POLLEN DISPERSION IN RELATION TO METEOROLOGICAL CONDITIONS, SEASONALITY, LOCATION AND ELEVATION IN COLLEGE STATION, TEXAS, USA

A Senior Scholars Thesis

by

KRISTEN HUANG

Submitted to Honors and Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

May 2012

Major: Environmental Geosciences

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Approved by:

Research Advisor:	Sarah Brooks
Associate Director, Honors and Undergraduate Research:	Duncan MacKenzie

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ABSTRACT

Pollen Dispersion in Relation to Meteorological Conditions, Seasonality,
Location and Elevation in College Station, Texas, USA. (May 2012)

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Pollen deposition has an immense effect on air quality and human health. There is new interest linking biogenic aerosols to possibly being cloud condensation nuclei (CCN). This field experiment focuses on pollen emission in relation to local meteorological factors, including temperature, relative humidity, solar radiation, pressure, rain, wind speed and wind direction. A biological microscope was used for identification of possible common species in College Station, Texas. Insight into the vertical and horizontal transport of pollen was achieved through time varying analysis of pollen count and concentration, and comparing ground-level and rooftop measurements. Pollen was collected almost daily between September and November 2011 and in March 2012 using Rotorod Model 20 samplers. During the fall campaign, a sampler and a weather station were both set up on the roof of the Eller Oceanography & Meteorology building (O&M) on Texas A&M University's (TAMU) campus. For the spring campaign, pollen was sampled at three locations; a sampler, sonic anemometer, and weather station were set up on the roof of O&M, another sampler was set up at ground-level of O&M, and the third sampler and a second weather station were located at TAMU Research Farm to provide a rural comparison. The concentrations of the most common types of pollen were counted and identified under a light microscope and correlated with meteorological factors. Results showed ragweed (*Ambrosia*) to be more prominent during the fall, the average pollen grains/m^3 on the roof to be considerably higher during the spring, and more species during the spring. The concentration of pollen grains decreases with increasing elevation. Farm concentration was far less than at O&M. Concentration of pollen seems to have a positive correlation with solar radiation, temperature, relative humidity, pressure, and wind speed, but more study needs to be done.

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NOMENCLATURE

A	The collector rod’s effective area
avg	Average
c	Pollen concentration
CCN	Cloud condensation nuclei
e	Percent evaluated
m	Meter
n	Total number of pollen grains
P	Pressure
r	Radius about which the collector rod rotates
RH	Relative humidity
RPM	Revolutions per minute
s	Motor speed
t	Time
T_{max}	Maximum temperature
T_{min}	Minimum temperature
V	Volume of air sampled
W	Watts

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CHAPTER I

INTRODUCTION

Biological particles, such as bacteria or pollen, may be active as both CCN and heterogeneous ice nuclei and can potentially have an impact on cloud formation (Möhler et al. 2007). There is evidence that climate change is the key environmental factor affecting aeroallergens like pollen or spores and that changes in climate lead to an increased incidence of allergic disease (Yang et al. 2011; Jin et al. 2011; Kim and Yoon 2011; Sheffield et al. 2011). Understanding correlations will help in determining treatments, preventing allergic diseases and controlling environmental allergens (Abreu et al. 2008). Currently, it is difficult to formulate trends over recent decades due to the lack of long-term, consistently collected pollen records in the United States (Ziska et al. 2011; Kim and Yoon 2011; Sheffield et al. 2011). Ragweed (*Ambrosia artemisiifolia*) is known as one of the most dangerous aeroallergen yielding plants (Agashe and Caulton 2009). So far, Sheffield et al. 2011 have concluded that there is a direct positive correlation between the increase in ragweed (*Ambrosia*) pollen production and temperature. This study contributes to a better understanding of how meteorological parameters may influence pollen emission.

This thesis follows the style of *Aerobiologia*.

CHAPTER II

MATERIALS AND METHODS

Field measurements were taken between 19 September to 3 November 2011 on the roof (13 stories high) of O&M at Texas A&M University and between 2 March to 5 March 2012 on the roof of O&M, ground-level of O&M and at TAMU Research Farm (about 10 miles away from O&M) in College Station, Texas (latitude 30^{o}36’05”N; longitude 96^{o}18’52”W). During this experiment, crops had not been planted at the farm.

Only one location was tested during the fall as a trial run. The fall run was incorporated into the results to note differences in pollen count, concentration, and species between the two seasons from the roof of O&M. A Rotorod Sampler (Model 20) and HOBO Weather Station were set up on the roof of O&M. During the spring, the experiment expanded to include a Rotorod Sampler at each location, the HOBO Weather Station and Sonic on the roof, and the weather station at the TAMU Research Farm Mesonet (Mesonet) at the farm. The Campbell sonic anemometer was used to measure the wind direction and speed in the x, y, and z directions from the roof at O&M.

Fig. 1 Rotorod Sampler (Model 20)

Collector
rods

The Rotorod Sampler, shown in Fig. 1, collects particles on two polystyrene collector rods (each 1.52 mm x 1.52 mm x 32 mm) that spin at 2400 RPM. The samplers ran continuously during the daily collection. Silicone grease was applied on the collecting side of the rods, i.e. the side that faces the rotation direction. These rods were then fixed onto the sampling head. Every 24-hours, the sampling head on the sampler would be replaced by a new sampling head for the next day’s collection. The sampling rods would be assembled and removed in the lab room. After a sample is collected for a 24-hour period, the rods were taken out of the sampling head and stored in a vial with the sample-side facing inward to prevent contamination.

