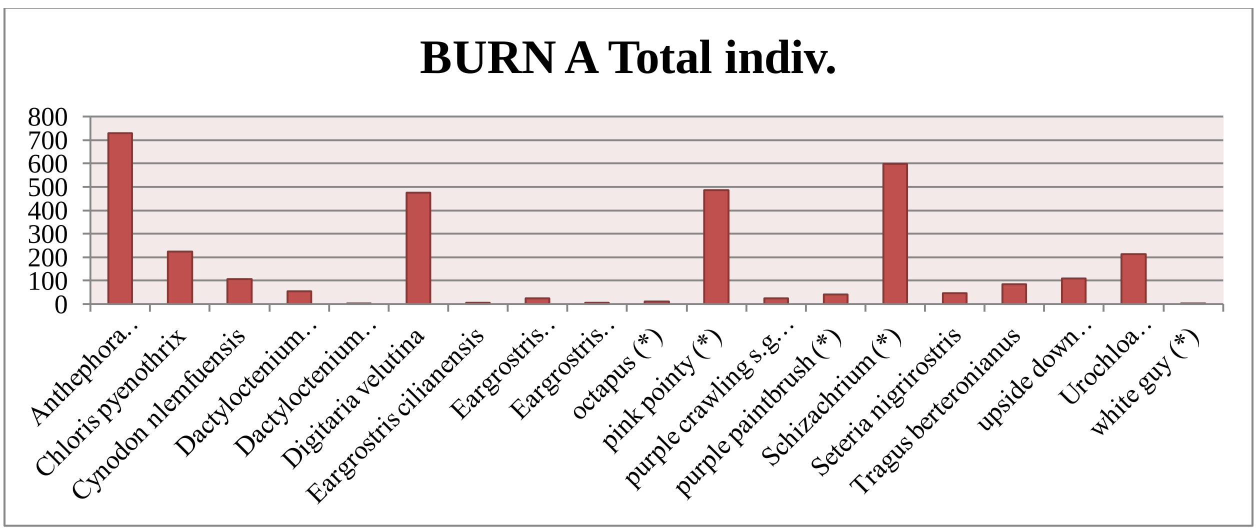
Appendix D—Total List of Species with Individual and Plot Totals

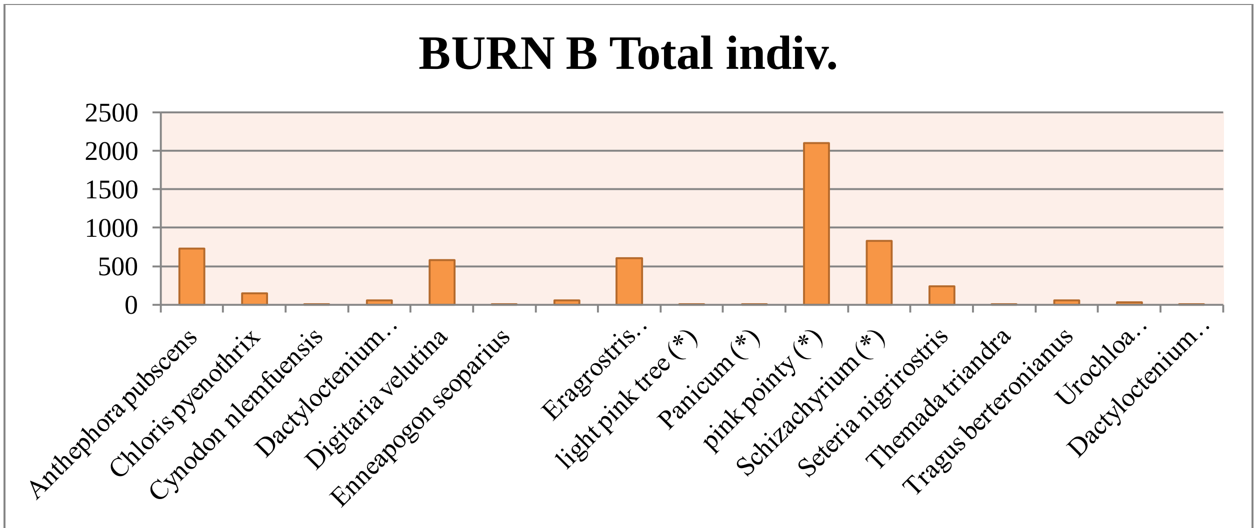
TOTAL SPECIES LIST	TOTAL Individuals	TOTAL plots
Anthephora pubescens	1891	170
big pink floppy (*)	182	23
Bracheria (*) bulbous	6	3
Bracheria (*) perpendicular	158	2
Bracheria brizantha	337	32
Chloris pyenothrix	714	130
Cynoden dactylln (*)	2	1
Cynoden nlemfuensis	1041	114
Dactyloctenium aegyptium	332	68
Dactyloctenium aegyptium (*) tall	76	9
Digitaria (*) brown	2	2
Digitaria eriantha	27	4
Digitaria velutina	2272	277
Eargorstis cilianensis	609	26
Eargorstis cilianensis (*) thick	191	46
Eargorstis habrantha (*) fuzzy	1373	162
Eargorstis habrantha (*) smooth	275	45
Enneapogon seoparius	334	26
Eustachys paspaloides	303	18
fuzzy white nodes (*)	14	5
green seeds, purple culms (*)	2	1
Heteropogon contortus	615	29
Hyparrheria	22	6
light pink tree (*)	4	1
octapus (*)	12	5
Panicum dregeanum (*)	228	11
Panreum (*)	48	10
pink lobster (*)	44	1
pink pointy (*)	4171	286
pink pointy (*) dark	40	6
purple crawling s.g. (*)	252	43
purple paintbrush (*)	223	6
purple seed (*)	206	4
Schizachrium (*)	9533	323
Setaria sphacelata	594	55
Seteria nigrirostris	396	31
Sporabolus pyamidalis	67	23
Themada triandra	222	31
Tragus berteronianus	836	87
Tristachya leucothix	4	1
unidentified	2	1
Unknown 1	24	1
unknown 2	6	1
unknown 3	2	1
Urochloa mosambicensis	929	113
white guy (*)	3	1

