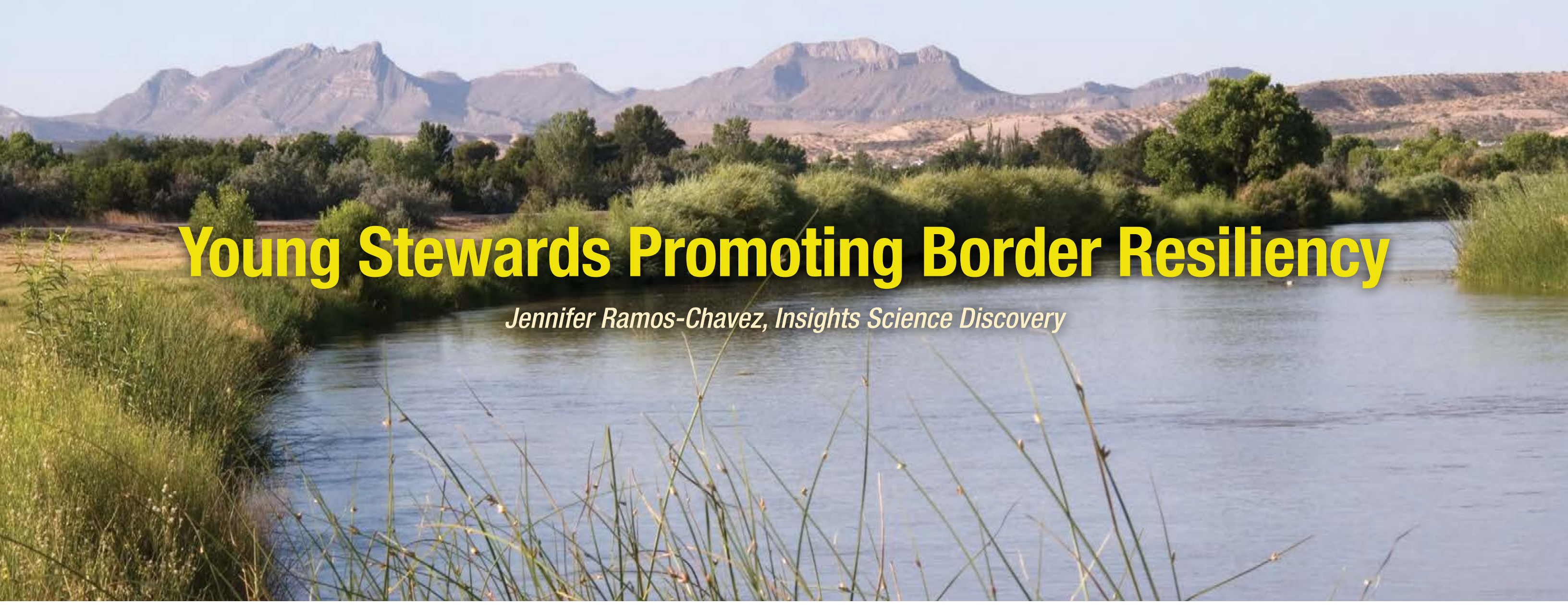

Young Stewards Promoting Border Resiliency

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Abstract

The city of El Paso is uniquely located along the Rio Grande River and borders of Mexico and New Mexico, all of which are situated in the Chihuahuan Desert. The region faces a variety of environmental threats, including habitat loss due to urbanization, deterioration of freshwater resources and climate change. The Border Region (82% Hispanic and poverty rate of 22%) is also very much an underserved community. Working in partnership with the Rio Bosque Wetlands Park and with funding provided by the NOAA Planet Stewards program, Insights Science Discovery (Insights) created the Young Stewards Promoting Border Resiliency project. The goal of this project was to arm high school students from underserved communities with the knowledge and skills to restore one acre of riparian wetland habitat. The project also fostered career development within STEM fields by providing students with opportunities to learn and engage with STEM experts. The students' efforts of removing invasive species followed by the transplanting of native vegetation within the wetland, helped restore a small portion of this river-valley environment while instilling a greater sense of conservational awareness among the next generation of decision makers.

