Plant Communities and Sand Dune Dynamics
on the Navajo Nation

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Introduction

Burial by wind-deposited sand is an environmental stress commonly encountered by plants of coastal, lake shoreline, and desert sand-dune communities. The tolerance of specific species and the general physiological responses of plants to varying degrees of burial have been extensively studied in coastal and lake-shore dune systems while few comparable studies have been conducted in desert systems (Brown 1997). With the lack of these studies others such as Hack (1941) and Gay (1999) have documented their observations and studies relating to vegetation and the influence of dune movement in arid and coastal communities. Their approach was from an observational perspective in which their exploration of the area in which they studied was either due to an archeological exploration (team from the Peabody Museum of Harvard University) or from (the staff of Marcona) Mining.

From these activities of exploration and curiosity this study begins with a similar approach the only difference being that I'm from the community of Tuba City/Howell Mesa, Arizona. Growing up and living where I do has given me the opportunity to know the natural beauty of the world around me. Since the 1980s I have been fortunate to know and call sheep camp my home away from home. Through the years the only conversation heard was through the speech of the Navajo language by my family, elders and relatives. Being immersed in my language has guided my education in learning and speaking Navajo as an adult. With the benefits of knowing my language I am able to ask questions regarding the natural world which we call home.

As a frequent traveler of returning to sheep camp the constant and sometimes dramatic changes occurring on the dunes along the dirt road continues to capture my attention. It appears to be a natural flow of movement for sand dunes to move along the landscape and with the frequent sand storms in the Tuba City community its no wonder where the sand supply comes from. Interestingly enough this is not where the winds begin taking the sand in the atmosphere to Tuba City but the reverse happens. The sand storm moves Northwest often not reaching the furthest location of our residence. What we do see during daylight hours is the red plume of sand in the sky over the community.

These intense wind patterns prevalent during the summer months always seem to decorate the sky, which brings me to the question of what happens to the community near, on and around a sand dune. Hesse (2006) suggests that the level of dune activity is controlled by vegetation cover and probably not by fluctuations of wind strength. Kocurek and Lancaster (1999) imply a different response in that transport capacity is the potential sediment transport rate of the wind. Not only is the wind important in understanding the sand dune dynamics but also the composition of species present. Brown (1997), Cox (2006), Hack (1941), and Malkinson (2003) have studied the patterns and productivity of species richness in arid systems and have found a relationship with where species are located on the dune. These studies establish some general expectations about ecological specialization among some of the plants in the Tuba City area (see Table below). Predictions of climate models for increasing drought in the southwestern US make increasing dune activity probable, and the local community already recognizes such change in dune frequency and activity, availability of surface moisture, and in vegetation. Understanding the impact of dunes on vegetation and the possibility of plant adaptations that could reduce their effects can benefit the community by making human adaptation possible in such activities as grazing .

Table 1. Plants commonly found between literature of Brown (1997) and Hack (1941) show the relationship of where they are found. *Same species found at dune sites in Tuba City, AZ.

Scientific Name	Common Name used in Literature	Acronym Key used in project	Area Observed	Cited in Literature
Poliomintha incana	Bushmint	*POIN	Active Parabolic Dune	Hack (1941)
Sporobolus airoides	Alkali sacaton	*listed as unkown	Free Transverse Dune Sparse	Hack (194)
Sarcobatus vermiculatus (Hook.) Torrey	Greasewood	*CHGR	Leeward, tolerates burial	Brown (1997)
Chrysothamnus nauseosus (Pallas) Britton ssp. Consimilis	Salt Rabbitbrush	*CHNA	Leeward, doesn't tolerate burial	Brown (1997)

Table 2. Similar plants demonstrating specialization by location (Malkinson et al. 2003)..

Community Type	Area Observed	Cited in Literature
Stipagrostis Scoparia Perennial Grass	Active dune tops	Malkinson et al. (2003)
Moltkiopsis ciliate Intermediate stage	Dune slopes	Malkinson et al. (2003)
Echichilon fruticosum Inter-dune	Stable dune	Malkinson et al. (2003)

<u>Hypotheses</u>

H1 – Burial by dunes produces physiological stress for plants, so that the density, diversity and species composition of plant communities behind dunes should differ from those unaffected ahead of dunes. Density and diversity should be depressed behind the dune, and species known to be tolerant of wind erosion should be better represented there.

H2 – Burial through sand deposition on the lee side of a dune produces different physiological pressures than erosion by wind scouring on the windward face of a dune, so that species composition should differ on lee and windward faces, reflecting species' different adaptations to these challenges. Further, added desiccation on the windward side could depress species diversity and productivity compared to the lee side.

