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## **Executive Summary**

### **Introduction**

Borderlands Restoration Network (BRN) is a nonprofit organization based out of Patagonia, Arizona, that partners with borderland communities to grow a restorative economy by rebuilding healthy ecosystems, restoring habitat for wildlife, and reconnecting border communities to the land through shared learning. Borderland communities encompass the southern United States and northern Mexico border, and BRN is centered within the Madrean Archipelago, one of the most important biodiversity hotspots in the world. A core program that BRN offers is the Borderlands Earth Care Youth (BECY). This paid internship-style program focuses on educating and training youth between fifteen and twenty to address the growing environmental and sustainability challenges associated with climate change, habitat fragmentation, aridification, and socio-economic injustices. Through the BECY program, BRN provides a critical opportunity for the Arizona communities of Douglas, Patagonia, Nogales, and Rio Rico. The purpose of this program is critical for borderland communities, given the historical marginalization of these communities. This can be seen with the demographics of these communities as the communities of Douglas, Nogales, and Rio Rico are all over 80% Hispanic/Latino identifying, according to the U.S. Census Bureau information from 2020-2022. With the majority of these communities being Hispanic/Latino, the implementation of an environmental education program that accounts for and supports cultural backgrounds and resources is one that is critical.

The advancement of quality education and networking opportunities in these communities helps to create a diverse conservation sector that will further support the restoration economy in borderland communities. In 2018, BRN completed a survey research project and found that ninety-two percent of overall respondents claimed they were inspired by the BECY program to make sustainable changes in their lives. Respondents reported that the program helped them

“To look at the environment differently, [and] the impact humans can have (positive and negative) on other species’ habitats,” and to recognize the benefits of “...the social aspect of community building, as well as the fundamentals of ecosystem and watershed restoration” on their environment (Anonymous Participants, 2018, BRN Program Evaluation).

These statements showcase the importance of BECY in shaping participants’ views of the environment and the role that they each play as stewards.

Over the course of nine months, the JKLM Sustainability Consulting team completed a project for BRN by using sustainability analysis tools and the North American Association for Environmental Education (NAAEE) guidelines to provide foundational information and guidance regarding environmental education curriculum development, program evaluation, and program expansion to assist BRN in achieving its youth education program expansion goals. The

deliverable of the consultation project was an updated and enhanced BECY curriculum and related activities guide to be used in Summer 2023.

## **Project Scope**

In Phase One of the project, the JKLM team collected qualitative evidence on BRN and similar environmental education organizations using key sustainability analysis tools: an (s)TOWS assessment, landscape analysis, and best practices assessment. The team also reviewed academic and scientific literature on environmental education. From the assessments and research, the team identified five key recommendations for BRN to implement that would support the current organization's work and its goals in expanding:

1. Update the existing curriculum and enhance offerings to include online formats.
2. Expand program offerings to early childhood and youth age groups.
3. Partner with local schools and community organizations to integrate BECY programming into their curriculum and after-school or summer programs.
4. Host community convenings to gain stakeholder input and collaboration on tailoring the curriculum to be culturally appropriate and meet the community's needs.
5. Conduct surveys and analyze results after the implementation of each new curriculum for evaluation purposes.

In Phase Two of the project, the JKLM team first administered a survey to the BRN management team to gather feedback on areas to provide insight and inform changes to the curriculum. The team then divided the full NAAEE guide into sections and reviewed it for relevant guidance for BRN and the borderland communities. Results from the survey and the NAAEE notes were then aggregated and combined with sustainability concepts to form seven key themes to implement throughout BECY and BRN's future work:

1. Utilize a Justice Equity Diversity Inclusion (JEDI) framework lens.
2. Embed Sustainable Development Goals.
3. Ensure the curriculum is community-centered and social justice driven.
4. Increase accessibility.
5. Support environmental literacy.
6. Consider positionality.
7. Develop and utilize program evaluation & continued future thinking with expansion goals.

The JKLM team then focused on addressing recommendation one from Phase One and made significant updates and enhancements to the BECY curriculum and activities guide by incorporating the seven key themes established from their research. These themes and the NAAEE framework strongly supported the additional four recommendations from Phase One for BRN to prioritize outside the scope of this consultation project.

## **Conclusion**

*Improving and expanding sustainability education is a climate solution.* The BECY program is an integral component of BRN's mission of supporting healthy ecosystems, community resilience, and a deep reconnection to the land. The JKLM team project provided a substantially updated and enhanced version of the BECY curriculum that will allow BRN to continue to support the next generation of sustainability and conservation stewards and strengthen the restoration economy in borderland communities. Additionally, the research and recommendations compiled by the JKLM team will assist BRN in its future strategic planning for environmental education and present expansion opportunities that are sustainable.

REBUILD. RESTORE. RECONNECT.

# BECY CURRICULUM



BORDERLANDS  
RESTORATION  
NETWORK



BORDERLANDS  
EARTH CARE  
YOUTH

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## INTRODUCTION

### Foreward

Four students from the College of Global Futures at Arizona State University completed this research and curriculum update sponsored by Borderlands Restoration Network as part of the culminating experience project for their Master in Sustainability Solutions program degree. Thank you and congratulations to the JKLM Sustainability Consulting group: Jordan Sene, Kayla Napper, Laney Meeker and Marshall Morgan Fabara.

We also want to thank Lindsey Sikorski for her work on the design of the final deliverable.



**BORDERLANDS  
RESTORATION  
NETWORK**

### Land Acknowledgement

We respectfully acknowledge that Borderlands Restoration Network engages in and promotes restoration practices developed by Indigenous peoples for the benefit of ecosystems and human communities in Northern Mexico and Southwest USA. BRN works on and occupies land within the homelands of the O'odham, Apache, Opata, Comcaac, and Yoeme (Yaqui). BRN acknowledges that our organization, and the communities and places we serve benefits from Indigenous knowledge along with past and present Indigenous natural resource stewardship.

We keep this at the forefront of our messaging to remind us of our organizational values and the need to strive towards equity, inclusion, and justice in our work. This acknowledgment also serves as an invitation for partnerships, knowledge sharing, criticism, and growth.

# What are the Sustainable Development Goals?

In 2015, 193 United Nations Member States adopted the 17 Sustainable Development Goals (SDGs) shown below:



(United Nations, SDG's)

The SDG's are considered a global call for action to “end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity” (United Nations). The goals were made with the recognition that they are interconnected, and any action taken on one will likely impact the others.

## Why are they important?

The UN Sustainable Development Goals are important because they provide a framework for countries and organizations around the world to work together towards a more sustainable future. These goals are meant to address some of the most pressing challenges facing our planet, such as climate change, biodiversity loss, and social inequality.

By promoting the Sustainable Development Goals in our curriculum, we aim to raise awareness about these sustainability-related challenges and hopefully inspire you to take action to address them. By learning about the importance of watershed, ecosystem, and community restoration, you can see how your actions can make a positive impact on the environment and the community you live in.

For example, by promoting responsible consumption and production, we can reduce waste and protect natural resources like water and soil, which can in turn support healthy ecosystems and communities. By taking climate action, we can reduce our impact on the environment and protect the biodiversity that depends on these ecosystems.

By helping you understand the importance of the Sustainable Development Goals and how they are connected to environmental stewardship, you may be more inclined to live a more sustainable lifestyle as an individual and then help your community be more sustainable as well. This iterative process of learning, practicing, and sharing your thoughts and abilities where you live or end up, can help ensure a more sustainable and resilient future for all of us.



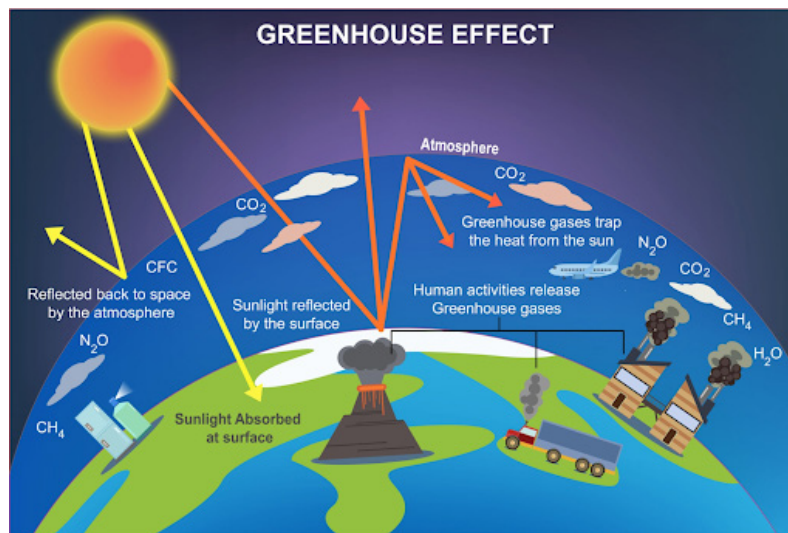
## What is Climate Science?

**Climate science** or “climatology” is the study of the Earth and its climate. Studying climate science often involves seeking “to understand how global, regional and local climates are maintained as well as the processes by which they change over time (Parker, 2018). This is sometimes called climate change. This can result in droughts, flooding, wildfires, hurricanes, and all sorts of natural disaster events. In the broader sense, climate science impacts all parts of our natural world and environment; the temperature outside, how much water is in a river, and even what kind of animal species can exist. There is no ecosystem or community on earth that is not impacted by our climate, but it is especially important to think about the communities who will be the most impacted by climate change over time.



(National Oceanic and Atmospheric Administration)

Much of what is studied in climate science is the “**greenhouse effect,**” or the warming of the earth’s atmosphere. The burning of fossil fuels and other activities by humans release large quantities of carbon dioxide into the atmosphere, which “acts as a blanket over the planet by trapping long wave radiation, which would otherwise radiate heat away from the plane. As the amount of carbon dioxide increases, so will its warming effect” (Auburn University, 2023) on the earth.



### Did you know?

Many different professions and industries engage in some form of climate science. Can you guess a few positions that work in climate science? Here are some:

- Climatologist
- Geoscientist
- Renewable Energy Scientist
- Environmental Engineer
- Conservation Scientist
- Agricultural Engineer

Climate science and sustainability science are closely interconnected fields that are crucial to the restoration and conservation career sector. Climate change is a major driver of biodiversity loss; climate change has a significant impact on ecosystems and wildlife. Rising temperatures, changes in precipitation patterns, and more frequent extreme weather events are causing habitat loss and fragmentation, leading to declines in many species. Sustainability science aims to address these challenges by promoting more sustainable practices and reducing greenhouse gas emissions. Restoration of ecosystems and habitats can help mitigate the effects of climate change by sequestering carbon dioxide and reducing greenhouse gas emissions. Restoration efforts such as reforestation, watershed restoration, and sustainable ranching and agriculture can also help to promote biodiversity and increase ecosystem resilience to climate change impacts.

The restoration and conservation career sectors can help promote sustainability by preserving natural resources and promoting more sustainable practices. For example, protecting watersheds and restoring Sonoran Desert ecosystems can improve water quality and availability, while sustainable forestry practices can promote sustainable wood production and reduce deforestation. Integrating climate and sustainability science in restoration and conservation efforts can lead to more effective conservation outcomes. For example, considering climate change impacts in habitat restoration planning can help ensure that restored habitats are resilient to future climate change impacts. Similarly, promoting sustainable agriculture practices can help reduce greenhouse gas emissions and improve ecosystem health. The interconnectedness of climate science and sustainability science is crucial to the restoration and conservation career sector. Engaging in both practices can lead to more effective conservation outcomes and promote sustainability.

## CHAPTER 1:

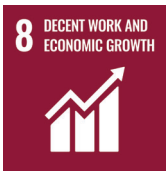
# Restoration in Border Communities

The Arizona borderlands region has experienced significant environmental impact and habitat loss over the years due to various human activities and climate change. Throughout this chapter, we will dive into how ecosystem restoration can help address these challenges, promote sustainable practices, and contribute to the Sustainable Development Goals.



**SDG 4:** By ensuring a quality education that emphasizes environmental education for borderland communities there is a corresponding emphasis on justice, equity, diversity, inclusion, and accessibility.

This empowers historically marginalized communities to develop environmental literacy skills that support them to take action and get involved in ecosystem restoration initiatives and community development opportunities.



**SDG 8:** By ensuring that there is decent work and economic growth associated with sustainability and conservation, both humans and the planet can prosper. Practices such as permaculture, rainwater harvesting, and ecotourism support the economic growth associated with a restoration economy.



**SDG 11:** In order to ensure the healthy development of our communities and ecosystems, it is critical that sustainable cities and communities are maintained.

This can be done through the implementation of environmental education programs that support environmental literacy and community development. For borderland communities that are often smaller and closer, this is critical for community development and empowerment.



## **SDG 13: Climate Action**

How does Restoration In Border Communities related to Climate Action?

### **What is a Sustainable Community?**

In the beautiful borderlands that Arizona shares with Sonora, Mexico, there are several aspects that make this region so unique. For example, the community values, cultures and languages of the region are distinctive. With cultures that stem from Jewish immigrants to Indigenous Peoples to the dominant Hispanic heritage in our Arizona borderland communities, there are always new neighbors to befriend and ways of life to learn. As this region is part of the Madrean Archipelago, one of the most diverse ecoregions in the world, it is our duty as residents of this land to be its steward together. To ensure the longevity and sustainability of the landscape so many people call home, it will take collaboration on the part of many with a roaring passion for caring for their homeland.

In order to best instill or expand this passion, it is critical that our community members are environmentally literate. Environmental literacy is the process that makes one environmentally literate. It is not the process of providing “right” answers to environmental issues and topics; it is instead the process of educating people about environmental topics and issues and then allowing them to develop their own perceptions and beliefs (Chepesiuk, 2007). While there are different methods for ensuring environmental literacy, one that is most effective is environmental education. Environmental education focuses on ensuring that learners can develop a deeper understanding of the environment and the issues that threaten it (Environmental Protection Agency, 2022). Environmental education can be taught within an institution or it can be studied independently. Additionally, it can be done through community engagement and developmental opportunities, like experiencing the Borderlands Earth Care Youth

program or similar internship. Environmental education ensures that communities can be environmentally literate so that current and future generations can live a sustainable life. According to the North American Association for Environmental Education, when it comes to ensuring that environmental education is successful in community engagement there are five key characteristics that the educational material needs to be:

- Community Centered
- Based on Sound Environmental Education Principles
- Collaborative and Inclusive
- Oriented Toward Capacity Building and Civic Action
- A Long-Term Investment in Change

These five key characteristics support environmental literacy, through engaging environmental education material which is critical for maintaining a sustainability-oriented community. An aspect that cannot be overlooked, especially when discussing borderland communities, is the importance of culturally responsive climate action and an emphasis in programming that is just, equitable, diverse, inclusive and accessible. One effective way this can be done is through the development of a Community Based Environmental Education (CBEE) program that focuses on creating environmental education material that is locally focused and includes input from local community organizations and members (North American Association for Environmental Education, 2017). For borderland communities, a CBEE is a great opportunity to develop change at the local level for the local level, which is especially important for borderland communities as they are often neglected due to communities being primarily populated by historically marginalized communities. This can be seen with communities like Douglas, Rio Rico, and Nogales, Arizona, all having a population that is over 80% Hispanic identifying (U.S. Census Bureau, n.d.). With the demographics of these communities, it is critical that environmental education material accounts for cultural practices

and beliefs so that the community is supported and engaged with environmental literacy. Proactive programming and training in the restoration of watersheds, ecosystems and communities helps ensure success for an individual and their communities.

## **Human Impact on the Environment**

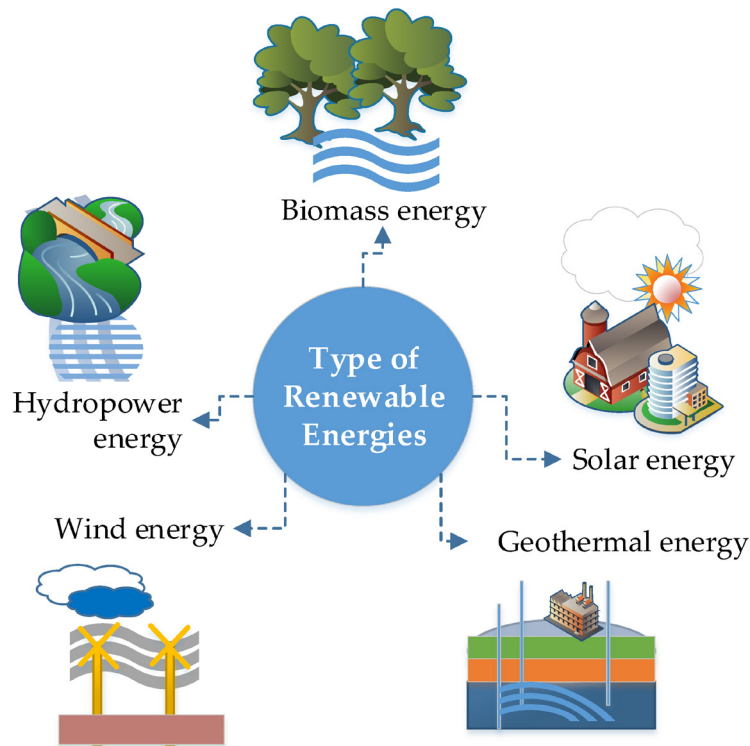
In any community, humans have a direct and indirect impact on the ecosystems that surround them, both locally and globally. These impacts can be both positive and negative, and as a result of a drastic increase in these impacts over the last 100 years, scientists with the International Union of Geological Sciences have claimed that we are currently living in the age of the anthropocene (Zhong, 2022). The age of the anthropocene can be classified as “period of time during which human activities have impacted the environment enough to constitute a distinct geological change” (Kolbert, 2022). Humans have undoubtedly impacted our world, and unfortunately, many of these impacts have been negative. Such impacts result from numerous unsustainable practices within numerous sectors such as energy, transportation, manufactured products, invasive species, agriculture, and ranching, to name a few. While all of these practices have had a negative environmental impact as a result of often being mismanaged there are methods and practices to mitigate the negative human impact associated with these practices. Within the next few sections, these practices will be explored. As you read, consider critically thinking about these several systems and develop your own environmental literacy skills in order to consider different challenges and the possible solutions to them.

### **Energy**

The opportunity you will have to develop and showcase your environmental literacy skills is with the topic of energy and the creation and usage of energy by humans. Energy is a critical part of our daily lives as it provides us with numerous developmental opportunities, such as transportation and manufactured

products. However, energy and its creation and usage of it in an unsustainable way have had a direct negative impact on our planet. This can be seen with human-driven climate change that has resulted in numerous threats to our planet and our race, such as rising temperatures, severe droughts, stronger storms, rising sea levels, melting ice covers, and a longer wildfire season (NASA, n.d.). It is important to note that while the unsustainable creation and usage of energy has significantly increased these threats, it is not solely responsible. Taking this into consideration, energy can still pose a serious risk, so it is still critically important that energy creation and usage be done sustainably.

There are different methods to do this, but one of the most common methods has been the increase in the desire and implementation of renewable energy sources. This can be seen with renewable energy being the fastest-growing energy source in the United States, increasing 90% from 2000 to 2022 (Center for Climate and Energy Solutions, n.d.)



(Avtar, R., Sahu, N., Aggarwal, A., et al., 2019)



Climate change is occurring, and humans are one of the driving factors. However, if we continue to adopt sustainable practices such as depending on renewable energy instead of fossil fuels, oil, coal, and gas, then we can mitigate immense amounts of greenhouse gas emissions from being released. Renewable energy needs to be the future of our planet. In the next subsection, we will be discussing transportation which directly relates to energy and the use of unsustainable and sustainable practices. When you are reading the next section, keep in mind the different ways you believe that transportation can use renewable energy sources.

### **Transportation**

Transportation is a critical part of our society, and the need for it is one that will only continue to grow and expand. This is one of the major reasons that it can pose a serious threat to our planet and our ecosystems if it is not done sustainably. In the United States, transportation is the largest greenhouse gas contributor, with it being responsible for 27% of the total greenhouse gas emissions that were released globally by the United States in 2020 (Environmental Protection Agency, 2022). In addition to the impact that transportation can have through greenhouse gas emissions, vehicles can have an impact on ecosystems as a result of direct and indirect wildlife casualties from vehicle accidents and the transporting of invasive species.

Wildlife casualties can often be found on the sides of roads. These casualties are not always considered when discussing transportation. These casualties can occur from general displacement when building transportation infrastructures, such as highways, and they can occur from automobile collisions. It is estimated that with automobile collisions alone, more than a million animals are killed every day, and as a result, automobiles are the leading cause of death for many animal species (National Geographic Society, 2022). One sustainable way that these deaths can be mitigated is through the creation of wildlife crossings.

These crossings provide a safe way for wildlife to cross highways without the risk of being killed in an automobile collision. In Arizona alone, since 2000, at least 20 wildlife corridors have been created, and as a result, in some areas, there has been a 90% drop in wildlife-related highway accidents (National Geographic Society, 2022). With a decrease in accidents, the creation and use of wildlife corridors lessen the impact that transportation has on ecosystems by providing a safer and more sustainable opportunity for wildlife and humans to travel.



Image of two javelinas using a wildlife corridor under a road in Marana, Arizona.

(Arizona Game and Fish Department, 2012).

When it comes to other sustainable practices to lessen the impact that transportation has on our planet, it is important to discuss private vehicles as it is the primary way that many people transport themselves. Having and using a private vehicle is not necessarily a bad thing, especially when it is the only available transportation option for many people. However, this is why it is important to discuss other transportation options, and it is critical for communities to offer and maintain these options. These options can include ensuring that there are safe and accessible

walkways and bike lanes; it could also include ensuring there is rapidly accessible public transportation (buses, trains, trolleys, etc.). By providing options that are safe and accessible, there is an effective way to mitigate greenhouse gas emissions that are created by cars (Ferreira and Wynn, 2022). While these options are effective, they are unfortunately not always present and available. This can be seen in our borderland communities of Douglas, Patagonia, Rio Rico, and Nogales, Arizona, all of which do not operate regularly scheduled public transportation. In these cases, taking a sustainable approach by carpooling with others can be a great option.

### **Manufactured Products**

One of the more visible ways that humans have negatively impacted our planet and ecosystems can be seen with our use and waste of manufactured products. There is nothing inherently wrong with manufacturing products; however, it can pose serious risks if the creation and usage of these products are done unsustainably. One big example of this can be seen with the Great Pacific Garbage Patch. This garbage patch is the name given to several garbage patches in the Pacific Ocean that are made of immense amounts of floating plastic that pose serious threats to marine wildlife and our global ecosystems (NOAA, 2023). With the continuous creation of manufactured products in an unsustainable method, the Great Pacific Garbage Patch continues to grow. And unfortunately, due to the vast size of the garbage patch in addition to the wind, ocean tides, and the fact that a majority of the debris is small pieces of plastic, it would be difficult to effectively locate and remove all of this waste from the ocean. As a result, one of the most sustainable things that we as consumers can do, is try to mitigate our waste so that it is not as likely to end up in ecosystems such as the ocean.



**“How Big The Great Pacific Garbage Patch Really Is”**

One way that this can be done is through the sustainable creation and usage of clothing items. Unsustainable clothing production and usage directly add to the climate change crisis. This has occurred through practices known as fast fashion, which is the practice of the fashion industry rapidly creating and marketing “new” styles of clothing that consumers buy cheap, throw away and then buy the next “new” style (UN Environment Programme, 2022). Through fast fashion, plastic fibers, wastewater, toxic dyes, and immense amounts of wasted textiles and clothing items are entering and polluting our planet and its ecosystems (UN Environment Programme, 2022). While fast fashion is unsustainable, the fashion industry itself is not necessarily unsustainable. This can be seen with an increase in sustainable production and disposal of clothing items made from organic materials. One such example of this occurring can be seen locally in the composting of organic clothing with Deep Dirt Farm and Institute in Patagonia, Arizona. You will have an opportunity to engage further with Deep Dirt and its sustainability programs in the next section **Sustainable Action**.

### **Invasive Species**

In this subsection, we will be exploring invasive species and the role that humans can play in, directly and indirectly, bringing invasive species to different ecosystems. Invasive species are non-native plants and animals that easily adapt to new areas, reproduce quickly, and cause harm to native plants and animals (Rutledge, McDaniel, Tang, et al. 2022). It is important to note that invasive species in one region might not be in another region. Additionally, it is important to note that invasive species can be introduced as a result of human intervention, animal relations, natural forces (like wind and water), or merely by migration. For the purpose of this subsection, we will be focusing on invasive species that have been introduced or increased due to human intervention that is a result of direct and indirect decision making. When it comes to direct decision-making, this can be seen with the introduction of Lehmann lovegrass. The Lehmann lovegrass is

a native plant species from Africa that is now an invasive species rapidly growing across southwestern US states, such as Arizona and New Mexico. While this plant has become an invasive species in borderland ecosystems, it was originally introduced into these ecosystems by humans who planted it to reduce soil erosion and to provide forage (U.S. Department of Agriculture, 2017). While the plant was introduced in hopes of bettering the borderland ecosystems due to its ability to reproduce quickly as it is not highly eaten by livestock, the Lehmann lovegrass has altered borderland ecosystems to result in more intense and frequent wildfires (U.S. Department of Agriculture, 2017).

Regarding the impact that indirect decision-making can have, this can be seen with the increase of invasive species in ecosystems as a result of policymakers preventing cultural burning and prescribed burning out of fear of forest fires and wildfires. While forest fires can be an absolutely destructive force, if done safely through cultural burnings or prescribed burnings, it can be an effective way to remove invasive species and hazardous fuels for potential forest fires and wildfires. Through the use of cultural burning and prescribed burnings, native plant and animal species have a better chance to thrive during the next growing season (National Park Service, 2016).

Prescribed burnings are certainly an effective way to remove some invasive species, but other times this can happen by hunting the animals that are considered invasive by local communities. One very famous example of this was the removal (and eventual reintroduction) of wolves in the Yellowstone National Park region. In the following case study, you will have the opportunity to engage with the complex issue surrounding wolves and if they should or should not belong. While reading this case study, use your own environmental literacy skills to come to your own conclusions if the wolves should or should not belong in this region.

## Case Study | Wolves of Yellowstone

During the western expansion of the United States during the 1800s, humans would drastically change ecosystems through the development of areas for agriculture and ranching. These changes would result in different wildlife (plant and animal) populations drastically falling, and because of the food chain, animals that preyed on these falling wildlife populations needed to find new food sources (National Park Service, 2022). This was the case for wolves in the Yellowstone National Park region. Due to human intervention, wolves struggled to find prey, and in turn, they began hunting and eating the domestic livestock that humans brought to that region. While the wolves did this to survive, it would actually lead to their downfall as humans began hunting, poisoning, and removing the wolves that were native to this region, as humans deemed them an invasive species (National Park Service, 2022). Similar practices were happening across the United States, which resulted in wolf populations drastically falling to the point that they would be listed as an endangered species in 1974.

With the removal of wolves from ecosystems such as Yellowstone, scientists began to observe the negative impacts that happened following the removal of an ecosystem's top predator. These impacts were predominantly seen in the drastic increase in prey populations such as elk and the overgrazing of different flora species, which resulted in animals starving themselves to death (Peterson, 2020). With increasing prey populations and decreasing food options, the ecosystem of Yellowstone was facing many challenges that were only getting worse, and it was at this point that scientists hoped the reintroduction of wolves into the region could balance and restore the ecosystem.

In 1995, wolves would begin to be reintroduced into the Yellowstone ecosystem, and a balance would begin to be found. Elk populations declined as they were the primary prey of wolves, and with the population of elk falling, the flora of the

region began to significantly increase (Peterson, 2020). This increase ensured that there was a sufficient food source for prey populations like the elk and for other animals in the region that could scavenge following the wolves' hunts (National Park Service, 2022). Overall, the reintroduction of wolves at Yellowstone has allowed the ecosystem in the region to once again find balance. Moving on from this case study, keep in mind the concepts of human intervention with the following subsections, **Agriculture** and **Ranching**, as these two practices can have a direct and indirect impact on invasive species in different ecosystems, as seen with the removal and then reintroduction of the wolves of Yellowstone.

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### **Agriculture**

Agriculture is a really important thing to consider when discussing borderland communities, as the growing, packaging, and distribution of these crops and resources play a significant role in the community's culture and economics. With a continuously growing global population, the demand for the agricultural industry in these communities (and others) remains ever-high. With high demand, the industry has often adopted unsustainable practices that ensure there are resources available for human consumption, but it has often been done at the sacrifice of our global ecosystems. This can be seen with numerous unsustainable practices such as that of the use of toxic pesticides and monoculture farming.

With agriculture, there are many different animals and insects that take advantage of the introduced food source that crops are. One of the big reasons is that the food originally eaten by this wildlife is often completely removed or displaced when agricultural facilities are established. Therefore wildlife eats the food that is being grown, and it has resulted in humans developing and implementing pesticides that can be used to mitigate crop destruction through the killing of these

“pests” in addition to the killing of undesired fungi and plants (Boudreau, McDaniel, Sprout, et al., 2022). While pesticides are effective for removing these undesired flora and fauna, it does pose some serious risks for humans and for the environmental ecosystems. This can be seen with certain pesticides such as DDT (dichlorodiphenyltrichloroethane) which was believed to contribute to cancer in humans, and it was associated with the dropping population of different birds such as the bald eagle (Boudreau, McDaniel, Sprout, et al., 2022). While DDT has been banned in the United States, the use of toxic pesticides that can enter human bodies through the consumption of fruits and vegetables is still common. Pesticide usage is also

known to reduce vital biodiversity while additionally negatively impacting soil nutrients (Heggie, n.d.). Overall, pesticides do serve a purpose, but given the potential risks they pose, it is critical that pesticide alternatives are used (such as biopesticides) in conjunction with minimum risk and organic pesticides.

Ted-Ed: “Can we create the “perfect” farm? - Brent Loken”



Monoculture farming is another practice that can be unsustainable and harmful. Monoculture farming is a practice in which farmers will plant one crop repeatedly on the same plot of land year after year, such as with the annual planting of thousands of acres of a single crop such as corn (McDaniel, Teng, Sprout, et al., 2023). While the practice of monoculture farming allows for an abundance of singular crops to be grown; it is harmful to the ecosystem, as the practice drains the soil of nutrients and it allows for pests, pathogens, and diseases to thrive (Heggie, n.d.). In order to prevent the risks associated with monoculture farming, the sustainable and somewhat easy practices of crop rotations can be used. Crop rotation is the practice of rotating the types of crops that are planted. Crop rotation is a great and sustainable practice that can prevent soil nutrients from being drained, and in doing so, it improves



crop quality while reducing soil erosion (Arizona Department of Water Resources, n.d.). Crop rotation is also a great practice as it increases water quality, water infiltration, and the water-holding capacity of soil (Arizona Department of Water Resources, n.d.). This is critically important, as water availability and water usage are a serious concern for not only the agriculture industry but for the communities and ecosystems that access the same water

When discussing the agriculture industry, another critical thing that needs to be considered is water availability and the abundant usage of water to keep crops alive. In places like Arizona, where agriculture is a major industry, irrigated agriculture can be the largest user of available water. This can be seen with irrigated agriculture in Arizona consuming about 74% of the available water supply, and this substantial amount was even larger before, with water usage being at 90% at one point (Arizona Department of Water Resources, n.d.) There are state and federal policies put in place to somewhat limit the usage of water by the agriculture industry, but these policies are not that effective. As a result, water availability continues to decrease, which can be seen with water reservoirs such as that of Lake Mead in Arizona, which is the largest water reservoir in the United States and is only at 27% capacity (Earth Observatory, 2022).

This continuous decrease in water not only puts the agriculture industry at risk but also puts humans and environmental ecosystems at risk. Water is the source of all life, so when it comes to agriculture or any practices that use water, it is critical that we think about our water usage sustainably.



**“Who’s really using up the water in the American West?”**

Throughout this subsection, you have had the opportunity to engage with the unsustainable and sustainable practices associated with the agriculture industry. While there are a lot of potential issues with sustainability, because of environmental

advocates like yourself, more and more people are demanding sustainable agriculture. These demands can be seen at multiple levels, from consumers to NGOs to even policymakers that are pushing for sustainable agriculture with things like the Farm Bill. As a result of an increase in sustainable agriculture desire, the 2023 Farm Bill proposes over 29.6 billion dollars towards conservation, sustainable energy, and forestry associated with agriculture (National Sustainable Agriculture Coalition, n.d.). While there certainly needs to be a continuous effort to ensure the agriculture industry is sustainable, because of passionate environmentalists like yourself, these efforts will happen, and our communities and our ecosystems will be all the better!

### **Ranching**

One of the other significant industries that can be seen in many borderland communities is that of ranching. While ranching practices can often be integrated with farming and crop agricultural practices, given the specifics and history of ranching cattle, it is important to think of them as two different practices. Similarly to crop agriculture, ranching focuses on using large areas of land for the purpose of growing a resource that offers some type of value for humans. With ranching, this resource that is grown is livestock, primarily grazing animals such as cattle and sheep, and ranching and livestock are growing faster than any other agricultural sector in the world (Boudreau, McDaniel, Sprout; 2022). With this growth, ranching has often been seen as an unsustainable practice as meat and dairy production uses 30% of the Earth's land service, and it is one of the largest driving factors for deforestation, biodiversity loss, and water pollution (Global Forest Coalition, n.d.). While the unsustainable impacts associated with ranching can be seen with many different types of livestock, they can predominantly be seen with cattle ranching.

Cattle ranching, if done sustainably, can actually benefit ecosystems and our planet, but if done unsustainably, it adds to climate change and ecosystem destruction. One of the biggest

differences between sustainable and unsustainable ranching occurs with grazing practices. If done sustainably, cattle grazing can have many benefits, including making soil better for trapping carbon pollution and trapping sediment, which results in better water quality, and reduced erosion (NRDC, 2014). However, if done unsustainably, cattle ranching can be responsible for immense overgrazing, which results in soil erosion, surface, and groundwater pollution, the destruction of ecosystems, and the displacement of the animals that occupied it. While sustainable and responsible grazing and cattle practices can account for a lot of these potential issues, one of the few things that this cannot account for is the climate impact associated with raising cattle for beef production. This impact can be seen with the production of beef adding 4 times the amount of CO<sub>2</sub> emissions from pork and 10 times the amount of CO<sub>2</sub> emissions from chicken (NRDC, 2014). Taking all of this information into account, we can see that cattle ranching certainly has complexities, and it is a practice that needs to ensure it is being done sustainably so that ecosystems and our planet are supported and not damaged. To see an amazing example of livestock being used to support ecosystems, scan the QR code to watch a video highlighting the use of bison for sustainable development. As you're watching this video, consider the complexities of cattle and if cattle can and/or should be used for similar development opportunities.



While there are many unsustainable risks associated with many ranching practices, it is important to note that ranching is not a practice that needs to be abandoned, but it is one that needs to undergo a cultural shift to become more sustainable. By focusing on sustainable ranching, ranchers can ensure that the resources needed for ranching can be protected, which would then ensure the longevity of our global ecosystems and the

ranching operations that they conduct. In order to shift towards sustainable ranching, some operational aspects that should be considered include rotational grazing, grass types, cattle breeds, and numbers, growing seasons, water availability, and weather patterns. In the following case study, you will have the opportunity to further engage with an organization that focuses on sustainable ranching and these aspects.

### ———— Case Study | Malpai Borderlands Group (MBG) ————

The MBG is a non-profit group of ranchers who call the 800,000 acres in the Malpai Borderlands region, located in Arizona & New Mexico, home. These ranchers, many of whose families have been in the region for generations, play the role of cattle growers and conservationists as they see the necessary actions that must take place to continue their way of life. These actions can be seen with the organization focusing on land protection, innovative cooperative land management, habitat restoration, and community outreach. These actions have allowed the MBG to protect over 78,000 acres of land through conservation easements that limit the potential uses of land in order to protect the land and its conservation value (Malpai Borderlands Group, 2021). MBG works closely with local ranchers and landowners to implement sustainable land management practices and restore degraded habitats.

One of the main focuses of MBG's work in the ranching profession is the promotion of holistic management practices. This includes implementing rotational grazing systems, which involves moving livestock to different pastures on a regular basis to prevent overgrazing and allow for natural vegetation recovery. By practicing rotational grazing, ranchers can improve soil health, increase water retention, and restore native grasslands. MBG also works to reduce the use of herbicides and pesticides in ranching by promoting integrated pest management techniques that rely on natural predators and other non-toxic methods. This helps to reduce the negative impacts of these chemicals on soil health and biodiversity.

