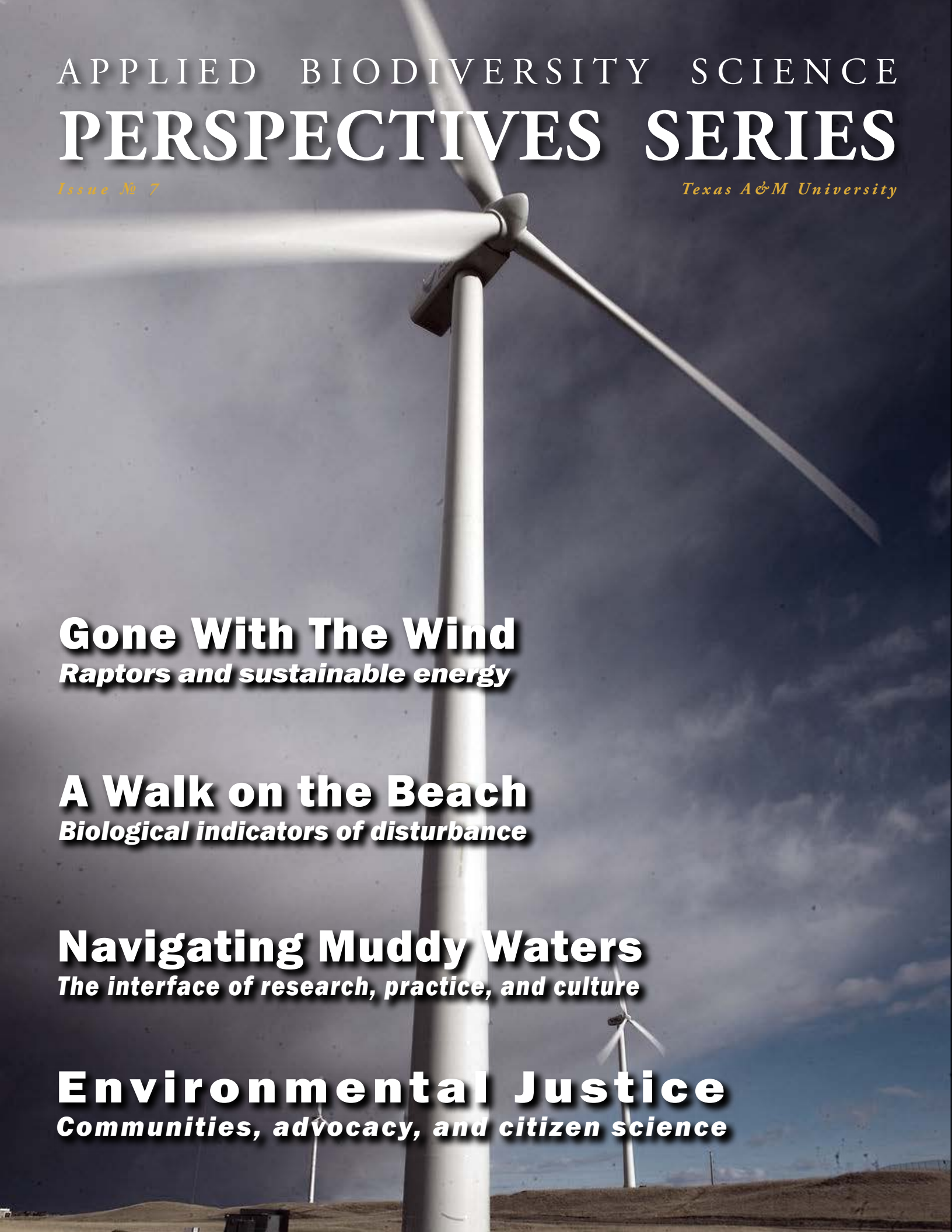

APPLIED BIODIVERSITY SCIENCE

PERSPECTIVES SERIES

Issue № 7

Texas A&M University

Gone With The Wind
Raptors and sustainable energy

A Walk on the Beach
Biological indicators of disturbance

Navigating Muddy Waters
The interface of research, practice, and culture

Environmental Justice
Communities, advocacy, and citizen science

Cover Art

Front: Wind turbine at F.E. Warren Air Force Base, Wyoming, April 6, 2010. The larger wind turbine was completed and online early in 2009 and is rated at 2 mega watts of electrical energy that goes directly into the base power grid (U.S. Air Force photo/Lance Cheung).

Inside: Bridge crossing scenic valley in Nantou county in the province of Taiwan. Taken on DSC-RX100M2 2017-02-18 with 11.0mm, f/4.0s, 1/100s, ISO 160 (CC 2.0).

Back: The Mexican Long-nosed Bat (*Leptonycteris nivalis*), is a vital pollinator in desert systems. They have a long, bristle-like tongue, allowing them to sip nectar from agave and cacti (U.S. Fish and Wildlife Service/CC 2.0).

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Applied Biodiversity Science Perspectives Series

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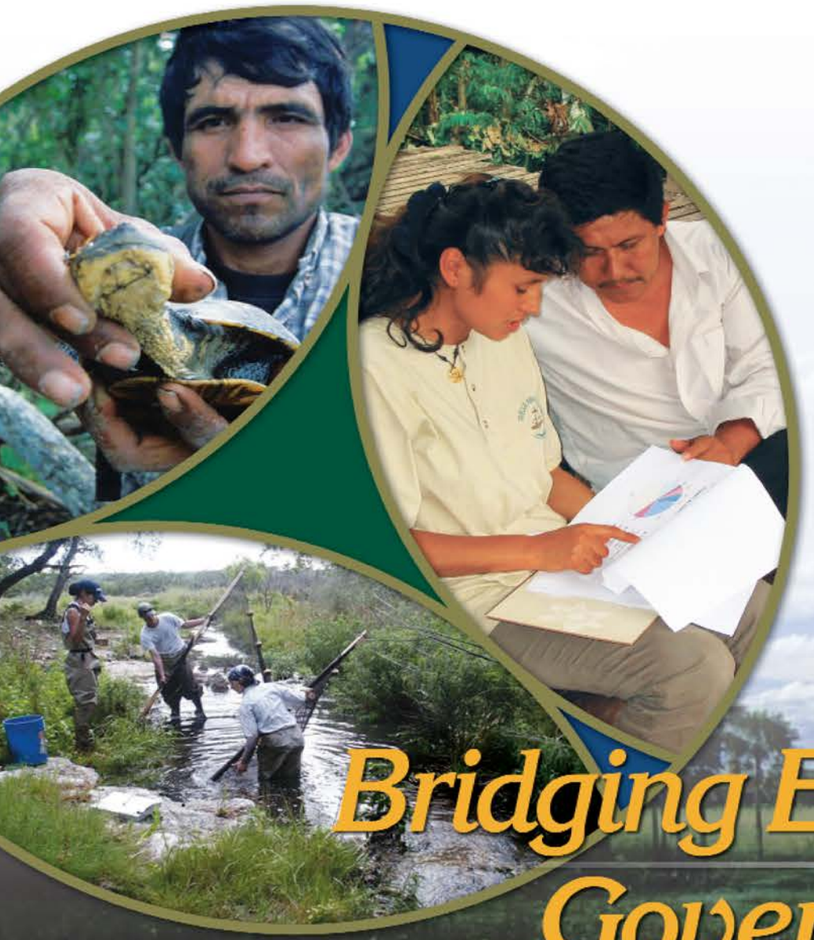
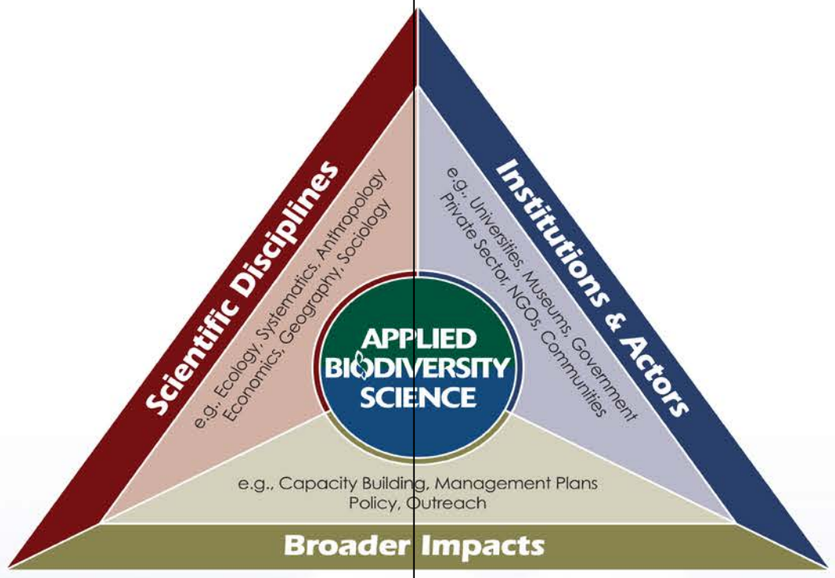
APPLIED BIODIVERSITY SCIENCE

The vision of the Applied Biodiversity Science (ABS) Program is to integrate biodiversity research and on-the-ground conservation practices.