One rod from each day of collection was manually counted and identified in the laboratory using an Olympus CX31 biological microscope. In order to do this, a rod was placed on a stage adapter that had grooves that hold the collector rods with the silicone grease side facing up. Five drops of Calberla's stain, which contains fuchsin, were applied to the adjacent islands of the sample. Sometimes, four drops was not enough, so five drops were used to sufficiently cover the sample. A cover glass was evenly dropped onto the sample and the stain. Immediately afterwards, the cover glass was gently moved side-to-side lengthwise to evenly distribute the stain, ending with the distal end not being covered for 1-2 mm and the cover glass being perpendicular to the slide. The sample was left to sit for at least five minutes in order for the stain to have time to penetrate the exine of the pollen grains and dye the grains pink. The sample was then evaluated under a light microscope at a magnification of 400X. The species of pollen was identified and tallied in order to get a total count of each taxa. Pictures were taken to document pollen grains using a Hitachi CCD Color Camera (Model KP-D20AU) and XCAP-Lite digital software for XCAP V3.7.

Standard procedures have proved that counting at least 400 pollen grains in a dense sample is a good measure of the sample (Multidata LLC 2002). Pollen concentration is defined by the total number of pollen grains divided by the volume of air sampled by the rotating collector rod, $c = n/V$. The volume of air sampled by the collector rod is given by $V = 2\pi rAst(e/100)$, where $r = 4.3$ cm is the radius about which the collector rod rotates, A = 1.52 mm x 22 mm is the collector rod’s effective area, s = 2400 RPM is the motor speed, t is the operating time in minutes and e is the percent of the area evaluated.

CHAPTER III

RESULTS

Comparison between meteorological factors and concentration of pollen grains

Meteorological data and pollen grains/m^3 for the fall and the spring are displayed in Fig. 2-4. Solar radiation values were not available for the days of 19 September, 20 September, 4 October, and from the Mesonet at the farm during the spring. The rain gauge in the fall was most likely faulty and showed that no rain was collected. A manual rain gauge was used during the spring. There was no rain collected during spring sampling.

Fig. 2 Comparison between meteorological factors and pollen concentration during the fall

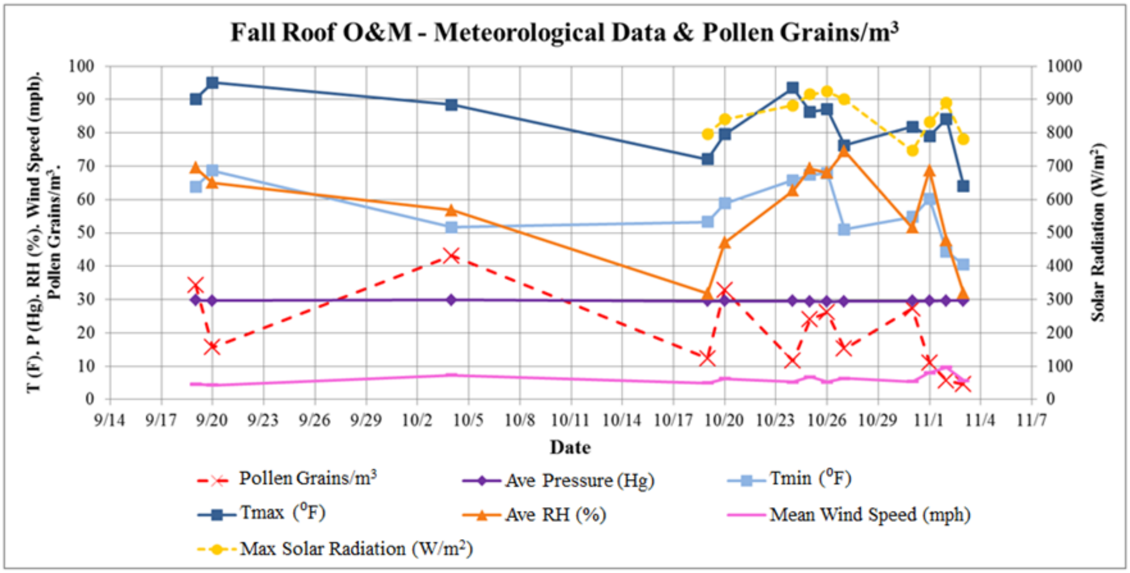


Fig. 3 Comparison between meteorological factors and pollen concentration during the spring at O&M

