Perception of Drought Impacts: South Central United States

Kyle Williams

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Abstract

The south central United States has experienced a nearly unprecedented drought over the past three years. In some parts of the region, the drought has persisted nearly unabated since October 2010. In other parts, the drought has intensified or improved periodically. This gives a unique opportunity to examine the different impacts drought has on the landscape over relatively short geographical distances. While much attention is often focused on agricultural and economic impacts of the drought, less is known about how the drought has affected ecological niches. Two steps have been taken to understand the impacts of drought; the first, which was the use of personal interviews with professionals, and the second, which was to create a survey based on responses and remarks that was sent to personnel in the industry. There were many different aspects of the survey that were tested for relationships with one another. There were many results that showed inconclusive numbers due to the small amount of data. There are also many of the test that were run which showed that there were no relationships between categories between government and non-government, species priorities, ecosystem types, personnel experience, and land area size. Of the many tests ran there were only a few showing relationships. After looking at all the results years of experience showed to have the largest influence on the perception of drought.

I. Introduction

Over the last three years, the south central United States has experienced an ongoing drought. The drought has been very prevalent in this region starting around October 2010. Depending on the specific location, the drought has either intensified or subsided, impacting different areas in different ways. The drought has greatly affected the agriculture, forestry, and natural preservation and conservation areas in the south central United States. The natural preservation and conservation areas are the primary focus because of how they reflect the most natural response to drought. These areas show how the natural environment reacts and where help is needed to lessen the impacts of drought. The agricultural and forestry land can be misleading when observing the impacts of drought. From an agricultural point of view there are many crops that are not natural to this area, which can lead to more or less observable impacts. The forestry side also has a bias towards drought impacts since the trees are continually being harvested, which, changes the amount of water and exposure the undergrowth receives. The natural areas allow for less biased results in recognizing the impacts from the drought because, the personnel working at these areas have as little impact on the land as possible in order to preserve its natural state. Through the use of surveys I want to analyze how the impacts of drought are perceived. More specifically analyzing the difference in organizations and how they perceive these impacts.

The objective for many of the government and non-governmental areas and areas like them is to preserve or conserve the ecology. This consists of many different things from the dirt and water to the plants and the animals. While some of

these organizations have different primary focuses, many of them need to preserve a portion of all these aspects to keep the ecosystem thriving. For example some areas have a focus on large mammals, like bison (Godfrey, personal communication, March 1, 2014). In order to keep these animals healthy there're needs to be plenty of grass for them to feed on and plenty of good soil for that grass to grow in. Therefore no matter the natural focus of the organization there is pertinent information to be found.

Throughout this project there is an overlying goal to look at the impacts of drought and how they are perceived by different organizations. The main source of data comes from the aforementioned survey. The survey was created after interviews with officials in order to better understand how to word and focus the questions to ensure consistency in responses. The survey has three different sections that will help convey the strategies, management, and locations of organizations. Through these surveys we can see how government and public organizations go about interpreting the impacts of drought and how they are perceived differently.

II. Literature Review

Drought is a condition that can be seen all around the world. It affects many different communities in many different ways. Drought in the south central United States is what I am looking into in this paper. There are handfuls of articles dating from 1969 to 2013 that address drought. Throughout the articles there are a three different themes seen: the first, which is how impacts of drought are perceived.

Second, management strategies and how perceptions are dealt with. Third is species response to drought.

II a.

Drought in the south central U.S. is a very pertinent topic seeing how there has been fairly severe drought occurring in the area for nearly four years. A drought of this severity can cause many hardships in multiple areas of industry. When looking at maps and data showing the amount of rainfall from 2010-2013 there was a great shortage. In this area of the U.S. there is a good amount of agricultural productivity that can greatly be affected by the drought. The main part that can be affected by the drought however is the natural wildlife. The natural environment and how it reacts to drought can be very telling and helpful in finding ways to combat drought. Observing what impacts the drought from 2010-2013 has had on natural wildlife conservation and preservation areas gives great insight to strategies for preparing for drought situations. Using these areas to see what the perceived impacts of the drought are. In some cases drought can be seen as much worse due to the fact that they are used to seeing much more rainfall than another area. In one article, which was, one of three separate in the series shows and talks about how differently areas of the world perceive ecological impacts of drought. The way these impacts are conveyed among people of different areas and nations can have many different meanings. Knowing or trying to create a base line showing if there is a point where a scale for drought can be very useful in determining the severity of the drought. From this same paper it made a point to talk about “the basic problem is

scale" which to some extent is true but again points back at the problem of perception of the impacts of drought (Heathcote, 1969, p. 178).

II b.

Rainfall and other numeric data are commonly used ways to analyze drought and its severity. Perception is also an area that is supported by the articles written by R. Heathcote. They show how areas have dealt with drought from an economic and social standpoint. One article looks at the perception of drought in Australia and how that leads into problems of perception and what causes problems of perception around the world. R. Heathcote is one of the more pertinent authors writing explicit focusing on perception aspects. He shows different ways in which drought has been looked at before from a mind set of perception. His article though is somewhat dated going back to the 1960's in Australia. Although this is the case the questions addressed in his articles are still very relevant. P. Croft looks at the occurrence of wildfires and how to combat them and how their affects compare to those of a drought. P. Croft's articles compare drought and its detrimental affects to those of wildfires to give a better grasp of impacts drought has. Wildfires and drought tend to go hand in hand but drought is not always the reason for wildfires. Drought when seen in a comparative relationship can also help analyze the size of the impacts. Although wildfires happen at a much faster pace the affects of a wildfire and drought are very similar in the end. Being able to compare droughts and wildfires gives another aspect to base perception.

II c.

This project could have multiple different focuses that would be relevant to the literature that found on drought. They each provide valuable information for this report some more than others. One article that is very important but rather dated is by Heathcote. His article is about the perception of drought in Australia and is from 1969, however this article also leads to a following of two more articles in 1988 and 1991. The first article being one of the most important addresses the perception and problems with perception of drought. In his article he goes through three main questions, which could be said to be the defining factors of why there is no universal definition of drought. The questions include "what is drought? what does drought do? and what does drought mean to us?" (Heathcote, 1969, p.175-176). Throughout this article these questions are answered in many ways showing how vague of a term drought can be seen as. From this paper drought is defined multiple times. Some of these definitions include "occurring whenever it was said to occur-a definition by acclamation" (Heathcote, 1969, p.176), "severe water shortage" (The Director of the Commonwealth Bureau of Meteorology, Heathcote, 1969, p.176), and "a period of rainfall deficiency, extending over months or years, of such a nature that corps and pasturage for stock are seriously affected, if not completely burnt up and destroyed, water supplies are seriously depleted or dried up, and sheep and cattle perish" (Heathcote, 1969, p.177). After reading these three definitions it can be seen how perception plays a large role in drought. For example the specificity of the third definition gives enough detail to fairly say it comes from an agricultural community. On the contrary the first could be from an area of heavy

precipitation where they encountered a week with out rain. Another problem mentioned in this article is the scale that drought is defined with. Something that is seen from reading these article and looking at the areas surveyed in this paper there are a lot of different scales that impacts of drought can be based on. Some instances compared the scale by looking at a desert ecosystem that sees maybe a total of 5 inches of rain and comparing that to a rainforest ecosystem. Comparing these to each other results in a very biased result. It makes it very difficult to determine whether or not either of them is enduring a drought.