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Bridging Ecology, Culture, & Governance for Effective Conservation

GONE WITH THE WIND

Implications of Wind Development for Raptor Populations

Lauren C. Naylor
Columbia University

Lynn, bald eagle (*Haliaeetus leucocephalus*) Photo credit: Hannah Baker

Willow, barred owl (*Strix varia*) Photo credit: Hannah Baker

As climate change continues to be a salient topic in both the scientific and political realms, investigations into how we can best address climate change have become increasingly popular and, in some cases, controversial. In the U.S, energy production is a primary contributor to overall emission rates, with as much as 40% of all carbon emissions produced by the electric sector alone.

With a projected growth of 39% in U.S. electricity demands by 2030, high emission rates will continue to be an issue unless drastic policy and infrastructure changes are implemented (DOE 2008).

One strategy for abatement lies in increasing our use of renewable resources for energy productions. There are various forms of renewable energy, but for the purposes of this study, I focus specifically on wind. While wind energy provides a viable solution for emission reductions, it comes at an environmental cost, particularly for birds.

As wind energy grows in popularity, its environmental impacts are becoming more apparent. Recent studies indicate that wind power has negative effects on proximate wildlife. These impacts can be direct—collision fatalities—and indirect—habitat loss (Fargione *et al*. 2012; Glen *et al*. 2013).

Negative impacts associated with operational wind farms include collision mortalities from towers or transmission lines and barotrauma for bats. Habitat loss and fragmentation, as well as avoidance behavior, are also consequences resulting from wind farm construction and related infrastructure.

The potential harm towards protected and migratory bird species are an urgent concern, especially for wind farms located along migratory flyways. In terms of mortality, wind turbines kill an estimated 300,000 to 500,000 birds, annually (Smallwood 2013). The high speed at which the fan wings move and the concentration of turbines create a gauntlet

Jinx, red-tailed hawk (*Buteo jamaicensis*) Photo credit: Hannah Baker

of hazards for birds to fly through. For example, Texas's Gulf Wind Farm in Kenedy County sits within two critical Central Flyway migratory paths and is ranked as the second-worst located wind farm in the US (American Bird Conservancy 2016). Exacerbating these issues is the fact that the height of most wind turbines aligns with the altitude many bird species fly at (Bowden 2015). Birds of prey—raptors—are of particular concern because of their slow reproductive cycles and long lifespans relative to other bird species (Kuvlesky 2007).

In response to the potential negative impacts of wind turbines and farms, my research explores direct impacts on raptors, stakeholder perceptions of these impacts, and plausible solutions. Specifically, I evaluate wildlife rehabilitation as a post-development mitigation strategy for birds of prey. The results of my research enable stakeholders to better understand the negative impacts of wind farms on birds of prey by providing data on bird injury frequency and severity as well as the types of environmental compensation and indemnities that can be provided in exchange for increased wind development.

Survey Data

In 2016, I sought to determine the number of raptors directly injured by turbines, the frequency of rescue after injury, the types of injuries received, and the level of recovery most often attained. Using a multi-step study framework—literature review, survey research methods, and post-survey interviews—I integrated biological and social sciences data through the analysis of peer-reviewed literature and local knowledge (i.e., information gained from surveys and interviews). This integrative process enables researchers, practitioners, and the public to see a more comprehensive picture of the problem and potential solutions.

Questionnaires were sent out to raptor rehabilitation centers in the six states that contain the largest percentage of wind development (Texas, Oregon, Washington, California, Iowa and Minnesota) (Fischlein *et al*. 2012). This provided a new source of data by addressing local rehabbers, and thereby exploring a local aspect of the human dimension that is often overlooked. Both the pre-survey literature review and post-survey interviews served to provide additional context.

The sample population consisted of rehabilitation centers and individuals with a state certification for wildlife rehabilitation (N = 76). The questionnaire focused on collecting important information regarding injury type, species treated, and rehabbers' opinions regarding mitigation options. Of the questionnaires returned (N = 24; 32% response rate), data revealed that the red-tailed hawk (*Buteo jamaicensis*), great horned Owl (*Bubo virginianus*), American kestrel (*Falco sparverius*), and red-shouldered hawk (*Buteo lineatus*) were the most commonly treated species across states. The majority of respondents reported wing or neurological injuries. Figure 1 displays the breakdown of all injury types as cumulatively reported, without separating out for state or birds with multiple injuries.

Wing injuries typically consist of compound fractures or open lacerations. Neurological injuries included ataxia (loss of body movement control) and non-ambulatory injuries, i.e., unable to walk. Beak injuries were least common. The category for "other" injuries included reports of malnutrition, electrocution, poisoning, and gunshot wounds, among others.

According to a post-survey interview with Luke Hart, the Executive Director of the Raptor Advocacy, Rehabilitation, and Education (RARE) group in Iowa, non-life threatening wing injuries at his center have a recovery and re-release rate of 30-40%. Figure 2 demonstrates the outcomes of different injury types of all centers surveyed, and

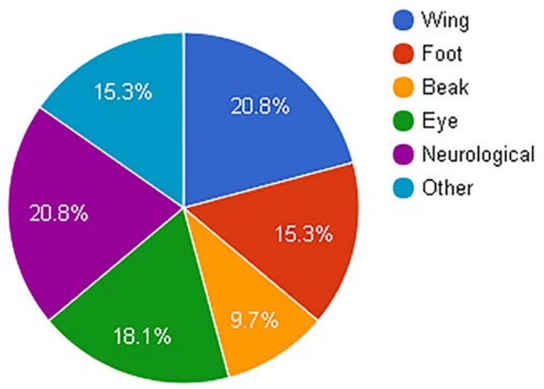


Figure 1. Percent of each injury types treated as reported by rehabilitation facility respondents.

emphasizes the low survival rate associated with neurological injuries. This figure provides a similar re-release rate for wing, foot, neurological, and miscellaneous injuries.

Interestingly, while 73% of rehabbers stated they were within 100 miles of a wind farm, only 40% believed they treat birds with injuries from wind turbine collisions. Rehabbers expressed low expectations that the birds they treat sustain injuries from turbine collisions; the highest estimate from rehabbers was 20%. Concerning rehabbers' opinions on mitigation options, 87% called for pre-development mitigation options as opposed to post-development mitigation or restitution. Examples of pre-development strategies included changing blade design or initial wind farm layout, while payment of fines was the example used for post-development mitigation. 100% preferred that wind farms minimize their impact on wildlife instead of simply providing restitution.

So What Does That Mean for Birds & Wind?

The data collected via surveys provide a quantitative account of the types of injuries sustained and number of birds that can be re-released after injury. The data collected

from interviews helped to provide context for the answers provided through the surveys, and offered added insight into the hurdles facing rehabilitation as a mitigation strategy. Post-survey interviews were conducted with experts in the field, from both rehabilitation and advocacy groups. Questions were tailored to the expertise of each individual interviewed, but in general asked for opinions regarding the extent of the impact that wind energy is having and what type of solutions should be pursued.

To represent the local rehabilitation centers, we interviewed Mr. Luke Hart, Executive Director of RARE. This organization takes in close to 200+ birds a year from eastern Iowa and Illinois. To represent advocacy groups, we interviewed Dr. Michael Hutchins, Director of the American Bird Conservancy's (ABC) Bird-Smart Wind Energy Campaign. This group aims to improve company decision- making and push for better regulations that mitigate bird and bat deaths caused by commercial wind energy. Dr. Hutchins claims that many conservation organizations have embraced wind energy without asking enough questions, and this campaign aims to ask those tough questions.

Mr. Hart helped to explain the low percentage of rehabbers reporting birds treated for injuries sustained by wind turbine collisions, clarifying that, in most cases, it is hard for rehabbers to tell exactly what happened to the birds when they are brought in. This, in turn, makes it difficult for survey respondents to say with certainty if raptors sustained wind turbine-related injuries. He also cited the low likelihood of those birds ever making it to a rehab center as a likely explanation. When asked about his opinions on the likelihood of recovery, Mr. Hart was not overly optimistic. Turbines have what Mr. Hart calls a "slice-and-dice" effect. He believes that a collision would result in either immediate death, or a traumatic injury that is unable to be treated.

To emphasize this low likelihood of immediate survival post-collision, some states have

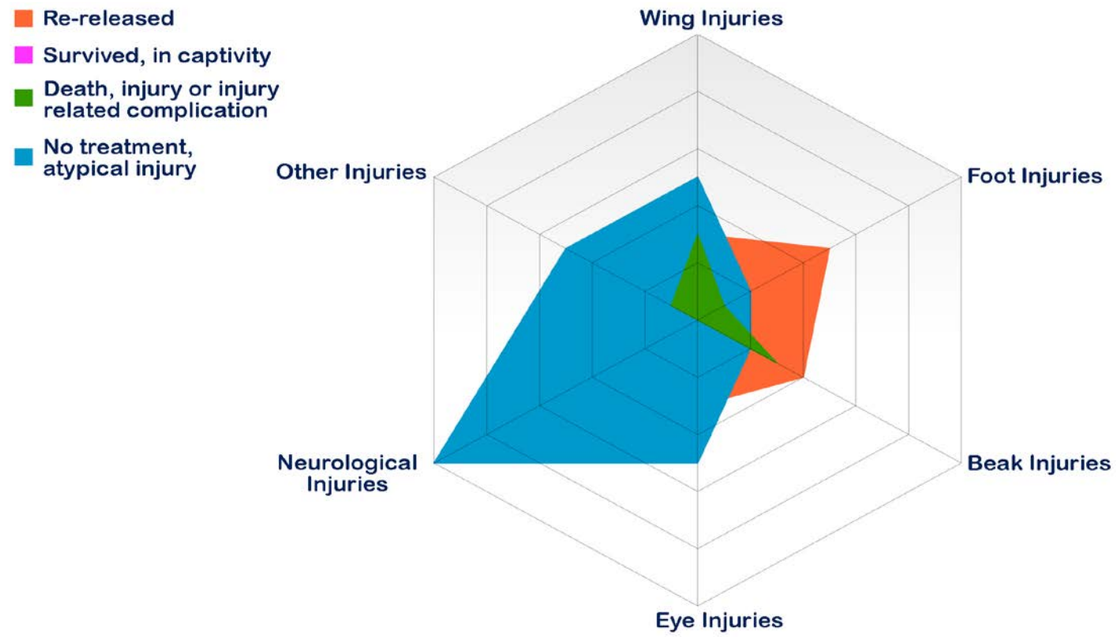


Figure 2. Radar chart displaying typical rehabilitation outcomes categorized by respective injury type.