In addition, MBG encourages ranchers to use native plant species in their grazing lands, which helps to support local ecosystems and prevent the spread of invasive species. They also provide education and training to ranchers on sustainable land management practices, helping them to improve their livelihoods while also conserving natural resources. Overall, the Malpai Borderlands Group is doing important sustainability-related work in the ranching profession by promoting holistic management practices, reducing the use of harmful chemicals, and restoring degraded habitats.

The sustainable actions of MBG have allowed the organization to help develop practices that will sustain ranching operations and the ecosystems that use them. This can be seen with MBG maintaining good land management practices, operating a re-seeding program, and the development of grass banks, which are areas off limits to cows unless in a grass emergency (Schuman, 2016). These practices ensure that the destruction of the prime grasslands can be mitigated and prevented, and in doing this, MBG ensures that ranchers in its region are able to raise cattle on land year after year sustainably.

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## **Sustainable Action**

We are living in a time where humans significantly have had and continue to have monumental impacts on our planet and its ecosystems. As we have explored so far, many of these impacts can be both negative and positive. There are numerous practices that result in positive impacts that help the planet while additionally creating a better quality of life for humans. In the following subsections, we will explore some of these practices, and we will use our developing environmental literacy skills to develop thoughts on permaculture, water harvesting, and ecotourism. While engaging with these subsections, make sure to think back on the topics you engaged with in the previous section **Human Impact on the Environment**.

## Permaculture

Permaculture is an approach to land management and philosophy that adopts arrangements observed in flourishing natural ecosystems. At the center of permaculture beliefs and practices there are a set of three ethics, which are as follows (Harland, n.d.):

1. Earth Care
2. People Care
3. Fair Shares/ Future Care

These ethics are meant to be guiding values that ensure both people and the planet can work together to ensure a long and sustainable life. These ethics are built into a set of 12 permaculture principles derived from whole systems thinking, and these principles can be applied in fields such as regenerative agriculture, rewilding, and community resilience. It is believed that these 12 principles can have the power to support the development of ourselves, our communities, and our planet (Manner, 2020). These principles are as followed (Manner, 2020) :



1. Observe and interact
2. Catch and store energy
3. Obtain a yield



4. Apply self-regulation and accept feedback
5. Use and Value Renewable Resources and Services
6. Produce no waste



7. Design from patterns to details
8. Integrate rather than segregate
9. Use small and slow solutions



10. Use and value diversity
11. Use edges and value the marginal
12. Creatively use and respond to change

Taking into account the ethics and principles of permaculture, think about ways that you have seen permaculture integrated into your community or in your life. Are there ways you believe

permaculture can support the development of ourselves, our communities, and our planet? In the following case study, you will have the opportunity to further engage with permaculture by learning about a non-profit borderlands organization focused on community development through permaculture.

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### Case Study | Deep Dirt Farm

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Deep Dirt Farm and Institute is a permaculture farm located in Patagonia, Arizona, which focuses on sustainable agricultural practices. The farm was established by conservation biologist Jim Berrian in 2010 with the aim of promoting regenerative agriculture and building resilient local food systems. The farm is situated on 4.5 acres of land, and it produces a diverse range of crops, including vegetables, fruits, nuts, and herbs.

At Deep Dirt Farm, permaculture is used as a guiding principle to design and manage the farm's ecosystem. The permaculture approach aims to create a self-sustaining system where each component of the farm works in harmony with the others. The farm uses a variety of permaculture techniques, such as rainwater harvesting, composting, cover cropping, and companion planting, to create a healthy and productive ecosystem.

One of the key permaculture practices at Deep Dirt Farm is rainwater harvesting. The farm captures rainwater from its roofs and stores it in tanks, which is then used for irrigating the crops. The farm also uses swales, which are shallow ditches on the contour of the land, to slow down the flow of water and allow it to penetrate the soil. This helps to recharge the groundwater and improves soil moisture levels, which is especially important in a dry and arid environment like Arizona.

Another permaculture technique used at Deep Dirt Farm is companion planting, where different plants are grown together to provide mutual benefits. For example, nitrogen-fixing plants like legumes are grown alongside other crops to improve soil

fertility, while other plants like herbs and flowers are used to attract beneficial insects that help control pests. The farm also uses a no-till approach to farming, which helps to preserve soil structure and reduce erosion. The farm uses cover crops to protect the soil and build soil fertility, and compost is used to enrich the soil and provide essential nutrients to the crops. Deep Dirt Farm is not only a working farm but also a permaculture education center. The farm offers workshops and courses on permaculture design, regenerative gardening, and sustainable living. The farm's mission is to inspire and educate people to create regenerative food systems that are environmentally sustainable, socially just, and economically viable.



Image of Deep Dirt Farm from Borderlands Restoration Network



## Rainwater Harvesting

As highlighted in the previous section, **Human Impact on the Environment**, water availability is becoming a serious concern not only for our borderland communities but also globally. While the issue of water is one that is quite substantial and complex, there are some solutions that can help ensure that water is available. One such solution is the creation and use of rainwater harvesting systems. These systems can be an effective way to collect and store rainwater that can then be used at a later point. There are two kinds of rainwater harvesting: passive and active. Passive rainwater harvesting focuses on the construction of landscape features to direct, slow, and sink water. Active rainwater harvesting focuses on the installation of cisterns or tanks for storing and using water in the home and on the landscape. Often with these systems, rainwater is collected from a roof-like surface and redirected to a tank, cistern, deep pit, aquifer, or reservoir with percolation, so that it seeps down and restores the groundwater. Other methods of rainwater harvesting include landscape-scale watershed restoration, which is a combination of onsite structures and home-scale rainwater harvesting work. These methods not only allow for the storage of water for human use but also helps reduce the load of water that travels immediately to local waterways, which mitigates the damage that those waterways may sustain in case of floods. In order to further engage with some of the real rainwater harvesting benefits and challenges, make sure to use the QR code here!



“Rainwater  
Collection For  
Beginners”

Given that rainwater harvesting can fall under watershed restoration, ecosystem restoration, and community restoration programming, which are core parts of the BECY program, it is important to familiarize yourself with rainwater harvesting development and terminology. This can be done by engaging with the following breakout text box:

### **Close-up of Cistern Construction**

When implementing active rainwater harvesting, such as a cistern, in your home, there are a few considerations/additions to make. For instance, your cistern may be too small for your roof – we will go more into this later. If you start to collect too much water in your cistern, it is best to divert that water somewhere else where it is not backing up the pipe, causing an overflow in the gutter system. A place to divert the overflow would be into a garden. Not only are you better using this water while still saving some for later use, but you are also preventing the need to water them later. Instead of running a pipe to a tree, adding a faucet where you can attach a hose to have a flexible way to spread the water is also a great idea.



BECY Douglas 2021 after installing cistern at the DHS Land Lab

## Rainwater Harvesting Earthworks

Earthworks are labor-intensive in the beginning but save work in later years. By moving the earth around a bit based on a well-designed plan, we can control how natural elements affect our site and make life easier in the long run. It's a lucrative retirement investment plan that also yields big dividends for the earth.

## Berms and Swales

A **swale** consists of a long shallow ditch and a low **berm** built from the soil taken from the ditch. It can usually be dug by hand, though it does not have to be. Swales collect rainwater and runoff, and spread it out along their width, encouraging it to seep into the soil to nourish the roots of the plants growing on the berm. Swales are built on contour. That means they follow the lines of equal elevation that you see on maps. The most precise measurement is the level at the bottom of the swale. It must be absolutely level along its length so that water doesn't pool in one place and potentially blow out the berm.

## Overflows

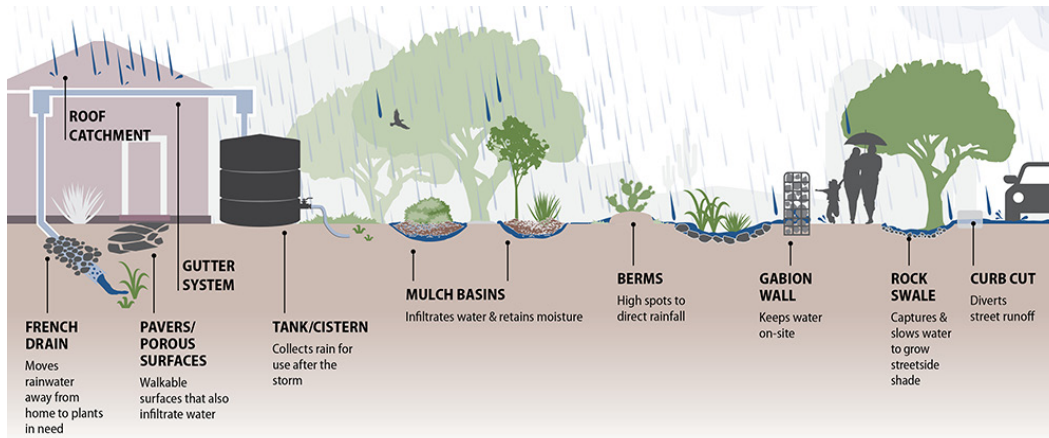
When building home-scale structures, always plan for multiple overflows so that your hard work doesn't blow out in the case of a large storm. Always plan for too much water!

## Terraces

Terraces increase planting area, soil retention, and water infiltration. It is ideal to place terraces in an area where they can receive runoff from roofs or other impermeable surfaces. Terraces can be constructed linearly or on contour, creating the largest amount of available planting space. Around the world, hillsides are terraced to arrest erosion and create valuable planting space.

## Basins

Basins are simply depressions in the ground where rainwater can pool and slowly infiltrate. They do not always have an associated berm.



## Harvest the Monsoon Rains: Ways to Capture and Collect Rainwater to Irrigate Plants, 2020

Additionally, when it comes to the actual implementation of a rainwater harvesting system, whether it be a passive or active rainwater harvesting system, it is important to consider the Seven Principles of Rainwater Harvesting. These principles have been outlined and adapted from *Rainwater Harvesting for Drylands and Beyond*, Volume 1, 3rd edition (Lancaster, 2019). By considering the accounts of the benefits and challenges of rainwater harvesting, in addition to the seven principles, you will have the knowledge and understanding to effectively complete the projects associated with the BECY program!

### Principles of Rainwater Harvesting

Adapted from Brad Lancaster's "Rainwater Harvesting for Drylands and Beyond"

#### 1. Begin with long and thoughtful observation.

Use all your senses to see where the water flows and how. What is working, what is not? Build on what works.

#### 2. Start at the top (highpoint) of your watershed and work your way down.

Water travels downhill, so collect water at your high points for more immediate infiltration and easy gravity-fed distribution. Start at the top where there is less volume and velocity of water.

### **3. Start small and simple.**

Work at the human scale so you can build and repair everything. Many small strategies are far more effective than one big one when you are trying to infiltrate water into the soil.

### **4. Slow, spread, and infiltrate the flow of water.**

Rather than having water run erosively off the land's surface, encourage it to stick around, "walk" around, and infiltrate into the soil. Slow it, spread it, sink it.

### **5. Always plan an overflow route and manage that overflow as a resource.**

Always have an overflow route for the water in times of extra heavy rains, and where possible, use the overflow as a resource.

### **6. Maximize living and organic groundcover.**

Create a living sponge so the harvested water is used to create more resources, while the soil's ability to infiltrate and hold water steadily improves.

### **7. Maximize beneficial relationships and efficiency by "stacking functions."**

Get your water harvesting strategies to do more than hold water. Berms can double as high-and-dry raised paths. Plantings can be placed to cool buildings in summer. Vegetation can be selected to provide food.

### **8. Continually reassess your system: the "feedback loop."**

Observe how your work affects the site, beginning again with the first principle. Make any needed changes, using the principles to guide you.

## Ecotourism

The final sustainable action practice we will be exploring in this section is ecotourism. In order for tourism to be considered ecotourism, as outlined by the **United Nations World Tourism Organization**, tourism would need to have one of the following five characteristics:

1. All nature-based forms of tourism in which the main motivation of the tourists is the observation and appreciation of nature as well as the traditional cultures prevailing in natural areas.
2. It contains educational and interpretation features.
3. It is generally, but not exclusively organized by specialized tour operators for small groups. Service provider partners at the destinations tend to be small, locally owned businesses.
4. It minimizes negative impacts upon the natural and socio-cultural environment.
5. It supports the maintenance of natural areas which are used as ecotourism attractions by:
  - Generating economic benefits for host communities, organizations and authorities managing natural areas with conservation purposes;
  - Providing alternative employment and income opportunities for local communities;
  - Increasing awareness towards the conservation of natural and cultural assets, both among locals and tourists.

Assuming the type of tourism meets one of the outlined characteristics, it would be considered ecotourism. For many environmentally-centric communities such as that of Patagonia, Arizona, the use of ecotourism is a major economic factor that these communities are somewhat dependent on. As a result, these communities want to ensure that environmental spaces used by tourists and locals are safe and inviting. In order to do this, communities can develop programs that focus on improving the natural landscape and ecotourism opportunities. In the following case study, you will have an opportunity to engage with such a program that was operated in Patagonia, Arizona.

### Case Study | Doc Mock Park Tree Planting

Doc Moc Park is a community park located in Patagonia, Arizona. The park covers an area of 4.5 acres and is operated by the Patagonia Community Parks and Recreation. The park was named in honor of Dr. Maurice (Doc) Mocatta, who served as a physician in Patagonia for many years. The importance of Doc Moc Park lies in its role as a community space for the residents of Patagonia. It serves as a venue for social events and recreational activities and as a place for families to spend time together. The park is also an important part of the town's tourism industry, as it is often used for outdoor events and activities that attract visitors to the area.

Additionally, the park's location in the Sonoran Desert ecosystem makes it an important site for conservation efforts. The park's natural landscape, including its many native plant species, provides valuable habitat for wildlife in the region. The park's proximity to the Patagonia Mountains and Sonoita Creek also makes it an important site for birdwatching and other wildlife observation activities. Borderlands Restoration Network and the Borderlands Earth Care Youth program recognize the ecological importance of the park. With support from the Town of Patagonia, the Tree and Park Committee, and residents, BECY Patagonia 2021 planted 74 native trees in the park. This project was funded by the Arizona Department of Fire and Forestry Management.



BECY Patagonia 2021 planting a tree at Doc Moc Park.

### Restoration Economy

A restoration economy refers to economic activities that aim to restore or enhance natural resources, such as forests, wetlands, and watersheds, while also generating economic benefits for communities. It involves restoring or improving ecosystem services, such as carbon sequestration, water filtration, and biodiversity, and creating jobs and income through activities like ecological restoration, sustainable agriculture, and eco-tourism.

“Habitat  
Restoration:  
An Economic  
Engine”



Several studies have been conducted on the restoration economy, highlighting its potential to support economic growth and environmental sustainability. For instance, a study by The World Bank found that every dollar invested in restoration activities generated an estimated \$7-\$30 in economic benefits (The World Bank, 2023). The mutual

benefits for economy and ecosystem, highlight that a restoration economy is an effective way to implement sustainable change that is beneficial to both humans and the environment. These benefits can even be seen on a local level in the following case study:



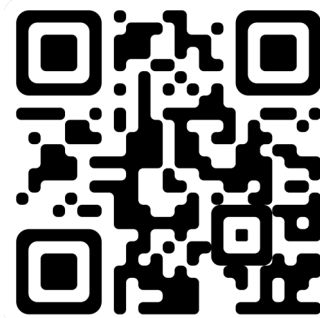
## Case Study | Nature-Based Restorative Economy in Santa Cruz County, Arizona

The Nature-Based Restorative Economy in Santa Cruz County, Arizona, was a study conducted by the University of Arizona that examines the potential for a restorative economy based on the conservation and restoration of natural resources in Santa Cruz County. The study looks at the relationship between the local economy and natural resources and explores the potential for the restoration of degraded ecosystems to create new economic opportunities.

The study found that natural resource-based industries such as tourism, recreation, and agriculture are vital to the local economy of Santa Cruz County and that these industries rely heavily on the quality and availability of natural resources. The study also found that the restoration of degraded ecosystems can create new economic opportunities in the form of ecosystem services, such as carbon sequestration, water filtration, and pollination. The study recommends the development of a restorative economy based on the conservation and restoration of natural resources, which would require collaboration between government agencies, private industry, and community organizations.

The study suggests that a restorative economy based on natural resources could provide multiple benefits, including job creation, increased economic activity, improved environmental health, and enhanced community well-being.

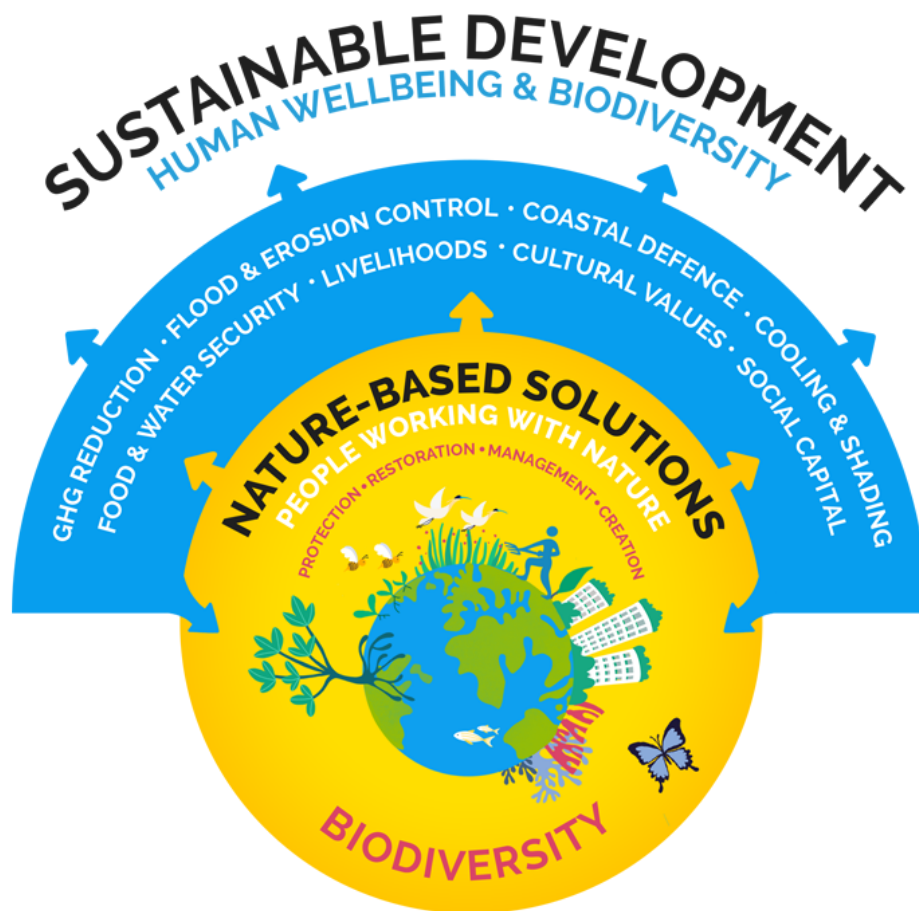
If you are interested in learning more, you can read more about this study from the University of Arizona's College of Agriculture and Life Sciences. Using the QR code here:



**“Nature Based Restorative Economy in Santa Cruz County, Arizona”**

**Some resources on restoration economy include:**

- **“Restoration Economy”** by Storm Cunningham: This book provides an overview of the restoration economy and the various sectors it encompasses, such as brownfield redevelopment, green infrastructure, and sustainable forestry.
- **“The Restoration Economy: The Greatest New Growth Frontier”** by Renewal Partners: This report summarizes the economic and environmental benefits of restoration activities in various sectors, including agriculture, forestry, and energy.
- **The Society for Ecological Restoration:** This international organization promotes the science, practice, and policy of ecological restoration and provides resources for professionals and practitioners in the field.



(University of Oxford, n.d.)

## CHAPTER 2: Ecological Restoration

The Arizona borderlands region has experienced significant environmental impact and habitat loss over the years due to various human activities and climate change. Throughout this chapter, we will dive into how ecosystem restoration can help address these challenges, promote sustainable practices, and contribute to the Sustainable Development Goals.



**SDG 3:** The health and well-being of both the natural world and the communities that depend on it, through ecosystem restoration efforts, aids in ensuring borderland communities have access to **Good Health and Well-being**. These practices help improve water quality, support biodiversity, and many ecosystems that benefit not only southern Arizona flora and fauna but also human health.



**SDG 9:** Educating the borderland communities with the importance of restoration ecosystem **infrastructure**, the benefits of a healthy environment, and **innovative** practices can help promote a greater understanding and appreciation for nature. This empowers the local communities to take action and get involved in future restoration **industry** opportunities.



**SDG 15:** Restoration work on our ecosystems is essential for achieving a sustainable **Life on Land**. Restoring land can help to enhance soil health, biodiversity, and production of natural resources. This helps improve the livelihoods of local communities and ensures the long-term resilience of the borderlands.



**SDG 13: Climate Action**  
How does Ecological Restoration relate to Climate Action?

## Ecosystem Restoration

### Problem – Threats to Biodiversity:

Over the last quarter century, important pollinator species in the Southwest have been on a decline. Some of these species include native bees, monarch butterflies, hummingbirds, and nectar-feeding bats. These shifts are currently being induced by climate change as well as other human stresses being put on the environment. Some human stresses include increased land use and the planting of **monotypic** plants (Buckley & Nabhan, 2016). There is evidence to suggest there is declining availability of key plant species and shifting flowering patterns due to changes in climate which are affecting the vitality of pollinator species (U.S. Department of Agriculture, n.d.). Wildflowers, important resources for pollinators, are blooming earlier in the spring than before. This is leaving gaps in nectar resource availability for certain pollinators that were previously available to these species (U.S. Department of Agriculture, n.d.).

### Solution – Support Ecosystem Resilience:

BRN's approach to ecosystem restoration is strategic, focusing on gaps in the food web and selectively planting native species to provide appropriate food sources for native wildlife as they adapt to changing ecosystem conditions. Our goal is to increase the resiliency of the natural ecosystem. Which involves identifying native plants to the region that have been lost and establishing viable populations of an assortment of fruit- and nectar-producing plants that will support many local animal species. This strategic mission is not only important for the local restoration economy and ecosystem, but also important when it comes to the world's collective Sustainable Development Goals: 3: Good Health and Well-being, 9: Industry, Innovation, and Infrastructure, 13: Climate Action, and 15: Life on Land.

BRN's efforts to engage local community stakeholders and promote community-based work with programs, such as BECY, align with the North American Association for Environmental

Education's (NAAEE) key themes to promote community engagement, equity, and accessibility to enhance environmental education and restoration opportunities. Their work reflects the importance of collaboration in successful environmental sustainability and restoration work.



(Ali, 2021)

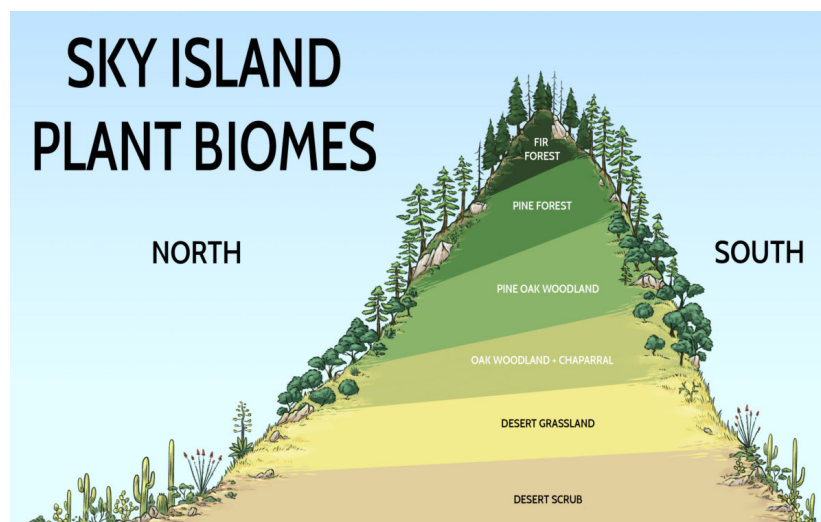
### What is an ecosystem?

An ecosystem is a geographic region where land, weather, plants, animals, and many other types of organisms all form a unique “bubble of life.” Within this ‘bubble,’ there are both **abiotic** (non-living) and **biotic** (living) factors contributing to an ecosystem (National Geographic, 2022). A healthy ecosystem depends upon the interactions of plants, animals, insects, and microorganisms. They all co-exist in a delicate balance on our planet and each species has an important role to play. Greater biodiversity ensures natural sustainability in all life forms. In Southern Arizona, we cohabit with a particularly biodiverse region known as the Madrean Archipelago.

This area of the basin and range topography is where two major mountain ranges, the Rocky Mountains to the north and the Sierra Madre Occidental to the south, geographically converge with the Chihuahuan Desert and Great Plains to the east and the Sonoran Desert to the west (United States Forest Service, n.d.). The rain shadow effect of saturated clouds hitting the Sierra Madres creates a Neotropical corridor for plants and creatures to travel to the Sky Islands from the jungle (United States Forest Service, n.d.).

### What are the Sky Islands?

The Sky Islands are mountain ranges in southeastern Arizona and northern Mexico. They are called "islands" because they are mountain ranges, mesas, and buttes surrounded by "seas" of desert and grasslands, making them distinct and isolated habitats (United States Forest Service, n.d.). The unique climate of the Sky Islands make them home to a wide range of plants and animals in a limited area. It is a bridge between the subtropical Sierra Madre mountain range in Mexico and the temperate Rocky Mountains in the United States allowing for the mixing of different types of plant and animal life (United States Forest Service, n.d.). The Sky Islands have a wide range of elevations connecting the Sierra Madre Occidental all the way to the Colorado Plateau which includes the plain grasslands, the Chihuahuan Desert, and the Sonoran Desert (Sky Island Alliance, n.d.).



Sky Island Alliance

### Why is the Sonoran Desert Unique?

The Sonoran Desert region is much of Arizona, Southern California, Northern Mexico state of Sonora, and Baja California. It is the wettest, greenest, and most diverse desert in North America due to the average amount of rain each year, and the biseasons of rainfall (ASDM, n.d.). And all the world's biomes are represented in the Sonoran Desert: tundra, coniferous forest, temperate deciduous forest, grassland, chaparral, desert, thornscrub, tropical forest, and riparian communities (ASDM, n.d.). Dive Deeper into Sonoran Desert Biomes by scanning the QR code here.



“A Look at the Sonoran Desert”

### Sonoran Desert Region

The Sonoran Desert Region consists of the Sonoran Desert itself plus the surrounding biological communities, including the Sea of Cortez (Gulf of California) and its islands



Arizona Sonoran Desert Museum 2006

## Flora and Fauna in the Sonoran Desert

### Adaptations of Flora and Fauna

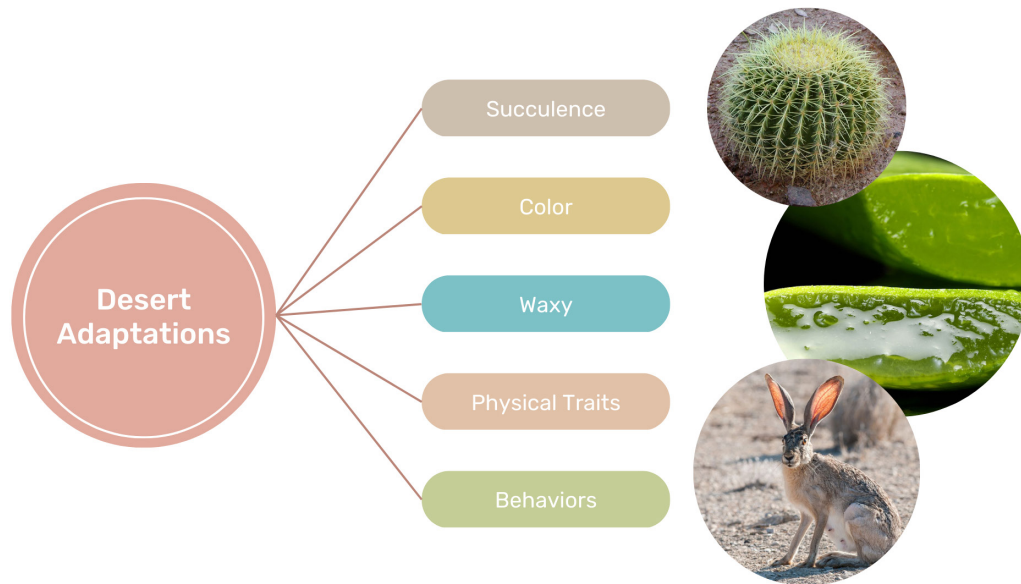
Many think that the desert is a 'hostile' environment to live in, but both **flora** (plants) and **fauna** (animals) of the Sonoran Desert have amazing adaptations to help them survive in the seasonal temperature changes and drought phases (Dimmitt, n.d.). Desert flora have three main adaptations: succulence, drought evasion, and drought tolerance (Dimmitt, n.d.). This can be seen in their fleshy succulent stems to help them retain and conserve water. Through their grayish-green waxy coloring, small leaves, and deep roots all these structural characteristics help with drought evasion and tolerance allowing them to survive in dry, hot conditions of the desert.

Desert fauna (animals) have many adaptations to help them cope with the challenges of living in a hot and arid environment with a limited water supply. Most desert animals are nocturnal; coming out to play during the evening to avoid the heat of the day, and typically sleep during the day in cool and hidden places like underground burrows, rock crevices, or cactus holes (ASDM, 1999). There are some desert animals that are active during parts of the day and have different adaptations to cope with the desert heat. A jackrabbit, for example, has long ears that are thin and full of blood vessels which help to cool it down (ASDM, 1999). A lot of desert animals get their water from the food they eat too. However, larger desert mammals like coyotes, bobcats, and foxes need to drink water and are typically within a decent traveling distance from a water source (ASDM, 1999).

### Did you know?

Kangaroo rats are the champions of water conservation as their special digestive system can extract enough water from the seeds they eat to survive without drinking water or eating juicy plants (ASDM, 1999).





### The Effect of Fire on Ecology

Wildland fires remove herbaceous and woody material that anchors sediment upslope, promoting soil loss by erosive forces. A combination of upland structures (such as rock rundown and media lunas) and in-channel features (trincheras, Zuni bowls, ORDs) can significantly reduce this impact. Additionally, increased soil moisture arms plant roots against fire effects. If a prescribed burn is expected to affect a large area, it is prudent to plan and install structures pre-burn.

Once the vegetation is lost after a fire, a major water-retaining feature is lost from the landscape. This means if there is a major rain event, there is a high likelihood this will cause major flooding. With this flooding, a flash flood can occur and pick up so much slash, or dead tree material, and carry it downstream where it can cause even more damage by physical force or by depositing this in a water harvesting system.

Wildfires in and of themselves are a natural phenomenon. Some ecosystems are differentiated from one another due to their fire frequency. For example, a grassland that has a fire regime of only a few years cannot support trees because frequent fires will

kill trees before they can truly become established. Fires are less frequent in forests which is why there are many established trees. Some of the trees in Southern Arizona, such as the Ponderosa Pine, have adapted to be more tolerant (not resistant) towards fire by having thick bark and shedding low branches.  
(Neary et al., 2008)

### **Did you know?**

You can tell the intensity of a fire by looking at the first 10 feet above the surface of the ground. If a small-intensity fire had gone through recently, the area will have short grass, very few young trees, and a lot of living, old trees. If a high-intensity fire had gone through, there would likely not be grass and the first 10 feet of trees would be charred. The last thing you want is for the fire to become so intense that it reaches the tops of the trees which causes fire to spread quickly.  
(Andrews et al., 2011)

### **Are there any ecological benefits of fires?**

“Wildland fire is a term used to describe fires that occur naturally or are set intentionally as part of planned burns.” (National Geographic Society, 2022) While all fires can be dangerous, prescribed burns are carefully planned with strict safety measures. “Fire is a natural occurrence, and certain plants and animals have adapted to depend on wildfires, which happen periodically, for ecological balance.” (National Geographic Society, 2022) They also help to clear out dead organic material, which benefits many ecosystems. Plant and animal populations sometimes even rely on the benefits fire brings for reproduction and survival. Prescribed burns are also an effective way to prevent more destructive wildfires from happening. The buildup of decaying organic matter on the ground can fuel wildfires, but periodic prescribed burns can help reduce the risk of more dangerous fires and clear out organic build-up.

## Grasses

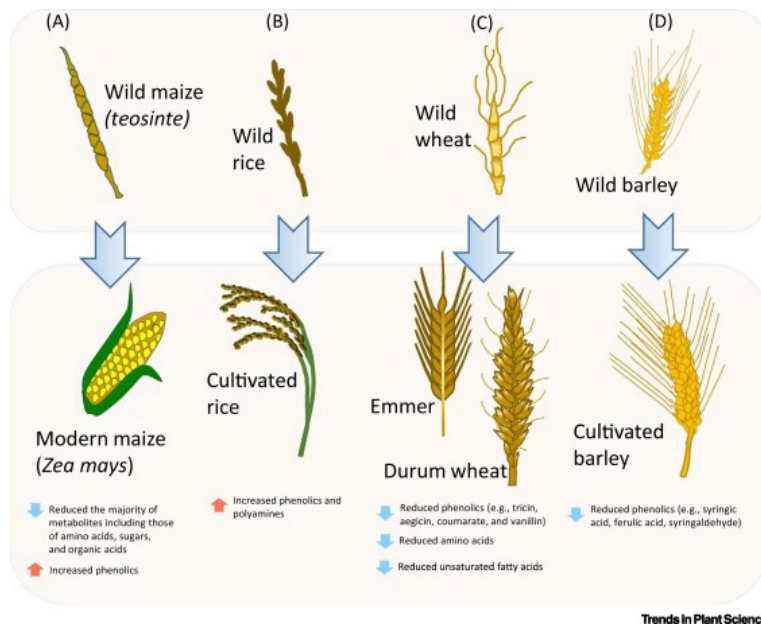
“Grasses are one of the most abundant plant groups across the globe feeding a lot of the world’s animals, including humans.” (National Wildlife Federation, n.d.) Some grasses have even been introduced by people who believe it will improve their livestock production. “When in reality the immediate ecosystem the non-native species of grass is introduced to, impedes the native species' growth within that region. It has no real predators and competes with native species, which can then significantly impact both flora and fauna species' reproduction and health.” (National Wildlife Federation, n.d.)



There is a wide range of grasses; there are those that have a tendency to grow in a low layer, spreading out across the ground, and those that grow tall. Some grasses have very small seeds and those that have much larger seeds, like corn! (See Figures...below)

### Did you know?

Corn is grass! Look back at selective breeding and you will see that the best-producing corn plants were left to breed, creating bigger and better offspring (United States Department of Agriculture, n.d.).



(Alseikh et al., 2021)

### Trees and Shrubs

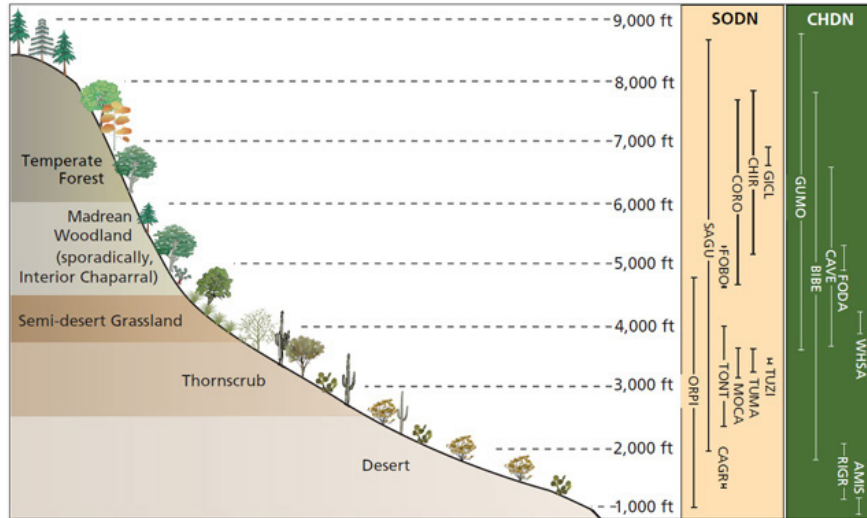
In Arizona, there are species of trees ranging from Mesquites to Douglas Firs. All trees are important to the environment, whether it be for the benefit of plants or animals. Plants benefit as taller trees provide shade and shelter, protecting more vulnerable plants from harsh sun or snow. Any litter caused by falling leaves creates a great layer of biomass on the ground which can be used by bacteria and fungi to add organic materials to the soil. For wildlife, trees are a source of food and habitat. Nuts and other

fruit provide a large part of diets for creatures including deer, birds, and many insects. Also, any hollows or horizontal branches provide a great place for roosting or nesting areas for birds. If a tree is too weak to sustain high winds and breaks it creates a lower shelter for a bedding area for deer or other animals.