Management and responses of personnel to the drought is another aspect that was looked into. D. Myburgh's article shows different strategies of how drought has been dealt with in previous scenarios. These strategies that are mentioned in the article go hand in hand with the interview responses. Some of the strategies mentioned by both the article and the interviews were water conservation and limiting the number of livestock. Other strategies included in the article are veld improvement, planting drought-resistant fodder crops, and drilling boreholes. Using these techniques reduces the impacts of drought in multiple ways. By planting crops it allows the livestock to continue feeding even during drought and drilling boreholes creates the possibility to get water. The veld improvement is another strategy that can be very useful, natural vegetation can help reduce the amount of invasive species and still provide feeding for the livestock.

More specific problems or perceptions of drought can also be seen. In these articles there is more information on drought and fire and how they go together and

affect the environment. One article by Touchette looks at a small scale more specific wetland ecosystem and talks about how drought like conditions affect the smaller organisms more than the large ones like wetland trees. Australia is a major focus for a few of the articles, which can be helpful but also misleading. Having Australia as the focus can show how different articles point out different aspects in the same location. On the other hand this can also be misleading having such a localized area. With the limitation of articles regarding drought the variety of areas where this has been studied is fairly small.

Data to represent drought is a major focus in some of these articles. Measurements of rainfall is used to determine how much of a shortage there is and whether or not this results in a drought. There is also research showing affects of drought through the measurement of vegetation growth and mass of organic materials. Using these ways to find the impacts of drought is very beneficial to the research focused on how to combat drought directly through the impact of plants. Other articles use fire ecology and compare drought impacts to those of wildfires.

When comparing drought to a wildfire it easily shows the extent of which a drought impacts the environment. Wildfires are typically in a much shorter timeframe than droughts; this allows the affects to be seen fairly immediately after the fire. Drought impacts tend to be slow growing, they takes months even years for their impacts to be fully comprehended. Being able to see the comparison of results from these side by side allows us to see what the potential outcome of drought is. When P Croft compares the two droughts tended to have longer lasting affects on

the regenerative capabilities of the vegetation. This article showed how drought has just as large an impact on the vegetation as wildfire and in some cases a worse impact. The impacts were determined by the use of the Chi Square test to show whether or not there perceptions of the vegetation growth had significance or not. Through this test they also looked into how fire followed by drought or drought followed by fire impacts the environment. The Chi Square test was used to help determine with the large amounts of animals if the results were significant or not. This test is often used when there are multiple categories being tested to show if there is significance in the results or not. These few test showed reason to question why the impacts of drought are not studied more. Seeing their test show drought as an equally devastating event puts a different view on the impacts of drought.

These articles used multiple different ways of analyzing statistical data in their research. One of the most commonly used was the ANOVA, others included the use of Chi Square, Wilcoxon Ranks test, RMANOVA, contingency tables, and Tukey HSD. These test are each used for different reason and I will be using the Chi Square to test the significance of the data that I have collected. The Chi Square test is used to test when there are 2 variables being tested for significance at the same time. Based on P Croft use of the Chi Square test I chose to use this for my statistical analysis. I can use hypotheses to test significance of relationships between categories found in the survey. Through the use of a survey I will have multivariate data that will be tested to see if there is a significant conclusion that can be made based upon the results.

II d.

Drought in the south central United States has been very prevalent since around October 2010 and has continued since. In some areas drought has slightly diminished and in others it has increased. Starting in October 2010 it was very modest and wide spread with few extreme areas. As it went into 2011 and continued into the summer July of 2011 had a major increase in the area that was affected by extreme drought. This extreme drought was primarily located in Texas, New Mexico, Oklahoma, Louisiana, and Arkansas where it continued in size through the end of 2011. In 2012 the drought had slightly decreased in the amount of area that was covered by extreme drought; Arkansas and Oklahoma had seen a drastic decrease in the area covered by extreme conditions up to around July. July 2012 the extreme conditions had returned and continued to expand further north first. In 2012 Kansas and Nebraska had seen the extreme drought before it expanded back into the south. At the start of 2013 unlike the previous years where the drought had slightly decreased over the winter months it had continued to increase. January through April it showed the some widest covers of land by the drought. The increases and decreases in size continue to fluctuate throughout 2013. At some points affect of the drought reach from California to New York, but have decreased in severity. This drought spanning from October 2010 to now have drastically changed the way resources and the natural environment are viewed.

III. Data/Methods

The main purpose focus for understanding is to look at how the impacts of drought are perceived and dealt with among different organization types. There are four main steps to the process of which I collected my data. The first step to this process was finding initial sites to interview. I went through maps of areas located in the south central region in order to find eight National Wildlife Refuges. These eight were chosen based on their size, location, ecology, and diversity of the plants and animals. The areas were Salt Plains NWR, Wichita Mountain NWR, Muleshoe NWR, Lower Rio Grande Valley NWR, Balcones Canyonland NWR, Cache River NWR, Sabine NWR, and Catahoula NWR. I did research and wrote descriptions of the areas (Appendix A) to have a good understanding of their animal and plant types, refuge size, and ecosystems.

After doing the research on these National Wildlife Areas I was able to start create a list of interview questions. When creating the questions there were many facets of the refuge areas I wanted to address. The questions were mainly split into two sections, which were background information about the individual and area along with the second section about the management strategies that are used to combat drought. The background section was to help know what part of the organization they most closely work with. These question included job title, how long they have been there, main species focus, and other similar questions (Appendix B). The second section, which looked at management strategies asked about adaptations they have made or new ideas that have been implemented over the past three years.

The next step was to conduct an interview with as many of the eight areas (Appendix A) as possible. When doing so I was only able to interview two places, Wichita Mountain NWR and Lower Rio Grande Valley NWR. From these two places I was able to talk to three individuals that consisted of a biologist, fire ecologist, and refuge manager (Appendix B Q1). I conducted an interview over the phone with the questions (Appendix B) in front of me, where I transcribed their response as we went through the interview. I felt this process was very beneficial in some ways but regret to not have the interview set up to be recorded. While being able to transcribe with them on the phone was very helpful. Doing this I was able to make sure I had written it in a way that conveyed their thoughts for each question. With the three interviews there was more than enough information to help create a survey that was used to collect the primary data for this project.

There were trends that could be seen solely from the interviews in most of the different areas discussed about. One of the major similarities was their focus on the mammals (Appendix B Q2). The mammals proved to be very important to most of the wildlife areas. The Wichita Mountain NWR showed bison, black cat, Texas longhorn, elk, and deer as some of their more important species in which they protect. The Lower Rio Grande NWR showed the Ocelot as one of their more important along with many endangered species they had in their area. However when asked about stress of animals from drought, they both responded differently, with reduced stock numbers and lower average weights of animals in herds where in the Lower Rio Grande NWR the noticed the plant life. Both of NWR's noticed from numbers and size of the plants and animals of the area (Appendix B Q5). Another

commonality was the impact of wildfires that have been seen since the start of the drought (Appendix B Q10). Both mentioned having more intense and less frequent fires due to drought causing more fuel for the fires to burn. Their reasoning for not having as many fires is having these more intense fires completely burns up everything and after one fire and having the drought continue there is no vegetation that continues to grow for the next fire. There are also impacts that were noticed among the invasive species, however they both did not have the same response there're noticeable impacts that can be seen from the drought (Appendix B Q7). From the Wichita Mountain NWR the amount of invasive grasses has increased creating less area for the native grass to fill back in. They also mentioned the amount of feral pigs has decreased and this was seen in both the Wichita Mountain NWR and Lower Rio Grande Valley NWR. The Lower Rio Grande Valley NWR also noticed how some of the invasive animals were minimally affected by the drought. Along with these questions there were many others that had similarities between the two, which helped see how the questions were being interpreted.