laws in place that dictate how particular injuries must be treated. The loss of a wing or leg, for example, would result in the animal being euthanized (USFWS Form 3-200-10b). Therefore, even if the animal survives the collision, the type of injuries that are likely to be sustained may still result in death via euthanasia. Dr. Hutchins similarly expressed concern that turbine-related injuries would be too extensive. He believes most birds die on impact, and that those that survive would both be difficult to find and to treat. The combination of uncertainty of causation with injuries and the low threshold for survival post-collision help to explain the absence of wind-farm related injuries in adjacent rehabilitation centers.

Alongside the issues associated with the lack of recovery potential for birds injured by wind farms, Dr. Hutchins' interview helped to shed light on the political and social components of the conflict between commercial wind energy development and wildlife. He revealed yet another obstacle to the use of rehabilitation as a form of post-development mitigation, lack of publically available information. It is difficult to get a full picture of the number of birds that are injured or killed each year due to collisions with wind turbines because the mortality data is not readily accessible.

According to Dr. Hutchins, the lack of transparency between wind facilities and the public presents a major problem. He cites the lawsuit that Pacificorp brought against the U.S. Fish and Wildlife Service in 2014. This lawsuit was intended to block the release of information regarding bird deaths at Pacicorp facilities, which Dr. Hutchins sees as evidence of this lack of transparency (Cappiello 2014). He states that the collection of the mortality data also presents a possible bias, as paid consultants collect data for the industry, as opposed to independent researchers. This data is not required to be collected in most states, as the protocols are voluntary. With policies such as the Bald and Golden Eagle Protection Act imposing fines on companies that cause deaths of protected species, companies are not likely to be willing to report injured birds if they think it might result in fines or other sanctions. At the same time, however, these policies are not heavily enforced. With only two prosecutions against wind companies for violations of these policies, the track record for protecting species is not particularly strong. Policies initially thought to help preserve wildlife are encouraging opaqueness from wind facilities and discouraging companies from implementing mitigation policies and practices. This represents an unfortunate consequence and ineffective public policy, wherein mutually beneficial resolutions are needed for real-world progress, both for renewable energy development and avian wildlife conservation.

Policy and Mitigation Implications

As alluded to above, mitigation-focused regulations are likely to play a role in future commercial wind farms operate siting. The creation of siting regulations could provide a viable form of pre-development mitigation. Disturbance-based siting, for example, encourages development in areas that have already been fragmented, and thereby help preserve areas of higher quality habitat (Kiesecker et. al 2011; Fargione et al. 2012). Post-development mitigation options mostly include structural changes to turbines, wind farm layouts, and operational adjustments, or compensation that could be provided in exchange for increased wind development. Our rehabilitation strategy aimed to add to these options.

When asked for their opinions on how serious of a threat they believed wind farms posed to raptors, both Mr. Hart and Dr. Hutchins believed it to be non-trivial. The losses are cumulative, and when all the anthropogenic influences are added up they become significant. The turbines are not the only danger, as the associated infrastructure (power lines, communication towers, etc.) also kill birds through collisions and

electrocution. Regarding mitigation techniques, Mr. Hart felt that reducing the "slice-and- dice" effect of wind turbines by changing their design would be the most effective way to minimize both the rate and severity of injuries. He would also like to see energy companies conducting more extensive impact studies pre-development to establish baseline information alongside a more thorough understanding of potential impacts. Dr. Hutchins added a preference for siting regulations that would move wind facilities out of areas with high bird abundance, e.g., migratory flyways. These sentiments were in line with the 87% of rehabbers who voiced a preference for pre-development mitigation techniques.

Conclusion

Results of this study suggest injuries sustained from collisions with wind turbines are unlikely to have a high rehabilitation success rate. Raptors either die on impact or suffer irreparable traumatic injury that results in euthanasia. This low success rate suggests that the use of rehabilitation as a form of post-development mitigation would be ineffective. In addition, we determined that the current state of communication and cooperation between commercial wind energy facilities and wildlife agencies and practitioners is not favorable for the creation of this type of program.

For successful rehabilitation, companies would need to be more willing to report injured birds and allow their collection. The lack of incentive for companies to report injured birds is a serious obstacle. Amongst local rehabbers, pre-development mitigation strategies were preferred, and minimization of impacts to wildlife is favored over restitution.

Integrating the scientific literature, professional expertise, and local knowledge offers a unique perspective of a complex issue. By assessing the knowledge of local rehabbers, who are on the front lines and deal directly with injured birds, we were able to gain a fuller understanding of recovery rates from collisions.

By identifying the probability for low survival rates, we were then able to conclude that preventative measures are better taken before injuries are incurred. This enabled us to establish an informed platform when we began talking with experts in the field, who were better able to explain to us the reasoning behind some of the obstacles we recorded. They then offered their own professional opinions about future solutions. Overall, pre-development mitigation strategies are preferred (e.g. siting, blade design, etc.).

Implications for Future Research

This project served as a pilot study, intending to identify gaps in the current research and highlight further research needs. Findings suggest that, as it stands, rehabilitation is not a viable mitigation option due to the severity of injuries sustained and the lack of industry cooperation.

To remedy some of these obstacles, further study is needed to explore alternative viable solutions. Design options that reduce the severity of injuries, bladeless technologies, and the creation of proper siting regulations are all possible resolutions. This study demonstrates the usefulness of using local knowledge to understand large-scale problems.

Follow-up research could include using this form of local knowledge to inform stakeholder preferences for pre-development mitigation strategies. Importantly, developing cooperative and transparent relations with companies would facilitate the collection of more accurate mortality data and strengthen understanding of the problem and potential solutions. Findings suggest that there is much uncertainty surrounding the extent of wind energy impacts on birds of prey, as well as the effectiveness of mitigation strategies. ☐

A Walk on the Beach

Haustoriid amphipods as indicators of beach disturbance

Zach Hancock

Texas A&M University

"Haustoriids are perhaps the most interesting group of amphipods and so diversified that by necessity many genera have been illustrated herein."

~J. Laurens Barnard, 1969

As you near the intertidal zone, where the last gasps of wave energy exhaust themselves upon the fine sand beach, note the band of mottled sanderlings (*Calidris alba*). These petite wading birds descend on the moist sand left by the retreating tide, pecking furiously for benthic critters. As the tide returns, the sanderlings bolt to dry land so that only their thin black legs are washed by seawater. They wait on the water's edge where they regroup; they will return.

Sandy beaches around the world attract thousands of tourists each summer—striped umbrellas and brightly colored beach towels with caricatures of sea creatures dot the landscape. Small children build sand castles while older siblings exchange blows with a cream-colored volleyball.

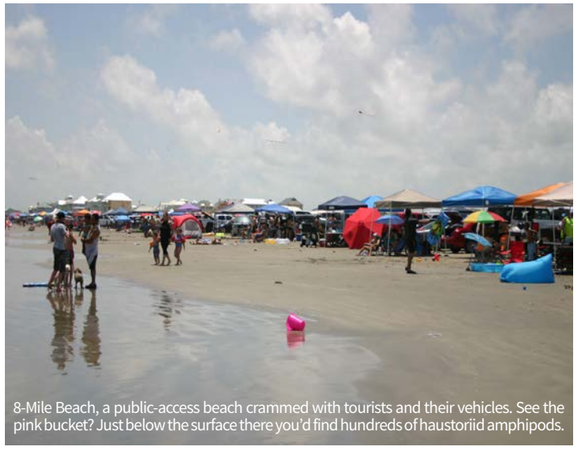
In Galveston, Texas, the occasional surfer can be seen attempting to ride the waves... and ending belly-flat on the board.

This increased foot traffic does not go unnoticed by shore residents. Schlacher et al. (2016) find that beach trampling by tourists can have an immense impact on beach-hoppers (Amphipoda) (~47% decrease in abundance). Black-bellied plover feed on these, and while the loss of these amphipods is negligible for adults, chicks scavenge for their own and are incapable of wandering far from the nest. If the shoreline near the nest is greatly disturbed by beach-goers, we could be looking at one unlucky chick.

Slivers of barrier islands line the Texas coast. South of Galveston, beyond Freeport and Port Aransas, is the Padre Island National Seashore. The park's website boasts that it has the "*longest stretch of undeveloped barrier island in the world*" (https://www.nps.gov/pais/index.htm). Indeed, about 70 miles of coastline are guarded from development.

