ST. EDWARD'S UNIVERSITY

Wild Basin Creative Research Center



Wild Basin Wilderness Preserve
2019 Annual Report

(October 1, 2018 – September 30, 2019)

Submitted by

Wild Basin Creative Research Center and St. Edward's University

to

Travis County Commissioners Court
and Transportation and Natural Resources

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Overview of Preserve Management and Operations

Wild Basin Wilderness Preserve is jointly owned and managed by St. Edward's University and Travis County (Appendix A). Wild Basin's mission is to protect and maintain its urban wilderness, and to promote the importance of environmental education, research, conservation and preservation.

Situated at the edge of the Texas Hill Country and surrounded by commercial and residential growth in west Austin (see Appendix B), Wild Basin is a unique conservation property for Travis County and the larger Balcones Canyonlands Preserve (BCP) system. As an urban and publicly accessible preserve, Wild Basin provides authentic environmental education and recreation experiences for the community. The preserve's location near a major urban area also brings challenges in the form of invasive species, water pollution, noise pollution, and litter. Wild Basin strives to incorporate these challenges into learning opportunities about our urban environments for students and the public.

In addition to helping implement preserve management, St. Edward's University operates the Wild Basin Creative Research Center based at the preserve, which houses a Visitor Center with environmental exhibits, staff offices, an Artist in Residence space, a classroom, a lab, and meeting spaces. The Research Center is a key resource for educating university level as well as K-12 students and provides a platform for public outreach and engagement.

Wild Basin's education, art, and preserve management programs are designed to promote conservation and environmental awareness, while encouraging and demonstrating land stewardship practices. Throughout 2018 and 2019, Wild Basin hosted stewardship days for students, the public, and corporate groups. Wild Basin provided 2 trainings (K – 12 and early childhood) for trail guides for school group tours; organized environmental educational and interpretive events, coordinated student internships and research activities, hosted undergraduate and graduate classes, maintained public trails, managed invasive species, performed restoration work, monitored and reported on water quality, hosted public and inter-agency meetings, workshops, and trainings, and hosted an Artist in Residence Program.

Since its merger with St. Edward's University in 2009, Wild Basin remains an important resource to the local community and continues to build on its rich history of promoting conservation, research, and environmental awareness. Wild Basin aspires to become

a model for urban preserves, a hub for stewardship, creative research, and environmental education, and a gateway to the BCP.

Wild Basin Vision

The vision of Wild Basin is to inspire conservation by connecting communities to a dynamic urban preserve. Together with our partners, we focus on the following goals for Wild Basin:

- Managing and restoring a mosaic of habitats indigenous to Wild Basin, including oak-juniper woodlands, riparian corridors, semi-open grasslands and cedar breaks;
- Protecting native biodiversity;
- Protecting habitat for the federally endangered Golden-cheeked warbler;
- Protecting habitats to support threatened and rare plant and animal species;
- Controlling non-native and invasive species;
- Protecting soil profiles and unique geologic features;
- Monitoring water quality relative to watershed inputs, runoff, and erosion;
- Protecting prehistoric and historic cultural sites;
- Managing a trail system that presents the regional flora and fauna, while minimizing impacts to the preserve's biotic community and inherent beauty; and
- Providing stewardship opportunities, research opportunities, and educational resources for students and the community.

Trail Maintenance, Restoration, and Construction

Trail Maintenance and Monitoring Activities:

- Weekly trail patrols were conducted along the trail system (Appendix A) to monitor trail conditions and identify potential hazards.
- Two TrailMaster trail counters (one at each trailhead) were maintained and checked regularly to document the total number of visitors as well as temporal patterns in activity. These units ceased to function in mid-2019. Visitation estimated from the remainder of the year were obtained through head counts conducted by security personnel, past visitation, and trail camera data. New Trafx trail counters were purchased and installed at each trailhead to aid in accuracy of visitation counts in the upcoming reporting year (2019-2020).
- Vegetation adjacent to designated trails was pruned throughout the year to maintain a visible trail for visitors and for safety purposes. Well-maintained trails will minimize confusion about trail edges so the public can easily and efficiently

hike to scenic areas. This maintenance is completed regularly to keep up with vegetative growth.

- As “social trails” (informal trails created by public or animals) were created throughout the year, signs were placed to indicate that visitors should stay on designated trails. In addition, dead and downed material was strategically placed to deter foot traffic by humans and wild animals.
- As in recent years, where rainfall runoff was causing erosion in trails, staff and volunteers installed berms and swales on the trail system at locations where rainfall runoff causes significant trail erosion to increase sheet flow of rainwater and reduce trail erosion.
- Several large snags that fell and blocked trails and presented risks to the public were removed by Wild Basin and St. Edward’s University staff and trained volunteers.

Trail Restoration Activities

- Wild Basin continued to work with trained stewardship volunteers and other volunteer groups (e.g., Boy Scouts, corporate groups, Central Texas Trail Tamers) to incorporate trail maintenance techniques that minimize erosion and lead to more sustainable trails. Wild Basin held workdays every Thursday, most of which were focused on trails. Wild Basin staff also performed trail work on Saturdays, often utilizing volunteers.
- Throughout the year, trail crews cleaned existing drainages and trimmed back encroaching vegetation along the entire trail system to improve functionality and allow water to drain from trails.
- A major trail restoration project begun in the previous reporting period continued to be implemented on and around the “Scenic Vista Overlook” trail north of the Wild Basin Visitor Center. The project was reviewed and approved by County TNR staff. Volunteers and staff worked to restore a social trail connecting the Overlook trail to Arroyo Vista Trail and building of a new trail to connect the two. Restoration work was also completed on a portion of the social trail leading downhill directly in front of the Scenic Vista Overlook.
- Land management activities used primarily native juniper and native limestone when needed for trail maintenance. No old-growth junipers or other native hardwoods are cut down in the preserve for such uses. All trail maintenance and other land management activities avoid impact or disturbance to cultural and archaeological resources.

Trail Construction, Building, and Maintenance Activities

- Three additional benches were added on Yaupon trail.
- Railings around the Overlook trail were replaced.
- Two failing benches were replaced on upper Arroyo Vista trail.

Boundary Management

Boundary Management Activities

- Wild Basin staff monitored the preserve's perimeter at quarterly intervals to check the integrity of fencing, boundary markers, and other issues.
- Unauthorized vendors were found to be parking in the eastern right-of-way of Highway 360 in two different locations adjacent to the preserve boundary. Upon inspection, preserve staff found several bags of trash at one of the locations (the old Wild Basin Ledge Road entry point), possibly left by vendors. To facilitate enforcement of parking restrictions by the Travis County Sheriff Department in these areas, at Wild Basin staff's request, TXDOT installed "No Parking" signs and barriers.
- TXDOT also erected "No Parking" signs on both sides of the entry drive into the preserve to prevent parking by visitors along Hwy 360 near for entry drive.
- Staff and volunteers picked up trash in the eastern right-of-way of Hwy 360 on multiple occasions to prevent it from traveling into the preserve and Bee Creek.
- Boundary signage or marking around inholding property was found to be lacking in some areas.
- Trash was found to be washing in from two residences along the southeastern portion of this boundary. Travis County Natural Resources and Wild Basin staff will be inspecting this area early in the next reporting year.
- Old brush piles exist in several places inside the preserve along the perimeter, mostly along southern portion. It is unclear whether some of these were from fence building or neighbors. These may need to be addressed for fire prevention.
- Clippings of Sego palm were found to have been deposited along the eastern boundary across the fence from neighbors.
- A leaking water pipe was found and reported along the Southeastern boundary. The water line belongs to Travis County and the proper authorities have been notified.
- Several locations have downed trees laying across the fence line, especially along the portions of the southern boundary that have not had clearing for shaded fuel breaks.
- A security camera was added to back gate.

- Signs discouraging holiday tree decorations were placed along Hwy 360 at the beginning of the 2018 holiday season. In addition, holiday tree decorations were removed from trees promptly to discourage further decoration and to prevent fallen decorations from blowing or washing into the preserve and Bee Creek.

Vegetation Management

Vegetation Management Activities

- Vegetation mapping. Wild Basin staff, volunteers, and researchers are currently using the citizen science platform iNaturalist to map the distribution of plants within the preserve. iNaturalist is accessible via a smartphone app or on the web from a computer. The app allows users to document locations, photos, and relevant notes about plant species on-site. Currently, we have two projects established in iNaturalist: one project for the public to report their observations along the trails (Wild Basin Biodiversity Project), and a second project for staff, researchers, and trained volunteers to report observations of rare plants and invasive species in off-trail locations (WBCRCMappingProject). In the case of rare or endangered species, all coordinates are obscured from the public so as not to encourage iNaturalist users to leave the trail. All iNaturalist observations can be exported and then uploaded to ArcGIS or Google Earth for mapping or further analysis. The iNaturalist Wild Basin Biodiversity Project currently has 1,111 Research Grade observations of 426 floral and faunal species. The project currently has a catalogue of 244 Wild Basin plant species.
- Rare plant species. All rare plant locations described are documented in the iNaturalist WBCRCMappingProject. Coordinates are obscured from the public when sightings are off-trail. A report from volunteer Master Naturalists monitoring rare plant species in Wild Basin can also be found in the research section of this report.
- Target rare and unusual plant species:
  Primary Species of Interest
  - Naked broom-rape (*Orobanche uniflora*): This species had been seen reliably for several years back in the 1980's, but the exact location has been lost. One stem with one flower was observed this year in the shaded fuel break area just outside of the boundary of Wild Basin.
  - Shooting-star (*Primula meadia*, formerly *Dodecatheon meadia*): Several excursions were made during the bloom period. Both populations were found. Two groupings of plants – one consisting of 12 plants and one of 8 plants - were observed in the North Hollow location. One flowering stem

was observed in this population. Four plants were observed in the southern population – two under the wire caging placed last year, and two additional plants 50 feet west outside of the caging.

- Texas Madrone (*Arbutus xalapensis*): An extensive survey was not conducted this year. Observations in passing the main and eastern populations show the populations to be healthy with no significant changes.

Secondary Species of Interest

- Canyon mock-orange (*Philadelphus ernestii*): Two cultivated plants were planted on the open oak-juniper slope just north of the visitor's center about 10 years ago. They are both still alive, however this is not the ideal habitat (should be mesic limestone ravine).

Tertiary Species of Interest

- Glass Mountain coral-root (*Hexalectris nitida*): Three stems were observed in a new location. A single stem of a presumed *H. nitida* was observed along the western side of Arroyo Vista Loop. The plant was located inside the paved trail path, and before protection could be placed around it, it was accidentally stepped upon and crushed. A protection protocol has been established to prevent a recurrence.
- Crested coral-root (*Hexalectris spicata*): Three stems of what is presumed to be *H. spicata* were seen this year. In 2016 and 2017, approximately 30 stems emerged 5-10 feet from the north side of the visitor's center and the observed plants this year were close to that area. No plants were observed in this area in the 2017-2018 reporting period.
- Heller's marbleseed (*Onosmodium helleri*): Two new Heller's were discovered and added to iNaturalist. Other plant populations were observed in passing and appeared healthy. No disturbance was observed, so no count was undertaken.
- Buckley tridens (*Tridens buckleyanus*): Three small clusters were found near the back gate. One was on the fenceline and the other two about 30 feet inside the property. Woody plants are encroaching upon this area, brush management is suggested to return to a more open canopy. Locations of all clusters noted in iNaturalist.
- Louisiana broomrape (*Aphyllon ludovicianum*; *Orobanche ludoviciana*). Collected in 1919 from the hills east of Bee Creek. Current status is unknown. None have been observed in Wild Basin.

- Ladies tresses orchids (*Spiranthes magnicamporum*): Fall of 2018 was an excellent season with blooms all over the preserve. In November two bloom stalks of the wet-footed Spiranthes in North Hollow were observed. Shrubs continue to encroach on the clearing. In December 2018, 7 plant were relocated from the parking lot paving project. Four were planted on the south side of the trail to the outdoor classroom and three were planted on the slope across from the back of the Visitor Center. Observations were posted to INaturalist. The rosettes persisted for several months and then went dormant along with all the rosettes in the preserve.
- Sticky Liatris (*Liatris glandulosa*): This plant was observed for the second year at Wild Basin by Carol Todzia, and confirmed through use of dissection scope.
- Virginia Snakeroot (*Endodeca serpentaria*): One observation of this plant was uploaded to INaturalist in October 2018. In July 2019 three stems were located in the same location, adjacent to creek trail, by Wild Basin staff and volunteers.

Invasive species management

Preserve and Travis County TNR staff, student interns, and volunteers continued to map, monitor for, and remove invasive, non-native species, such as Japanese honeysuckle (Lonicera japonica), Chinese Tallow (*Triadica sebifera*), Chinaberry (Melia azedarach), firethorn (*Pyracantha coccinea*), Japanese privet (Ligustrum japonicum), Chinese privet (*Ligustrum sinense*), nandina (*Nandina domestica*), King Ranch bluestem (*Bothriochloa ischaemum*), Johnson grass (*Sorghum halepense*), chaste-tree (*Vitex agnus-castus*), bastard cabbage (*Rapistrum rugosum*), and giant cane (*Arundo donax*), among others. Between October 2018 and September 2019, Wild Basin and Travis County TNR staff and volunteers removed 2,220 stems of invasive plants in this reporting cycle. Between 2016 and 2019, 3,285 invasive plant species have been removed from Wild Basin through these efforts. Staff dedicated 58 hours and volunteers dedicated 130 hours for a total of 188 hours working on invasive species management for a total of 188 hours.

Invasive species are regularly mapped and monitored using the iNaturalist platform. Management efforts are also now recorded in the GIS “Collector” app in cooperation with Travis County TNR. This year a large population of Beggar’s ticks (*Torilis arvensis*) were removed on the north side of the parking lot between the trailhead and security shed. Invasive species control measures at Wild Basin involve manual

removal of plants by invasive species crews (Appendix C). In addition, in collaboration with Travis County TNR personnel, we use a either a “cut and paint” method or “girdle and treat” method utilizing Garlon herbicide. These treatments are used on plants too large to be removed manually or with a Weed Wrench (generally plants greater than 2.5” diameter). Chemical treatments are performed under supervision of Julie Murray, Travis County BCP Natural Resource Specialist, a licensed applicator through Texas Department of Agriculture.

- Protection from browse pressure. Wild Basin staff maintained existing deer exclosures of hog wire cages around stands of young native trees and shrubs to prohibit excessive browse by deer and other animals.
- Fuel reduction. A project was coordinated by Travis County and the City of Westlake to cut fuel breaks along the southern border of Wild Basin in areas adjacent to residential areas. In FY 2017, 0.6 acres were treated Lake Travis Fire and Rescue near the preserve’s back gate. An additional 1.6 acres were treated along the southern perimeter bordering residential areas in FY2017 and FY2018. No treatments were needed in these areas during FY2019.
- Firewise guidelines of clearing debris and trimming back branches continue to be followed in the area immediately surrounding the visitors center.

Wildlife Management

Wildlife Management Activities

- Golden-cheeked Warbler. A total of 38 surveys were conducted at Wild Basin and Vireo Preserve between 12 March and 10 June by Darrell Hutchinson and Jim O’Donnell for a total of 108.5 survey hours. Between the two preserves, six separate males were detected during the breeding season. Four males paired, but only one of these nesting pairs reproduced successfully. Two males failed to find a mate and departed the plot. One of these males was detected only three times, and so is not considered territorial. Compared to recent years, plot density was a little higher, but reproductive success remains low. All six males are color-banded. One color-banded male was a return from previous years. All of the other five males were banded this year. Notably absent was NB/WH:MV/SI, also known as ‘Candy’. Candy was banded at Vireo Preserve in 2011 and returned every year to approximately the same territory for seven years in a row. For a full report see Appendix D.
- Feral Hogs (*Sus Scrofa*). No signs of the possible presence of feral hogs were observed within the reporting period. Wild Basin staff continue to monitor for any

signs and will communicate any observations or concerns to Travis County TNR personnel.

- As part of a project to study wildlife movement across Wild Basin boundaries, between September and November of 2017, 15 motion-triggered cameras were installed along the perimeter of Wild Basin in areas bordering residential areas and the Vireo Preserve. Wildlife images from the cameras have been utilized by one University of Texas undergraduate student in an assessment of wildlife movement. The cameras continue to be maintained, data is being collected and analyzed by Wild Basin staff, interns, and research students regularly, and currently two UT undergraduate students are working to expand the scope of the study through the placement of additional cameras at key wildlife movement points along the perimeter and into neighboring areas, including at Vireo Preserve.

Water Quality

Water Quality and Quantity Monitoring Activities

Water quality testing was conducted for ten of the months during the reporting period by Wild Basin staff (with assistance from student interns) using the Colorado River Watch Network water quality monitoring protocols. Several different parameters were tested, including pH, nitrates, turbidity, dissolved oxygen, specific conductance and E. coli. All data from water quality testing at Wild Basin can be found online at the CRWN website (https://crwn.lcra.org/events.aspx?qrySite=72).

Outreach, Education, and Volunteer Coordination

Wild Basin actively provides environmental educational opportunities and volunteer stewardship opportunities for the community. A total of 1,166 volunteer hours were logged at Wild Basin on a number of outreach-related activities, including trail maintenance and stewardship (described above), environmental education, and research. The major programs held at Wild Basin from October 1, 2018 to September 30, 2019 are summarized below.

Environmental Education and Interpretive Programs

- School Programs – Approximately 1,177 school-aged children, including students from local schools and community groups such as scouts, attended education programs at Wild Basin. Guided program group size is restricted to a maximum of approximately 40 students per day to control for impact on the preserve and ensure volunteer guides have manageable group sizes. In FY2019, approximately 16

trained volunteer guides donated an estimated 226 hours to assist with these education programs.

- Public Programs – Local children and adults (approximately 750 total) attended several public programs hosted by Wild Basin staff and volunteers, including monthly Second Saturday Guided Hikes, quarterly e-Bird surveys, four Artist in Residence events, specialty guided hikes and a day-long family event at Wild By Wild Basin, Earth Day Austin at Huston-Tillotson University, and the Mother Earth Day Festival at Barton Springs, among others.
- Artists in Residence – Wild Basin welcomed its second and third Artists in Residence in the fall of 2018 and spring of 2019, respectively. The Fall 2018 awardee was local artist Jamie McCormick, who is experienced in acrylic, gouache, and collages and works in paint and mixed media art. Her latest work involves building unique canvas through resist-dyeing and subsequently painting her interpretation of the dye's movement. Wild Basin visitors viewed and purchased McCormick's art at a reception in February. McCormick returned in June to host a nature art workshop for children ages 5-10 called *Finding Shapes in Nature*.

  Spring 2019 Artist in Residence and Texas State University School of Art and Design professor Bethany Johnson works mostly in the medium of drawing, intermingling the aesthetic approaches and media associated with landscape art traditions with data-oriented, informational components, such as seismic imaging, geologic surveys, and others. In May, Johnson guided 15 children ages 5-9 to look to nature for visual inspiration, and then use recycled materials (book and magazine clippings) for Earth-friendly art making to take home. In June, approximately 20 visitors attended a reception for Johnson as she concluded her successful artist residency at Wild Basin. The reception included a talk by the artist, refreshments, and art for sale.
- Educator Training – In September 2019 Wild Basin hosted a training for the national environmental education curriculum, Project WILD, in conjunction with Texas Parks and Wildlife, UT-Austin's Texas Memorial Museum, and the Austin ISD Science curriculum department. The Saturday workshop for educators at Wild Basin trained 12 Austin ISD educators with environmental education activities appropriate for PK-8th grade classrooms.
- Certified Interpretive Guide Training – Wild Basin hosted a National Association for Interpretation Certified Interpretive Guide (CIG) course for 8 professionals and informal educators from Texas and New Mexico, hosted by CIG Trainer Clark Hancock. The 32-hour course included: history, definition, and principles of

interpretation using tangible objects to connect audiences to intangible ideas and universal concepts in interpretive programs presentation and communication skills.

- Trail Stewardship Training: Central Texas Trail Tamers conducted a workshop entitled: Introduction to Trail Maintenance in April of 2019 at Wild Basin.

Environmental Education Resources for the Public

- Interpretive Visitor Center – Visiting groups and the general public have access to the Wild Basin Visitor Center on Monday-Friday, 9am-4pm, year-round excluding major holidays. Visitors can explore the educational exhibits, including projector microscopes to view natural science specimens, interactive bird calls and binoculars, as well as look up trail sightings using iNaturalist data on 2 touch screen monitors. Exhibits also include information on the Balcones Canyonlands Preserve and the protection of endangered species, and an interpretive slideshow of wildlife photos from a trail camera research project.
- Public Visitation – This year we continued to monitor two trail counters at the trailheads to estimate the number of visitors using the Wild Basin trail system. We assume that each individual is counted twice (arriving and leaving), so we total both counters together and divide by two for monthly visitation estimates. Due to malfunctioning trail counters that were taken out of service in July 2019, we also utilized head counts provided by our Wild Basin Security Guard. Estimates from the trail counters indicate Wild Basin welcomed approximately 37,727 visitors during the 2018-2019 fiscal year. Visitation rates were lowest in August 2019 (approximately 1342 visitors) and greatest in December 2018 (approximately 5586 visitors). An independent study of visitation rates in 2016 confirmed the accuracy of trail counter data have been found to be fairly accurate, although in this fiscal year both units became inoperable and high readings were common with at least one unit. New units were purchased and are in place for the upcoming fiscal year. Effort was made to look at any anomalies in daily visitation and, when found, were replaced by visitation data for the closest date corresponding to that day of the week in the prior year.