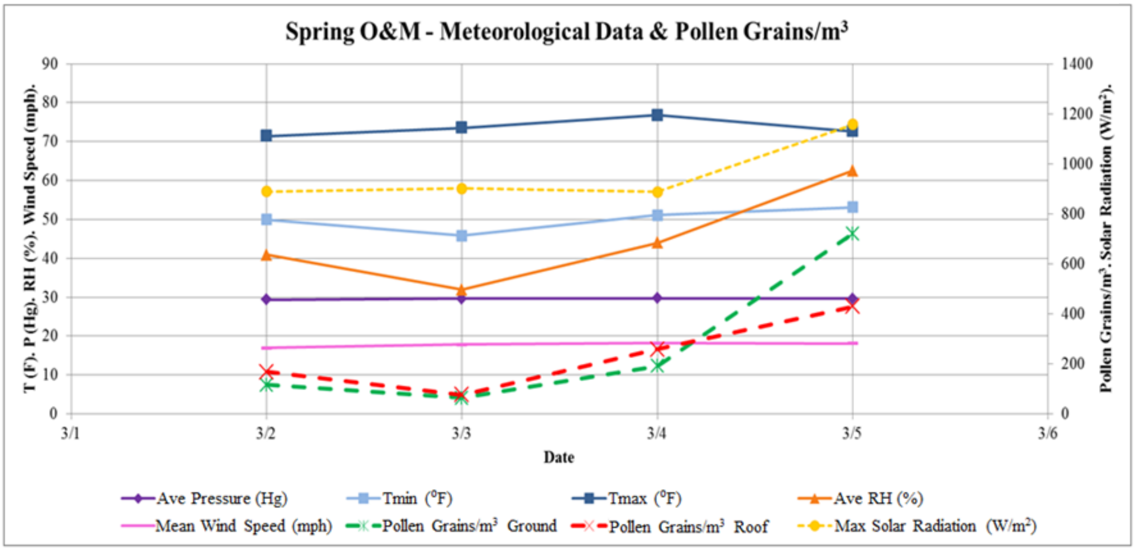


Fig. 4 Comparison between meteorological factors and pollen concentration during the spring at TAMU Research Farm

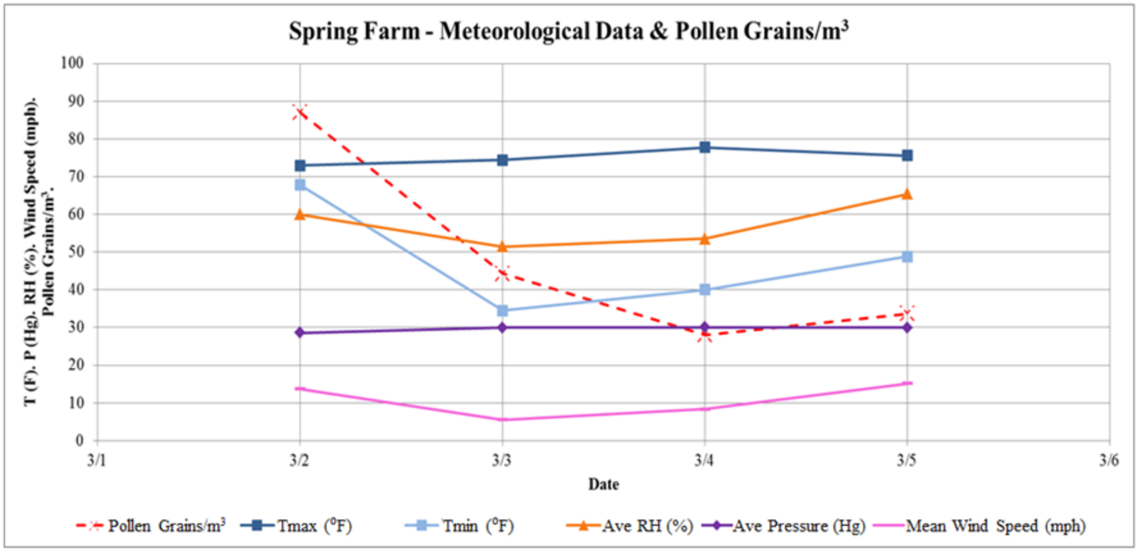


Table 1 Spearman's rank correlation coefficients between meteorological factors and pollen concentration during the fall and the spring

Season	Location	Max Solar Radiation (W/m^2)	Tmax (^{o}F)	Tmin (^{o}F)	Avg RH (%)	Avg Pressure (Hg)	Mean Wind Speed (mph)
Fall	Roof	-0.177	-0.590	-0.486	-0.158	-0.350	0.574
Spring	Roof	0.429	0.429	0.810	0.810	0.810	0.810
Spring	Ground	0.429	0.429	0.810	0.810	0.810	0.810
Spring	Farm		0.810	-0.143	0.429	0.810	0.429

Spearman's rank correlation coefficient measures the statistical dependence between two variables. It determines the relationship between the two variables with +1 being a perfect correlation and with -1 occurring when both variables are a perfect monotone function of each other. This correlation coefficient is commonly used in other studies correlating pollen count or concentration to meteorological factors.

Spearman's rank correlation coefficient was computed in Table 1 to compare how well the meteorological factors correlated with concentration. In the fall, there was a negative correlation for all of the factors except for mean wind speed. During the spring, the correlations were positive except for a low negative correlation at the farm with minimum temperature.

The fall average concentration on the roof was 20.29 pollen grains/m^3. Fig. 5 displays pollen grains/m^3 for the spring at all three locations. This shows a lot of variation each day. Table 2 shows the average concentration of pollen grains was highest on the ground of O&M and it can be noted that some pollen grains decrease in count with increasing elevation. The average concentration of pollen grains at the farm was very low compared to the values at O&M. This could be due to collecting before planting season and the sparse vegetation of trees and bushes around the area.

Fig. 5 Locational differences in pollen concentration

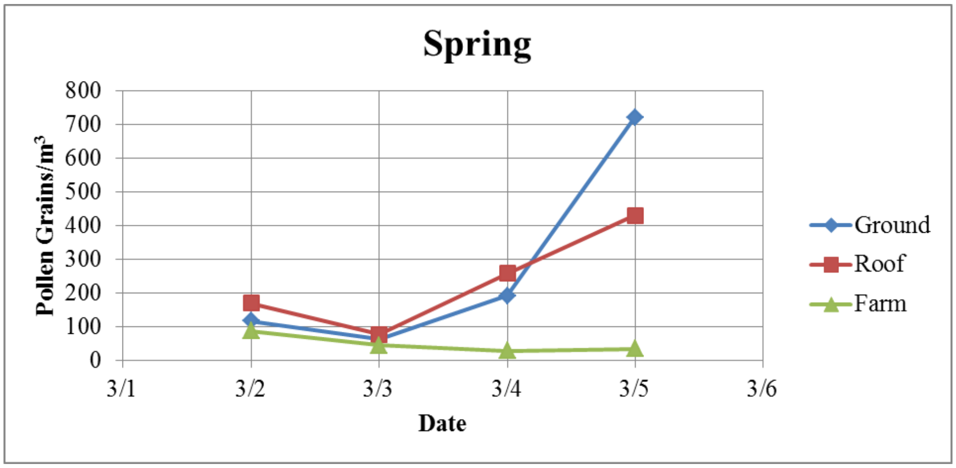


Table 2 Locational averages of pollen grains/m^3

Location	Average Pollen Grains/m^3 at the 3 Locations
Roof	233.31
Ground	272.86
Farm	48.27

