SAGEBRUSH DECLINE ON THE COLORADO PLATEAU:

A LOOK AT SAGEBRUSH AND SOILS

by

April M. Darger

A thesis submitted in partial fulfillment

of the requirements for the degree

of

MASTER OF SCIENCE

In

Ecology

Approved:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Eugene W. Schupp

Major Professor

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Thomas A. Monaco

Committee Member

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Janis L. Boettinger

Committee Member

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Mark McLellan

Vice President for Research and

Dean of the School of Graduate Studies

UTAH STATE UNIVERSITY

Logan, Utah

2016

ABSTRACT

Sagebrush Decline on the Colorado Plateau:

A Look at Sagebrush and Soils

by

April M. Darger, Master of Science

Utah State University, 2016

Major Professor: Dr. Eugene W. Schupp

Department: Wildland Resources

Sagebrush ecosystems are being lost and fragmented at a distressing pace. Not only is the sagebrush (Artemisia *tridentata*) disappearing, but the associated flora and fauna are facing their own unique problems as a result. Land that has typically been used for grazing, deer and elk winter habitat, and recreation is seeing a drastic shift in vegetation. Land managers need to know where sagebrush can potentially be reestablished, and where they may begin to see further die off. To aid restoration efforts on the Colorado Plateau we examined which environmental characteristics are related to various vegetation types, with an emphasis on sagebrush. We further looked at sagebrush physiology in relation to soils to explain the variation in the health of living sagebrush. Prior to this study it was observed that sagebrush in the study area were typically found in moderately deep to shallow soils while sagebrush further north in the Great Basin are typically found in deeper soils. This was thought to be due to low water availability and extremely sandy soils that allowed water to quickly escape the rooting zone. Because of this we hypothesized that shallower soils, soils with more clay, higher in carbonates, or other factors that might slow the water would result in a higher sagebrush presence.

(??? pages)

PUBLIC ABSTRACT

Sagebrush Decline on the Colorado Plateau:

A Look at Sagebrush and Soils

by

April M. Darger

ACKNOWLEDGMENTS

Thank you to the Utah Agricultural Experiment Station for funding this project.

I would like to Dr. Eugene W. Schupp, my major advisor, who granted me this singular experience and opportunity to expand my knowledge and education. Thank you for your support and insightful advice as well as for pushing me to improve my skills in statistics. I will never forget all that you have done for me, or that “the only thing constant is change!” I would also like to thank my graduate supervisory committee Janis L. Boettinger and Thomas A. Monaco. Janis provided many of the soil resources necessary for this study. She also gave hours of her time helping me with site selection and understanding the soil variable data. Tom gave insight into the sagebrush health portion of this study, and provided the LECOS machine which produced nitrogen and protein percentages.

Susan Durham is the amazing statistician who explained, reviewed, brainstormed, and demonstrated for hours on end. Thank you for all the effort and care you put into both this project, and my education.

Barry Baker and Canyonlands Research Center provided research and living facilities incredibly near to the study site at very little cost. Barry Baker in particular was always available to offer encouragement, excitement, and discuss local research. The Canyonlands Research Center facilities are located on Heidi Redd’s Dugout Ranch. Heidi offered valuable insight into the local cattle industry, as well as historic flora and fauna.

USU Ecology Center and Quinney College of Natural Resources provided excellent courses pertinent to this study, facilities for research, and supportive staff.

Field technician Eric Sodja was exceptionally committed and a self starter. Thank you not only for your work, but also for insightful questions and thoughts about this research that sparked so many more.

I am especially grateful for my family’s unwavering support and pride, particularly that of my parents Crystal Darger and Allan Darger. Mom, you were the driving force behind all that I’ve done. Dad, your complete faith in my abilities kept me sane.

April M. Darger

CONTENTS

Page

ABSTRACT………………………………………………………………………………ii

PUBLIC ABSTRACT

ACKNOWLEDGMENTS

PREFACE

LIST OF TABLES

LIST OF FIGURES

CHAPTER

1. INTRODUCTION
2. SOIL CHARACTERISTICS RELATING TO CHANGES IN VEGETATION TYPE
3. SOIL CHARACTERISTICS RELATING TO CHANGES IN SAGEBRUSH HEALTH
4. CONCLUSION

APPENDIX

CHAPTER 1

INTRODUCTION

Sagebrush ecosystems are important habitat for mule deer, greater sage grouse, and many other charismatic fauna. They are also important rangeland for the western livestock industry, and considered by many to be vital recreation areas and an icon of the American west. However, these ecosystems are also in decline. Sagebrush ecosystems once covered approximately 150 million acres. Now natural and anthropogenic threats degrade this iconic ecosystem and regionally imperil over 350 species of associated plants and animals.

Growing concern has led to studies on the dynamics of sagebrush ecosystems and their obligate species, mostly in the Great Basin. However, little is known about how sagebrush responds on the Colorado Plateau, which has drier and monsoonal climatic conditions as well as different soils and vegetation. This is problematic because there is little to suggest that restoration successes in well studied areas will be successful on the Colorado Plateau.