Community Science

- eBird quarterly walks – Wild Basin staff and volunteers coordinated quarterly bird walks for the public to participate in the community science program, eBird, run by the Cornell Lab of Ornithology and National Audubon Society. Three sections of Wild Basin's trail systems are included as separate survey locations (360 Trail Segment, Bee Creek Segment, and North Hollow Segment), and all birds seen or

heard during the quarterly walks were recorded in the eBird database. Twenty-seven bird species and 75 total birds were recorded during the 2018-2019 eBird walks, with over 19 volunteers contributing as participants. The eBird walk on September 28, 2019 was cancelled due to rain.

- iNaturalist – Students, volunteer natural resource stewards, and the public are encouraged to participate in the Wild Basin Biodiversity Project, a community science project on the iNaturalist platform (http://www.inaturalist.org/projects/wild-basin-biodiversity-project). This project allows users to submit observations of flora and fauna, supported by photos or sound recordings, using either their mobile device or desktop computer. The community of members on iNaturalist then helps to determine or confirm the identity of the animal or plant, and it becomes a valuable data point for our natural resource management efforts as well as broader scientific research. iNaturalist also allows users to view observations uploaded by other visitors to the preserve. A total of 1,111 observations documenting 426 species have been reported by students and visitors in the Wild Basin Biodiversity Project on iNaturalist.

Volunteer stewardship

- Volunteer Stewardship Workdays- Wild Basin provides opportunities for the public to volunteer and assist with land management activities, as well as learn about the BCP and conservation issues. Collectively, land management volunteers contributed approximately 446 hours from Oct 2018 to Sept 2019. This includes contributions from approximately 83 volunteers participating in Saturday workdays, corporate group stewardship events, and a dedicated small group of volunteers participating in weekly workdays. Specific stewardship events include the following:
    - Saturday Workdays – The Liberal Arts and Science Academy High School Honor Society is invited to participate in stewardship days at Wild Basin one Saturday per quarter. During the period from Oct 2017-Sept 2018, volunteers on Saturday workdays collectively contributed over 27 hours of service.
    - Thursday Volunteer Workday - A small group of dedicated Wild Basin volunteers participated in weekly land stewardship activities including trail pruning and protection, invasive plant removal, and pond repair. Collectively, Thursday volunteers contributed 184 of land stewardship hours.
    - Austin Association of Facilities and Maintenance Engineers (AAFAME) - Wild Basin has created a new relationship with a local professional volunteer organization, AAFAME. Volunteers help local non-profits by carrying

out projects that require professional and technical skills in engineering. On June 7th, twenty members of AAFAME contributed 80 hours to help Wild Basin rebuild one of our trash receptacle kiosks and began refurbishing the small building in our parking lot.

- Texas Conservation Corps - Wild Basin served as a host park in the "It's My Park Day" by the Austin Parks Foundation on March 3rd. We had over 20 volunteers contribute 60 hours cleaning drains that keep water off the trails and armoring a muddy section of the trail with large stones.

Public events, meetings, workshops, and conferences

- Wild Basin hosted a week long Wild by Wild Basin event between March 19 – March 23, 2019 culminating in a Family Fun Day with about 150 people in attendance. Events during the week included a Mindfulness Hike, Plant Walk, Bird Talk, and Guided Hike. Family Fun Day included nature-themed music, guided hikes, a wildlife photo booth, a photo contest, and activities for kids. Partners such as TreeFolks, City of Austin-Coyote Management, and Native Plant Society of Texas tabled at the event.
- Wild Basin participated in Earth Day ATX on April 27, 2019, the largest sustainability event in Central Texas. The event was held at Huston-Tillotson University and staff shared information about Wild Basin's effort in sustainability and conservation with about 100 attendees.
- Wild Basin tabled at a Texas Master Naturalist-Balcones Canyonland Chapter meeting on August 29, 2019 and shared volunteer opportunities with about 40 members in attendance.
- Wild Basin participated in the Mother Earth Day festival on September 13, 2019 at Zilker Park, a kid friendly event to raise awareness about the Barton Springs/Barton Creek watershed in Austin. Staff shared information and provided nature-themed activities for about 140 attendees.
- Wild Basin Preserve Manager/Research Coordinator, Niki Lake, gave a presentation on September 24, 2019 at St. Mary's University to 12 students whose interests ranged from GIS and fieldwork to water issues and sustainability. Lake talked about her job as a Preserve Manager and how it related to the students' interests.
- Recreational Equipment Incorporated – REI conducted 12 Star Walks in 2019.
- Tree Folks – Tree Folks held a class at Wild Basin for their 2019 Urban Forestry Steward training.

- Meetings of local organizations – Wild Basin hosted several group meetings for entities such as Hill Country Alliance, Capital Area Master Naturalist, Tree Folks, and Women Empowering Women in Nature (WeWIN).
- Meetings of businesses and government entities – Wild Basin hosted several group meetings for entities such as Adlucent, CMIT Solutions, Environmental Survey Consulting, International Society of Arboriculture-TX Chapter, National Association of Interpretation, Partners for Fish and Wildlife, Project WILD, and City of Austin – Watershed Protection Department.
- The Wild Basin Director, Dr. Barbara Dugelby, gave two invited public presentations about Wild Basin, both entitled "Wild Basin: A History of Important Research and the Preserve's Relevance to Austin and the Hill Country".
    - The University of Texas at Austin Osher Lifelong Learning Institute (UT OLLI); University of Texas, October 27, 2018, and
    - The Balcones Chapter of the Master Naturalist Program, Concordia University, November 7, 2018.

St. Edward's University Events

- Staff Retreats and Meetings - Various departments and school groups from SEU scheduled their planning and staff retreats at Wild Basin including, School of Arts and Humanities, Campus Ministry, School of Natural Sciences, Admissions, and Student Services.
- Freshmen Accelerated Research Methods Workshop (FARM)-On August 19, 2019, Preserve Manager/Research Coordinator, Niki Lake, led a workshop for 10 incoming freshmen where they learned research tools and methodologies in preparation for college research and careers in science. Students learned about invasive plant species and used the community science application, iNaturalist, to read about current invasive plant projects for research ideas.
- Biology 1107 - Cells, Genetics, and Organ Systems and Biology 1108 – Populations and Organisms - The introductory biology labs incorporated a course-based undergraduate research experience (CURE) that allowed students to participate in hands-on research. Approximately 108 116 students participated in a project to collect water samples and evaluate water quality parameters in Bee Creek.
- MAC 6353 Graduate Group Counseling Course (visited 10/25/18 - William McHenry)
- BIOL 3139 Microbiology Lab (visited 3/6/19 - Patricia Baynham)
- BIOL 1310A Contemporary Biology - held Class (Judy Walther)

- BIOL 1310 Environmental Biology and Society for Non-Majors (visited 9/10/19 - Robert Edwards)
- Student research presentations – student researchers presented their work on Wild Basin-related research projects at the following symposiums and conferences:
    - "Fitness response of *Asclepias asperula*, antelope horns milkweed, with the inoculation of arbuscular mycorrhizal fungi" by Rebecca Woodard, Texas Society of Ecological Restoration Annual Meeting, November 10, 2018.
    - "Changes in plant and animal diversity and movement in response to shaded fuel break fire mitigation" by Jonathon Brooks, Michael Gembarowski, Conlon McOsker, and Madison Tumicki, Texas Society of Ecological Restoration Annual Meeting, November 10, 2018.
    - "Travis County stream assessment: macroinvertebrate indices in response to urbanization" by Patrick Kelleher, 2018 MSEM Graduate Student Research Symposium, St. Edward's University, December 6, 2018.
    - "Fitness response *of Asclepias asperula*, antelope horns milkweed, to the inoculation of arbuscular mycorrhizal fungi in the Balcones Canyonlands Preserve, Austin, TX" by Rebecca Woodward, 2018 MSEM Graduate Student Research Symposium, St. Edward's University, December 6, 2018.
    - "Evaluation of ecosystem function of a 30-year old dump site at Wild Basin Preserve in Austin, TX" by Adriana Lee, 2018 MSEM Graduate Student Research Symposium, St. Edward's University, December 6, 2018.
    - "Impact of human foot traffic on native mammal use of trails in an urban preserve" by Paul Finch, Barbara Dugelby, PhD, St. Edward's University School of Natural Sciences Lucian Symposium, September 27, 2019.
    - "Using Water and Adjacent Soil Reservoirs of Microbials to Characterize Antibiotic Resistance Impacted by Urbanization", by Taylor Kelley, Annual Biomedical Research Conference for Minority Students (ABRCMS) in Anaheim, California (Best Presentation Award), November 2019
- Wild Basin Internship Program – Wild Basin provided internships for 10 students. This includes internships in Land Management, Sustainability, Environmental Education, and Outreach/Public Relations. Projects included water quality testing, invasive species removal, trail maintenance, monitoring animal behavior with camera systems, butterfly garden maintenance, tabling events, and trail patrol.
- St. Edward's University events – Wild Basin staff provided resources and community outreach at several SEU events on campus such as the Fall 2019 Student Involvement Fair, Fall 2018 and Spring 2019 Internship Fairs, Earth Day

Fair, Fall 2019 Outdoor Fest with the Outdoor Adventure Student Organization, the Fall 2019 Nonprofit and Volunteer Fair and a Pop Up in the School of Natural Sciences on September 11, 2019. A total of about 76 students signed up to the email list for more information.

- Courses – A list of undergraduate and graduate courses that incorporated Wild Basin into their curricula in Fall 2018 and Spring 2019 is included in Table 1. Approximately 174 university students visited Wild Basin as part of their course work in 2018-2019.

Table 1. Undergraduate & graduate classes taught at Wild Basin in 2018-2019.

Course #	**Title**	**# of Students**	**Semester**
BIOL 1310A	Contemporary Biology	12	Spring 2019
BIOL 1107	Cells, Genetics, and Organ Systems Lab	48	Fall 2018
BIOL 1108	Populations and Organisms	96	Spring 2019
BIOL 3139	Microbiology Lab	17	Spring 2019
BIOL 1310	Environmental Biology and Society for Non-Majors	15	Fall 2019
MAC 6353	Graduate Group Counseling	14	Fall 2018
	TOTAL	**202 students**	**6 classes**

Publications

- Wild Basin staff and interns reported on Wild Basin news, events, and volunteers in three email newsletters, as well as updates in regular blog posts and social media outlets.
- An article titled, “How to Explore the Best that Austin, Texas Has to Offer” recommending Wild Basin as a place for hiking was published on USA Today https://www.10best.com/interests/explore/how-to-explore-best-austin-texas-has-to-offer/
- An article titled, “Austin City Limitless: Andy Roddick’s Guide to Austin, TX” recommending Wild Basin as a place to hike by the former tennis player, was published on Golf.com https://www.golf.com/travel/2019/03/26/andy-roddick-guide-austin-texas/

Scientific Research

Eleven research projects received Scientific Research Permits and 6 academic courses received education permits from Travis County and completed work at Wild Basin in 2018-2019. Short summaries of all permitted projects are included below.

(1) Anderson, C. Aural Anuran Survey of Bee Creek at Wild Basin Wilderness Preserve

Project Description: The goal of this project is to inventory the frog and toad species of Wild Basin by performing manual calling surveys at several sites along Bee Creek. This study will create a replicable framework for routine monitoring of the Wild Basin frog and toad community in the future. We plan to survey up to five sites along Bee Creek following AZA FrogWatch standard procedures and record calls using an iPhone with an enhanced microphone approximately two nights per week from May 24 – July 31, and again between mid-August and Oct. 31. No more than four people will be going off trail on any one night for this purpose.

Progress Report: The anuran species recorded during this study to date are: *Acris crepitans, Bufo debilis., Bufo nebulifer, Bufo punctatus, Eleutherodactylus cystignathoides, Eleutherodactylus marnockii, Hyla chrysoscelis/versicolor, Pseudacris clarckii,* and *Rana berlandieri.* Based on an initial analysis, the anuran community at Wild Basin appears to be dominated by *A. crepitans* and *R. berlandieri*. Both species were present during nearly every survey event, except for the surveys conducted in the fall, and *A. crepitans* was recorded calling at the highest intensities. Conversely, *P. clarckii* and *E. cystignathoides* were only present in the September 15 survey. For a full report see Appendix E.

(2) Dugelby, B. Bivens, G., and Finch, P. Documenting spatial and temporal patterns in wildlife distribution across Wild Basin.

This permitted research had two components: (a) Documenting wildlife distribution and movement patterns along and through Wild Basin boundaries and (b) Study of the impact of human foot traffic on native mammal use of trails in an urban preserve.

(a) Documenting wildlife distribution and movement patterns along and through Wild Basin boundaries

Project Description This study will employ approximately 15 motion-triggered wildlife cameras to document wildlife species and their activity patterns across the Wild Basin landscape. Cameras will be set up either on a sample grid of points spaced approximately 250m apart from each other or along Wild Basin boundaries. For a full progress report see Appendix F.

(b) Study of the impact of human foot traffic on native mammal use of trails in an urban preserve.

Project Description: This study will examine the effect of human activity on wildlife use of preserve trails using 13 – 16 motion-triggered wildlife cameras. We aim to evaluate the impact of human relative activity (HRA) on wildlife relative activity (WRA) at different locations along the trail network at Wild Basin.

Progress Report: Motion-sensing cameras were placed throughout the trail network and image data was gathered for an 8-week period in June and July. We found high human relative activity across all camera stations, although declining with distance from Visitor Center, and increasing wildlife relative activity further from the trailhead. A total of 771 trap days were collected from the 13 camera stations during the sampling period. Of 1093 images, humans were the most detected species overall. Coyote were the most frequently captured large mammal species, followed by fox the white tailed deer. Squirrels were the most frequently detected small mammals represented in the study. See Appendix G for the full report.

(3) Brooks, J., Gembarowski, M., McOsker, C., and Tumicki, M. Impacts of fuel mitigation treatments on plant and animal diversity and abundance

Abstract: Perennial fuel build-up in U.S. forests due to fire suppression, along with increased drought and lengthened fire seasons have led to increased occurrences of large, high-severity wildfires. Meanwhile, a greater number of people are living in the Wildland-Urban Interface (WUI) adjacent to fire-prone wilderness. The number of people affected has heightened awareness for the need of fire hazard reduction treatments. Shaded fuel breaks are used extensively throughout the Texas Hill Country including in the Balcones Canyonland Preserve (BCP) system which provides habitat for multiple endangered species, yet little research has been conducted on their impacts to plants and wildlife in these locations. Using before-after-control-impact (BACI) experimental design we analyzed a shaded fuel break treatment taking place at Wild Basin Wilderness Preserve within the BCP to determine 1) whether the shaded fuel break treatment impacts the diversity and abundance of wildlife in the mitigated areas, and 2) whether it impacts plant diversity and abundance, specifically, if mitigation treatment favors the regrowth of non-native plant species over native species. Data collected in the month after treatment showed decreased plant diversity and an average increase in animal diversity and use in mitigated areas, however no results were significant. Continued monitoring of the plots is recommended. Long-term results could assist decision makers and land managers in crafting and carrying out fire mitigation policies concerning similar cases in the future. For a full report see Appendix H.

(4) Grove, E. The Effects of Urbanization on Austin's Wildlife: Comparing Species Abundance & Richness in Invasive Forests vs. Mixed Forests Using Camera Traps

Project Description: During the Fall Semester of 2018, I advised a graduate student, Elayna Grove, in her research project studying wildlife movement and abundance in urban parks around Austin, TX, using camera traps. Her goals were to determine (1) which mammal species are using urban parks compared to species that are known to be present in the region (e.g., what are the effects of urbanization?), and (2) whether there was a difference in species richness or abundance in parks dominated by the invasive privet tree compared to mixed forests with some invasive plants but whose overstories were dominated by native Texas trees. We deployed camera traps for one month in the Fall of 2018 at 6 locations: 3 invasive and 3 mixed forests in and around Austin, TX. Each camera was placed in along a use path or obvious location where mammals were likely to walk and a lure was placed opposite the trap with the goal of capturing maximum number of species and individuals using the area. Elayna's results are described more thoroughly in her final report (attached), and summarized below.

Progress Report: The student completed her research project in December 2018 and her final report is attached. Currently, there is no work being done on this project. However, this work compliments the existing on-going project that I am involved with, the Austin Urban Wildlife Information Network. I would like to pursue Elayna's research question further with students who have experience with GIS and can integrate connectivity and park size into the calculations, which would increase the utility of our findings.

Preliminary or Final Results: A total of 9 mammal species were captured in the traps from Oct-Nov 2018, 8 of which appeared in both the invasive and mixed forests. These included: armadillo, coyote, fox, possum, rabbit, raccoon, squirrel, and white-tailed deer. Of these, the rabbit was only seen in the invasive forest, but the rest were seen at both types of sites. The average species richness and average number of individuals observed were both higher in the invasive forest than mixed, but there was a lot of variability between parks and the differences were unlikely to be significant. We had predicted that invasive-dominated forests would harbor reduced diversity, since habitat would be altered and food or other resources that native mammals depend on might be missing from these novel ecosystems. Surprisingly, we found no difference in the two forest types. This study was limited in that the sample size was small and we did not account for differences in size or connectivity between parks.

Still, our finding, that privet forests supported the same number and diversity of wildlife as mixed forest suggests that many of the species that can persist in Austin's urbanized environments are generalist species that are not dependent on native forest cover, but rather, they can live in any kind of forest.

(5) Guenther, A., Nagalingam, S., Ortega,J. Next steps for improving Texas biogenic VOC emission estimates

Project Description: Conducted field measurements of isoprene, monoterpene and sesquiterpene emission factors of important eastern Texas plant species and investigate the variability within and among species and vegetation types. Also investigated sensitivity of updated biogenic emissions estimated for Texas and surrounding regions. During several days in June 2019, measurements were made on foliage of trees near edge of Wild Basin Research Center parking lot. Biogenic volatile organic compound (BVOC: e.g., isoprene, monoterpene and sesquiterpene) emission factors were measured using enclosure techniques. We deployed a three-person field team to operate two BVOC emission factor measurement systems. The enclosure systems are custom built BVOC measurement system designed to minimize leaf disturbance and constructed of inert materials coupled with a pump to collect solid absorbent samples that were shipped to our Irvine CA lab for BVOC analysis by Gas Chromatography with Time-Of-Flight Mass Spectrometry and Flame Ionization Detector (GC-TOFMS/FID).

Summary of Final Results

The overall goal of this project was to improve numerical model predictions of regional ozone and aerosol distributions in Texas by reducing uncertainties associated with quantitative estimates of biogenic VOC and NO emissions from Texas and the surrounding region. We improve the capability of the Model of Emissions of Gases and Aerosols from Nature (MEGAN, Guenther et al., 2012) framework to estimate emissions of these compounds. This was accomplished by conducting measurements of isoprene, monoterpene and sesquiterpene emission factors at eastern Texas field sites including at the Wild Basin Research Center and integrating these results, and those from other studies, into MEGAN.

Specific conclusions include the following

- Multi-modal enclosure (isoprene-only, speciated terpenoids, comprehensive BVOC) measurement approach can effectively maximize regional characterization of a broad range of vegetation and chemical species.
- Eight-eight terpenoid compounds were emitted from 20 Texas trees. These compounds are mostly monoterpenes and sesquiterpenes but include some aromatic monoterpenes, oxygenated monoterpenes and sesquiterpenes, a homoterpene and a diteprene.
- The dominant Texas monoterpene is a-pinene and dominant Texas sesquiterpenes include b-caryophyllene, a-humulene and d-cadinene.

(6) Kelleher, P. Travis County Stream Assessment: Macroinvertebrate Indices and Water Composition Comparison

Project Description: Urbanization and human impact are rapidly increasing in Travis County which lies in a critical recharge zone for the Edwards Aquifer, home to sensitive and endangered species. Research is urgently needed on how these changes are affecting water quality. Macroinvertebrate community assemblages are commonly used to measure water quality because they consist of a variety of species and life cycles that are receptive to changes in the environment. Many species are sensitive to habitat degradation and have been found to respond to a range of urbanization effects on stream quality. This study determined the stream bed stability of four streams in Travis County measuring the biotic indices used to classify the degree of pollution in the aquatic systems and using water quality tests for common pollutants. We hypothesized that benthic diversity and abundance of sensitive species (biotic indices) would be greater where water quality was higher. We also hypothesized that water quality would be lower in more urban areas such as streams that enter the lake through downtown Austin. We calculated species richness and Shannon diversity index for each sample site and evaluated the distribution and density of pollutant tolerant or intolerant species by running an EPT analysis. The EPT Index is named for three orders of aquatic insects that are common in the benthic macroinvertebrate community: Ephemeroptera, Plecoptera, and Trichoptera, and higher numbers are associated with higher water quality. Bank vegetation was measured using linear transects and GIS was used to calculate canopy cover and impervious coverage around streams.