The survey was created using the interview questions along with some different more clearly written questions (Appendix C). In the survey there were a few more sections to initiate more specific responses. From the interview questions we moved the survey towards a more perception-based approach than a statistical open-ended response approach. The survey included background information, land/ecological information, drought information, and management information. These surveys were then sent out to 400 individuals plus or minus the few that had

or hadn't been forwarded. From these there were 59 respondents that showed a good representation of the states.

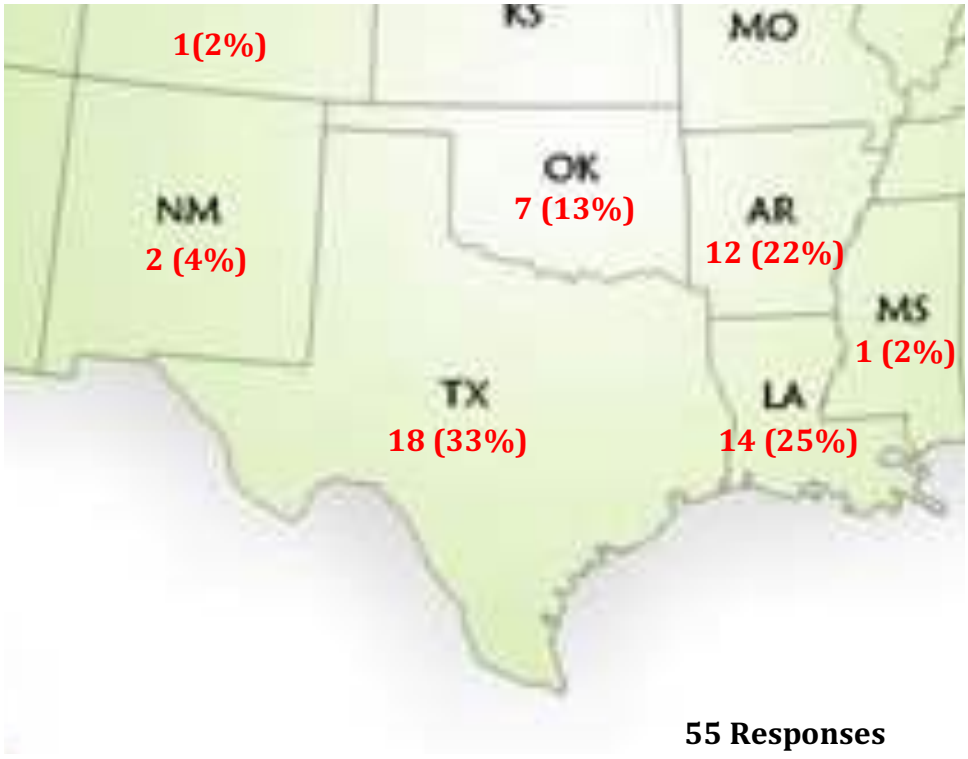
IV. Analysis

The survey is divided into three different parts aimed at background information, drought information, and management. The background information is to obtain the type of areas and habitats the responses are coming from. The drought section shows what the personnel observed over the last 3 years during the drought and how it has affected the plants, animals, and environment. Lastly we look at the management process of managing the area during the drought (Appendix C).

Background Information:

The survey was distributed June 9, 2014 to around 400 people plus or minus the few that had been forwarded and of these there were 59 people that responded. It can be seen in figure 1, that there was a good diversity in states and areas. There were a few that chose not to respond to this question.

Figure 1



55 Responses

We also asked about the agency or organization that they worked for, where the majorities were for the U.S. Department of Interior (56%) and the rest are scattered between 12 others (Figure 2, Appendix C Q2). Among these were universities, non-governmental/non-profit organizations and state, local, or tribal wildlife management. Knowing the position of the personnel taking the survey was also important to know the credibility of the responses. 56 percent of the respondents are or were managers of the agency (Figure 3, Appendix C Q3). There were also researchers, educators, and others.

Figure 2

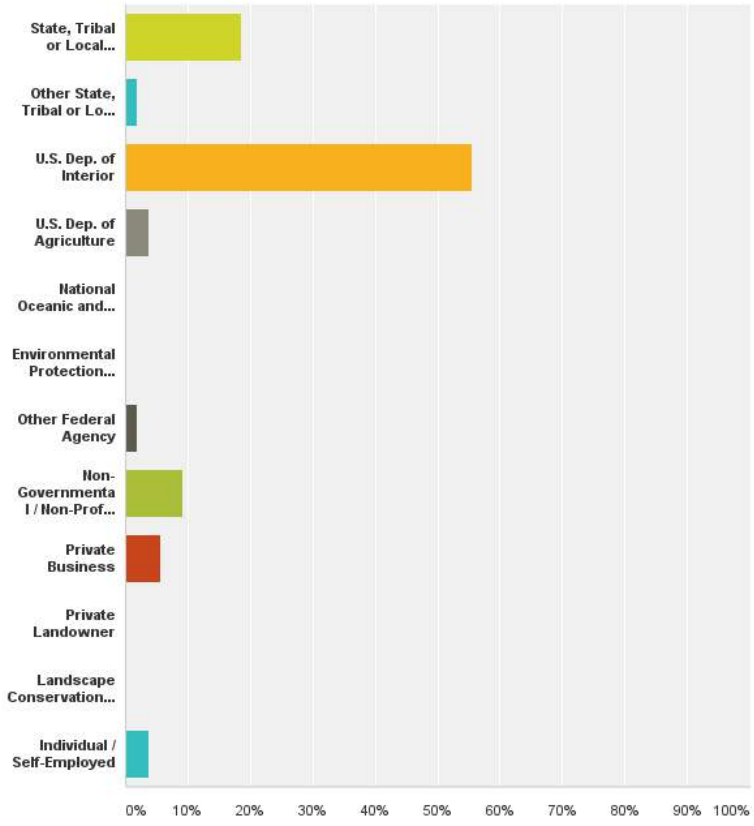
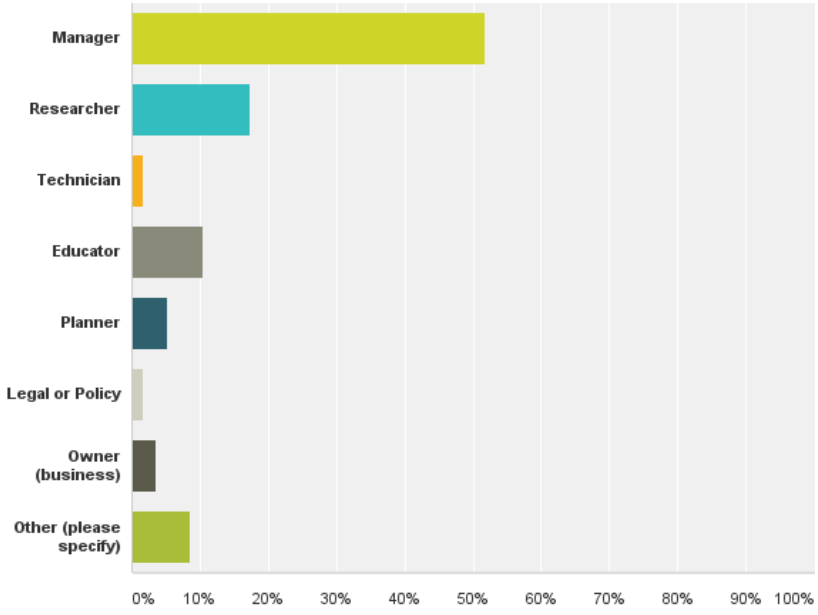


Figure 3



More than 60% (35) of the respondents have worked at the agency or organization for 10 years or more and only one person had worked there for les than one year. This ensured that the personnel were experienced and educated on the area surveyed about.