Introduction

The Border Region of West Texas, Southern New Mexico and Northern Chihuahua is uniquely situated along the Rio Grande River and in the critical ecoregion of the Chihuahuan Desert which faces a variety of threats, including habitat loss, deterioration of freshwater resources and climate change. According to the National Park Service (https://www.nps.gov/im/chdn/ecoregion.htm), the Chihuahuan Desert is considered one of the most diverse deserts of the world, and a critical reservoir for conserving biodiversity. Unfortunately, the Chihuahuan Desert Ecoregion is also one of the most endangered regions in the world (Briggs et al., 2019).

The El Paso Border Region in west Texas is one of the nation's fastest growing metropolitan areas. With a steady annual population growth rate of an average of 0.7% per year between 2010 and 2021 (U.S. Census, 2021), El Paso City and County planners have primarily focused on tapping into the binational workforce unique to this region and have thus dedicated projects and funding to commercial, industrial and residential growth. Unprecedented rates of urban sprawl have farmers and environmentalists at odds with government planners.

Wetlands and riverside forests once dominated the banks of the Rio Grande in the Border Region. They were the most productive natural habitats in the area. Historically, the floodplains of the river used to stretch up to 8 miles wide when flooding of the Rio Grande occurred during spring and early summer. Native riparian vegetation such as screwbean mesquite, willows and cottonwood trees were once dominant in these habitats. However, today these historical riparian forests and wetlands are virtually gone as a result of channeling and damming of the Rio Grande, land conversion, border fence building, and stressors such as the introduction of invasive salt cedar (*Tamarix spp.*) (Howe & Knopf, 1991).

Wetlands serve as a vital habitat for plants and animals, act as a natural filter for water, decrease erosion and promote land stability, provide aesthetic value, and play a crucial role in combating climate change. It is well established that riparian wetlands play a significant role in carbon sequestration (Tan et al., 2020). Though quantitative measures in riparian wetlands within the El Paso Border Region are limited, if Rio Bosque's sequestration potential is anything comparable to its functioning as a flourishing habitat in areas that have been since restored, then the Rio Bosque Wetlands in El Paso, Texas is confidently a considerable environment for carbon sequestration. This not only has a positive impact on local environmental health, but globally as well as we face environmental and climate change.

Though the Border Region faces multiple environmental challenges, a number of adult organizations are actively engaged in environmental stewardship, but few youth programs exist. With an 82% Hispanic population and poverty rate of 22%, El Paso, Texas is an underserved community as a whole (U.S. Census, 2022) West Texas is geographically isolated from the state's environmental education services in based in central regions of the state. Moreover, the Chihuahuan Desert and its environmental issues cross city, state and national boundaries in the Border Region.

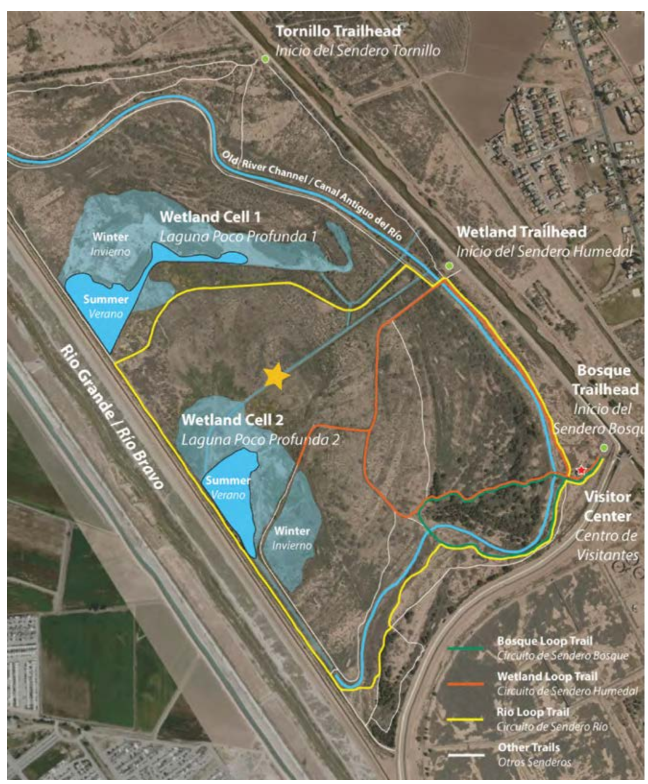


Figure 1. Map of Rio Bosque Wetlands Park. The yellow star indicates the project's restoration site.