Fig. 6 and 7 show the wind direction values for the fall and the spring, respectively. The sampler and weather station on the roof were not well-placed since wind direction was affected by the observatory. The sampler at the ground of the building was poorly placed since it was surrounded by buildings, which would affect the speed and direction of the wind. This location would also make it difficult to determine the source regions. Wind direction for the fall was computed using values from the Mesonet. Fig. 8 shows that the HOBO Weather Station wind direction values are highly variable compared to the Sonic wind direction values even though they are located about 3 yards from each other. The farm and Sonic values generally have a good correlation in changes in wind direction.

Fig. 6 Wind direction plot for the fall

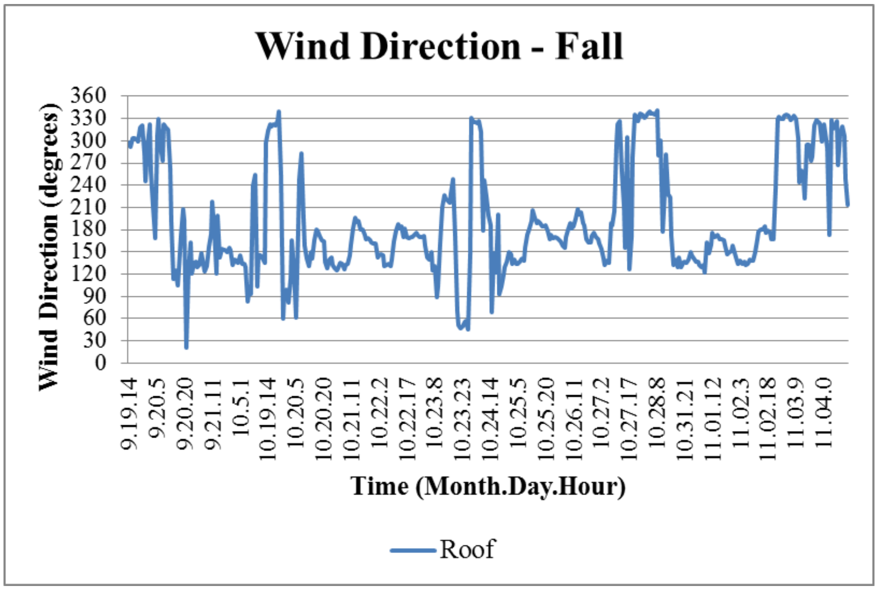


Fig. 7 Wind direction plot for the spring

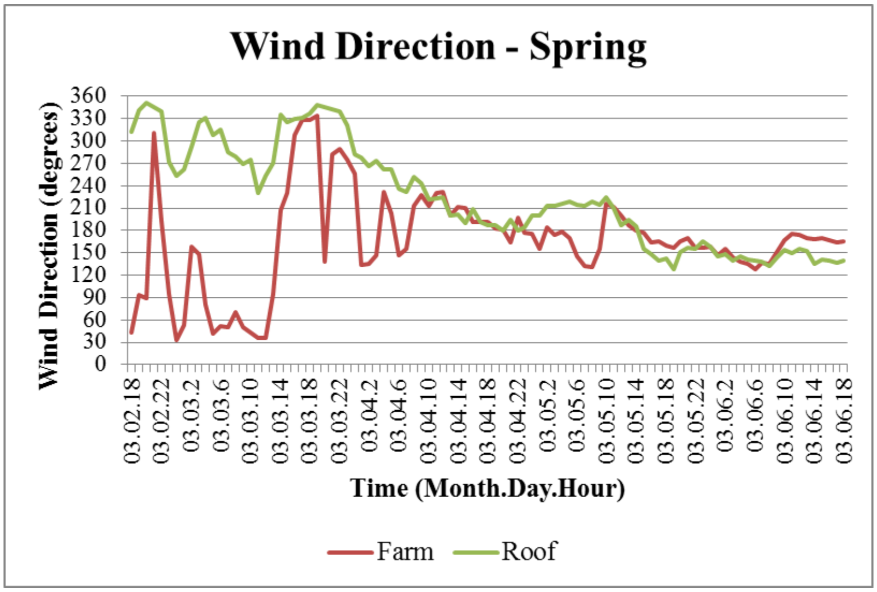
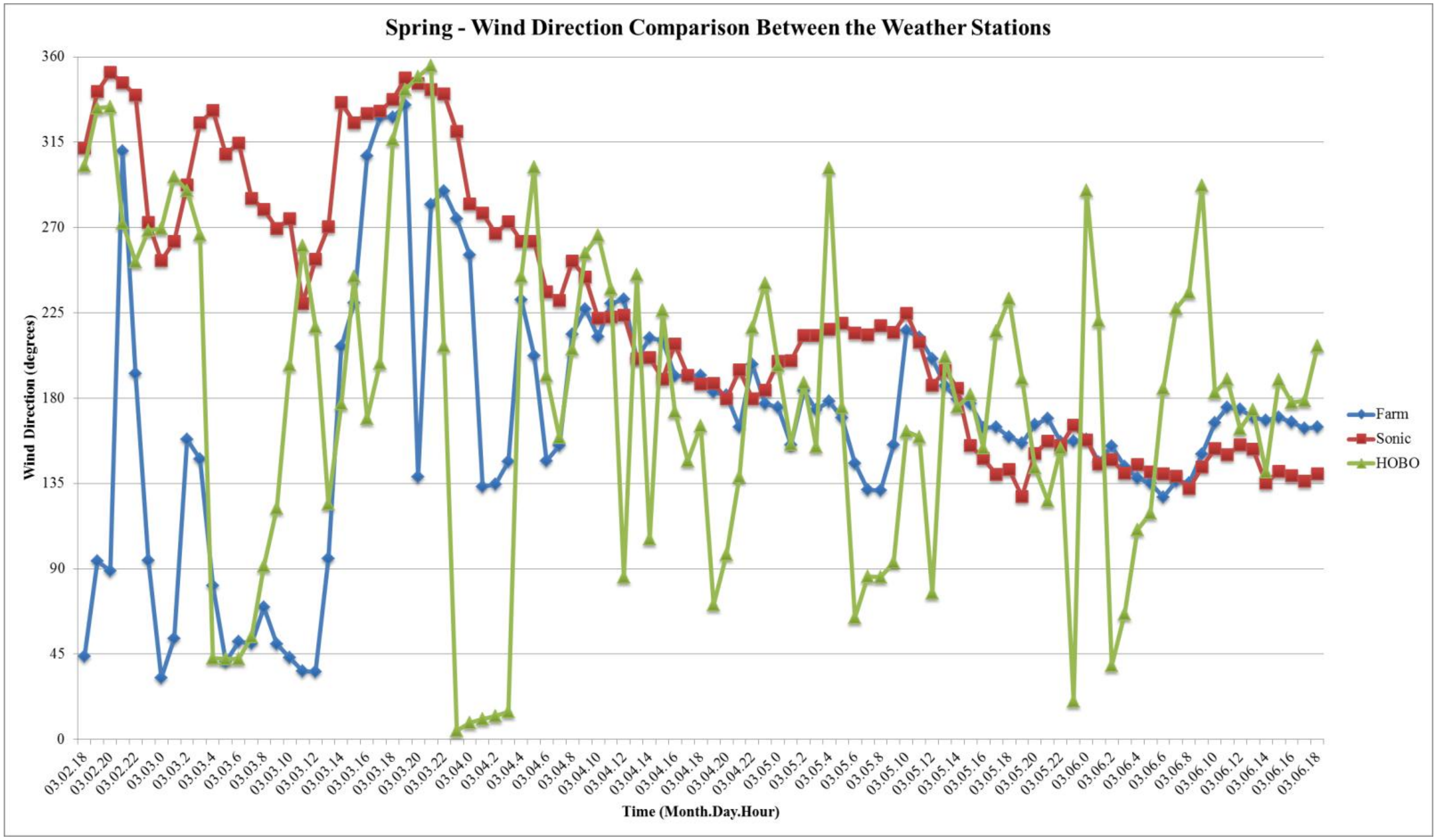


Fig. 8 Wind direction comparison between the weather stations and the sonic



Species

The species found in the fall are shown in Fig. 9.

Fig. 9 Species collected in the fall. Images that are labeled have high identification confidence ratings of 4 and 5 from Table 3