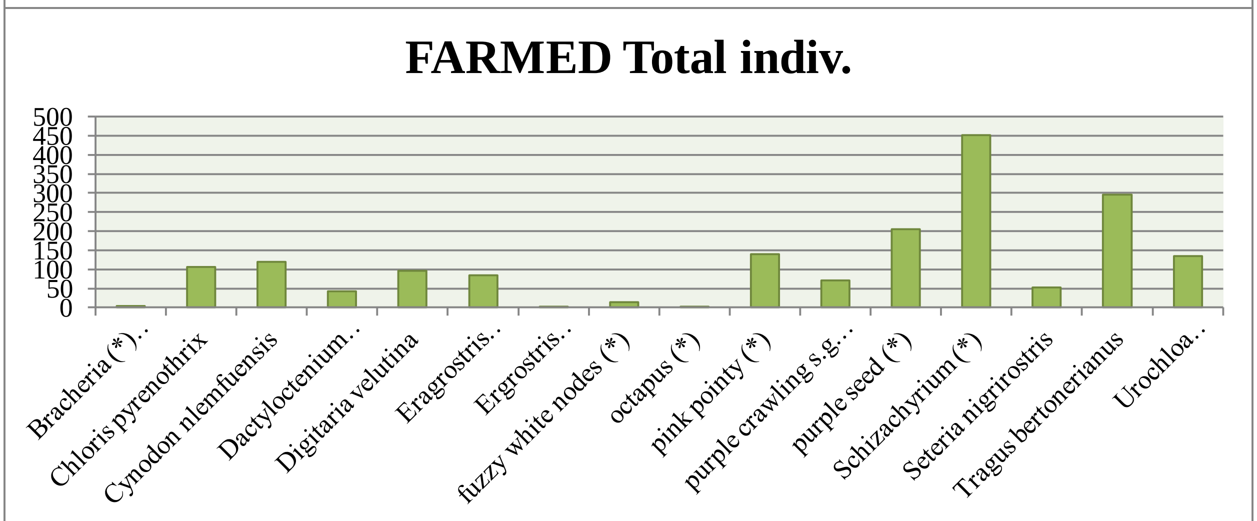
Appendix E—Total Individual Distributions of Species in Each Sub-Population

