Bordering Disaster:

Vegetation Disturbance Along the United States-Mexico Border Wall in the Chihuahuan Desert

A Remote Sensing Approach

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ABSTRACT

Precipitated by the terrorist events of September 11th, 2001, the United States government heightened national security efforts, prompting the extensive construction of barrier walls along the border with Mexico. As of 2020 approximately 738 miles (1,187 km) worth of barrier walls have been constructed along the 1,954 mile (3,145 km) border (United States CBP 2020). This project will focus on how the building of the border wall has impacted vegetation in the New Mexico-Mexico region of Chihuahuan Desert. Research on the impacts of the border wall mainly focus on animal species in Texas and Arizona. Comprehensive literature on the impacts of vegetation disturbance in the Sonoran and Mojave Deserts suggests vegetation disturbance in arid environments can have long lasting impacts on the ecosystem. Utilizing Landsat data, this project will study vegetation cover over a 30 year period, in three areas along the border, each with either pedestrian fence, vehicle barrier or a patrol road. Analysis of Variance will be used to assess the differences in vegetation cover over time. Past studies on vegetation disturbance suggest the results will show a correlation between the different types of barrier walls and the degree of disturbance. Findings would allow for further understanding of the amount of damage caused by border barriers to the vegetation of the Chihuahuan Desert, one of the most biodiverse desert environments in the world.

LITERATURE REVIEW

The Chihuahuan Desert and Indigenous People

The Chihuahuan Desert is North America's largest desert, covering 250,000 square miles (647,500 Km) spanning Mexico and the southern parts of Texas and New Mexico in the United States (Hoyt 2002). The Chihuahuan Desert is one of the most biodiverse arid ecosystems in the

world (Hoyt 2002). Arid ecosystems account for approximately 33% of Earth's biomes and are variable ecosystems, which are easily disturbed and difficult to regenerate (Lawley, Lewis, and Ostendorf 2016). The Chihuahuan Desert is home to many indigenous species of flora and fauna and to many Indigenous peoples, many of whom were divided, displaced or even "disbanded" with the implementation of the treaty of Guadalupe Hidalgo which established the current border between the United States and Mexico (Kowalski, 2017.). Within 200 miles of the northern and southern borders of the United States there are 40 Tribes who traditionally lived in these areas; those that currently reside on the southern border include the Limpan Apache El Calaboz Ranchería, the Ysleta del Sur Pueblo and the Kickapoo Tribe in Texas, the different communities of the Tohono O'odham Nation and the Cocopah Tribe in Arizona, and the Kumeyaay of California (Singleton, 2009). The artificial division created by the United States-Mexico border has both physically and culturally divided the Indigenous people of the borderlands, cutting off access to sacred sites and areas where traditional food and medicine are gathered (Kowalski, 2017.). Additionally due to the building of the border wall and subsequent over-militarization irreparable damage has been caused to sacred sites, burial grounds and the habitats of medicine and food plants (Kowalski, 2017). The purpose of this research is to assess the damage to vegetation in the borderlands of the Chihuahuan Desert with the goal of preserving the habitat of traditional food and medicine plants.

Vegetation Disturbance in Arid Environments

Researchers have studied how disturbance in arid areas impacts vegetation, specifically in the Mojave and Sonoran Deserts. The arid environments of the Southwest have been disturbed by wildfires, roads, railways, the building of towns, and military facilities (Abella 2010). The

building of infrastructures causes mass disturbance, often stripping away vegetation and layers of topsoil present, leaving these areas highly susceptible to soil-wind erosion which can cause a public health hazard (Grantz et al. 1998). A literature review of 47 studies in the Sonoran and Mojave Deserts was conducted by Abella in 2010, examining revegetation processes in disturbed areas. Estimated timelines for complete revegetation and plant succession varied from as little as five years to over 200 years depending on the severity of the disturbance (Abella 2010, Webb, Steiger, and Turner 1987). Multiple studies also found precipitation variability greatly impacted how quickly vegetation was reestablished (Abella 2010). However due to the harshness of desert environments, the unpredictability of weather, and the monetary expense to revegetate such areas, most of the disturbed vegetation in the American Southwest has been left to recover naturally (Abella 2010). While vegetation disturbance in the Sonoran and Mojave Deserts is generally well understood, there is little to no information on how the building of the southern border wall has impacted these dynamics and the possibility of revegetating such areas in the Chihuahuan Desert.