Follow the main road beyond the visitor's center and you'll eventually find yourself on a beach highway clogged with RVs, trucks, campsites, and the occasional drunken crowd of tourists only mildly aware they're about to be struck by your vehicle. Traffic jams are common—someone is trying to turn around, backing into the dunes and slinging pillars of sand in wild puffs into the sweltering summer air—others are maneuvering around RVs parked just on the water's edge, partially sinking into the moist sand.

A view of the Galveston Seawall following beach replenishment program in March 2017. Before this, the ocean came right up to the wall. Photo credits: Janelle Goeke



8-Mile Beach, a public-access beach crammed with tourists and their vehicles. See the pink bucket? Just below the surface there you'd find hundreds of haustoriid amphipods.

This continues for 60 miles.

Numerous studies have addressed the impact of both on- and off-road vehicles on sandy beach health, most of which focused on the impacts on ghost crabs (*Ocypode* spp.) (Schlacher & Lucrezi 2010, Lucrezi *et al*. 2009). One exception examined effects on the coquina clam, *Donax deltoides* (Sheppard *et al*. 2009).

The impact studies mentioned for each of these disturbances—human trampling, vehicular traffic—use common shore animals to assess how these disturbances affect local biota. Each also argues for this idea in reverse; that is, that the abundances of these organisms can be used to predict the extent of disturbance. In this way, these critters are '***indicator species***.'

Specifically, indicator species are those that respond to certain ecosystem alterations in known ways. The most common of these for sandy beaches are ghost crabs. Schlacher *et al*. (2016b) performed a meta-analysis of all studies involving various *Ocypode* species as indicators of beach disturbance, ranging from trampling to off-road vehicles, replenishment, oil spills, and dune camping. Others (e.g. Ogden et al. 2014) have argued for shorebirds as indicators of coastal environmental health as they occupy a key role as macroinvertebrate predators.

Issues surrounding the use of shorebirds as indicators are obvious—they are difficult to physically assess without capturing, which may be forbidden for some endangered species. Ultimately, many studies (e.g. Schlacher et al. 2016a) resort to using the food source of the birds as proxies for population health. The ghost crabs, likewise, have their pitfalls as indicators, specifically on heavily trampled dunes. Lucrezi et al. (2009) discusses some of these short-comings, which include

Top: A ghost crab burrow at Port Aransas, TX.
Middle: Lateral view of an undescribed haustoriid amphipod from Jamaica Beach, TX.
Bottom: Dorsal view of the rostrum, antennae, and eyes of a haustoriiid collected at Padre Island National Seashore. The yellowish coloration behind the head is the sand that fills its digestive tract. Photo credits: Zach Hancock

The author sampling amphipods using a 435 micrometer sieve at Matagorda Beach, TX and Dr. Mary K. Wicksten releasing a Portuguese man-o-war (*Physalia physalis*), a common member of marine plankton.

the difficulty of fingering the casual impact factor of population differences.

Is it human trampling and beach recreation that have driven the crabs down-shore?

Or is it, instead, increased artificial light, such as from street lamps near seawalls, that have led them to migrate?

Since burrow-counts are proxies for crab numbers, this could lead to underestimating crab densities in two key ways:

(1) In areas that have been traversed, burrow-openings may be covered by sand, leading to an artificially reduced number.

(2) Ghost crabs readily enter old, abandoned burrows that may not be counted.

Back at the beach, those sanderlings have regrouped and are darting behind the retreating waves. In spastic, jerking motions they press their needle-like beaks into the wet sand—the same sand that is shifting and engulfing engulfing your bare feet.

What sustenance can be found in this unstable sediment?

At the wave's edge, there are effectively two players: spionid polychaetes, mostly *Scolelepis squamata*, and the burrowing amphipods of the family Haustoriidae.

The first is a hardy cosmopolitan species that is quite resistant to disturbance (Martínez *et al*. 2015). The latter, however, is susceptible to human trampling (Martínez *et al*. 2015) and vehicular traffic (Wicksten *et al*. 1987).

Additionally, haustoriids are impacted by oil spills (Sweet 1987), and populations decline following hurricanes (Croker 1968, Witmer 2011). They are easily collected with a shovel and sieve, allowing true counts of the organism instead of relying on burrows or nests. And yet, apart from the studies cited herein, haustoriids have received little attention for their potential roles as bioindicators.

For one, sand-burrowing amphipods on the Texas coast are small, less than 6 mm. They are transparent, with the only obvious coloration coming from their milky-white eyes and the sand that fills their digestive tract. Their small size is counterbalanced by the high density in which they occur in a square meter of sand (average reported by Grant 1980 was 1,111 individuals/m^2). Therefore, the two major factors crippling the usefulness of haustoriids as bioindicators are:

(1) Lack of awareness and
(2) Absence of a dichotomous key of Texas coast species

The former issue can be mitigated by promoting the unique ability of haustoriids to serve as a universal indicator of disturbance. Haustoriids are not hindered by the shortcomings of other bioindicators. For example, as burrowing species, artificial lights, such as from nearby streets or coastal infrastructure, have no appreciable effect on their distribution along the shore; they don't rely on the presence of dunes, and are thus useful for studying the effects of beach armoring (e.g., the Galveston Seawall). In addition, since they occur at the immediate land-sea interface, they are impacted by events offshore (such as oil spills, Sweet 1987).

Amphipods also lack a pelagic larval stage—the female brood their young through the first molt—which limits their ability for extensive migration. Furthermore, haustoriids are food sources for a variety of organisms, including shorebirds, cownose rays (*Rhinoptera bonasus*; Ajemian & Powers 2012), and various other fish (Croker 1967, Sameoto 1969).

The second issue is the most pressing. Witmer (2011) note that the absence of a key to Texas coast species hinders their usefulness in environmental assessment surveys. Sweet (1996) find that there may be as many as three undescribed genera in the Gulf of Mexico—no formal descriptions were ever published from this.

Past studies show that haustoriids vary in their zonation patterns, salinity and temperature tolerances, and reproductive seasonality (Sameoto 1969). For these reasons, formal taxonomic descriptions and a dichotomous key are critical to assess beach disturbance.

This task is being undertaken at Texas A&M University in the lab of Dr. Mary K. Wicksten. Using specimens collected by Witmer (2011), Collection of Marine Invertebrates at the Biodiversity Research and Teaching Collections (BRTC), and those I have collected over the past several months, I aim to fill in the taxonomic gap hindering haustoriids' usefulness in conservation biology. This will also facilitate future work on this relatively obscure but abundant family.

The issues illustrated above demonstrate the convergence of conservation and taxonomy. In recent years, there has been a dramatic shift away from classical descriptions; a move that has created the so-called 'taxonomic impediment' (Wheeler 2008, Bortolus 2008). And while advances in phylogenetics have reorganized taxonomic groupings, often no formal redescriptions are made (Padial & Riva 2007).

Sandy beaches are some of the most heavily impacted areas due to coastal development, which includes damming rivers that reduce the sediment flow to beaches resulting in erosion, tourism, oil spills from offshore platforms, and, ultimately, sea-level rise due to climate change.

To understand how we are affecting our planet, we need bioindicators that are accessible, numerically abundant, and form the base of the ecosystem in question. Haustoriid amphipods fill all three criteria.

Spare a final glance to the band of mottled sanderlings on the water's edge. Watch as they wiggle their little legs to disturb the burrowing amphipods, tricking them into revealing their location. How many thousands of years has natural selection worked molding this interaction? But the past is stone—unchanging, stoic. The past is guaranteed. The future of sandy beaches, and the fascinating creatures that live there, is not. ❐

Acknowledgements:

Thanks to Dr. Mary K. Wicksten for introducing me to haustoriid amphipods and welcoming me into her lab, and Janelle Goeke of Texas A&M University-Galveston for her willingness to hold buckets and snap pictures.

References:

Ajemian, MJ, Powers, SP. (2012) Habitat-specific feeding by cownose rays (*Rhinoptera bonasus*) of the northern Gulf of Mexico. Environ. Biol. Fish. 95:79-97. DOI 10.1007/s10641-011-9858-3.

Barnard, JL. (1969) The Families and Genera of Marine Gammaridean Amphipoda. United States National Museum Bulletin 271. Smithsonian Institution Press. ISBN 978-1-333-29910-1.

Bortolus A. (2008) Error cascades in the biological sciences: the unwanted consequences of using bad taxonomy in ecology. AMBIO 37: 114-118.

Croker, RA. (1967) Niche Diversity in Five Sympatric Species of Intertidal Amphipods (Crustacea: Haustoriidae). Ecological Monographs, 37(3), 173-200. doi:10.2307/1948437.

Croker, RA. (1968) Distribution and Abundance of Some Intertidal Sand Beach Amphipods Accompanying the Passage of Two Hurricanes. Chesapeake Science, 9(3), 157. doi:10.2307/1351181.

Grant, J. (1980) A flume study of drift in marine infaunal amphipods (Haustoriidae). Marine Biology, 56(1), 79-84. doi:10.1007/bf00390597.

Lucrezi, S, Schlacher, TA, Robinson, W. (2009) Human disturbance as a cause of bias in ecological indicators for sandy beaches: Experimental evidence for the effects of human trampling on ghost crabs (*Ocypode* spp.). Ecological Indicators 9:5 913-921. https://doi.org.ezproxy.library.tamu.edu/10.1016/j.ecolind.2008.10.013.