If you see a cavity in the ground next to a charred, downed tree, that hole was likely the result of the root system burned by a forest fire. Though a tree was lost, it created a place where water collects and a carbon source. Since the ground is most likely softer now, the water can more easily be filtrated into the soil. This also creates a pool that is a great water source for wildlife in the area. Even after the tree is dead, it still provides an ecological service!

Shrubs are also an important component in a healthy ecosystem environment. They are usually more common in the lowlands but are found in every region of the Sky Islands. They provide a food source for wildlife and pollinators, and you are likely to find some rabbits hiding in and around these plants. Shrubs bridge the height gap between low-growing forbs and grasses and sky-scraping trees. (Examples Following/See Figure...)



(U.S. National Park Service, n.d.)

### Succulents: Aloe, Agave, Cacti, Yucca

There are four main types of succulents: aloe, agave, cacti, and yucca. Succulents are more than little cacti you find planted in terracotta pots. They can be fleshy aloe succulents, leathery agave, stringy yucca, or prickly spiky cacti. Saponin found in Soaptree Yucca roots has antibacterial properties for hand washing. The spines, leaves, and fronds from the Saponin plants can be wound into cordage to make baskets or ropes. They are also a major contributor to pollinator survival. This range of desert flora (aloe, agave, cacti, and yucca) have incredible adaptations and makes the Sonoran Desert unique, green, and so diverse!



## **Wildlife in the Borderlands**

Included in the idea of Ecosystem Restoration is the connection between everything, whether it be flora or fauna, everything is intertwined. Wildlife continues to be mentioned throughout this handbook as that is one of the ecological groups that we are working to preserve. Previous work in the BECY program includes working to establish ponds for habitat for the Chiricahua Leopard Frog (***Rana chihuahuensis***) and pollinator plants for species like bats and birds.

The Madrean Archipelago (or Sky Islands), which spills into southern Arizona, includes a region known as the neotropics. A common fauna found in this region is the jaguar. Arizona is home to the only known jaguars in the United States. The first documented jaguar sighting was in the mid-1990s by a local rancher and mountain lion roundsman, Warner Glenn. This came as a major surprise to Glenn when he answered his dogs' howls and came across this spotted feline. Many jaguars have been spotted before and in the United States, this was the first. The experience is documented in Glenn's book **Eyes of Fire: Encounter with a Borderlands Jaguar**.

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### **Case Study | Borderlands Jaguar**

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Information from Malpai Borderlands Group website.

"In early spring of 1996, Warner Glenn and his daughter Kelly were on a mountain lion hunt in the Peloncillo Mountains when they got on the trail of what appeared to be a large lion. When Warner finally caught up to it, the "lion" turned out to be a jaguar. As luck would have it, Warner had a full roll of film in his camera. The photos he took of the jaguar were the first ever taken of a wild jaguar in the United States. Jaguars have occasionally been seen in Arizona over the years, one as far north as the Grand Canyon in 1932, but all seem to have been wandering individuals, with no clear evidence of a population north of the Mexican border.

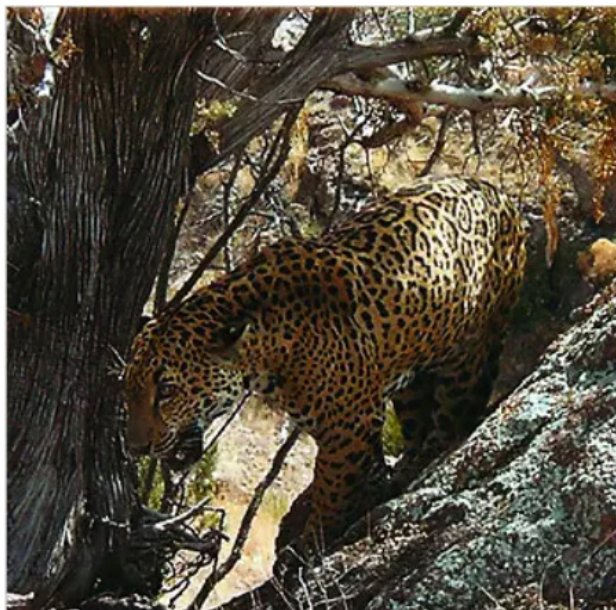
Warner's sighting of the jaguar caused us to take a closer look at the status of jaguars in the area. We invited Alan Rabinowitz, one of the world experts on jaguars, to visit our area and evaluate how suitable habitat in the borderlands might be for the big cats. He emphasized three main factors of importance for jaguars: access to water, abundant prey, and isolation from human populations. He thought that the borderlands are too dry, and prey abundance too low, to support a jaguar population. He said, "If a jaguar lived here, he would have to pack his lunch."

However, a short reconnaissance to the south, just 130 miles from the border, showed the canyons of the Rio Yaqui, and its tributaries the Rio Aros and Rio Bacadehauchi, to be more suitable, with reliable perennial water and many square miles of rugged barrancas with no roads. Shortly after that, Mexican biologist Carlos Lopez conducted a study of the status of jaguar in the mountains of eastern Sonora through interviews with local ranchers and hunters. He found lots of evidence of a jaguar population in a remote, roadless area of the Sierra Madre; unfortunately, much of the evidence was in the form of jaguars killed by Mexican ranchers, totaling nearly two dozen over a three-year period. A follow-up study using remote monitoring cameras has documented numerous jaguars in what is probably the largest jaguar population for many hundreds of miles. The Malpai Group started a jaguar conservation fund with proceeds from sales of a book of Warner's photos. This fund is intended to be used to reimburse ranchers for the loss of calves killed by jaguars. The fund also has been used to support jaguar studies such as those conducted by Carlos Lopez. Despite the population just a little over 100 miles away, there has been no further evidence of jaguars in our area until 10 years later. The drought of the last few years has probably made conditions too harsh here for this tropical animal, but we hope that by keeping the country open and wild we will see them here again when the rains increase, and water and wildlife conditions improve. The Northern Jaguar



Project is working 125 miles south of MBG to preserve the core population of Jaguars that affect our area.

A new jaguar photo was taken by Warner Glenn in the Malpai Borderlands in 2006, 10 years after he photographed the first jaguar in the area. It is not the same jaguar that Warner photographed in 1996. The spot patterns were different. This jaguar also was a large male. He was in beautiful shape. Looked to be an older cat. Seven people saw the cat as it went on its way. The core jaguar breeding population is approximately 140 miles to the south. This is not that great a distance for a male jaguar to travel, making his rounds to see the country. Many other species reap the benefits of our work and will continue to for generations. The recurrence of perennial flows will not only bring back drinking water to these arid lands but will also support more vegetation for food. More vegetation means more small prey animals for predators. Though these are long-term expectations, animals have already visited our structures – we can tell this by finding and identifying their tracks and/or scat on and around our structures.” (Malpai Borderlands Group, 2021)



(Blakeslee, 2006)

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### Case Study | Wildlife Biologist & Jaguars

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Sergio Avila is a conservation scientist and wildlife biologist who currently serves as the Senior Scientist and Regional Coordinator for the Sierra Club's Borderlands Program. He is a leading expert on jaguars and has worked extensively on their conservation and management in the United States and Mexico. Sergio was born and raised in Mexico and developed a passion for wildlife and conservation at a young age. He received a bachelor's degree in biology from the Universidad Autónoma de Baja California Sur in La Paz, Mexico, and later earned a Ph.D. in wildlife ecology and management from the University of Arizona in Tucson. During his Ph.D. studies, Sergio focused on the ecology and conservation of jaguars in the United States and Mexico. He conducted field research in the Sonoran Desert and the Sierra Madre Occidental, studying jaguar behavior and habitat use patterns. His research helped to establish a better understanding of the ecology of jaguars and the importance of maintaining their habitat connectivity across international borders.

After completing his Ph.D., Sergio joined the Borderlands Program at the Sierra Club, where he works to protect wildlife and habitat in the U.S.-Mexico borderlands region. He has played a leading role in efforts to conserve jaguars in the region and has been instrumental in establishing a network of cameras that monitor jaguar populations and movements. Sergio is deeply passionate about jaguars and their conservation. He believes that jaguars are a vital part of the cultural and ecological heritage of the borderlands region and that their conservation is essential for preserving the region's biodiversity and cultural identity. He has spoken widely on the importance of jaguar conservation and has been featured in numerous media outlets, including National Geographic, The New York Times, and the BBC.

Take some time to learn more from Sergio's experience working in the conservation field and with jaguars.

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In the podcast episode "Changing the Narrative in Science & Conservation" with host Kristina Young, wildlife biologist and conservation scientist Sergio Avila discusses his work in conservation and his efforts to increase diversity and inclusivity in the field. The episode begins with Avila discussing his background and how he became interested in conservation. He talks about his childhood in Mexico and how his grandmother's love for nature inspired him to pursue a career in conservation. Avila also discusses his academic and professional journey, including his work with the Borderlands Restoration Network and his research on jaguars.

The conversation then turns to the topic of diversity and inclusivity in the conservation field. Avila notes that the conservation field has historically been dominated by white, male voices, and discusses the importance of increasing representation and mentorship opportunities for underrepresented groups. He also talks about his own experiences as a Latino scientist working in the field, and the challenges he has faced.

Avila emphasizes the need for a more holistic approach to conservation that takes into account the interconnectedness of ecosystems and the importance of community involvement. He discusses the work of the Borderlands Restoration Network in restoring habitat and building community partnerships in the borderlands region, and notes the importance of working with local communities to address conservation challenges.



Interview with  
Sergio Avila



(Diversity in Action, 2022)

## The 'Food Web'

### What is the food web?

A **food web** is the natural interconnection of food chains and a graphical representation of what eats what in an ecological community (Wikipedia, n.d.). A good graphical representation of how producers and consumers coexist is the trophic or ecological pyramid that shows the flow of energy at each trophic level in an ecosystem...“a trophic level is the group of organisms within an ecosystem that occupy the same level in a food chain.” (Biology Dictionary, 2019)

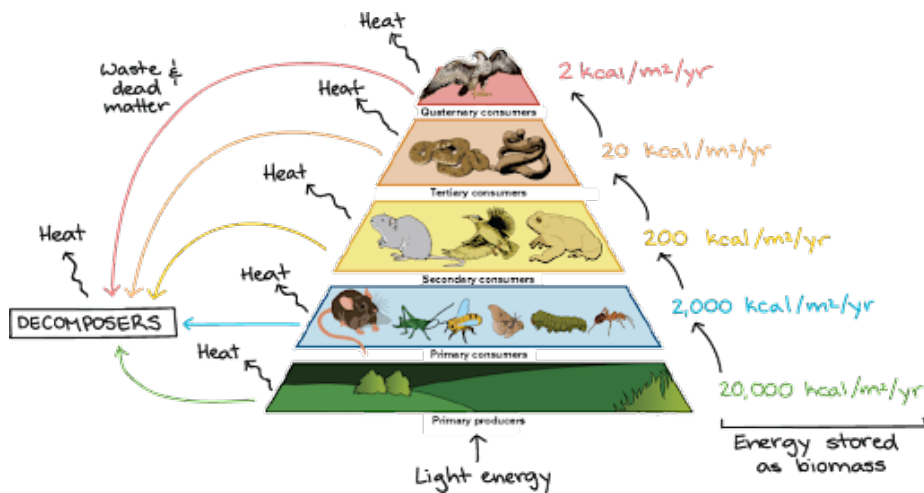
Within a food chain, there are five trophic levels, each differing in nutritional relationship with its primary energy source (the sun). The sun provides energy input used by **primary producers (autotrophs)**, like plants or algae, which perform photosynthesis to provide their own food source. The second trophic level consists of **primary consumers (herbivores)** they retain energy by eating primary producers. Primary producers (autotrophs) make up the first trophic level. The other trophic levels are made up of **consumers (heterotrophs)** which cannot produce their own energy and must consume other organism species to gain nutrition.

The third, fourth, and fifth trophic level consists of **carnivores** (animals that survive off other animals) and **omnivores** (animals that eat both plants and other animals). The third trophic level consists of **secondary consumers: carnivores and omnivores** who eat herbivores (primary consumers). The fourth trophic level also contains carnivores and omnivores which eat secondary consumers (third trophic level species) these are the **tertiary consumers**. Lastly, the fifth trophic level contains **apex predators**; these animals are at the top of the food chain and do not have a natural predator.

(Biology Dictionary, 2019)

“Decomposers such as fungi, bacteria, earthworms, and flies, recycle waste material from all other trophic levels and are an important part of a functioning ecosystem.” (Biology Dictionary, 2019) The energy transfer of total biomass between the levels decrease from the bottom up. Most of the energy is lost in heat transpiration, physical behavioral activities, and other biological functions; the gradual loss of energy and transfer of biomass between each trophic level is viewed as a trophic pyramid (Biology Dictionary, 2019).

Note that ecosystems are complex! Most animals have both prey and predators making trophic levels not uniform. The typical “food chain” ideology can be best understood and viewed as a food web instead. The disturbance within one of the trophic levels, like the extinction of a predator, or the introduction of a new species, can have a significant effect on the other trophic levels (Biology Dictionary, 2019).



(Khan Academy, n.d.)

### Did you know?

Why is veganism and vegetarianism more sustainable? It is all about energy transfer! Your trophic level is your position on the food chain, which determines how much energy you require. Animals store only a small fraction of the energy they extract from the food they eat, and the rest is lost as heat. If you eat animal foods, most of the energy in the plants those animals ate has been lost as heat and only a fraction of it reaches you. Eating plants is more efficient, meaning that less of the energy the plants contain is lost. Ultimately, this means that less land is required to support a population of vegetarians or vegans compared to someone that mainly eats animal products.

### Case study | Monarch Butterflies / Xceres Society for Invertebrates

In the Sonoran Desert region of Arizona, native milkweed plants are an essential component of the ecosystem. These plants are adapted to the hot, dry conditions of the desert and are well-suited to providing food and habitat. However, many populations of native milkweed have been lost due to human development, habitat destruction, and the use of pesticides. Planting native milkweed is important for the ecosystem because it helps to support the monarch butterfly population and maintain the balance of the local food web. By providing food and habitat for monarch butterflies, native milkweed helps to ensure that this important pollinator species can continue to thrive in the region.



(Monarch Butterfly Conservation, n.d.)

Overall, the relationship between monarch butterflies and native milkweed plants is a **mutualistic**, with both species benefiting from the presence of the other. By planting native milkweed and supporting monarch butterfly habitat restoration efforts, we can help to ensure that this important relationship continues to thrive in the Sonoran Desert and beyond (Fallon et al., 2015).

The Xerces Society for Invertebrate Conservation is a nonprofit organization that works to protect and conserve **invertebrates** and their habitats, including monarch butterflies and native milkweed plants. They have been a key partner in monarch butterfly conservation efforts in the United States. The organization has played a leading role in promoting the planting of native milkweed and other pollinator-friendly plants, as well as advocating for the reduction of pesticide use in agriculture and urban areas. The Xerces Society also conducts research on monarch butterfly populations and their habitat needs, which helps to inform conservation strategies and policy decisions. Overall, the work of the Xerces Society is critical for the conservation of monarch butterflies and native milkweed plants in the Sonoran Desert region and beyond. (Xerces Society, n.d.)

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### **What is the food web foundation?**

Plants need pollinators to survive, and pollinators need plants to survive; they are not mutually exclusive. Pollinators are the foundation of the food web! There are many types of pollinators: hummingbirds, bees, bats, butterflies, other small animals, and even humans. All of which help the reproduction of plants and ecosystem resilience (Pollinator Partnership, n.d.). Pollinators are important because they transport the pollen necessary for seed production. This is the classic phenomenon of ‘the birds and the bees.’ How is this done? Pollen from a male flower is taken to a female flower where it will bloom into a fruit that bears seed.

If the fruit were produced without pollen the seeds would not be viable. Let us break it down into a simple formula:



### Pollinator Garden Design

When you are thinking about planting a garden to attract pollinators, think of coherency, color, contrast, and continuity between seasons. Think of the specific “life history” needs of pollinators, from larval host plants and nectar sources for the Arizona swallowtail butterfly. Even to the nesting substrates and foraging distances of cactus bees. It is their needs (not ours) that must be met through the structure and seasonality of the groups of plants that you integrate into a comprehensive design.

It may take some time and study to adequately select plants for a pollinator garden design that creates the greatest seasonal continuity. Nevertheless, it will be well worth the effort if the knowledge you have acquired can help to better support a haven for foraging, nesting, or roosting pollinators. At the very least, a pollinator garden should offer insects and birds enough nectar and pollen to survive. At best, these plantings can enhance the health of the entire biotic community they reside within, including their human neighbors.

#### Case Study | BECY Intern’s Pollinator Garden

Nicole Luna, a graduate of the BECY program, turned a vast portion of her yard into a pollinator sanctuary. This continuous project has grown with time through Community Restoration Projects and her love of conserving pollinator species. Her garden is set up to host get-togethers while also serving as an



educational space for those wanting to learn about the multiple gardens flourishing in her yard. With spring in the air, we get to see many flowers bloom and are surrounded by many beautiful living things. The following is an excerpt from Nicole's experience:

“My backyard has been a host to many of our pollinating guests. We all start somewhere and for these eager pollinators, one of their many stops took place in my backyard. One of the visitors was a bee, that collected nectar from the Aloe Vera flower, going in and out of the tubular flowers. As these friendly guests come and go, I spotted another pollinator: a giant swallowtail butterfly fluttering around the white flowers of my Dancy Tangerine Tree tasting the sweet nectar of the blooms.

As the days passed, we got a special visitor, a hummingbird, that comes every morning, midday, and then again during sunset. Wonderful hummingbirds circled the feeders hanging from the Prosopis Chilean Mesquite Tree enjoying the tasty nectar from the feeders. It is fascinating to see how many pollinators came and revisited my backyard. With each new day that passes new arrivals show up. So anxious to see what my flower garden will bring next!”

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Ideally, we would like to design pollinator habitats by being able to see, smell and feel their microclimates as hummingbirds, bats, bees, and butterflies or night moths do. If we were successful, we would be able to create environments where pollinators could easily find nectar and pollen foraging resources, comfortable roosts, and potential nesting or mating sanctuaries with ease. Because you may lack the capability to fully sense the world as they do, at least remember that pollinators must meet three essential needs to survive and reproduce: sustenance, shelter, and safety.

### Did you know?

“Pollinator Syndromes” describe flower characteristics or traits, that may appeal to a particular type of pollinator. Such characteristics can be used to predict the type of pollinator that will aid the flower in successful reproduction. A combination of color, odor, the quantity of nectar, location and type of pollen, and flower structure can each affect a potential pollinator's ability to locate a flower and its food resources.

**Sustenance:** Most pollinators are rewarded for their fertilization services to the flower with a kind of nectar suited to their nutritional needs. Flower nectars vary in their ratios of different kinds of high-energy carbohydrates, fructose, sucrose, glucose, etc. These roughly tend to match the needs of their most allegiant pollinators. But nectar alone does not provide enough liquid for pollinators – they must also drink free-standing water, either from surface water or a damp, seep-like patch of soil. Meanwhile, pollen, which is gathered by many bees, supplies the essential amino acids that are used to maintain body tissue and assist in raising young.

Pollinators prefer variety and it is best to have three or more different plant species flowering at a given time. It's especially important to maintain a healthy pollinator population in the face of climate change by choosing plants that flower early in spring and late in fall (U.S. Department of Agriculture, n.d.). “Pollinators thrive when native flowers dominate their diet!... However, alternatives are an option too. For instance, artificial hummingbird feeders have their place in some instances. They can bring life to areas that are not conducive to planting large gardens, assuming they are cleaned and refilled routinely” (U.S. Department of Agriculture, n.d..

**Shelter:** Some plantings, intended to aid pollinators, temporarily centralize a few kinds of common bees or hummingbirds in one location, but without increasing the size or diversity of their resident or migrating populations. Expanding and diversifying these populations requires achieving a mass of foraging, nesting, and roosting habitat. Creating shelter to buffer from cold or extreme heat and unfortunate events may also help pollinator populations build through time rather than decline. Dead branches and hollows on trees and shrubs can provide roosting and nesting habitat, so they should not necessarily be pruned away. These woody plant structures provide habitats for a variety of pollinators, which then help local flora nearby thrive.

Similarly, grasses are useful for bumblebees, they nest within or beneath clumps of dead grass stalks. Native bees may lay eggs in trimmed hollow-stemmed grasses. In the desert and climbing uphill into the Sky Islands, Yucca, Sotol, and Agave stalks often house carpenter bees. A pile of dry, loose sand in an area that receives warm sun in the morning invites ground-dwelling bees. Artificial dwellings, such as bee boxes can bring creative and inviting spaces into a pollinator garden too!

**Safety:** Gardens are best when they are a place where both humans and pollinators can be safe from threats. “Pesticides pose a threat to pollinators, especially to insect pollinators like butterflies, bees, and moths. The United States Department of Agriculture cautions that inappropriate use of pesticides may be one of several contributing sources of Colony Collapse Disorder, which has in recent years destroyed honeybee populations across the globe.” (United States Environmental Protection Agency, 2022) If you want to maintain populations of native bees or honeybees, you should avoid the use of pesticides and herbicides to maintain healthy pollinator specie populations.

## Pollinator Habitat Design in the Arid West

If you want to design your own pollinator garden, you do not have to start with a huge plot of land. You can start with a small garden at first then expand as you learn what plants were visited the most or what species you did not see visit your garden. This way you can better plan out what plants you want to have. What plants were not taken into consideration. And what plant species could be replaced that attract pollinator species you want to see more of. Another idea is to have several small locations along a pollinator migration corridor. Along a piece of land, where a species is commonly migrating, you can ensure they have enough nectar along their journey. This does not require huge plots of land but still helps the pollinator populations in the area and can be constructed in collaboration with friends, family, and other partners.

Regarding the basic design principles for habitats that attract pollinators and other beneficial wildlife, we've taken much of our inspiration from Bill Mollison's Introduction to Permaculture and Janine Benyus' **Biomimicry: Innovation Inspired by Nature**. They remind us that in designing any habitat, we should:



1. **Try to mirror nature** – practice intentional observation of how the local natural systems interact and avoid thoughtless action.



2. **Focus on getting most of the work done through the use of local, renewable resources** – collect rainwater to irrigate plants, compost, and build soil from local nutrients and organic materials



3. **Maximize the value of edge effects** – extend the length of the garden edge with curves to increase habitat space, biodiversity, and plant growth.



4. **Accelerate natural ecosystem processes** – create depressions in the ground where water naturally pools to harvest rainwater. Filling these depressions with plant mulch and other organic materials brings the soil to life while also storing water.



5. **Stack functions** – arrange species into layers; selecting plants that form multiple functions i.e. nursery plant canopies provide roosts for birds as well as shade and frost protection, shrubs and trees help with restoring nitrogen in the soil and provide fauna habitat, low ground crawling species (vines) shade the ground and reduce aridity.

### Looking Inward

The local ecosystem, flora, fauna, and pollinators are not the only things that matter in the mission to mitigate and adapt ecosystem restoration. **You** are a major part of the mission of restoring the environment and ecosystem too! Your mental, physical, and spiritual health is just as important to help restore the natural world.

**Sometimes it is not what you can do for nature it is what nature can do for you. (Sterry, 2021)**

Listed are a few resources to look into and practices to consider. They may aid in cultivating your own inner sustainability to help you with the hands-on restoration work you will do during the BECY program:

- In 2005, author Richard Louv coined the term “Nature - Deficit Disorder” with his book **Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder**. This term came forth in response to human’s detachment from the natural world due to the advancement of electronic communications, disappearing open space, and a loss of the importance of the natural world in education.

- **The Nature Fix: Why Nature Makes Us Happier, Healthier, and More Creative**, by Florence Williams, cites multiple studies that demonstrate the benefits of spending time outdoors. In one study, hikers took creativity tests before and after three days of hiking. There was a “50 percent improvement in creativity after just a few days in nature.” (Williams, 2017)
- Shinrin-Yoku is translated from Japanese to literally mean “Forest Bath”. Forest Bathing comes from the physical immersion in nature and what healing properties it has on the body. Though there are practitioners who guide people on a journey through Shinrin-Yoku, it is more of a self-guided practice. Nobody knows you more than you. This journey does not require a certain hike or exercise, it encompasses being immersed in nature. (Li, 2018)

## CHAPTER 3:

# Watershed Restoration

Exploring Sustainable Development Goals in this section  
In this section, we'll be exploring the importance of watershed restoration and how it intersects with some of the United Nations' Sustainable Development Goals. Watersheds are complex systems that are influenced by a wide range of environmental factors, and restoring and protecting them requires a deep understanding of the relationships between these factors.



### **SDG 6: Ensure availability and sustainable management of water and sanitation for all.**

Having clean, safe, and reliable water was declared a human right by the United Nations in 2010. While access to functional and appropriate sanitation systems should also be a human right, it is necessary to ensure that water systems like rivers and streams are not contaminated with waste. Access to clean water and adequate sanitation systems go hand in hand. Communities that lack access to water and sanitation are more likely to face negative health impacts, lower socioeconomic opportunities, and more barriers to thriving. Healthy watershed management is crucial to ensuring that water resources are sustainable and remain unspoiled for all of life on Earth. When you help to restore watersheds, you are ensuring access to sustainable water and sanitation for all.



### **SDG 10: Reduce inequality within and among countries**

Our environment and access to natural resources determines much about our day to day experiences, and can determine our quality of life. Environmental education can empower communities to understand the delicate balances in a healthy ecosystem, and can inform them on what actions they

can take to protect and restore their communities, therefore improving their own quality of life. Watershed restoration is a great example of an action that can reduce inequalities in a community by increasing environmental resiliency and ensure sustainable access to water resources for generations to come.



### **SDG 12: Ensure sustainable consumption and production patterns**

Water is a finite resource, therefore it's imperative that we use this resource as efficiently as we can to reduce waste and unnecessary consumption. By using water in a sustainable way, we can reduce our impact on the environment and protect the natural balance of our ecosystems. More importantly, this will ensure these natural and limited resources are available for generations to come. We can support and restore our watersheds by building erosion control structures with natural materials found around us, which can protect resources and reduce harmful pollution from entering waterways.



### **SDG 13: Climate Action**

How does Watershed Restoration relate to Climate Action?

## **The Water Cycle**

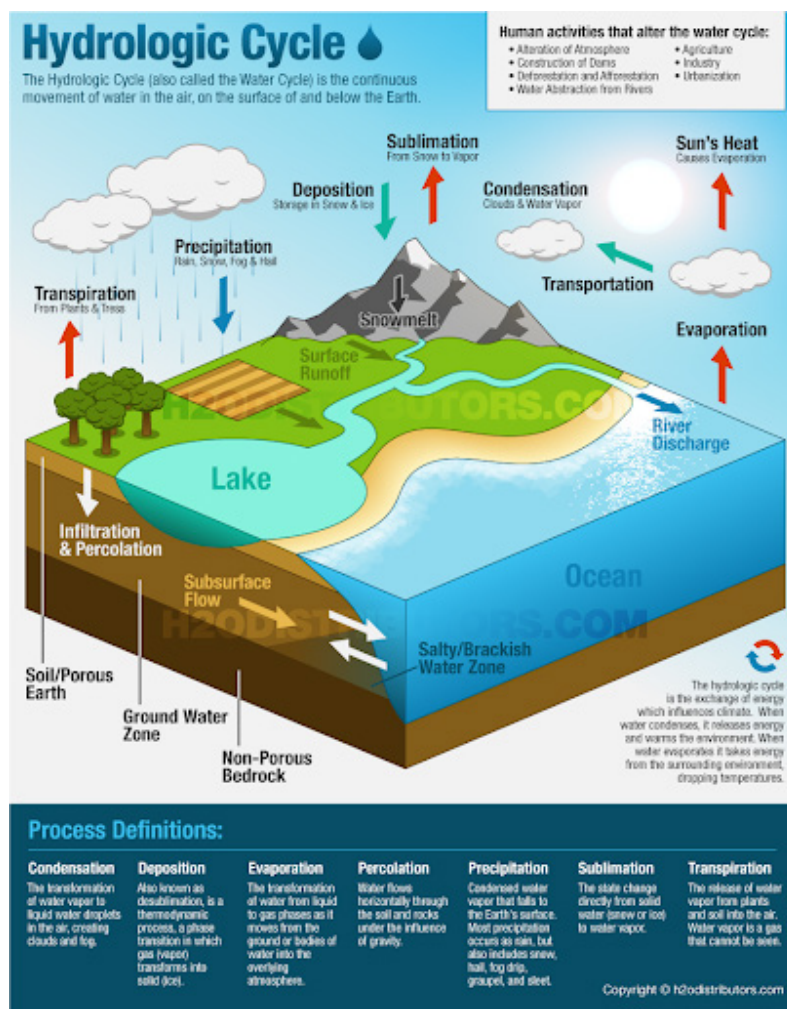
### **Did you know?**

Did you know that our bodies are more than 70% water? The water we drink keeps our bodies running strong by facilitating necessary biological processes.

Have you ever thought about where your drinking water comes from? Well, just about all the water we drink once fell to the earth as rain, and here in the Sonoran Desert, we average only three



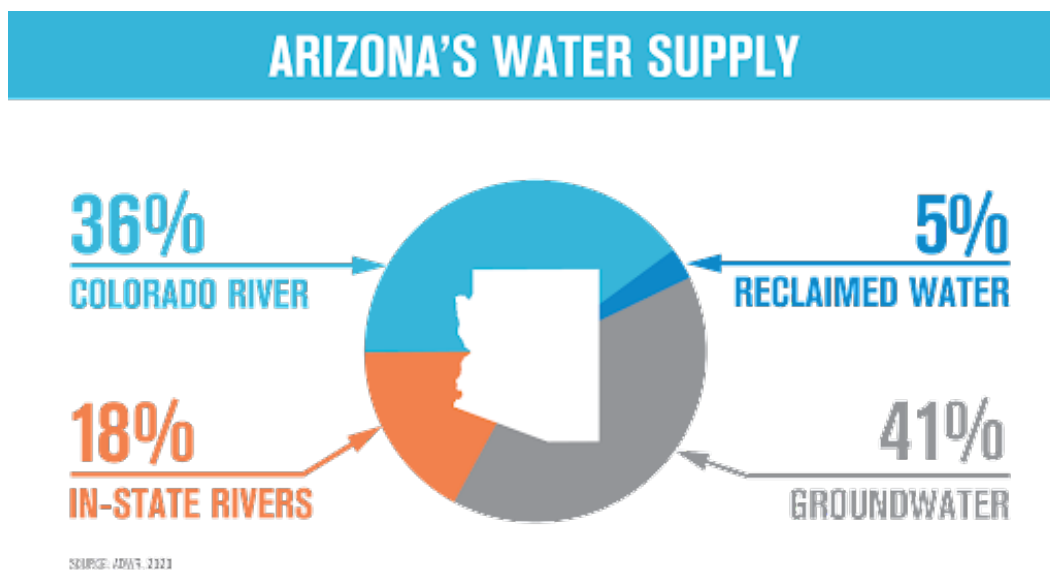
to fifteen inches (76 to 400 mm) of rain a year (Arizona-Sonora Desert Museum). The majority of our rain comes during summer **chubascos**, or “monsoon season” in the summer months, with lighter and less rains in the winter months. Rain falls to the earth and collects in creeks, streams, and rivers, making its way downhill in these ancient water pathways. This rainwater runoff has multiple possible destinations - it may enter the ecosystem through plant roots, sink deep below the Earth’s surface and enter groundwater reserves, travel all the way to an ocean, or evaporate back into the atmosphere. This is called the **water cycle**, or the “the continuous movement of water within the Earth and atmosphere” (National Oceanic and Atmospheric Administration, 2019).



(The Hydrologic Cycle (water cycle), H2O Distributors, Inc.)

## Water Basics in Arizona

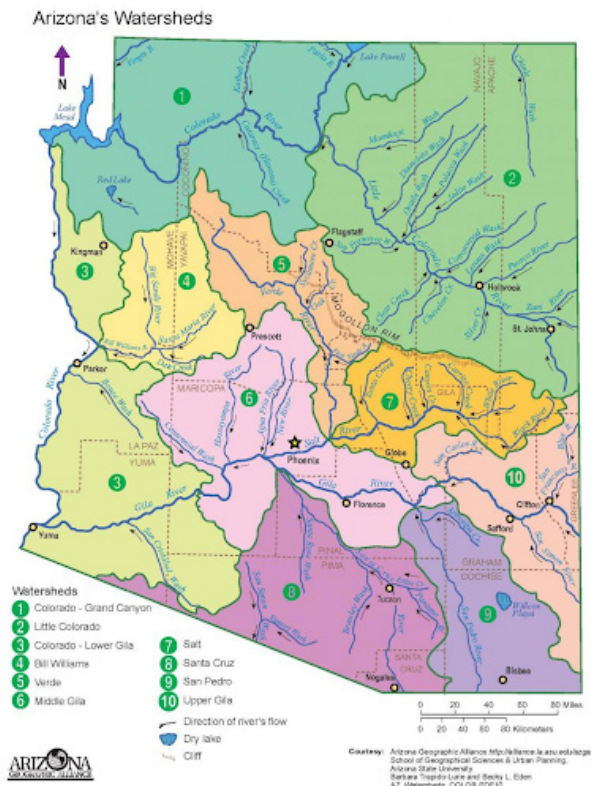
Have you ever met someone while traveling or had not been to the Southwest, and who seemed surprised that Arizona has large bodies of water? Did they seem confused that there are streams, rivers, and lakes in Arizona? Many people think that the desert is a barren wasteland. In fact, water in Arizona has historically been plentiful, and can be roughly divided into four basic categories: Colorado River water, surface water other than Colorado River water, groundwater, and effluent. The **Colorado River basin** runs through seven states; Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. In Arizona, Colorado River water is allocated among mainstream users according to their historic priority, and based upon the prior appropriation doctrine (Miller, 2017). **Surface water** is just like it sounds, water that you can see and flows through rivers and streams. **Groundwater** is the opposite of surface water and is found underground, often in aquifers and basins. Lastly, **effluent water** “has been collected in a sanitary sewer for subsequent treatment, and is treated and occasionally put through recharge until it becomes stable like surface or groundwater (Miller, 2017).



(Arizona Department of Water Resources)

## Watersheds and Sub-watersheds

A watershed is an area of land that drains surface and subsurface runoff to a common point such as a river, a lake, or a stream (U.S. Geological Survey, 2019). Watersheds are often named for the large body of water they contribute to. For example, looking at the map below, the Santa Cruz river flows into the Santa Cruz Watershed. In a large watershed, such as that of a river, there are several **sub-watersheds** that make up the small streams, gullies, and tributaries that connect to the river. “Watersheds are important because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point” (U.S. Geological Survey, 2019). All watersheds change over time and are constantly in a flux of erosion and deposition. Eroded soil particles are transported by water until the force of water is no longer great enough to transport them. At this point the soil particles are deposited on the bottom of the stream or along its floodplain.



(EPA, 2020).

## Case Study | The San Pedro Watershed

The San Pedro River is located in the borderland communities of Southern Arizona and northeast Sonora, Mexico. In 1988, Congress officially created the San Pedro Riparian National Conservation Area. This river is an important north-south migratory bird flyway and has been called the “last remaining major natural and intact river ecosystem in southern Arizona” (Lower San Pedro Watershed Alliance). The river is also home to several endangered species: the southwestern willow flycatchers, Huachuca water umbel, desert pupfish, loach minnows, spikedace, yellow-billed cuckoos, Arizona eryngo and northern Mexican garter snakes (Center for Biological Diversity, 2022). In the last several decades, a concentrated increase in populations of the nearby towns of Sierra Vista and Fort Huachuca have had a significant impact on the River. As you’ve learned, this region of Arizona does not have groundwater regulation, and the increase in population has led to excessive and unregulated groundwater pumping, diverting precious water resources to human consumption and disrupting the delicate balance of the ecosystem it supported. “Between 1995 and 2000, a broad partnership of community and business leaders, university faculty, and international government researchers and land managers worked together to evaluate the consequences of natural and human-induced environmental change on the Upper San Pedro Watershed” (Kepner, 2001). The stakeholders were concerned with the current stability of the San Pedro River ecosystem, and the future sustainability of the River’s water availability, ability to support wildlife habitat, the water quality’s impact on erosion, and impact of livestock forage on native grasslands (Kepner, 2001). Together they formed the Semi-Arid Land-Surface Atmosphere (SALSA) Program, which focuses on the collaboration between environmental science researchers and community stakeholders to reach across “disciplinary, institutional, and political boundaries” (Kepner, 2001) to address the environmental issues they faced in their community.