Background and Site History

Rio Bosque Wetlands Park is part of El Paso's city park system and is managed by the University of Texas at El Paso's Center for Environmental Resource Management (CERM). Since 1997, partnerships among the University of Texas at El Paso, the City of El Paso, the International Boundary and Water Commission (IBWC), Ducks Unlimited and El Paso Water Utility have worked to rebuild the wetland.

The park spans 372 acres. Early wetland restoration efforts involved re-building the old river channel through the park and creating a system for diverting water from this channel into two large shallow wetland cells designed to recreate shallow-water emergent wetland habitats.

Active restoration establishing native species and controlling exotic species (Watts et al., 2002), along with natural regeneration responses to exceptionally wet years of 2006 and 2008, has slowly transformed the wetland park into a habitat resembling what was once present with the historical meandering Rio Grande. In the years since, wildlife has increased in diversity and density, and natural progression of vegetation has reclaimed several of the previously cleared areas.

In the early years of the wetland project at Rio Bosque, the only available source of water was treated wastewater from El Paso Water's Bustamante Wastewater Treatment Plant, located immediately north of the park. It was often only available for 3 to 3.5 months in late fall and early winter (Watts et al., 2002). The rest of the year, including throughout the growing season, the park was completely dry. In recent years, the park's water availability has increased thanks to El Paso Water and El Paso County Water Improvement District No. 1. Today, the park relies on three different water sources: treated wastewater, groundwater, and irrigation water from the Rio Grande. The availability of water during the growing season has greatly accelerated the development of wetland and riparian ecosystems at Rio Bosque.

Project Goals/Objectives

The Young Stewards Promoting Border Resiliency project aimed to build a strong environmentally conscious future for the Border Region by providing young community members, many of whom come from underserved communities, with skills and experiences to promote a new generation of conservational awareness. The project's overarching goal was to advance efforts that combat land conversion and shrinking wild habitats by restoring approximately one acre of the wetland by clearing invasives and replanting native vegetation.

Learning Topic	Presenter's Profession
Land conservation and preservation	Wildlife Biologist and Land Trust/ Conservation Administrator
Ecological Restoration and Rain Water Harvesting	Biologist and Restoration Expert
Invasive Species	Botanist/Ecologist
Wetland vegetation and the importance of wetlands	Biologist and Botanical Curator
History of El Paso water and the Rio Grande River	Hydrogeologist and Professional Engineer
Wetland water; Water of the Rio Bosque; groundwater	Hydrogeologist and Geochemist
Wetland birds, particularly resident and migrant birds of the Rio Bosque	Wildlife Biologist and Avid Birder (Audubon Society President)
Burrowing owls, conservation efforts for the species and the role Rio Bosque plays for the owls	Urban Wildlife Biologist
Desert wildlife tracking and monitoring	Ecology and Evolutionary Biology PhD students
Native desert pollinators and the importance of pollinator gardens/native vegetation	Texas Master Naturalist
Science communication, citizen science, participatory science, and the importance of diverse and inclusive science and research	Ecologist and Environmental Scientist

Table 1. Project's priming lesson topics and the corresponding presenter's profession. Priming lessons served as a means to provide information and knowledge students would need to understand field trip objectives, as well as a means of career exposure and development.

This project was a partnership with Insights Science Discovery (http://www.insightselpaso.org/), a local non-profit with the mission of providing equitable access to Science, Technology, Engineering, Arts, and Math (STEAM) education, the University of Texas at El Paso's CERM, and the Rio Bosque Wetlands Park. Keeping in the spirit of youth empowerment and environmental ownership, we enlisted students from a nearby high school, Mission Early College High School, many of whom had never visited nor heard of the wetlands despite being located only six miles from their school campus. Forty students worked side by side with restoration experts and researchers to understand the process and importance of habitat restoration.