Martínez, MJ, et al. (2015) Response of intertidal sandy-beach macrofauna to human trampling: An urban vs. natural beach system approach. Marine Environmental Research 103:36-45 http://dx.doi.org/10.1016/j.marenvres.2014.11.005 0141-1136.

Ogden, JC et al. (2014) Waterbirds as indicators of ecosystem health in the coastal marine habitats of southern Florida: 1. Selection and justification for a suite of indicator species. Ecological Indicators 44:148-163 http://dx.doi.org/10.1016/j.ecolind.2014.03.007.

Padial, JM, Riva, I. (2007) Taxonomy, the Cinderella science, hidden by its evolutionary stepsister. Zootaxa 1577:1-2.

Sameoto, DD. (1969) Comparative Ecology, Life Histories, and Behaviour of Intertidal Sand-Burrowing Amphipods (Crustacea: Haustoriidae) at Cape Cod. Journal of the Fisheries Research Board of Canada, 26(2), 361-388. doi:10.1139/f69-036.

Schlacher, TA et al. (2016b) Human threats to sandy beaches: A meta-analysis of ghost crabs illustrates global anthropogenic impacts. Estuarine, Coastal and Shelf Science 169:56-73 doi 10.1016/j.ecss.2015.11.025.

Schlacher, TA, Carracher, LK, Porch, N, Connolly, RM, Olds, AD, Gilby, BL, et al. (2016a) The Early Shorebird Will Catch Fewer Invertebrates on Trampled Sandy Beaches. PLoSONE 11(8): e0161905.doi:10.1371/journal.pone.0161905.

Schlacher, TA, Lucrezi, S. (2010) Compression of home ranges in ghost crabs on sandy beaches impacted by vehicle traffic. Mar Biol 157:2467-2474.

Sheppard, N, Pitt, KA, Schlacher, TA. (2009) Sub-lethal effects of off-road vehicles (ORVs) on surf clams on sandy beaches. Journal of Experimental Marine Biology and Ecology 380:1-2 113-118. https://doi.org.ezproxy.library.tamu.edu/10.1016/j.jembe.2009.09.009.

Sweet, MH. (1987) Effect of the Alvenus oil spill on Jamaica beach macrofauna. Unpublished M.S. Thesis, Texas A&M University, College Station.

Sweet, MH. (1996) The Evolution of the Haustorioidea of the world, and post-embryonic development, taxonomy and ecology of the Haustoriidae (Amphipoda: Crustacea). A dissertation. Texas A&M University.

Wheeler, QD. (2008) Taxonomic shock and awe. In Q.D. Wheeler. The New Taxonomy. 76. Boca Raton: CRC Press 211–226.

Wicksten, MK, Green, TM, Sweet, MH. (1987) A quantitative study of sandy beach organisms at Padre Island National Seashore. Cooperative Park Studies Unit, Department of Recreation and Parks, Texas A&M University. Technical Report 7:1-117.

Witmer, A. (2011) Ecology of sandy beach intertidal macrofauna along the Texas upper coast. A dissertation. Texas A&M University.

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References

American Bird Conservancy (2000). 10 of the worst-sited wind energy projects for birds. Available at https://abcbirds.org/10-worst-wind-energy-sites-for-birds/

Bowden, T. S., E. C. Olson, N. A. Rathbun, D. C. Nolfi, R. L. Horton, D. J. Larson, and J. C. Gosse. 2015. Great Lakes Avian Radar Technical Report Huron and Oceana Counties, Michigan. U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP-2015

Cappiello, Dina . Associated Press. "Wind energy firm sues to block bird death data release". PBS. Public Broadcasting Service. (2014)

DOE. "20% Wind Energy by 2030 Increasing Wind Energy's Contribution to U.S. Electricity Supply". U.S. Dept. of Energy, Energy Efficiency and Renewable Energy. . (2008)

Fargione, Joseph, et al. "Wind and wildlife in the Northern Great Plains: identifying low-impact areas for wind development." PLoS One 7.7 (2012): e41468.

Fischlein, Miriam, et al. "Which way does the wind blow? Analysing the state context for renewable energy deployment in the United States." Environmental Policy and Governance 24.3 (2014): 169-187.

Glen, Alan M., Rebecca D. Barho, and Laura M. Evans. "How Federal Wildlife Laws Impact Development of Wind Energy." Trends 44 (2012): 14.

Kiesecker, Joseph M., et al. "Win-win for wind and wildlife: a vision to facilitate sustainable development." PLoS One 6.4 (2011): e17566.

Kuvlesky Jr, William P., et al. "Wind energy development and wildlife conservation: challenges and opportunities." Journal of Wildlife Management (2007) 71.8

Smallwood, K. S. (2013). Comparing bird and bat fatality- rate estimates among North American wind- energy projects. Wildlife Society Bulletin, 37(1), 19-33.

USFWS. What you should know about a Federal Migratory Bird Rehabilitation Permit. Form 3-200-10b. U.S. Fish and Wildlife Service . (2013).

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A Call to Action

Engage, Educate, and Empower Politically Disenfranchised Communities to Advocate for Environmental Justice

Policies designed to protect communities from environmental degradation are not consistent across the United States, particularly among low-income, underrepresented minority communities. Environmental degradation, i.e. air and water pollution, in these communities is often higher and more pervasive in comparison to affluent communities.

Additionally, underrepresented and minority groups (Asian, Hispanic, African-American), makeup only 16% of staff in U.S. environmental organizations and agencies (Taylor, 2014). Therefore, it is crucial for low-income communities to be introduced to and engaged in environmental science and policy to empower community members and create environmental change.

Here, we discuss engagement by participation in citizen science programs, education achieved through a Science, Technology, Engineering, and Math (STEM) training program, and empowerment through the Congressional Hispanic Caucus Institute Fellows program. We intersperse the discussion of these programs in relation to environmental justice with the experiences of participating undergraduate and graduate students.

ENGAGE: Citizen Science

Citizen Science in Action in Urban Environments

The innovation of Citizen Science projects involves ordinary people in scientific discovery. These projects are of particular importance to disenfranchised communities because they engage members and identify environmental issues within the community.

Earthwatch is a worldwide, non-profit environmental organization focused on connecting everyday people with the world's top scientists to conduct vital field research.

This organization has been collaborating with California State University, Los Angeles for the past two years in collecting data on tree species across the city to identify those that provide the greatest amount of benefits (e.g. shade) with the least amount of resources (e.g. water).

In 2016, twenty students from the upper division "Fundamental Writing for Biologists" class participated in a tree sampling event—recording tree GPS locations and measuring canopy sizes, diameters, and ground permeability—in Ascot Hills Park, East Los Angeles (Fig. 1).

Figure 1. Students from California State University, Los Angeles sampling an endemic species of tree, Engelmann Oak (*Quercus engelmannii*), in Ascot Hills Park, Los Angeles, California in Summer 2016.

The activity immediately transformed into a scientific scavenger hunt for the students. Groups would approach each tree and after a short pause to assess and compare the tree's morphological features to those described in the tree guides, the reaction was either sadness, followed by footsteps, or rejoice having found the target species.

The summer heat wave did not damper the student's enthusiasm. They added 36 new trees and increased the regional goal to 40%. As Citizen Scientists, the students gained an appreciation for the ecological role and health benefits of trees to their everyday life in an urban environment In addition, each student made a direct scientific contribution, improving tree planting and planning for Los Angeles communities.

This is a prime example of the impact of Citizen Science in underrepresented communities through education, research, and active participation with minimal training. Long-term investments into Citizen Science projects in politically disenfranchised communities could generate additional unforeseen benefits and environmental improvement.

Citizen Science as a Mitigation Tool for Politically Disenfranchised Communities

The involvement of the participant in Citizen Science can range from voluntary data collection (as above) to a **co-creative equal partnership** (Shirk *et al*. 2012). In the latter approach, a community's issues or needs drive the development of the research with an equal partnership between scientists and participants in all stages of the project.

This co-creative equal partnership Citizen Science model is ideal for underrepresented communities as the members designate the questions of importance in relation to environmental concerns. The findings of these studies then empower the community to make informed decisions to mitigate the issue and influence policies.

To execute these projects, collaboration across a wide array of participants is necessary, including university and college students, local community groups, non-profit organizations, and the private sector to host community conferences, education and training workshops, sampling events, and disseminate research findings. The implementation of co-creative Citizen Science projects in marginalized communities provides an integrative program of training, research and outreach.

Although examples of Citizen Science as a method to engage, educate, and empower are very few (e.g. grassroots groups monitoring environmental impacts of the oil and gas business development in the Northeast U.S.; Jalbert, 2016), they represent a type of initiative that can give a voice to politically disenfranchised communities.

The Flint Water Study is an example of this type of Citizen Science initiative and a result of concerned community members in the quality of the tap water in Flint, Michigan. Residents noticed color, odor, and taste differences, as well as a rise in health problems in children, after the state switched from Lake Huron to the Flint River as the main water source. The Michigan Department of Environmental Quality failed to treat the corrosive water after the switch, which began dissolving the city's iron and lead pipes, causing lead to leach into the drinking water.

Despite the alarm raised by residents of Flint, a population composed of 56.6% African-American and 41.2% of residents living below the poverty line (U.S. Census Bureau, 2016), they were ignored by the city. A team of researchers at Virginia Tech University united with community members to collect and process samples. The results found lead levels were 2.5 times higher than hazardous waste threshold designated by the Environmental Protection Agency.