Progress Report: This research was completed in December 2018 and currently, there is no work being done on this project. Findings are summarized below and the final report is attached.

Preliminary or Final Results: EPT was significantly lower where the percent impervious coverage was highest, and higher with an increase of bank vegetation. Likewise, species richness and Shannon diversity were positively related to bank vegetation and negatively related to impervious coverage percent. We found no significant differences in water quality indicators of lead, heavy metals (Pb, Fe, Cu), bacteria, pesticides, alkalinity, pH, hardness, chlorine, nitrates and nitrites or DO between the sites. Significantly, we found an apparent threshold for impervious coverage of 10%, above which EPT scores were low suggesting low water quality. This is in agreement with previous research in other cities, which found similar results. Based on this, we recommend that impervious coverage should be minimized to less than10% around streams that connect to critical recharge zones to protect aquatic biota and water quality.

(7) Kelley, T. Using Water and Adjacent Soil Reservoirs of Microbials to Characterize Antibiotic Resistance Impacted by Urbanization

Project Description: Antibiotic resistance is an increasing issue in our society that has the potential to alter how we utilize antibiotics to combat bacterial infections. The goal of this study was to analyze stream and soil reservoirs of microbials for antibiotic resistance within Wild Basin Wilderness Preserve. Analyzing antibiotic resistance within an urban area can aid our understanding of the effect of urbanization on the spread of antibiotic resistance.

Summary of Results:

Through the use of culture based-methods and molecular analysis, stream and soil samples were characterized for antibiotic resistance. Samples were collected upstream and downstream of Bee Creek within Wild Basin Wilderness Preserve. Serial dilutions were conducted and then plated on selected and non-selective media types. Samples were plated on 25% Tryptic Soy agar to promote the growth of all bacteria. Samples were also plated on MacConkey agar, which selects for gram-negative bacteria. Plates were incubated for 72 hours at 27 degrees Celsius. Colony-forming units were conducted to quantify total microbial cells present in the sample. Colony counts between 30-300 were deemed free of methodological error. Polymerase chain reaction (PCR) was used to characterize samples for multidrug

resistance. Primers were used to detect the presence of vanA and tetA resistance genes. Samples were loaded into a 1% agarose gel with 1x TAE buffer and analyzed through gel electrophoresis. The gel was imaged using Chemidoc.

Tetracycline resistance was not found in stream samples upstream or downstream of Bee Creek within the preserve. Resistance to tetracycline was observed in stream sediment, adjacent, and reference soil. Vancomycin resistance was observed in stream and adjacent soil samples collected upstream of Bee Creek within the preserve. Complete analysis of vancomycin resistance could not be completed due to time limitations. PCR amplification showed colonies from adjacent soil samples that were resistant to tetracycline on MacConkey agar also had resistance to vancomycin. Further research will be conducted to characterize multi-antibiotic resistance within samples.

(8) Lee, A. Evaluation of ecosystem function of a 30-year old dumpsite in Wild Basin Wilderness Preserve

Project Description: The Wild Basin Wilderness Preserve, outside of Austin, Texas is a vast area and home to a diverse array of plants and animals, including several endangered species. In the 1920s this area was a privately-owned ranch contracted by the city of Austin to dispose of the city's glass, metal, and plastic waste. The ranch owner had an area at the back corner of his property where he burned trash and then placed it into a manmade ravine. The dump decommissioned in the late 1940s and was purchased in the 70s by a women's group *Now or Never* jointly with the City of Austin to be turned into a preserve. It was then found that the area of the dump backed up to a creek which runs directly into Bee Creek and then enters the sensitive recharge zone of the Edwards Aquifer. Remediation of the site became a major concern.

In an effort to rehabilitate portions of the dumpsite of greatest concern, *Environmental Survey Consultants* completed a series of experimental plantings, including attempts to regenerate native forest communities using an active restoration approach that included seeding and planting native species. Other areas of the dump were passively restored; the company placed a layer of dirt over the garbage in an effort to help the area regenerate on its own. Since the entire dump was not actively restored it provided a good opportunity to test the effectiveness of restoration approaches: passive versus active.

Previous work at this site found that there was an increase in woody vegetation and diversity due to the restoration. However, ecosystem function is not always directly correlated to composition and diversity of the plant community, and we were interested in also determining how these treatments affected functioning of the forest. We compared ecosystem structure and function of this 30-year old dumpsite based on restoration approach (passive vs active) to the native undisturbed forest. We hypothesized that the actively restored site would match the native site in function, whereas the passively restored site will not. However, 30 years had already passed since the initial treatments, so we could not rule out the possibility that function had been fully restored at both the actively and passively restored sites.

Progress Report: This research was completed in December 2018 and currently, there is no work being done on this project. Findings are summarized below and the final report is attached.

Preliminary Results: All three sites were dominated by Ashe juniper, and there was no significant difference in canopy cover by site. Species richness in the understory did not differ by site, but abundance of cover was highest in the undisturbed forest and about equal in the passive and actively restored sites. Similarly, the ecosystem function metrics that we compared differed between the undisturbed forest and the restored forest, but not by restoration technique. Decomposition rate and productivity were highest in the undisturbed forest and similar in restored sites. Temperature, moisture and pH were measured to determine whether they impacted decomposition and productivity differently based on site, but we did not find significant differences in these variables by restoration treatments. These results suggest that full restoration of ecosystem structure and function may take longer than 30 years. However, the restored sites seem to be close to their original composition and function. The active restoration site was adjacent to the passive site and seed sources from the plantings may have helped supplement seed rain from the native forest, moving the passive restoration along more quickly. Full report available in Appendix I.

(9) Todzia, C. Updated Checklist of the Vascular Plants of Wild Basin Preserve

Summary: The most recent accounting of the vascular plants of Wild Basin is by Bill Carr (1996). This list of 455 species is a compilation of the plant lists previously undertaken at Wild Basin (Muzos, 1986; Walther, 1985; Williams, 1977). No actual field work at Wild Basin was conducted specifically for this checklist. Anecdotal observations indicate that the list is not complete (Bill Carr, pers comm). The goal of

this study is to update this checklist compiled 23 years ago, voucher uncommon species, and put information in database format which will be Web accessible.

Progress: Wild Basin Preserve was visited on approximately 24 days between April and November. For most of these visits Terri Siegenthaler, Wild Basin botanical and geographic expert, graciously assisted. Plants were identified using Flora of North Central Texas by Diggs, Lipscomb and O'Kennon, Flora North America, and the USDA Plants database.

Results: One hundred and twenty species have been verified on the Wild Basin plant list. Six species are added: Cheilanthes horridula, Salvia engelmanii, Tragia brevispica, Asclepias viridiflora, Campsis radicans and Ruellia caerula. The latter two are used in the nursery trade and may be non-native to Wild Basin. Additionally, the Wild Basin plant list (a Word document) has been transferred into an Excel spreadsheet. This Excel file will be delivered to Wild Basin before the end of the year.

(10) Walther, J. Field Biology Class for New College, St. Edward's University

Summary: The spring 2019 Contemporary Biology class had a total of sixteen students, four New College students and twelve traditional students. The class topics included topographic maps, geology, plant identification, habitat restoration, riparian habitat and endangered species. During the three-hour hikes, students worked on field handouts to map locations, find and identify fossils and rock types, used a dichotomous key for plant identification, collect and identify aquatic insects, mapped the Bee Creek drainage basin, and observed and listened to the golden-cheeked warbler and its habitat. Students wrote essays about each hike's topic, wrote wondering questions generated from their reading assignments and took short quizzes. Their last assignment was to hike alone and answer questions during their solo hikes. Students expressed positive reactions to their hikes and what they learned. For many of the students this class represents a first true nature study opportunity. Course evaluations and final papers indicate that many of the students believe the course will have a lasting impact on their outlook for and appreciation of wild nature.

(11) Schwarz Taylor, E. Course based undergraduate research experience within an introductory biology course (BIOL 1107) at St. Edward's University

Summary:

Sampling structure: During the Spring 2019 semester, the course BIOL 1108 at St. Edward's University had approximately 70 students conducting research at Wild

Basin. Three different sections of BIOL1108, each with approximately 23 students, completed sampling at 3 different sites of Bee Creek: 1) upstream of the waterfall, the closest point at Bee Creek to the Highway 360 Bridge while staying on trail, 2) midstream near the intersection of Creek Trail and the path to the Scenic View, and 3) downstream where Creek Trail intersects the creek at the furthest distance south and east. Students quantified periphyton biomass, macroinvertebrate diversity, and coliform concentration. This data was made available to all of the students enrolled in BIOL 1108, so that they could compare sites across Austin to obtain a better understanding of how land use and other factors may affect stream quality.

Coliform sampling: The data for the coliforms were not conclusive as the students faced the issue of contamination and inconsistent colony counting technique.

Macroinvertebrate sampling: Students collected macroinvertebrates using the kick and sweep method which utilizes a kick screen to collect individuals. The students brought the samples back to the lab and anesthetized and preserved the animals in 70% ethanol and then identified the individuals. Students were required to identify the organisms to family and then calculate % EPT, which is the percent of families identified that belong to the orders: Ephemeroptera, Plecoptera, and Trichoptera. These organisms are more sensitive to pollution so serve as bio-indicators.

Facilities and Signs

Facilities

- Wild Basin's parking lot was paved in March of 2019 courtesy of Travis County TNR. In addition, a fire lane was designated and striped (yellow) for parking and turnaround of emergency vehicles.
- The building's security system is currently monitored by ADT.
- We have been actively working on rodent control in the building using live traps.
- Compost toilets are being maintained with wood shavings. St. Edward's University replaced one urinal on the Clivus composting toilets and replaced the associated drain line.
- A wireless keypad for the automatic entry/exit gate system was purchased and installed.
- Dark sky compliant lighting was installed on the exterior of the Visitor Center.
- Urinal in men's Clivus restroom was replaced.

- Additional surveillance cameras were installed in parking lot - Currently there are 5 cameras around the parking lot/trailhead, one at the Visitor Center, and two surveillance video cameras on the Security shed.
- Two evaporative toilet units were purchased through a grant awarded by REI. These toilets will eventually replace the current portalet unit located in the parking lot once a final location is determined and a building to house the units is constructed.

Signs and maps

- Currently, we have two versions of digital maps available on the website homepage (www.wildbasin.org) for visitors to access on their smartphones, including a Google Earth file for the trail system and a PDF copy of the trail map. We also have other resources available on the website, including interpretive information and resources for specific age groups. Paper maps are still available inside the Visitors Center, and a weather-resistant map of the trail system is mounted at each trailhead.
- "No Parking" signs were installed by Travis County TNR around parking lot. "Fire Lane signs were installed in the area designated for emergency vehicle parking and/or turnaround.
- Numerous signs around the parking lot and trailheads were manufactured this year courtesy of funding provided by Travis County. A full list of these signs can be found in Appendix J. Installation of signs is approximately 75% complete.
- The Wild Basin directional signs located along Loop 360 were replaced by TXDOT. Travis County manufactured the signs, TXDOT installed them, and Wild Basin will be responsible for maintenance of these signs.
- "No Parking" signs were installed along Loop 360 by TXDOT to discourage vendors along the western boundary as well as visitors wishing to park along 360 to access the preserve.

Security, Access, and Safety

Emergency Preparedness

Wild Basin staff continued to improve the Wild Basin Wilderness Preserve (Wild Basin) Emergency Response Plan (ERP) developed with St. Edward's University Campus Safety personnel. This plan describes how staff, student interns, and volunteers respond to emergencies, addresses various types of hazards and establishes policies, responsibilities and operations designed to effectively and efficiently address an incident. Wild Basin personnel developed this ERP in collaboration with the Director

of Campus Resilience and the current draft reviewed by the Director this year. This plan outlines the roles and responsibilities of identified parties and as well as the training and exercises that will be conducted on a regular basis. All staff and volunteers who work at Wild Basin have access to a copy of the ERP. It is located in the "Wild Basin Share" directory of the SEU online file hosting service "Box", filed under "***Safety Resources and Emergency Response Plan.***" Additionally, a hard copy of this ERP is stored in a labeled binder located under the hutch on the front desk of the Wild Basin Creative Research Center.

Security

- As of January 14, 2019 Wild Basin has a security officer onsite 5 days per week. This officer is provided by Travis County in response to security and integrity issues such as vandalism, car break-ins, and visitors bringing dogs into the Preserve.
- This security guard has been extremely helpful, but Wild Basin continues to face many of the same issues when the guard is off duty. Surveillance cameras and incidental observations show dogs on trails when staff or security are offsite or off work. Additionally, there was a car break-in during fall, 2019, on an afternoon when the officer was not on duty.
- Five game cameras and 2 surveillance video cameras are located between the entrance of the preserve and at the trailheads.
- There is an automated gate at the preserve entrance timed to open at first light and close at sunset. The gate is equipped with a sensor that will open the gate arms when people leave the preserve after hours. Gate and trail cameras have captured a number of images of visitors on trails and in the parking area after hours. To minimize unauthorized activities after hours Wild Basin is planning to install a mechanisms and signage that will allow the gate to stay locked after dark, with visitors being advised to call the Travis County Sheriff's Office to be let out of the preserve.

Training

- Armed Intruder
- Wilderness First Aid certification and Wilderness First Responder recertification of Wild Basin Staff
- Reviews of sections of the ERP and medical response scenarios during staff meetings.
- Testing of emergency equipment such as radios, weather station, etc.

Fire Safety and Preparedness

In August, 2018, Wild Basin and St. Edward's University Campus Safety personnel met with personnel from the Westlake Fire Department and Travis County to discuss wildfire preparedness and response strategies. WFD personnel gave an overview of the potential for wildfire and explained their potential response time and approaches to different wildfire scenarios. At the meeting, Travis County and Wild Basin personnel agreed to share GPS coordinates of key trails and points of interest at Wild Basin for rescue personnel to use in the future in responding to 911 calls. In 2018-2019, Wild Basin staff continued to improve upon the fire management section of the ERP.

- Koetter Fire Protection in coordination with St. Edwards university staff completed their annual inspection of the Visitor Center in July 2019. All extinguishers were functioning properly and the holding tank was drained and refilled.
- Wild Basin trimmed brush back from building as per fire-wise recommendations. Wild Basin continues to work to complete Westlake FD fire management recommendations.
- Wild Basin held one fire extinguisher review session and one fire drill during this reporting year.

APPENDICES

Appendix A: Map of Wild Basin Wilderness Preserve Trail System

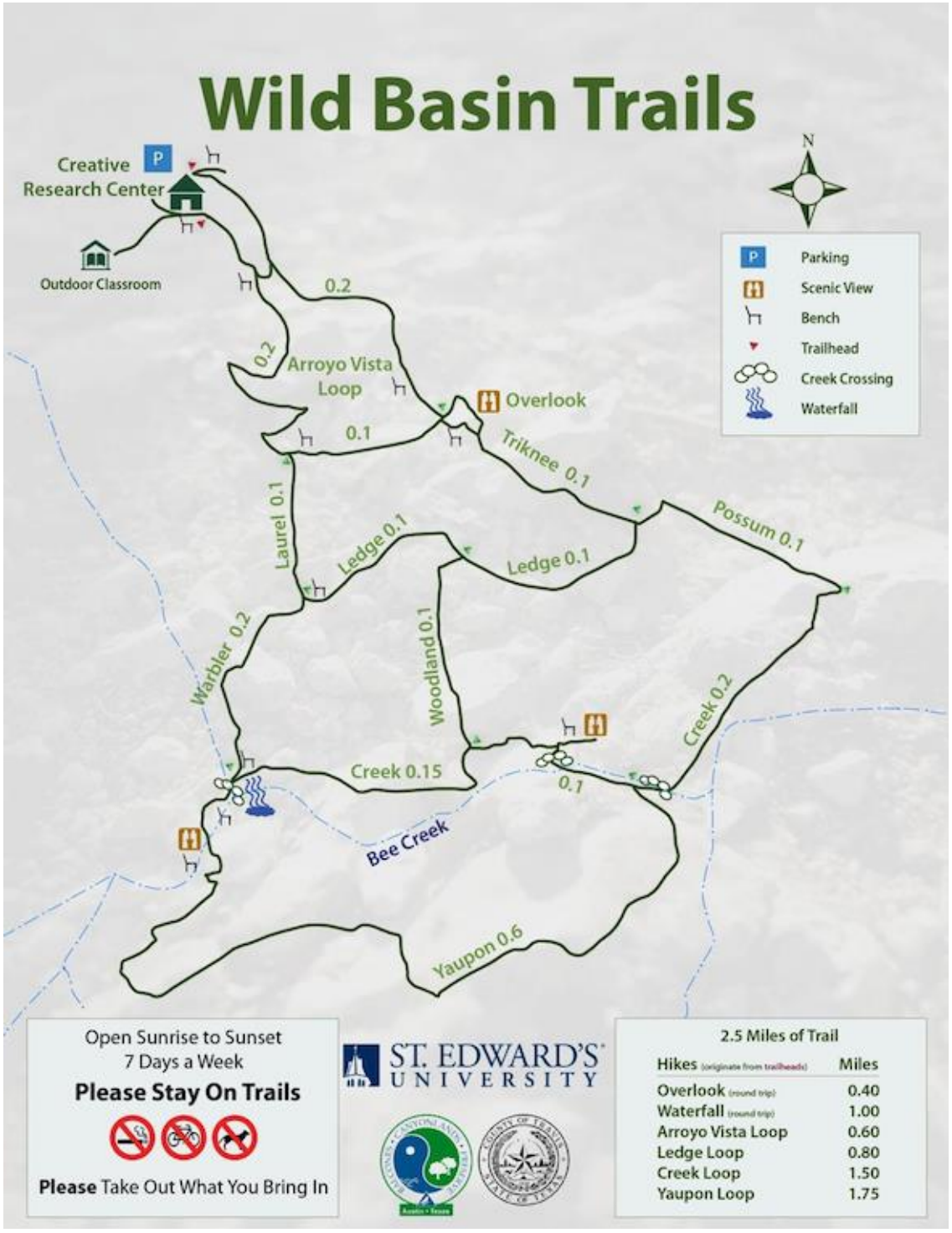


Figure 1. Map of Wild Basin Wilderness Preserve Trail System

Appendix B: Aerial Map of Wild Basin and Residential Neighbors



Figure 2. Aerial Map of Wild Basin and Residential Neighbors

Appendix C: Invasive species removal work at Wild Basin Oct 2018-Sept 2019 and impacts 2016 - 2019

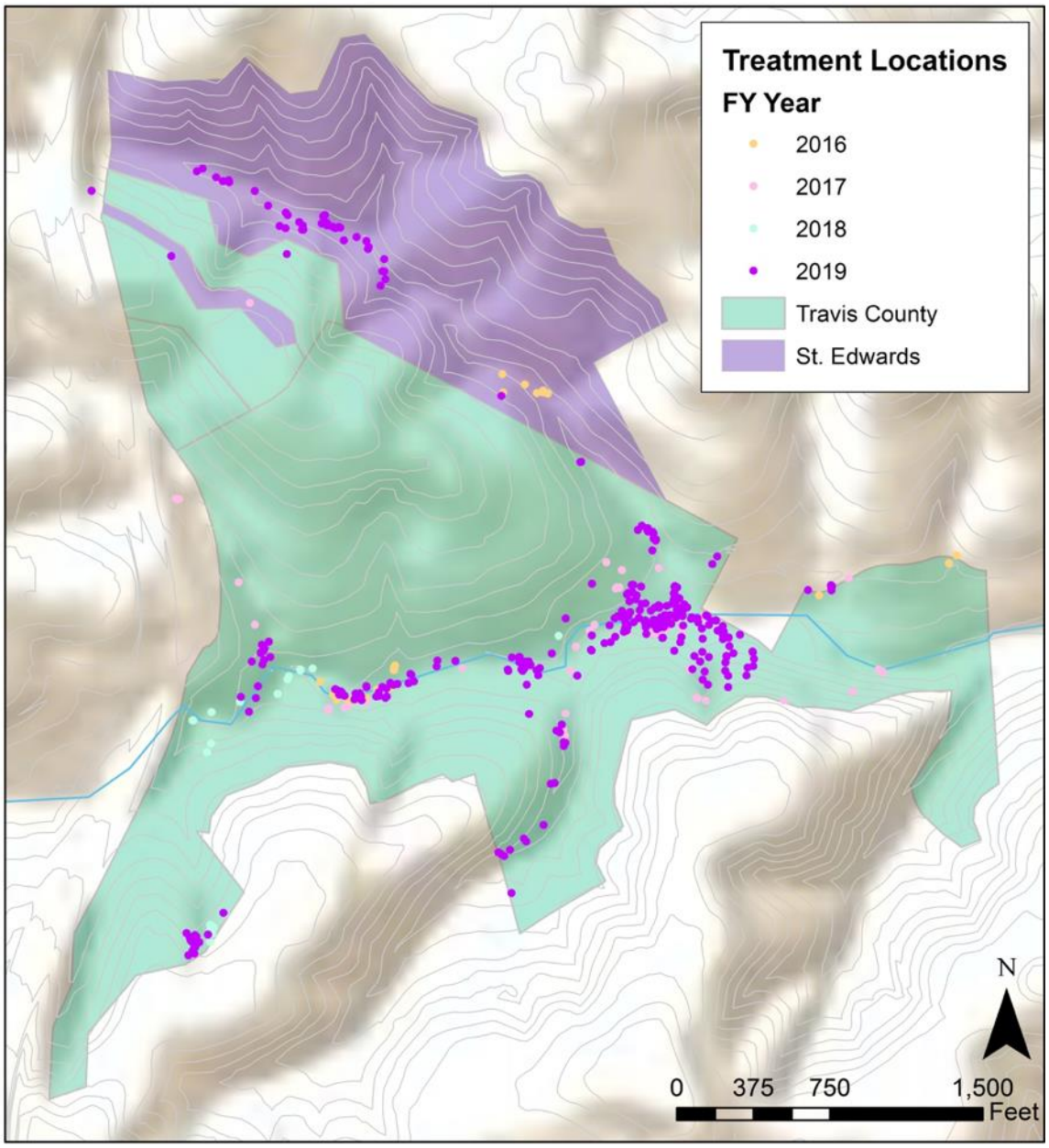


Figure 3. Locations of invasive species removal at Wild Basin Oct 2018-Sept 2019 (*map and data courtesy of Julie Murray, Travis County BCP*)