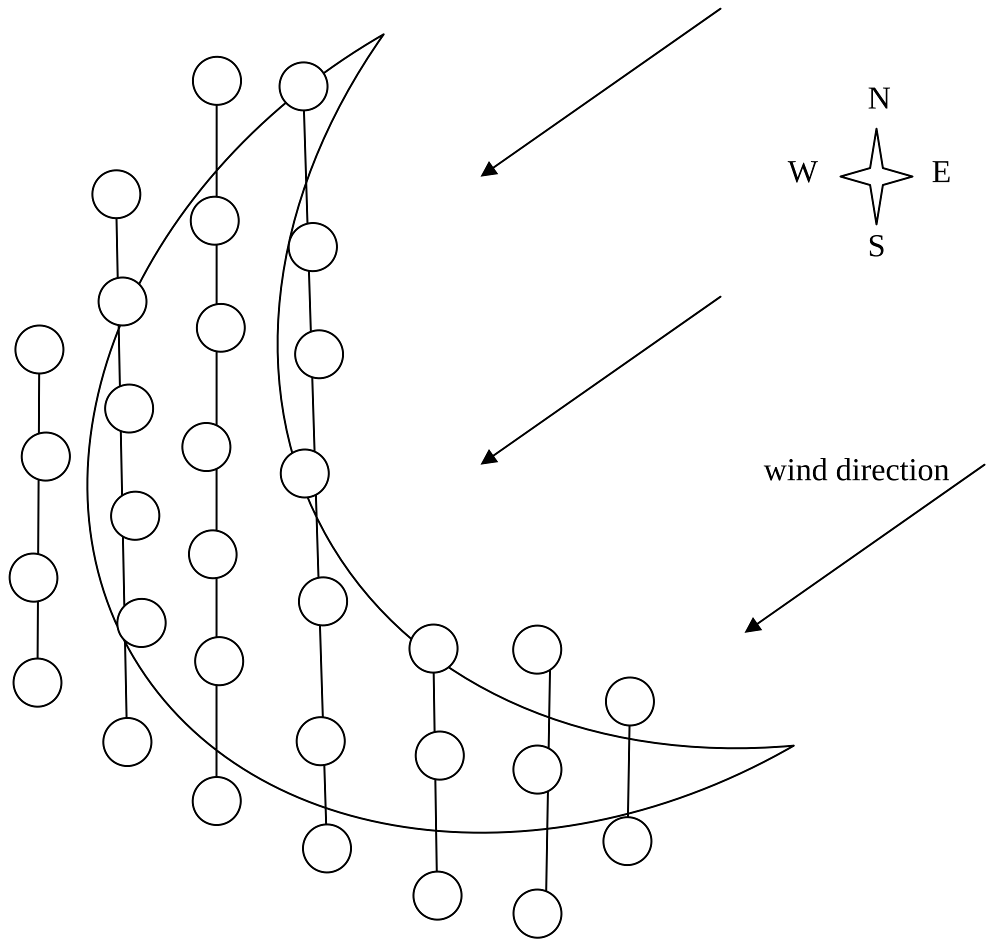
H3 – Dunes of differing activities (rates of movement) should have different species composition because of varying severity of stresses imposed by moving sand.

H4 – In such a rich flora, specialization to particular zones on a dune is expected, resulting in patchy species distributions across a dune.

Study Area & Methods

Along a six-mile stretch of road NW of Tuba City, five dune sites were selected on the basis of location, size and by activity level. Activity level refers to the speed of movement of the dune across the landscape and is related to the force of sand movement at the surface. At one extreme, stabilized dunes move little and support more vegetation. The sites are easily accessible except for one dune which is off the main road. They were chosen to illustrate the range of variation of dunes in the area, with regard to activity level and the plant community surrounding the dune. What sets them apart visually is the shape of the dunes and the density of vegetation on them.

North-south transect lines were established on each dune, then repeated from east to west with 3m-radius sampling plots separated by 10m. Within plots, all species were identified and counted. Included was the collection of mean size, flowering Y/N, and number of plants greater than 10cm. Photos were taken of species observed and also of unidentifiable plants. The photos served as a field guide for all species that are observed to be in the area. Not only did the photos document what species are present but also to document the changes that the plant went through during growing season.



Aerial photography provided images that allowed us to look at the dune in its entirety revealing a clearer shape of the dune. United States Geological Survey provided the balloon, rope, helium, and a wooden box equipped with a camera. A remote control was used to capture the aerial images by one person walking the surface of the dune gauging and directing the balloon overhead with the second person. The timing of balloon lift was dependent on the weather and wind conditions. Risk of loosing the balloon in wind speeds above 10 m.p.h. at ground level could be likely. A restriction of having a vertical lift not greater than 200 meters was the precaution we took. The images demonstrate the extent of movement from the earliest observed to its current position.

Results

I sampled plants on two dunes in the summer of 2007: Beegashii (cow) and Gah bejaa (rabbit ears), and I found that species composition of plant communities differed ahead of dunes compared to the communities in the dune's wake. I also found that density was low behind the dune compared to the so-far unaffected vegetation ahead of the dune (Figure 1 below). For instance, snakeweed (GUSA), rabbitbrush (CHNA), and Apache plume (FAPA) are among the dominant species ahead of dunes, and substantially more abundant there than behind dunes. Wright bird beak (COWR) in contrast was not recorded ahead of the dune but was the most abundant species behind.