A state of emergency was declared in Flint, which helped initiate some of the changes residents has been demanding from their local and state government. The water source was changed, the process of replacing the lead pipes was started, emergency federal funding and assistance was requested, and criminal cases were filed against local and state officials. Despite the long-term ramifications of city officials' negligence in exposing a community to lead, The Flint Water Study exemplifies the potential of Citizen Science in gaining access to new information, skills, and political strategies to create environmental change and emphasizes the importance for co-creative equal partnerships.

EDUCATE: Training Programs

Advancing Minorities in the STEM Fields

Historically, science was once only accessible to the elite. However, the rise of the middle class and increased access to research institutions has made science more accessible to a broader American public, yet a gap still exists. Today, full-time professors in the STEM fields are made up of only 4% Black/African-American, 3% Hispanic, and 9% Asian/Pacific Islander (U.S. Department of Education NCES, 2016). Training programs provide the skills necessary for future employment and are necessary for the advancement of the STEM disciplines. In underrepresented

Figure 2. Instructor Adam Deras and NHEC students processing soil samples in Great Kills Park, Staten Island, New York, a part of the Staten Island unit of Gateway National Recreation Area in Summer 2015.

communities, these programs provide access and economic opportunities that provide long-term benefits to society. The National Hispanic Environmental Council (NHEC) is a pioneering organization with a record of accomplishment attracting, training, and advancing the next generation of minorities in STEM fields.

Since 1997, NHEC has filled a void and become a leading voice for minorities on environmental issues at the national level. The NHEC STEM Institutes, 7-10-day training course held every summer held since 2001 in New Mexico, New York, and California, has the goal of training top students from across the country on environmental issues, federal quantitative environmental assessment methods. and environmental mitigation practices. The National Hispanic Environmental Council has secured funding for this STEM-focused initiative from federal agencies including the National Parks Services, U.S. Forest Service, Natural Resources Conservation Service, and the Environmental Protection Agency.

A unique aspect of the NHEC STEM Institutes is facilitating employment into these agencies through the Student Career Experience Program, Student Temporary Employment Programs, and Youth Conservation Core. In the last three years, 70% of the participants funded were female, reflecting changing societal dynamics, i.e., 57% of the workforce being women (U.S. Department of Labor, Women's Bureau, 2016). In contrast to

other programs, the NHEC instructors and role models reflect the population diversity and the students they serve. The success and impact of NHEC in federal, industry, and leadership positions across the nation is reflected in the current positions of past alumni, for example Jasmine Benitez is Assistant Director of Public Programs at Rocking the Boat Inc. in the Bronx, NY and Victor Medina is a Park Ranger for the National Park Service at Lowell National Historic Park in Massachusetts. NHEC has recently partnered with the 21st Century Conservation Service Corps (21CSC), a conglomerate of organizations aimed to increase civilian national service positions on public lands, to further advance the mission of NHEC in diversifying the STEM workforce.

Advancing Minorities in the STEM Fields

"This was the first site where we were going to put our knowledge from the classroom to the test", recalls Daniel Dallate (second from the right in Fig. 2). "We arrived at the beach and our team was responsible for conducting soil testing under the guidance of our Instructor, Adam (Conservation Biologist from Los Angeles, CA)." "We took samples along a perpendicular transect to the beach and as we identified the soil types and processed samples, we told a couple jokes." Adam spent his vacation from his position as the Wildlife Refuge Specialist at US Fish and Wildlife Service in Medicine Lake serving as a great mentor and dedicated instructor.

At the completion of the Institute, Daniel and four other participants became employed for the U.S. Forest Service for the remaining summer at the Chippewa National Forest in Walker, Minnesota under the mentorship of Sherry Fountain (District Ranger). In the fall, following his internship, Daniel became a freshman at Ohio Wesleyan University as an Environmental Science and International Studies major and part of the Track & Field Team. This summer he is working 3,600 feet above sea level at the Shasta-Trinity National Forest as a Student Trainee for the U.S. Forest Service, where he is learning about recreational use and management strategies of the forest. The long-term effects of NHEC on the lives of young adults like Daniel are countless and highlight the need to support and expand these types of programs.

Figure 3. Congressional briefing on the reclamation of abandoned mines in Washington, D.C. (April 2016).

EMPOWER: Environmental Policy

The political needs of disenfranchised low-income minority communities often go unrepresented at the federal and state level in the United States. Unfortunately, opportunities that expose underrepresented youth to the legislative process and policy making in natural resource management and environmental science are minimal.

The Congressional Hispanic Caucus Institute (CHCI), Congressional Black Caucus Foundation (CBCF), and the Asian Pacific American Institute for Congressional Studies (APAICS), bridge this critical gap through policy training progra that focus on educating and empowering emerging leaders from politically disenfranchised communities to tackle issues that disproportionately impact ethnic and minority groups. These unique programs provide emerging leaders with the opportunity to learn the government protocol on policy development and implementation, as well as the opportunity to network with successful role models in public service, industry, and scholars. These programs recruit college students and recent college graduates to experience the development of legislation and public policy in Washington, D.C.

Uncovering the Development of Environmental Policy on Capitol Hill

As a past Congressional Hispanic Caucus Institute fellow, the co-author (G.S.; 2015-2016) worked in the Committee on Natural Resources in the U.S. House of Representatives to explore the topic of abandoned mines in the U.S. Southwest. This is a serious environmental issue that disproportionally impacts minority and disenfranchised communities.

In April 2016, a public policy briefing and roundtable discussion was held in the Cannon House Office Building on the reclamation of over 100,000 abandoned mines in federal lands among congressional staff, national public policy experts, and academics (Fig. 3). Subsequent research led to the publication of a white paper as a feature article in the Harvard Journal of Hispanic Policy (Sosa, 2017). The fellowship experience provides valuable knowledge on the legislative process, empowering individuals to advocate at the highest levels of government and provides a voice to promote environmental justice on behalf of disenfranchised communities.

A Call to Action

As demographics of the American population shift (54% will be from Black, Hispanic or Asian decent by 2065; Pew Research Center, 2015), the continued development of innovative programs like those mentioned above are needed to engage, educate, and empower politically disenfranchised communities. Citizen Science programs can be successfully employed using the co-creative equal partnership approach to directly involve communities in scientific research to mitigate environmental degradation.

Implementing education and training models led by a diverse staff with subsequent employment into the STEM fields has proven fruitful and greatly improves the likelihood of minority leaders in non-profits, federal agencies, and the private sector. The NHEC model can be duplicated, improved, and expanded to generate a well-educated demographically representative community to spearhead conservation/environmental efforts and create a pipeline for a demographically balanced STEM workforce.

The next generation of advocates fighting for environmental justice in these at-risk communities should have the knowledge to navigate the policy development process. These efforts can be effectively supported in collaboration among community members, local and national organizations, non-profits, scientists, and government agencies to serve as a catalyst for change in creating a healthier environment for generations to come. ☐

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References

- Jalbert K (2016) https://goo.gl/BSnyoL
- National Science Board (2016) https://goo.gl/9zdaF6
- Shirk JL et al (2012) https://goo.gl/s6hZUR
- Taylor D (2014) https://goo.gl/Lvk1xC
- US Census Bureau (2016) https://goo.gl/QiyzhR
- US Dept of Education (2016) https://goo.gl/ab2AMu
- US Dept of Labor (2016) https://goo.gl/KP19Bj
- Sosa G (2017) https://goo.gl/EEKSXi
- Pew Research Center. (2015). https://goo.gl/ErCq7W

Motivations for International Conservation Research

bridging conservation and culture on a personal level

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I took my first international trip at two years old to attend my uncle's wedding in Taipei, Taiwan. Over the next decade, all trips and vacations were exclusively to visit family in Taiwan every few summers. Unfortunately, after I started middle school, visits to Taiwan fell out of priority, and summers became focused on camps, classes, and internships. Over the ensuing years, revisiting Taiwan was never considered seriously, and I had become unaware of the cultural heritage that played such an influential part of my formative years.

After graduating college, I learned of news that forced my scope of interests to widen again and include my Taiwanese family and cultural heritage. I learned that my grandma, who had helped my parents raise me in Austin for the first year of my life, was beginning to lose her memory dramatically. My sharp, active, and spirited 4 ft. octogenarian grandma had started losing her lively spark. Suddenly I realized how long it had been since I had seen my family, who I was so close with in my early childhood. Over a decade had passed since I last saw many of them, and a desire for reconnection with my family and heritage began to brew.

When I enrolled in the Applied Biodiversity Science (ABS) program at Texas A&M University in 2014, I didn't have a concrete project in mind. I knew I was driven to study anthropogenic effects on the ecology of herpetofauna, and that I was interested in studying biodiverse and tropical systems that were strongly impacted by these effects.

When I discovered the National Science Foundation East Asia & Pacific Summer Institute (NSF-EAPSI) summer research fellowships, I saw an opportunity for my personal and academic desires to overlap. I could, essentially, concurrently pursue my desires to reconnect

The author (far left, seated) celebrating Lunar New Year with her extended family.

with my family and heritage and conduct an independent research project on the densely populated tropical island of Taiwan. As a first generation student from the USA, I had been removed from my Taiwanese heritage, and I desired to rediscover my family and culture. Additionally, Taiwan was exceptionally suitable for my conservation interests as an island that "appear[s] to feature exceptional plant endemism and exceptional threat," as Myers et al. 2000 stated in their seminal "Biodiversity hotspots for conservation priority" Nature article.