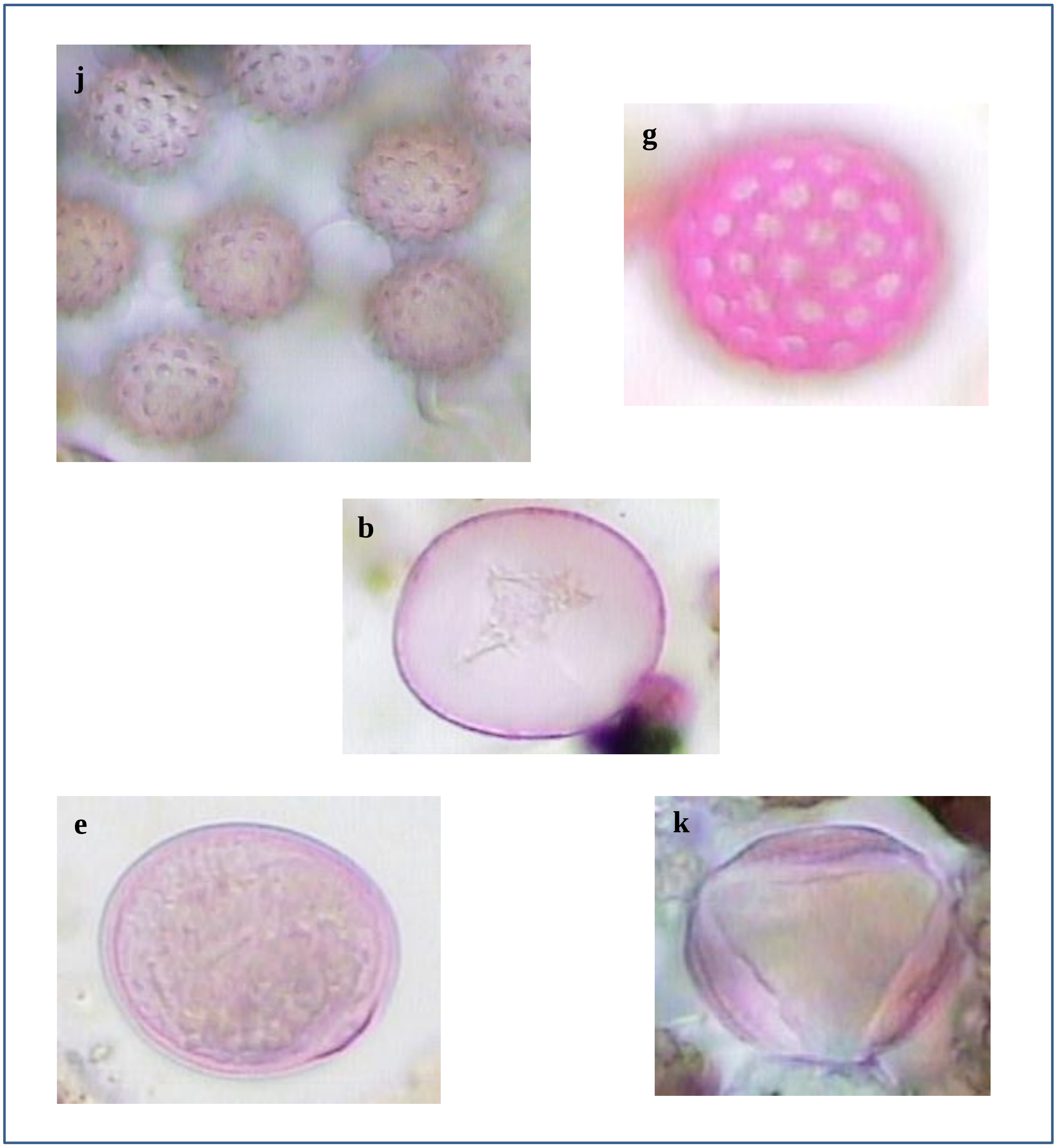
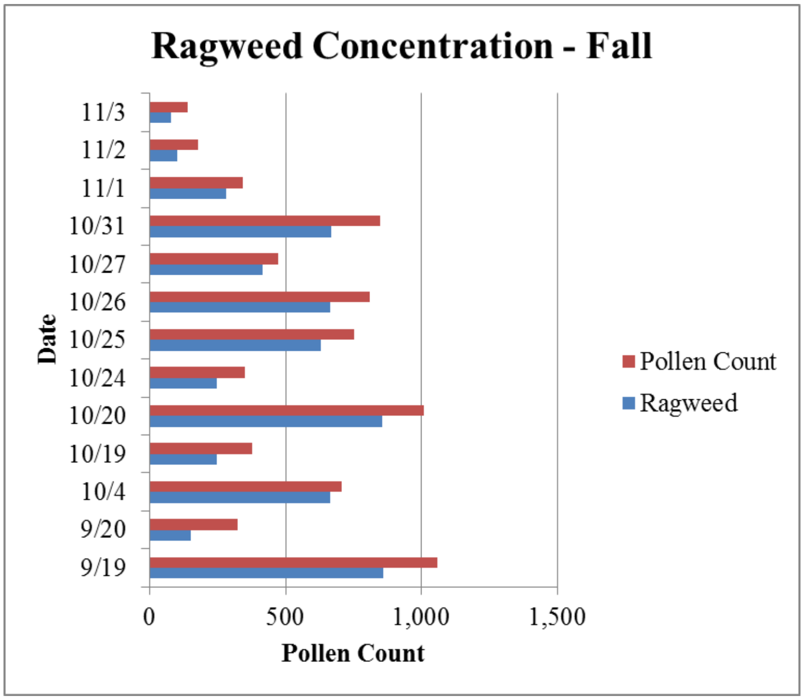


Fig. 10 Daily concentration of ragweed (*Ambrosia*) in the fall



During the fall, ragweed (*Ambrosia*) was the prominent species. Ragweed (*Ambrosia*) was present on average 74.87% in the daily samples, as shown in Fig. 10. In the spring, ragweed (*Ambrosia*) only made up on average 0.50% in the roof samples and only 0.17% in the ground samples.*

Species identification during the spring was very difficult due to the increased amount of species as well as pollen count. Pictures taken from the spring collection are shown in Fig. 11.