Since the project administrators and volunteers had limited time with the participating students, the project was designed to provide monthly learning lessons on different wetland topics and issues before each field trip over the course of the school year. For these lessons, we employed the help of local experts who presented on the topic and also highlighted their experience in their career field, as well as their journey to reaching that point. Several of these guest speakers attended in-person field trips and served as mentors to the high school students. The students would then participate in stewardship activities (invasive removal and native planting) and hands-on lessons relating to the correlating topic during the subsequent field trip at the site. In total, eleven priming lessons, which included providing introductory information for the respective field trip, a deeper dive into the respective field trip topic by a STEM expert, and material preparation for hands-on activities, (Table 1) were given and seven of the eight planned field trips took place. Due to constraints related to the Covid-19 Pandemic, some activities were rescheduled or canceled altogether.

Data Collection

This project included a number of data collection activities. Students learned to collect physical data within the restoration area as well as at a control site (where no stewardship activities were conducted) at several intervals within the project timeframe. The control site served as a comparison for environmental assessments. The project administrator also collected data on student perceptions and learning outcomes.

Environmental Monitoring

In an effort to enhance student learning and understanding of habitat restoration, environmental measures including vegetation assessments, soil and water analyses, pollinator surveys and bird counts were conducted by the students under the guidance of experts and volunteers and served as a means to illustrate how habitats can be monitored, and restoration efforts guided based on the results. The number of native plants installed and amount of invasive biomass were also monitored and recorded.

Vegetation assessments included pre and post-linear transects. Linear vegetation surveys (LVS) were conducted along a 50 m transect parallel to a water channel within the restoration and control sites.

Image 1. Students conducting linear vegetation transects to measure and record present species and calculate the most dominant species at the site.

Photo Credit: Dr. Ramos-Chavez

Image 2 (left). Students learned about soil dynamics within wetland/riparian habitats and conducted soil analyses to compare nutrient levels between the control and restoration sites.

Photo Credit: Dr. Ramos-Chavez

Image 3 (right). Participating students learned that the diversity of wildlife can indicate habitat health. During the project, students learned to identify and survey wetland bird species.

Photo Credit: Dr. Ramos-Chavez

Species data was collected at random points along the transect both at 1 meter towards the water channel and 5 meters away from the water channel. This double, simultaneous LVS allowed for a more robust understanding of the vegetation along the varying ecotones within the riparian habitat.

We had intended to conduct pre and post assessments but the second half of the project year was faced with pretty severe drought conditions. Water that was planned to be delivered to the wetland was diverted to farmers downstream in Socorro and San Elizario, Texas and elsewhere further down river. The wetland was bypassed by two upstream river releases in February and April and remained dry during the duration of the second half of the project. Despite this, students did learn how to conduct the assessments and learned how these measures are used to determine habitat health and the relationship between water quality/ quantity and vegetation along with the presence of wildlife.

Student Learning and Perceptions

To assess student learning and perceptions of riparian wetland restoration, we utilized two abstract survey techniques. The Draw-an-Ecosystem Approach (Sanford et al., 2017) consists of a pre-test and post-test in which students draw and label an ecosystem and is graded based on a rubric (https://ncsce.net/the-draw-an-ecosystem-task-as-an-assessment-tool-in-environmental-science-education/) including eight categories (abiotic/biotic mass transfer, energy input, trophic interactions, human activities, hydrologic cycle, atmosphere, system/environmental issues) each with a 0–3 score, where 0 represented no display of that category and 3 represents a comprehensive response. We also investigated the effects of hands-on educational programing on student's environmental perceptions using Bogner and Wiseman's Model of Ecological Values using an Environmental Perception (ENV) scale (Bogner and Wiseman, 2004). Multiple choice questionnaires regarding wetland habitats were scored on a 5-point Likert scale ranging from "strongly agree" to "strongly disagree". The pre-test for both methods were administered before students were introduced to any habitat restoration concepts, and the post-tests were administered upon completion of the project.