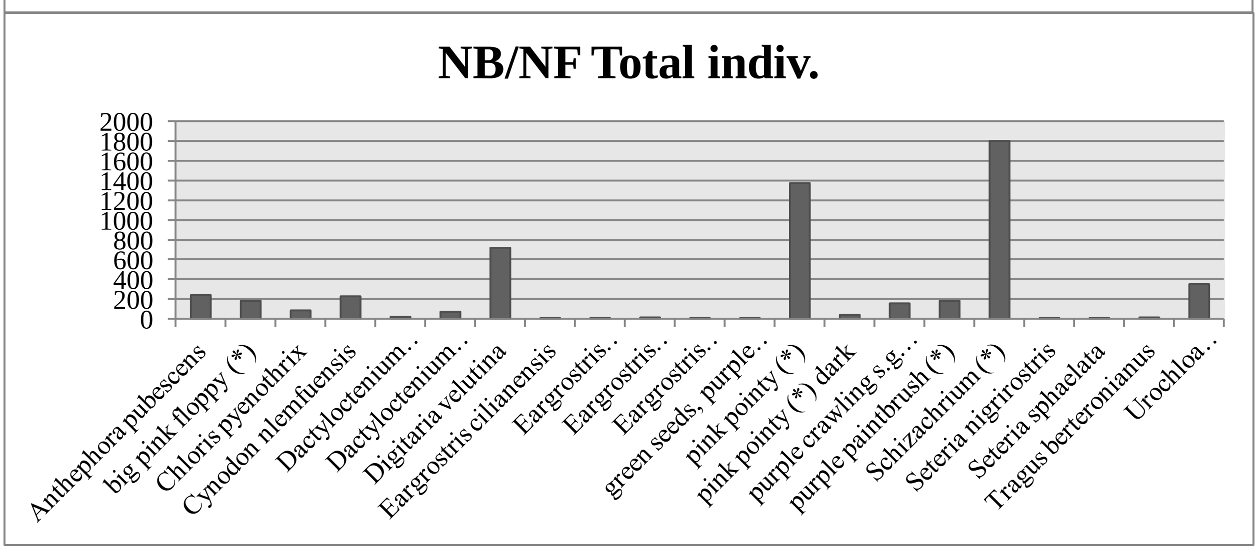




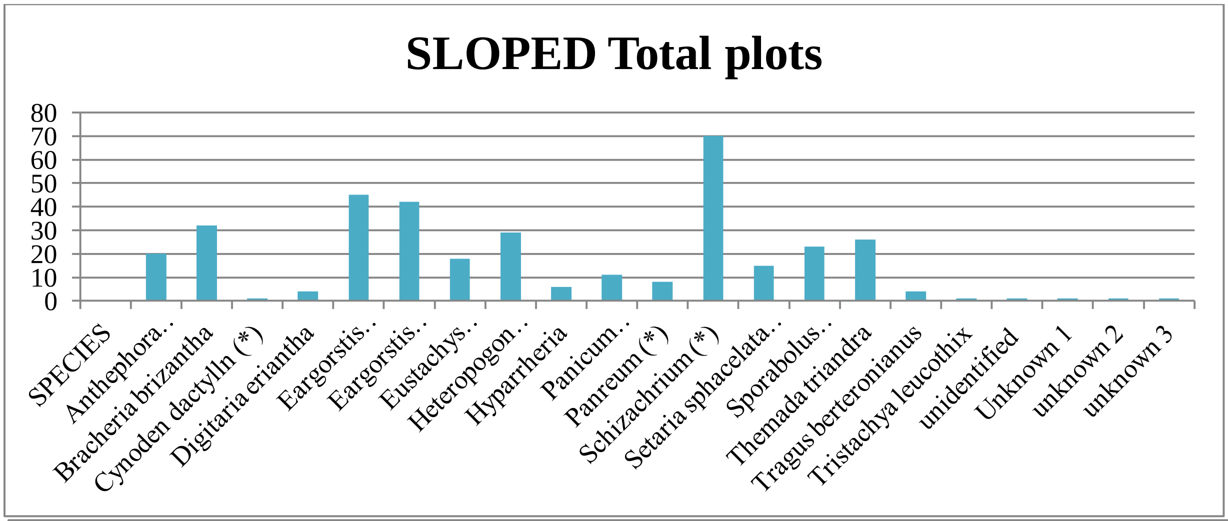


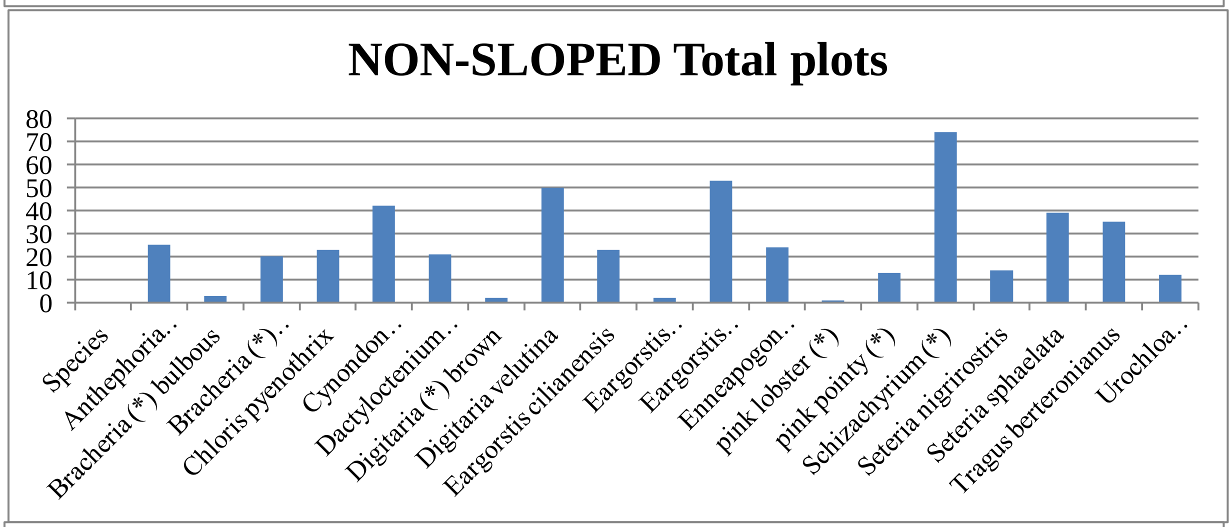

BURN B Total indiv.
2500
2000
1500
1000
500
0
Anthephora pubscens
Chloris pyenothrix
Cynodon nlemfuensis
Dactyloctenium…
Digitaria velutina
Enneapogon seoparius
Eragrostris…
light pink tree (*)
Panicum (*)
pink pointy (*)
Schizachyrium (*)
Seteria nigrirostris
Themada triandra
Tragus berteronianus
Urochloa…
Dactyloctenium…