In the late 1980’s sagebrush (Artemisia *tridentata*) in and around Beef Basin, Utah, began declining rapidly, with areas seeing 70% to100% die off, and a transition to grasslands. Unfortunately one of the grasses taking over the basin is cheatgrass (Bromus *tectorum*), which is problematic for sagebrush restoration for a number of reasons (Carling, J. 2012). Chief among them is the tendency for cheatgrass to burn every three to five years. This makes it nearly impossible for sagebrush to successfully establish and mature because they need between twenty five and fifty years to reach maturity. Another problem with cheatgrass is its tendency to take over an area, particularly following a fire or other disturbance, and form a monoculture or near monoculture which effectively excludes the establishment of other species and prevents restoration to a previous ecological state (Wisdom and Chambers 2009, Miller et all 2008).

In Beef Basin, the lower elevation plains aren’t the only place sagebrush habitat is being encroached upon. The pinion and juniper woodlands that characterize the rocky basin slopes have become thicker and thicker, which is closing off the upper canopy, and allowing these trees to outcompete understory species, including sagebrush, for key resources (Carling, J. 2012). This results in a severe decrease in understory species, and becomes a fire hazard which could then potentially be replaced by cheatgrass (Miller et all 2000, 2005).

Beef Basin is considered crucial habitat for both mule deer and elk during the winter and spring (Carling, J. 2012). Mule deer in particular utilize South Plain in Beef Basin, and have seen population decreases, even as the sagebrush continues to decline (EA2.pdf). In 1956 a road was built to provide greater access to Beef Basin for hunters to curtail the (then explosive) deer population. According to local rancher Heidi Redd there were roughly 6,000 deer using the basins in and around the 60’s, about 2,000 deer in the 90’s, and now only about 200 deer and 200 elk are using the area (Heidi Redd, personal communication, 6/5/2014).

Beef Basin is also used as rangeland for cattle from winter to early spring. Historically, the entire southeastern portion of Utah saw only small cattle herds prior to the 1880’s, but during the boom in the cattle market in the late 1800’s cattle use skyrocketed. From Arches National Park down to the city of Bluff and encompassing the LaSal Mountains, Canyonlands National Park, Beef Basin, and the Abajo (Blue) Mountains it is estimated that there were more than one hundred thousand head of cattle using the area (Utah Historical Quarterly). During the winter and spring herds in the Abajo Mountains were usually moved down into what is now Beef Basin and Canyonlands National Park. In 1879 the Abajos alone had 2,000 head of cattle, by 1880 there were 15,000, and by 1885 10,000 head of cattle (Historic Resource Study: Cattle Raising in the Canyons). By the mid 1890’s the cattle market had crashed, and southeastern Utah was suffering from an overstocked, overgrazed range which resulted in the exodus of big cattle companies, leaving only small ranchers and herds (Utah Historical Quarterly). In 1936 the BLM required grazing permits and only allowed 500 head of cattle in Beef Basin (Historic Resource Study: Cattle Raising in the Canyons). In 2016 Beef Basin has been allotted 200 head of cattle for five months, which translates into 1000 animal month units (AUM’s). Their diet consists primarily of needle-and-thread grass (*Hesperostipa comata*).

The objective of this study is to determine which soil characteristics are associated with the presence of sagebrush on the landscape in order to ascertain where restoration efforts will potentially succeed. Further, in areas where sagebrush still exists it is important to know the range of sagebrush health.

**Literature Cited**

Miller, R. F., R. J. Svejcar, and J. A. Rose. 2000. Impacts of western juniper on plant community composition and structure. J. Range Management. 53:574-585.

Miller, R. F., J. D. Bates, A. J. Svejcar, R. B. Pierson Jr., *and* L. E. Eddleman. 2005. Biology, ecology, and management of western Juniper (Juniperus *occidentalis*) Agricultural Experiment Station, Oregon State University Corvallis.

Miller,R.F., R. J. Tausch, D. E. McArthur, D. Johnson, *and* S. C. Sanderson. 2008. Development of post-settlement Pinon-Juniper Woodlands in the Intermountain West: a regional perspective Research Paper RP-69. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Wisdom, M.J. and J.C. Chambers. 2009. A landscape approach for ecologically based management of Great Basin shrublands restoration ecology. Vol 17 No 5 pp. 740-749.

Sheire, J. 1972. Historic Resource Study: Cattle Raising in the Canyons. U.S. Department of the Interior, National Park Service, Denver Service Center, Historic Preservation Team.

Denis, C. L. 2012, Departure of the Late Nineteenth Century Cattle Companies from Southeastern Utah: A Reassessment. Utah Historical Quarterly. Vol 180 No 4 pp. 354-373.