Images 4, 5, 6. Part of the project's restoration efforts included removal of invasive species. Students remove an invasive tree tobacco; remove tumbleweed growing along the water channel, and students amass a large pile of invasives during one of the project workdays.

Photo Credit: Dr. Ramos-Chavez

Results

Environmental Monitoring

As a result of the students' stewardship efforts, approximately one acre of riparian wetland habitat was improved and well on its way to natural regeneration. The restoration site was dramatically improved and cleared of many invasive species.

	West - Restoration	West - Control	East - Restoration	East - Control
# of species @ 1m	5	3	6	5
# of species @ 5m	5	4	7	7
Total # of species	6	5	9	9
Most frequent species @ 1m	Tumbleweed; Coulter's horseweed	Bare ground; Tumbleweed	Tumbleweed	Bare ground; Lamb's quarters
Most frequent species @ 5m	Tumbleweed	Indian rushpea	Bush seepweed; Tumbleweed	Fall tansyaster; tumbleweed; Lamb's quarters
Most frequent overall	Tumbleweed	Tumbleweed	Tumbleweed	Tumbleweed; Lamb's quarters

Table 2. Linear Vegetation Survey pre-assessment. Transects were conducted on both sides of the water channel (East and West), and both in the restoration and control sites. Pre-assessments show that Salsola kali (tumbleweed) was the dominant species within the restoration and control sites.

	West - Restoration	West - Control	East - Restoration	East - Control
# of species @ 1m	2	3	2	2
# of species @ 5m	3	3	5	5
Total # of species	5	4	6	6
Most frequent species @ 1m	Bare ground; Hoary tansyaster	Indian Rushpea; Tumbleweed	Bare ground; Bush seepweed	Bare ground; Tumbleweed
Most frequent species @ 5m	Bare ground; Willow baccharis	Tumbleweed	Bare ground; Willow baccharis	Tumbleweed
Most frequent overall	Hoary tansyaster	Tumbleweed	Bush seepweed; Narrowleaf Globemallow	Tumbleweed

Table 3. Linear Vegetation Survey post-assessment. Transects were conducted on both sides of the water channel (East and West), and both in the restoration and control sites. Post-assessments illustrate that native wetland vegetation like willow baccharis (*Baccharis salicina*) and hoary tansyaster (*Machaeranthera canescens*) became more established within the restoration site, while the control sites remained dominated by tumbleweed.

Vegetation pre-surveys showed that invasive tumbleweed (*Salsola kali*) was the dominant plant species within the site (Table 2).

After invasive removal, native wetland vegetation like willow baccharis (*Baccharis salicina*) and hoary tansyaster (*Machaeranthera canescens*) became dominant and established in areas where tumbleweeds were removed (Table 3).

A total of 65.2m^3 of invasive plant material (including tumbleweed, tree tobacco (*Nicotiana glauca*) and Johnson grass (*Sorghum halepense*)) was removed from the site. 72 native plants and seedlings, including Rio Grande Cottonwood (*Populus deltoides wislizenii*), Goodding Willow (*Salix gooddingii*), Broom snakeweed (*Gutierrezia sarothrae*), and Sand sagebush (*Artemisia filifolia*) to name a few, were transplanted while three dozen seeds were germinated offsite for future transplantation.

Student Learning and Perceptions

According to the pre-assessment survey multiple choice questionnaire a majority of the students had existing positive and strong beliefs about environmental science and awareness of their environment. This was reflected once again in the post-assessment survey. However, some students felt that the same beliefs and awareness may not be shared by their school and community. More than half the students felt unsure as to whether their school/community shared the same beliefs after stewardship activities were conducted.