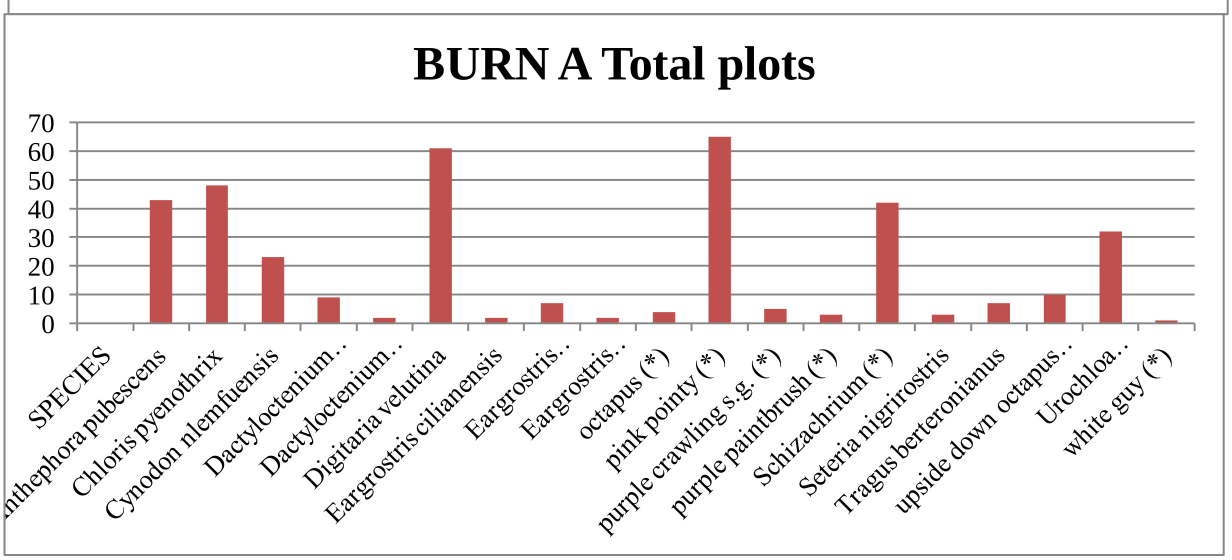

FARMED Total indiv.
500
450
400
350
300
250
200
150
100
50
0
Bracheria (*)…
Chloris pyrenothrix
Cynodon nlemfuensis
Dactyloctenium…
Digitaria velutina
Eragrostris…
Ergrostris…
fuzzy white nodes (*)
octapus (*)
pink pointy (*)
purple crawling s.g…
purple seed (*)
Schizachyrium (*)
Seteria nigrirostris
Tragus bertonerianus
Urochloa…

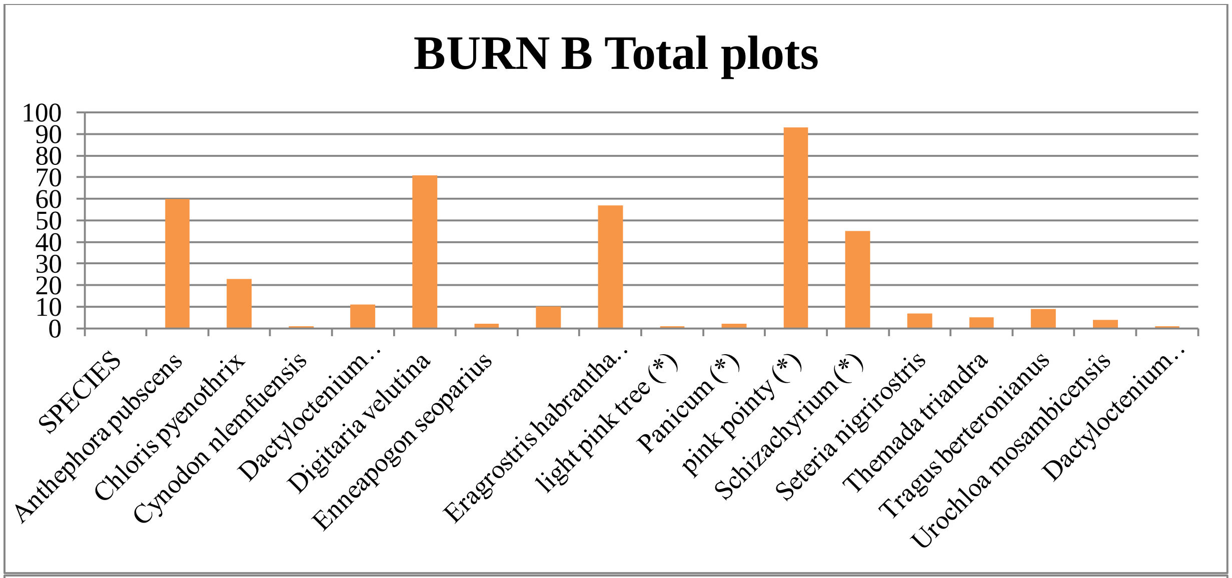

NB/NF Total indiv.
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Anthephora pubescens
big pink floppy (*)
Chloris pyenothrix
Cynodon nlemfuensis
Dactyloctenium…
Dactyloctenium…
Digitaria velutina
Eargrostris cilianensis
Eargrostris…
Eargrostris…
Eargrostris…
green seeds, purple…
pink pointy (*)
pink pointy (*) dark
purple crawling s.g…
purple paintbrush (*)
Schizachrium (*)
Seteria nigrirostris
Seteria sphaelata
Tragus berteronianus
Urochloa…