Table 2. Hours dedicated to invasive species control Oct 2018 – Sept 2019

Date	Tract	NNP Plot	Loc.	Staff	Hrs	# Staff	# Vol.	Staff Hrs	Vol. Hrs	Total Hrs
2/27/19	WB	W03	Bee Creek	JM	6.5	1	11	6.5	71.5	78
1/30/19	WB	W03	Moats bound.	JM	8.5	1	5	8.5	42.5	51
4/18/19	WB	W02	Bee Creek	JM	3	1	2	3	6	9
1/14/19	WB	W03	Near Moats	JM	1.5	1		1.5	0	1.5
9/24/19	WB	W03	Long Hollow	JM, KM, NL	2.5	3		7.5	0	7.5
2/21/19	WB	W01	Long Hollow Draw	JM	2	1		2	0	2
1/17/19	WB	W03	Long Hollow Draw	JM	0.5	1		0.5	0	0.5
6/26/19	WB	W02	near waterfall	JM, NL	1	1	1	1	1	2
2/15/19	WB	W02	North Hollow	JM	1	1	0	1	0	1
6/13/19	WB	W01	N. side creek, w. of Moats	JM, DM, techs, NL	3	8	3	24	9	33
11/5/18	WB	W04	Yaupon Valley FM area	JM	2.5	1		2.5	0	2.5

Table 3. Number of Invasive Species Controlled or Addressed at Wild Basin 2016-2019

Species	**2016**	**2017**	**2018**	**2019**	**Total**
Chinaberry	3		1	22	26
Chinese Ligustrum		1	2	69	71
Honeysuckle				1	1
Ligustrum	162	674	76	1891	2803
Loquat				1	1
Nandina	105	29	7	112	253
Photinia		2		22	24
Pyracantha				1	1
Tree of Heaven			3		3
Vinca				100	100
Vitex				1	1
Total	**270**	**706**	**89**	**2220**	**3285**

Appendix D: Summary of 2019 Golden-cheeked Warbler Surveys at Wild Basin Wilderness Preserve

Darrell Hutchinson, City of Austin Field Biologist

A total of 38 surveys were conducted at Wild Basin and Vireo Preserve between 12 March and 10 June by Darrell Hutchinson and Jim O'Donnell for a total of 108.5 survey hours.

Between the two preserves, six separate males were detected during the breeding season. Four males paired, but only one of these nesting pairs reproduced successfully. Two males failed to find a mate and departed the plot. One of these males was detected only three times, and so is not considered territorial. Compared to recent years, plot density was a little higher, but reproductive success remains low.

All six males are color-banded. One color-banded male was a return from previous years (Fig. 4). OR/YE:NB/SI was banded at Vireo Preserve in 2014 and has returned for five years in a row. All of the other five males were banded this year. Notably absent (and missed) was NB/WH:MV/SI, also known as 'Candy'. Candy was banded at Vireo Preserve in 2011 and returned every year to approximately the same territory for seven years in a row.

RD/SI:NB/BL was banded on 17 March as an after-second-year (ASY) bird. We suspect that he is a return from last year, because he occupied the same territory as a bird detected late in the 2018 breeding season. The territory is located at the back gate and traverses Wild Basin Preserve, Vireo Preserve, the in-holding property, and Wild Basin Ledge. The female built her nest in Vireo Preserve and the nest fledged on 6 May. The male was observed with up to 3 fledglings several times until 31 May. OR/YE:NB/SI occupied the territory at the bottom of North Hollow, which had previously been held by Candy. The female built her nest just north of Possum Trail. The nest was found predated on May 6. On 10 May, we detected an unconfirmed male close to the nest site. Afterwards, no further detections of the pair were made suggesting the pair shifted or abandoned the plot.

MV/WH:DG/SI was banded on April 15 as a second-year (SY) bird. The female built her nest close to Yaupon Trail. The nest was found predated on 29 April. The male was last detected on 11 May, suggesting the pair shifted or abandoned the plot.

BL/SI:DB/DB was banded on 26 March as a second-year (SY) bird at Vireo Preserve. The male paired successfully. Although the nest was not found, we believe she built near the water tower. The nest failed and the male was last observed on 16 May.
RD/SI:GR/BK was banded on April 4 as a second-year (SY) bird at Vireo Preserve. The male failed to attract a mate and was last detected on 28 April.

GR/SI:OR/YE was banded on 25 March as a second-year (SY) bird at Vireo Preserve. The male failed to attract a mate or establish a territory, and was last detected on 4 April.

Surveys were funded by City of Austin Wildlands Conservation Division and conducted according to City of Austin's Balcones Canyonlands Preserve GCWA Demographic Study protocols. Special thanks to Bob and Luisa Moats who kindly granted access to their private in-holding.

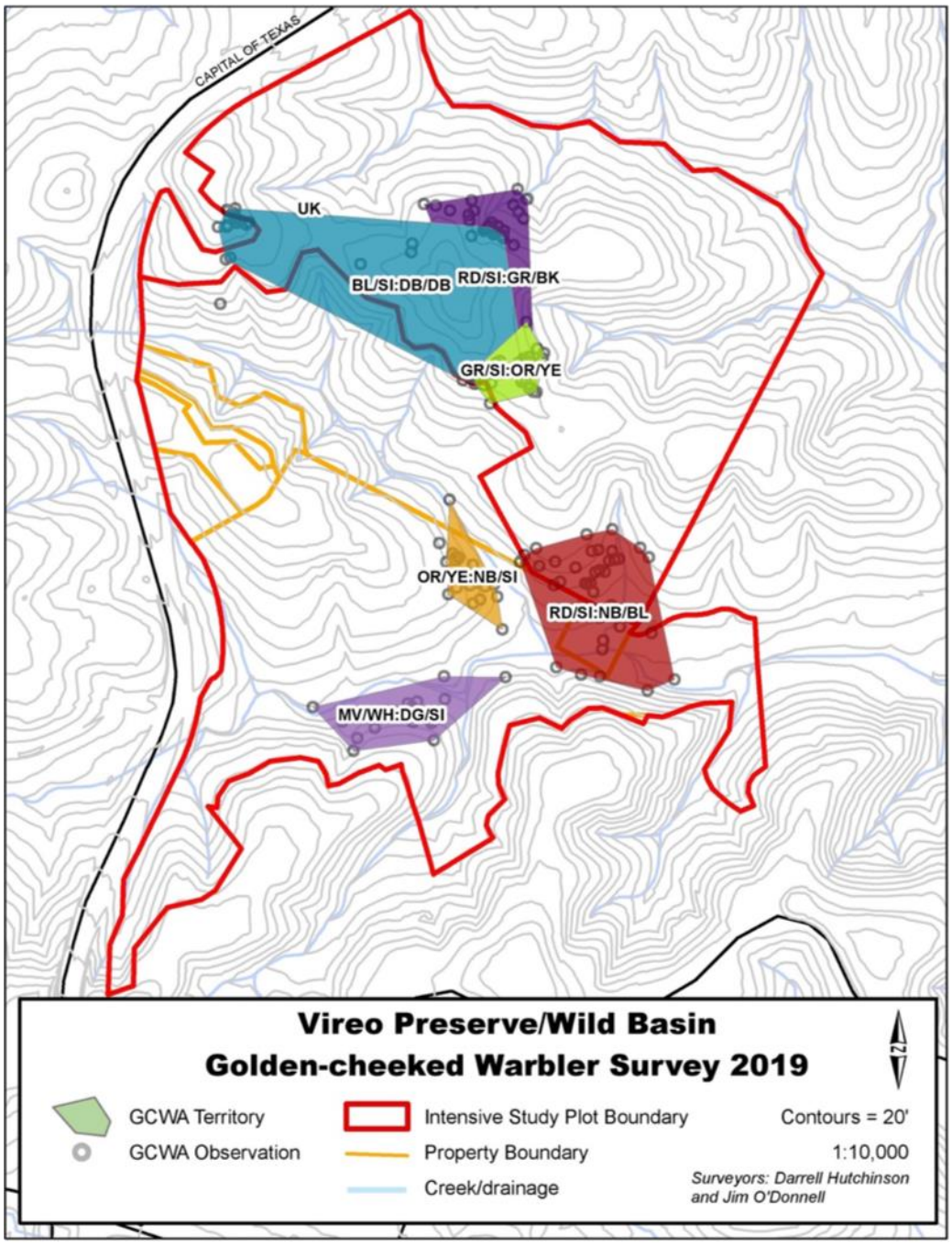


Figure 4. 2019 Golden-cheeked Warbler territories in Vireo Preserve and Wild Basin

Appendix E: Capstone Research End of Semester Report: Aural Anuran Survey of Bee Creek at Wild Basin Wilderness Preserve

Carlie Anderson, Environmental Science Institute, The University of Texas, 11 December 2019

Introduction

Anomalous declines in amphibian populations worldwide have been well-documented since the 1970s (Collins and Crump, 2009). Amphibians are considered bioindicators due to their unique biology, and as a result, their populations are coarsely analogous to ecosystem health (Weir and Mossman 2005). Frogs and toads (Order *Anura*) rely on species-specific vocalizations for reproduction. Anuran call surveys utilize this behavior to effectively assess population distributions and declines (Heyer *et al.,*1994, Weir and Mossman, 2005).

The most recent formal assessment of amphibian populations at Wild Basin Wilderness Preserve occurred in 2001 (Drozd, 2001). In that study, amphibians were only considered as one component of a larger herpetological study (Drozd, 2001). This study aims to address this gap in knowledge of community composition at Wild Basin, and broadly assess the current anuran community along the Wild Basin segment of Bee Creek. Manual calling surveys, supported by acoustic recordings, provide data that will be used to determine the spatial and temporal distribution of anuran species at seven sites located along Bee Creek.

Manual calling surveys evaluate the intensity of male anurans calling at a site, which yields species-specific occupancy data for each site sampled (Dorcas *et al.*, 2009). I hypothesize that the species assemblage at a site will vary with abiotic conditions, species breeding strategy, and phenology (Saenz *et al*., 2006). The abiotic factors measured at a site include air temperature, wind speed, recent precipitation, and barometric pressure.

The listening survey data in conjunction with environmental data gathered at each site can be used to monitor communities over time and gauge responses to habitat and climate variation (Dorcas *et al*., 2009). By assessing the presence or absence of species at different sites under varying conditions and seasons, educated recommendations can be formulated for the locations and timing of future monitoring efforts. This study will contribute to the development of a broader framework utilizing replicable field methods for future monitoring of wildlife at Wild Basin Wilderness Preserve.

Methods and Timeline

Study Area and Methods

This study employs a modified version of the North American Amphibian Monitoring Program (NAAMP) survey protocol. The NAAMP was developed in 1994 as a standardized protocol for assessing North American amphibian species by anuran calling surveys (Weir and Mossman, 2005). The protocol specifies that surveys are to be conducted at least 30 minutes after sunset and conclude before 0100h. Environmental conditions must be suitable for anuran calling - air temperature must be above 5.6 □C and wind speed must be less than a 4 on the Beaufort Wind scale. The observer records air temperature, wind speed, and barometric pressure at each site. The standard listening period is 3 minutes long, following a 2-minute period of silence. Calls heard during the listening period are recorded on the Amphibian Calling Index (ACI) which ranks calling intensity for each species heard on a scale from 1 to 3. Additional visual and auditory observations are also noted, as they provide valuable contextual data.

This study takes place at seven sites along Bee Creek that were selected on May 24, 2019. Bee Creek runs through Wild Basin from west to eat. It was chosen for the location of all survey sites since it is the main body of water in the Preserve. Anurans rely on water bodies for breeding, so the anuran community at Wild Basin is likely to be centered around the creek. The seven site locations are (see also Fig. 5):

Site 1: N 30 18.290, W 097 49.436
Site 2: N 30 18.337, W 097 49.396
Site 3: N 30 18.315, W 097 49.292
Site 4: N 30 18.342, W 097 49.208
Site 5: N 30 18.331, W 097 49.124
Site 6: N 30 18.370, W 097 49.067
Site 7: N 30 18.369, W 097 48.999

Survey sites are approximately 200m apart, consistent with the recommendation made by the Chicago Academy of Sciences (2019), suggesting that sites for roadside calling surveys should be within 200 meters of suitable anuran habitat.



Figure 5: Survey site locations overlaid on Google Earth imagery

Timeline

To date, the progress of this study has followed the timeline outlined below:

- May 24, 2019: Survey sites selected along Bee Creek. First spring survey completed.
- May-June 2019: Five spring and two summer survey events completed.
- September 15, 2019: First fall survey completed.
- October 2, 2019: Capstone proposal completed.
- October 2019: Two fall survey events attempted. No anuran observations or recordings.
- December 11, 2019: Capstone end-of-semester report completed.

The continuation of this study in the Spring of 2020 will follow the general plan below:

- February 2020: Attempt winter survey on evening when temperature is > 5.6C.
- March 2020: Mid-term report on preliminary findings (March 1), conduct one to two additional surveys, dependent on temperature.
- March-April 2020: Data analysis.
- May 4, 2020: Capstone final report completed.
- May 30, 2020: Presentation of findings in EVS 151.

Progress to Date

The anuran species recorded during this study to date are: *Acris crepitans, Bufo debilis, Bufo nebulifer, Bufo punctatus, Eleutherodactylus cystignathoides, Eleutherodactylus marnockii, Hyla chrysoscelis/versicolor, Pseudacris clarckii,* and *Rana berlandieri.*

Based on an initial analysis, the anuran community at Wild Basin appears to be dominated by *A. crepitans* and *R. berlandieri*. Both species were present during nearly every survey event, except for the surveys conducted in the fall, and *A. crepitans* was recorded calling at the highest intensities. Conversely, *P. clarckii* and *E. cystignathoides* were only present in the September 15 survey. Presence/absence data for each species in relation to survey date is presented in Table 4.

Table 4. Summary of anuran presence/absence data collected during all surveys to date. P = species present. *A. crep = A.crepitans; B. deb = B. debilis; B. neb = B. nebulifer; B. pun = B. punctatus; E. cys = E. cystignathoides; E mar = E. marnockii; H chr = H. chrysosclis/versicolor; P. cla = P. clarkii; R. ber = R. berlandieri.*

Species	24-May	31-May	11-Jun	17-Jun	19-Jun	24-Jun	26-Jun	15-Sep
A.cre	P	P	P	P	P	P	P	
B. deb		P						P
B. neb		P		P	P			
B. pun		P	P			P	P	
E. cys								P
E. mar		P				P		
H. chr					P			
P. cla								P
R. ber	P	P	P	P	P	P	P	P

Drozd (2001) was a broad herpetological study conducted at Wild Basin. Drozd used transects and randomly-selected points throughout the Preserve to record visual observations of both reptiles and amphibians. They conducted the surveys during the day and at night. A total of fifteen survey events were recorded for the spring and summer of 2001. Drozd recorded the presence of eleven anuran species present at Wild Basin, while this study has recorded nine species (Table 5).

Table 5. Summary of anuran presence/absence data collected by Drozd (2001). Combined transect and random point data for visual observations. P = species present. *A. crep = A.crepitans; B. deb = B. debilis; E. cys = E. cystignathoides; E mar = E. marnockii; G. oli = G. olivacea; H chr = H. chrysosclis/versicolor; P. cla = P. clarkii; P. cru = P. crucifer; P. ste = P. streckeri; P. tri = P. triseriata R. ber = R. berlandieri*

Spp	**16-My**	**23-My**	**25-My**	**29-My**	**31-My**	**1-Jn**	**4-Jn**	**6-Jn**	**7-Jn**	**11-Jn**	**12-Jn**	**19-Jn**	**3-Jl**	**16-Jl**	**17-Jl**
A.cre	P			P	P		P		P	P		P	P	P	P
B. deb								P							
E. cys															P
E. mar	P											P			
G. oli								P							
H. chr			P												
P. cla		P			P										
P. cru			P												P
P. str			P			P	P		P						
P. tri						P			P	P					
R. ber											P				P

Drozd (2001) reported finding seven of the nine species found to date in this study. Species documented in 2019 but not documented by Drozd (2001) include *B. nebulifer* and *B. punctatus*. *B. nebulifer* is one of the most dominant anurans at Wild Basin according to my preliminary results, so it is particularly interesting that Drozd reported no individuals of this species at all. Drozd also reported several species that have not been found so far in this study. These species include: *Gastrophyrne olivacea, Pseudacris crucifer, Pseudacris streckeri* and *Pseudacris triseriata*. Given the considerable overlap in the seasonal timing of this study and the surveys conducted by Drozd, it is notable that four species present in 2001 would be lacking from my preliminary results altogether.

Proposed Next Steps

The next phase of this study will take place in the remainder of the fall 2019 semester and for the duration of the spring 2020 semester. Through data analysis I hope to achieve three goals: 1) determine the spatial and temporal distribution of anuran species along Bee Creek, 2) determine the environmental conditions correlated with higher calling intensity of individual and groups of species, and 3) compare observed species richness and phenology with the findings of the Drozd (2001) study. When all of these goals have been achieved, I hope to use the information to develop a framework for future monitoring of anurans at Wild Basin.

In order to determine the spatial distribution of anuran species, the relative intensities of calling and number of species recorded at each site for all survey events will be mapped

using ArcGIS. Mapping the data will aid in visualizing the spatial distribution of calling intensity and species richness along Bee Creek. The temporal distribution of species will be qualitatively described by assessing the observed phenology of each species with comparison to the relevant literature.

The second goal, to determine the temperature and rainfall range correlated with highest calling intensities and species turnout, will directly contribute to recommendations for future monitoring. Using statistical software, I will test for a correlation between environmental conditions (rainfall in inches occurring over the 48 hours prior to a survey and on-site temperature) and the average number of species recorded per site and the average calling intensity per site. The results of this analysis will yield the optimal temperature and rainfall conditions for listening surveys in the future.

Lastly, observed species richness and timing of species presence will be qualitatively compared to the findings of Drozd (2001). Given different sites and methods, any differences between the findings of this study and of Drozd will have to be described, rather than tested statistically. This information may give some guidance as to how the anuran community at Wild Basin has changed since 2001 and may continue to change over time.

Literature Cited

Collins JP and Crump ML. 2009. Extinction in our times: global amphibian decline. New York (NY): Oxford University Press.

Dorcas ME, Price SJ, Walls SC, Barichivich WJ. 2009. Amphibian ecology and conservation: A handbook of techniques. New York (NY): Oxford University Press. Chapter 16, Auditory monitoring of anuran populations; p. 281-298.

Drozd NK. 2001. Study of Herpetology at the Wild Basin Wilderness Preserve [thesis]. [Texas A&M University (TX)].

Granda JR, Pena RM, Pierce BA. 2008. Effects of disturbance, position of observer, and moonlight on efficiency of anuran call surveys. Applied Herpetology 5(3): 253-263.

Heyer RW, Donnelly MA, McDiarmid RW, Hayek LC, Foster MS. 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Washington: Smithsonian Institution Press.

Peggy Notebaert Nature Museum. Chicago Academy of Sciences, Monitor Instructions (2019), (available at https://frogsurvey.org/?page_id=17).

Saenz D, Fitzgerald LA, Baum KA, Conner RN. 2006. Abiotic correlates of anuran calling phenology: The importance of rain, temperature, and season. Herpetological Monographs 20:64-82.