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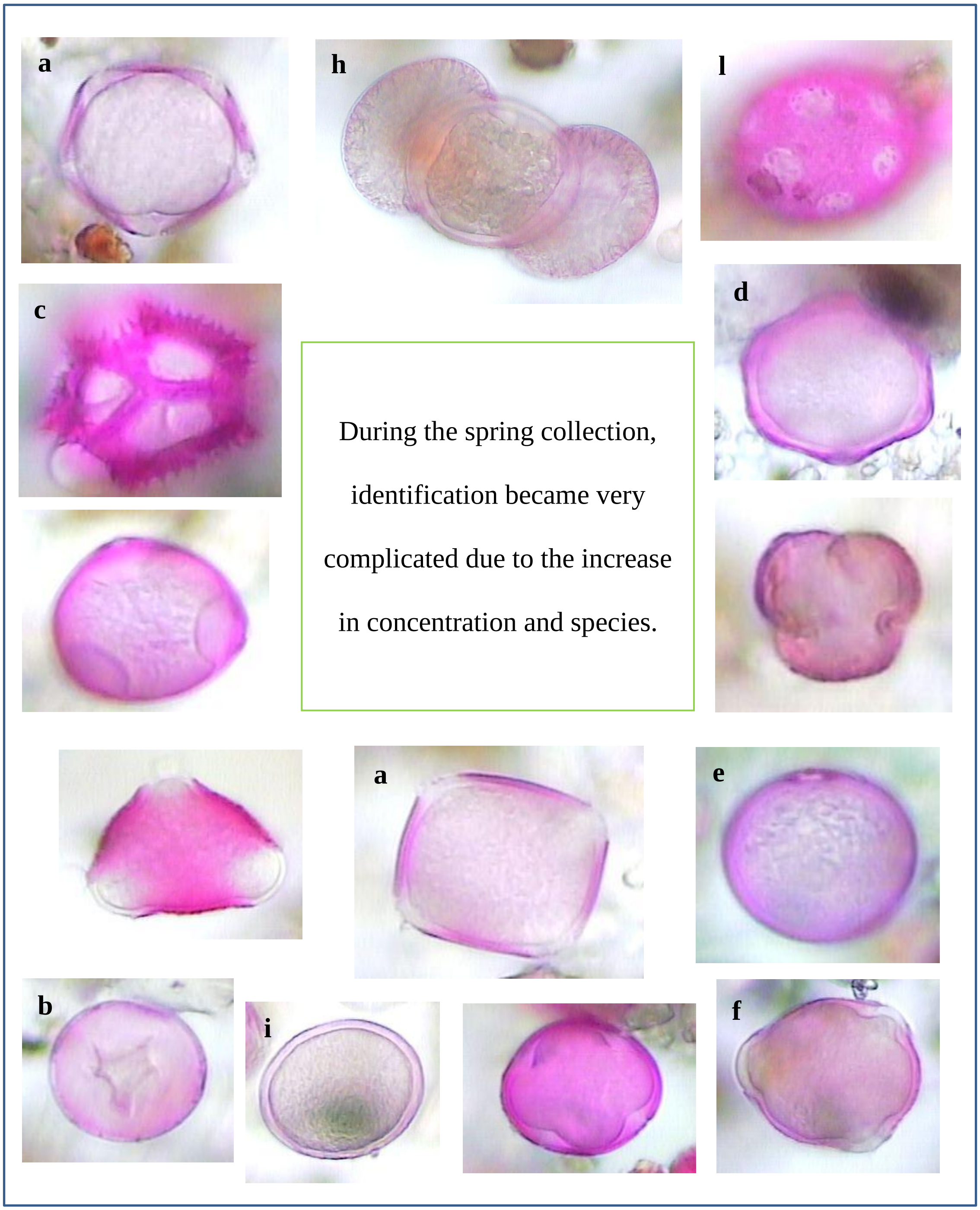
*Spring ragweed (*Ambrosia*) concentration is based on preliminary data.

Fig. 11 Species collected in the spring. Images that are labeled have high identification confidence ratings of 4 and 5 from Table 3



During the spring collection, identification became very complicated due to the increase in concentration and species.

As seen in Fig. 12, identification of a particular species is quite challenging. Table 3 shows my confidence ratings in identifying pollen. The standard identification technique used in this project was not sufficient enough, so acid processing will be utilized in future projects.

Fig. 12 Different species of pollen that seem similar (Smith 1990)

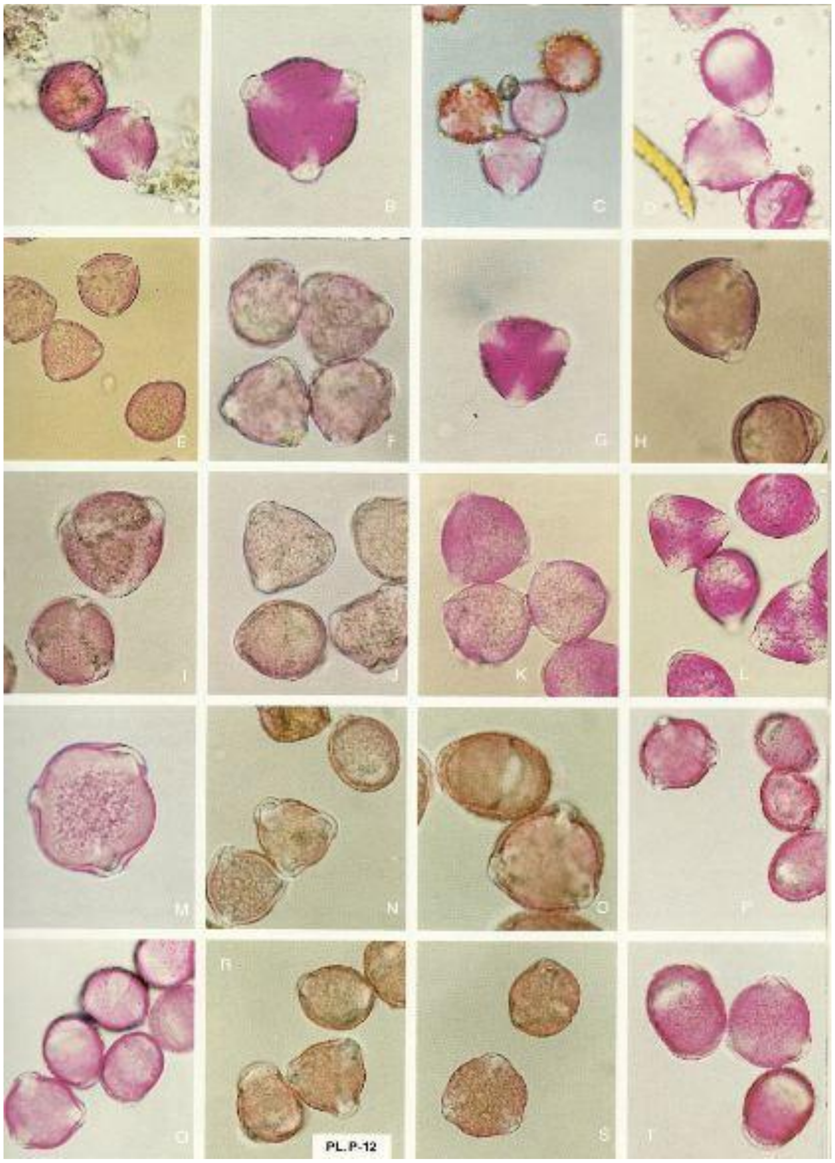


Table 3 My confidence ratings for identifying pollen. 5 represents high confidence and 1 represents low confidence. Images are provided a label with high confidence ratings of 4 and 5.