While excessive and unregulated groundwater pumping is still posing threats to the San Pedro River, there has been considerable environmental action taken to protect the River's ecosystem, as well as some legal actions to stop additional development in this area. This is an important example of how civic engagement and community action rarely result from one event or activity, and often a series of integrated strategies is necessary (NAAEE, 2022). When you design your restoration programs around a community's needs and make an intentional effort to collaborate with invested community stakeholders, your approach is more equitable and your outcomes more likely to be successful.



(Lower San Pedro Watershed Alliance)

## Water Resources in Arizona

### Historical Water Resource Management

Water is perhaps the most important resource for healthy communities – this includes both humans and non-humans. When the first Spanish colonizers entered what is now the state of Arizona over 500 years ago, the landscape looked vastly different from what we see today. Along with vibrant indigenous communities with rich agricultural traditions, water flowed year-round between lush mountain ranges, indicative of saturated underground aquifers. Today, significantly less surface water still flows compared to 500 years ago. Where did all that water go? As more people moved in, more wells were dug into the earth. Simultaneously, years of mismanagement of fragile arid ecosystems, such as historic overgrazing of introduced cattle, washed away the spongy topsoil that kept rainwater where it landed. Centuries of poor land and water resource management has stripped the arid borderlands of much of its lushness, the consequences of which we are still dealing with today.

### Modern Challenges to Protecting Water Resources

While the influx of new populations, cattle ranching, and agriculture in the region have caused much of the massive **aridification** of the borderlands, there is much that can be done to address these challenges today. As we know, water is a finite resource. In the Southwest region, climate change has resulted in increased aridification, creating considerable negative consequences on the water cycle. Aridification can be defined as a process where increased average temperatures, combined with low precipitation, reduce the snowpack and increase water evaporation in Southwestern soil, leading to severe and persistent drought (Specktor, 2021). The region is entering its twenty-third year of consecutive drought, while the population continues to grow and spur an increased demand on the available water supply.

In rural landscapes, such as the federal United States Forest Service lands, on grassy private ranches, or locally owned properties, Borderlands Restoration Network builds **erosion-control structures** out of rock and wood in places where water flows or collects. When water flowing across earth's surface encounters these glorified speed bumps, water slows down, spreads out, and slowly sinks into the earth. As water seeps back into the earth, it becomes available to plants while recharging underground reserves of water. In towns and cities, rainwater-harvesting cisterns capture rain that falls on roofs. This water can be used throughout the year to water plants in wildflower or food gardens.

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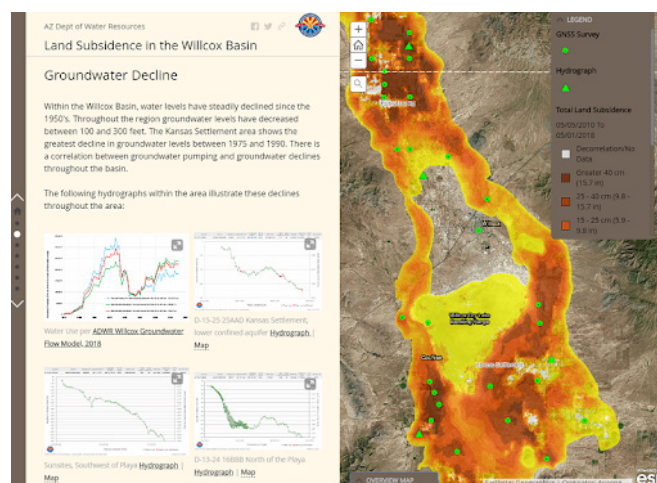
### Case Study | Willcox Water Basin

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The Willcox Basin covers an area of approximately 1,911 square miles in the borderlands region of southeastern Arizona. As the modern agriculture industry began to rise in the 1940's, agriculture became the main economic driver in and around the town of Willcox. This meant that the Willcox region began to rely on this water basin to produce everything from cotton to pecans, apples to wine grapes. While historically an agriculture region made up of small family growers and farmers, in recent decades there has been an influx of large scale agriculture production companies purchasing land and moving into the area. As you learned earlier in the BECY program, water rights belong to the landowner in Arizona. Without stringent groundwater regulation, groundwater can be pumped in excess in one area, draining the underground basin for the whole region. These large agriculture companies often move from out of state and can include dairy farmers from eastern parts of the United States, as well as pecan growers out of neighboring California. Due to the lack of groundwater regulation in this area, there is an abundance of over pumping and overuse of water resources in this area, leading to growing concern over the sustainability of the Willcox Basin.

The Arizona Department of Water Resources who is responsible for monitoring both ground and surface water resources throughout the state, has recorded “steep groundwater declines in the basin as well as identified areas of severe land subsidence and some of the highest concentrations of mapped earth fissuring within the state, all of which are indicative of groundwater overdraft” (ADWR, 2015). **Land subsidence** can be defined as a gradual settling or sudden sinking of the Earth's surface due to removal or displacement of subsurface earth materials” (U.S. Geological Site) like groundwater withdrawals or underground mining. The poor management of groundwater resources has resulted in “subsidence that has opened nearly 45 miles of fissures in the Willcox Basin” (Davis et al., 2022).

As of 2022, the Willcox Basin has been averaging a 7-foot decline each year. At the current rate of water consumption by big agriculture users and local residents, and without additional groundwater regulation, it is predicted that the basin will continue to run at a deficit. While conservation efforts alone are not enough to prevent the aquifer’s decline, promising research by the United States Geological survey has been shown on the effects of rock detention structures and their effects on the water recharge rate in Willcox (Hsieh, 2021). This is an example of how watershed restoration techniques are an important tool to protecting our precious water resources in the Southwest.

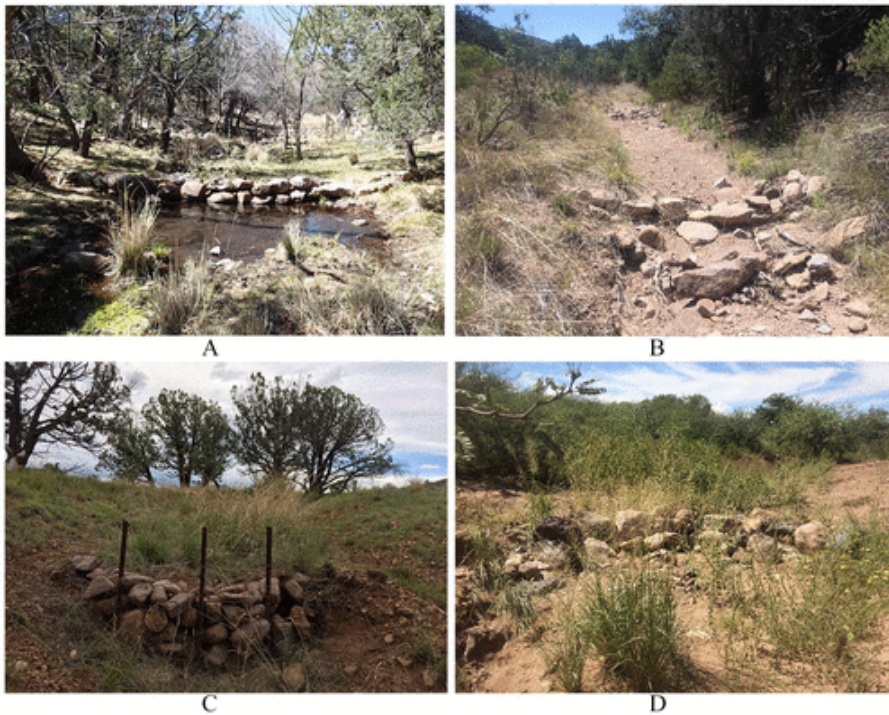


(Arizona Department of Water Resources)





(AZGS's Todd Shipman at earth fissure ca. 2008)



Photos of small structures at (A) Turkey Pen in the El Coronado Ranch (photo by Leila Gass, March 23, 2016); (B) Bar Boot Allotment on the Douglas Ranger District, USFS (photo by Natalie R. Wilson, July 19, 2019); (C) Tex Canyon on the Douglas Ranger District, USFS (photo by Natalie R. Wilson, July 14, 2015); (D) Silver Creek on the Malpai Ranch (photo by Natalie R. Wilson, September 12, 2016).

## Environmental Degradation & Erosion Control

Excessive erosion in watersheds can have negative consequences for both the environment and communities that depend on them. If soil erosion occurs more rapidly than it can be replaced, it can lead to issues such as topsoil loss, sedimentation, flooding, and damage to infrastructure. However, it is important to keep in mind that not all erosion is harmful. In reality, erosion is a natural process that plays an essential role in shaping the landscape and providing diverse habitats. Small-scale erosion, for instance, can create microenvironments for plants and animals, and the erosion of rocks can assist in the creation of soil. The trick is to control erosion so that it happens at a natural pace and does not harm the environment or surrounding communities. This chapter and activity guide will discuss a range of measures that can be used to accomplish this.

### Soil

To be fully healthy, soil needs plant residue, the sun, air and water. In many landscapes along the borderlands, soils have been seriously degraded by the impact of uncontrolled land uses, such as unmanaged grazing, mining, construction, pollution, and excavation. In many cases, “these activities have led to a hardening or removal of the topsoil, making it difficult for rain or snowmelt to **infiltrate** the soil” (Zeedyk & Jansens, 2009, p. 1). Soil is the foundation of life on earth. “Therefore, it is of utmost importance that the soil structure – composed of mineral particles, decomposing organic matter (**humus**), and microorganisms – is healthy and stable (Zeedyk & Jansens, 2009, p. 1). The ability for soil to capture and absorb water is considered the **pore-space** (Zeedyk & Jansens, 2009, p. 1). A sign of unhealthy and degraded soil is when the pore-space is damaged, or there is a loss of **moisture holding capacity** (Zeedyk & Jansens, 2009, p. 1). Conservation efforts seek to restore this sponge-like effect.

### Did you know?

It takes 1,000 years to naturally build 1-inch of soil in the arid borderlands? By now you already have a better picture of the importance of keeping topsoil in place.

#### Erosion

Without healthy soil, **rainwater runoff** flows across the land surface in large quantities. This can create **Erosion**, or when water flows with more force than the ecosystem can sustain. Erosion can look different depending on many factors – rainfall, soil and rock type, angle of slope, human activity, etc (Queensland Government). Here in the borderlands region, erosion usually takes one of two forms: sheet erosion or gully erosion. **Sheet erosion** occurs when water uniformly flows down a gentle slope, stripping soil of its fine particles and organic matter, and therefore of its moisture-holding capacity. Severe sheet erosion can result in barren landscapes devoid of plant life. **Gully erosion** occurs when fast-moving water against the earth can “flow strongly enough to detach and move soil particles” (Queensland Government). Gullies may develop at low points where the water runoff becomes concentrated. A common marker of gully erosion is exposed plant roots (they should be underground!) and vertical cuts, where natural drainages form a gentle slope with overflowing water flooding the bank’s edge. “This type of erosion is highly visible and affects soil productivity, restricts land use, and can damage roads, fences and buildings” (Queensland Government). In the borderlands region, it is common to find sheet and gully erosion together.

If we want to return health to landscapes, it is important to help the soil hold more water. One way to do that is to slow down water. Because once water slows, it spreads out, and can soften the soil's crusty structure and soak into the ground. **When in doubt, just remember to...**



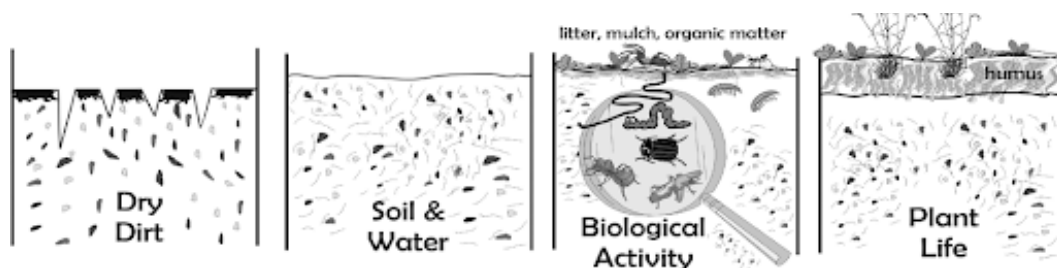
**SLOW IT DOWN, SPREAD  
IT OUT, SOAK IT IN**

(LSPA Watershed Wise)

The increase of underground water “wakes up” the roots of microorganisms like mycelium (fungi), that can absorb more water and help transport water from the soil pore-space to plant roots, strengthening the plants and soil (Zeedyk & Jansens, 2009, p. 2). This can also affect seeds that have lied dormant in the soil, causing them to retain moisture and germinate (Zeedyk & Jansens, 2009, p. 2). More moisture in the earth can help boost plant populations by supporting those that already exist, and those beneath the surface waiting to germinate! This is important because plants can help to intercept and slow down rain as it runs down along plant leaves and stems so it can soak into the soil. Plants also slow air movement and can shade the ground from the sun, reducing evaporation and protecting the water resources available to plants. Plant stems and roots hold together the soil, dead plant matter adds to the organic components of the soil, stimulating the proliferation of microorganisms, and plant roots again support other microorganisms. (Zeedyk & Jansens, 2009. p . 2-3).

If the soil's biology is healthy, it can help retain soil particles and reduce soil loss due to erosion. This can also reduce any pollution of waterways with the runoff sediment, and result in an increase in native plant growth (Zeedyk & Jansens, 2009. p . 2), often referred to as “sponge” restoration. Sponge restoration can support **plant succession**, or a substantial and key boost to the native ecosystem's capacity to grow new plants (Zeedyk & Jansens, 2009. p . 2-3). With more plants often comes a greater range of plant diversity and vegetative cover. This can make the “plant community much more resilient to sudden, or catastrophic events like fire, pests, flooding, or drought” (Zeedyk & Jansens, 2009. p . 3). This is very important when we consider that climate change has increased the frequency and intensity of catastrophic events, and their detrimental impacts on the environment.

As you've learned, plant life is intrinsically intertwined with the local wildlife. Healthy, diverse, and abundant plant life can “help create habitats for more wildlife including insects, arachnids, reptiles, birds, and mammals” (Zeedyk & Jansens, 2009, p. 3). The impact of intervening with the land, or even reshaping the land, to receive water can facilitate ecosystem recovery for the betterment of wild and human communities alike.



Zeedyk & Jansens, 2009. p . 2)

## Reading the Landscape

Reading a landscape is an important first step before implementing erosion control measures in a watershed because it allows you to understand the natural processes and features of the area, and how they may be impacted by erosion. Here are some steps to read a landscape:

### Identify the landform:

Look at the overall shape of the landscape, including the slope, aspect, and elevation. This will give you a general sense of the terrain and how water is likely to flow across it.

### Observe the vegetation:

Take note of the types and densities of plants growing in the area. Vegetation plays a critical role in controlling erosion, so understanding the natural plant communities is essential for developing effective erosion control measures. The vegetation will tell you about the health of the landscape. Think about what plants are present, is there diversity, are there invasive species etc.

### Assess the soil:

Evaluate the soil structure, texture, and composition to determine its erodibility and potential for retaining water. This will help you identify areas where erosion is most likely to occur and where it may be necessary to implement erosion control measures.

### Look for evidence of erosion:

Examine the landscape for signs of past and current erosion, such as gullies, landslides, and sediment deposits. This will help you identify areas where erosion control measures may be most needed. When we complete erosion control, we will think about where the water is coming from, how it will be moving, where it will cause erosion if left alone and what will happen if structures are implemented.

### **Determine the impact of human activities:**

Think about what happens on the land you are standing on. Was it historically or currently used for things such as agriculture, grazing, or developments. These activities can contribute to erosion, so it's important to understand their effects before implementing erosion control measures.

Once you have a good understanding of the landscape and the potential for erosion, you can begin developing erosion control measures that are appropriate for the specific site. This may include techniques such as restoring vegetation, creating buffer zones, implementing conservation tillage, or different erosion control techniques.

**By taking a landscape-based approach to erosion control, you can ensure that your efforts are effective, sustainable, and tailored to the unique needs of the watershed.**

## **How to Prioritize Restoration**

### **Planning**

Due to the historical mismanagement of land along the border, there is a near-endless amount of restoration work needed ahead. How do we decide where to work? How do we know which watersheds deserve our attention? Restoration **prioritization** is the result of much deliberation, research, and thoughtful observation. Planning is not something to be rushed, especially when a project is a collaboration between partnering organizations, individuals, or state and federal agencies (National Research Council, 2002). All of the projects Borderlands Restoration Network completes are collaborations with partners. Developing a strong relationship and building trust is key in developing a project that maximizes the benefits and is mutually beneficial for the land, stakeholders and the local restorative economy. When thinking about restoration sites, here are some key elements to consider:

### **What is the health of the landscape?**

Example: Organizations need to prioritize sites that can be helped with a short-long term plan. A group might prioritize work on a wildlife corridor with a medium need of rehabilitation via implementing 100 rock structures over the removal of Johnson grass in a part of Forest Service land that is not considered a migratory passageway.

### **What is the scale of the project?**

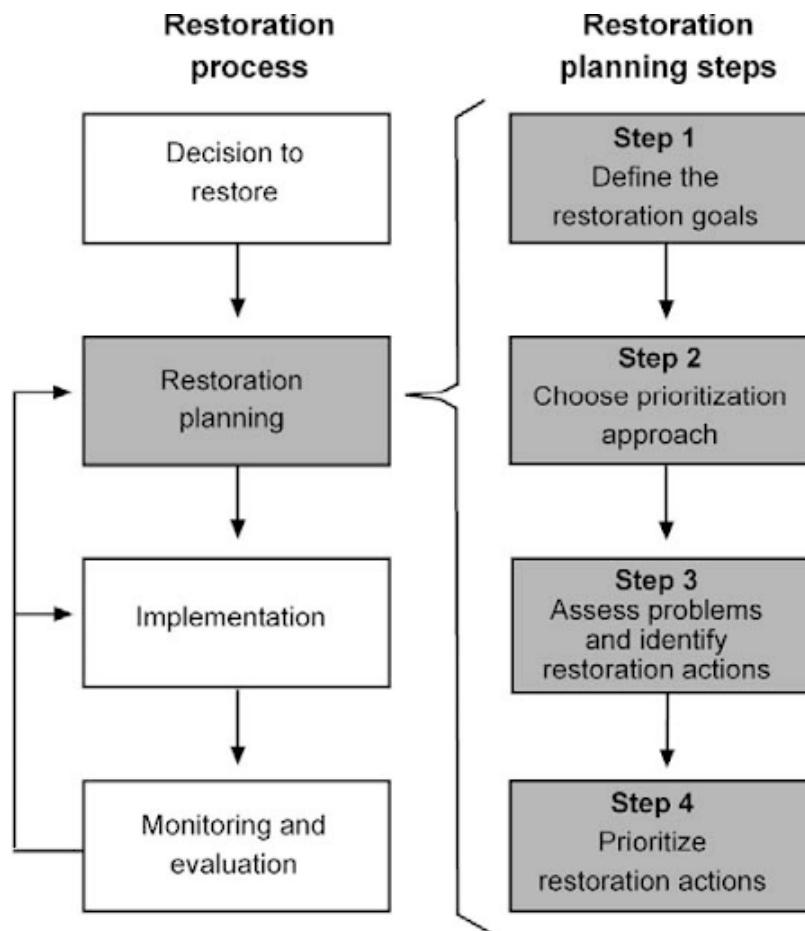
Example: In our area, the border wall affects the landscape, wildlife and people. As it's constructed, parts of the watershed are blown out, flattened, covered in cement. It wouldn't make sense to have our crew work alongside the border, there might be continued construction, and the scale of this project is too huge for a crew to do by hand. Heavy machinery would be needed to install gabbions that are a few feet high and wide.

### **What is the goal of the project?**

Goals for a project vary, especially depending on grant deliverables and partnerships on projects. Some projects are focused on protecting a particular species by enhancing their habitat. Other projects are solely focused on the preserving water and the ecological health of a landscape in order to keep receiving ecological services. As organizations put together a plan, they have to consider all of the intersections of a project in order to complete holistic work. Interacting with one part of a landscape like water or soil, will affect other parts such as flora and fauna.



When we have identified the restoration site, where do we begin? Reading the landscape involves looking for physical and biological cues that indicate the health of a watershed or system. It is a necessary skill for determining areas that need to be restored and choosing where to place restoration structures.



(Beechie et al., 2008)

### Think about stream dynamics

Water moved with gravity and the path of least resistance. Even when there is not a clear path, the weight of gravity and water can create a new path where there was not one previously. This can be destructive, depending on the stream's cycle of erosion and deposition. The goal of watershed restoration is to promote healthy stream dynamics – in other words, to support the waterway's natural desire to meander. The meandering process

naturally results in the evolution of an adjacent floodplain, except in situations where the natural landscape prohibits this (Zeedyk, 2003, p. 1). **Floodplains** are an area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flood (Naturally Resilient Communities). These are beneficial in “reducing and spreading the force of flood water across a wide area, and can also reduce the intensity of flood impacts downstream, facilitate sediment retention, and provide habitats for streamside vegetation and wildlife” (Zeedyk, 2003, p. 2).

Occasionally stream channels become impacted by human factors like the building of roads, movement of livestock, mining. Other times natural factors like the change in water flood level or frequency can impact the stream channels. When this happens, a stream channel may become Incised and “no longer have access to the adjacent floodplain” (Zeedyk, 2003, p.1). **Incised** channels tend to move towards straighter forms, have increased velocity and sediment load with decreased deposition. These high flows with a lot of power tend to pick up heavy material causing massive flooding episodes.

Given enough time, consistent weather cycles, and therefore a return to watershed equilibrium, incised channels will naturally “evolve towards a state of dynamic stability appropriate to the watershed geology, sediment characteristics, climate, and flood frequency and magnitude” (Zeedyk, 2003, p.2).



(Pima County Regional Flood Control District)

### Working in the watershed

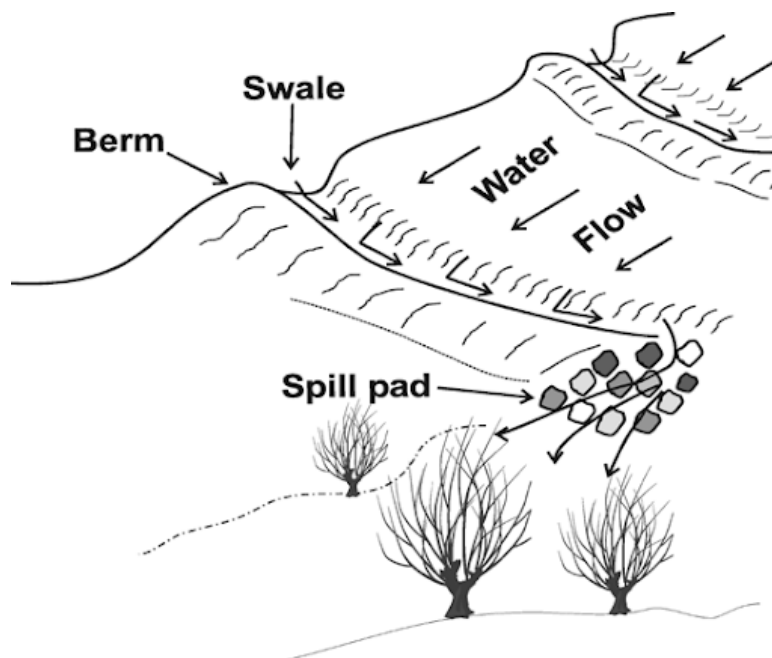
It is important to start at the top of a watershed and work your way down. Since water flows downhill, it picks up momentum the further downstream you go. The best way to soak water into the ground is to slow it down high up, before it has picked up energy downstream. The most effective way to approach watershed restoration is to start high up in the watershed where you notice the first signs of erosion and work your way downstream. Who knows, by building small structures where the erosion begins, you may have fixed the issue, allowing the watershed to heal itself further downstream where the erosion is a bigger problem. Big structures are expensive and can cause major unintended consequences if they fail. **When in doubt, start small and high up in the watershed!**

When we know where to start working, should we focus on building fewer big structures or more small structures? Structures support one another – building multiple structures at intervals maximizes the impact on the water flow. It can be

difficult to find the balance between maximizing the amount of water you can harvest with oodles of small water interventions and covering a greater area with fewer large structures. As with all things life throws our way, a balance must be struck. The ideal watershed restoration project creates a series of sinks. To maximize the potential for infiltration, always think about where water will go next. Will the water be slowed downstream, perhaps by hitting another structure or a rock wall?

### Detaining versus retaining water

When harvesting rainwater in a landscape setting, it is important to **detain** water, or slow it down for a short period of time, rather than **retain** water, or stop it permanently. Concrete dams are a key example of how to retain water, or holding the water back until it is needed. Rock erosion-control structures can also detain water, slowing it down so the water pools, sinking into the earth. Simultaneously, retained water slowly seeps between the loosely stacked rocks, reducing the **potential energy** (i.e., destructive power) of the water held behind the structures.



(Figure 2, Diversion drains. Zeedyk & Jansens, 2009, p. 5).

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## Case Study | San Bernardino Ranch

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When Valer Clark and her husband purchased the San Bernardino Ranch near Agua Prieta, Sonora in the 1990s, the land was dry and cracked, scattered with stones. Small mesquites and creosote bushes fanned out across the landscape as deep arroyos cut 20 to 30-feet into the dusty earth (Dobie, 2012). This once-healthy land had been grazed so relentlessly that grasses were depleted, and soil reduced to a fine powder. Hundreds of thousands of cattle had been moved to what is now the San Bernardino Ranch in the late 1880s. “Forests were heavily harvested to support mining operations; marshes drained for farming; and fire – a natural process that helps regulate forests and grasslands – was suppressed” (Dobie, 2012). Once the land was stripped and unstable, rain stopped replenishing the ecosystem. Instead, rainfall cut away at the earth, leaving it worse off than it had previously been. Thirsty plants dried up, and the animals that depended on these plants either died off or moved elsewhere.

The first step to replenishing health to the ecosystem required a significant reduction in overgrazing. Valer and her husband then built erosion-control structures, *trincheras*, that you will learn about later in this chapter. The *trincheras* worked well enough for Valer and her husband to build 20,000 of them across the ranch land (Dobie, 2012). Despite the drought that the Southern Arizona and Northern Sonora region has been experiencing over the past couple of decades, streams bubbled above ground, flowing year-round for the first time in a century. Once water returned, riparian plants quickly followed. In less than five years, the grasses and many native animal species became reestablished. In addition to restoring upland streams and grasslands, Cuenca Los Ojos is restoring the Rio San Bernardino in northeastern Sonora – and already the results are apparent, with perennial stream flow returning to a five-mile stretch of the river and over 2000 acres of new riparian vegetation.



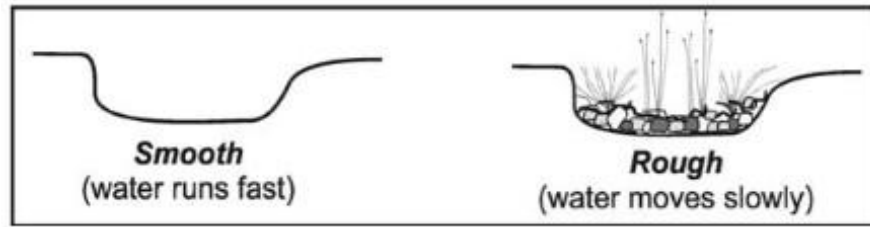
## Techniques to Healing Soil and Erosion

### Soil & Erosion Healing Approach

When soil quality is poor or there has been significant erosion, there are helpful approaches to heal the soil and mitigate the effects of erosion. As you know, in the Southwest region of the United States there is little average yearly rainfall, and plants, animals, and humans must make do with limited water resources. Harvesting rain water and using techniques to store this in the soil can ensure that water “evaporates slowly and flows gradually downhill to the main watercourses and wetlands of the area, providing valuable flow to **springs** and **seeps**, which maintain riparian habitat” (Zeedyk & Jansens, 2009, p.4). This can be done by creating structures to retain and move caught water, hold water in one place so it can soak into the ground, or by using organic mulch material to protect the soil against erosion ( Zeedyk & Jansens, 2009, p. 4-5). In your activities you will learn more on how “water harvesting on slopes can be achieved best by placing barriers on **contours**, technically forming a small **terrace**” (Zeedyk & Jansens, 2009, p. 4).

As you learned earlier, a gully can form as a type of erosion due to the force of water against the earth. The good news is that gullies can be healed using a variety of techniques. First, surface water flow should be slowed, this increases infiltration and prevents the dangerous concentration of swift- flowing

water. Next, the headcut should receive attention, stabilizing the greatest gradient within the path of the fast-moving water. Then, there should be a focus on slowing down water within the channel – whether that is reducing the gully slope or increasing gully roughness with rock structures. Finally, gully-healers should focus on retaining soil moisture to improve the habitat for plants. (Zeedyk & Jansens, 2009, p. 9-11).



(Figure 4, Zeedyk & Jansens, 2009, p. 9)

**Disclaimer:** All of the following text is taken directly from the From Erosion Control Field Guide by Craig Sponholtz & Avery Anderson.

### Trincheras

They are loose-rock erosion control structures that are used to encourage water spreading, floodplain re-establishment, reduction of water velocity, and sediment deposition. Trincheras can be widely used in watershed restoration efforts where the channel is not yet incised (when a one-rock dam may be more appropriate), but greater water-soil infiltration is desired. As they collect and fill in with sediment, they will become camouflaged and blend with the natural landscape yet still serve their function.

### Zuni Bowl

A headcut control structure composed of rock lined step falls and plunge pools that prevents headcuts from continuing to migrate upstream. Zuni Bowls stabilize actively eroding headcuts by dissipating the energy of falling water at the headcut pour-over and the bed of the channel. The structure converts the single cascade of an eroding headcut into a series of small falls.

Zuni Bowls also serve to maintain soil moisture on the face of the headcut, encouraging the establishment of protective vegetation.

### One-Rock Dam

A low-grade control structure built with a single layer of rock on the bed of the channel. ORDs stabilize the bed of the channel by slowing the flow of water, increasing roughness, recruiting vegetation, capturing sediment, and gradually raising the bed level over time. The single layer of rock is effective rock mulch that increases soil moisture, infiltration, and plant growth.

### Rock Mulch Rundown

A headcut control structure where the face of the headcut has been laid back to a stable angle of repose (minimum of 3:1 slope), and then covered with a single layer of rock mulch. The mulch serves to slow runoff, increase soil moisture, recruit vegetation, and ultimately prevent the headcut from migrating further up the slope. Rock Mulch Rundowns are ONLY to be used on low energy headcuts, like those found in upland rills and gullies with small catchment areas, and where sheetflow conflicts and enters a channel. Original concept by Craig Sponholtz.

### Media Luna

Media Luna structures are used to manage **sheet flow** and prevent erosion from surface flow. There are two types of Media Luna structures – both used to manage sheet flow and prevent erosion.

- **“Sheet flow spreaders”** (horns UP) are used on relatively flat ground to disperse erosive channelized flow and reestablish sheet flow where it once occurred.
- **“Sheet flow collectors”** (horns DOWN) prevent erosion (i.e., headcuts) at the head of rills and gullies by creating a stable transition from sheet flow to channel flow at the collection point. They prevent the gully to continue traveling upstream.



## **CHAPTER 4:**

### **Looking to the Future**

A major goal of this program is to support the next generation of conservationists by hiring youth to participate hands-on with conservation, restoration, and preservation, particularly in the borderland region that they call home. This is why we actively invited professionals to come and spend the day with all of you and introduce their careers to you all and be able to answer any questions you may have about their organization, career expectations, as well as the process and education they went through to get to where they are. In addition to these great connections and resources, a few of the graduates of BECY have gone on into such fields of study, including your facilitators. So they are also great resources to refer to and talk to over the years on your future endeavors. What this program allows is the ability for students to meet professionals in many different, specialized fields. Also, having the experience of this program and listing it on a resume only further develops the individual as a competitive applicant in a career or academic setting. Meeting these professionals also sheds light on what options there are in this industry.

Included in your folders is a Resource Guide. This guide outlines a vast array of career opportunities that are available at different education levels as well as how and where to achieve these goals. If a student plans on joining the workforce, these are careers outlined. If a major goal is to attend college or trade school, we have listed several local and highly regarded institutions. If a student is unsure, there are opportunities to broaden the amount of different job types as well as foreign countries to work in. Future career opportunities extend outside of building rock structures within our watersheds.

Lastly, remember that by being a part of BECY, you will always have us as a support network and as a resource to help you grow!

Whether you pursue a career in habitat restoration or not, all of you are the stewards of our planet and our communities, so always remember that the work you are doing is critical and greatly appreciated by all! The Sky Island region is a worldwide phenomenon that enlists the help of many young minds who share the views and experiences of the graduates of the BECY program.

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### **Case Study | Grace McGuire**

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One example of how participation in BECY can shape lives and career trajectories is seen in the case study of Grace McGuire, who grew up in Patagonia. Grace began work with BECY Patagonia in 2014 as a high schooler at Patagonia Union High School. She was impacted by the meaningful work that the BECY crews accomplished, and decided to return as a facilitator of BECY Nogales in 2017. As a facilitator, she gained knowledge about how best to work on teams, and engage with students about the outdoors. Though it is often challenging to begin work long before the sun rises, and carry on physical activity in the heat of the summer, she found that work with BECY led her to develop patience, problem-solving skills, and to rely on her intuition about the environment being impacted by human activity.

Grace chose to study Sustainable Built Environments at the University of Arizona, intending to learn as much about waste recycling, passive building strategies, and ways that communities can build restorative economies. After time away, she applied to the Education Support Coordinator position at Borderlands Restoration Network, and began working with the organization in 2023.

Grace sees the opportunity to return to her hometown as a way to remain connected to the land she grew up in, and to her family and community. As advice to fellow BECY graduates and participants, Grace would like to encourage others to view their hometowns as resources, and to find ways to engage in

supporting the elements that make those places special. It is often easy to want to leave as fast as possible, which is a great way to gain perspective and acquire new ways of thinking, but it is also rewarding to give back to your community through dedicating time and effort into leading adult lives in those places.

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### **Case Study | Duke Norton**

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Another testament of the impact BECY can have on one's life is seen in Duke Norton's experiences with the program. Duke began volunteering at age 14 in different restoration projects underway at his high school with mild intentions of simply spending time with his friends in the program. Duke was inspired by his peers and the fulfilling work which they accomplished together, making him continue to work with BECY, eventually becoming an intern and facilitator. His relationship with the program gave him opportunities to explore, learn, and network with local professionals in various ecological niches, and to develop his own professional interests. As a facilitator, Duke found that he cares for, and has the capacity to make a genuine connection with youth and to celebrate life through work that fulfills such intention.

Duke studies Mathematics at the University of Arizona with a concentration in Applied Mathematics, where he hopes to use his degree as a mathematical modeler for studying environmental phenomena. He was a facilitator midway through his undergrad and felt little direction with the degree in engineering he was pursuing at the time; however, after his time with BECY as a facilitator, he knew he wanted to specialize in something which would bring him closer to environmental studies and places with business ethics interesting to him. Duke feels his ideas about life and his aspirations were a majority formed through his experiences in BECY, and encourages youth to discover new things about themselves and their environment through joining the program like he did.

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### **Case study | Valeria Cañedo**

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In 2018, Valeria Cañedo, participated in the Borderlands Restoration Network’s Field School. This month-long course made her realize all the many aspects that we must take into consideration when we are conducting conservation and restoration work in our ecosystems. As a conservation biologist, her focus used to be on priority species for conservation and she didn’t see the connection between society and these species. After receiving training and mentoring from experts on topics such as Social Justice, Human Migration, Arts and Ecology, Watershed Restoration, Permaculture, among many others, she felt her perspective change, helping her to create integrative projects that make visible the correlation that exists between communities and the ecosystems we seek to protect.