Remote Sensing in Arid Environments

Arid environments are highly variable and ecosystem changes depend greatly on fluctuations in temperature, precipitation, and fire (Lawley, Lewis, and Ostendorf 2016). Due to the nature of arid environments, taking accurate measurements of the health of arid ecosystems can be difficult as results are highly dependent on the time of year. Additionally, bio-assessments done in these areas are often only conducted once every several years over small areas due to high temperatures and expansive land areas (Lawley, Lewis, and Ostendorf 2016). One way to overcome these obstacles is through the use of remotely sensed imagery, although images must

be interpreted with care. Past studies utilizing remote sensing in arid or semi-arid environments found exposed soil and rocky geological features could be misinterpreted as changes in green-biomass (Elvidge and Lyon 1985). Results from a study done in the Northern Jornada basin of the Chihuahuan Desert, found the ideal time to take images of vegetation in this environment was late spring as this time of year allows for greater differentiation between grasses, shrubs, exposed soil and ground litter (Muldavin, Neville, and Harper 2001). Muldavin, Neville and Harper (2001) developed a simple remote sensing plant biodiversity index for use over large low disturbance areas of the Chihuahuan Desert which accounted for previously known issues through the generalization of plant land cover data and minimal data manipulation. This project will utilize the methods from Muldavin, Neville and Harper, focusing on the changes in vegetation in high disturbance areas.

Habitat fragmentation

Habitat fragmentation is one consequence of building the border wall. Anthropogenically caused habitat fragmentation occurs when an ecosystem habitat is divided by some sort of physical barrier like a road, railway, or fence (Liu et al. 2020). Barriers can have negative impacts on biodiversity by hindering the migratory patterns of plant and animal populations, thus preventing intermixing, and reducing genetic diversity. For example, the bighorn sheep's already small population was divided by the southern border wall, causing issues with genetic diversity as the now divided populations can no longer interbreed and bolster the dwindling population numbers (Flesch et al. 2010). Current research on habitat fragmentation has focused mainly on roads and railways, limiting research on habitat fragmentation caused by artificial barriers between international countries (Ogden 2017). The building of the southern border wall has

caused increased habitat fragmentation, due to both smaller barriers and large walls. My research will increase knowledge of how this fragmentation has impacted vegetation.

Biodiversity Impacts

The building of the southern border wall by the United States government has had significant impacts on biodiversity. Research on the building of barriers along the borders of Slovenia and Croatia in Southeast Europe have also shown these barriers to be problematic for biodiversity (Pokorny et al 2017). The building of razor wire fences split populations of many different species and disrupted the migration routes of large mammals. Deer species in particular have issues with getting tangled in the fence while attempting to cross, often resulting in death (Pokorny et al. 2017). Along the United States southern border wall similar issues arise for species such as the Sonoran pygmy owl and bighorn sheep, with the pygmy owl unable to fly high enough to breach the border wall, and the bighorn sheep unable to continue their natural migration patterns (Flesch et al. 2010). Much of the research done on the impacts of border walls on biodiversity has focused on animals, particularly bird and mammal species. However, few in depth studies on how plant biodiversity has been impacted by infrastructure have been conducted. Scientists agree that to fully understand how border walls impact the ecosystems in which they reside, it is necessary to study plants and how they have been impacted (Liu et al. 2020). Planning on how to mitigate, or remediate damage done by the building of the border wall requires a comprehensive understanding of the impacted ecosystems and there is a gap in the literature regarding plants (Liu et al. 2020). This project will contribute to the body of knowledge by researching how plants have been impacted by the expansion of the southern border wall and

how different types of barriers impact plant distribution using remote sensing to quantify vegetation disturbance.

INDIGENOUS PERSPECTIVE

Western science tends to view everything as separate, and non-human beings are not often seen as having their own inherent sovereignty and right to live. People have asked me, "Why should I care about the desert? Why should I care about vegetation?" expecting me to reply with an answer about biodiversity, or carbon fixation. But that is not why I care about these issues, other beings do not exist solely for our benefit and, I care about these issues because it is my responsibility as a good relative to care about all other beings human and non-human alike. Within recent years Western science has begun to recognize the validity of Indigenous Traditional Ecological Knowledge (TEK). As the people who have lived on these lands since time immemorial, Indigenous peoples have valuable insights into their specific homeland ecosystems which can be utilized to combat the impacts of climate change and other disturbances. TEK is not a uniform body of knowledge and each Indigenous community will have their own unique knowledge based in their culture, beliefs and lived experiences (Pierotti and Wildcat 2000). However one recurring theme among TEK is the concept of relatedness and interconnection, meaning that all beings human, animal, plant and land are related and connected in an intrinsic way (Pierotti and Wildcat 2000). As a Tigua person from the Ysleta del Sur Pueblo, I feel that it is my responsibility to care for my relatives and my home in the Chihuahuan Desert. This connection is what drives me to question how the border wall has impacted not just our plant relatives but the land, our mother itself.