The size of the area the organization or agency in which they are working with is also vey important. It is very helpful to know how large scale or small scale the changes can be noticed. Some of the larger areas give an overall look at what is going on where the smaller areas give a better look at specifics. Large areas gave insight to wildfires and heard sizes where small areas we saw more specifics on disease prevalence. The survey showed 24 respondents (50% of 48) work on areas greater than 95,000 acres and the rest are spread between less than 5,000 and

65,000 acres (Appendix C Q5). Along with these questions we wanted to know what species was seen as the highest priority.

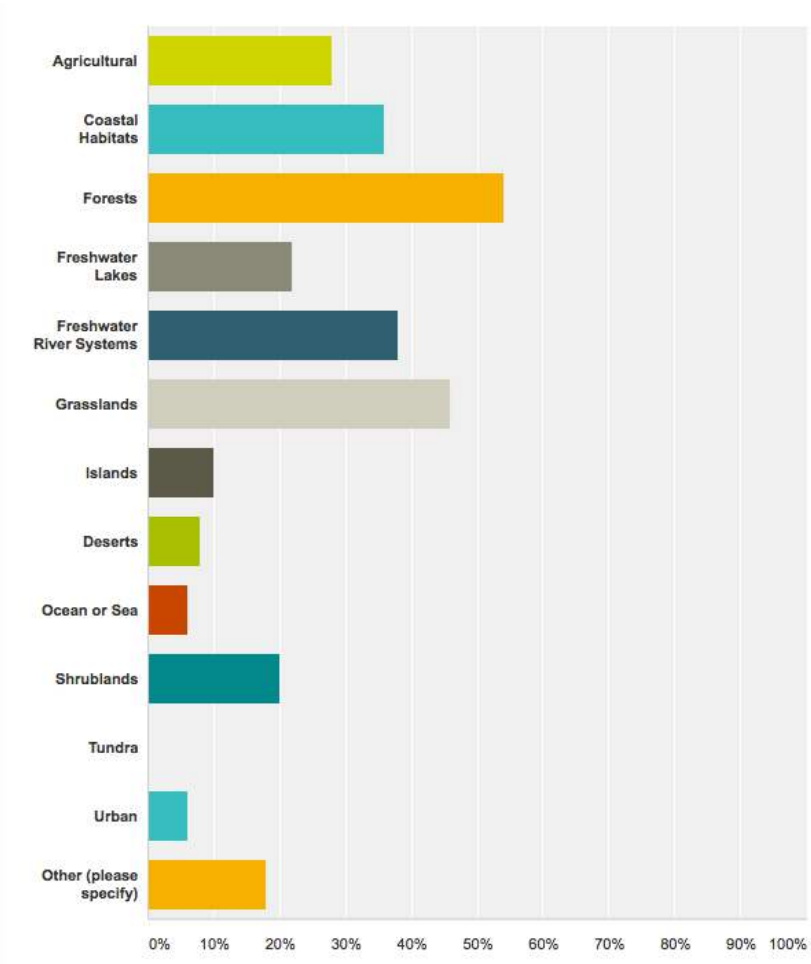
Many of the areas chose migratory birds as the highest priority species with 75% of the respondents ranking them the highest (Figure 4, Appendix Q6). There are some responses stating that the most important are the endangered animals and mammals. Large mammals and fish/sea came next on the list having 48 and 45 percent.

Figure 4

	Most important	Somewhat important	Not very important	Not applicable	Total	Average Rating
Migratory birds	75.51% 37	16.33% 8	2.04% 1	6.12% 3	49	2.61
Large mammals	48.89% 22	26.67% 12	13.33% 6	11.11% 5	45	2.13
Fish/Sea	45.83% 22	27.08% 13	10.42% 5	16.67% 8	48	2.02
Predatory birds	37.50% 18	39.58% 19	12.50% 6	10.42% 5	48	2.04
Reptiles	30.43% 14	52.17% 24	10.87% 5	6.52% 3	46	2.07
Small mammals	28.89% 13	51.11% 23	8.89% 4	11.11% 5	45	1.98
Amphibians	28.89% 13	46.67% 21	17.78% 8	6.67% 3	45	1.98

Lastly in the background information section we asked about the ecological systems they most closely work in (Figure 5, Appendix C Q8). From the chart you can see that forests and grasslands have the highest numbers along with freshwater river systems and coastal habitats. The respondents could choose multiple for this question. This made sense when interviewing and learning how large the areas are that are managed.

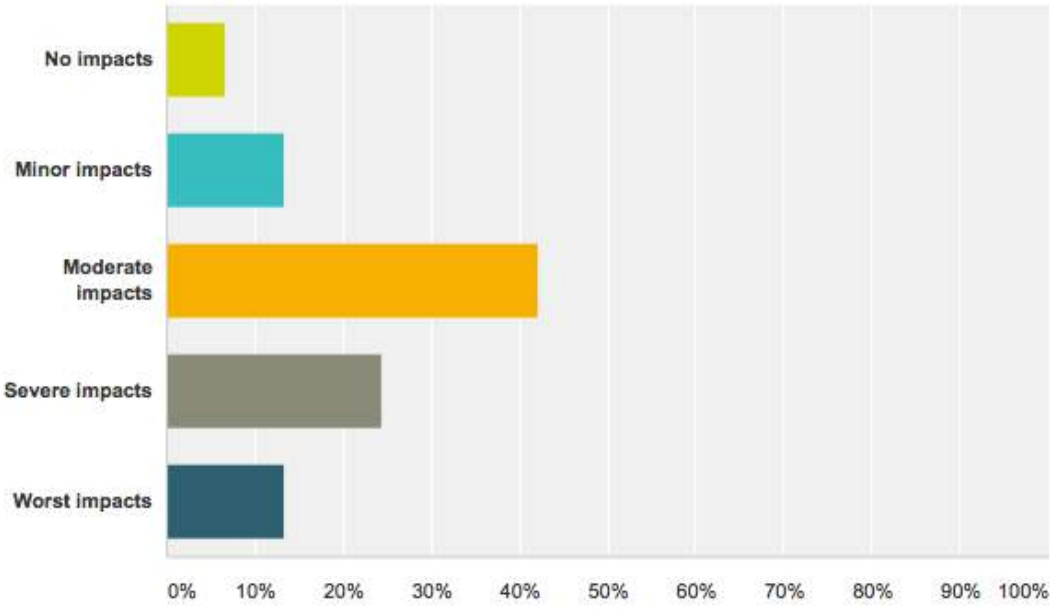
Figure 5



Drought:

This part of the survey is to find out how drought has impacted the areas surveyed and how it compares to other instances of drought if experienced (Figure 6, Appendix C Q9). Also we are looking into how drought has been dealt with from a management standpoint. The first question we asked relates to how the drought over the last 3 years has compared to any other drought. In comparison the majority of people stated that it was moderate in impacts with 19 (43%) and from moderate to worst there was a total of 36 (80%).

Figure 6



Next we looked at how drought has affected species or habitats in the areas. The categories analyzed include wildfire information, invasive species, diseases, and other areas (Figure 7, Appendix C Q10). Fire intensity showed the highest result with 55% of respondents seeing an increase. Fire frequency followed closely with

around 50% of respondents also seeing an increase. After looking at this question it can be seen that there is a potential that the increase in weeds and invasive plant species could be providing the fuel for the increase in fire intensity and frequency. Many of the other categories have little in either direction.