One of Valeria’s long-term goals is to continue working closely with communities that produce bacanora. Working with bacanora for the past 5 years, she has learned more about the natural resources and the importance of sustainability and resilience within the ecosystem to keep conserving and harvesting bacanora. With the project “Bacanora for Bats” a team designed a series of agroecological techniques to improve the way that natural resources are managed to achieve sustainable development in the bacanora industry. She has developed strong relationships with these communities through her close work with them and she’s passionate about continuing to work with small communities. Valeria shared that she wants to continue to find ways to improve their livelihoods based on conservation actions because this is where the real value in conservation is.

## GLOSSARY

**abiotic:** non-living species

**active rainwater harvesting:** the installation of cisterns or tanks for storing and using water later when it is needed.

**anthropocene:** relating to or denoting the current geological age, viewed as the period during which human activity has been the dominant influence on climate and the environment.

**apex predators:** species that do not have natural predators; top of the food chain

**aquifer:** a body of permeable rock holding a contained reservoir of groundwater.

**arid ecosystem:** an ecosystem adapted to a severe lack of rainwater or precipitation. Arid ecosystems, such as grasslands, can have more rainfall than deserts.

**aridification:** a process where increased average temperatures, combined with low precipitation, reduce the snowpack and increase water evaporation in soil

**arroyo:** a dry wash or steep-sided drainage formed by fast-flowing water in an arid ecosystem. Arroyos only hold water for a few days every year.

**berm:** a flat strip of raised land used to harvest rainwater.

**biodiversity:** the variety and variability of life in a given habitat or location.

**biopesticides:** biological substance or organism that damages, kills, or repels organisms seen as pests. Biological pest management intervention involves predatory, parasitic, or chemical relationships. They are obtained from organisms including plants, bacteria and other microbes, fungi, nematodes, etc.

**biotic:** living species

**boomerang swales:** earthen structures where the structures are built with the same parent material as the soil as compared to using either rocks or sticks as in a media luna.

**borderland:** the district near a border.

**capitalism:** an economic and political system in which trade and industry are controlled by private owners for profit (as opposed to state-run). Capitalism relies on the surplus created during increased growth. In an ideal capitalistic system, exponential growth occurs. The problem with too much growth is that we live on a planet with only a finite number of resources.

**carnivores:** animals that survive off other animals

**channel:** the sunken location where water moves, channelization, or steep banks, can occur when water moves swiftly through a system.

**chubasco:** the scientifically accurate name for monsoon rainstorms.

**cienea:** a spring or wet, marshy area at the foot of a mountain, in a canyon, or on the edge of a grassland where groundwater bubbles to the surface.

**conservation easement:** a voluntary, legal agreement that permanently limits uses of the land in order to protect its conservation values

**consumers (heterotrophs):** species that can't produce their own energy and consume other animals

**contour lines:** the lines on a topographic map that indicate points of equal elevation and are marked with the above-sea level elevation in feet.

**climate science:** the study of the Earth and its climate. Also known as "climatology".

**cultural burning:** the Indigenous practice of the intentional lighting of smaller, controlled fires to provide a desired cultural service, such as promoting the health of vegetation and animals that provide food, clothing, ceremonial items and more

**degraded ecosystem:** the deterioration of the environment by depleting or polluting natural resources such as air, water, and soil. Degradation can lead to habitat destruction, extinction of wildlife, and ecological harm within human communities.

**deposition:** a general term for the accumulation of sediments by either physical or chemical sedimentation.

**desiccation:** loss of water from something, such as from soil.

**ecoregion:** a major ecosystem defined by distinctive geography receiving uniform solar exposure and rainfall/precipitation. Tucson is in the Sonora Desert ecoregion. Patagonia, Nogales, and Douglas are in the Madrean Archipelago ecoregion.

**ecosystem:** a biological community of interacting organisms and their physical environment.

**ecological restoration:** a process of rehabilitating degraded ecosystems, such as landscapes, lakes, and oceans to regain their ecological functionality.

**ecosystem service:** any positive benefit that wildlife or ecosystems provide to people.

**ecotypes:** a sub-type of habitat within a larger ecosystem.

**effluent water:** water that has been collected in a sanitary sewer for subsequent treatment and recharge

**erosion:** the process of breaking down rock or soil by wind, water, glacier, biological, or mechanical forces.

**erosion-control structure:** a human-made formation that is built to reduce the harm of unnatural erosion.

**extractive economy:** an economic system based on harvesting or removing natural resources from a landscape for sale or trade. A result of extractive economies is the depletion of the health of natural ecosystems.

**fauna:** the animals of a particular region, habitat, or geological period.

**floodplain:** an area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding.

**flora:** the plants of a particular region, habitat, or geological period.

**food web:** a system of interlocking and interdependent food chains.

**frugivore:** a fruit-eating creature, such as birds and insects.



**food web:** natural interconnection of the food chain; what-eats-what in an ecological community

**gabion:** a type of rock structure where rocks are enclosed in a metal wire cage.

**gradient:** a slope, determined by dividing the vertical distance (“rise”) between two points by the horizontal distance (“run”).

**greenhouse gas effect:** a process that occurs when energy from a planet's sun goes through its atmosphere and warms the planet's surface, but the atmosphere prevents the heat from returning directly to space, resulting in a warmer planet.

**groundwater:** water found underground, often in aquifers or basins

**gully erosion:** the concentrated removal of soil in a drainage as opposed to evenly across the landscape.

**headcut:** the sudden change in elevation at the leading edge of a gully.

**headwaters:** the place(s) where a stream or river starts; the top of a watershed.

**humus:** the organic part of the soil formed by the decomposition of leaves and plants, often the top-most layer of soil.

**incised channel:** a stream channel in which the bed has dropped and as a result, the stream is disconnected from its floodplain.

**infiltrate:** the slow movement of water into the earth.

**invertebrates:** animals that do not have a backbone

**media luna:** a crescent shaped structure used to manage sheet flow and prevent erosion from surface flow.

**moisture-holding capacity:** the physical ability of soil to hold water, oftentimes based on the amount of organic material in soil.

**monotypic:** having only one species.

**mycelium:** the subterranean fungal network consisting of fine white filaments.

**mulch:** material such as decaying leaves, bark, or compost that is spread around or over a plant or rock structure to enrich or insulate the soil.

**mutualistic:** both species benefits from the presence of the other

**native:** (of a plant or animal) of indigenous origin or growth.

**omnivores:** animals that eat both plants and other animals

**one rock dam:** A low-grade control structure built with a single layer of rock on the bed of the channel. ORDs stabilize the bed of the channel by slowing the flow of water, increasing roughness, recruiting vegetation, capturing sediment, and gradually raising the bed level over time.

**passive rainwater harvesting:** the construction of landscape features to direct, slow, and sink water.

**perennial stream:** a stream that flows year-round, never drying up.

**permaculture:** a way of interacting with the world that utilizes patterns in natural ecosystems to maximize human sustainability and resiliency.

**phenology:** the study of cyclic and seasonal natural phenomena, especially in relation to climate and plant and animal life.

**plant succession:** the long-term cumulative change in plant species that occupy a given area over time.

**pollinator:** an animal that moves pollen from the male anther of a flower to the female stigma of a flower, oftentimes in exchange for nectar.

**pore-space:** the volume of spaces between soil particles that can be filled by water and/or air.

**prescribed burning:** the controlled application of fire by a team of fire experts under specified weather conditions to restore health to ecosystems that depend on fire

**primary consumers (herbivores):** species that retain energy by eating plants (autotrophs)

**primary producers (autotrophs):** species that perform photosynthesis to provide their own food source (plants or algae)

**prioritization:** the action or process of deciding the relative importance or urgency of things or situations. In restoration, many stakeholders must work together to prioritize sites for restorative activities.

**provenance:** the place of origin or earliest known history of a specific thing.

**rainwater harvesting:** is the collection and storage of rainwater that would otherwise flow down gutters into the drain.

**rainwater runoff:** after a rainfall event, runoff is the water that flows over the ground surface.

**resilience:** the capacity to recover quickly from difficulties, toughness, or the ability of an ecosystem to experience disturbance without harming the balance of life.

**restoration economy:** a system of exchange based on putting resources into the health of a land and its people.

**rill:** a small stream, or erosion caused by a small stream.

**riparian:** pertaining to the banks of a river or stream.

**rock mulch rundown:** A headcut control structure where the face of the headcut has been laid back to a stable angle of repose (minimum of 3:1 slope), and then covered with a single layer of rock mulch.

**secondary consumers:** species that eat primary consumers

**sediment load:** the amount of heavy and light sediments carried by a stream or river.

**series of sinks:** in watershed restoration, diverting water so it maximizes the number of potential locations for infiltration.

**sheet erosion:** uniform loss of soil and/or vegetation when water flows down a slope.

**sheet flow collector/spreaders:** a component of the media luna rock structure that collects sheet flow, which flows over the ground surface as a thin, even layer, not concentrated in a channel.

**splash apron:** located at the end of a rock structure, it prevents further erosion and collects sediment, helping backfill the channel.

**stick structure:** using wood as a resource to build structures when rocks are unavailable. The best technique for implementing these structures is to interlace/weave these materials together to make a sturdier structure

**sub-watershed:** watersheds for smaller creeks or streams, often tributaries of larger rivers.

**sustainability:** is a broad policy concept in the global public discourse and is often conceived of in terms of three "dimensions" or "pillars": environmental, economic, and social.

**subsidence:** land subsidence is a gradual settling or sudden sinking of the Earth's surface due to removal or displacement of subsurface earth materials

**surface water:** water that you can see and flows through rivers and streams

**sustenance:** food and drink regarded as a source of strength; nourishment.

**topsoil:** the top-most layer of soil where most of the biological activity occurs.

**tributary:** a small stream that contributes to a larger stream or river.

**tertiary consumers:** species that eat secondary consumers

**trinchera:** a type of loose rock erosion-control structure placed within channels meant to slow down water, so it infiltrates into the earth.

**trophic pyramid:** a graphical representation designed to show the biomass or bioproductivity at each trophic level in a given ecosystem.

**undercut:** a space formed by the removal of material from the lower part of a cliff/overhang.

**watershed:** an area of land that drains to a single point, such as a river, lake, or stream.

**wildlife:** wild animals collectively; the native fauna (and sometimes flora) of a region.

**zuni bowl:** A headcut control structure composed of rock lined step falls and plunge pools that prevents headcuts from continuing to migrate upstream

## ACTIVITY BOOKLET

### Reflection Project: Complete over the summer

Participants will have the opportunity to keep a journal during the summer. Within the journal, participants will answer prompts, draw, compile field data, quick write and keep notes. Taking time to reflect on your experiences helps your personal development, skill building and you can check to see if the learning material is benefiting you. During the program, we want to promote lifelong learning habits that you can employ in other situations after program completion.

We will have time daily or weekly to work in our journals. Towards the end of the program, you will create a summary reflection that you will present at graduation on the last day of the program. You will choose a specific topic, scenario or memory that stood out to you during the program to focus on. You will also choose what format or combination of formats you'd like to use to share your reflection with others. Below are some format ideas you can do solo or within a small group.

The program coordinator, facilitator, team members and guest presenters will be able to support your reflection process, provide feedback and help you along the way!

Written	Visual	Tactile	Auditory
Blog Post	Video	Sculpture / Model	Podcast Episode
Short Story	Painting / Drawing	Dance	Song / Music
Poem	Photography	Play / Acting	Interviews
Written Reflection	Field Journal	Pressed Plant Art	Storytelling

## Quick Diary: Reflection

The crew will regularly reflect using the quick diary format in their journals during the program.

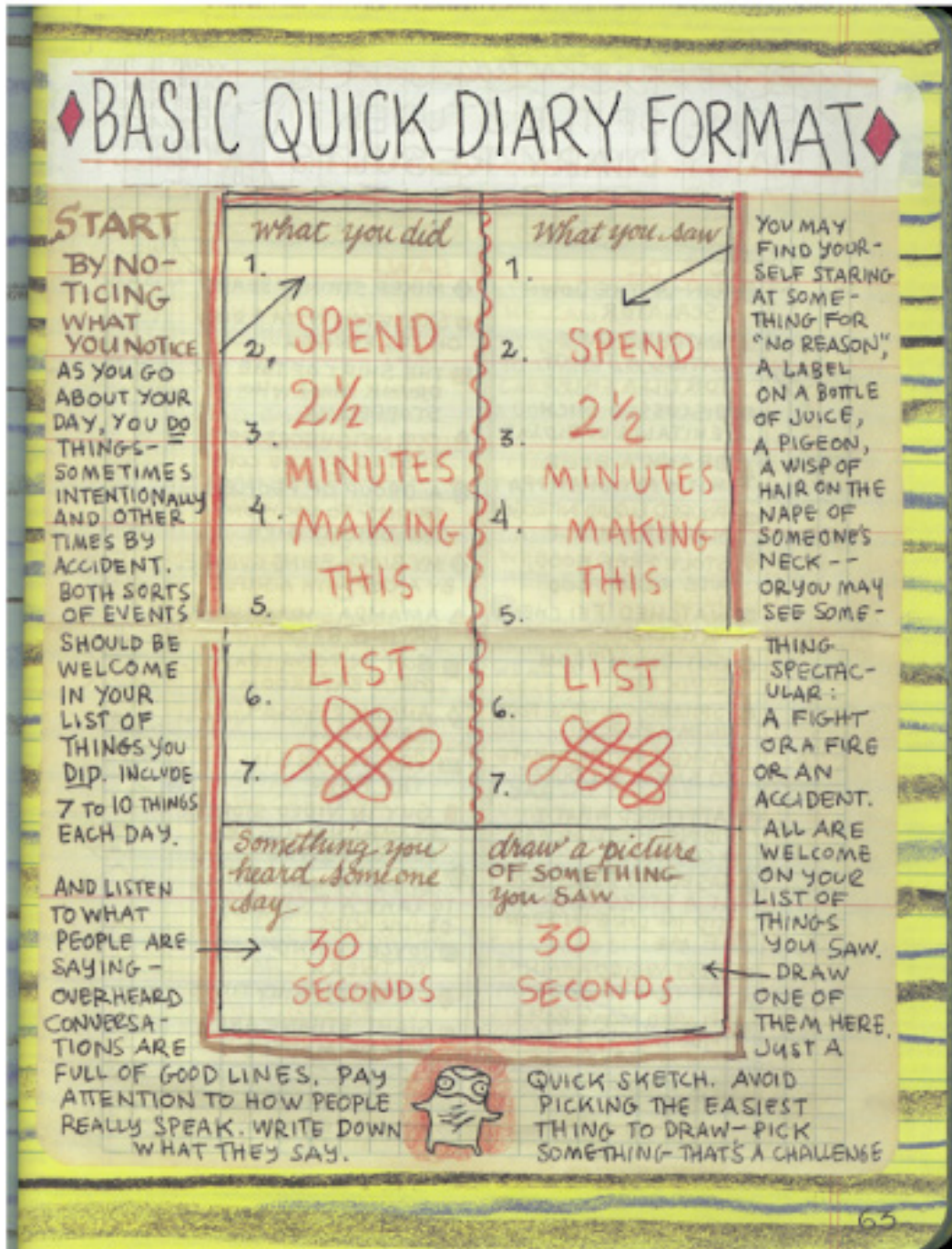


Image from Susan Briante, Southwest in Field Studies Program



# Orientation Activities

## Activity 1: Leadership Personalities

True Colors is a model of personality identification that is easy to understand, remember, and apply. Essentially the model stems from the work of Isabel Briggs-Myers, Katherine Briggs and David Keirsey. A student of David Keirsey, Don Lowry, developed the True Colors system to facilitate a deeper understanding of people's communication styles. His hope was to produce positive self-worth and self-esteem.

The True Colors System was designed to promote a mental, emotional, and spiritual model that would increase the understanding of the SELF and others, which in turn would reduce the conflict. The idea is that once you learn the your color and the color of your co-workers or people you relate to on a daily basis, you will have a better understanding of how others may see you, and also why they behave the way they do.

With the colors of Blue, Gold, Green and Orange –True Colors distills the elaborate concepts of personality theory into a user friendly, practical tool for fostering healthy productive relationships. True Colors has been utilized throughout corporations, education and therapeutical settings for over 25 years as a tool that improves communication, relationships, team-building, leadership, morale, and conflict resolution skills.

By taking this test you will:

- Learn how to create and sustain better relationships
- Learn to appreciate the differences in others and respect them
- Learn how to create instant rapport with the opposite sex
- Learn to respond to others more appropriately, consciously, and compassionately
- Maximize relationships through use of the True Color Personality Assessment Quiz

Each color is associated with certain personality traits or behaviors. Everyone has some degree of each color, but one color is predominant. The following quiz will identify your color spectrum. Print out the following five pages. Follow the directions carefully and transfer your score to the score sheet. If you have two colors with the same score, you pick which one you think more accurately describes you.

## How to Use the True Colors Personality Quiz

Describe Yourself: In the boxes below are groups of word clusters printed **horizontally** in rows. Look at all the choices in the first box (A,B,C,D). Read the words and **decide which of the four letter choices is most like you**. Give that a “4”. Then rank order the next three letter choices from 3-1 in descending preference. You will end up with a box of four letter choices, ranked from “4” (most like you) to “1” (least like you). Continue this process with the remaining four boxes until each have a 4, 3, 2, and 1.

Box One			
A _____ active opportunistic spontaneous	B _____ parental traditional responsible	C _____ authentic harmonious compassionate	D _____ versatile inventive competent
Box Two			
E _____ curious conceptual knowledgeable	F _____ unique empathetic communicative	G _____ practical sensible dependable	H _____ competitive impetuous impactful
Box Three			
I _____ loyal conservative organized	J _____ devoted warm poetic	K _____ realistic open-minded adventuresome	L _____ theoretical seeking ingenious

Box Four			
M _____ concerned procedural cooperative	N _____ daring impulsive fun	O _____ tender inspirational dramatic	P _____ determined complex composed

Box Five			
Q _____ philosophical principled rational	R _____ vivacious affectionate sympathetic	S _____ exciting courageous skillful	T _____ orderly conventional caring

A,H,K,N,S \_orange\_ = \_\_\_\_\_

B,G,I,M,T \_gold\_ = \_\_\_\_\_

C,F,J,O,R \_blue\_ = \_\_\_\_\_

D,E,L,P,Q \_green\_ = \_\_\_\_\_

## BLUE

*I need to feel unique and authentic*  
**Enthusiastic, Sympathetic, Personal**  
*I look for meaning and significance in life*  
**Warm, Communicative, Compassionate**  
*I need to contribute, to encourage, and to care*  
**Idealistic, Spiritual, Sincere**  
*I value integrity and unity in relationships*  
**Peaceful, Flexible, Imaginative**  
*I am a natural romantic, a poet, a nurturer*

### **In childhood...**

- I was extremely imaginative and found it difficult to fit into the structure of school life.
- I reacted with great sensitivity to discordance or rejection and sought recognition.
- I responded to encouragement rather than competition.

### **In relationships...**

- I seek harmonious relationships.
- I am a true romantic and believe in drama, warmth, and empathy to all relationships.
- I enjoy the symbols of romance such as flowers, candlelight, and music and cherish the small gestures of affection.

### **At work...**

- I have a strong desire to influence others so they may lead more significant lives.
- I often work in the arts, communication, education, and helping professions.
- I am adept at motivating and interacting with others.

### **Leadership Style...**

- Expects others to express views
- Assumes “family spirit”
- Works to develop others’ potential
- Individuals oriented
- Democratic, unstructured approach
- Encourages change VIA human potential
- Change time allows for sense of security
- Expects people to develop their potential

### **Symptoms of a Bad day...**

- Attention-getting misbehaving
- Lying to save face
- Withdrawal
- Fantasy, day-dreaming, and going into a trance
- Crying and depression
- Passive resistance
- Yelling and screaming

## **GOLD**

*I need to follow rules and respect authority*  
**Loyal, Dependable, Prepared**  
*I have a strong sense of what is right and wrong in life*  
**Thorough, Sensible, Punctual**  
*I need to be useful and belong*  
**Faithful, Stable, Organized**  
*I value home, family, and tradition*  
**Caring, Concerned, Concrete**  
*I am a natural preserver, a parent, a helper*

### **In childhood...**

- I wanted to follow the rules and regulations of the school.
- I understood and respected authority and was comfortable with academic routine.
- I was the easiest of all types of children to adapt to the education system.

### **In relationships...**

- I am serious and tend to have traditional, conservative views of both love and marriage.
- I enjoy others who can work along with me, building secure, predictable relationships together.
- I demonstrate admiration through the practical things I do for the ones I love.

### **At work...**

- I provide stability and can maintain organization.
- My ability to handle details and to work hard makes me the backbone of many organizations.
- I believe that work comes before play, even if I must work overtime to complete the task.

### **Leadership Style...**

- Expects punctuality, order, loyalty
- Assumes “right” way to do things
- Seldom questions tradition
- Rules oriented
- Detailed/thorough approach - threatened by change
- Prolonged time to initiate any change
- Expects people to “play” their roles

### **Symptoms of a Bad day...**

- Complaining and self-pity
- Anxiety and worry
- Depression and fatigue
- Psychosomatic problems
- Malicious judgments about yourself or others
- Herd mentality exhibited in blind following of leaders
- Authoritarianism and phobic reactions

## ORANGE

*I act on a moment's notice **Witty,**  
**Charming, Spontaneous** I  
consider life a game, here and now  
**Impulsive, Generous, Impactful**  
I need fun, variety, stimulation, and excitement  
**Optimistic, Eager, Bold**  
I value skill, resourcefulness, and courage  
**Physical, Immediate, Fraternal**  
I am a natural trouble-shooter, a performer, a competitor*

### **In childhood...**

- Of all types of children, I had the most difficult time fitting into academic routine.
- I learned by doing and experiencing rather than by listening and reading.
- I needed physical involvement in the learning process and was motivated by my own natural competitive nature and sense of fun.

### **In relationships...**

- I seek a relationship with shared activities and interests.
- I like to explore new ways to energize the relationship.
- In a relationship, I need to be bold and thrive on physical contact.
- I enjoy giving extravagant gifts that bring obvious pleasure to special people in my life.

### **At work...**

- I am bored and restless with jobs that are routine and structured.
- I am satisfied in careers that allow me independence and freedom, while utilizing my physical coordination and my love of tools.
- I view any kind of tool as an extension of myself.
- I am a natural performer.

### **Leadership Style...**

- Expects quick action
- Works in the here and now
- Performance oriented
- Flexible approach
- Welcomes change
- Expects people to “make it fun”

### **Symptoms of a Bad day...**

- Rudeness and defiance
- Breaking the rules intentionally
- Running away and dropping out
- Use of stimulants
- Acting out boisterously
- Lying and cheating
- Physical aggressiveness

## GREEN

*I seek knowledge and understanding*

**Analytical, Global, Conceptual**

*I live by my own standards*

**Cool, Calm, Collected**

*I need explanation and answers*

**Inventive, Logical, Perfectionist**

*I value intelligence, insight, fairness, and justice*

**Abstract, Hypothetical, Investigative**

*I am a natural non-conformist, a visionary, a problem solver*

### **In childhood...**

- I appeared to be older than my years and focused on my greater interests, achieving in subjects that were mentally stimulating.
- I was impatient with drill and routine, questioned authority, and found it necessary to respect teachers before I could learn from them.

### **In relationships...**

- I prefer to let my head rule my heart.
- I dislike repetition, so it is difficult for me to continuously express feeling. I believe that once feelings are stated, they are obvious to others.
- I am uneasy when my emotions control me; I want to establish a relationship, leave it to maintain itself, and turn my energies to my studies, work or other interests.

### **At work...**

- I am conceptual and an independent thinker. For me, work is play.
- I am drawn to constant challenge in careers, and like to develop models, explore ideas, or build systems to satisfy my need to deal with innovation.
- Once I have perfected an idea, I prefer to move on, leaving the project to be maintained and supported by others.

### **Leadership Style...**

- Expects intelligence and competence
- Assumes task relevancy
- Seeks ways to improve systems
- Visionary
- Analytical
- Encourages change for improvement
- Constantly “in process” of change
- Expects people to follow through

### **Symptoms of a Bad day...**

- Indecisiveness
- Refusal to comply or cooperate; the silent treatment
- Extreme aloofness and withdrawal
- Snobbish, put-down remarks, and sarcasm
- Perfectionism due to severe performance anxiety
- Highly critical attitudes toward yourself or others

## BLUE

### BLUE ATTRIBUTES

Mediators	Need to Feel Special
Optimistic	Always has a kind word
Caretakers	Enjoys symbols of romance
Passionate	Strong sense of spirituality
Peacemakers	Sensitive to needs of others
True Romantics	Peace harmony and relationship

### BLUE MAY SEE SELF AS:

### OTHERS MAY SEE BLUE AS:

Warm	Affirming	Over-Emotional	Aloof, unfeeling
Caring	Expressive	“Bleeding Heart”	Too Trusting
Compassionate	Caretaker	Mushy	Smothering
Romantic	Idealistic	Other-worldly	Slick,
Spiritual	Empathetic	Flaky	Manipulative
Creative	Inspiring	Hopelessly Naïve	Ignores policy
Likes to Please	Social Expert	Chatterbox	Easily Duped
			Teachy

## GOLD

### GOLD ATTRIBUTES

“Be Prepared	Strives for a sense of security
Loves to plan	Punctual, predictable, precise
Detailed oriented	Value order and the status quo
Service oriented	Duty, loyalty, useful, responsible
Values family traditions	There is a right way to do everything
Helpful and trustworthy	Tends to be left-brain and analytical
Conservative and stable	Strong belief in policies, procedures and rules
“Shoulds” and “Should not”	Most comfortable with format environment
Never breaks the speed limit	

### GOLD MAY SEE SELF AS:

### OTHERS MAY SEE GOLD AS:

Stable	Executive type	Rigid	Limited flexibility
Provides security	Dependable	Controlling	Uptight
Firm	Always has a view	Dull, boring	Sets own agenda
Efficient	Realistic	Stubborn	Predictable
Decisive	Orderly, neat	Opinionated	Rigid idea of time
Good Planner	Punctual	System-bound	End justifies the means
Organized	Finish what starts	Unimaginative	Limited
Realistic		Judgmental	

## ORANGE

### ORANGE ATTRIBUTES

Playful	“Let’s Make a deal”
Energetic	Natural Entertainer
Charming	High Need for mobility
Risk Taker	Visual and kinesthetic
“Just do it”	Pushes the limits
Tests limits	Natural Non-Conformist
Quick Witted	Thrives on Competition
Master Negotiator	Likes tangible rewards
Creative, Inventive	External locus of control
Impulsive	Appreciates immediate feedback

### ORANGE MAY SEE SELF AS:

### OTHERS MAY SEE ORANGE AS:

Fun Loving	Enjoys Life	Irresponsible	Manipulative
Spontaneous	Here & now	Flaky	Wishy-washy
Flexible, adaptable	person	Scattered	Cluttered
Carefree	Multi-Tasker	Not serious	Uncontrollable
Proficient	Eclectic	Indecisive	Disobeys rules
Problem Solver	Can deal with chaos		
	Curious		

## GREEN

### GREEN ATTRIBUTES

“Should I be able to”	Visionaries, futurists
“Why?”	Can never know enough
Intellectual	Cool, calm, collected
Theoretical	Work is play, play is work
Idea People	Often not in the mainstream
Philosophical	Abstract, Conceptual, Global
Very complex	Need for independence and private time
Perfectionists	Explores all facets before making decisions
Standard setters	Can spell and pronounce big words

### GREEN MAY SEE SELF AS:

### OTHERS MAY SEE GREEN AS:

Superior Intellect	Calm	Intellectual Snob	Cool, aloof,
98% right	Under control	Arrogant	unfeeling
Tough-minded	Precise	Heartless	Afraid to open up
Efficient	Able to find flaws	Unrealistic	Ruthless
Powerful	Creative	Eccentric	Not on my side
Organized	Seeking justice	Unfair	Weird
Rational			Unappreciative



## HOW COLORS SPEAK

### BLUE

#### In Conversations with others, Blues:

Love to talk  
Tend to be direct and honest  
Talk about how they feel  
Voice appreciation to others  
Avoid issues that might end in conflict  
Are verbally expressive and outgoing  
Ramble and get off the subject  
Are willing to talk about anything and everything  
Prefer dealing with people concerns, not facts  
Are very sympathetic  
Pay attention to nonverbal communication  
Personalize the situation

### GREEN

#### In Conversation with others, Greens:

Tend to rely on the facts  
Ask many questions  
Say things only once  
Avoid small talk  
Take a long time to make up their mind  
Argue both sides of an issue  
Use large vocabulary  
Wander from idea to idea  
Take logical approach  
Worry they are not understood  
State things in overly technical terms  
Are unaware of nonverbal cues  
Appear to be indecisive

### ORANGE

#### In conversations with others, Oranges:

Say just the right thing  
Use languages as a tool to make their point  
Dominate what is being said  
Cut in on others  
Get right to the point  
Make decisions quickly  
Want to know what has been done already  
Want to get on with things  
Want to limit the conversations to the basics  
Argue for argument sake  
Create energy and excitement  
Focus on results

### GOLD

#### In conversations with others, Gold:

Use clear and precise language  
Reach conclusions quickly  
Do not want to get sidetracked  
Want to keep the conversation in order  
Want to follow an agenda or plan  
Establish goals for follow-up  
Focus on things that need to be done  
Talk about fulfilling duties  
Focus on how efficient things are  
Cut the small talk

### **Activity 2: Group Dynamics**

Facilitators will review the rules and policies with the crew. Any questions or concerns will be addressed. Then, crew members will be split up into small groups and be given a stack of sticky notes. On the sticky notes, groups will add individual answers to these questions:

1. What traits, skills or abilities do you bring to a team?
2. What do you need from your teammates to feel comfortable and successful within the group?
3. What about teamwork is challenging to you?

Facilitators will guide an open, honest discussion about crew answers together.

### **Activity 3: BECY Group Contract**

**Purpose:** This activity, ideally done at the beginning of the program, helps to 1) build community, 2) create a safe space for all participants, and 3) create participant buy-in.

**Total Time: 25-45 minutes**

#### **Set-up:**

Explain that we will be working to decide, as a group, how we want to treat each other and be treated. We will lay down abstract principles and specific actions that we want to support, and those that we want to dispel. This is a space for open discussion. Explain that after the contract is signed, there will be consequences for violating it, which follows the same track as the consequences for breaking the rules.

### **Activity:**

Have the group sit in a circle, and designate a writer. Pose a potential item for the contract, such as “don’t use offensive language”. Ask what is missing – does it need further definition? Provide it if necessary. Ask if someone will “second” the addition, then if somebody will “third”. Ask the writer to add it to the contract. Students can pose additions, and if they are “seconded” and “thirded”, they can also be added.

Once all students have had the chance to pose all the additions they feel necessary, ask the students to sign the contract. Facilitators and leaders will also sign.

### **De-Brief Questions:**

- Explain that this contract is an addition to the “rules” that have been decided at the organizational level. It supports those rules, but does not replace them in any way.
- Does the contract seem reasonable to you?
- Why is it important to have group buy-in in creating a contract?

## **Water Restoration Activities**

### **Activity 4: Reading the Landscape**

A landscape is the visible features of an area of land, its landforms, and how they integrate with natural or man-made features, often considered in terms of their aesthetic appeal. Being able to read a landscape is the first step to any restoration related project. After reading guidance about what factors you should consider when reading a landscape, journal about the factors you notice. Can you relate your findings back to the provided local watershed maps?

### Activity 5: Build A Watershed

**Materials:** Blank sheet of white paper, colored markers

1. Take your sheet of paper, crumple it up
2. Uncrumple the sheet, lay it flat; this is your 3D model of a watershed
3. Color the peaks one color (brown)
4. Color the channels another color (blue)
5. Draw downward facing arrows from the peaks to the channels and other arrows to where the channels are moving toward; this is the movement of water in a watershed.

Spray some water on your 3D watershed model from above. Notice how the water moves. Have a group discussion about how water moves on a landscape.

#### Questions to consider:

**Where does water come from and where does it go?**

**Answer:** Discuss the water cycle. Water can come from precipitation, irrigation or overflow of groundwater. Plants soak it up. Evapotranspiration is the combination of water's most likely exit points: evaporation and transpiration.

**How does water move through the landscape?**

**Answer:** Gravity and pressure move water downward and sideways underground through spaces between rocks. Eventually it emerges back to the land surface, into rivers, and into the oceans to keep the water cycle going.

**How does water create landscapes?**

**Answer:** Water moves weathered rock from their original location, carving out the landscape. This process can be either fast or slow, depending on the elements. Rainwater causes weathering and erosion.

## Activity 6: Label A Watershed

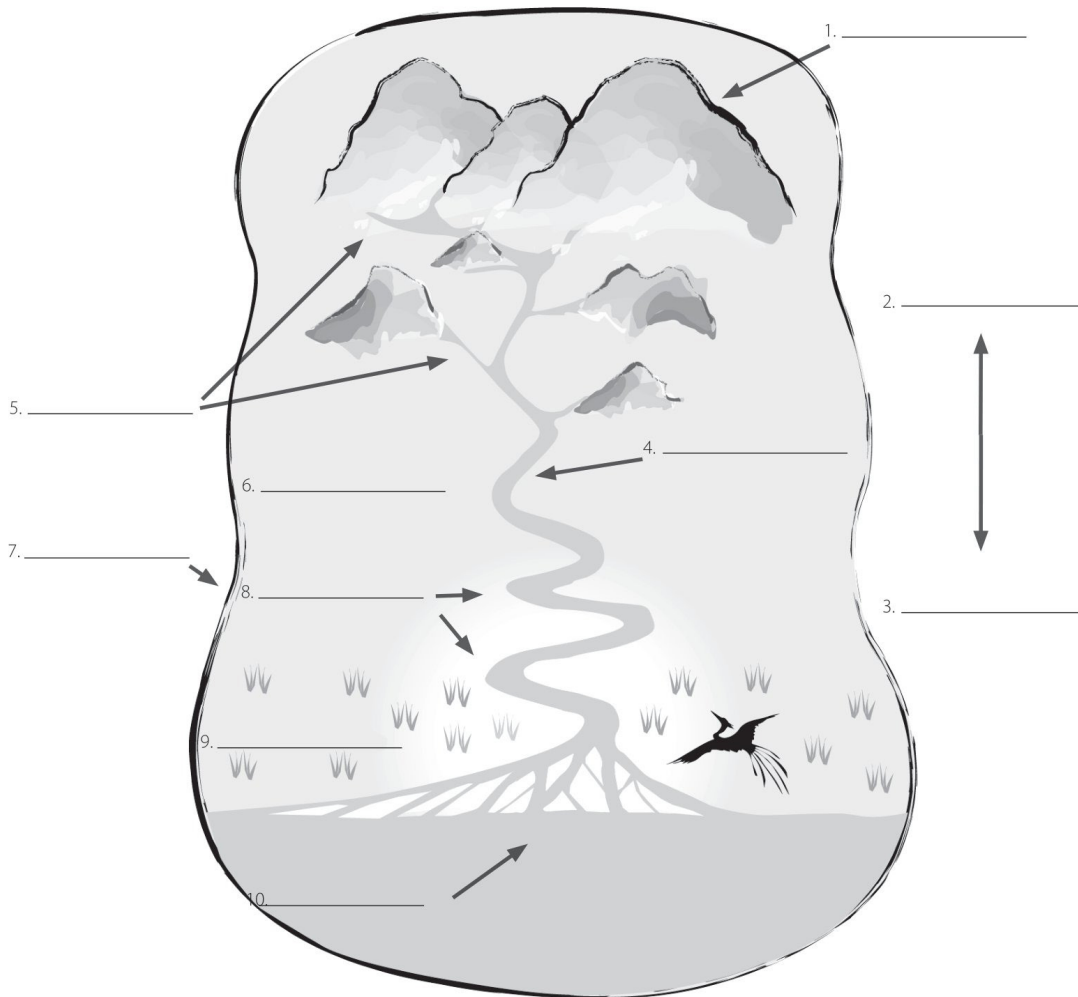
Label the components of a watershed and color in your diagram. Then, as a group we will look at maps of local watersheds and describing its features.

Name \_\_\_\_\_ Date \_\_\_\_\_

### Components of a Watershed

Use the words below to label the watershed diagram. Each label should appear only once on the diagram, in one of the spaces numbered 1–10.