On the Beegashii dune, composition of the plant community on the lee slope was substantially different in species composition from the community on the windward slope, and this was true at the edges of the dune (Figure 2) as well as on the more interior parts of the dune (Figure 3) and in the center (Figure 4). In the first two of these three zones, the species diversity of plants, measured by the reciprocal Simpson's index ($D= 1/\mathrm{sum}(p_i^2)$) was greater on the lee slope than windward. At the edges, where sand depth is less and less sand is moving, cheatgrass (BRTE), snakeweed (GUSA) and rabbitbrush (CHNA) are the three most abundant species while, of those three, only snakeweed is also common on the windward slope. Dominance shifts on the interior of the dune (20-30m from the edge), where broom groundsel (SESP), pale evening primrose (OEPA), and sand sagebrush are most abundant, while snakeweed is again the dominant species on the interior windward slope. In the center of the dune, where sand is deepest and most mobile, dominance shifts again and stickleaf (MEPU), gravel milkvetch (ASSA) and fragrant sand-verbena (ABFR) are the dominants. These three are uncommon on the windward center, where pale evening primrose dominates.

Sampling on the Gah bejaa dune was not complete, but some comparisons are possible. This was a more active dune, and the plant community was thinner. In the interior of the dune, 20-30m from the edge, the lee community differed from the windward in that only one species, *Dicoria,* was recorded on the windward side, while that species was joined by several others leeward (Figure 5). There was substantial change in the plant communities comparing across dunes, and only two species of the commonest six were common to both Gah bejaa and Beegashii on the leeward edge(Figure 6), and only one of six on the leeward interior (Figure 7). The next season's sampling will include five dunes to further explore this interdune variation. I am also summarizing individual species' distributions by zone on Beegashii to further test ideas about ecological specialization of dune plants.

Plant communities change with the seasons, particularly as they appear to the botanist ("sand-duneologist"). In October, I sampled all five of the dunes scheduled for study in the summer of 2008, using a coarser sampling scheme in which points were established at 20m intervals. These data have not yet been analyzed, but they will at least provide a rough idea of how much measurable plant abundances can change seasonally. Sampling in the summer of 2008, especially on Beegashii, will also contribute to understanding annual variation on the same dune.

Figure 1.