Weir LA and Mossman MJ. 2005. Amphibian declines: the conservation status of United States species. Berkeley (CA): University of California Press.

Appendix F: The Effects of Surrounding Urbanization on Mesopredator Landscape Utilization within Wild Basin Wilderness Preserve.

Gracen Bivens, Environmental Science Institute, The University of Texas, May 2019

Thesis Statement

Urbanization of the natural landscape has resulted in various behavioral responses in mesopredator species. This research aims to determine the behavioral adaptations of local mesopredators, including coyote (*Canis latrans*), bobcat (*Lynx rufus*), and grey fox (*Urocyon cinereoargenteus*), within Wild Basin Wilderness Preserve to the development surrounding their habitat using motion-triggered game cameras.

Introduction

Recent ecological studies have shown that human alteration of landscapes and resulting habitat fragmentation have led to novel behavioral responses, such as niche differentiation, within mesopredator communities. Resource scarcity associated with loss of habitat can result in behavioral adaptations among similarly sized mesopredators that decrease the effects of interspecific species competition, such as diet shifts and spatial or temporal habitat divisions (Schuette et al., 2013; Litvaitis and Harrison, 1989). With prior knowledge of the behaviors of coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and grey foxes (*Urocyon cinereoargenteus*) in their natural habitats, this research will be able to assess potential behavioral adaptations of these mesopredator species to the development of the Austin area surrounding Wild Basin Wilderness Preserve (Bekoff and Wells, 1981; Chamberlain et al., 2003; Johnson and Franklin, 1994).

Research Question

1. How have the mesopredator species of Wild Basin Wilderness Preserve adapted to this urbanized landscape relative to interspecific species interactions?
    a. Have spatial adaptations occurred between species in their utilization of this habitat?
    b. Have temporal adaptations occurred between species in their utilization of this habitat?

Hypothesis

This research aims to assess the role of urban settings in changes within mesopredator communities, including their interspecific species interactions and behavioral adaptations to this environment. It is hypothesized that the coyote, bobcat, and grey fox mesopredator species in the Wild Basin area have modified their natural behaviors and interactions as a response to urban-associated factors, such as human occupancy and resource scarcity associated with habitat fragmentation/loss. It is hypothesized that a modification in the utilization of the Wild Basin landscape has occurred in at least one of these mesopredator species, such as a temporal or spatial behavioral shift. Additionally, this research will show the interspecific species avoidance activity of the coyote, bobcat, and grey fox.

Methodology

The data associated with this research is being collected using 13 (current) motion-triggered game cameras that were selected based on the abundance and frequency of sightings of the three mesopredator species. The previously placed cameras along the northern and southern boundaries of Wild Basin will be also be utilized in this study for the determination of interspecific species avoidance and behavioral adaptation. In addition, one camera was placed at the culvert along Bee Creek inside Wild Basin and there are plans to place another camera on the other end of the culvert that lies outside of Wild Basin. The position of these culvert cameras may provide information on interspecific mesopredator use of dispersal routes, as this culvert provides an avoidance mechanism to highway-crossing. Two game cameras were placed along the northern boundary of Vireo Nature Preserve to provide information on the mesopredators entering/exiting the preserve area along this highly urbanized border. Each camera location is mapped using a handheld GPS navigation device. Data from the game cameras will be collected approximately once a week for 16 weeks and will be analyzed by identifying the species present in the motion-triggered photograph that was captured.

Expected Outcomes

The expected findings are to reveal various behavioral responses and interactions of the coyote, bobcat, and grey fox within their changing environment. Regarding spatial adaptations, it was predicted that coyotes and bobcats would not be observed in similar camera locations based on their avoidance of overlapping home ranges with one another in natural ecosystems. However, the data has shown that cameras #02 and #30 are the two most frequently sighted cameras for both species. The prediction that the fox and coyote ranges would overlap, due to the niche similarities that these two species experience in most natural environments, has been confirmed by the data as both species are frequently spotted at camera #35 (Kozlowski et al., 2008). An expected observation is that a temporal adaptation may be observed as to when coyotes and bobcats are most active in the protected area of Wild Basin in avoidance of human occupancy, based on previous studies (Tigas et al., 2002; Gerht, 2007).

The intraspecific behavioral adaptation predictions will be greatly enhanced as the data collection continues as it is difficult to accurately predict how a mesopredator may behaviorally adapt to various anthropogenic impacts on its' environment, especially while coexisting with other mesopredator species. In reference to the spatial and temporal novel behavioral responses of the coyote, bobcat, and grey fox we expect to observe with this research, data remains under analysis for the bobcat and grey fox. However, I have observed a temporal response in the coyote population of Wild Basin where the coyotes have altered their natural behavior of being a primarily diurnal species to being largely nocturnally active. Researchers have documented an increase in the nocturnal activity of coyotes with the level of human activity or development within their home range (Gerht, 2007). This novel behavioral response indicates that coyotes are adapting to this human-dominated landscape in order to hunt the prey associated with human development (i.e. trail associated species) but also minimize the likelihood of a human encounter. Continuing the collection of data will allow further analysis of intraspecific and interspecific interactions of the coyote, bobcat, and grey fox within this changing environment.

Future Applications

The final report of this research project would benefit the Balcones Canyonlands Preserve by providing behavioral analysis of three of Texas' most well-known mesopredators, as well as provide information on their species interactions and dispersal preferences when traveling through a human-modified environment. This research will benefit Wild Basin and Vireo Preserve by providing recent data on these mesopredators and how they interact with the preserved lands, as well as assisting the preserve managers in educating the surrounding community on these species.

Cameras Selected for Study

Relevant to:	**Camera(s):**
All 3 species	WB02
Bobcat/Coyote	WB30
Bobcat /Fox	WB13, WB32
Coyote /Fox	WB35
Only Bobcat	WB36
Only Coyote	WB07, WB09
Only Fox	TAM2
Culvert	C1 & C2
Vireo Preserve	V1 & V2

Expected Timeline

Spring 2019

- January: Data collection continues
- March: Analysis of mesopredator interactions based on camera data
- May: Summarize current observations

Fall 2019

- August: Obtain preliminary results of collected data
- October: Draft final report
- December: Finalize report, present research

Status Report: 05/03/2019

During the spring semester, I checked the SD cards of game cameras within Wild Basin with the assistance of my mentor, Dr. Dugelby, and other students. We went on several

hikes to look for potential additional camera sites, added some cameras and relocated others. From the collected SD cards, the camera data was uploaded into a Box folder where I was able to scan through the photographs, make notes, and record the date, time, and species onto the response data sheet. Other students and volunteers have access to this data sheet to help record data responses as well.

In addition, Dr. Dugelby and I have discussed the observations we are making from the game cameras. We have discussed the temporal data most recently, noting the crepuscular nature of the bobcat and the possibly nocturnal-adaptation of the coyote. These discussions have led us to determine the focus of my study at Wild Basin. We have eliminated the prior elements of dispersal routes and human occupancy factors (for now) and decided that I will focus more on the spatial and temporal behaviors of the bobcat, coyote, and grey fox. With this revised focus, I will have a much larger sample size (N) as we will focus on the overall sightings instead of each individual camera site—which would provide a smaller sample (N). Moving forward, additional cameras are to be installed to increase the overall sample size and sighting frequency.

Literature Cited

Bekoff, M. and Wells, M.C., 1981. Behavioural budgeting by wild coyotes: the influence of food resources and social organization.

Chamberlain, M.J., Leopold, B.D. and Conner, L.M., 2003. Space use, movements and habitat selection of adult bobcats (Lynx rufus) in central Mississippi. The American Midland Naturalist, 149(2), pp.395-405.

Gehrt, S.D., 2007. Ecology of coyotes in urban landscapes. In Wildlife Damage Management Conferences--Proceedings (p. 63).

Johnson, W.E. and Franklin, W.L., 1994. Spatial resource partitioning by sympatric grey fox (Dusicyon griseus) and culpeo fox (Dusicyon culpaeus) in southern Chile. Canadian Journal of Zoology, 72(10), pp.1788-1793.

Kozlowski, A.J., Gese, E.M. and Arjo, W.M., 2008. Niche overlap and resource partitioning between sympatric kit foxes and coyotes in the Great Basin Desert of western Utah. The American Midland Naturalist, 160(1), pp.191-208.

Litvaitis, J.A. and Harrison, D.J., 1989. Bobcat–coyote niche relationships during a period of coyote population increase. Canadian Journal of Zoology, 67(5), pp.1180-1188.

Schuette, P., Wagner, A.P., Wagner, M.E. and Creel, S., 2013. Occupancy patterns and niche partitioning within a diverse carnivore community exposed to anthropogenic pressures. Biological Conservation, 158, pp.301-312.

Tigas, L.A., Van Vuren, D.H. and Sauvajot, R.M., 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation, 108(3), pp.299-306.

Appendix G: Impact of human foot traffic on native mammal use of trails in an urban preserve

Paul Finch, St. Edward's University, School of Natural Sciences, Department of Biology.

Introduction:

It is well known that anthropogenic disturbances have an influence on wildlife abundance in urban areas. Especially detrimental are the effects of urbanization and habitat fragmentation as a result of this human development (Tigas et al., 2002). Furthermore, human disturbances have been shown to cause pressure and behavioral shifts in breeding, movement, and survival of wildlife (Whitacre and Knight, 1998). For example, coyote (*Canis latrans)* have been shown to make temporal shifts to prefer nocturnal activity over diurnal activity in recreation areas (Reilly et al, 2017). Similar patterns are seen in other native mesopredators such as bobcats (*Lynx rufus*) and foxes (*Urocyon cinereoargenteus*) (Harrison 1997, Gaynor et al., 2018). In the United States, outdoor recreation has been a leading cause of population decline of threatened and endangered species (Losos et al., 1995; Czech et al., 2000; Taylor and Knight, 2003). Rapid urbanization in Travis County in Central Texas in the 1970's inspired the creation of Wild Basin Preserve, a 227-acre urban wilderness preserve. Preserves and other protected areas with active outreach programs, such as Wild Basin, serve to educate the public about the needs of native wildlife and other species and ecosystems, while leaving habitat relatively untouched by human development for the purposes of nature conservation. For example, a primary goal of Wild Basin is to protect the endangered Golden-cheeked warbler (*Setophaga chrysoparia)* a migratory bird that nests and breeds only in the Texas Hill Country (Ladd & Gass, 1999).

Studies have supported that mammals, although nonetheless sensitive to anthropogenic activity, have varying tolerance to low levels of human disturbance. In this way, some species are better able to adapt to resource scarcity caused by development when presented areas such as preserves or city parks (Riley 2006, Goad et al., 2014). Wild Basin Preserve (WBP), a wilderness preserve in the hills of southwestern Austin, Texas, presents an interesting location for a study on the impacts of human recreational and related activity (e.g., hikers, educational groups, researchers, and preserve managers). At WBP, wilderness preservation measures coupled with habitat fragmentation caused by urban development and public access to hikers, researchers, and other educational activities, create an area of study that is both very human and very natural. Hiking trails network through the southern region of the

preserve while the northern area is left protected and preserved by the County with minimal human disturbance. This coupled human-natural coexistence results in unique pressures for different mammal species. Some studies suggest large carnivorous mammals are generally dependent on human-generated disturbance to cope with fragmentation, but those observations shift greatly across other mammals in a community (Oberosler et al., 2017). For example, shifts in temporal activity in response to human activity have been observed in deer, which rely on abundant resources to support their active foraging behavior (George and Crooks, 2006).

The goal of this study, which is still ongoing, is to better understand wildlife patterns of activity on hiking trails and the potential influence of human foot traffic on these patterns in WBP. Motion-triggered game cameras were employed to record both wildlife and human activity on trails in WBP. It was hypothesized that trails with higher human foot traffic would have low mammal relative abundance on trails more heavily visited by hikers, such as those near the trailhead of the preserve. Likewise, we predicted that remote trails further from the trailhead with low human foot traffic would have higher mammal relative abundance. These tendencies would be due to mammalian wildlife's natural sensitivity to anthropogenic disturbance, especially in the case of native mesopredators, which have relatively low population densities and require large areas for foraging and breeding (Noss et al. 1996).

Methods:

WBP in Austin, TX is one of several preserves within the Balcones Canyonlands Preserve network managed by Travis County and the City of Austin. WBP includes 227 acres of total habitat co-managed and co-owned by Travis County and St. Edward's University approximately 5 miles west of downtown Austin (30.3103, -97.8235). Twelve Bushnell trophy cameras were located at key points throughout the trail network of WBP to record human foot traffic and wildlife activity at each location (Fig. 6).

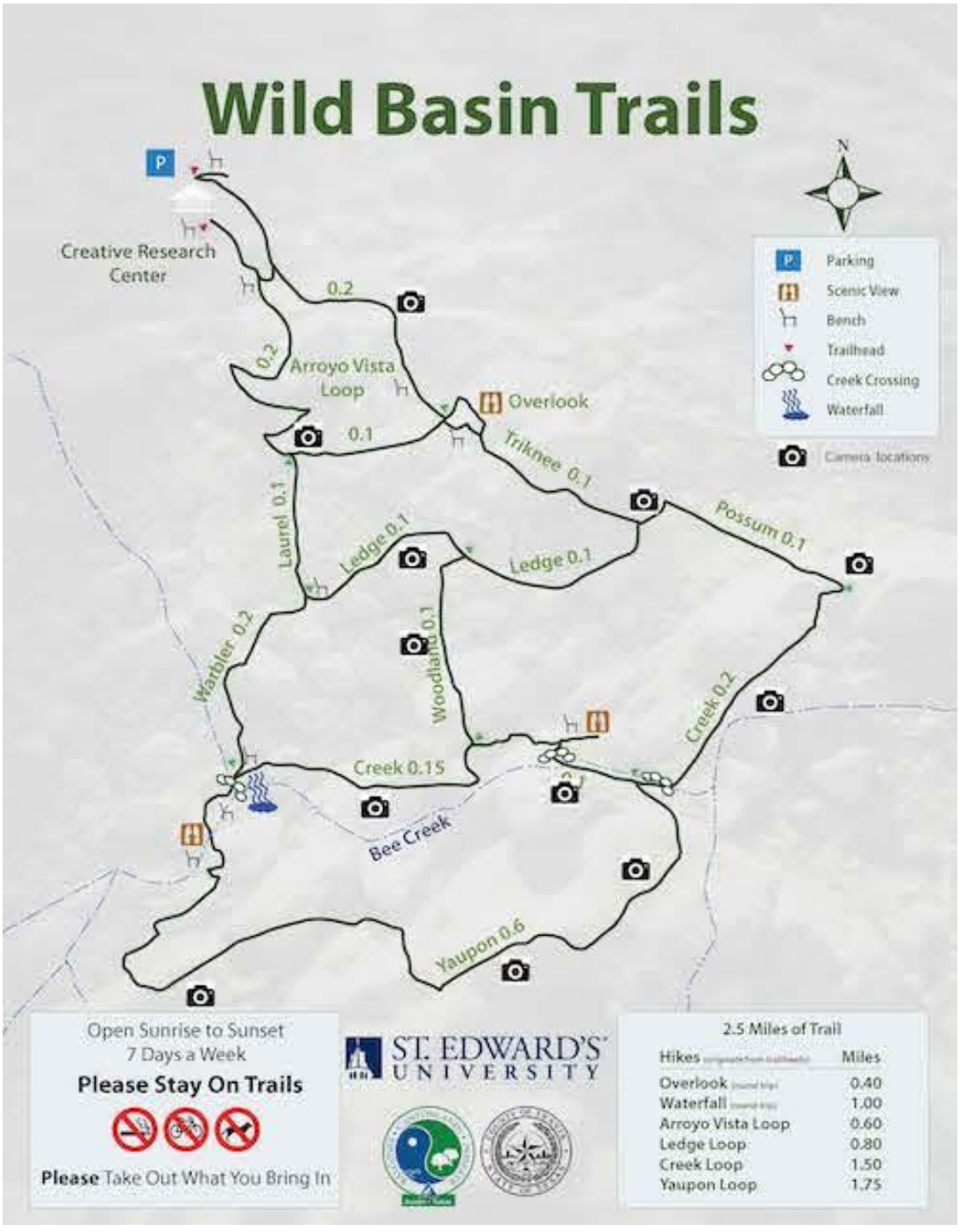


Figure 6. Map of Wild Basin Preserve trail network and camera locations

Camera locations (“stations”) were determined after surveying trails for signs of wildlife (e.g, scat, footprints, fur) and ensuring a fair spread of cameras throughout the trail network. The only trail not accounted for by cameras was Triknee. No cameras was located on Triknee trail due to little indication of wildlife activity, the short length of the trail (0.1 mi), and difficulty finding a suitable camera location. Longer trails such as Creek (0.45 miles) and Yaupon (0.6 miles) trails each had three camera sites to account for length and, in the case of Creek trail, the fact that hikers can join and leave the trail at multiple points. With that, these trails have more indications of wildlife than those near the trailhead, or front of the preserve. At each location, cameras were placed no more than approximately two feet above the ground, tied and locked around a tree trunk, and angled downward with the shutter facing the trail (Fig 7).



Figure 7. Principle author installing game camera trap on tree along trail.

In this position, photo capture of wildlife activity on the trail was optimal with the trail itself being the focus in each image. This position also ensured quality pictures of wildlife without capturing human faces to be respectful of privacy. Once stations were chosen and cameras set, their exact location was recorded using a Geographic Positioning System (GPS) device.

Study cameras’ infrared sensors have a maximum detection distance of 80ft (18.3m), with an optimal distance of 1 – 29’ (0.3–9.1m). Cameras were programmed to record 3 images at 10-second intervals upon detection of movement. These settings ensured capture of quick movement of both humans (hikers and runners) and wildlife. All

cameras were fitted with SD cards to store images. Cards were pulled and replaced biweekly, with one group of cameras pulled per week. Group A included 6 cameras: those at Arroyo, Arroyo-Laurel intersection, Woodland, Creek 1, Possum Intersection (where 3 trails meet), and Ledge. Group B included 7 cameras: those at Warbler, Yaupon, Yaupon 2, Yaupon "Stream", Creek 2, Creek 3, and Possum-Creek intersection. Cameras battery levels were also checked during SD card replacement. SD cards were changed at the end of the sampling period in mid-July 2019. Once pulled, images on SD cards were uploaded to a shared online file network for scoring by trained staff, students, and volunteers.

A Google data form developed for the study was used to record the following information about each wildlife image: camera name, date, time, species of wildlife, number of individuals, and any other important notes if needed. When the same species was captured by a particular camera within 10 minutes, only one form was filled with the assumption that the photos represented the same individual. This assumption was generally supported due to cameras being set to capture 3 images at 10 second intervals. In the case a camera image captured multiple individuals of a species, each individual was counted.

A separate Google data form and response spreadsheet were created to document human numbers by trail and date. A clicker app was used to count pairs of feet in photos for each date. The Google form automatically transferred all responses into a Google Sheets spreadsheet, which reflected all the parameters described above. Any errors, duplicate scores, or discrepancies were removed from the Google response spreadsheet prior to carrying out statistical analyses.

Data analysis

The study period to date has included 58, 24-hour capture periods (hereafter referred to as "trap days"). These initial trap days were considered a pilot study period during which researchers would test camera locations, response rates, and identify any other issues (e.g., cameras being too exposed to hikers and vulnerable to manipulation). As a result, there are not yet sufficient data for in-depth statistical analysis. However, using information generated in pivot tables summarizing data for both human foot traffic and wildlife on trails, it is possible to observe initial patterns in the data with respect to the study hypothesis. As the study evolves and more data are collected[1], study authors will explore the utility and appropriateness of various statistical analyses, such as

[1] The study will continue over a full 12-month period.

correlation analysis and linear regression, aimed at investigating the potential impacts of human foot traffic on wildlife activity and distribution on WBP trails. We will also examine the relationships between human and wildlife activity with distance from the WBP visitor center and trailhead.

Wildlife image data summarized in pivot tables were used to estimate an index of wildlife relative activity (WRA) at each camera station by dividing the number of images of all wildlife at a station by total number of trap days at a given station. We used WRA as measure of the spatial displacement of wildlife species in response to human foot traffic across the 13 camera locations. This index provides a helpful measure of the relative activity wildlife at each sampling location (Cutler and Swann, 1999; Carbone et al., 2001). An index of human relative activity (HRA) was estimated using the same method. We used correlation analysis to examine the relationships between numbers of human hikers and all mammals, as well as for separate groups of mammals (ungulates, carnivores, squirrels, rabbits, armadillos, and opossums). We also examined the relationship between carnivore and small prey (squirrels and rabbits) activity. Finally, we examined the relationship between numbers of human hiker activity and the activity of different wildlife groups and overall with distance of station (straight-line) from WBP visitor center (VC). Once at least 6 months of image data have been collected for all stations, we expect to revisit correlation analyses, as well as explore the use of logistic regression to determine if human foot traffic activity is a significant predictor of the probability of a species using a monitored trail (for all 13 camera stations) as well as the probability of a species exhibiting spatial or temporal displacement due to human activity levels.