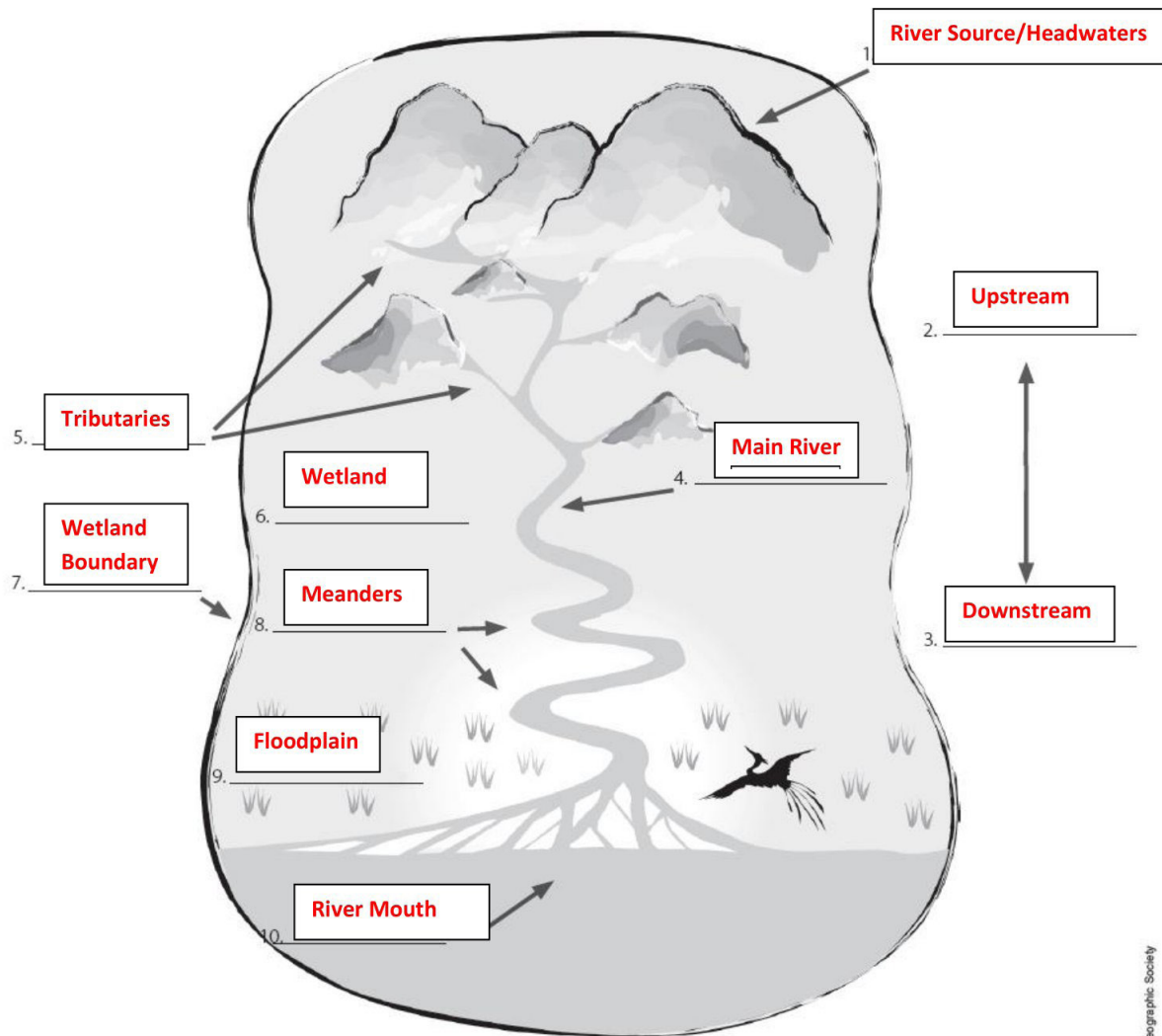
Tributaries	River Source	River Mouth	Upstream	Wetlands
Watershed Boundary	Main River	Floodplain	Downstream	Meanders



**Watersheds**

Label the following on the diagram below. Then on the back, define watershed and list the benefits of watersheds.

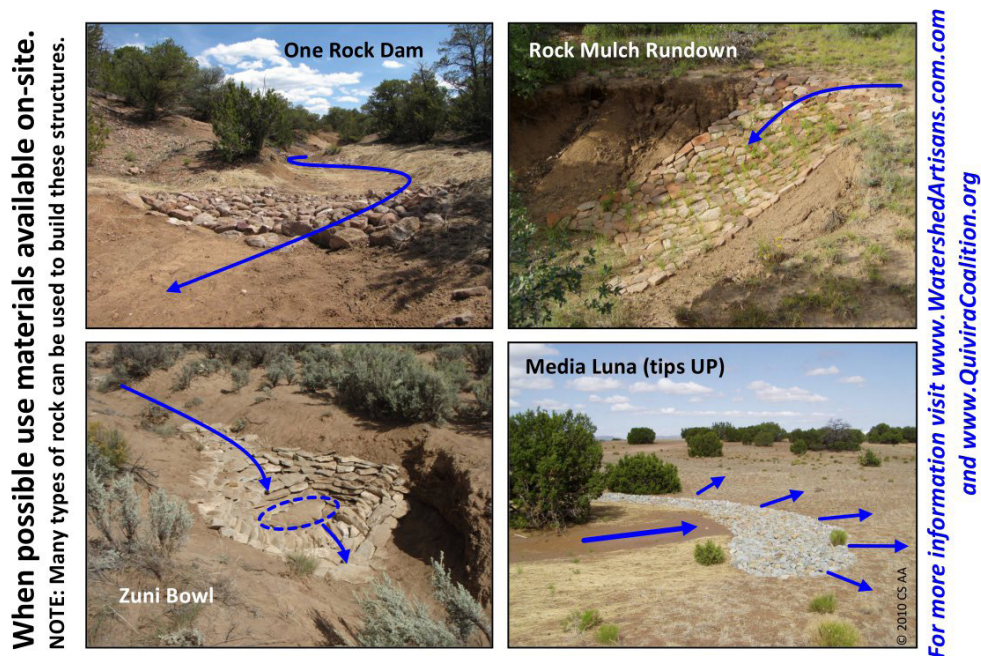
Tributaries	River Source	River Mouth	Upstream	Wetlands
Watershed Boundary	Main River	Floodplain	Downstream	Meanders



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## Erosion Control Structures

Images are from PDF Erosion Control Field Guide Craig S.



### Design and Construction: Trincheras

Trincheras make up the bulk of the total structure amount constructed by the BECY program. Many have been a few feet long and others have stretched the length of two vehicles. Though they may seem like simple structures, there are a lot of considerations which need to be accounted for before any rock placement can be made.

1. Choose an appropriate site for the structure that will produce maximum benefit to the surrounding landscape features. Trincheras should be constructed on the “straight-aways” or meander crossovers of the stream channel.
2. Dig out the channel and slightly into the bank to set large anchor rocks. Pile any removed sediment upstream of structure location.

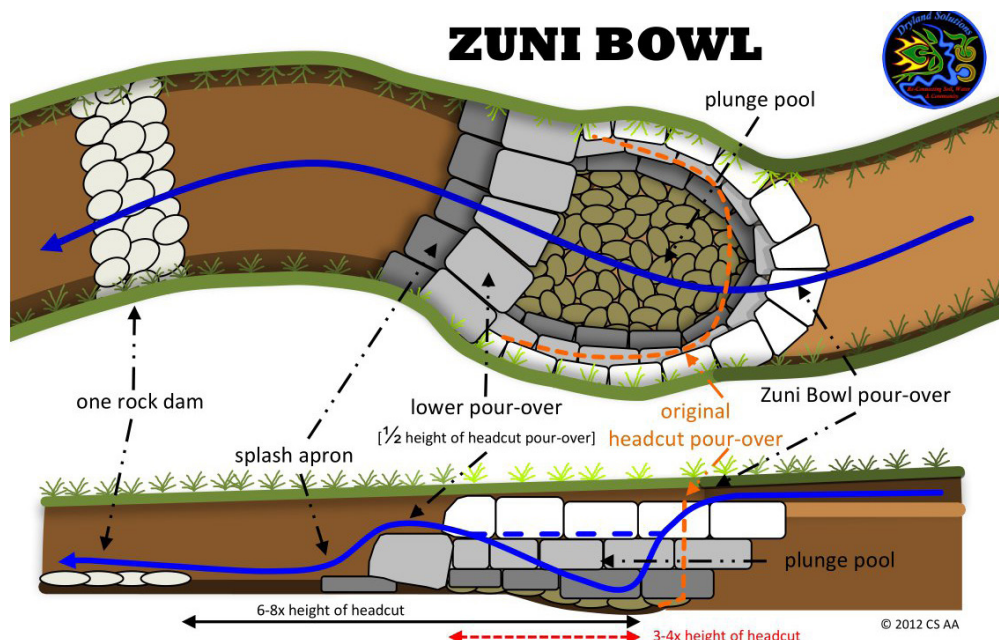
3. Continue to stack large and medium sized rocks until structure height is at the bank level yet slightly lower towards the center of the channel, creating a “U” shape, as shown in the picture below.
4. Stabilize the bank with more rocks. Extend structure onto banks of floodplains to encourage spreading. Mulch upstream with brush if available.
5. A concave structure is used when you are trying to collect water from the outside into the middle to create a narrow stream flow as opposed to very wide flow. A convex structure produces the opposite result and spreads water across an area rather than concentrating it into a small area.

### **Design and Construction: Zuni Bowl**

1. Select a headcut for treatment; shape and layback the face of the headcut to create a uniform surface on which to build.
2. Determine the height of the headcut. Next measure and mark the location downstream from the face of the headcut that is three times the height of the headcut. At this location dig a shallow trench and fill with one or two rows of rock, so that no rock protrudes more than the inches above the bed of the channel. This will serve as the splash apron for the Zuni Bowl.
3. Scatter native grass and wildflower seeds in the area where the Zuni Bowl is to be built.
4. Gather the largest rocks available, and place them in a row just upstream from, and in contact with, the splash apron. These rocks should sit at an elevation approximately  $\frac{1}{2}$  the total height of the headcut. This will serve as the lower pour-over of the Zuni Bowl.



5. Armor the bottom of the plunge pool with a single layer of rocks. Place these rocks at a uniform height to create a stable foundation for the rest of the Zuni Bowl.
  6. Starting just upstream from the lower pour-over, lay courses of rock around the face of the headcut., This will form the walls of the bowl. Maintain contact with the shaped surface. The structure will have more integrity if built with layers of off-set rocks that form a sloping wall around the headcut, as opposed to merely lining the face with rock. Improve the durability of the structure by avoiding gaps in the rock work. As an extra precaution, you can use biodegradable geotextile fabric to line the face of the headcut prior to laying rock.
  7. Continue to lay courses of rock around the face of the headcut until you reach the height of the headcut pour-over. No rocks should protrude above this level.
  8. Construct an ORD downstream from the Zuni Bowl. Place the upstream edge of the ORD approximately 4-6 times the height of the headcut away from the headcut pour over.
- BECY Douglas 2021 after maintaining a Zuni Bowl structure





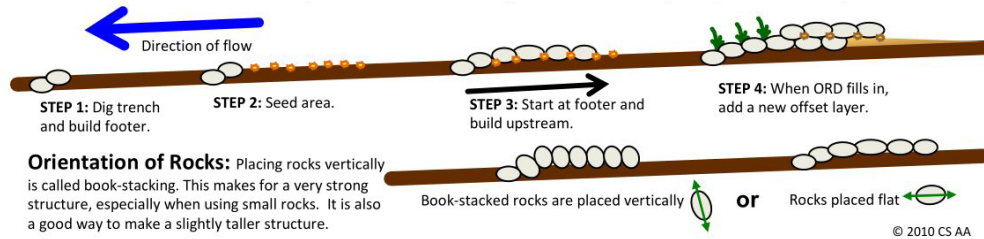
### **Design & Construction: One-Rock Dam**

1. Select area to build the ORD; dig a shallow footer trench and fill with one or two rows of rock, so that no rock protrudes more than two inches above the bed of the channel. This will serve as the splash apron for the ORD.
2. Scatter native grass and wildflower seeds in the area where the ORD is to be built.
3. Start building at the footer and continue upstream, laying down one layer of rock horizontally, as if you were building a rock wall.
4. The orientation of rocks is important too. A structure where the rocks are stacked vertically create more of a disturbance to water flows. This disturbance slows water flow, making it lose power and drop sediment it was carrying into the structure, though it is more likely to be deconstructed if the water force is too great to handle.

- Once the ORD is filled with sediment, another layer can be added to further raise the bed of the channel and capture more sediment. The original ORD becomes the splash apron for the new.

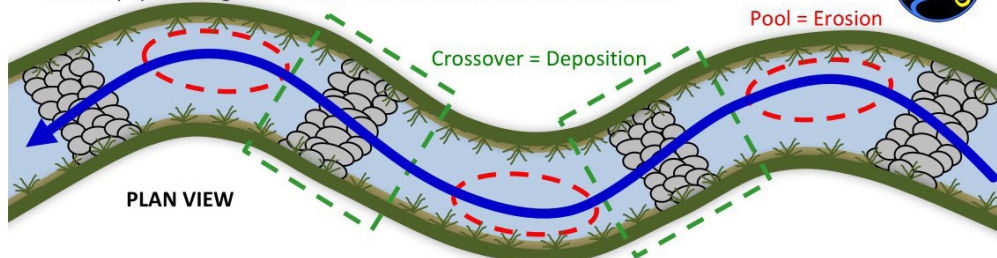
### When to use an ORD instead of a trinchera?

ORDs slowly regrade the streambed over time when the water velocity is unknown, or time is not an issue. Trincheras have a larger footprint and last longer but take more time to construct and require more materials and specialized materials as well.

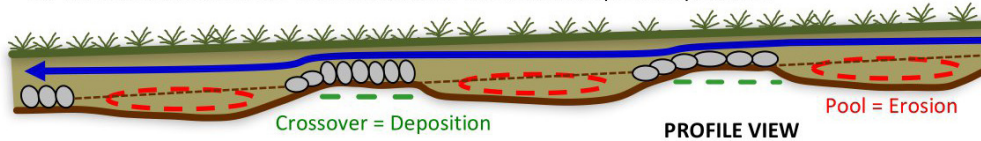


## ONE ROCK DAM

- Always position grade control structures at meander crossovers.



- Placement at crossovers maintains natural erosion and deposition patterns.



- Always maintain a low point in the channel cross section to prevent bank erosion.



Position grade control structures at meander crossovers (green, below). This preserves the natural erosion (red) and deposition (green) cycle of the channel. With one rock dams and trincheras, always protect the banks.

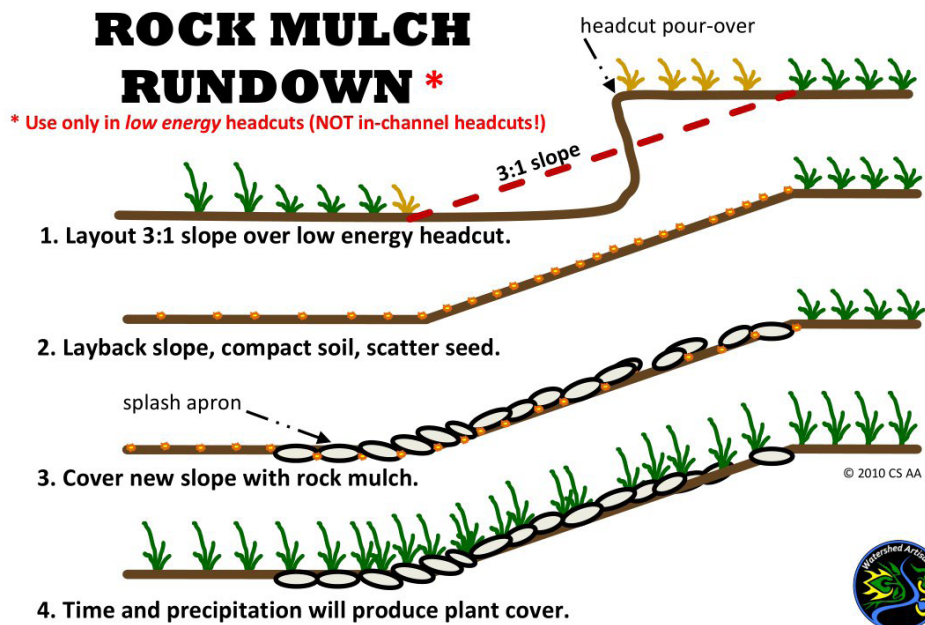
## Design & Construction: Rock Mulch Rundown

1. Select a low energy headcut for treatment.
2. Determine the extent of the 3:1 slope. Take care to balance the cutting required to achieve a 3:1 slope vs. the potential disturbance to existing vegetation.
3. Layback the headcut by cutting away soil from the top of the face, and then use the cut material to fill the base of the headcut. Where possible, the Rundown should be the entire width of the channel below the headcut. Narrow headcuts may need to be widened to accommodate the rock work. Adjacent headcuts, separated by uneroded fingers of earth, but leading to the same channel, can be combined into a single Rundown structure. Knock down the uneroded earth between the headcuts and use it as fill.
4. Compact the fill.
5. Scatter native grass and wildflower seed and rake the surface of the Rundown.
6. Dig a shallow trench on the down slope side of the Rundown and fill with one to two rows of rock, so that no rock protrudes more than 2in/5cm above the bed of the channel. This will serve as the splash apron for the Rundown.
7. Cover the entire surface of the Rundown with a single layer of rock mulch. The center of the Rundown should be the lowest point in the structure so water will not run around the edges.
8. Continue to lay rock on the surface of the Rundown until you reach the height of the headcut pour-over. No rocks should protrude above this level to allow water to flow freely over the structure. It is very important to avoid gaps in the rock work because gaps cause weak points in the structure. Fill gaps

with small gravel if needed. To improve durability, you can use a biodegradable geotextile mesh to line the surface of the Rundown prior to laying down rocks.

## ROCK MULCH RUNDOWN

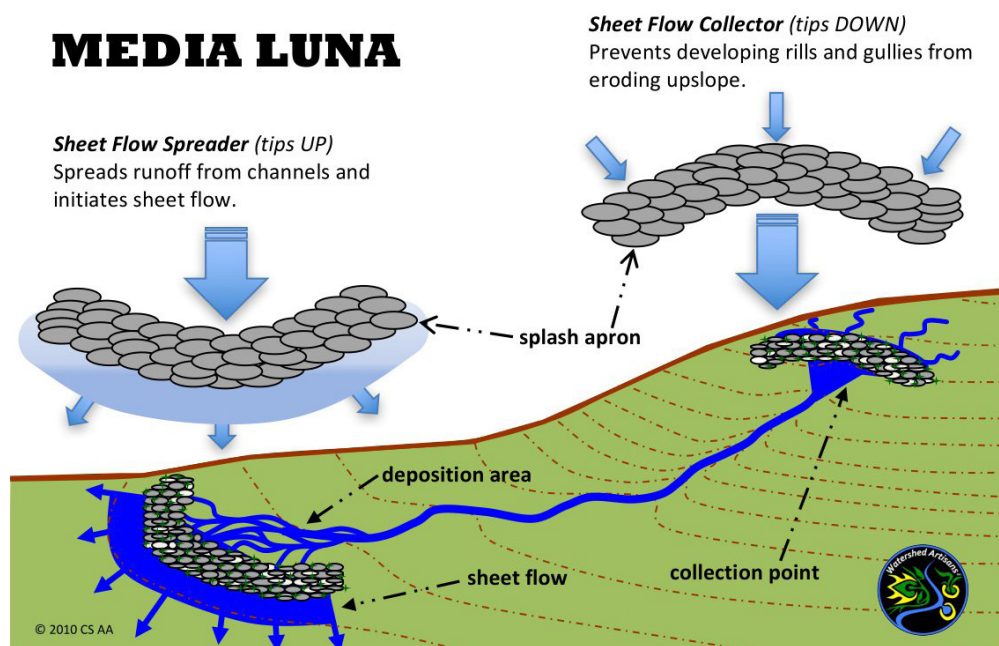
A headcut control structure where the face of the headcut has been laid back to a stable angle of repose (minimum of a 3:1 slope), and then covered with a single layer of rock mulch. The mulch serves to slow runoff, increase soil moisture, recruit vegetation, and ultimately prevent the headcut from migrating further up slope. Rock Mulch Rundowns are ONLY to be used on low energy headcuts, like those found in upland rills and gullies with small catchment areas, and where sheetflow collects and enters a channel. Original concept by Craig Sponholtz.



### Design & Construction: Media Luna

1. Identify which type of Media Luna (i.e., “horns UP” or “horns DOWN”) is appropriate for the treatment site.
2. If the treatment site is at the collection point of a network of rills or small gullies, then use a sheet flow collector (horns DOWN). Select two points 6 inches above the bed on each bank of the main channel immediately downslope of where the rills collect. Layout an arc from bank to bank so that the tips point down slope.

3. If the treatment site is located where runoff from a shallow channel (<1 ft deep) can easily be spread across relatively flat ground, then use a sheet flow spreader (horns UP). Layout an arc across the flat area with the tips at the same elevation (i.e., use a leveling tool) and the center slightly lower.
4. Layout the up-slope edge of the structure by tracing an arc parallel to the lower edge to create a band that is at least four feet wide. Media Lunas composed of wider bands of cobble mulch offer more protection from erosion, improved infiltration and increased plant recruitment.
5. Start by digging a shallow trench from tip to tip along the down slope side. Fill the trench with one or two rows of rock, so that no rock protrudes more than two inches above ground level. This will serve as the splash apron for the Media Luna.
6. Mulch upstream with brush if available.



## **Activity 7: Group Discussion on Watershed and Ecosystem Restoration**

The crew will split up into 2 groups. Each will re-read their designated section create a mind-map with the information they read and can come up with as a group. Below are prompts to get you started, program facilitators will visit groups to help guide the conversation. At the end, you will share your completed mind map and provide the details to the crew.

### **Watershed**

- What is watershed restoration?
- How do we restore watersheds?
- Who does watershed restoration?
- Why is this important?

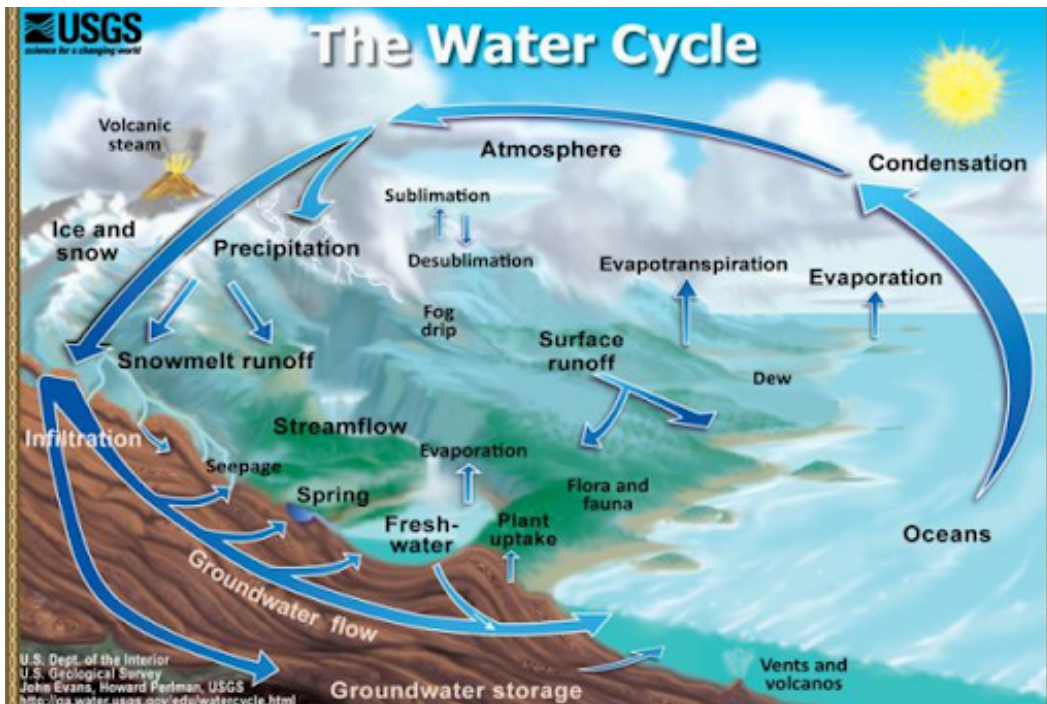
### **Ecosystem**

- What is ecosystem restoration?
- How do we restore ecosystems?
- Who does ecosystem restoration and who benefits?
- Why is this important?

## Activity 8: Water In Different Environments

Facilitators will present models that showcase three different scenarios: water in nature, water in the city, water at home in a water harvesting system. Water will be poured into these models, note how it moves in each model. We will be answering these questions:






1. How did water move in model 1, 2 and 3?
2. What happens when you bring nature elements back into the city?







## Benefits of Harvesting Rainwater

-  Conserves water
-  Decreases your bills
-  Lowers demand on freshwater resources
-  Slows erosion in dry environments
-  Reduces flooding in low-lying areas

**Treehugger**

### **Activity 9: Fixing Eroding Landscapes**

Interns build a miniature watershed with structures from what is available in the immediate area. Interns will form pairs within the group. Each pair finds a small slope with a dirt surface with few plants, roughly 2-4 square feet, to perform a watershed simulation. This dirt surface is a watershed you have been assigned to restore.

After 15 minutes of “restoring” the watershed using rocks/wood/dirt/etc., facilitators will ask groups to describe their process and philosophies behind their design. Facilitators will then pour water at the top of each restored watershed. Pair’s “win” this activity by creating the least erosion/runoff when facilitators pour water on the watershed. After each team performs their watershed simulation, the crew circles up to discuss the factors that altered the erosion and runoff.

#### **Questions to ponder:**

- What structures did you use and why?
- Would you have changed which structures were used?
- What would you have changed about these structures, i.e., materials used?
- Did it meet your expectations?

## **Ecosystem Restoration Activities**

### **Activity 10: Identify Native Succulents**

Interns will learn to identify common succulents in the area. Break into pairs. Each group is assigned one of the following native succulents. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

### **Activity 11: Identify Native Cacti**

Interns will learn to identify common cacti in the area. Break into pairs. Each group is assigned one of the following native succulents. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

### **Activity 12: Identify Native Trees**

Interns will learn to identify common trees in the area. Break into pairs. Each group is assigned one of the following native trees. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

### **Activity 13: Identify Native Wildflowers**

Interns will learn to identify common native wildflowers in the area. Break into pairs. Each group is assigned one of the following native trees. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

#### **Activity 14: Identify Native Grasses**

Interns will learn to identify common native grasses in the area. Break into pairs. Each group is assigned one of the following native grasses. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

#### **Activity 15: Identify Native Shrubs**

Interns will learn to identify common native shrubs in the area. Break into pairs. Each group is assigned one of the following native shrubs. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

#### **Activity 16: Identify Native Birds**

Interns will learn to identify common birds in the area. Break into pairs. Each group is assigned one of the following native birds. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

#### **Activity 17: Identify Native Mammals**

Interns will learn to identify common mammals in the area. Break into pairs. Each group is assigned one of the following native mammals. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

#### **Activity 18: Identify Native Reptiles**

Interns will learn to identify common reptiles in the area. Break into pairs. Each group is assigned one of the following native reptiles. Look up further information online or in a field guide.

Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

### **Activity 19: Identify Native Insects**

Interns will learn to identify common insects in the area. Break into pairs. Each group is assigned one of the following native insects. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

### **Activity 20: Identify Invasive Species**

Interns will learn to identify common invasive species in the area. Break into pairs. Each group is assigned one of the following invasive species. Look up further information online or in a field guide. Present information about the plant to the rest of the crew: how to identify, where it grows, and its adaptations to its environment. Fill out the worksheet guide.

# WILDLIFE IDENTIFICATION: Succulents

## Firesticks Succulent Cactus (*Euphorbia tirucalli*)

Description:

Adaptations:

Habitat:

Facts:



## Palmer's Century Plant (*Agave palmeri*)

Description:

Adaptations:

Habitat:

Facts:



## Banana Yucca (*Yucca baccata*)

Description:

Adaptations:

Habitat:

Facts:



## Lady Slipper (*Euphorbia macrocarpus*)

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION: *Cacti*

## **Saguaro (*Carnegiea gigantea*)**

Description:

Adaptations:

Habitat:

Facts:



## **Prickly Pear (*Opuntia*)**

Description:

Adaptations:

Habitat:

Facts:



## **Teddy Bear Cholla (*Cylindropuntia bigelovii*)**

Description:

Adaptations:

Habitat:

Facts:



## **Fishhook Barrel (*Ferocactus wislizeni*)**

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION:

# Trees

## Velvet Mesquite (*Prosopis velutina*)

Description:

Adaptations:

Habitat:

Facts:



## Sycamore (*Platanus occidentalis*)

Description:

Adaptations:

Habitat:

Facts:



## Canyon Hackberry (*Celtis laevigata*)

Description:

Adaptations:

Habitat:

Facts:



## Fremont Cottonwood (*Populus fremontii*)

Description:

Adaptations:

Habitat:

Facts:





# WILDLIFE IDENTIFICATION:

# Wildflowers

## California Poppy (*Eschscholzia californica*)

Description:

Adaptations:

Habitat:

Facts:



## Chuparosa (*Justicia californica*)

Description:

Adaptations:

Habitat:

Facts:



## Desert Globemallow (*Sphaeralcea ambigua*)

Description:

Adaptations:

Habitat:

Facts:



## New Mexico Thistle (*Cirsium neomexicanum*)

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION: *Grasses*

## **Blue Grama (*Bouteloua gracilis*)**

Description:

Adaptations:

Habitat:

Facts:



## **Deergrass (*Muhlenbergia rigens*)**

Description:

Adaptations:

Habitat:

Facts:



## **Giant sacaton (*Sporobolus wrightii*)**

Description:

Adaptations:

Habitat:

Facts:



## **Six-weeks Grama (*Bouteloua barbata*)**

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION:

# Shrubs

## Ocotillo (*Fouquieria splendens*)

Description:

Adaptations:

Habitat:

Facts:



## Manzanita (*Arctostaphylos*)

Description:

Adaptations:

Habitat:

Facts:



## Desert Lavender (*Condea emoryi*)

Description:

Adaptations:

Habitat:

Facts:



## Creosote (*Larrea tridentata*)

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION: *Birds*

## **Mourning Dove (*Zenaida asiatica*)**

Description:

Adaptations:

Habitat:

Facts:



## **Common Grackle (*Quiscalus*)**

Description:

Adaptations:

Habitat:

Facts:



## **Cactus Wren (*Campylorhynchus brunneicapillus*)**

Description:

Adaptations:

Habitat:

Facts:



## **Gambel's Quail (*Callipepla gambelii*)**

Description:

Adaptations:

Habitat:

Facts:





### **Jaguar (*Panthera onca*)**

Description:

Adaptations:

Habitat:

Facts:



### **Coyote (*Canis latrans*)**

Description:

Adaptations:

Habitat:

Facts:



### **Javelina/Peccary (*Tayassuidae*)**

Description:

Adaptations:

Habitat:

Facts:



### **Lesser-long Nosed Bat (*Leptonycteris yerbabuena*)**

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION:

# Reptiles

## **Gila Monster (*Heloderma suspectum*)**

Description:

Adaptations:

Habitat:

Facts:



## **Sidewinder (*Crotalus cerastes*)**

Description:

Adaptations:

Habitat:

Facts:



## **Common Chuckwalla (*Sauromalus ater*)**

Description:

Adaptations:

Habitat:

Facts:



## **Sonoran Desert Toad (*Incilius alvarius*)**

Description:

Adaptations:

Habitat:

Facts:





**Arizona Bark Scorpion (*Centruroides sculpturatus*)**

Description:

Adaptations:

Habitat:

Facts:



**Giant Desert Centipede (*Scolopendra heros*)**

Description:

Adaptations:

Habitat:

Facts:



**Red Velvet Ant (*Dasymutilla occidentalis*)**

Description:

Adaptations:

Habitat:

Facts:



**Swallowtail Butterfly (*Papilionidae*)**

Description:

Adaptations:

Habitat:

Facts:



# WILDLIFE IDENTIFICATION: *Invasive Species*

## **Johnsongrass (*Sorghum halepense*)**

Description:

Adaptations:

Habitat:

Facts:



## **Buffelgrass (*Cenchrus ciliaris*)**

Description:

Adaptations:

Habitat:

Facts:



## **Arundo (*Arundo donax*)**

Description:

Adaptations:

Habitat:

Facts:



## **Bullfrogs (*Lithobates catesbeianus*)**

Description:

Adaptations:

Habitat:

Facts:





### **Activity 21: Soil Characterization Activity - The Carazas Test**

Interns will learn to demonstrate the physical characteristics of soils containing high clay, silt, or sand content. Break into pairs. With your soil sample, work with a partner to follow the instructions on the worksheet. Interns will be able to manipulate soil samples using different amounts of water and compaction to achieve different results. This is an outdoor activity that can be completed on pavement.

Groups will compare results at the end of the activity, and discuss which group had a sample with the most clay, silt, or sand content.

**Teaching point #1:** Arizona soils have a very high pH (alkalinity).

They are considered basic. This is due to natural weathering of rocks containing calcium carbonate. The limited amount of annual rainfall in Arizona also does not flush away the accumulated salts in the soil, which contributes to alkalinity.

Luckily, native plants are adapted to this soil environment!

Non-native plants often do not fare well in basic soil, and need amendments such as sulfur to be able to grow. This is a great way to open the conversation further towards why BRN focuses specifically on native plants, and why using native plants in habitat restoration is a best practice.

**Teaching point #2:** Different species prefer different variations of physical soil - some species like seep willow and *a. thurberi* prefer sandy, well draining soil. You see these species in the washes and arroyos. Species like Clay soils have the highest nutrient holding capacity, but are harder for roots to grow through because there are fewer air pockets.

## Activity 22: Soil Organic Matter - Compost Jar Experiment

Interns will build their own compost jar and understand the components of how soil organic matter is formed. Break into pairs: each intern will have access to a mason jar, "greens", and "browns" for use in layering, water, and a stirring stick. We will drill holes in the lids of the mason jars to allow for air to access the mixture. Directions include shaking the jars each day, and placing them in a shaded spot inside your house.

**Teaching point #1:** Soil microbiology (bacteria and fungi) is responsible for creating soil organic matter, and is a process of decomposition.

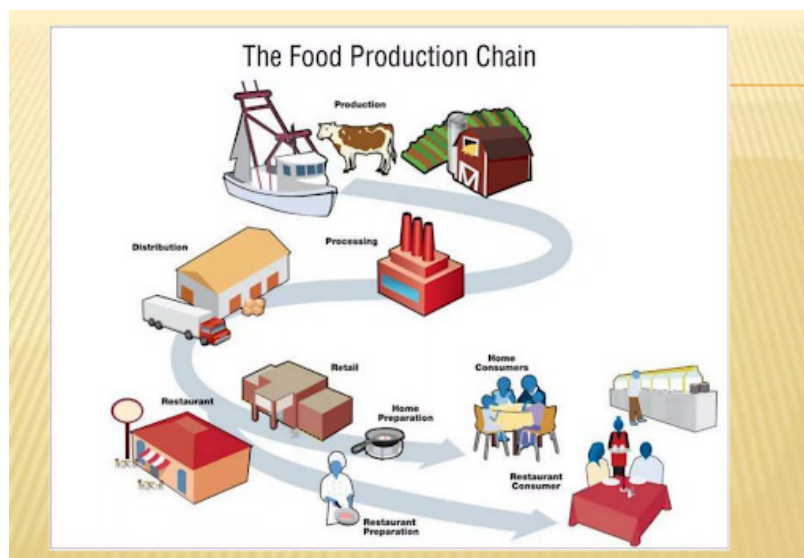
**Teaching point #2:** Landfill space is limited, and we can create fertilizer for food-growing soils from our organic household waste.

**Teaching point #3:** Arizona soils have less than 2% organic matter.

## Community Restoration Activities

### Activity 23: Food Travels

Take a look at your lunch. Reflect on each individual product, and what it took for it to get there. You can check the label to see how the food was processed or where it came from.



## Activity 24: Placemaking

Placemaking is the process of creating and enhancing public spaces to improve the quality of life in a community. It involves collaborating with community members to design and activate public spaces in ways that reflect the needs and aspirations of the community.