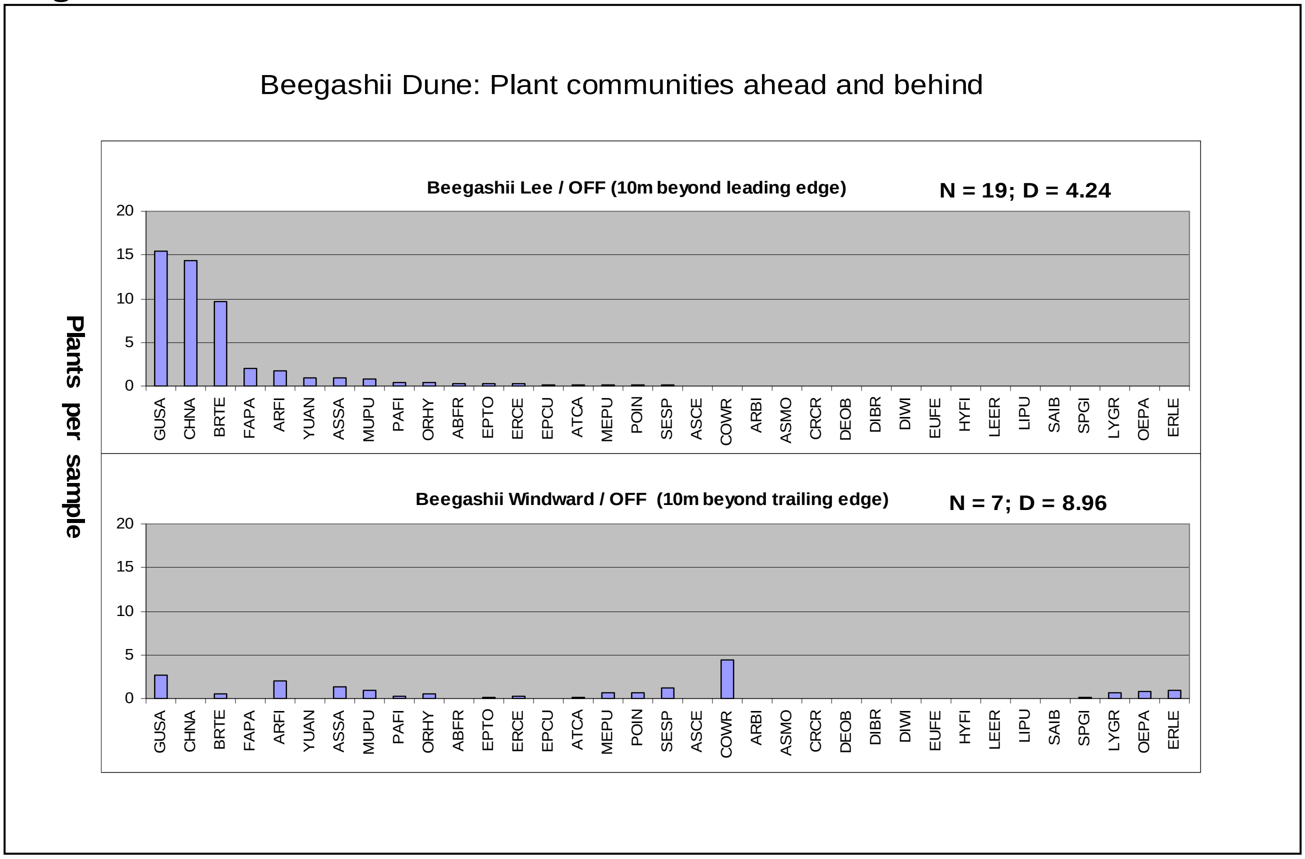
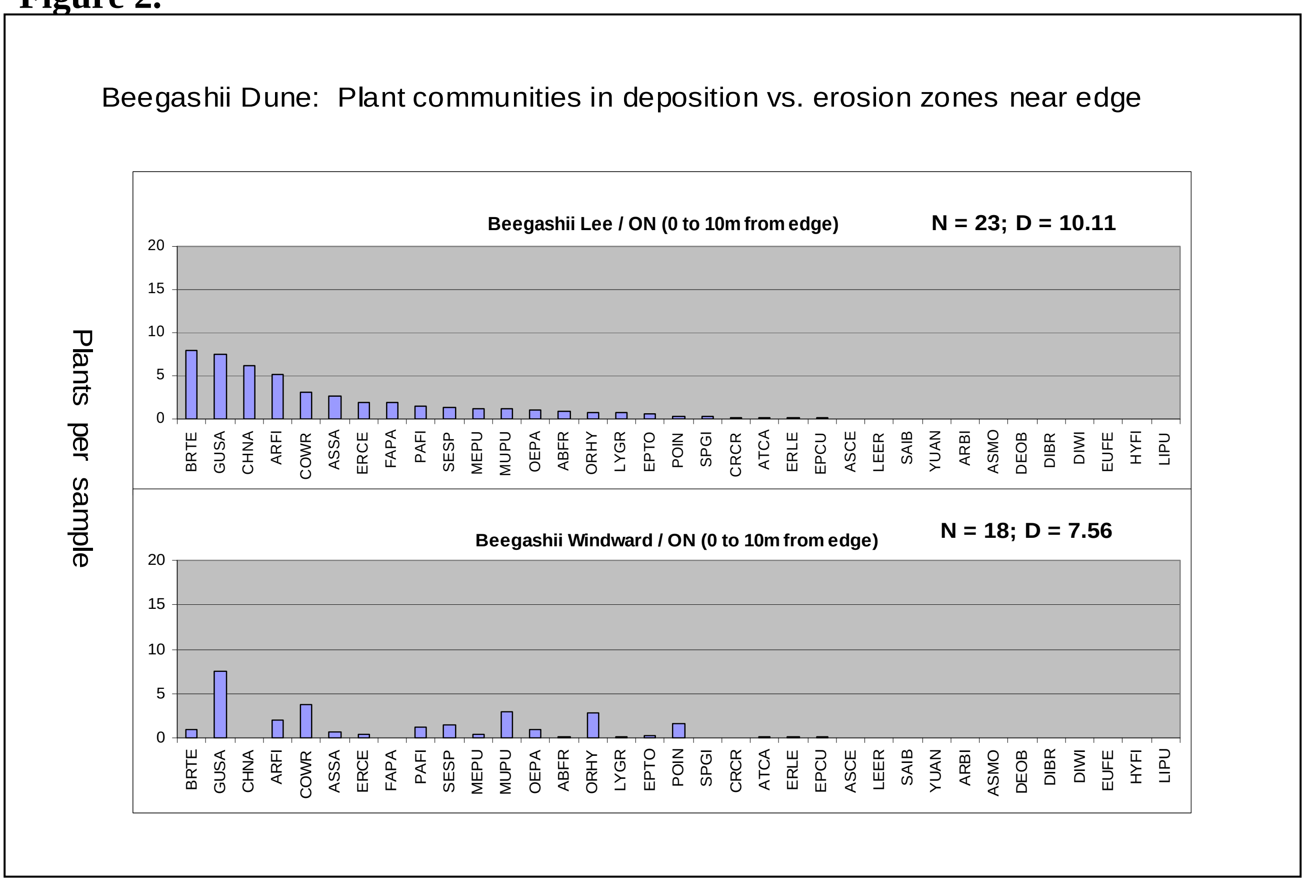


Figure 2.