Common Name (*Scientific Name*)	**1**	**2**	**3**	**4**	**5**	**Label**
Ash (*Fraxinus*)				x		a
Cedar (*Cupressaceae*)				x		b
Dandelion (*Taraxacum*)					x	c
Dock (*Rumex*)	x					
Elm (*Ulmus*)				x		d
Grass (*Poaceae*)				x		e
Maple (*Acer*)	x					
Nettle (*Urtica*)			x			
Oak (*Quercus*)				x		f
Pigweed (*Amaranth*)					x	g
Pine (*Pinus*)					x	h
Poplar (*Populus*)				x		i
Ragweed (*Ambrosia*)					x	j
Rose (*Rosa*)		x				
Sagebrush (*Artemesia*)					x	k
Sweetgum (*Liquidamber*)					x	l

CHAPTER IV

CONCLUSIONS

Conclusions

There was seasonal variation between the average concentration of pollen grains on the roof of O&M, ragweed (*Ambrosia*) concentration, and types of species. During the spring, average concentration of pollen grains on the roof was about eleven times as much as during the fall. Ragweed (*Ambrosia*) was the prominent species in the fall. A wider array of species was collected during the spring which resulted in a difficult task to count and identify the species.

Location does have a significant impact on the distribution of pollen grains. From the results, it can be concluded that the concentration of pollen grains decreases with increasing elevation. Also, being in a rural area, the farm contained a far fewer concentration, which could be due to sampling before planting and the sparse trees and bushes.

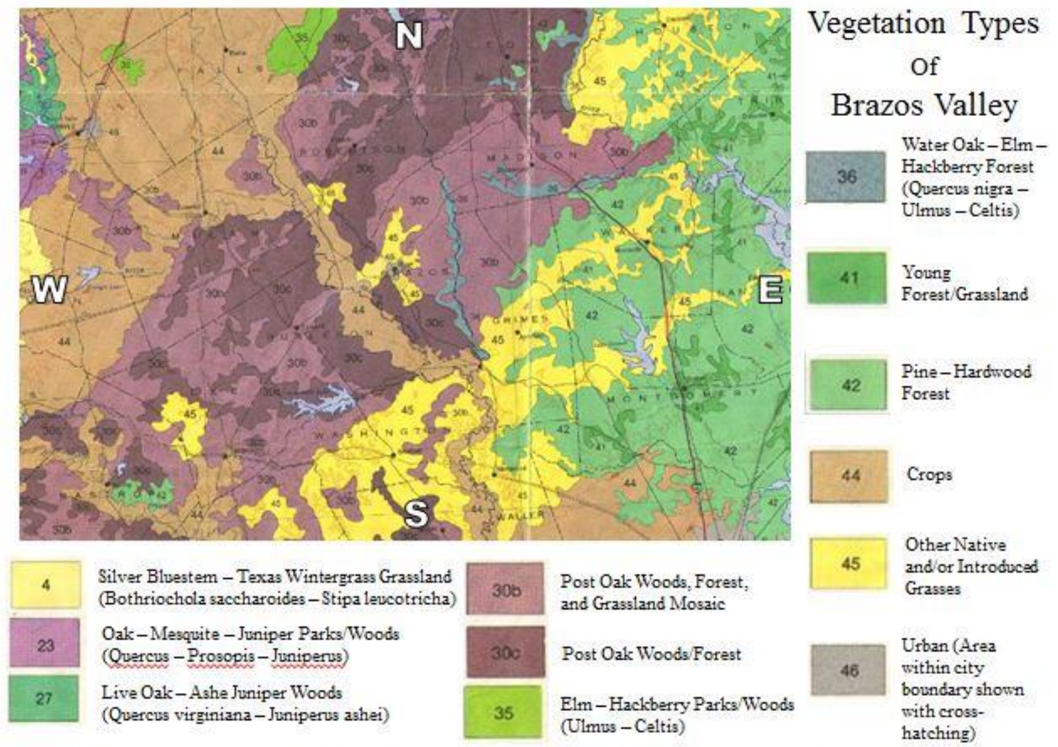
There generally seems to be a positive correlation between pollen concentration and with all of the variables measured in this experiment, including solar radiation, temperature, relative humidity, pressure, and wind speed.

Future work

Recommendations for future studies are:

1) Improvements on pollen identification will be utilized through acid processing techniques. Acid processing dissolves organic matter, allowing key features to be identified. Standard identification techniques were performed in this beginning experiment in order to see how effective this widely-used technique is compared to a more tedious and costly acid processing technique.
2) Collecting at more locations and variable elevations is always desirable, especially since there is not much known about pollen potentially being considered as CCN. While sampling at different elevations, a sonic anemometer should be used to measure wind speed and direction in the x, y, and z directions in order to account for altitudinal differences.
3) Sampling at better time resolutions would allow for a more thorough understanding of pollen emission times and a more narrow focus of which meteorological factors contribute to increased distribution of pollen grains.
4) Identification of source regions based on local maps like Fig. 13.

Fig. 13 Vegetation types of Brazos Valley



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