I began to formulate my dissertation, influenced by both academic and personal motives. My drive to perform research in Taiwan was fueled by my enthusiasm for conservation on a tropical island with highly juxtaposed ecological and economic interests Thus, Taiwan seemed to be the perfect stage for me to explore the ABS mission of bridging ecology, culture, and governance.

The ensuing summer of 2015, I collaborated with local road ecologist, Te-En Lin, at the Taiwan Endemic Species Research Institute (TESRI), a Taiwan governmental research and management institution, on an exploratory study of the effects of roads on Taiwan's native and endemic reptiles and amphibians (herpetofauna) funded by the NSF-EAPSI fellowship.

I was incredibly fortunate that Te-En expressed interest in hosting me during my fellowship, as he managed an extensive roadkill observation citizen science network. The Taiwan Road Observation Network (TaiRON) is a Taiwan citizen science group that collects opportunistic road kill observations for potential scientific and wildlife management use. Te-En and a concerned group of citizens started the informal Facebook interest group in 2011 with no specific scientific goals in mind, but it has since then grown into a Facebook group with over 13,000 members from all disciplines and professions. I was also able to visit a few family members a handful of times over the eight-week fellowship, but not as much as I had hoped.

Though I briefly explored Taiwan, my motivations to return were stronger than before. Academically, I had the opportunity to continue a large-scale, long-term conservation project that would provide insights and aligned with my scientific interest in road effects. I would maintain my supportive Taiwanese connections and involve hundreds of local citizens with the conservation of reptiles and amphibians. My personal motivation stemmed from heartbreaking news I received during my visit; my grandma had been diagnosed with Alzheimer's. Since she has not been capable of travel to the U.S. for several years, I felt the need to visit her as often as possible before her memory degraded. I was determined to return for a longer period of time to accomplish more in-depth collaboration and instill deeper connections to my family and heritage. So I applied for and received a Fulbright Research Fellowship.

Currently, indigenous peoples are the only citizens allowed to own guns for and hunt due to traditional rights. Despite the fact that indigenous peoples are the only people permitted to hunt, poaching is rampant across the island, which targets highly endangered species like the Formosan Pangolin (*Manis pentadactyla pentadactlya*) and Yellow-margined box turtle (*Cuora flavomarginata*).

Unfortunately, Taiwan's government have been focused on economic policy for the past few decades, leading to soft conservation regulations that negatively impact the unique and heavily endemic biodiversity in Taiwan.

My independent project gave me the opportunity to practice conservation strategies encouraged of ABS students, such as co-management of ecological projects with local actors. I worked closely with Te-En and his lab in designing studies that engaged citizen scientists in implementation of fieldwork, and I

The author using a snake hook to hold a Bamboo Pit Viper (*Trimeresurus stejnegeri*) found foraging during a night survey in Taiwan's montane jungles.

helped field projects his lab managed. I feel privileged to have been able to act as a cultural and linguistic bridge between US, Taiwanese, and Australian conservation and road ecologists who expressed interested in our project.

Te-En, has an impressive handle of his road ecology operations in Taiwan, and I was lucky to learn citizen science project management skills from him and contribute what I could, mainly in international networking and study design. Since Te-En wasn't confident in his English, I was able to help garner the international attention Te-En's incredible work deserves by introducing him and his project to prominent western road ecologists, as road ecology is still a predominantly western field. I am also engaging Te-En and other local researchers across several Taiwan governmental and academic institutions in co-publishing studies utilizing TaiRON's data for English journals.

I have gained tremendous amounts of academic experience and perspective, but it is exceeded by my personal growth. One of the first and most notable realizations I had was how at home I felt in Taiwan, though I had spent so little time there as an adult. Although I was aware and conscious of my role as a foreign researcher, I have also never been so readily and warmly accepted into a community and greater society. This is not only because the Taiwanese are extremely welcoming and hospitable, but also because I've never been somewhere where my last name was so common, and the way I looked was in the majority. I've never been a Smith or a Jones.

It was strange to reconcile my expatriated self with how easily and literally at home I felt in Taiwan. I seized the opportunity to reconnect and spend invaluable quality time with aging family members, as well as see and meet cousins and other family I hadn't seen in over a decade. I spent all my Taiwanese holidays surrounded by my large extended family, a vast difference from holidays in the states with my small nuclear family, which has given me a much greater sense of rootedness in Taiwan. I feel extremely fortunate to have been able to connect with Taiwan on such a meaningful and personal level, with both its cultural and ecological heritage.

My past year has given me a much deeper connection to Taiwan's community and culture, as well as deeper understanding and knowledge of the ecology, natural history, and conservation efforts in the country. I've also noticed

The author (left back row) and adviser Dr. Lee Fitzgerald (left front row) with her Taiwanese host collaborator, Te-En Lin (middle back row) and his lab after a successful day of looking for salamanders on Ali Mountain. Photo credit: Lee Fitzgerald

how the culture shapes conservation uniquely. TaiRON is likely the largest and most successful citizen science road observation network in the world, and the robust and highly participatory nature of the TaiRON citizen science group is due to the communal, caring, responsible culture in Taiwan. I personally have experienced this strong sense of community and high societal care myriad times, like when I dropped my wallet in the metro and it was easily found, or when I paid the equivalent of $6 USD for a dental exam because I, an alien resident, was covered under Taiwan's universal National Health Insurance (consistently rated one of the best medical programs in the world), or how everyone greets strangers as their aunties, brothers, and family. Because of this care and strong community, I believe Taiwanese culture is able to sustain its robust and highly participatory citizen science programs, and I have high hopes for the modern spread of robust community care of wildlife and conservation ethic in Taiwan.

It is hard to fully encompass the impact the year in Taiwan has had on my academic and personal endeavors, or the impact I have had on the road ecology community in Taiwan. Over the year of working with Taiwanese collaborators, attending a range of conferences focused on policy and ecology in Taiwan, conversing with locals, and spending precious time with family, I gained a much deeper understanding of the intersection between Taiwan's ecology, policy, and culture. ☐

Working at the Interface of Integrative Research, Conservation Practice, and Cultures

Navigating Muddy Waters

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The ***Bat-Agave-People Team....*** That's what I call myself and my collaborators on my dissertation research that focuses on conserving the endangered Mexican long-nosed bat (*Leptonycteris nivalis*) in northeast Mexico. As the name implies, our work spans the gamut of bat biology, plant population biology, and social science; all in the name of learning how best to protect this endangered species.

The bats, agaves, and people are part of a complex social-ecological system, in which both the bats and local communities rely on agaves as an important natural resource. The bats feed on the nectar of the agave flowers during their long-distance migrations from central Mexico to northeast Mexico and the U.S. Southwest. At the same time, Mexican farmers and rural communities harvest agaves for a wide range of cultural products like alcoholic drinks, food, and fibers. During harvest, the agave plant is prevented from growing its enormous flowering stalk, therefore removing the food resources for the bats.

Recent conservation efforts have begun focusing on ways to encourage local communities to adopt "bat-friendly" agave management practices (e.g. allowing some agaves to flower or replanting wild agaves) and understanding how to implement these practices in ways that are most beneficial to nectar-feeding bats.

Identifying potential motivations and/or barriers to adopting "bat-friendly" practices and determining the optimal "design" of these practices to maximize benefit to the bats and communities are the two main objectives of my dissertation research. Specifically, I am working near two important roosting caves in northeast Mexico to examine the social, political, and economic contexts of local communities and their current agave management practices, and to conduct foraging studies of the bats. As part of the University of Georgia's Integrative Conservation (ICON) program, my dissertation research spans boundaries between the natural and social sciences in an effort to integrate approaches to address the complexities and nuances of the bat-agave-people conservation challenge.

A typical day (and night) in the field involves setting up infrared cameras to monitor the

bats foraging on flowering agaves, sitting with these cameras for six hours each night, conducting agave/plant surveys at each of the monitoring sites during the morning/mid-day, and conducting several semi-structured interviews with community leaders and agave harvesters in the afternoon and evening. And repeat.

This juggling between natural science and social science field work means having to mentally switch gears throughout the day as I'm a bat biologist one minute, a field botanist the next, and an anthropologist the next. But as anyone trained in the natural sciences attempting to work (and not just dabble) in the social sciences (or vice versa) can attest to, this often translates into feeling like a Jack-of-all-trades, master of none.

Feelings and thoughts like "Am I sacrificing rigor and depth in order to gain a more nuanced understanding of the system and conservation challenge?" and "Am I gaining a smorgasbord of skills but not truly mastering any of them?" come up quite often, especially as a graduate student.

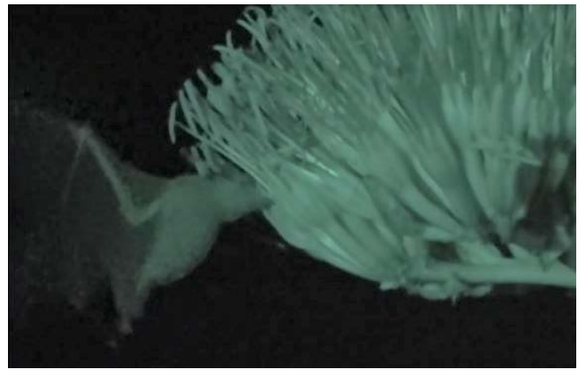
Mental exhaustion is a challenge, particularly while in the field and trying to juggle the day-to-day logistics of coordinating such different types of field work. These experiences are not unique to me, and seem to be par for the course among graduate students involved in integrative research.