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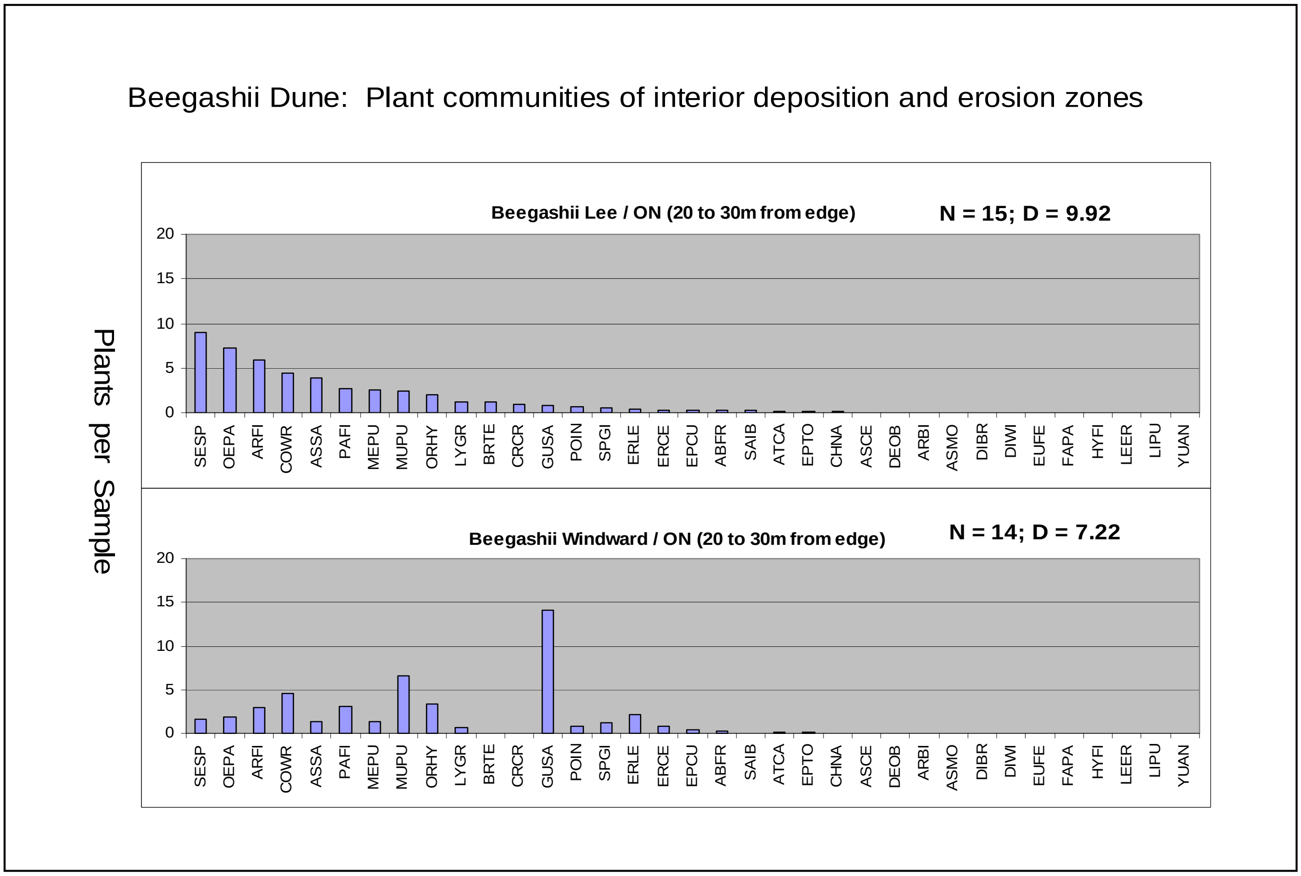