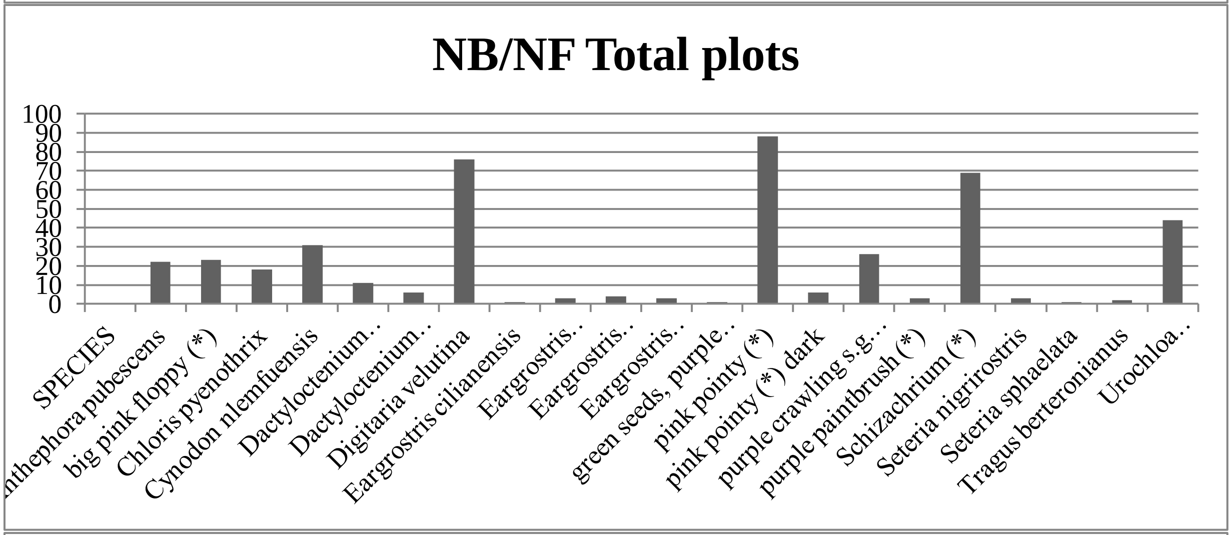
Appendix F—Total Plot Distribution of Species in Each Sub-Population

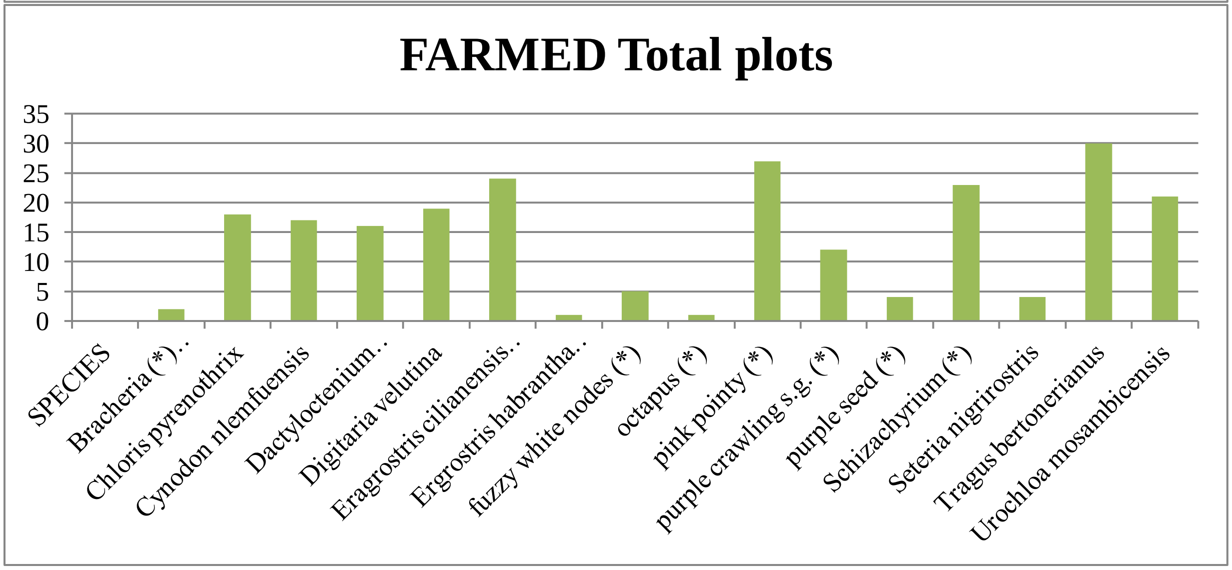







BURN B Total plots
100
90
80
70
60
50
40
30
20
10
0
SPECIES
Anthephora pubscens
Chloris pyenothrix
Cynodon nlemfuensis
Dactyloctenium…
Digitaria velutina
Enneapogon seoparius
Eragrostris habrantha…
light pink tree (*)
Panicum (*)
pink pointy (*)
Schizachyrium (*)
Seteria nigrirostris
Themada triandra
Tragus berteronianus
Urochloa mosambicensis
Dactyloctenium…