Figure 7

	Large increase	Slight increase	No change	Slight decrease	Large decrease	Don't know	Total	Average Rating
Fire intensity	25.58% 11	30.23% 13	25.58% 11	0.00% 0	0.00% 0	18.60% 8	43	0.81
Fire frequency	13.95% 6	37.21% 16	27.91% 12	4.65% 2	0.00% 0	16.28% 7	43	0.60
Weeds	13.95% 6	25.58% 11	32.56% 14	2.33% 1	2.33% 1	23.26% 10	43	0.47
Invasive plants	9.09% 4	38.64% 17	29.55% 13	4.55% 2	0.00% 0	18.18% 8	44	0.52
Invasive animals	6.98% 3	9.30% 4	48.84% 21	11.63% 5	0.00% 0	23.26% 10	43	0.12
Trees/shrubs	4.65% 2	4.65% 2	18.60% 8	41.86% 18	11.63% 5	18.60% 8	43	-0.51
Plant disease	4.65% 2	25.58% 11	25.58% 11	0.00% 0	0.00% 0	44.19% 19	43	0.35
Native grasses	2.38% 1	14.29% 6	30.95% 13	26.19% 11	4.76% 2	21.43% 9	42	-0.17
Animal disease	0.00% 0	16.28% 7	37.21% 16	0.00% 0	0.00% 0	46.51% 20	43	0.16

The following couple questions refer to the plants and animals specifically. One of the questions refers to the behavior of the fish or wildlife during drought and whether or not their behavior has changed due to it. The responses show 25 (57% of 44) said no the have not noticed any behavior changes (Appendix C Q11). Along with this question we also asked if the animal and plant counts have changed due to the drought (Figure 8, Appendix C Q12). The results for this question showed that there was a slight decrease to no change in the counts. 2011 showed the largest

amount of decrease with 37% of respondents showing a decrease. There are many responses to this question showing no change.

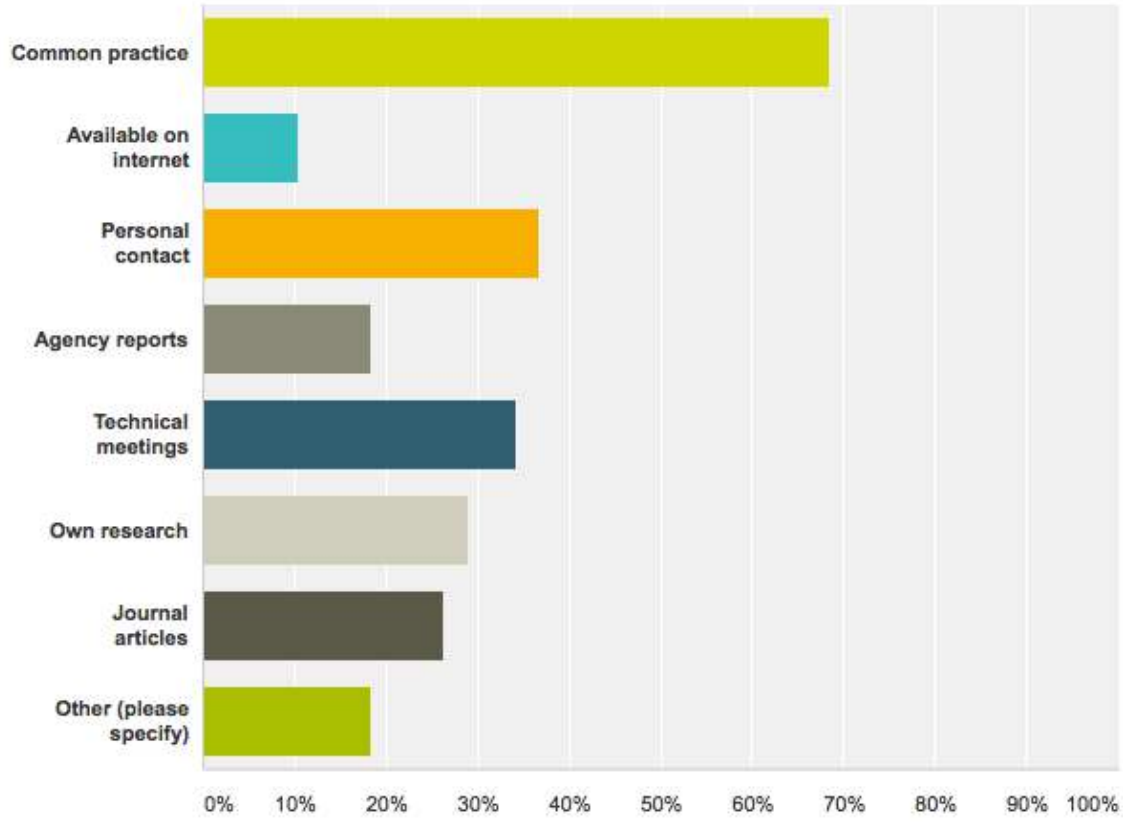
Figure 8

	Large increase	Slight increase	No change	Slight decrease	Large decrease	Don't know	Total	Average Rating
2010	0.00% 0	18.60% 8	32.56% 14	11.63% 5	4.65% 2	32.56% 14	43	-0.02
2011	0.00% 0	11.63% 5	25.58% 11	25.58% 11	11.63% 5	25.58% 11	43	-0.37
2012	0.00% 0	11.63% 5	30.23% 13	18.60% 8	11.63% 5	27.91% 12	43	-0.30
2013	0.00% 0	16.67% 7	19.05% 8	23.81% 10	9.52% 4	30.95% 13	42	-0.26

Management:

The management portion of the survey is focused on how to help with drought. The first question involved management strategies and how they have adapted over the last 3 years (Appendix C Q13). Many of the responses to this question bring higher notice to water use in ways of policy, monitoring, and minimal flows. Other strategies include land restoration projects and involving the community to help keep grounds clear and the amounts of brush down. They also manage large mammal carrying capacities to help with preserving the condition of the land. The second question in this section looks into how management found the strategies they are using, whether it came from research or word of mouth (Figure 9, Appendix C Q14). Many of the respondents listed the strategies as common practices in their areas as well as learning them from personal contacts and technical meetings. The respondents could choose multiple responses to this question.

Figure 9



Statistical Analysis:
Fail to reject null hypothesis p > .05
Reject null hypothesis p < .05

After collecting data from the surveys I was able to run it through the Chi Square test to see if there were any significant relationships. There were many different ways the data can be tested through the Chi Square test. I tested 12 different hypotheses that were the most applicable to seeing how impacts of drought are perceived. When using the Chi Square test I used a 95% confidence interval, which test the probability against a p-value of 0.05. These tests showed whether or not there was a statistically significant relationship between the categories of data that were collected.

The first test I ran was to look at the relationship between the type of agency and the drought impacts associated. After the Chi Square test it showed that there was no relationship between the two with a p-value of .2283 (Figure 10). Although the test showed no relationship visually the table shows the government agencies having seen more severe impacts. This could possible be from the amount of experienced workers in the government agencies, which was what I anticipated.

Figure 10
Rows: For what agency or organization type do you work?
Columns: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?