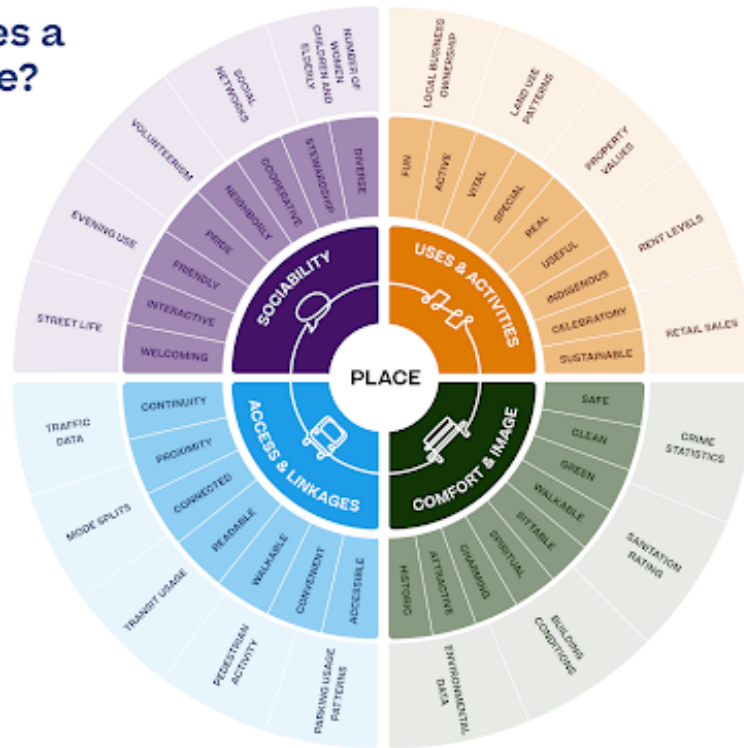
Placemaking is important to developing sustainable communities because it fosters a sense of belonging and ownership among community members, which in turn leads to increased social cohesion and resilience. When people have a say in how their public spaces are designed and used, they are more likely to feel invested in their communities and to take responsibility for their upkeep and maintenance.

In addition, well-designed public spaces can help promote physical activity, reduce social isolation, and mitigate the effects of climate change by providing shade, reducing urban heat islands, and capturing stormwater. By prioritizing placemaking in community development, we can create more vibrant and sustainable communities that are better equipped to meet the challenges of the future.

Describe what makes your hometown a great place? What are aspects you would change to improve sense of place where you live? Write a reflection, we will groupshare.

## What Makes a Great Place?

Project  
for Public  
Spaces



### Investigate Local Environmental Issues

Investigate the effects of human activities in the local community. Create a scrapbook or slideshow of local environmental issues using newspaper and magazine articles, brochures, and other resources. Identify both the direct and the indirect impacts of human actions, including stories of local environmental stewardship projects or other human actions that have helped or had a negative effect on the local area. Present “Hero Awards” to local citizens and fellow students who are environmental stewards.

### Activity 25: Chapter 1 - Community Restoration Review

Use these learning outcomes to review your comprehension Chapter 1.

- Participants will understand the importance of environmental literacy and education in maintaining a sustainability-oriented community, as well as the various methods for achieving environmental literacy.
- Students will be able to describe the unique aspects of the borderlands region they are from, including its cultures, languages, and diverse ecoregions, and the importance of culturally responsive climate action in supporting historically marginalized communities.
- Students will understand the critical role of stewardship and collaboration in maintaining the longevity and sustainability of the borderlands landscape and the importance of proactive programming and training in the restoration of watersheds, ecosystems, and communities.
- By studying the impacts of human activities on ecosystems and recognizing the negative consequences associated with unsustainable practices, learners will be able to identify and evaluate potential solutions to mitigate these negative impacts and promote sustainability. Additionally, learners will develop critical thinking skills to evaluate different challenges and potential solutions related to current environmental issues.
- Participants will be able to analyze and evaluate the effectiveness of various sustainable practices such as permaculture, water harvesting, and ecotourism in reducing negative human impacts on the environment while also improving human well-being. They will also be able to develop informed opinions on the feasibility of implementing these practices in their own communities.

### Activity 26: Chapter 2 - Ecological Restoration Review

Use these learning outcomes to review your comprehension Chapter 2.

- Explain the importance of greater biodiversity in ensuring natural sustainability in all life forms, and understand how the Madrean Archipelago is one of the most biodiverse areas in the entire world.
- Appreciate the unique geographic and climatic features of the Madrean Archipelago and recognize the importance of protecting this ecoregion for the many important species that call it home.
- Connect the BRN's approach to ecosystem restoration to the Sustainable Development Goals of Climate Action and Life on Land, and understand how this work contributes to the larger global effort to protect and restore our planet's natural resources.
- Identify the three main adaptations of desert flora (succulence, drought evasion, and drought tolerance) and explain how these adaptations help the plants to survive in the desert.
- Describe how desert fauna have adapted to living in the desert, including their nocturnal behavior, use of underground burrows, and consumption of water through food.
- Understand the interconnectedness of flora and fauna in the desert ecosystem, including how animals rely on plants for water and how plants rely on animals for pollination and seed dispersal.
- Analyze the components of a food web and identify the relationship between the five trophic levels and energy transfer across the food chain.

- Learn the components of creating a habitat for native pollinator species via a pollinator garden regardless of the size of the plot of land, starting with a small garden and expanding as they learn more about the plants visited by pollinator species.

### Activity 27: Chapter 3 - Watershed Restoration Review

Use these learning outcomes to review your comprehension Chapter 3.

- Define the water cycle and its significance for maintaining the availability and quality of water on Earth.
- Describe the main sources of water in Arizona and explain water resource allocation in the region.
- Differentiate between surface water and groundwater then, dispel the misconception that Arizona is a barren wasteland when we can't see water on the landscape.
- Explain what a water is and its importance in the management of water resources.
- Summarize the role of erosion and deposition in shaping watersheds and how water and wind shape the landscape.
- Identify the factors that affect streamflow and water quality in a watershed.
- Understand the historical water resource management in Arizona, including the impact of human activities such as overgrazing, population growth, and agricultural practices on water availability and quality.
- Comprehend the current challenges facing water resources in Arizona, including aridification and climate change, and the potential consequences for water availability and quality.
- Identify and describe the benefits of slowing down water flow and increasing underground water in restoring the health of landscapes and supporting plant populations.



- Implement erosion-control structures and rainwater-harvesting cisterns, and learn how they can be used to protect and conserve water resources in Arizona.
- Understand the importance of protecting water resources for both human and non-human communities, and the potential long-term consequences of not addressing water-related challenges and excessive erosion.
- Identify key elements to consider when prioritizing restoration sites, including the health of the landscape, the scale of the project, and the project goal.
- Determine the physical and biological cues that indicate the health of a watershed or landscape system and choose where to place restoration structures.

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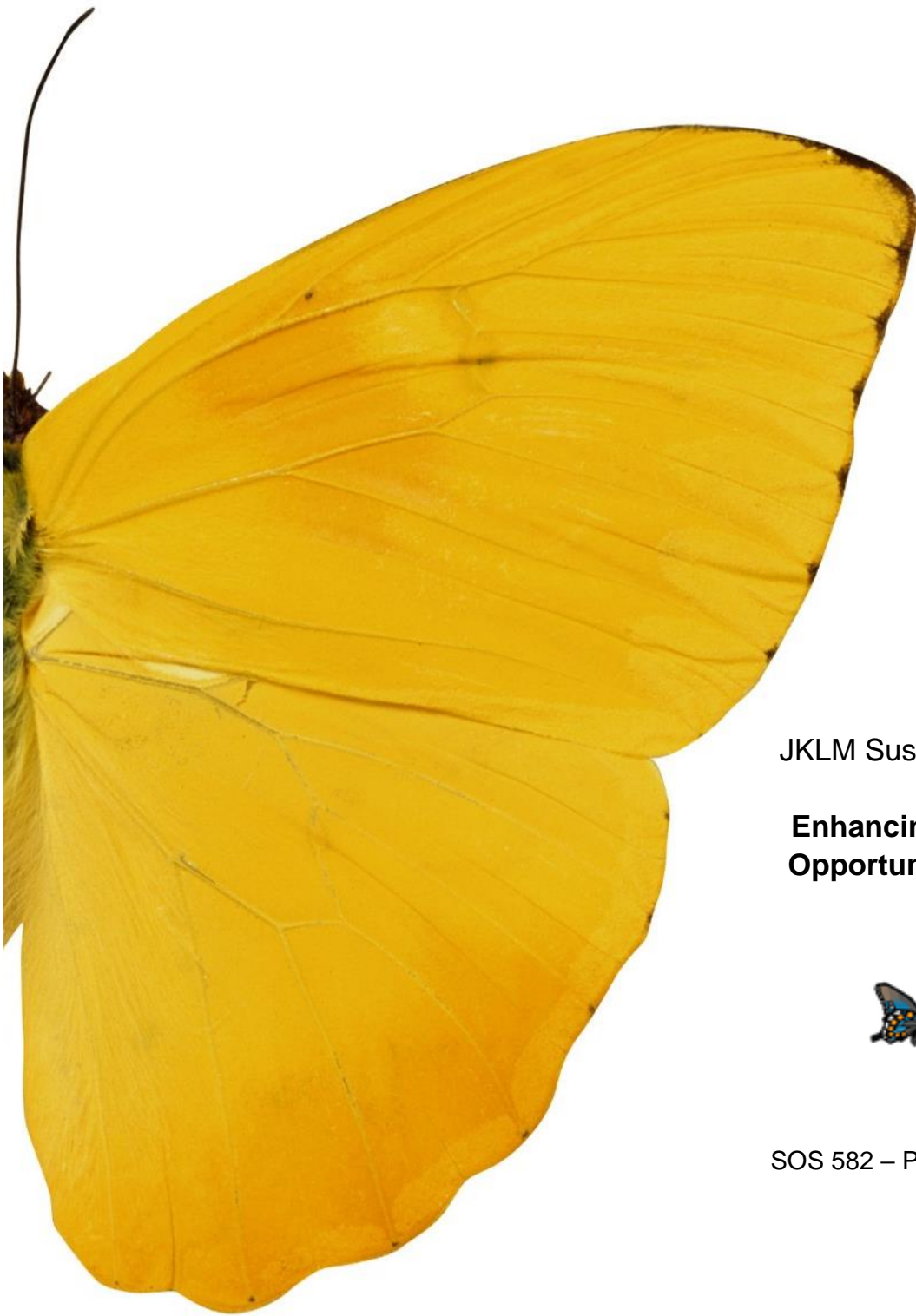
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**BORDERLANDS  
RESTORATION  
NETWORK**

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JKLM Sustainability Consulting Presents:

**Enhancing Environmental Education  
Opportunities within the Borderlands**

Prepared for



Arizona State University  
SOS 582 – Project Management for Sustainability



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## ABOUT JKLM SUSTAINABILITY CONSULTING



Jordan Sene is a graduate student in the Master of Sustainability Solutions accelerated program at Arizona State University. As the Youth Education Program Coordinator for the Borderlands Earth Care Youth (BECY) program, she is interested in community development, program evaluation, and continuing to build a culturally responsive environmental education curriculum that serves the diverse communities that BRN partners with. Following her graduation in May 2023, Jordan will continue supporting Borderlands Restoration Network’s mission of supporting a far-reaching restoration-based economy through educational outreach and programming.

Kayla Napper is a part-time Customer Service Specialist within the Enterprise Technology department and a full-time second-year graduate student in the Masters of Sustainability Solutions program at Arizona State University (ASU). She received her Bachelor of Arts in Psychology and a minor in Sustainability in 2019 from ASU as well. Her academic passions and interests involve environmental psychology and ecology. More specifically, how humans react to a more sustainable environment mentally, physically, and spiritually. She hopes to continue her studies on this topic and eventually teach the importance of psychology within environmental education to better ourselves and the world around us with a traditional ecological knowledge approach. Aside from school, in her free time, she enjoys gardening, traveling, snuggling with her dog, and finding the next best thrift store deal!



## Culminating Experience – Project Plan



Laney Meeker is a Community Programs Manager with the Arizona Food Bank Network, the statewide anti-hunger coalition. In her role, she focuses on creating innovative and community-driven solutions to address the barriers to food access and security throughout the state. While engaging in this work, her approach is deeply rooted in the intersections of social justice, sustainability, and public policy. Laney is presently enrolled in the concurrent Master of Public Administration and Master of Sustainability Solutions graduate programs at Arizona State University and will graduate in Spring 2023. She holds a Bachelor of Science in Justice Studies from Arizona State University. In her free time, she's an avid reader, enjoys hiking and camping around the Southwest, and traveling to new places.

Marshall Morgan Fabara is a second-year student in the Masters of Sustainability Solutions program at Arizona State University. Prior to beginning his Master's program, Marshall graduated Summa Cum Laude from Arizona State University with concurrent degrees in Sustainability and History. Marshall's work is driven by his desire to educate the next generation and to serve as an advocate for historically marginalized communities that lack sustainable resources and infrastructures. Marshall's work has resulted in his involvement with numerous non-profit organizations, such as the Latino Heritage Internship Program, and federal agencies, such as the National Park Service. Marshall hopes to continue assisting historically marginalized communities in gaining critical environmental education opportunities and sustainability resources following his graduation in May 2023.



## EXECUTIVE SUMMARY

According to Borderlands Restoration Network’s newly-released Strategic Plan (2022-2027), the organization wants to broaden the reach of the education, outreach, and training programs they host in order to inspire more people to advance a restorative economy. This priority includes the expansion of Borderlands Earth Care Youth (BECY) to the Rio Rico and Nogales, Arizona communities. Additionally, the organization wants to increase capacity to accommodate more local youth participants in the BECY program.

To effectively assist BRN in achieving its youth education program expansion goals, JKLM Sustainability Consulting used sustainability analysis tools to provide foundational information and guidance regarding environmental education curriculum development, program evaluation and program expansion. In addition to these analyses, JKLM focused primarily on reviewing the BECY curriculum and the potential opportunities for its evaluation and expansion. By analyzing current BECY operations in comparison to other similar existing programs, JKLM gathered information needed to provide recommendations and next steps. Using guidelines and criteria from the North American Association for Environmental Education and its Arizona affiliate, we identified appropriate themes from successful programs in the landscape analysis, anchoring our recommendations. In summary JKLM identified through our analyses five key recommendations for implementation:

1. Update existing curriculum and enhance offerings to include online formats.
2. Work with local schools and community organizations to integrate BECY programming into their curriculum and after-school or summer programs.
3. Expand program offerings to early childhood and youth age groups in target expansion areas.
4. Host community convenings to gain stakeholder input and collaboration on tailoring the curriculum to be culturally appropriate and meet the community’s needs.
5. Implement program evaluation of each new curriculum and program completed moving forward to determine improvements.

It is important to note that JKLM will not be implementing these recommendations at BRN. We will provide additional information for BRN to implement any recommendations they might want to adopt. In the following semester, we will review and provide recommendations for enhancement of the current BECY education curriculum. We will also research the environmental education curriculum accreditation process and provide the next steps to BRN for consideration. Finally, we will conduct outreach to local schools and community organizations in targeted expansion areas to gauge interest in partnering with BRN and implementing BECY curriculum.

## BACKGROUND

Borderlands Restoration Network (BRN) is a nonprofit organization based out of Patagonia, Arizona that partners with borderland communities to grow a restorative economy by rebuilding healthy ecosystems, restoring habitat for wildlife and reconnecting our border communities to the land through shared learning. BRN works closely with four independent organizations that share a common vision: Borderlands Restoration, Wildlife Corridors LLC, Cuenca Los Ojos, and Deep Dirt Farm. With the grants and contracts received through collaboration with private, public and federal entities, BRN coordinates their Native Plant Program, Watershed and Habitat Restoration, and the Borderlands Wildlife Preserve along with several Education and Outreach initiatives. BRN's educational outreach has reached 2,895 participants (BRN).

BRN is a unique organization that is centered within the Madrean Archipelago, one of the most important biodiversity hotspots in the world. Since the organization works within the trinational borderlands region of Arizona, Sonora, Mexico and the Tohono O'odham Nation, there are a host of sustainability challenges and opportunities surrounding issues such as climate change, habitat fragmentation, aridification, and several dynamic socio-economic injustices pertaining to the economy, race, food, migration and climate.

### Borderland Restoration Network Mission & Vision

*"We envision connected borderlands where rivers flow, plants, wildlife, and cultures thrive, and communities develop an inclusive restorative economy where a sense of place inspires a sense of purpose."*

The areas of Rio Rico and Nogales, Arizona are quite unique, given the history and culture of the communities. Like many other borderland communities, the areas of Rio Rico and Nogales were independent Indigenous areas until they became a part of Mexico. Having a population background of Indigenous and Latino members, these borderland regions developed their own traditions and cultures. However, in 1848 things would permanently change for these groups as the Mexican-American War would come to an end with the signing of the Treaty of Guadalupe Hidalgo. The reason that this treaty was impactful for the communities of Rio Rico and Nogales is that it set the precedent of the United States acquiring land that was part of Mexico. In 1954, just six years after the Treaty was signed, the United States leveraged its power and influence over Mexico to purchase 29,670 acres of land from Mexico. This is known as the Gadsden Purchase, and it would result in the communities of Rio Rico and Nogales becoming part of the United

## Culminating Experience – Project Plan

States of America. This is important to highlight that the Gadsden Purchase resulted in Nogales being split in two. Today, there remain two cities of Nogales, one in the state of Arizona and one in Sonora. Given this rich history, while they are a part of the US many of the community members still have strong cultural and familial ties to Mexico. As a result of these connections, when analyzing the populations of Rio Rico and Nogales, Arizona, it is critical to consider this background before tailoring environmental education programs for these borderland communities.

The population of Nogales is an estimated 94.8% Hispanic or Latino, and Rio Rico is 87.6% Hispanic or Latino (United States Census Bureau). Based on the history of Rio Rico and Nogales, Arizona, these populations remain marginalized and are challenged by a lack of community resources. This correlates to significant socioeconomic injustices in these borderland regions, and there remains a lack of established sustainability-focused education opportunities for the youth. Environmental education is still often considered a specialized or unnecessary curriculum. BRN is seeking to expand their programming into Rio Rico and Nogales, Arizona to address this perception and these inequities. As a result, BRN has the potential to create educational opportunities that are culturally inclusive and mutually benefit the community members and the organization itself.

## Hispanic/Latino Demographics

<b>United States Demographics</b>	As Of 2020, Hispanics/Latinos Make Up 19% Of The Total US Population.	As Of 2020, 17% Of Hispanics/Latinos Living In The US Live At Or Below The Poverty Line.	As of 2020, 31% Of The Hispanic/Latino Population In The US Is Younger Than 18 Years Old.
<b>Rio Rico, Arizona Demographics</b>	As Of 2020, Hispanics/Latinos Make Up 88% Of The Rio Rico Population	As Of 2020, 18% Of The Total Population In Rio Rico Live At Or Below The Poverty Line.	As of 2020, 31% Of The Total Population In Rio Rico Is Younger Than 18 Years Old.
<b>Nogales, Arizona Demographics</b>	As Of 2020, Hispanics/Latinos Make Up 95% Of The Nogales Population	As Of 2020, 28% Of The Total Population In Nogales Live At Or Below The Poverty Line.	As of 2020, 26% Of The Total Population In Nogales Is Younger Than 18 Years Old.

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A key BRN program is Borderlands Earth Care Youth (BECY), which has been successfully implemented in Patagonia and Douglas, Arizona over the past ten years. BECY is a paid internship-style program focused on inspiring and training the next generation of land stewards in the borderland communities. Youth, ages 15 - 18, work alongside conservation professionals from the federal government, local ranches or farms, and private and public spaces, to restore watersheds, ecosystems, and their communities. This grassroots-driven educational program was created to empower culturally diverse youth living in often overlooked and underserved areas. Some of the program activities include building erosion control structures, installing rainwater harvesting systems, removing invasive species, planting native plants and seeds, and implementing several community rehabilitation projects that support nature and people.

## PROBLEM STATEMENT

The advancement of quality education and networking opportunities helps create a diverse conservation sector and will further support the restoration economy in borderland communities. In Arizona, not all borderland communities have access to these environmental education opportunities to contribute to local conservation efforts. Rio Rico and Nogales, Arizona are two borderland communities that would benefit from Borderland Restoration Network's (BRN) programs and could contribute to water conservation, ecosystem rehabilitation, and civic engagement.



As a non-profit, common challenges faced by BRN include fundraising, membership retention, and capacity building. Notably, BRN is a smaller-scale non-profit organization with only twenty-three staff members and three of those are in the Education and Outreach branch. Expanding to new areas or changes to program operations requires careful planning and prioritization of limited staff time. To be successful it is crucial that they develop a culturally responsive curriculum that meets the needs of community members and improves environmental sustainability education. In these target expansion areas, building connections with local schools and afterschool programs will take considerable time and effort. Lastly, BRN lacks a standard framework for evaluation to determine whether program expansion areas are successful or not.

## METHODOLOGY

JKLM used a framework provided by the North American Association for Environmental Education and Arizona Association for Environmental Education to make recommendations on curriculum development and standardization, program evaluation, and community engagement. Our research approach included collecting qualitative and anecdotal evidence using key sustainability analysis tools: a sTOWS Analysis, a Landscape Analysis, and a Best Practices Assessment. Our sTOWS Analysis provided insight into the strengths, opportunities, threats, and weaknesses of Borderlands Restoration Network (BRN) as an organization and provider of environmental education through its youth programming. This was necessary to guide our recommendations from the collected evidence. Throughout the Landscape Analysis, we researched organizations providing environmental education programming in other borderland communities, and then organizations providing community-based environmental programming in other rural areas outside of the borderlands. Additionally, we reviewed the academic and scientific literature on the approaches identified throughout our Landscape Analysis but did not feel it was necessary to include a formalized Literature Review for this report. We chose these methodologies as appropriate for non-profit-based research, and in order to identify recommendations that would be both sustainable and beneficial for the Borderlands Restoration Network’s long-term environmental education goals. The Best Practices Assessment allowed us to evaluate key themes leading to the success of similar organizations, as well as the plausibility for implementation with the current and future work of BRN. These tools allowed us to focus on gaining a deeper understanding of the organizations’ approaches to their environmental education curriculum, and how this was received by local communities.

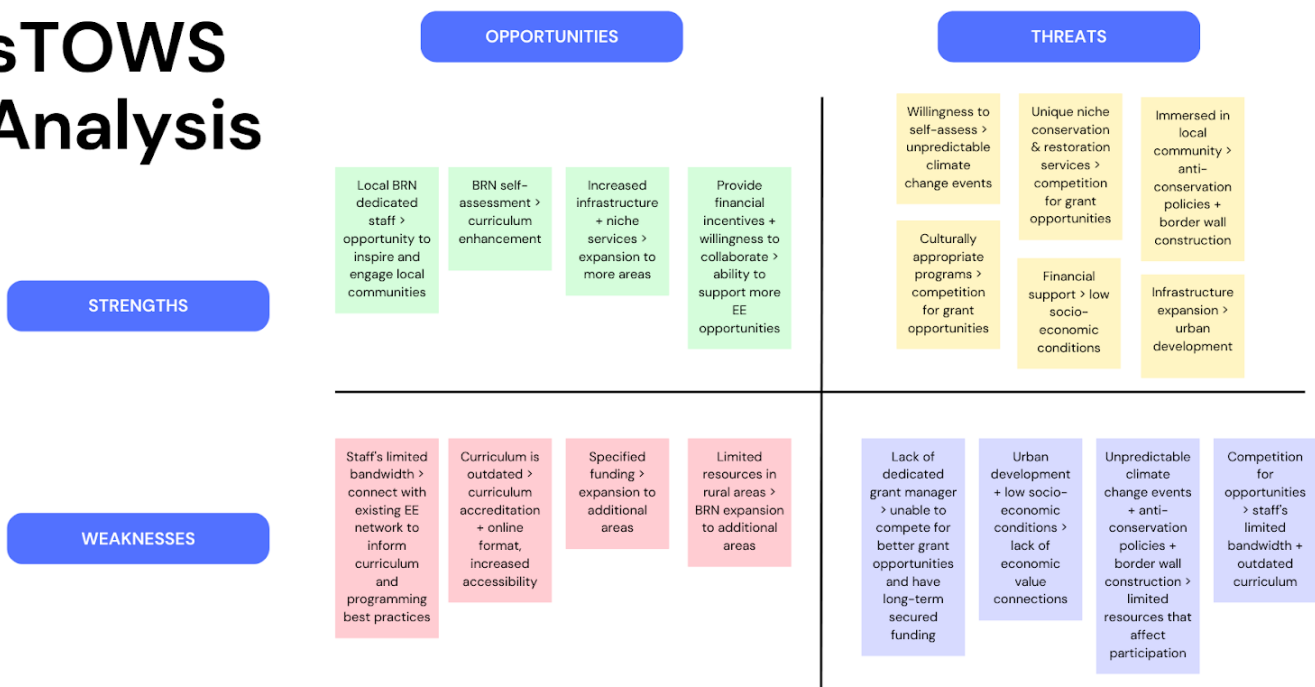


*BECY crew at work*

## SUSTAINABILITY TOWS ANALYSIS

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) assessment is a surface level analysis that lists internal and external situational factors related to a subject, in our case BRN’s youth environmental educational programming. After completing a basic inventory of these factors, JKLM completed a sTOWS assessment by crossing the internal and external factors to formulate strategies for improvement BRN could use to better use opportunities by amplifying its strong points, reducing weaknesses and moving forward despite imminent threats. Throughout this process, JKLM kept a holistic sustainability lens by emphasizing the intersections of people, the environment and social systems.

# sTOWS Analysis



*Recognize **strengths** to capitalize on opportunities*

For strengths, we recognized that Borderlands Restoration Network (BRN) provides niche services related to environmental restoration and conservation of natural resources within the borderlands. With BRN’s dedicated professional staff, increased infrastructure, and additional acquisition of demonstration spaces like Deep Dirt Farm and the Borderlands Wildlife Preserve, there is increased opportunity to expand to neighboring communities such as Nogales and Rio Rico. BRN has been working on its five-year strategic plan, demonstrating that they are willing to self-assess organizationally. Therefore, we’ve recognized that these strengths put them in a good position to enhance the BECY curriculum and appropriately apply newfound Best Practices from environmental education in neighboring regions. BRN has the potential and influence to broaden collaboration opportunities with other organizations including local schools and



further support environmental education opportunities that underpin the restoration economy.

*Leverage strengths to mitigate threats*

Sustainability and climate resiliency education are fast-growing fields that are under constant change. BRN's willingness to self-assess and ability to be flexible programmatically according to community needs and wants is valuable as climate change-related effects on socio-environmental systems become more complex and unpredictable. Although there is high competition for grant opportunities related to ecological restoration and sustainability programming, BRN's community-driven approach to rehabilitating ecosystems and habitats in lower socioeconomic borderland communities is providing a crucial service. We identified that an emphasis on building up a restoration-based economy would elevate economic opportunities in the targeted areas as people are negatively impacted by the current poor socioeconomic conditions, anti-conservation policies, and effects of border wall construction. Since BRN is immersed in Patagonia, and interested in branching out to other local communities, there is potential to offer more culturally appropriate programming, education, training, and jobs to surrounding historically overlooked and underserved communities in the borderlands.

*Forecast opportunities that can be negatively impacted by weaknesses*

We've identified that there are several opportunities for BRN to connect with existing environmental education networks to inform potential curriculum enhancement and development of programming best practices. However, it is general knowledge that non-profit organizations are often challenged by fundraising, working with limited resources, and retaining staff and volunteers. We've discerned that BRN is most likely not immune from these issues. The limited bandwidth of BRN's employees, limited resources or personal connections within the targeted rural communities, and not standardizing the provided curriculum can hinder the capability of program expansion.

*Be aware of weaknesses combined with threats*

We've associated the lack of a dedicated grant manager to the inability to compete more aggressively for larger and better grant opportunities to secure long-term funding. We've also made the correlation between these aspects and how it might affect the staff's limited bandwidth as Program Managers and Coordinators need to search, apply for, and win their own funding to continue their work. The high competition for grant opportunities, even between BRN's own departments, could cause the continuation of the youth environmental education curriculum to be outdated as this might be a low priority activity for grantors and funders. The act of educating and sharing knowledge is not as quantifiable as restoration measures such as the amount of erosion control structures installed, plants put into the ground, soil captured, and water conserved. This finding also supports the notion that border communities that are impacted by increased urbanization and poor socioeconomic conditions are often unaware of the economic value connected to restoring the environment and building a more sustainable community. These communities who've experienced the impacts associated with unsustainable forms of

ranching, agriculture, and mining may need to learn the worth of a restoration-based economy system, and the organization can fill this need.

## LANDSCAPE ANALYSIS

“A Landscape Analysis outlines the strengths, resources, and needs of a particular community. It provides a framework for designing a service and ensuring that it is embedded directly in the needs of the community...the information you gather through a Landscape Analysis will allow you to thoroughly map these community needs and desires, ensuring that they remain paramount when you design your program, set priorities, and make strategic decisions.” (National Student Support Accelerator)

This Landscape Analysis seeks to provide information on environmental education programs comparable to the Borderlands Restoration Network (BRN). The programs provided by BRN are unique in that they operate within communities alongside the border of the United States and Mexico and are in culturally rich and diverse communities. The scope of the landscape was originally to view comparable programs in similar borderland communities in Arizona, however, we found these to be extremely limited and therefore programs throughout Arizona and in other borderland regions in neighboring states such as New Mexico, were also considered. The analysis will provide additional insight into the methods and engagement strategies of other organizations that could be applied to BRN.

With climate change and the massive negative impacts on our natural world, the focus on Environmental Education (EE) for our youth is growing. In fact, the United Nations Laboratory of Ideas “has set a new target: to make environmental education a core curriculum component in all countries by 2025” (Azoulay, 2021). Currently, EE is still often considered a bonus curriculum and is not required in kindergarten through high school standard curriculum in Arizona. This is incredibly important when we consider the opportunities associated with implementing environmental education in schools in lower socioeconomic communities: “environmental education has led to a number of positive impacts, from improving academic performance to enhancing critical thinking skills, to developing personal growth and life-building skills including confidence, autonomy, and leadership” (eePRO, 2021). There is considerable opportunity for BRN to expand its program offerings in this industry, as well as to other target communities in the borderland region.

BRN is established in a unique situation at an industry level. Where the non-profit is headquartered, the South32 mining operation is quite prevalent in the quaint town of Patagonia, Arizona. In 2018, South32 purchased Arizona Mining Inc. and gained control of the mine holding in the Patagonia Mountains in the Coronado National Forest. South32 has plans to add an open pit mine and an underground mine in the area. Although creating jobs in these regions, this will affect all natural resources and ecosystem services. For example, Patagonia’s watershed dynamics, groundwater levels, ecosystems, and economics of the eco-touristic environment of the town and surrounding areas will be greatly affected by these mining activities. Additionally, the target

## Culminating Experience – Project Plan

communities of this study are all impacted by the geopolitical nature of border wall construction.

Conservation organizations like BRN have experienced high turnover rates due to the impacts of the Covid-19 pandemic, and businesses and families in the communities they serve have also been affected. Culturally responsive environmental education is needed in these spaces to support a restoration-based economy so that rural communities do not have to be a part of extractive-based unsustainable practices that harm them in the long run. Providing education related to the impacts of climate change and continued anthropogenic activities can instill a sense of community responsibility, and civic engagement and inspire collective action for socio-environmental justice.

Below are the most relevant environmental education curricula and youth programming JKLM could find preliminarily that BRN can leverage for its own growth.

### PROGRAMS IN OTHER REGIONS OF ARIZONA

*Willow Bend Environmental Education Center* is a part of the Coconino Natural Resources Conservation District. The Center provides curriculum for elementary, middle school and adult programs that focus on environmental awareness. Comparable to BRN, Willow Bend emphasizes responsible stewardship of natural and cultural resources. Since the COVID-19 pandemic called for a shift to virtual education, the organization provided environmentally focused programs for the 2019-2020 school year through Facebook Live, Zoom, and Google Slides. Similar to BRN, this type of education was funded by the United States Forest Service and Arizona Community Foundation. BRN can use the resources provided to design their own virtual format for their curriculum to make it more accessible to others or be inspired by the topics shared such as wildlife tracking, birding, geology, insects, seeds and more.

*The Nina Mason Pulliam Rio Salado Audubon Center* is based out of Phoenix, Arizona and their youth EE curriculum targets K-8 Youth involved in science, technology, engineering, arts and mathematics (STEAM) programs at school. The organization offers field trips and in-classroom presentations. Audubon's field trips pertain to nature in neighborhoods, schoolyards or birding expositions for hummingbirds and owls. Program costs range from \$150 to \$225, a discount is provided for Title 1 schools.

### PROGRAMS BASED IN BORDERLAND COMMUNITIES IN NEIGHBORING STATES, AND ADDITIONAL U.S. LOCATIONS

*Environmental Education of New Mexico* based in Albuquerque targets each grade level from preschool to 12th grade. Their outdoors and environmental learning including, but not limited to conservation, experiential, environmental, land-based, nature-based, outdoor, and place-based education and learning. Recommendations were developed through a series of community convenings hosted by Environmental Education of New Mexico (EENM) from 2018 - 2020. The convenings utilized a radical inclusion approach using “whole systems” thinking. These gatherings were open to educators, teachers, youth providers, interested community members, and youth, and brought together over

## Culminating Experience – Project Plan

200 individuals representing interconnected interests like outdoor recreation, education, conservation, and environmental justice. BRN could look at their [program handbook](#) to learn how the organization is creating a curriculum that centers accessibility and community involvement to create a program that follows state education policy.

The *[Sonoran Joint Venture](#)*, who already is a BRN partner, is located in Tucson but operates in southern Arizona, California and in the Mexican states of Sonora, Sinaloa, Baja California, Baja California Sur, western Chihuahua, western Durango, and northern Nayarit, as well as the Gulf of California and its islands. Their educational curriculum targets elementary to high school aged students. They facilitate workshops on bird monitoring and guide an ecology club. The organization provides opportunities for social services, internships, and volunteering. Something that BRN's departments can look up to is SJV's strong link between the different work programs such as the Marine Mammal Monitoring Program, the Indigenous Community Partnership Program, the Wetlands Conservation Program, and the Waterbird Monitoring Program. They also collaborate across a range from U.S. and Mexican non-profit organizations and local, state, and national government organizations to private citizens which is public on their partner list.

*[Ecology Project International](#)* serves in Baja California, Gulf of California and the Sierra Cacachila mountains. Engages young people in educational programming and activities that focus on science, conservation, and sustainability. Through their [Mexico Field Program](#) they worked with schools over a long period of time per program. Participants engage in sea turtle monitoring and protection, biodiversity surveys in the urban ecology studies in La Paz focused on regional water issues, and conservation service through beach clean-ups.

*[Mainspring Conservation Trust](#)* is based out of Franklin, North Carolina. They have different programs tailored to students in the K-12 range. The topics range from nature games, fish and aquatic insects, chemistry, water cycle and human impacts, watershed, habitats, geology, trees and migration among others. Mainspring works closely with schools in the (upper) Little Tennessee and Hiwassee River Basins, summer programs and homeschool groups at many grade levels to encourage hands-on educational activities that allow kids to experience their natural surroundings in a way they can't inside the classroom.

*[YMCA of the Fox Cities](#)* based in Appleton, Wisconsin provides environmental education opportunities to youth offered at the Apple Creek YMCA throughout the week. They provide younger children with age-appropriate learning. Participants are engaged in sea turtle monitoring and protection, biodiversity surveys in the urban ecology studies in La Paz focused on regional water issues, and conservation service through beach clean-ups. All classes have an indoor and outdoor component and combine stories, crafts, hikes and activities with hands-on exploration and learning.

## ENVIRONMENTAL EDUCATION STANDARDS

The *North American Association for Environmental Education* (NAAEE) promotes excellence in environmental education throughout North America and its influence reaches 30 countries and affiliate organizations within the United States, Canada and Mexico. NAAEE provides resources for sustainability focused businesses, governments, higher education platforms and formal and nonformal educators. One of the resources that will be useful for the JKLM team and beneficial to BRN are the Guidelines for Excellence Series, which are a set of guidelines and recommendations for several topics including community engagement, building environmental education programs and materials, and professional development for educators. JKLM will be using the K-12 Environmental Education Guidelines for Excellence which were developed to support state and local environmental education efforts by setting standards for performance and achievement. This resource will be helpful in making recommendations for BECY curriculum enhancement and provide steps to standardization to instill before the program expands.