NB/NF Total plots
100
90
80
70
60
50
40
30
20
10
0
SPECIES
nthephora pubescens
big pink floppy (*)
Chloris pyenothrix
Cynodon nlemfuensis
Dactyloctenium…
Dactyloctenium…
Digitaria velutina
Eargrostris cilianensis
Eargrostris…
Eargrostris…
Eargrostris…
green seeds, purple…
pink pointy (*)
pink pointy (*) dark
purple crawling s.g…
purple paintbrush (*)
Schizachrium (*)
Seteria nigrirostris
Seteria sphaelata
Tragus berteronianus
Urochloa…


FARMED Total plots
35
30
25
20
15
10
5
0
SPECIES
Bracheria (*)…
Chloris pyrenothrix
Cynodon nlemfuensis
Dactyloctenium…
Digitaria velutina
Eragrostris cilianensis…
Ergrostris habrantha…
fuzzy white nodes (*)
octapus (*)
pink pointy (*)
purple crawling s.g. (*)
purple seed (*)
Schizachyrium (*)
Seteria nigrirostris
Tragus bertonerianus
Urochloa mosambicensis

Nut and Bolts

The long and short of it is- Ndarakwai is an awesome place to do an ISP, especially if you have a friend or two with you! We would have gone crazy if we were there alone with just grass species as friends. Here's the advice we have for anyone interested!

Food: if you have people cooking for you who don't usually cook for others, be specific with what types of food and how much that you want. For example, if you don't like sardines, say please no samaki. But be flexible with time, punctuality is not as strict in Tanzania as in the US, so it would be rude to be impatient. Everyone is kind and trying their best!

Transportation: we highly recommend hiring a driver to get you to and from the ranch. We took a bus, two daladalas, and some other questionable forms of transport to get there during Prep week. With all our camping gear/bags/food, that would have been impossible for the real thing. We hired Olias, of Klub Afriko, to drive us there and pick us up at the end for 400,000 Tsh split between three people. While at camp, you should be able to hitch a ride with supply cars coming and going from Boma Ngombe near Moshi. You can get everything you need there, including food, soap, and beer.

Fees: It costs $100 USD to camp at Ndarakwai, it goes to the conservation fund. We were not asked to pay for our askaris, but we did leave them a nice tip because they spend a lot of time with you and are very kind and helpful.

Other Things We Learned the Hard Way:

- Don't camp under trees that have monkeys- they are terrors and will throw stuff at your tent. However camping under trees without monkeys helps to shield your tent from the rain- very important for Spring semester rain season.
- Ticks are everywhere, but they don't bite if you pull them off quickly. Just be prepared for them and don't panic. There is no lime disease in Tanzania.
- If going in the Spring, make sure to have a good rainfly, footprint, raincoat, good boots, many pairs of socks so you have a dry pair to wear most days. Wet socks are no fun.
- Camping for three weeks is long, even if you think you love it, bring a pillow.
- It gets a little chilly at night, bring sweat pants and a fleece.
- Bring your usual medication bag with you, we made good use of Nyquil and Cipro.
- Internet is available at the lodge- the receptionist, Saba, is very nice. No need to buy an internet stick.
- Technology is safe there in your tent so don't be afraid to bring camera, laptop, etc.
- All the staff, askaris, and most guests are incredibly welcoming!!! Talk to people and make friends, it will be so helpful to your project and make your time that much more enjoyable!
- On the off chance anyone wants to study grasses (we promise it is way more fun and interesting than it sounds) we'd love to talk to you about it if we could help at all, so hit us up. Good luck and have fun!!!

Best of luck! Enjoy! Theresa and Hallie
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