	Minor impacts	Severe impacts	Total
Government	13	12	25
Non-Governmental	12	5	17
Total	25	17	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	1.4511945	0.2283

The next hypothesis I tested was between the agency type and the priority species. In this test I looked at the relationship to see what species were prioritized higher than others among the two agency types. From the tests there were statistically significant results in three of the seven species tested. The three were large mammals with a p-value .0173 (Figure 11), reptiles with a p-value of .0169 (Figure 16), and fish/sea with a p-value of .0406 (Figure 17). Looking at the relationship with the large mammals you can see easily the priority the government has for large mammals. I was not too surprised with this result due to the

government having a focus on large mammals since they play a large roll in what the people see and brining in donations. The results of the reptile were also to be expected, since they showed that they were not a high priority. In the areas studied these results were not out of the ordinary. The results for fish/sea however were surprising; I didn't expect to see this as one of the higher prioritized species. Fish/sea were more prevalent than realized due to the amount of lakes, rivers, and the coastline. Along with these two species I also tested small mammals (Figure 12), migratory birds (Figure 13), predatory birds (Figure 14), and amphibians (Figure 15). These other species that showed no significant relationship had some trends that could be seen in the contingency tables. Many of these other species had very similar results showing that there was not a priority or lack of priority among the species between the agencies. Like the large mammals, reptiles, and fish/sea the importance was very similar.

Figure 11
Rows: For what agency or organization type do you work?
Columns: Large mammals

	Most important	Somewhat important	Total
Government	9	10	19
Non-Governmental	13	2	15
Total	22	12	34

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	5.6684742	0.0173

20% of cells have an expected count less than 5.

Figure 12
Rows: For what agency or organization type do you work?
Columns: Small mammals

	Most important	Somewhat important	Total
Government	5	15	20
Non-Governmental	8	8	16
Total	13	23	36

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	2.4080268	0.1207

Figure 13
Rows: For what agency or organization type do you work?
Columns: Migratory birds

	Most important	Somewhat important	Total
Government	24	4	28
Non-Governmental	13	4	17
Total	37	8	45

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.61832841	0.4317

20% of cells have an expected count less than 5.

Figure 14
Rows: For what agency or organization type do you work?
Columns: Predatory birds

	Most important	Somewhat important	Total
Government	10	13	23
Non-Governmental	8	6	14
Total	18	19	37

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.65046675	0.4199

Figure 15
Rows: For what agency or organization type do you work?
Columns: Amphibians

	Most important	Somewhat important	Total
Government	7	16	23
Non-Governmental	6	5	11
Total	13	21	34

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	1.8317045	0.1759

Figure 16
Rows: For what agency or organization type do you work?
Columns: Reptiles

	Most important	Somewhat important	Total
Government	5	18	23
Non-Governmental	9	6	15
Total	14	24	38

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	5.7118012	0.0169

Figure 17
Rows: For what agency or organization type do you work?
Columns: Fish/Sea

	Most important	Somewhat important	Total
Government	11	11	22
Non-Governmental	11	2	13
Total	22	13	35

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	4.193787	0.0406

20% of cells have an expected count less than 5.

This hypothesis tested the relationship of the impacts seen by the personnel and the ecosystem type. Of the 11 ecosystems that were tested only 7 had enough data reported to run viable tests. Among those 7 there were only 2 that had statistically significant results showing a relationship. The two areas were forests with a p-value of .0458 (Figure 20) and shrublands with a p-value of .0293 (Figure 24). Forests showed a relationship of forests having more perceptions of minor drought impacts than other areas. Shrublands had a relationship showing a perception of more severe impacts. The result for forests was surprising; I thought it would see more severe impacts being such a water dependent ecosystem. Although he results from the shrublands were what I expected since it is also a very water dependent ecosystem. The other ecosystems also showed some patterns through the contingency tables. In these tables the consensus was that they either showed a pretty equal distribution between minor and severe or a trend leaning towards minor impacts. Freshwater lakes (Figure 21) and grasslands (Figure 23) showed to be fairly equal in the amount of minor and severe where freshwater river systems (Figure 22), agricultural (Figure 18), and coastal habitats (Figure 19) showed a trend leaning towards minor impacts. The other 4 ecosystems had very little data to conclude a trend or pattern in any direction. These 4 were deserts, islands, urban, and ocean or sea, which was to be expected since this is in the south central region of the United States and the focus, is on natural areas.

Figure 18
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Agricultural

	No	Yes	Total
Minor impacts	17	8	25
Severe impacts	12	5	17
Total	29	13	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.031717897	0.8586

Figure 19
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Coastal Habitats

	No	Yes	Total
Minor impacts	16	9	25
Severe impacts	13	4	17
Total	29	13	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.73632704	0.3908

20% of cells have an expected count less than 5.

Figure 20
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Forests

	No	Yes	Total
Minor impacts	7	18	25
Severe impacts	10	7	17

Total	17	25	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	3.9903779	0.0458

Figure 21
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Freshwater Lakes

	No	Yes	Total
Minor impacts	20	5	25
Severe impacts	12	5	17
Total	32	10	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.49411765	0.4821

Figure 22
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Freshwater River Systems

	No	Yes	Total
Minor impacts	14	11	25
Severe impacts	12	5	17
Total	26	16	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.91316742	0.3393

Figure 23
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Grasslands

	No	Yes	Total
Minor impacts	15	10	25
Severe impacts	7	10	17
Total	22	20	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	1.4374332	0.2306

Figure 24
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Shrublands

	No	Yes	Total
Minor impacts	22	3	25
Severe impacts	10	7	17
Total	32	10	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	4.7484706	0.0293

20% of cells have an expected count less than 5.

The relationship between years worked for the agency and impacts seen was the next hypothesis I tested. It had a p-value of .0795 which shows that there is no relationship between the years worked and drought impacts (Figure 25). The table shows a visual pattern that where the people with more than 5 years experience have seen a higher number of severe impacts. These results are what I expected for this test, since most of the people have worked for less than 5 years will not have

had many other experiences to compare this drought too. What they see could look less severe due to them not having seen what a non-drought conditions look like.

Figure 25
Rows: How long have you worked at the agency or organization?
Columns: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?

	Minor impacts	Severe impacts	Total
Less than 5 yrs.	9	2	11
More than 5 yrs.	16	15	31
Total	25	17	42

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	3.074542	0.0795

20% of cells have an expected count less than 5.

This test shows the relationship between the size of the area managed and impacts seen over the last three years. It had a p-value of .7318 showing that there was no relationship between the size of the area managed and the impacts seen (Figure 26). From the table it was evenly distributed between the two size categories and impacts. I thought there would be more impacts seen in the more than 50,000-acre size than the less than 50,000-acre size. This was because it had a larger area and there are more chances to have different impacts happen and affect the area. However after thinking through the table it could also have been easier to miss the impacts on the larger area due to the size, which could balance out the impacts seen.

Figure 26
Rows: What is the size of the area managed?
Columns: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?

	Minor impacts	Severe impacts	Total
Less than 50,000	10	8	18
More than 50,000	14	9	23
Total	24	17	41

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.11748129	0.7318

Next I tested whether or not there was a relationship between the size of the area that is managed and fire frequency. This test had no statistical significance with a p-value of .8259 and it was clear looking at the table that there was not a relationship (Figure 27). In the table you can see that there was a near even split in the two size categories. I was surprised to see that they are even in the increase category between the two area sizes. I thought that there would be a larger increase in the larger area due to the size and having to manage that amount of land.

Figure 27
Rows: What is the size of the area managed?
Columns: Fire frequency

	Increase	No change/Decrease	Total
Less than 50,000	11	6	17
More than 50,000	11	7	18
Total	22	13	35

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.048391151	0.8259

In this test I wanted to see of there was a relationship between the size of the area and fire intensity. This test resulted in a p-value of .2006 but had a rather small

sample size (Figure 28). After reviewing the table you can see that there was a slight trend showing more of an increase in the larger areas. The distribution among the areas was also split nearly down the middle making it easy to assess in the table.