However, spanning disciplinary boundaries is only one part of integrative graduate programs like UGA's ICON program. It is equally as important to cross the academic-practice divide if the research is to have real-world applicability to on-the-ground conservation efforts.

I have spent three summers working and collaborating with a local conservation organization in northeast Mexico, Especies, Sociedad y Habitat, A.C. (ESHAC) in an effort to ensure that my work directly contributes to their conservation efforts.

Members of ESHAC have been invaluable collaborators in the development of the research and its implementation in the field. They help me navigate the culture of the Mexican government to obtain permissions to do the field work, teach me local customs of the communities in which I'm working, and provide valuable insights into the logistics of doing field work in the region (including whether or not certain areas are safe).

My goal is that through our collaborations, I can directly contribute my skills and research to further their mission, even after completion of the field work.



Switching gears as a bat biologist (opposite, top), field botanist (opposite, middle), and anthropologist (opposite, bottom). Mexican long-nosed bat feeding (right, top). Group of flowering agave (right, bottom). Photo credits: I. Castrejon, A. Castaneda Aguilera, J. Juan Flores Maldonado.

Up to this point, I have been talking about the challenges of doing integrative graduate research. But what happens when you factor in the added challenge of doing graduate research internationally, in a different language and cultural context? Doing international research brings in a whole other suite of challenges related to logistics, including getting equipment to and from the field, getting the necessary permits, and traveling in areas with different traffic laws and customs. Then there is the language barrier. For me, this has been the biggest challenge, especially when combined with the mental gymnastics that integrative research requires.

Going into my first season of field work in the summer of 2015, I had a relatively intermediate Spanish-language background, with over 8 years of formal training in school. However, practice makes permanent, and I had not practiced my Spanish skills in a long time. I spent my first summer in Mexico feeling quite isolated, even when among a group of people, because I could not fully comprehend what was going on or being said around me. Luckily, that first summer I was just completing an internship with ESHAC and was not actually leading any field work.

However, my second summer I conducted a pilot study with the bat-agave monitoring and the community interviews, which required a bit more from my language skills. I managed to get by, even though I often felt like I couldn't fully communicate with our field team while doing field work. Then this past summer was my first full field season, complete with my own field vehicle and money to travel to the field where and when I needed. Coordinating field trips with the team, figuring out logistics, and even communicating via walkie-talkie at night really put my language skills to the test!

I realized that the more we did our bat monitoring, agave surveys, and community interviews, the more we fell into a routine as a team and the easier "work-related" conversation became. Of course, there were still times when frustrations boiled to the surface under the hot, beating sun or after a night of little sleep; communicating your frustrations in a second language is no easy task. It was often impossible for me to communicate exactly how I was feeling or exactly what I was thinking. However, this is all part of learning a new language in any context, and patience is key. Communication is never perfect, even in your native language, but research and collaboration is still possible!

Part of the 2017 Bat-Agave-People field team (above). Showing how to set up the infrared cameras to monitor the agaves (below). (Photo by Bernardo Marino)

Many of these experiences are probably familiar to graduate students doing integrative research, especially in a foreign country and language. For any student interested in or currently involved in this kind of work, I hope that the following "*words of wisdom*" will be useful.

***Doing an integrative research project*:**

- Remind yourself that you do not have to address every aspect of your study system or conservation challenge. Wanting to do everything to fully address all the nuances of the system is a common theme among graduate students attempting integrative research. Remember that your work is only one piece of the puzzle!
- Be kind to yourself. Remember that you are pushing your boundaries doing integrative research and that you come from a particular background. Your Ph.D. is a learning process; you are not expected to (and cannot) be "perfect"! There will be times parts of your project take precedence over others. This does not mean that you are neglectful; each part will get its day in the sun.
- Imposter syndrome is real. Talking to others about their experiences can help you realize most graduate students experience the same thing!
- You have many voices helping you through your program but you will have to make the ultimate decision on much of your work. Listen to your voice and stand up for what you think is best.

***Crossing the academia-practice divide*:**

- Make connections outside of academia! Networking has been an immensely helpful "tool". It will serve you well, too, especially if considering a career outside of academia.
- Maintain open and continued communication with collaborators. This can be difficult: schedules get busy, priorities shift, and other things change. However, if your research is going to have real-world impact, you need to communicate with your collaborators outside academia and understand their perspective and needs.

***Working in a foreign country and language*:**

- Do not feel restricted to doing your research in your native country. While working in another country adds another layer of complexity and difficulty, it has probably been one of the most rewarding parts of my graduate work. It can help you push your boundaries, learn new skills, and expand your professional network.
- Accept the fact that you will not understand everything that is going on around you. Make sure to communicate the vital things well, and don't fret the chitchat. That kind of understanding comes with practice and exposure.
- Accept having "off" days in your language ability. I have compared my Spanish language ability to a roller coaster: some days I feel fantastic and confident, and I can speak and listen well. Other days I feel like I cannot comprehend or say anything right. This is a normal part of the language-learning process. It DOES get easier with time and practice!

The endangered Mexican long-nosed bat (*Leptonycteris nivalis*)

Navigating muddy waters between integrative research, conservation practice, and cultures is not a straightforward task. It requires persistence and optimism. If you are willing to push your personal and professional boundaries and are comfortable with discomfort, the path will be full of rewards. ☐

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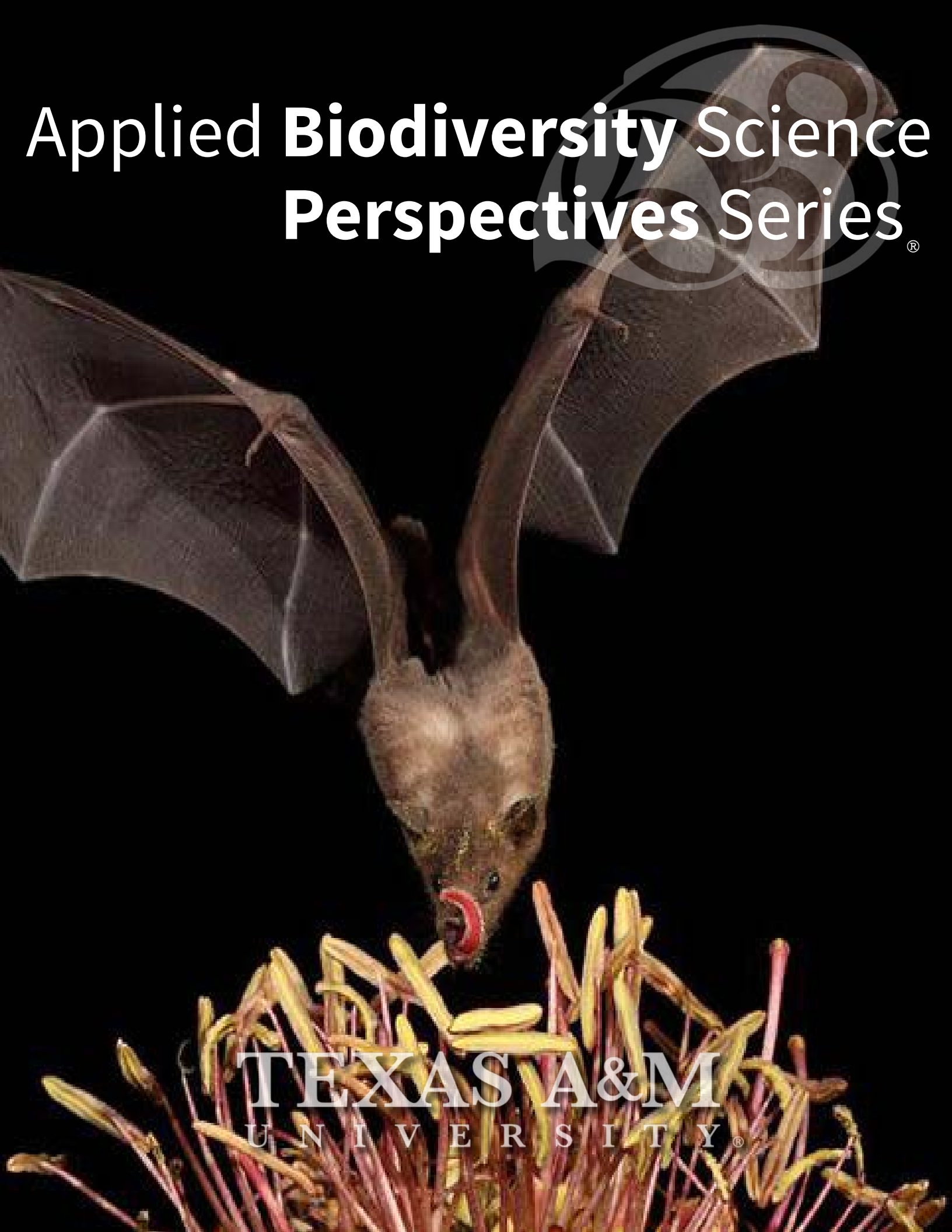

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