Results

From May 20 through July 15, 2019, cameras stationed at 13 sites operated for a total of 771 trap days, yielding 1093 images of humans and native wildlife species (Table 6). Coyote were the frequently most detected large mammal, followed by the fox and then white tailed deer (Table 6). Coyote and fox were detected at most of the camera stations in WBP. Humans were the most detected species overall, and were captured at all stations throughout the preserve. Among small mammals, squirrels were the most frequently detected, and were the most frequently detected of all mammalian wildlife species (Table 6).

Table 6. Camera station visits during 62 trap days across 13 stations in WBP.

Camera Station	Trap Days	Distance	Armadillo	Bobcat	Coyote	Deer	Grey Fox	Opossum	Rabbit	Racoon	Squirrel	All Wildlife	Humans
Arroyo	62	2.02	0	0	1	1	6	0	3	3	1	15	3,233
Arroyo Laurel	62	2.5	0	1	0	0	0	0	1	0	5	7	2,958
Creek-1	62	5.62	0	0	7	0	1	0	3	0	8	19	1,184
Creek-2	62	6.16	9	0	3	1	1	0	13	2	11	40	893
Creek-3	62	6.77	0	0	6	0	3	1	7	1	44	62	2,294
Ledge	62	3.66	0	0	2	3	2	0	5	0	0	12	1,049
Possum Creek	62	6.66	3	0	6	2	3	0	1	6	1	22	1,733
Possum Intersection	62	5.05	0	1	1	0	6	0	19	0	8	33	2,732
Warbler	56	5.15	1	0	0	0	1	0	0	14	36	52	1,352
Woodland	62	4.58	0	0	4	7	6	2	7	2	17	45	1,576
Yaupon	62	7.08	1	0	23	3	3	0	14	3	35	82	1,809
Yaupon-2	41	7.23	2	0	1	2	1	0	11	3	21	41	1,500
Yaupon-S	54	7.04	0	0	10	0	4	0	1	2	7	24	696
Totals			**16**	**2**	**64**	**19**	**37**	**3**	**85**	**36**	**194**	**454**	**22,229**

Human Activity

Independent observations of humans along trails varied among camera stations (Table 6), but overall human hiker activity along WBP trails was negatively related to distance from the preserve VC where the trailhead is located (Table 7).

Table 7. Correlation coefficients between capture rates wildlife and people activity and distance from visitor center to camera stations.

Species	**Distance to VC**
Armadillo	0.313
Bobcat	-0.399
Coyote	0.530
Deer	0.033
Grey Fox	-0.153
Opossum	-0.009
Rabbit	0.293
Racoon	0.137
Squirrel	0.474
All Native Mammals	0.593
Humans	-0.562

Wildlife Activity

Independent observations of mammalian wildlife species also varied among camera locations (Table 6). The highest number of observations at one station of one species was squirrel, where 44 individual squirrel observations were made (Table 6). The greatest number of wildlife photo captures occurred at Yaupon (Table 6). Overall wildlife mammal activity along WBP trails was positively correlated with distance to VC, but looking at wildlife species individually, armadillo, coyote, deer, squirrels, rabbit, racoon, and squirrel all showed a positive correlation with distance to VC, with coyote having the strongest positive correlation (Table 7). All other wildlife species (bobcat, grey fox, opossum) exhibited a negative correlation with distance to VC, with grey fox showing the strongest negative correlation and noting that the correlation for opossum was negligible (Table 7). Carnivore activity had a strong positive correlation with activity of small prey (Table 8).

Table 8. Correlation coefficients between capture rates (#individuals/trap days) of small prey groups and carnivore activity on trails

Prey Group	Correl Coeff
Squirrels	0.261
Rabbits	0.288

With 62 trap days of data, we acknowledge that more data are required to test for correlations between human activity and the activity of different wildlife species. Overall, wildlife showed a slight negative correlation with human activity along trails (Table 9). Bobcat showed the strongest positive correlation with human activity, but this is based on only 2 data points (Table 9). Grey fox, opossum, and rabbit all showed positive correlations with human activity on trails. Of the remaining wildlife mammal species monitored, armadillo showed the strongest negative correlation, followed by deer, coyote, racoon, and squirrel. A comparison of wildlife relative activity (WRA) and human relative activity (HRA) by station indicate that there is much variation in the correlation between WRA and HRA by station (Figure 8).

Table 9. Correlation coefficients between capture rates (#individuals/trap days) of human activity and different wildlife groups on trails.

Wildlife Group	Correl Coeff
Armadillo	-0.365
Bobcat	0.591
Coyote	-0.227
Deer	-0.175
Grey Fox	0.345
Opossum	0.023
Rabbit	0.101
Racoon	-0.167
Squirrel	-0.045
All Native Mammals	-0.120

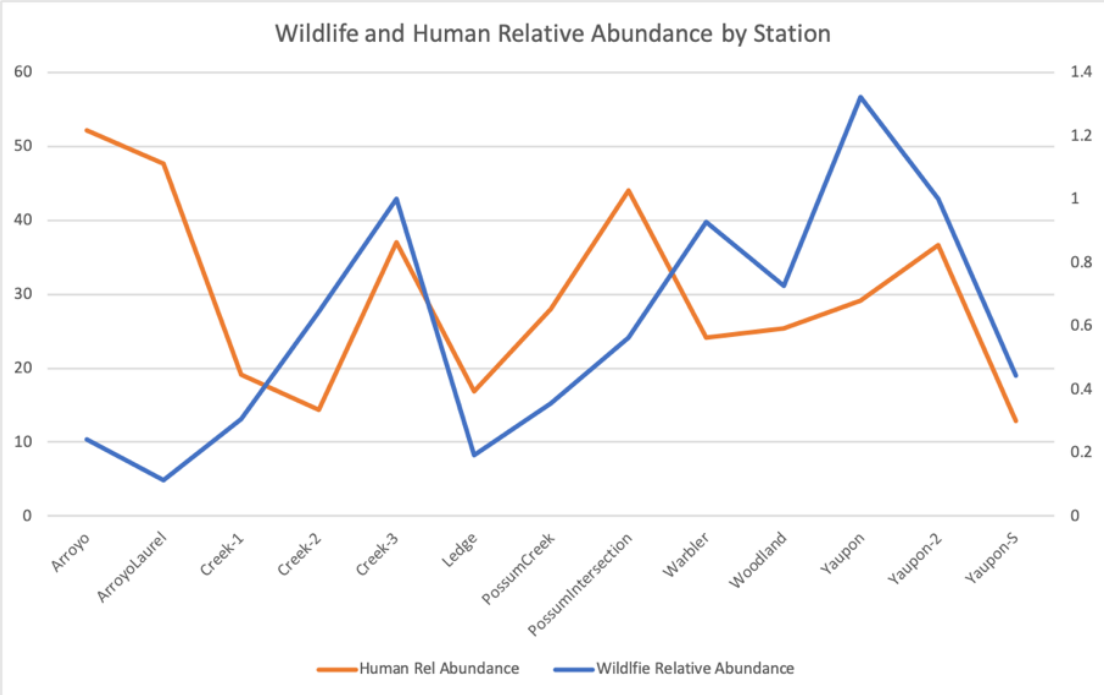


Figure 8. Line graph comparison of WRA and HRA

Discussion:

Humans were the most frequently observed species on all WBP trails, with activity declining the further away from the preserve's visitor center and trailheads. With the data gathered to date, there appears to be little impact on use of trails by monitored wildlife species. Armadillos showed the strongest negative response to human activity, followed by deer, coyote, racoon, and squirrel. Camera stations on trails that experienced the highest relative human activity, including Arroyo, Arroyo Laurel, and Possum Intersection, were also among the closest to the visitor center and exhibited much lower relative wildlife activity. However, due to the high variability in the correlation between WRA and HRA by station, and the limited amount of data gathered to date, it is too early in the study to make any clear statements about the potential influence of human activity on wildlife activity along WBP trails.

It is possible that the lower wildlife activity observed on trails with the highest human activity indicate that human activity must reach a certain threshold in order to begin having a significant impact on wildlife use of trails. Based on a broad survey of human and wildlife activity on hiking trails in eastern North America, Kays et al (2016) found no strong or consistent avoidance of hiking trails by wildlife, suggesting that wildlife species in protected areas with high recreational or hunting activity may become habituated to periodic human activity, shifting their behavior to short-term

avoidance of hiking trails rather than long-term avoidance of areas with human presence.

Our observations that human activity was greatest near the visitor center and that near-visitor center cameras captured the lowest levels of wildlife activity, may suggest that camera stations located closer to the visitor center may reveal even stronger negative impacts on wildlife activity.

Similarly, data analysis to date have looked at impacts of human activity on wildlife activity across the full span of study period days. However, human activity increases greatly on WBP trails on weekends and holidays. Comparing potential impacts on wildlife activity of low versus high human activity days may reveal a stronger negative correlation between human and wildlife activity on trails. If additional data and parsing days based on levels of human activity due show a stronger impact on wildlife use of trails, this could provide helpful information to preserve managers who are charged with managing human activity so as to prevent or limit negative impacts on native wildlife.

Initial results indicate that there may be negative impacts of human activity on wildlife once human activity reaches a certain threshold, and/or is closer to centers of human activity (e.g., research stations, visitor centers, parking lots). Additional sampling closer to these centers of human activity, accompanied by sampling on “social trails” (off trail networks rarely visited by common hikers but possibly heavily used by wildlife) could potentially reveal more nuanced impacts of human activity on wildlife use of preserve trails.

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Literature Cited

Crooks, K., George, S. 2006. Recreation and large mammal activity in an urban nature reserve. *Biological Conservation*, 133:107-117

Gaynor, KM., Hojnowski, CE., Carter, NH., Brashares, JS. 2018. The influence of human disturbance on wildlife nocturnality. *Science*: 1232-1235

Kays, R, AW Parsons, MC Baker, et cl. Does hunting or hiking affect wildlife communities in protected areas? *Journal of Applied Ecology* 54:242-252.

Ladd, C. and L. Gass. 1999. Golden-cheeked warbler (Dendroica chrysoparia). In: Poole, A., and F. Gill, editors. *The birds of North America*, number 420. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

Noss, R. F., Quigley, H. B., Hornocker, M. G., Merrill, T. and Paquet, P. C. (1996), Conservation Biology and Carnivore Conservation in the Rocky Mountains. *Conservation Biology*, 10: 949-963. doi:10.1046/j.1523-1739.

Oberosler, V., Groff, C., Iemma, A., Pedrini, P., Rovero, F., (2017), The influence of human disturbance on occupancy and activity patterns of mammals in the Italian Alps from systematic camera trapping. *Mammalian Biology*, 87:50-61

Reilly, M.L., Tobler, M.W., Sonderegger, D.L, Beier, P. (2017), Spatial and temporal response of wildlife to recreational activities in the San Francisco Bay ecoregion. *Biological Conservation*, 207:117-126

Tigas, L., Van Vueren, D., Sauvajot, R. (2002) Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation*, 108:299-306

Appendix H: Changes in plant and animal diversity and abundance in response to shaded fuel break treatments

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Abstract

Perennial fuel build-up in U.S. forests due to fire suppression, along with increased drought and lengthened fire seasons have led to increased occurrences of large, high-severity wildfires. Meanwhile, a greater number of people are living in the Wildland-Urban Interface (WUI) adjacent to fire-prone wilderness. The number of people affected has heightened awareness for the need of fire hazard reduction treatments. Shaded fuel breaks are used extensively throughout the Texas Hill Country including in the Balcones Canyonland Preserve (BCP) system which provides habitat for multiple endangered species, yet little research has been conducted on their impacts to plants and wildlife in these locations. Using before-after-control-impact (BACI) experimental design we analyzed a shaded fuel break treatment taking place at Wild Basin Wilderness Preserve within the BCP to determine 1) whether the shaded fuel break treatment impacts the diversity and abundance of wildlife in the mitigated areas, and 2) whether it impacts plant diversity and abundance, specifically, if mitigation treatment favors the regrowth of non-native plant species over native species. Data collected in the month after treatment showed decreased plant diversity and an average increase in animal diversity and use in mitigated areas, however no results were significant. Continued monitoring of the plots is recommended. Long-term results could assist decision makers and land managers in crafting and carrying out fire mitigation policies concerning similar cases in the future.

Introduction

Fire has long been an integral part of many ecosystems, impacting the distribution of biomes, helping maintain ecosystem structure, and also acting as a driver of evolutionary adaptations in plants and animals (Bond and Keeley 2005). Historically, frequent, low-severity fires reduced fuel build-up in North American forests by killing understory vegetation and leaving large fire-resistant trees behind (Schoennagel *et al*. 2017). However, since the mid 1800s fire suppression throughout the United States has caused fire frequency to decline substantially leading to undisturbed growth in understory and canopy fuel loads in many wildernesses, making forests
more susceptible to large, high-severity (stand replacing) wildfires (Keane and Karau 2010; Marlon *et al*. 2012). Lengthened fire seasons, increased drought, and earlier

snowmelt due to climate change have further increased this susceptibility (Schoennagel *et al*. 2017). Concurrently, rapid development and urban sprawl especially over the last few decades have led to more people living in the Wildland-Urban Interface (WUI). The WUI describes the area where urban development meets and intermingles with wildlands (Rapaport *et al.* 2012). The number of houses in burned areas within the WUI nearly doubled between 1990 and 2010 and in the next 20 years, nearly 40% of the current WUI is projected to face moderate to large increases in wildfire risk (Radeloff *et al.* 2018; Schoennagel *et al*. 2017). The greater number of people affected along with the increase in large, stand-replacing wildfires has heightened public concern and raised awareness for the need of fire hazard reduction treatments (Schwilk *et al*. 2009). Land managers have employed a number of fire break/mitigation tactics to try and minimize the risk of fire spreading from residential neighborhoods into preserved wilderness and vice-versa.

A common technique used to mitigate fire is a shaded fuel break, especially in urban areas where prescribed burning is more difficult to implement (Schwilk *et al*. 2009). The goal of a shaded fuel break treatment is to reduce the understory fuel load and raise the base height of the canopy to prevent ground fires from leaping up into the canopy. Shaded fuel breaks are not designed to stop fires, but to serve as a buffer that gives firefighters more time to successfully control them (Agee *et al*. 2000). Shaded fuel breaks have been used as early as the 1960s to help with wildfire mitigation around the country, however, there has been little standardization between cases regarding their width or fuel manipulation; some of the smaller-end breaks are recommended to be at least 65m while larger breaks can extend up to 400m in width (Agee *et al. 2000*).

While fire surrogate treatments and other mitigation techniques such as shaded fuel break treatments are widely used and accepted throughout the United States (Schoennagel *et al.* 2009), they may have unintended consequences. The mulching of land to suppress fuel loads and retain soil after a fire is a common technique, however, wood chips on the ground have other effects.

They suppress grow-back, increase soil moisture retention, alter soil nitrogen availability, and can lead to increased invasive species cover. Indeed, in one study, researchers found that 60% of the plants growing after the mulch had been applied were non-native (Miller and Seastedt 2009). Animal use of the cleared area may also be altered. One study found that animal responses to fire

and fire surrogate treatments varied greatly depending on the species (Fontaine *et al.* 2012). Another found that animal movement through the treated area may be reduced because cleared land provides less cover from predators such as coyotes. Even larger animals like white-tailed deer have been found to avoid areas where cover has been removed, especially females during the lactation period (Lashley *et al.* 2015). Some animals like the smoky mouse were found to be unaffected by fuel breaks up to 30ft (Macak *et al.* 2017). Thinning the understory can also increase edge habitat as well as exposure to wind penetration which greatly affects temperature and humidity (Bierregaard *et al.* 1992), with potential effects on habitat suitability.

The shaded fuel break treatment is used extensively throughout the Texas Hill Country including in the Balcones Canyonland Preserve (BCP) system which provides habitat for multiple endangered species, yet little research has been conducted on its impacts in these locations. We focused on a shaded fuel break treatment taking place within the BCP at Wild Basin Wilderness Preserve, located just 8 miles from Austin, Texas. The 227-acre preserve is dominated by Texas live oak and Ashe juniper woodland (Poage 1989). The Austin Fire Department determined that a fuel break of 50ft would be sufficient for use at Wild Basin. Additionally, a thin layer of mulch was spread over the cleared ground to suppress grow-back following the treatment. These treatments took place in fall 2018. We took advantage of this planned treatment to collect before/after data and examine non-target impacts.

Our objectives were 1) to determine whether the shaded fuel break treatment at Wild Basin Wilderness Preserve impacts the diversity and abundance of wildlife in the mitigated areas, and 2) to determine whether it impacts plant diversity and abundance, specifically, if mitigation treatment favors the regrowth of non-native plant species over native species. Because there are many types of fire mitigation methods that vary based on the specific circumstances of the landscape they are applied to, the body of research on their effects on animalss and vegetation does not cover each case. Our results along with previous research can ultimately be used to accurately and appropriately craft fire mitigation policies which help keep individuals living in the Wildland-Urban Interface of the BCP safe while minimizing impacts on the surrounding wilderness.

Methods

Study site

We conducted our sampling at Wild Basin Wilderness Preserve located 8 miles outside Austin, Texas (30°18’37”N, 97°49’24”W). The border of Wild Basin exemplifies a WUI as the preserve contains relatively undisturbed oak-juniper woodland habitat adjacent to homes and businesses. Hikers use the preserve, however there is little off-trail activity. The preserve is bordered by residential neighborhoods, another wildlife preserve (Vireo Nature Preserve), and a 4-lane highway, 360. Dominant tree species include *Juniperus ashei* (Ashe juniper) and *Quercus fusiformis* (Texas live oak), which is characteristic of much of the forested areas in the Texas Hill Country. Wild Basin’s area is 227 acres, and elevations range from 700 to 900 ft. Mean annual precipitation is 34.25 in. The preserve experienced a large fire in the 1960s which led to decades of reduced fuel loads. Because of this along with steep hillsides in some areas, fire mitigation has not previously been conducted at this site until recent years.

The preserve received a shaded fuel break fire mitigation treatment along sections of its perimeter in September-October 2018. The treatment included removing all understory cover, small trees, and lower branches of larger trees. The removed fuel was then mulched and spread over the cleared areas to suppress grow-back. There are ongoing efforts within Wild Basin to remove invasive species including *Ligustrum japonicum* (Japanese privet), *Ligustrum sinense* (Chinese privet), *Nandina domestica* (Nandina), *Sorghum halepense* (Johnson grass), and *Bothriochloa ischaemum* (King Ranch bluestem). As one of the preserves that make up the Balcones Canyonlands Preserve system (BCP) Wild Basin provides habitat for the endangered *Setophaga chrysoparia* (Golden-cheeked Warbler) which uses Ashe juniper bark to build their nests. A fire on the preserve would eradicate one of the last protected ecosystems for these birds, increasing the importance of fire mitigation treatment in the area.

Data collection

Our study employed a before-after-control-impact (BACI) experimental design to compare the areas receiving shaded fuel break treatment with untreated areas at Wild Basin. To measure any changes in animal movements, abundance, and diversity in treated vs. untreated areas we looked at footage from 8 game cameras (4 in mitigated areas and 4 in control areas), all of which were placed along the fenced border of Wild Basin. Two of the cameras in the sites receiving treatment were placed one week before treatment began (late September 2018), the other 2 were set up a year prior. The 4 cameras in control areas had been up for at least one year. To account for

trends resulting from habitat variation, the cameras in both control and mitigated areas were placed in sites ranging from densely forested with thick understory cover to open and grassy. For the mitigated areas, we looked at footage beginning one week leading up to the treatment (late September 2018) and continued a month after the treatment took place (through October 2018). We then examined the footage from the same time period of the prior year (September-October 2017) to minimize any seasonal behavioral differences. For the control, we looked at images from 3 cameras during the same two months each year in areas that never received mitigation treatment, but provided a similar range in habitat to the treatment-receiving areas. We recorded the time, date, and location of each image, along with notes including how many animals were in the photo and any discernible behavior. Animal identities were confirmed by two group members.

To measure response of vegetation to the treatments, we set up fixed-area plots around the 8 locations where the game cameras were placed, 4 in control areas and 4 in treated areas (Fig. 9). We measured vegetation structure and composition in fixed-area 15 x 15-m^2 plots placed along the fence line and starting at the camera. We measured two levels of vegetation within each plot: the canopy and the understory. For the canopy we identified and measured the diameter of each large tree (trees with a trunk diameter greater than or equal to 5 cm) within the entire 15 x 15-m^2 plot (Fig. 10). This measure was then used to calculate the basal area per hectare. Percentage canopy cover was also measured using a densiometer in each one of the three subplots inside the larger 15 x 15-m^2 plots. We kept canopy measure constant by facing west during every reading and having the same two people take separate readings at each plot and then averaging them for our final results. Canopy cover, basal area, and tree species composition measures allowed us quantify the forest structure and ecosystem type of each plot to see direct impacts of the treatment and to better understand if certain aspects of the treatment influenced animal response. For understory vegetation, we sampled 3 subplots with a 5 m diameter within the larger plot and identified the abundance of all plants within them, including both herbaceous and woody species. The three subplots were at distances of 3, 7 and 12 m down the fence from the starting corner and the center of each subplot was placed at 7, 12 and 5 m out from the fence respectively. Lastly we conducted a census of all plant species within the 15 x 15-m^2 plots that had not already been found in the subplots.