Carling, J., Giffen, C., Grench, L., Leaver, B., Plemons, P., Scott, M. 2012. Beef Basin/Dark Canyon Plateau Sagebrush Restoration. Environmental Assessment UT-Y020-2011-0047-EA. United States Department of the Interior, Bureau of Land Management, Monticello Field Office.

CHAPTER 2

SOIL CHARACTERISTICS RELATING TO CHANGES IN VEGETATION TYPE

**Abstract**

**Introduction**

**Methods**

*Study area*

This study was conducted in Beef Basin, which is in San Juan County, Utah. It is in the Monticello District of the Bureau of Land Management (BLM), and located on the Colorado Plateau. It can be found just to the south of Canyonlands National Park, and to the north of the Abajo Mountains, which are also locally known as the Blue Mountains. Beef Basin is an area characterized by flat plains of deep sandy soil covered in grass, and interspersed and surrounded by shallow rocky outcrops with pinion pine and juniper. The average precipitation of the study area is approximately 20.5mm during the winter and 28.4mm during the summer, with the average winter temperature ranging from 5.4˚C to -7.7˚C, and average summer temperature ranging from 30.2˚C to 13.2˚C (1981-2010 PRISM data, Daly et al. 2008).

This study focused primarily on North Plain and South Plain which are the two southernmost plains in the basin, but a larger view of the whole basin was also conducted using data collected by and in collaboration with the United States Geological Survey (USGS). Recreation and cattle grazing are the primary uses for the area.

*Sampling design*

The majority of plots were selected using ArcGIS to randomly sample across North Plain and South Plain based on the three dominant soil types (Begay, the Ignacio/Leanto complex, and Mido)(Utah AGRC) and 4 vegetation classes which were assigned using a quintile break based on September 2011 NDVI values(2011 NAIP 1m 4-band imagery from Utah AGRC). They were buffered a minimum of 50-m from roads, the edge of the study basins, and other sample points. The USGS plots were selected from the whole of Beef Basin using condition Latin Hyper Cube (cLHC). These selected plots were then subject to elimination or minor adjustment based on certain on the ground criterion. Sites had to be within one vegetation type, safely accessible (ie. not on a cliff face), and buffer requirements set above using ArcGIS were confirmed on the ground. A total of 99 plots were sampled within North Plain and South Plain, with an additional 37 USGS plots added to the dataset for a total of 136 sampled sites. 6 of the USGS plots were located within North Plain or South Plain. Sites were sampled from May to August in 2013. Additional sagebrush leaf samples were collected in early June 2014.

In 2013 line-point-intercept (LPI), shrub density, and soils data were collected from each site. Sagebrush leaf samples were collected from each site that had sufficient sagebrush from which to collect a viable sample. Five 30-m transects spaced 7-m apart were positioned parallel to the hillslope contour, with the middle transect centered 2-m above the soil pit. In the absence of a discernible slope, transects were oriented on an east-west axis with the center transect offset to the north. Plot photos were taken at the four cardinal directions and at the beginning and end of each transect. LPI was collected on all five transects beginning at 0.5-m and collected every half meter thereafter to the 30-m point, resulting in 60 points per line and 300 points per plot. Shrub density was collected in a 2-m belt, 1-m on either side of lines 1, 3, and 5. Each shrub was tallied and placed in one of five height classes: <15cm (Juvenile), <15cm (Mature), 15-50cm, >50-100cm, and >100cm. A soil pit was located at the center of each plot, and augered to the depth of bedrock or up to 2-m in depth. Where the soil was too rocky to use an auger, a sharpshooter was used to dig a soil pit. Sagebrush leaf samples collected were the interior winter persistent leaves, and not the exterior early ephemeral leaves. They were collected twice, once in 2013, and once in 2014. In 2013 leaves were collected and weighed at night between midnight and 5:30 a.m. Because of the limited timeframe and poor visibility only 16 viable sites were sampled. Where possible a total of four sagebrush were sampled at each plot, with ten leaves collected from each plant, otherwise all sagebrush present were sampled. Samples were kept on ice while transferred to the lab, and leaf area was measured within 12 hours of collection. They were then dried and measured again. From this the percent dry weight in grams, and the specific leaf area (SLA) in centimeters was obtained. The 2014 leaves were collected during the day, dried, and weighed. They were then wrapped in a square of tin foil and ran through a LECOS machine which provided nitrogen and protein percentages for 67 sites.

**Literature Cited**

Daly, C., M. Halbleib, J. I. Smith, W. P. Gibson, M. K. Doggett, G. H. Taylor, J. Curtis,

and P. P. Pasteris. 2008. Physiographically sensitive mapping of climatological

temperature and precipitation across the conterminous United States. International

Journal of Climatology 28:2031–2064.

**Please cite the PLANTS Database as:**

USDA, NRCS. 2015. The PLANTS Database ([http://plants.usda.gov](http://plants.usda.gov/), 19 October 2015). National Plant Data Team, Greensboro, NC 27401-4901 USA.