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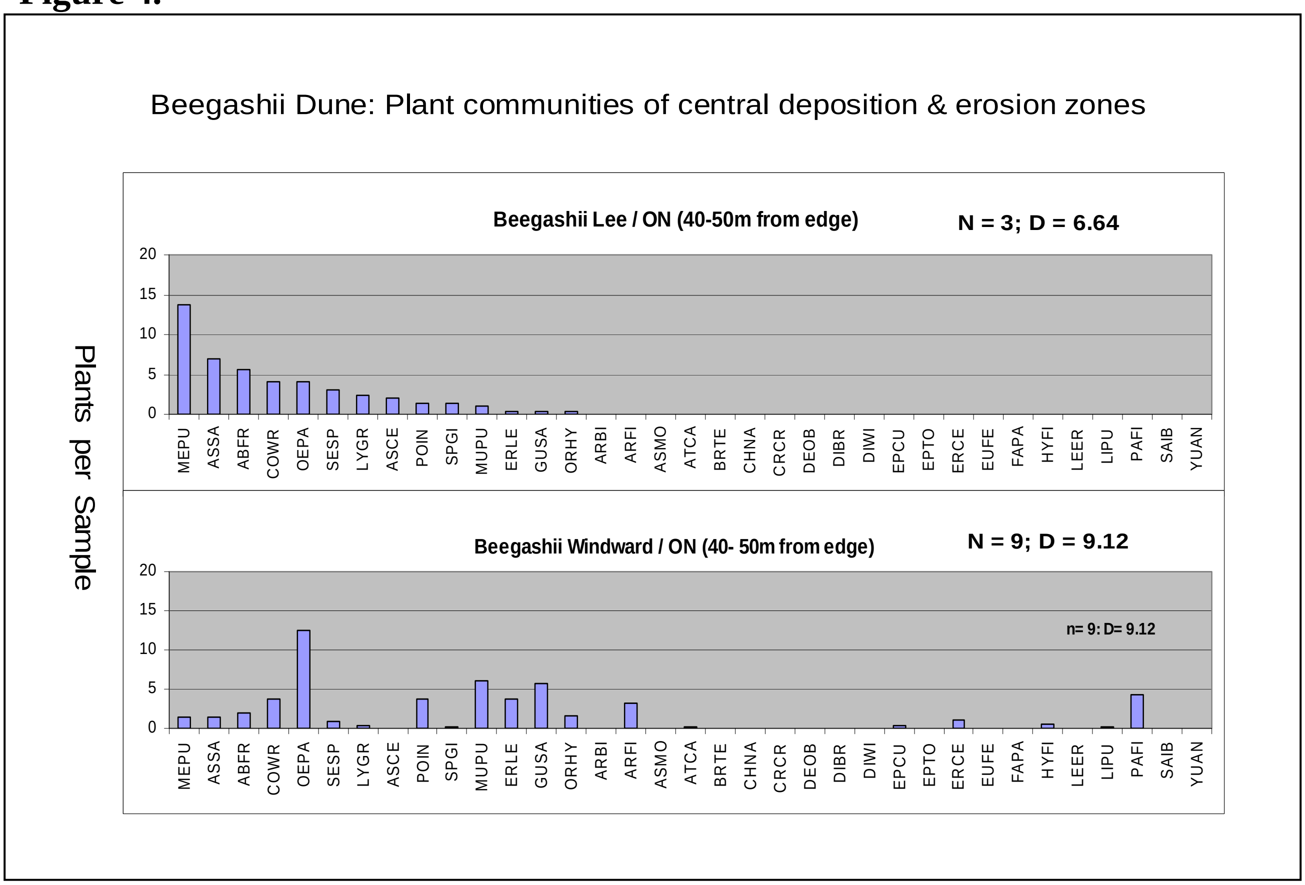
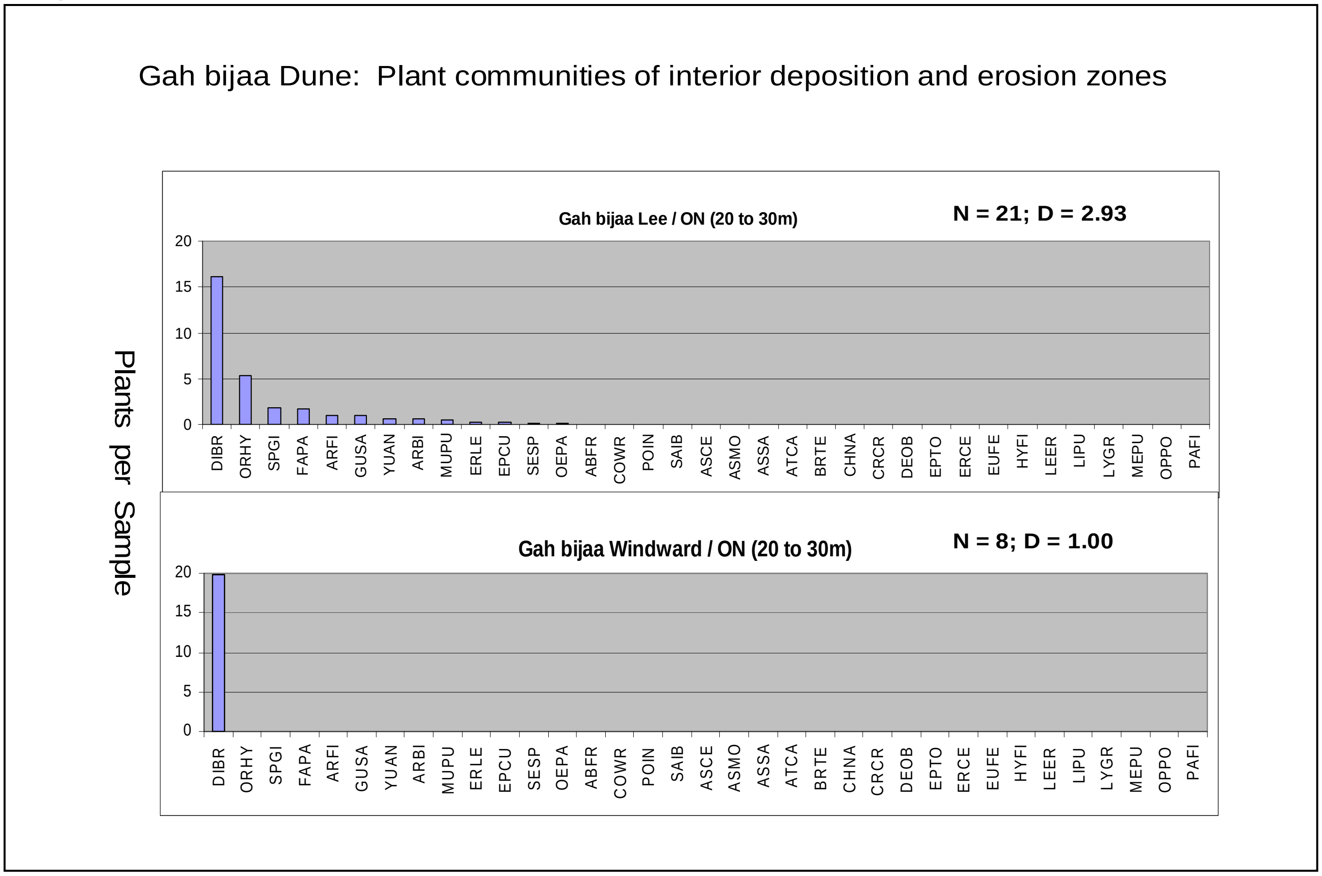


Figure 5.