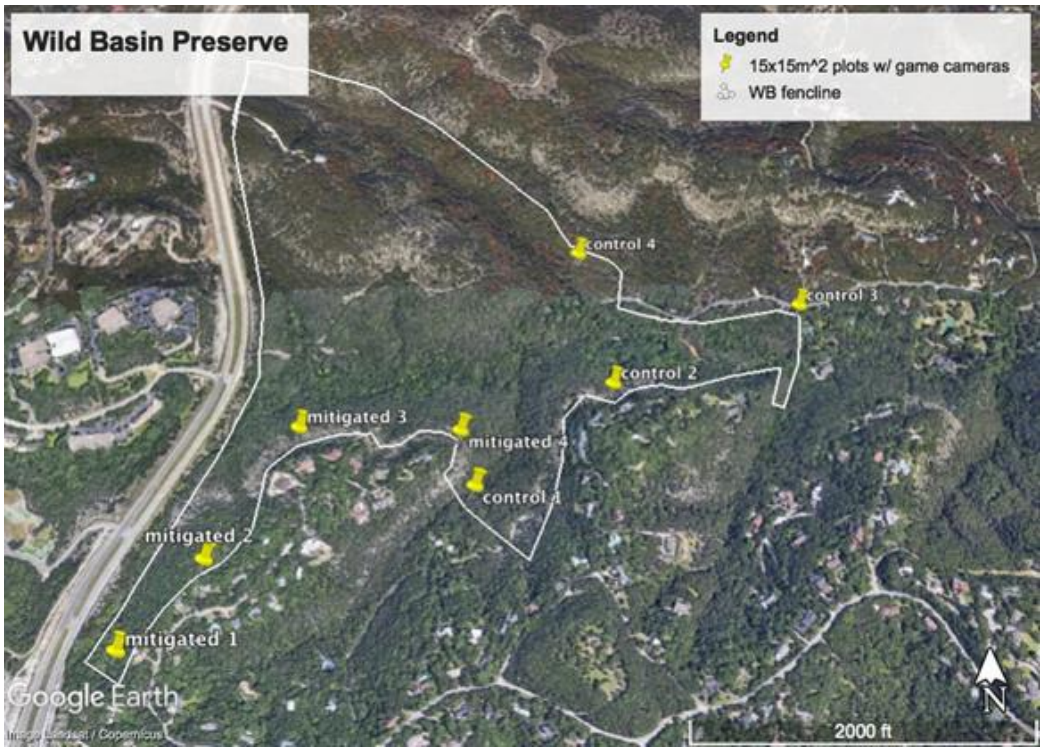


Figure 9. Locations of the 8 plots where data collection took place. The mitigated and control plots had similar variation in ecosystem type.

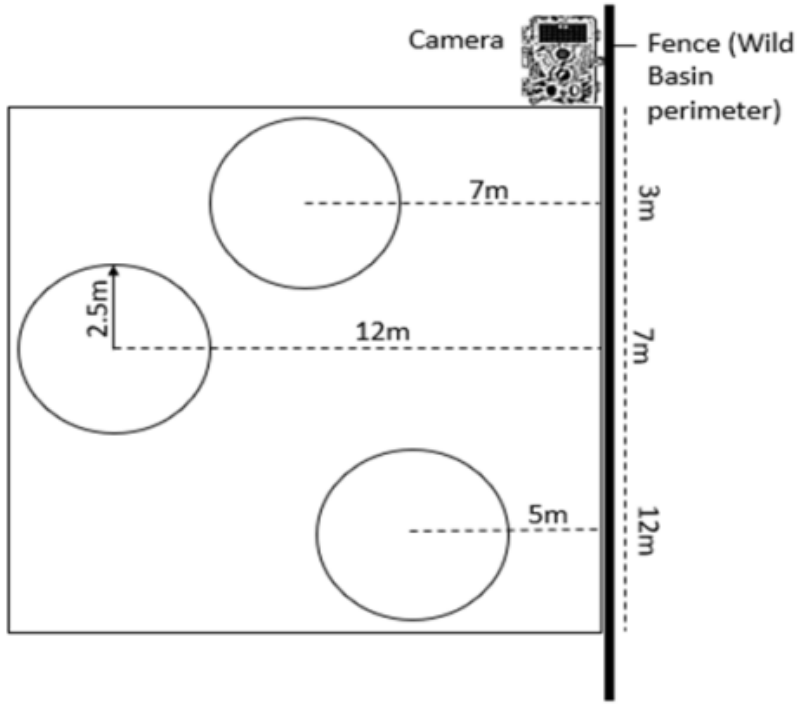


Figure 10. Layout of each fixed-area eight 15 x 15-m² plot where sampling was conducted. Each plot was located along the fenced perimeter of Wild Basin. Canopy cover measures were taken using a densiometer at the center of each of the three 5m diameter subplots.

Data Analysis

To analyze our data we used two tailed unequal variance t-tests to determine significance between pre and post-treatment species richness. The same test was used to compare animal use and species richness between the pre-treatment and control plots as well as pre vs post-treatment plots. A p-value of 0.05 was used and all calculations were made through Microsoft Excel.

Results

The dominant ecosystem types identified within the plots were 1) predominantly oak and juniper woodland, 2) predominantly juniper woodland and 3) grassland with interspaced junipers. Prior to the mitigation treatment, average canopy cover, species richness, and number of invasive plants were relatively consistent between control plots and mitigated plots with no significant differences. The average canopy cover was 74% for pre-mitigated plots and 80% for control plots. The average species richness was 20 for pre-mitigated plots and 21 for control plots. The average number of invasive species was 1 for control plots and 1.25 for mitigated plots. The average basal area of the control plots was slightly higher, 21m^2/ hectare, compared to 17 m^2/ hectare for the mitigated plots, however this difference was not significant. The control and pre-treatment species richness and basal area varied greatly between individual plots (Table 10).

Following the shaded fuel break treatment, average canopy cover for the mitigated plots barely changed (decreased by 1%), although individual plots varied greatly (Table 10). While plant species richness decreased across all plots (Table 10), this decrease was not significant (p-value = 0.09). Post-treatment species richness was similar across all plots (Fig. 11). The number of invasive species decreased slightly in post-treatment plots. Privet (*Ligustrum lucidum*) and nandina (*Nandina domestica*) were the most common invasive species identified across all plots.

Overall 111 photos of wildlife were identified over a 2 week period for both control and mitigated plots. Large variation in animal use and species richness existed across all 8 plots before and after the shaded fuel break treatment. The pre-treatment plots had an average species richness of 2 compared to the control plots with 2.3. Wildlife use was not significantly different between pre-treatment and control plots. Average species richness and use both increased following the treatment (Fig. 12, Fig. 13), however the changes were not significant (species richness p-value = 0.30; use p-

value = 0.44). The most abundant species captured in all plots was white-tailed deer (*Odocoileus virginianus*).

Table 10. Plant data for all shaded fuel break study plots. Species richness and number of invasive plants are for entire 15 x 15m² plot; canopy cover taken within 3, 5m diameter subplots and averaged. Control plots never received treatment so measurements for these plots were only taken once.

		Canopy cover %		Basal area (m²/ha)	Species richness		# of invasive plants	
Plot	Ecosystem	Pre-treatment	Post-treatment	Pre-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Mitigated 1	Oak/juniper woodland	74	87	24.3	27	13	3	1
Mitigated 2	Juniper woodland	90	94	23.6	21	12	2	2
Mitigated 3	Juniper grassland	82	47	9.5	16	13	0	0
Mitigated 4	Juniper grassland	50	63	10.5	14	12	0	0
Control 1	Oak/juniper woodland	94	-	25.6	18	-	2	-
Control 2	Juniper grassland	63	-	16.5	20	-	0	-
Control 3	Juniper woodland	82	-	21.3	26	-	1	-
Control 4	Juniper grassland	63	-	20.7	18	-	1	-

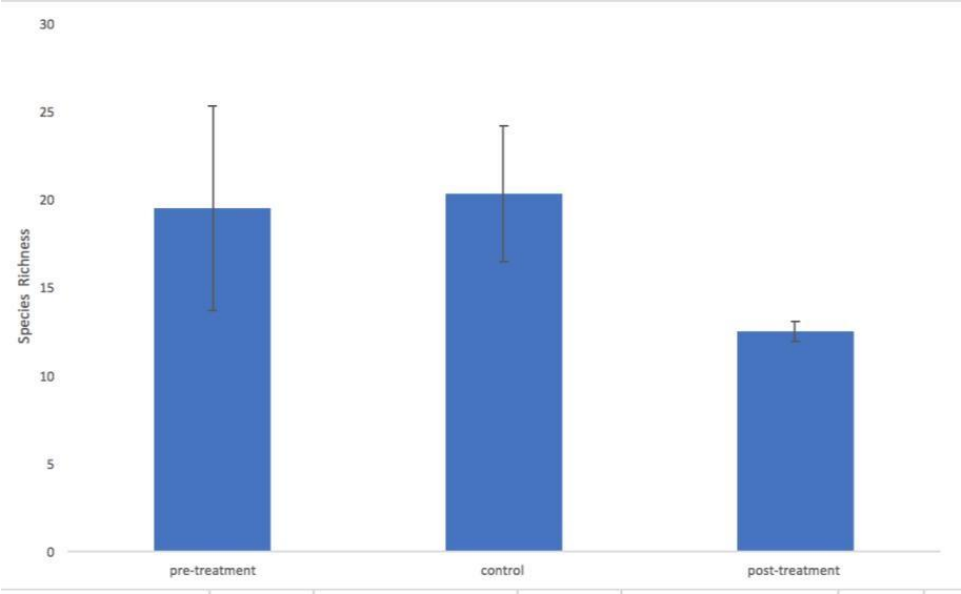


Figure 11. Average plant species richness for control plots and mitigated plots pre- and post-mitigation (n=4). Error bars represent standard deviation of the mean (pre-treatment =±5.8; control =±3.9; post-treatment =±0.58).

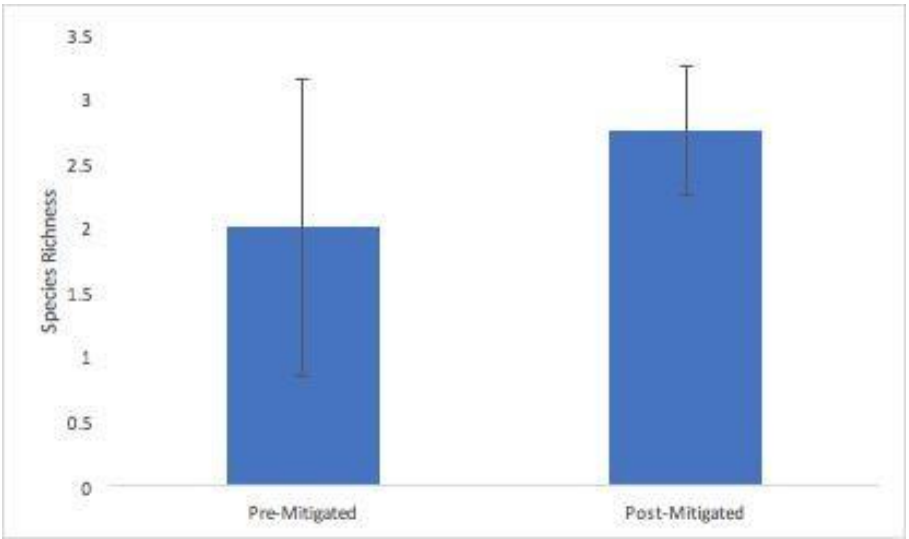


Figure 12. Averaged animal species richness (n=4) for mitigated plots over a 7-day period pre vs. post mitigation treatment. Error bars represent standard deviation of the mean. Pre-mitigated standard deviation = ±1.15; post-mitigated standard deviation = ±0.58.

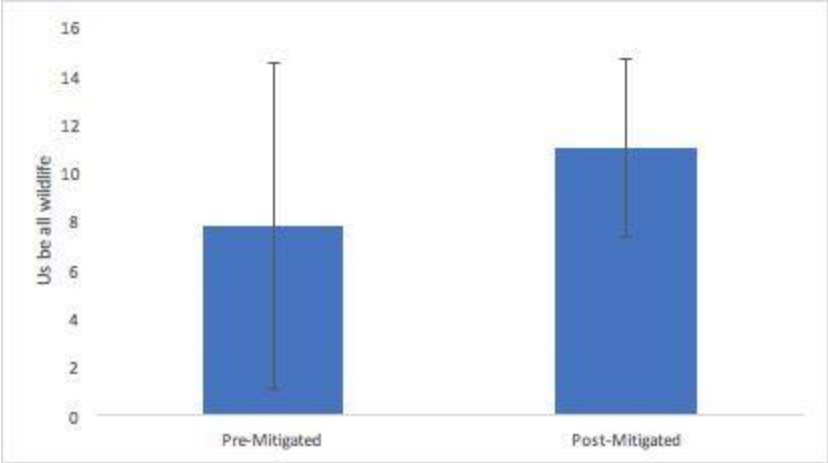


Figure 13. Average use (n=4) by all animals over a 7-day period pre-mitigation vs. post-mitigation. Use is defined as every time a different individual was captured or every 10 minutes if the same individual was still being captured. Error bars represent standard deviation of the mean (pre-mitigated = ±6.7; post mitigated = ±3.7).

Discussion

Our results showed a large, but not statistically significant reduction in plant species richness within the mitigated plots. This reduction was expected because shaded fuel break treatments consist of removing the understory and because the majority of grasses and forbs were covered by a layer of mulch. The canopy cover did not change significantly showing that the Austin Fire Department carried out the shaded fuel break properly and preserved the canopy well. The 1% reduction could be explained by the removal of dead trees (a required aspect of the treatment). Deciduous hardwoods had already begun losing their leaves for winter which could have also decreased the percentage of canopy cover. Few invasive species were seen in the post-mitigated plots and continued monitoring of growback will be needed to accurately assess how the mulching affects natives vs non-native

For wildlife, the large variation in species richness and use across all sites could be explained by the variation in landscape on the opposite (non-Wild Basin) side of the fence. Some homeowners had very manicured, landscaped lawns while others left their land completely unmanaged. Some plots were also bordered by two rows of fencing that could have made it more difficult for animals to enter the preserve and be captured on the game camera. Both wildlife species richness and use increased slightly following the treatment, however neither value was significant. The increase could be caused by a few factors. First, pre-treatment data was collected during September and October which were unusually rainy months. This could have reduced overall wildlife use and richness compared to the post-treatment data which was

collected in November. Second, the removal of the thick understory cover in some plots could have made it easier for the camera to be triggered or for animals to be seen by those reviewing the footage, especially for smaller animals.

While six cameras had been set up years prior, two were set up for this study only a week before the shaded fuel break treatment took place. This along with other time constraints limited the other sites to one week of data. One week of data may not be a full representation of animal responses and could have missed some animals altogether. This made it difficult to determine the effect of the shaded fuel break treatment on specific species, although studies have indicated that animal responses to fire mitigation treatments and other disturbances may vary by species (Fontaine *et al.* 2012). Another two cameras malfunctioned so data from the prior year (2017) had to be used. While the same three months (September-November) were analyzed each year, variations in weather between the two years could have impacted animal use and richness in these two plots. Other plots had game cameras that were not ideally positioned (low to the ground and pointing downward), which could have led to fewer animals being captured.

Although time constraints have limited the post-treatment analysis window of this study, the plots and game cameras will continue to be monitored into the coming months and years providing information on how different plant and animal species respond to shaded fuel break treatments over time. The plant species that respond well initially to mulching do not always remain established and conversely, some species take months to become established following a disturbance (Bates *et al*. 2011). Thus, a monitoring period of at least three years following treatment would show which species respond well in the long term (Miller and Seastedt 2009). Continued research will be needed to ascertain the long term effects of shaded fuel breaks on plant and animal diversity and abundance at Wild Basin.

With increasing wildfire frequency and intensity across the Western and Southwestern United States and the increased threat to homes, businesses, and people within the WUI, fire mitigation treatments such as shaded fuel breaks have become an important aspect of land management. As there is little research on the non-target impacts of shaded fuel breaks and little standardization in their application regarding width, location, and fuel manipulation, our research at Wild Basin could be used to better understand similar cases in the future, specifically across the BCP. This study has revealed information about how shaded fuel breaks can alter canopy and understory

structure as well as some of the short term wildlife responses. To better understand these effects, further research such as adding more game cameras along the fenceline of Wild Basin, continued monitoring of growback and animal movement, and expanding the study to other preserves across the BCP could be useful. We hope our study can bring forth the conversation to fuel further research and ultimately help inform management and policy decisions concerning fire mitigation treatments across the Hill Country.

Literature Cited

Agee J, Bahro B, Finney M, *et al*. 2000. The use of shaded fuel breaks in landscape fire management. *Forest Ecology and Management* **127**:55-66.

Bates JD, Davies KW, and Sharp RN. 2011. Shrub-steppe early succession following juniper cutting and prescribed fire. *Environmental Management* **47**: 468-481.

Bierregaard R, Lovejoy T, Kapos V, *et al.* 1992. The biological dynamics of tropical rainforest fragments: A prospective comparison of fragments and continuous forests. *Bioscience* **42**: 859-866.

Bond W and Keeley J. 2005. Fire as a global 'herbivore': the ecology and evolution of

flammable ecosystems. *Trends in Ecology and Evolution* **20**: 387-394.

Fontaine JB and Kennedy PL. 2012. Meta-analysis of avian and small-mammal response to fire severity and fire surrogate treatments in U.S. fire-prone forests. *Ecological Applications* **22**: 1547-1561.

Keane R and Karau E. 2010. Evaluating the ecological benefits of wildfire by integrating fire and ecosystem simulation models. *Ecological Modeling* **221**:1162-1167.

Lashley MA, Chitwood MC, Kays R, *et al*. 2015. Prescribed fire affects females white-tailed deer habitat use during summer lactation. *Forest ecology and Management* **348**: 220-225.

Macack VC, *et al.* 2017. Forest fire break not a barrier to movement for threatened rodent, the smoky mouse, Pseudomys fumeus (Rodentia: Muridae). *Life Science Weekly:* 2310.

Marlon JR, Bartlein PJ, Gavin DG, *et al.* 2012. Long-term perspective on wildfires in the western USA. *PNAS*: E535-E543.

Miller EM and Seastedt TR. 2009. Impacts of woodchip amendments and soil nutrient availability on understory vegetation establishment following thinning of a ponderosa pine forest. *Forest Ecology and Management* **258**: 263-272.

Poage J. 1989. Wild Basin of Bee Creek: A city dump was once a prominent feature in this recently restored natural area in Austin, Texas. *Earth Science* **42**: 1.

Radelhoff VC., Hammer RB., Stewart SI, *et al*. 2005. The wildland-urban interface in the United States. *Ecological Applications* **15**: 799-805.

Schoennagel T, Balch JK, Brenkert-Smith H, *et al*. 2017. Adapt to more wildfire in western North American forests as climate changes. *PNAS* **114**: 4582-4590.

Schoennagel T, Nelson CR, Theobald DM, *et al*. 2009. Implementation of National Fire Plan treatments near the wildland-urban interface in the western United States. *PNAS* **106**: 10706-10711.

Schwilk DW, Keeley JE, Knapp EE, *et al.* 2009. The national fire and fire surrogate study: effects of fuel reduction methods on forest vegetation structure and fuels. *Ecological Applications* **19**: 285-304.

Sherren K, Rapaport E, and Whitman E. 2013. Modeling fire susceptibility to delineate Wildland-Urban Interface for multiple-scale fire risk management. *Environmental Management* **52**: 1427-1439.

Appendix I. Evaluation of Ecosystem Function of a 30-Year Old Dumpsite in Wild Basin Wilderness Preserve in Austin, Texas

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Introduction

Disposal of waste has been an issue for generations (Eriksen 2016; Högberg 2017). Instead of reducing waste production, humans have been trying to find new methods of disposal or recycling (Brunclíková 2017; O'Dell 2011). However, population growth has continued to soar (Ehrlich 1971) at alarming rates along with waste generation (Fig. 14) and space for waste is running out. Now, refuse is being displaced from developed nations to the undeveloped to help hide the problem (Eriksen 2016). There is yet to be a method of disposal that is best for humans *and* the environment.