Image 7. Students work to install native plants where invasive tumbleweeds were removed. Photo Credit: Dr. Ramos-Chavez

Image 8. A student works alongside the park assistant manager to plant a native willow tree in November 2021. Photo Credit: Dr. Ramos-Chavez

Image 9. Students plant wolfberry seeds to germinate plants that will be installed at the site once matured. Photo Credit: Dr. Ramos-Chavez

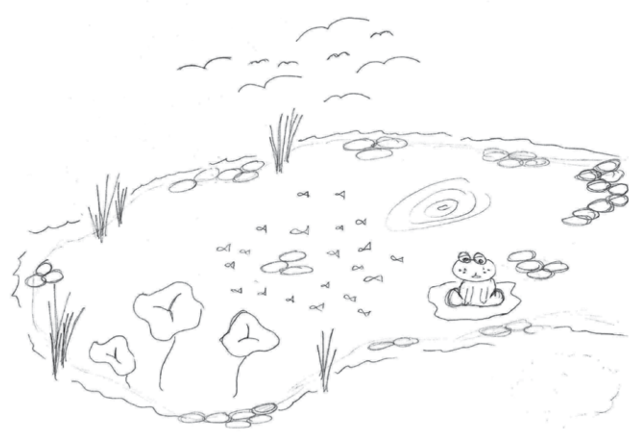
The Student's Environmental Perceptions and Behavior pre-survey (https://docs.google.com/document/d/18F2lW1wthTGNrUKqjO1iNw1c8CVry5vnykT4NwvmGik/edit?usp=drive_link) illustrated little connection and knowledge about wetlands among students, particularly in desert ecosystems like the Chihuahuan Desert. However, the post-survey showed much higher correct responses to specific wetland concepts. For example, the pre-survey indicated that 30% of students were unsure about migratory species' connections to desert wetlands. However, the post-survey showed 93.8% of student respondents understood these connections. This is directly attributable to lessons and stewardship activities as a part of this project. Finally, as a result of the activities and interactions incorporated in this project, more students have indicated that they would like to pursue a career in STEM fields (pre-survey: 72.5% agreed, post-survey: 100% agreed) and perhaps one that incorporates scientific research (pre-survey: 52.5% agreed, post-survey: 65.7% agreed).

Score	Pre-assessment # of Students	Post-assessment # of Students
0	1	0
1	13	0
2	12	1
3	9	4
4	2	3
5	0	4
6	0	2
7	0	0
8	0	2
9	0	1
10	0	5
11	0	2
12	0	1
13	0	1
14	0	1
15	0	1

Table 4. Draw-an-Ecosystem pre and post-assessment student scores. Thirty-seven total students participated in the pre-assessment, while 28 students participated in the post-assessment. The highest possible score is that of 24; no students scored higher than 15 on either assessment.

The Draw-an-Ecosystem pre-assessment mirrored results from the questionnaire which illustrated the students' lack in understanding/knowledge of desert wetland ecosystems. The rubric provides that an individual can obtain an overall score of 0 to 24. Comparing the pre/post assessments showed a stark increase in student scores. Most students scored between 1 and 2 on the pre-assessment, however, most students obtained a score between 5-10 on the post-assessment (Table 4). The highest score obtained on the pre-assessment was a score of 4 (n=2). The highest score obtained on the post-assessment was 15 (n =1, though 6 students scored eleven or higher).

The pre-assessment drawings were rudimentary depictions of desert habitats displaying very basic manifestations of the following categories: External energy input (a sun), Geosphere (rocks/mountain features), Trophic levels/organism interrelationships (predator/prey), and Hydrologic cycle (a water source).