Figure 28
Rows: What is the size of the area managed?
Columns: Fire intensity

	Increase	No change/Decrease	Total
Less than 50,000	10	6	16
More than 50,000	14	3	17
Total	24	9	33

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	1.6378676	0.2006

20% of cells have an expected count less than 5.

This test showed the relationship between agency type and size of the area managed. This test had a p-value of .7624 showing there was no relationship between agency type and the size of the managed area (Figure 29). The table showed that there were more government agencies than non-government in the table. Both agency types showed that they consist mainly of areas larger than 50,000 acres. I did not expect to see the similarity in results between government and non-government. I thought government agencies would have a higher number of larger areas since they would have more easily accessible funding for them.

Figure 29
Rows: For what agency or organization type do you work?
Columns: What is the size of the area managed?

	Less than 50,000	More than 50,000	Total
Government	13	17	30
Non-Governmental	7	11	18
Total	20	28	48

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.091428571	0.7624

Next I tested the relationship between the impacts of drought and fire frequency. It had a p-value of .332, which showed that there is no relationship between drought impacts and fire frequency (Figure 30). When looking at the table you can see that there was a noticeable difference in the severe impacts category. There was also an increase in the minor category but it was not as drastic.

Figure 30
Rows: How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?
Columns: Fire frequency

	Increase	No change/Decrease	Total
Minor impacts	11	9	20
Severe impacts	10	4	14
Total	21	13	34

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.94118263	0.332

20% of cells have an expected count less than 5.

In these last two tests I looked for a relationship between fire frequency and weeds and invasive plants. Fire frequency and weeds showed no relationship with a

p-value of .5518 (Figure 31). The table for this test also looked to support that since there was not a distinct increase in fire from the increase in weeds. On the other hand in the invasive plants test it also showed no relation between the two with a p-value of .5217 (Figure 32). This test however did have a noticeable pattern of when the invasive plants increased the sires did also or vice versa. By just looking at the table there was no statistical certainty of a relationship.

Figure 31
Rows: Fire frequency
Columns: Weeds

	Increase	No change/Decrease	Total
Increase	9	10	19
No change/Decrease	7	5	12
Total	16	15	31

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.35407529	0.5518

Figure 32
Rows: Fire frequency
Columns: Invasive plants

	Increase	No change/Decrease	Total
Increase	13	7	20
No change/Decrease	7	6	13
Total	20	13	33

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	0.41054734	0.5217

Conclusion

Drought is a climatological event that occurs all around the world. It has especially been seen recently in the south central United States from October 2010-October 2013. After reviewing this area of the U.S. I chose to use natural preservation and conservation areas for my focus in order to see the more natural impacts from the drought. This drought has given unique opportunity to analyze and study the impacts it has on the area and how they are perceived. Drought has been studied in many other aspects like amounts of precipitation, socioeconomic influences, and water shortage. These aspects look at hard number to represent drought and show when there is one occurring. However, these don't take into account the differences in areas, they are for more isolated impacts. Drought can be seen differently everywhere, for example, what is considered drought in Oregon would be much different than what is considered drought in Africa.

Much of the data that was collected was either analyzed through descriptive techniques using tables and graphs to look at the results or statistically using the Chi Square test. The Chi Square test was chosen after reviewing P Croft's article where he used it to analyze his data. In most of the data the tables and graphs showed a fairly even distribution of data between the categories showing no obvious trends. There were a few categories that did seem to show slight trends, the most noticeable being experience. There were also some relationships noticed during the statistical analysis but were inconclusive in the comparison of others due to the structure of the question. These included the impacts of drought perceived in the

different ecosystem types. Forests and shrublands were the only two that showed significance of the 11 tested along with 5 of the ecosystems not having enough data to conclude results. Many of the other Chi Square tests that were ran included testing the relationships between government and non-government, size of the area, priority species, invasive plants and animals, and wildfire frequency and intensity.

There are a few things I would change going back. One of which was the background information on areas. In the survey I only asked for the state of which they were located, while for some of these this was fine but for others like Texas where there are many different ecosystem types. Along with this I had the survey formatted so that the respondents were not required to give the state, which left me with 55 responses (Appendix C Q1). The survey also lacked in other areas where there was not enough data to run the tests or to have a statistical conclusion. The main reason for this was the way I had the questions set up for responses. Many of the questions allowed the respondents to skip the question all together if they were unsure but I also had an option in the question to answer 'Don't know". Another problem along those same lines that made the data hard to analyze was in questions where I allowed them to reply with multiple responses (Appendix C Q8,13,14). Due to these problems with the response I had to simplify my categories when running the Chi Square tests. There are multiple of the questions where I had to take the minor and moderate categories and make one as well as with the severe and worst categories. After fixing this problem I was able to tests the hypotheses. For the categories where I allowed for multiple response which was for the ecosystem type since some of the areas were so large and encompassed multiple ecosystem types

(Appendix C Q8). This data I had to separate the no responses and change them to a "no" in order to test them against the other ecosystems. Being able to repeat what I had written was very beneficial in the process of understanding fully what their responses were. Although the interviews went really well I will make sure to record them in the future.

I used this drought to study what influences the perception of drought impacts in the south central United States. In the survey there are many questions that are used to determine what aspects played a role in the perceptions of drought impacts. These impacts after analyzing the results mainly showed an influence from the years of experience the respondents had. This category looked to have the clearest showing in how the impacts were perceived differently. Other aspects tended to be inconclusive or not have enough data to give a statistical conclusion.

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Appendix

A) National Wildlife Area Descriptions

Salt Plains NWR:
32,197 acres located in northwest Oklahoma. It was established as a refuge and breeding ground for birds and use as a sanctuary for migratory birds. Has largest saline flat in the central lowlands of North America and is habitat to approximately 312 bird species and 30 mammal species. Provide essential shelter, foraging and breeding habitat. It is designated as critical whooping crane habitat. It has a mixture of non-vegetated salt flat, open water and vegetated land.

Wichita Mountain NWR:
59,020 acres located in southwestern Oklahoma. It is untouched mixed grassland due to the large amounts rocks in the ground. It is habitat for large grazing animals such as bison rocky mountain elk, white-tailed deer, and Texas longhorn cattle. It contains more than 50 mammal, 240 bird, 64 reptile and amphibian, 36 fish and 806 plant species.

Muleshoe NWR:
6,440 acre located in the Texas panhandle/central Texas. Most of the habitat is untouched grass prairie. It is important to migratory birds, and has one of the largest concentrations of lesser sandhill cranes. There are three main playa lakes, and only source of water is from rainfall. The three lakes combined provide 600 acres of water when full. It is also provides habitat for mule deer, fox and coyotes.

Lower Rio Grande Valley NWR:
88,000 acres located in south central Texas. It has a 365 day growing season and rich soils have created a documented 1,200 plant species. Leoparadus pardalis (ocelot) is a management priority here. Refuge follows 275 river miles through different landowners and land types. It contains humid corridors of lush riparian vegetation, particularly during times of drought and extreme heat. It also has saline flats, marshes, shallow bays and wind blown clay dunes.

Balcones Canyonland NWR:
23,000 acres located in central Texas. The area is very reliant on ashe juniper and oak woodlands for birds. It has deep clear water pools good for drought and vegetation is often cleared from flash floods. They have 245 bird species and 37 different kinds of dragonflies during summer.