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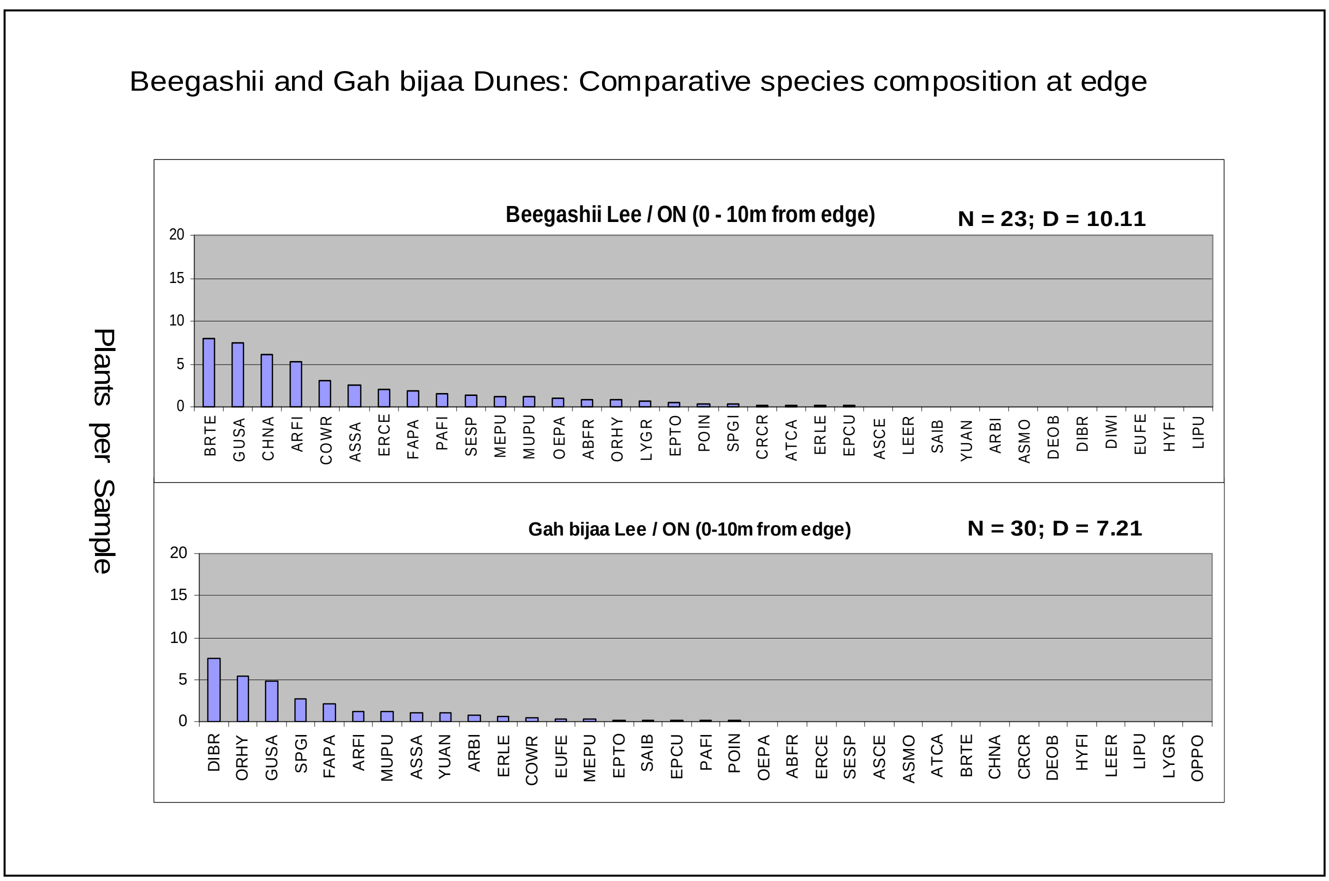
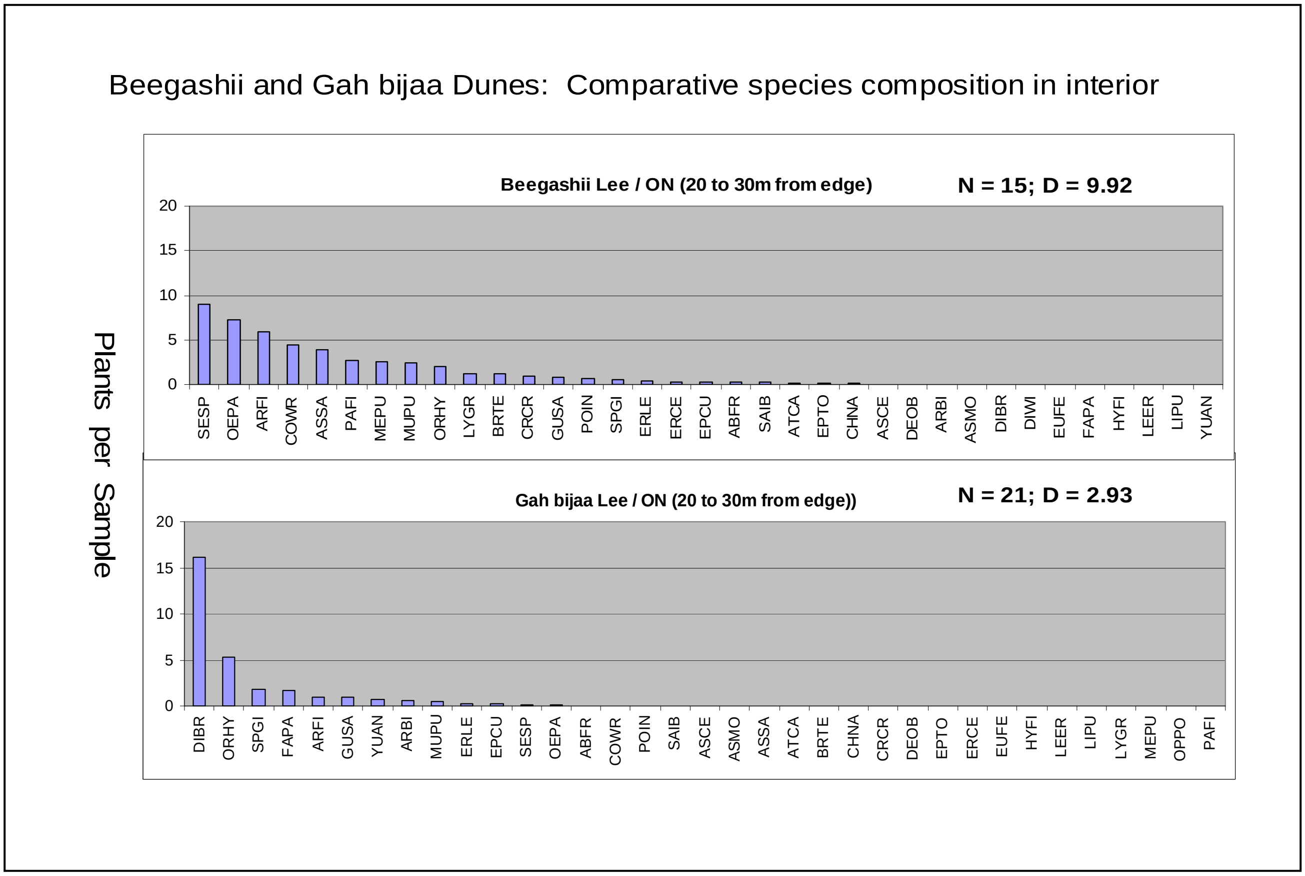