The *Arizona Association for Environmental Education* (AAEE) is the state affiliate of NAAEE. As a professional association, they are working to cultivate environmental literacy in Arizona and provide resources to empower everyone to improve collective effectiveness throughout the region. In addition to JKLM's landscape analysis, the team will be using data provided by the State of Outdoor and Environmental Learning in the Southwest (SOEL) project. The online tool was created through a partnership between the USDA Forest Service's Southwestern Region (3), Arizona Association for Environmental Education (AAEE), and Environmental Education of New Mexico (EENM) that involves shared values of community, interdependence, and care for present and future generations led to the development this landscape analysis of opportunities in the Southwest. SOEL is a regional inventory of outdoor and environmental learning initiatives, curricula, and programs in the Southwestern region. SOEL can help BRN find data-driven solutions to provide meaningful learning experiences, identify future collaborators or communities to engage with and adapt their programming in response to state needs.

## BEST PRACTICES AND RECOMMENDATIONS

“Best practices are techniques or methodologies that are proven to lead to superior results compared to those achieved by other means.” (Destiny, 2022) When analyzing research findings in local and other environmental education programs we made sure to be open to the multiple possibilities that these practices would strengthen the execution of BECY, while also keeping in mind those that may not work as well in enhancing the current practices Borderlands Restoration Network (BRN) accomplishes.

### *Enhance Field Curriculum*

While BRN already has a comprehensive curriculum for BECY, compared to other environmental education organizations, we found that the current materials could use some enhancement and improvement when it comes to the customizability and execution of the curriculum. We were unable to find a best practice procedure currently used by BRN for curriculum review, but there should be a routine best practice established in order to compete more aggressively as a borderland’s environmental educator, improve outreach to other organizations, and enhance curriculum efficacy.

Another technique that may be beneficial to the Borderlands BECY program would be to adopt a dynamic, customizable online curriculum. One example from our Landscape Analysis is Willow Bend Environmental Education Center in Flagstaff, Arizona offers some of their curricula in online formats via Zoom and Google slides. Other examples include the Ecology Project International (EPI), who are “piloting new curriculum, webinars, and workshops designed to support the extraordinary teachers who are instilling a love of nature and the environment in their students every day.” (EPI, 2022). This approach would be incredibly helpful for potential partnerships with local schools and the expansion into classrooms or summer programs. EPI has created a “virtual classroom” that is “free, online, and can be adapted to a variety of teaching and learning formats” (EPI, 2022). In the post Pandemic environment, these online format options would greatly increase accessibility and enrollment and allow for year-round engagement in the BECY programs. While it is unlikely that all activities within the curriculum could be completed online, there are certain sections that would do well in either format or could be easily converted from the existing curriculum. Additionally, BRN could expand new areas of focus into an all-online curriculum to ensure relevant and culturally appropriate environmental education modules that could be easily modified if needed.

### ***Expand Age Range***

In our research/findings on other borderlands curricula and youth environmental education curricula, we see many programs targeting early childhood (Kindergarten-3rd) and youth education (3rd - 12th). This inclusionary approach ensures that educators and students from all grade levels are engaged in environmental issues, and community members relate to current and future environmental education opportunities that provide resources and access to programs or environmental internships. While BRN's Borderlands Earth Care Youth (BECY) program targets young adult youth between 15 - 18 years of age, it may be beneficial to establish environmental education programming appropriate for early childhood and youth between five and eighteen years of age. Research shows that exposure to environmental education during early childhood can lead to positive impacts on "environmental literacy development, cognitive development, and social and emotional development" (Ardoin & Bowers, 2020). Throughout our Landscape Analysis, we discovered that many organizations have programming that includes small field trips, or recruitment of early childhood youth for future restoration or conservation project internships. We see this practice in the Environmental Education of New Mexico, targeting kindergarten through 12th grade, with a "multi-year shared vision and strategy to provide daily equitable access to the outdoors and environmental learning" approach (Everett, 2022).

### ***Partner with local schools and organizations***

Many of the successful organizations identified in the landscape analysis demonstrated the importance of partnering with schools and community organizations in their regions to embed environmental education into classroom and afterschool programs. For example, Mainspring Conservation Trust in Franklin, North Carolina partners closely with schools and summer programs at multiple grade levels to encourage hands-on educational activities that allow kids to experience their natural surroundings in a way they can't inside the classroom. This helps to combat the idea that environmental education is a specialized or unnecessary curriculum, and instead prioritizes this knowledge as integral to community wellness and resiliency to the negative impacts of climate change. This also promotes the existence of local restoration economies that youth can participate in starting at an early age, and increases the chance they may eventually pursue future career opportunities within. Since Rio Rico High School and Nogales High School are deemed Title 1 schools, BRN can increase equitable access to environmental education opportunities in the local school system where it does not currently exist. While BRN currently partners with schools and organizations in Patagonia to complete restoration projects, we recommend this is a priority in potential program expansion to Rio Rico and Nogales communities.

### ***Convene Community Stakeholders***

In sustainability, a key concept is systems thinking. This approach “is concerned with expanding our awareness to see the relationships between parts and wholes rather than looking at just discrete, isolated parts” (Seibert, 2018). Throughout our Landscape Analysis, we discovered that the Environmental Education of New Mexico (EENM) incorporated this sustainability approach into their programming by hosting a series of convenings between 2018 and 2021 that invited stakeholders like teachers, and community members to discuss and provide insight into their curriculum (See Appendix Figure 2). They reported that “over 200 individuals representing interconnected interests like outdoor recreation, education, conservation, and environmental justice” (EENM), participated and provided direct recommendations incorporated into their curriculum. To further BRN’s close ties to the communities they currently serve, expand to new borderlands communities, and continue to provide culturally appropriate curriculum, there is an opportunity to incorporate this as a best practice now. While BRN is not seeking to serve the whole state, it is likely that a community convening could be held over a few months, and the results could be analyzed and incorporated while tailoring the curriculum to a new area before expansion. Additionally, these systems thinking concepts in sustainability initiatives and environmental education support a holistic approach that helps to identify existing systems of power, and how environmental education programs can uplift environmental justice and equity in communities.

### ***Assess and Evaluate***

“Evaluation is the systematic assessment of the operation and/or the outcomes of a program or policy, compared to a set of explicit or implicit standards, as a means of contributing to the improvement of the program or policy” (Thomson & Hoffman, 2022). In the non-profit sector, and specifically environmental education organizations, “environmental educators are increasingly being challenged by their funders and their audiences to demonstrate their results, and where accountability and performance measurement techniques are increasingly being emphasized” (Thomson & Hoffman, 2022). Throughout our Landscape Analysis, we identified that most organizations had an annual review and evaluation process of their environmental education programs. Surveys, interviews and focus groups were among utilized tools, and could be implemented by BRN to gather and assess data provided by program participants regarding new curriculum implementation. This would be beneficial moving forward to determine future improvements according to participants interests and needs. This would be helpful for BRN to adopt as changes or new programming may possibly be dependent on acquiring new grant opportunities, as well as existing operations being largely dependent on grant funding. These should be based on the standard frameworks provided by the Arizona Association of Environmental Education (AAEE) and the North American Association for Environmental Education. By establishing a method of evaluation and assessment, they will improve their ability to speak to the successes of their programs and attract additional funding with clearly aligned goals and objectives.



## Key Recommendations for Borderlands Restoration Network

- 1 Update existing curriculum and enhance offerings to include online formats.
- 2 Expand program offerings to early childhood and youth age groups.
- 3 Partner with local schools and community organizations to integrate BECY programming into their curriculum and after-school or summer programs.
- 4 In target expansion areas, host community convenings to gain stakeholder input and collaboration on tailoring the curriculum to be culturally appropriate and meet the community's needs.
- 5 Conduct surveys and analyze results after the implementation of each new curriculum for evaluation purposes.

## PROJECT PLAN

As noted in our Executive Summary, due to project timeline restrictions, we are not assisting BRN in implementing all five recommendations. However, JKLM will be able to conduct several steps next semester to provide additional information for BRN's consideration of their own implementation of the recommendations.

In support of recommendation #1, JKLM will compose a written survey to be completed by the Borderlands Restoration Network leadership team, which will outline known issues and desired changes to the Borderlands Earth Care Youth (BECY) curriculum. Participation will be particularly important by Tess Wagoner (Watershed Restoration Program Manager), Caleb Weaver (Community Restoration Program Manager), and Francesca Claverie (Native Plant Program Manager). As the Youth Education Program Coordinator at Borderlands Restoration Network, Jordan will facilitate a group virtual meeting to discuss the results of the survey and plans for curriculum enhancement. The JKLM team will begin curriculum enhancement, which will consist of reviewing and providing suggested edits to the curriculum. Examples include converting sections to an online format or creating teacher excerpts along lessons. Also, the team will update the resource guide that includes information about higher education programs, paid internship opportunities, and career pathways in conservation. The JKLM team will complete BECY curriculum enhancement by April 3rd, 2023, and an evaluation tool will be created as well.

## Culminating Experience – Project Plan

In support of recommendation #3, the JKLM team will begin conducting outreach to schools and community organizations to survey interest in implementing an Environmental Education program like BECY. Additionally, these efforts are intended to establish relationships and contacts for BRN to possibly implement programming in the future. This information will be compiled and provided in a document for future reference.

<b>Recommended Timeline</b>	
January 2023 - April 2023	JKLM Sustainability Consultants meet with BRN staff to gather input on desired changes to the curriculum. JKLM reviews and provides recommended changes to enhance BECY curriculum. JKLM provides findings on possible accreditation of curriculum to BRN.
May 2023	BRN solidifies the desired outcome for the Master of Sustainability Leadership Team to complete a mini project over the summer. Create BECY staff a survey to evaluate the new curriculum and program's efforts to reach goals.
May 2023 - August 2023	BRN hosts enhanced BECY curriculum partner with Youth summer interns. BRN project sponsor works with MSL team on the mini project.
August 2023	Continue program evaluation and implementation of changes as needed. Contact potential schools and community organizations to implement BECY's environmental education curriculum.



*Passive Erosion Control Structures*

## TEAM ROLES

The JKLM Sustainability Consulting team is composed of Jordan Sene, Kayla Napper, Laney Meeker, and Marshall Morgan Fabara, hence their name.

Jordan will be the main communication liaison between the JKLM team, and the Borderlands Restoration Network (BRN) team for the duration of the project. She will be responsible for setting up meetings with Kurt, the project sponsor, as well as any other BRN leadership. She will be responsible for curriculum enhancement in the “Activities” section, with a goal to make the twenty activities more engaging and in line with BRN’s new strategic planning goals for education and outreach. . She will also be responsible for creating a “Program Completion Survey” for the 2023 students to take to provide measured results on the new enhanced curriculum.

Laney will be responsible for curriculum enhancement on the “Watershed Restoration” section. Next semester, she will also be responsible for conducting primary outreach regarding possible curriculum accreditation with an environmental education authority. She will also be responsible for all final editing and reviewing of group documents.

Kayla will be responsible for curriculum enhancement on the “Ecosystem Restoration” section.

She will also conduct the primary outreach to community organizations regarding interest in Environmental Education.

Marshall will be responsible for curriculum enhancement on the “Community Restoration” section. He will also be responsible for the primary outreach to schools in the communities regarding interest in Environmental Education.

All group members will be responsible for adding to the “Resources” section that will contain information pertaining to career paths, other Non-Governmental Organizations, volunteer opportunities, degree programs, and certifications from local universities or community colleges.

## PROJECT FEASIBILITY

The feasibility of key aspects of the project assessment, such as completion of curriculum enhancement and initial outreach to local schools and community organizations for potential curriculum adoption, being completed in the Spring 2023 semester is high. We believe there is low feasibility of several other key aspects of the project assessment being completed by May of 2023. These aspects include accreditation of enhanced curriculum, and expansion of curriculum into the new target areas of Rio Rico and Nogales, Arizona. We are limited by the length of the graduate program and believe that these aspects will take more leadership involvement from Borderlands Restoration Network and are overall more unpredictable and lengthier processes. We recommend that this scope of work could be furthered by the Borderlands Restoration Network team applying for a Masters of Sustainability Leadership (MSL) program culminating experience project, whose cohort could continue working on these extended portions of the project during a seven-week session over Summer 2023. We would provide a detailed handoff.

The project timeline of task completion (Gantt Chart) is Figure 5 in the Appendix.

## CONCLUSION

Throughout our analysis, we learned that the Borderlands Restoration Network (BRN) is well established in the current communities where they provide unique and engaging environmental education opportunities. While our team's project is still in the early phases, through our research analysis we identified five key tasks that can be prioritized to provide BRN the ability to increase the effectiveness and sustainability of their different programs and the organization as a whole: (1) update existing curriculum and enhance offerings to include online formats, (2) expand program offerings to early childhood and youth age groups in target expansion areas, (3) work with local schools and community organizations to integrate BECY programming into their curriculum, and after school or summer programs, (4) host community convenings to gain stakeholder input and collaboration on tailoring the curriculum to be culturally appropriate and meet the community needs, and (5) conduct program evaluation through tools such as surveys, interviews and focus groups regarding the new curriculum implementation moving forward to determine future improvements according to learner's interest and needs. Many of the challenges associated with implementing these key tasks are related to BRN's small staff, associated lack of capacity, and the need for diversified funding. These challenges can be mitigated through the planning and the adoption of the outlined Best Practices over the recommended timeline for execution.

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APPENDIX

Figure 1: Mind Map



Figure 2: Stakeholder Map

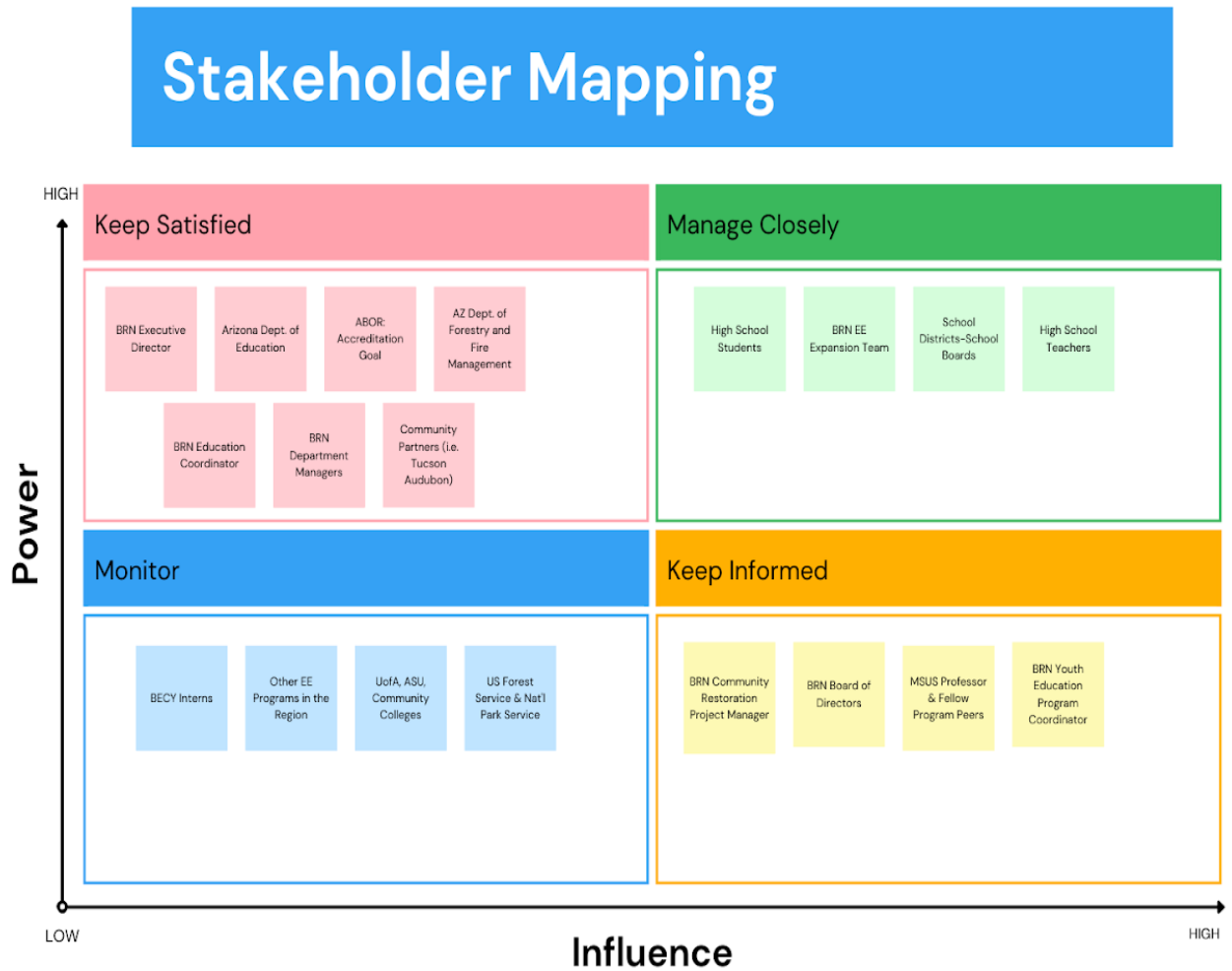


Figure 3: sSWOT Analysis

# sSWOT Analysis

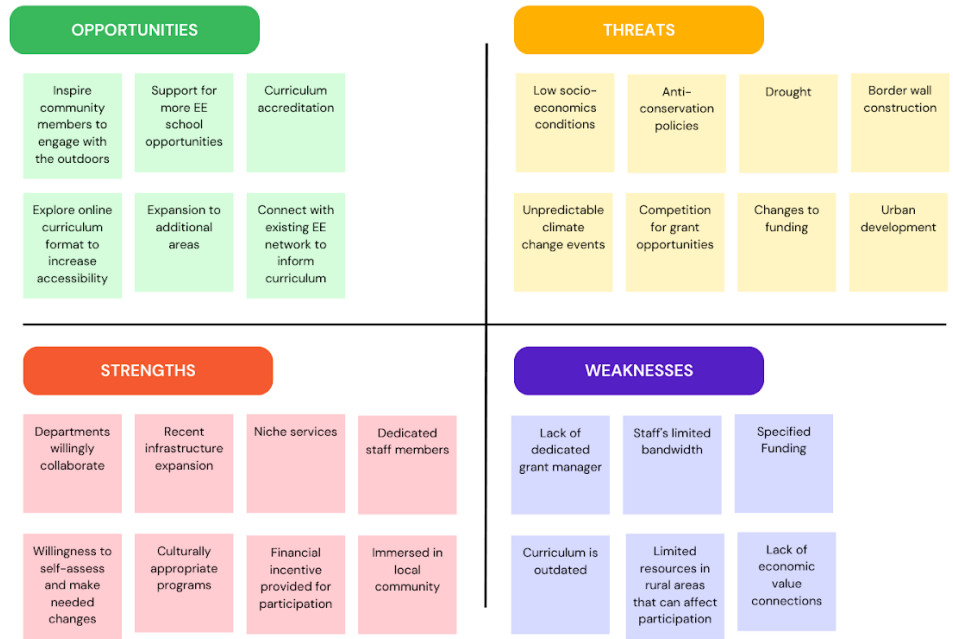
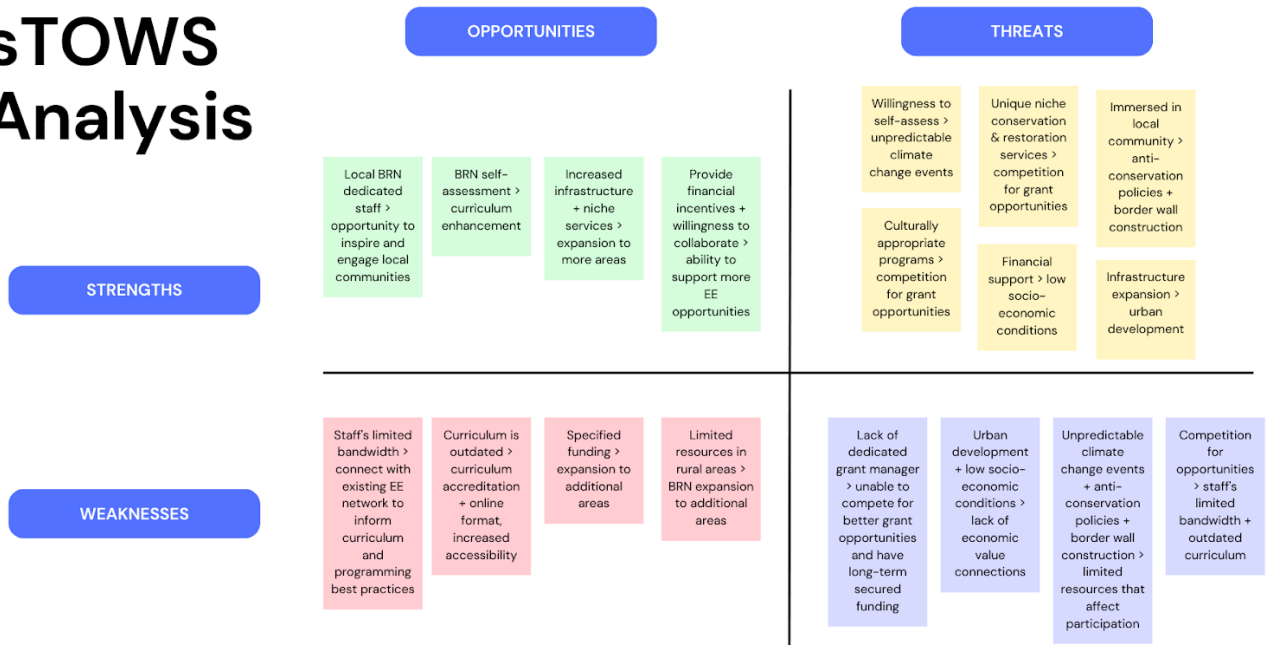


Figure 4: sTOWS Analysis

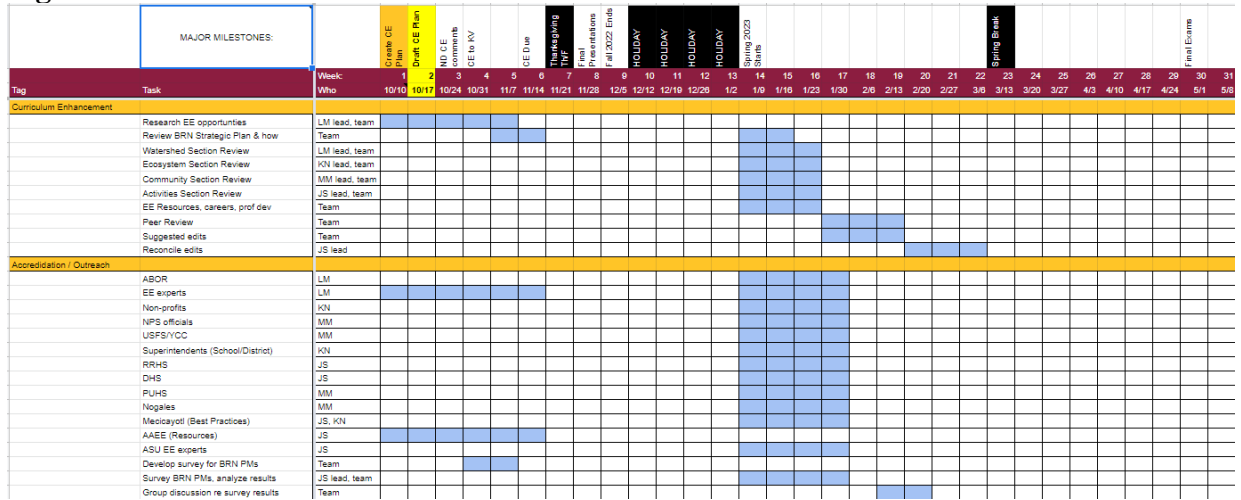
# sTOWS Analysis



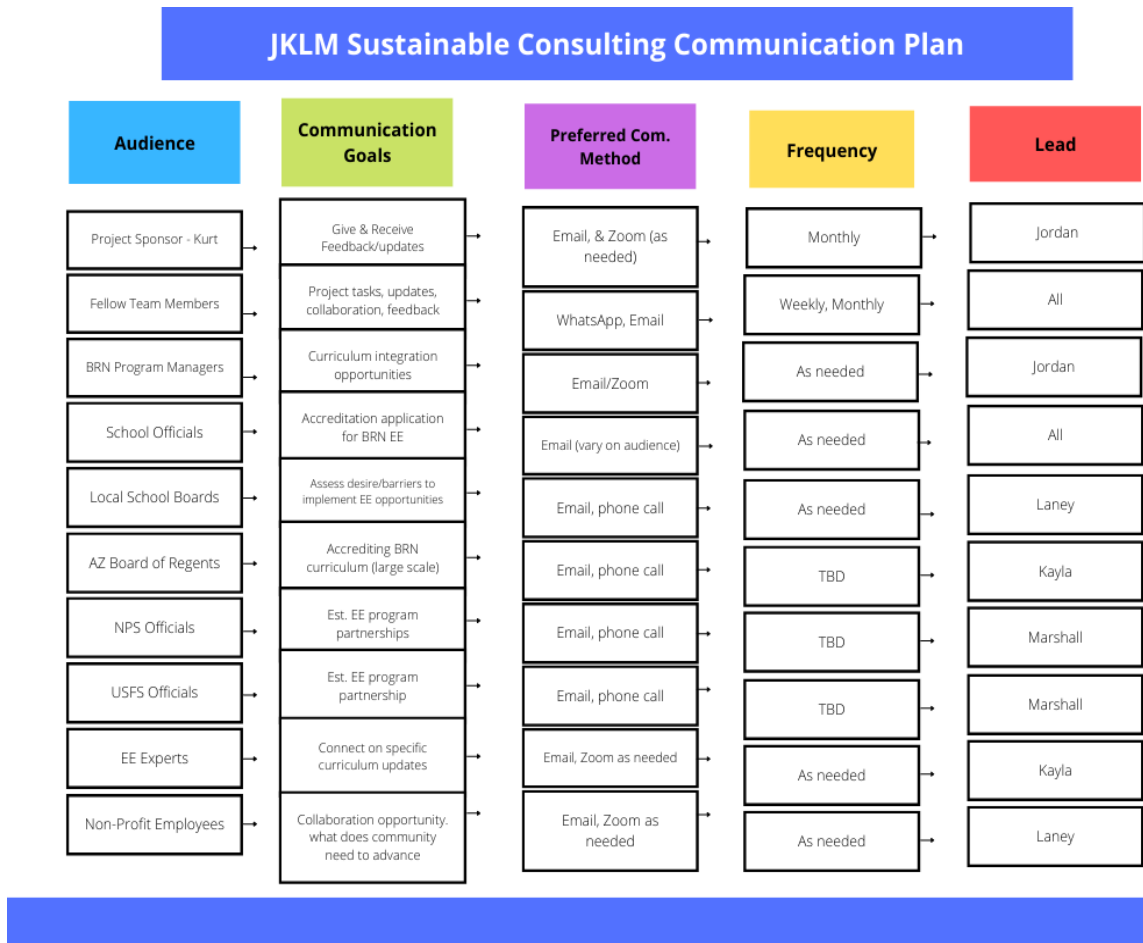


# Culminating Experience – Project Plan

**Figure 5: Gantt Chart**



**Figure 6: Communication Plan**



## Culminating Experience – Project Plan

### **School outreach information:**

#### Rio Rico:

- Youth is 30.9% of the population
- 87.6% identify as Hispanic or Latino
- Schools include:
  - San Cayetano Elementary School (K-5<sup>th</sup>)
  - Little Red Schoolhouse (K-8<sup>th</sup>)
  - Coatimundi Middle School (6<sup>th</sup> – 8<sup>th</sup>)
  - Patagonia Union High School
  - Mountain View School (K-5<sup>th</sup>)
  - Calabosas School (6<sup>th</sup> – 8<sup>th</sup>)
  - Rio Rico High School
- Organizations include:
  - Rio Rico Community Center

#### Nogales:

- Youth is 26.3% of the population
- 94.8% identify as Hispanic or Latino
- Schools include:
  - Nogales High School
  - Lincoln Elementary School (K-5<sup>th</sup>)
  - AJ Mitchell Elementary School (K-5<sup>th</sup>)
  - Pierson High School
  - Wade Carpenter Middle School (6<sup>th</sup> – 8<sup>th</sup>)
  - Desert Shadows Middle School (6<sup>th</sup> – 8<sup>th</sup>)
  - Mary Welty Elementary School (K-5<sup>th</sup>)
  - Mexicayotl Charter School (K-8<sup>th</sup>)
  - Colegio Petite Elementary School (K-5<sup>th</sup>)
  - Lourdes Catholic School (PreK – 12<sup>th</sup>)
- Organizations include:
  - Nogales Community Center
  - Boys and Girls Club of Santa Cruz County
  - Chicanos Por La Causa
  - United Way Nogales

TEAM CHARTER

Team Name: JKLM Sustainability Consulting (Borderlands Restoration Network – Jordan, Kayla, Laney, Marshall)

Team Members: Jordan Sene, Kayla Napper, Marshall Morgan Fabara, Laney Meeker

Charter Element	Key Questions	Your Response
Mission Statement	<p>Who you are as a team:</p> <ul style="list-style-type: none"> <li>What is your overall purpose (e.g., pursuing excellence and producing quality work as a team)?</li> </ul>	<ul style="list-style-type: none"> <li><i>A team of dedicated young professionals that are motivated to increase access to sustainably oriented environmental education opportunities for borderland communities.</i></li> </ul>
Goals	<p>What you do as a team:</p> <ul style="list-style-type: none"> <li>What are your team's performance goals? Common performance goals include the grade you would like to obtain on team project(s) (e.g., at least an A-). Other goals may include learning and skill-building goals.</li> <li>What are your goals for project deadlines (e.g., turn projects in one day early)?</li> <li>What other goals do you have as a team (e.g., open communication, mutual respect, learning about and from one another)?</li> </ul>	<ul style="list-style-type: none"> <li><i>Gain valuable skills in sustainable project management that will be applicable to future career opportunities</i></li> <li><i>Strengthen communication skills with various stakeholders across different sectors</i></li> <li><i>Produce high quality work that all team members are proud of and have contributed to, resulting in progress for the project</i></li> <li><i>Foster strong team relationships and open communication</i></li> </ul>
Expectation of Members	<p>What your roles are in the team:</p> <ul style="list-style-type: none"> <li>What are your strengths? Your weaknesses?</li> <li>What roles will each of you take on?</li> <li>Will you rotate roles?</li> <li>What are your responsibilities (e.g., project manager, who ensures that everything is turned in on time; editor, who ensures that written assignments are professionally done and presented in one voice)?</li> <li>How will you determine the role of Project Manager (e.g., volunteer, vote)?</li> </ul>	<ul style="list-style-type: none"> <li><i>Behave respectfully and professionally towards fellow team members and all external stakeholders</i></li> <li><i>Communicate thoughtfully and hold space for one another's ideas and contributions. Be intentional when having conversations with each other. Call each other out to engage when needed.</i></li> <li><i>Draw from the varying lived experiences and skills that each team member possesses</i> <ul style="list-style-type: none"> <li><i>As an employee of BRN, Jordan has internal insight and immense passion for this work, and is a</i></li> </ul> </li> </ul>

Culminating Experience – Project Plan

Charter Element	Key Questions	Your Response
Expectation of Members	<p>What your roles are in the team:</p> <ul style="list-style-type: none"> <li>• What are your strengths? Your weaknesses?</li> <li>• What roles will each of you take on?</li> <li>• Will you rotate roles?</li> <li>• What are your responsibilities (e.g., project manager, who ensures that everything is turned in on time; editor, who ensures that written assignments are professionally done and presented in one voice)?</li> <li>• How will you determine the role of Project Manager (e.g., volunteer, vote)?</li> </ul>	<p><i>local with deep roots and connections to the community</i></p> <ul style="list-style-type: none"> <li>○ <i>Marshall has experience with environmental education in the target region, as well as connections with local schools and NPS</i></li> <li>○ <i>Kayla has a passion for indigenous communities and environmental psychology in creating positive environmental education experiences</i></li> <li>○ <i>Laney has experience working in nonprofits, local food systems and sustainability, and can bring insight into building resilience in local communities</i></li> </ul> <ul style="list-style-type: none"> <li>• <i>Roles will be interchangeable as the project progresses to ensure all team members have the opportunity to gain different experiences. We plan to divide and conquer specific goals and assign as needed.</i></li> <li>• <i>Act like a team and be available for peer review, accountability, and assistance for one another.</i></li> <li>• <i>Weekly check-in on reports</i></li> </ul>
Norms, Rules and Guidelines	<p>How you do as a team:</p> <ul style="list-style-type: none"> <li>• How will you communicate (e.g., email, text, Zoom)?</li> <li>• What are your communication and meeting norms (e.g., return email within 24 hours, set dates/times for virtual meetings, attendance required, encourage everyone to have a voice)?</li> <li>• How will you encourage all members to participate during meetings (e.g., create an agenda ahead of time and all members are expected to be prepared at the meeting)?</li> </ul>	<ul style="list-style-type: none"> <li>• <i>We will use WhatsApp and Zoom for weekly remote coordination and meetings, and will schedule more in person meetings as needed for team building and group work</i></li> <li>• <i>We will respond to internal team communication and to external communication within 24 - 48 hours on weekdays</i></li> <li>• <i>We will be playful and communicate around planned vacations to set the team up for success. Team will also be respectful of time off or sick time for work/life balance</i></li> </ul>

Culminating Experience – Project Plan

Charter Element	Key Questions	Your Response
	<ul style="list-style-type: none"> <li>• How will you encourage all members to complete task for the team?</li> </ul>	<ul style="list-style-type: none"> <li>• <i>For meetings with the project sponsor, we will have hard agendas, saved in Google Drive, reviewed by everyone before use</i></li> <li>• <i>For group meetings, we will have soft agendas within our notes, we will each debrief, and delegate tasks at the end of each meeting. (In Google Drive)</i></li> </ul>
Team Challenges	<p>What your challenges are as a team:</p> <ul style="list-style-type: none"> <li>• Are there any gaps in your team that are important for the project?</li> <li>• Are there any other challenges to overcome (e.g., members in different time zones, technology difficulties, time-based constraints, life-based constraints)?</li> <li>• How will you overcome your challenges?</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Our team all has different schedules, so schedule coordinating can be a challenge</i> <ul style="list-style-type: none"> <li>◦ <i>We will overcome this by being flexible with group members joining the meeting in person and/or via Zoom</i></li> </ul> </li> <li>• <i>Being located in Phoenix rather than southern Arizona may pose challenges</i></li> <li>• <i>We do not have years of experience in this industry so there will be some natural learning curves</i></li> <li>• <i>We will overcome these challenges by having open communication and problem solving collectively as a team</i></li> </ul>
Team Motivation and Effectiveness	<p>How you will achieve success as a team:</p> <ul style="list-style-type: none"> <li>• How will you keep each other motivated (e.g., pep talks, verbal praise)?</li> <li>• How will you evaluate each other's performance and provide feedback to one another (e.g., peer evaluation and feedback after team projects)?</li> <li>• How will you make decisions (e.g., vote or consensus)?</li> <li>• How will you resolve conflicts (consider task-based and relationship-based conflicts)?</li> <li>• How will you hold each other accountable and deliver consequences to those members who are not delivering? What are the consequences?</li> <li>• How will you reward individuals (e.g., team recognition of a member's efforts) and the team (e.g.,</li> </ul>	<ul style="list-style-type: none"> <li>• <i>We will have clear and positive communication and be sure to celebrate small wins along the way</i></li> <li>• <i>We will remind one another that we are a team and provide support to one another as needed</i></li> <li>• <i>We will engage in team bonding activities outside of class and pointedly celebrate wins</i></li> <li>• <i>We will keep in mind that we all have obligations outside of the class and be supportive of one another to keep morale high</i></li> <li>• <i>To be proactive and avoid task-based or relationship-based conflicts, we will have a shared task sheet where we can all view, comment, and assign tasks to each other.</i> <ul style="list-style-type: none"> <li>◦ <i>If conflict still arises, we would talk about it during one of the regular team meetings</i></li> </ul> </li> </ul>

Culminating Experience – Project Plan

<b>Charter Element</b>	<b>Key Questions</b>	<b>Your Response</b>
	mini team celebration) for a job well done?	<ul style="list-style-type: none"><li>• <i>We will respectfully hold one another accountable</i></li><li>• <i>Consequences will look like:</i><ul style="list-style-type: none"><li>○ <i>First talking directly to the team member to find out what is going on</i></li><li>○ <i>If issues continue this will result in looping in the professor</i></li></ul></li></ul>

Note: Team Charter is subject to change with all team members' approval.