RESEARCH DESIGN

Methods:

Landsat imaging will be used to assess vegetation cover over time. Three Landsat images of each area over time will be used: one current, one from 2005 and one from 1990. The three areas chosen along the border will be characterized by the presence of a road, vehicle or pedestrian barrier, as well as two control areas. These control areas will be located a short distance away on either side of the border and will be characterized by minimal disturbance. The presence of culturally important and endangered plant species will be taken into consideration in the choosing of each study area. Data will be statistically analyzed using Analysis of Variance (ANOVA) to determine if there has been significant change in vegetative cover over time. The control groups will ensure that any vegetation loss indicated by the analysis is due to the barrier wall and not outside factors such as climate change or drought.

Data collection:

Landsat imaging will be utilized to collect the needed data. The areas will be chosen based on distance from each site and placement relevant to the study area. Past and current grazing and agricultural use of each area will be taken into consideration as well as proximity to nearby towns and cities. Precipitation and temperature data from the National Oceanic and Atmospheric Association (NOAA) and nearby weather stations will be gathered for the time period of the study to account for periods of drought and abnormal weather events. Landsat images will all be extracted 15 years apart in the spring of 2020, 2005, 1990. Previous research using remote sensing in an arid environment found that assessing plant coverage was most accurate if the images analyzed were taken in the late spring before the hot summer (Muldavin, Neville, and Harper 2001). This collection method would also allow for data comparison over

time which is beneficial in seeing how each area has been impacted and the historical amount of vegetation cover.

Data analysis:

Data will be analyzed by calculating the fractional vegetation per pixel of each image in the five areas. Fractional vegetation is the amount of each pixel in the Landsat image that contains vegetation. The fractional vegetation of the earlier images will be subtracted from the current image to measure the change in vegetation over time. Using Analysis of Variance (ANOVA) to statistically analyze fractional vegetation will reveal if statistically significant fractional vegetation exists. ANOVA was chosen as the main analysis tool as it allows for the comparison of multiple data sets to find the variance between them.

ACADEMIC PREPARATION

My previous undergraduate research on vegetation in wetland ecosystems, provided knowledge of field research on plant ecology. Experience with studying vegetation in an endangered ecosystem has furthered my knowledge of the importance of studying and preserving fragile ecosystems. During Undergraduate Research (ENVS 480, ENVS 481) I observed the spread of the holoparasitic plant *Cuscuta Glomerata* in the Baker Wetlands located in Lawrence, KS, utilizing geographic information systems (GIS). The spread of Cuscuta was more pronounced than in past years and, the holoparasitic plant killed off large patches of vegetation in places where it had not been present in previous years. Cuscuta was studied both by tracking the spread via GIS as well as through collecting samples to be studied in the lab and through literature review. Specific course work such as Remote Sensing (GEOG 340), Plant Ecology (ENVS 390), and Biostatistics (BIOL 385) have provided me with the skills needed to complete

this project. My research paper on the impacts of the border wall for the class Environmental Protection in Indian Country (AIS 320) provided background knowledge on the topic. My recent internship with the Haskell Environmental Research Studies (HERS) program provided knowledge on data carpentry, critical thinking, writing development, utilization of Indigenous Traditional Ecological Knowledge and ethical research development.

CONCLUSION

Preservation and restoration of plant biodiversity in the Chihuahuan Desert along the United States-Mexico border will require an analysis of the relationship between the different types of border walls and vegetation disturbance. Statistical analysis will provide evidence for determining if the building of the border wall has had a significant impact on vegetation.

This research will be the main focus of my upcoming graduate thesis. Furthermore, the data collection and analysis methods can be refined and utilized to study vegetation disruption in other ecosystems impacted by habitat fragmentation due to artificial barriers. An assessment of the damage to the plant ecosystem could be utilized to create a plan for remediation and restoration of these damaged areas after the completion of this research. Focus would be centered on endangered plants as well as plants that are important food and medicinal plants for Indigenous peoples.

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