Cache River NWR:
56,000 acres located in east central Arkansas. Cooperative farming program helps with manpower and equipment to complete management. It was created to protect wetland habitats, provide feeding and resting areas for migrating birds. Their goal is to re-forest former farming areas with native vegetation. It is a very important wintering area for mallard ducks in North America.

Sabine NWR:
124,511 acres located in the southwest Louisiana. It was established to provide habitat for waterfowl and other birds. Consists of wetlands that are maintained by prescribed burning, water level and water quality manipulation. It is home to more than 200 species of birds.

Catahoula NWR:
25,162 acres located in east central Louisiana. The habitat is primarily lowland hardwood forest subject to flooding. Management manipulates water levels to promote moist soil vegetation and use it as their primary tool. Forest surveys are conducted to document forest resources and prescribe specific management practices.

B) Interview Questions

1. What is your position at … refuge? How long have you been there?

2. Tell me what species are managed at the refuge?

3. Have you noticed any species or habitats that have been stressed by drought?

4. Going back to how things were in 2010 before the drought began what changes have you noticed on the refuge?

5. (Take 1 species they mention specifically) What affected them and when?

6. Did you notice any recovery? Did the recovery last?

7. Have you seen any changes in the invasive species?

8. Do you keep annual counts of population? How have these changed? (2010, 2011, 2012, 2013)

9. Did you have any outbreaks of diseases?

10. Have you had problems with wildfires? How did that impact forage, cover, nesting…?

Management:

11. How did your management strategies adapt over the last 3 years?

12. How did you come up with these ideas? (in-person, by phone, online/report)

13. How hard was it to find that information?

14. Do you have any reports or documents on the refuge/status from the last few years? (newsletters, etc.)

15. Is there anything else you think we should know that I haven't asked here?

C) Survey Questions

Ecological Impacts of Drought

Ecological Impacts of Drought

This survey will assess the ecological impacts of drought on conservation and preservation areas throughout the south central region of the United States. It is being conducted by the Southern Climate Impacts Planning Program (SCIPP; http://www.southernclimate.org). Results from these surveys will be used to see how wildlife areas are impacted and what can be done or is being done in order to preserve and protect the area now.

The survey consists of 16 questions and should take no more than 10 minutes to complete. It is being distributed to all federal, state and local level authorities involved in wildlife or educated management.

If you have any questions or concerns about the survey, please contact SCIPP at (405) 325-7809 or scipp@southernclimate.org. We encourage you to ask further questions of SCIPP.

We appreciate your participation in this survey. SCIPP will prepare a summary report, available this Summer. If you would like to receive a copy of the report, please provide your contact information at the end of this survey or contact SCIPP separately. Thank you.

Background information

The following questions ask about your background information and the agency or organization which you represent.

1. In which state are you primarily located?

State:

2. For what agency or organization type do you work?

- ◯ State, Tribal or Local Wildlife Management
- ◯ Other State, Tribal or Local Agency
- ◯ U.S. Department of Interior
- ◯ U.S. Department of Agriculture
- ◯ National Oceanic and Atmospheric Administration
- ◯ U.S. Environmental Protection Agency
- ◯ Other Federal Agency
- ◯ Non-Governmental / Non-Profit Organization
- ◯ Private Business
- ◯ Private Landowner
- ◯ Landscape Conservation Cooperative Staff
- ◯ Individual / Self-Employed

Other (please specify)

Ecological Impacts of Drought

3. Which of the following most describes your position in your agency?

- ◯ Manager
- ◯ Researcher
- ◯ Technician
- ◯ Educator
- ◯ Planner
- ◯ Legal or Policy
- ◯ Owner (business)
- ◯ Other (please specify)

_____

4. How long have you worked at the agency or organization?

- ◯ Less than 1 yr.
- ◯ 1-5 yrs.
- ◯ 6-10 yrs.
- ◯ More than 10 yrs.

Land/Ecological information

The next few questions ask about agency or organization ecological and land information. This is to obtain an understanding of size and an ecological background.

5. What is the size of the area managed?

- ◯ less than 5,000 acres
- ◯ 5,000-20,000 acres
- ◯ 20,000-35,000 acres
- ◯ 35,000-50,000 acres
- ◯ 50,000-65,000 acres
- ◯ 65,000-80,000 acres
- ◯ more than 95,000 acres

Ecological Impacts of Drought

6. What species are your highest priority?

	Most Important	Somewhat Important	Not very Important	Not applicable
Large mammals	○	○	○	○
Small mammals	○	○	○	○
Migratory birds	○	○	○	○
Predatory birds	○	○	○	○
Amphibians	○	○	○	○
Reptiles	○	○	○	○
Fish/Sea	○	○	○	○

7. What species is considered the highest priority?

8. With which ecological systems do you work most closely? (multiple responses allowed)

- ☐ Agricultural
- ☐ Coastal Habitats
- ☐ Forests
- ☐ Freshwater Lakes
- ☐ Freshwater River Systems
- ☐ Grasslands
- ☐ Islands
- ☐ Deserts
- ☐ Ocean or Sea
- ☐ Shrublands
- ☐ Tundra
- ☐ Urban
- ☐ Other (please specify)

Drought information

The last few questions ask you to identify information about how the drought has affected plants/animals.

Ecological Impacts of Drought

9. How does the drought of the last 3 years compare to the worst impacts you have experienced from any drought?

- ◯ No impacts
- ◯ Minor impacts
- ◯ Moderate impacts
- ◯ Severe impacts
- ◯ Worst impacts

10. How has drought affected species or habitats?

	Large increase	Slight increase	No change	Slight decrease	Large decrease	Don't know
Native grasses	◯	◯	◯	◯	◯	◯
Trees/shrubs	◯	◯	◯	◯	◯	◯
Fire frequency	◯	◯	◯	◯	◯	◯
Fire intensity	◯	◯	◯	◯	◯	◯
Weeds	◯	◯	◯	◯	◯	◯
Invasive plants	◯	◯	◯	◯	◯	◯
Invasive animals	◯	◯	◯	◯	◯	◯
Plant disease	◯	◯	◯	◯	◯	◯
Animal disease	◯	◯	◯	◯	◯	◯

11. Have you noticed changes in fish or wildlife behavior during the drought?

- ◯ Yes
- ◯ No

12. How have animal/plant counts changed?

	Large increase	Slight increase	No change	Slight decrease	Large decrease	Don't know
2010	◯	◯	◯	◯	◯	◯
2011	◯	◯	◯	◯	◯	◯
2012	◯	◯	◯	◯	◯	◯
2013	◯	◯	◯	◯	◯	◯

Management

Ecological Impacts of Drought

13. How have your management strategies adapted over the last 3 years?

- [ ] Bring in water
- [ ] Move to locate water
- [ ] Use irrigation
- [ ] Manage carrying capacity
- [ ] Land restoration project
- [ ] Involve community
- [ ] Other (please specify)

14. How did you come up with these ideas?

- [ ] Common practice
- [ ] Available on internet
- [ ] Personal contact
- [ ] Agency reports
- [ ] Technical meetings
- [ ] Own research
- [ ] Journal articles
- [ ] Other (please specify)

15. Is there anything else you'd like to share that hasn't been asked?

Summary Report

If you would like to receive a copy of the summary report, please complete the information below. Your response is optional and any identifiable information you provide will not be linked to any of your survey responses. Again, if you have any questions about this survey, please contact us at scipp@southernclimate.org or (405)325-7809.

On behalf of SCIPP, we thank you for your participation in this project.

16. Contact Information (optional):

Name

Organization

Email