Figure 7.



Conclusions. Hypotheses 1-3 were mostly supported; however, much more data are needed to explore them thoroughly given the great diversity of plants in the system, variations in their distributions among zones on and around the dune, and variation across dunes and across seasons. This appears to be a diverse community of fairly specialized species with a wide variety of adaptations to the desert environment and to the particular challenges presented by dunes.

Related Activities

June & July: Participated the Tuba City Chapter Council meetings, presenting a poster, demonstrating my field guide, and explaining the project to community members. I received a letter of permission from the Chapter in July, and will attend future Chapter meetings.

August: Attended the Symposium of the Community Forestry Fellows in Tennessee, along with Kerry Rabenold and Lucille Saganitso-Krause (grazing officer of the Tuba City Chapter), where I presented a poster and talk entitled “Plant Communities and Sand Dune Dynamics”.   Lucille also presented a talk concerning the importance of my studies to the Navajo Nation, and we all participated in two days of panel discussions concerning efforts to make research understood, relevant and useful to local communities.

October: presented a talk entitled ““Plant Communities and Sand Dune Dynamics” to the Gem Scholars program consisting of Purdue faculty and students working with Ojibway students from Bemidji State University and nearby Tribal Colleges.

<u>Timeline 2008</u>

February – Begin Institutional Review Board process for approval of my proposed interviews with Navajo elders concerning plant names and characteristics.

March – if applicable will attend Chapter planning meeting (during spring break)

April – prepare data sheets/books, gear checklist

May 12 to June 6 – Planning/Chapter Meeting, Field work (data collection)

June 9 to June 30 – Chapter Meeting, Interviews (traditional knowledge)

July 8 to July 31 – Progress Meeting, Field work (data collection)

August – return to campus

Timeline will be modified as semester and season progresses.

References

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