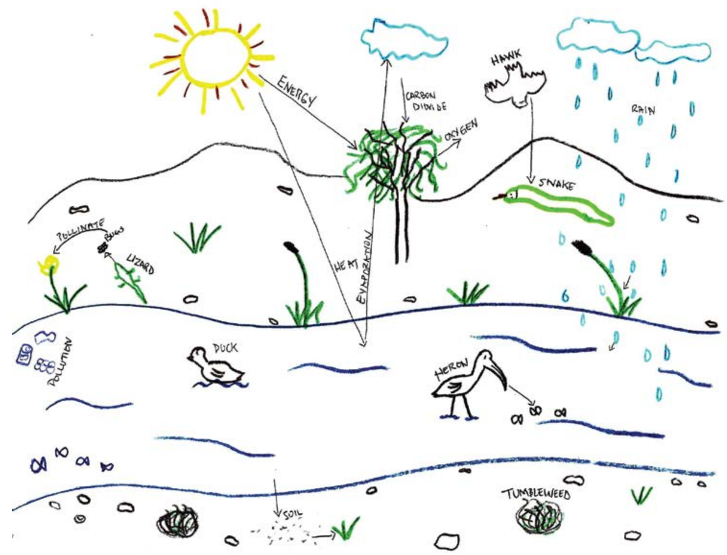


Image 10a (left). Student example of Draw an Ecosystem Preassessment shows very basic and elemental depictions of a wetland ecosystem illustrating the lack of knowledge and/or experience/exposure to these habitats.

Image 10b (right). Student examples of Draw-an-Ecosystem post-assessment. Overall, the post-assessment drawings were clear portrayals of what they had learned and experienced during their interactions with the project activities.

None of the students included any representation of the following categories: Nutrient cycling/Abiotic and biotic mass transfer, Human activities, Atmosphere, and Systems and environmental issues on the pre-assessment drawings. There was evidence of student learning in the above-mentioned categories as depicted in post-assessments drawings except 'Nutrient cycling' where only a few students obtained 1 point for that category. The teacher agreed that this tends to be where most students struggle as these concepts were only briefly discussed in class. Though we did discuss nutrients and nutrient cycling in one of the lessons and field trips, it is illustrated here that this is a challenging concept for these students.

Conclusion

This project helped restore a small portion of this river-valley environment and it inspired young community members, a majority of whom (93%) are minorities, to be stewards of their environment far beyond the duration of this project. It also provided the skills and knowledge needed to make real environmental improvements to their own communities and beyond. The two-pronged approach of hands-on, practical experiences coupled with career development via expert mentors provided a unique and perhaps singular opportunity for many of the participating students.

In all, students helped rehabilitate approximately one acre of desert wetland/riparian habitat by removing invasive species and planting native vegetation. Though carrying out this project in the middle of a global pandemic was challenging, we feel this project was quite successful and can serve as a model for future hands-on, participatory projects with the intention of including young people from diverse experiences, backgrounds and cultures. We found that these in-person and hands-on experiences connected with the students far more than any other classroom lesson could.

The city of El Paso is at a critical point in its development and in order to ensure that natural, open spaces are conserved for future generations, it is imperative that we delegate the leadership and solution development to the young people that will soon inherit the responsibility of legislative, community, and environmental decision-making. Furthermore, arming high school students in this region with the knowledge and resources necessary to

Image 11. Students work alongside volunteers to level out a water channel to allow for more water flow and bank inundation once water is released into the wetlands. Photo Credit: Dr. Ramos-Chavez

affect environmental change empowers not only student participants, but an entire community of traditionally economically, environmentally, and educationally disenfranchised citizens.

Acknowledgements

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About the Author

Jennifer Ramos-Chavez, P.h.D., is the Environmental Education Manager at Insights Science Discovery where she coordinates and implements immersive environmental education programming. Additionally, Dr. Ramos-Chavez is a Postdoctoral Researcher at the University of Texas at El Paso where she studies the intersection between the environment, energy and education. Specifically, her research focuses on community-based participatory environmental research and community-centered outreach. She is interested in understanding how student perceptions and behaviors are influenced by immersive environmental and engineering education programming. Prior to her appointments, Dr. Ramos-Chavez led a United States Agency for International Development (USAID) funded project centered around cost-effective environmental monitoring research in Indonesia. Jennifer can be reached at jennifer@insightselpaso.org.

Additional Resources

Lesson – Conservation Wetland: Impacts of Human Activities on the environment and biodiversity (https://docs.google.com/document/d/1cDAOk7U-ovmT204IQGgrToEDls7hATktTj9iU88QY2M/edit)

Additional Chihuahuan Desert Educational Materials Developed by Insights (https://www.insightselpaso.org/sesi-teacher-resources)

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