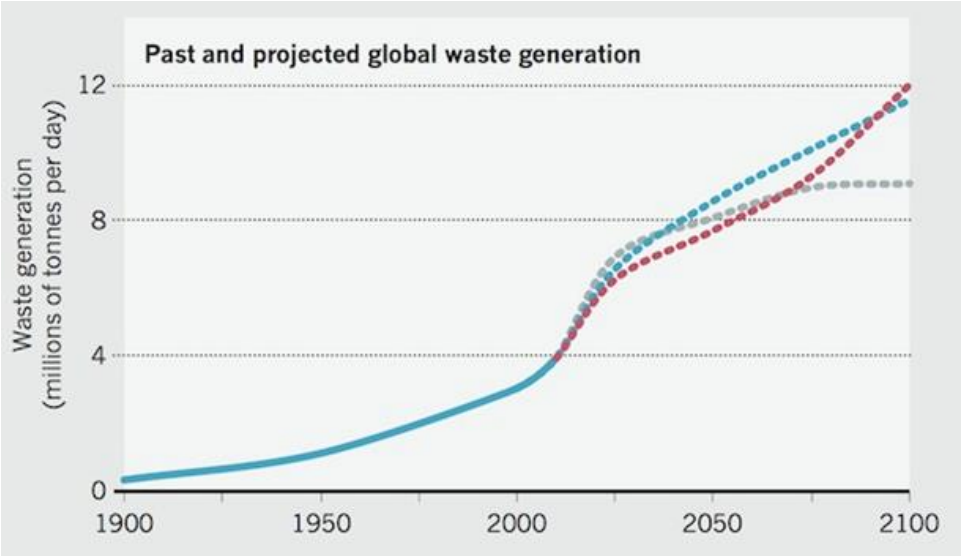


Figure 14. Predicted rise in global waste production from 1900s to 2100. Blue line is the current projection, red is a scenario with accelerated population growth, and grey depicts a wealthier more environmentally conscious consumption behavior. Source "Eriksen 2016".

Early dumpsites were built as simple holes dug into the ground to hide refuse and then covered up with a top layer of soil (Corvellec 2013; Maugh 1979). This disposal method was effective because most things were natural and decomposable. Today, there are approximately 5,500 active landfills in the U.S. (Callaway 2005) and plastic makes up a majority of the waste (Worm, 2015); it is high in chemicals and compounds and can take millions of years to decompose. Due to the changes in refuse composition the waste in the holes is not breaking down so new holes have to be dug

to hide the waste. An increase in the number of landfills is exceeding available land (Eriksen 2016).

Land used for waste is often forgotten once municipalities have exceeded available space. It is important to look at what happens to this land after dumpsites are decommissioned (Giusti, 2009). Most states are supposed to follow decommissioning instructions (Collum, 2017) to ensure the safety of surrounding land. These are stringent rules that require the city to provide proper cover to avoid contamination of waterways (Collum, 2017). However, these rules have only been in place for about 60 years (Bayliss, 2003). So, all dumpsites that were created or decommissioned prior to regulatory stature do not meet today's requirements, and therefore have needed more funding to decommission.

Once land has been used for refuse it is often unviable to be used for *anything* else (Robinson, 1993). In some landfill's chemicals have leached into the ground making it unusable for agriculture, cattle or development. There have been several national tragedies; an extreme example is Love Canal, where developers built a large neighborhood on top of this type of land and then the residents developed deadly diseases or birth defects due to the contaminants that were in the soil beneath them. Love Canal was the major environmental disaster that mobilized the United States to acknowledge these sites exist and they need to be taken care of. The Comprehensive Environmental Response Compensation Liability Act was developed to provide federal funding for these types of sites. Areas such as Love Canal became known as Superfund sites and received national attention. This was the turning point for more stringent regulations and decommissioning laws for landfills and chemical disposal sites.

Overlooked decommissioned waste sites are left untouched and up to mother nature for restoration unless the city or an organization decides to step in. If decided upn some sites can be remediated. Part of the remediation process is restoration. There are two main restoration approaches: used to benefit the environment; passive or active restoration (O'Dell, 2011; SER, 2004; Sheoran et al, 2010). Passive restoration is disturbed land where the stressor is removed with an added layer of top soil and is left with minimal human impact to be restored (mother nature). Often, passive restoration is a slower process and may not work, but it is also a more cost-effective option. Active restoration is disturbed land that not only removes the stressor, but cleans up the area and is redesigned and restored using the best methods for

reintegration of native vegetation. This involves some kind of active management (rather than just letting the land sit). Active restoration jumpstarts the ecosystem and can be very effective, but the costs are higher. In order to justify these higher costs, it is important to evaluate the difference between the two approaches and confirm that active management really does result in a faster, more complete restoration. However, there are very few articles that compare the two types of restorations (Gornish et al 2017). Restoration practitioners often state no one method is better than the other, one is simply more ideal for the site and the goals the land manager is trying to achieve (Gornish et al. 2017). Some amount of ecosystem function and structure can be restored using either type of restoration method (SER, 2004).

The goals of restoration are crucial to determining which approach suits a particular location or project. Some key components that land managers often test to see whether biotic and abiotic function has returned to a site include nutrient cycling, productivity, ground cover, and canopy height (Callaway, 2005; Palmer et al, 2009; SER, 2004). To break it down further, testing can be separated into two categories, structure and function. Subcategories for structure include canopy coverage, species richness and species composition. Measurements for function include, decomposition and productivity. Structure is the most commonly studied area in determining success leaving a gap in the literature for studies of function. In my research I studied both structure and function to determine success. Additional variables that could have an effect on an ecosystem and can therefore serve as covariates (with restoration treatments) are temperature, pH and moisture. All should be considered when testing for success of an ecosystem.

One specific place where both passive and active restoration methods can be compared is The Wild Basin Wilderness Preserve, in Austin, Texas. It is a vast area and home to a diverse array of plants and animals, including several endangered species. In the 1920s this area was a privately-owned ranch contracted by the city of Austin to dispose of the city's glass, metal, and plastic waste. The ranch owner had an area at the back corner of his property where he would burn the trash and then place it into a manmade ravine. The dump decommissioned in the late 1940s and was purchased in the 70s by a women's group *Now or Never* jointly with the City of Austin to be turned into a preserve. It was then found that the area of the dump backed up to a creek now named North Hollow, previously, Contaminated Creek. North Hollow runs directly into Bee Creek which enters the sensitive recharge zone of the Edwards Aquifer, Austin's main water source.

Remediation of the site became a major concern. In an effort to rehabilitate portions of the dumpsite within Wild Basin, *Environmental Survey Consultants* completed a series of experimental plantings, including attempts to regenerate native forest communities. The restoration of the dumpsite that connects to Bee Creek was important to prevent contaminated runoff from reaching the Edwards Aquifer. *Environmental Survey Consultants* first cleaned the trash from .5 of an acre along the main ravine connecting to Bee Creek. The active restoration model consisted of collecting seeds and native plants from other areas of Wild Basin to be planted in the restored site (Mahler 1987). Active restoration in this area was most important because of its proximity to North Hollow. The rest of the dump was passively restored; the company placed a layer of dirt over the garbage in an effort to help the area regenerate on its own. Since the entire dump was not actively restored it provides a good opportunity to test the effectiveness of restoration approaches, passive versus active restoration specific to a dumpsite (Passell 2000; Purcell et al 2002; SER 2004).

Beyond preliminary studies, including a one-year post restoration survey and a more recent vegetation survey, the site has not been evaluated for ecosystem success. From the 2016 survey, we know that there has been an increase in woody vegetation and diversity at the restored site (Evaluating Vegetation Communities in a Restored Historic Dumpsite, Unpublished). However, ecosystem function and structure is not always directly related to composition and diversity. More than 30 years have passed since the initial treatments, and it is possible that the ecosystem has improved even to the dumpsite that received passive treatments. It is also possible that both the active and passive dump site are still functionally and structurally different than the undisturbed forest.

I compared ecosystem function of a 30-year old dumpsite and the restoration methods used to reclaim the area. My hypothesis for this experiment is that active restoration restores ecosystem function and structure. My predictions are: 1. the active restoration site will show fully restored function and structure, equivalent to an undisturbed control site, 2. the passive restoration site will be functionally and structurally different from the undisturbed control sites and the actively restored site.

Objectives

1. Compare ecosystem function and structure of a previous dumpsite that was actively restored, dumpsite that was passively restored, and a reference area that was never a dumpsite.
2. Compare species composition of all three sites in 2018 to that available in the 1986 literature.

Study Site

This study was conducted at 5 transects with similar forest composition, slope and elevation in the Wild Basin Wilderness Preserve, part of the Glen Rose formation. Although the largest formation in Central Texas, there has been little information published on the area (Whitney 1952). In this area of Texas, the Edwards Plateau it is a dry subhumid region (Thonthwaite 1948) with an average rainfall of less than 85cm (Arbingast et al 1976) during peak months of May and September (Carr, 1967). Plant communities along the Balcones Escarpment, constituting one-third of the Edwards Plateau Region are comprised of relatively open shrub forests (Gould, 1969). The community composition is primarily juniper-oak-persimmon forest (Van Auken et al, 1979,1980). The dominant species found over much of the plateau are *Juniperus ashei* and *Juniperus pinchotii* (Shaw et al, 1980). Before settlement of Central Texas, the Edwards Plateau was a fire-maintained savanna (Buechner, 1944; Gould, 1962). Once livestock were introduced heavy grazing removed the fuel for grass fires and that is when Ashe juniper (*Juniperus ashe*) took over and is now the dominant community (Fowler, 1986).

Field Methods

I set up three 1m² quadrats (A, B and C) along the same plane, 5 meters apart from the left and right (Fig. 15) in 15 different locations for a total of 45 plots. Each plot was labeled with field flags. To reduce bias each plot was 10 meters from one another heading North of the road at the Wild Basin Wilderness Preserve where the transects begin. If the measurement landed in an open field I remeasured another 10 meters North until an *Ashe juniper* forest was reached, to ensure comparable community composition to that of the dumpsite. I monitored seven variables at different scales using a nested plot approach for: species richness, species composition, canopy cover, decomposition, productivity, temperature, moisture, and pH.

Structure

Key elements in determining diversity are understory vegetation and canopy cover (Magurran 1988; Hunter 1990). Species richness can be measured by the number of species in the community or by an index of the species (Weitzman, 1992). Methods to find cover class for understory vegetation can use plots, lines or point proportions to estimate percent coverage of species (Brown 1954). In October of 2018 within a 1m² quadrat (Fig. 16); I visually estimated cover for each species within the plots according to Daubenmire (1959), 0-5% cover classes (Morris et al. 2011). On-site observation of the species was taken as well as, photographs of the entire plot and the individual species to better identify all vegetation. The connection between species richness and ecosystem function is important because of the services they provide (Garcia and Martinez 2012, Loreau et al. 2001). Typically, the higher the biodiversity count is the greater the plant biomass and nutrient cycling will be (Cardinale et al. 2006, Schmid et al. 2009). However, a simple count is not the only factor to consider (Garcia and Martinez 2012). The relationship the canopy coverage plays has an effect on species richness (Ganey andBlock 1994; Zollner and Crane 2003).

Measuring canopy cover is an important indicator of woody vegetation (Gill et al. 2000, Fassnacht et al. 1994). I used a densiometer, a common and accurate tool for estimating the crown closure of an area (Paletto & Tosi 2009). Tree height had to be at minimum 1.3m to be considered towards the total canopy coverage anything under would be considered in undergrowth (Fennica, 2006). Using a Spherical Crown Densiometer Concave Model C 43888 to estimate total crown coverage or canopy cover of the plots. Standing in the center of the plot and holding the densiometer flat in the palm of my hand I noted the field of view from the densiometer. Canopy coverage is the area covered by the crowns of the trees (Fennica 2006) and is an important factor often affecting wildlife and microhabitat (Morrison et al 1999). This measurement also helps determine the amount of woody vegetation in the site providing a protective barrier for climatic or environmental factors that may affect the area.

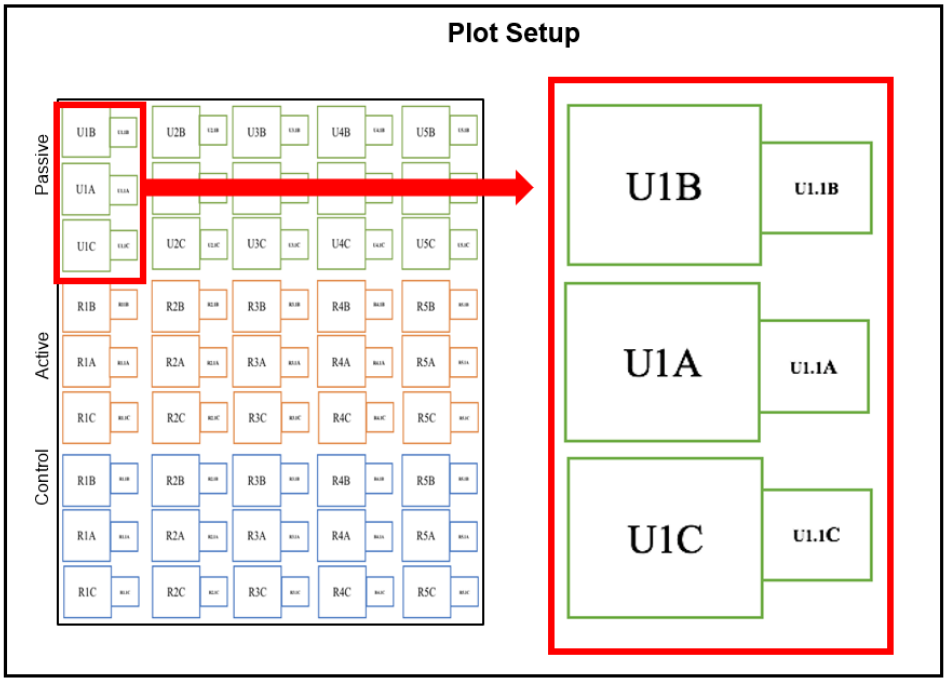


Figure 15. Experimental design for each site tested at Wild Basin Wilderness Preserve, in Austin, Texas. The three areas are an actively restored dumpsite, passively restored dumpsite, and a control Ashe juniper forest (reference site). Each site was tested for the same seven response variables for ecosystem function and structure.

Function

Testing decomposition with the litterbag method can best be used to see how much carbon the leaf litter is putting back into the nutrient cycle. The litterbag is a small wire mesh bag filled with leaflitter and left outside to decompose (Coleman 2004). Using a Sartorius Entris 64-1s analytical balance I weighed each mesh bag with the tag on them. Then using leaflitter collected from Wild Basin I filled each bag and weighed it again. I placed all litterbags into a Fisher Scientific Isotemp Heating and Drying Oven and let them dry for 48 hours. Once they were dry I weighed them again and then placed the bags within each of the subplots using a garden staple to keep it in place. After four weeks I collected all of the litterbags and weighed them again to calculate the total decomposition of the plots.

The direct method/approach to above ground net primary productivity (ANPP) is the form of measurement I used to measure productivity. ANPP is the aggregate of biomass over time (Singh et al. 1975). The direct method has low uncertainty and is quick and efficient (Lauenroth et al. 1986). For each treatment, aboveground biomass was removed using hand clipping and collection. All vegetation at ground level measured in a 20 X 20cm^2 quadrat subsection of each plot. Samples were collected

at 15 points along the three selected sites (n=45). Biomass was dried in a Fisher Scientific Isotemp Heating and Drying Oven at 50°C for 48 hours and then weighed (Camill et al, 2004)

Additional Variables

I used a Dr. meter S40P-V probe, of Thousandshores Inc. to measure the temperature and pH of the soil four times per month for four weeks between 9:30am and 11:30am for every measurement. Temperature was sampled at four points within each of the three subplots at each site (n=720).

Soil samples were collected from the center of the quadrat to measure moisture. After clearing debris and leaflitter I took one scoop of soil placed in a small plastic bag from each of the three subset plots to determine moisture. The sample was weighed and then dried in a Fisher Scientific Isotemp Heating and Drying Oven at 50°C for 48 hours and then weighed again.

Analytical Methods

I used linear regression models and analysis of variance tests, established statistical methods for calculating ecosystem contamination loads (Irish et al. 1998) to predict the success of all three reference sites. With these tests I was able to identify the relationship between independent variables (weather conditions and sample timing) and the dependent variables (temperature, moisture, and pH) to one another. To assess the significance of the relationship between the dependent and independent variables I completed an ordinary least squares regression analysis. A linear regression was used to assess if any significant relationship exists between temperature, moisture and pH with respect to decomposition and productivity. I also performed an analysis of variance (ANOVA) using R statistical package to determine significance between 1. Decomposition and the reference sites and 2. Productivity and the reference sites.

Results

Structure

I found that the actively and passive sites show similar biodiversity and ecosystem functioning, but vary from the control site. The research area is primarily composed of Ash juniper and its vastness consuming most of the canopy. Between all three sites there was more than 50% of the canopy covered by the crown of Ash juniper trees. There was no significant difference between sites for canopy cover. Percent coverage

estimates show an increase in vegetation as you move from the unrestored site to the control site (Table 11). The percent coverage was highest in the control site with the active and passive sites being more similar to each other. The coverage of the restored site was about 65% of the control site and the coverage of the unrestored site was about a 60% of the control site. Results for species richness showed that similar species could be found within all three areas. The original restoration noted over 451 different individuals were planted (Mahler 1987). Out of those I identified 20 different species. Because all data was collected in the fall it was difficult to identify some vegetation. There were several unknowns which could account for other species from the original restoration.

Table 11. Total percent coverage and species richness for all vegetation identified within the 45 plots from Wild Basin Wilderness Preserve

Species	**Origin**	**% Cover Unrestored**	**% Cover Restored**	**% Cover Control**
Grama Grasses	Native	13	85	394
Sedge Grass	Native	17	2	69
Day Flower	Native	10	5	22
Panic Grass	Native	29	48	51
Silk Tassel	Native	27	57	46
Texas Buckeye	Native	5	23	15
Yaupon	Native	83	48	50
Ashe Juniper	Native	67	15	18
Moss	Native	25	40	27
Oak Seedling	Native	4	9	37
Prickly Pear	Native	21	20	10
Oxalis	Native	11	6	10
Virginia Creeper	Native	3	10	22
Privet	Alien	8	5	10
Evergreen Sumac	Native	5	28	15
Cedar Sage	Native	76	48	55
Poison Ivy	Native	32	35	18
Yucca	Native	5	5	10
Unknowns		26	44	31
Debris		28	15	1
Total Count		**495**	**548**	**911**

Function

Decomposition varied between all three of the sites. However, there was no significant difference (p= 0.0844) between the control site and the active and passive sites. (Fig. 15). The control site had the highest decomposition rate out of all three sites. Analysis of productivity (Fig. 16) did show statistical significance (p=1.83e-6) between the three sites. The control site had the highest productivity in comparison to the active and passive sites. The active and passive sites had similar productivity to one another.

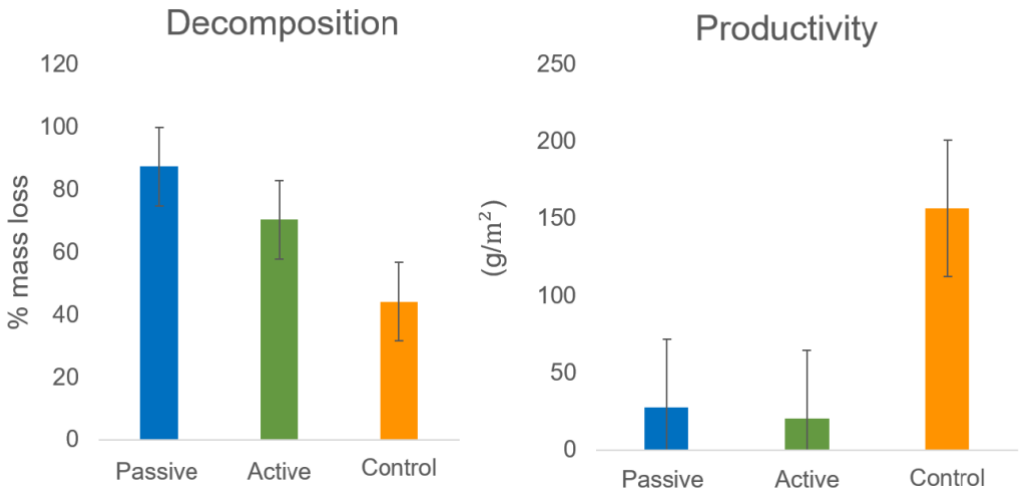


Figure 16. Ecosystem function by treatment (1) decomposition and (2) productivity. Decomposition does not show significance (p-value=0.0844) between the three sites. Productivity showed a significant (p-value= 1.83e-6) difference in the control site with respect to the active and passive sites.

Additional Variables

Temperature, pH and moisture are all important contributing factors to determining the return of ecosystem function. In Fig. 14 we can see that there is little variation, but there is a positive trend with decomposition than with productivity. As temperature and moisture increases so does decomposition. Productivity increases with temperature but it decreased with higher moisture. Another slight difference was in pH for the sites. The passive site had a pH of 6.9 no matter what plot was tested. All subplots in the active and control area had a pH of 7.0 which is a normal basic pH level.

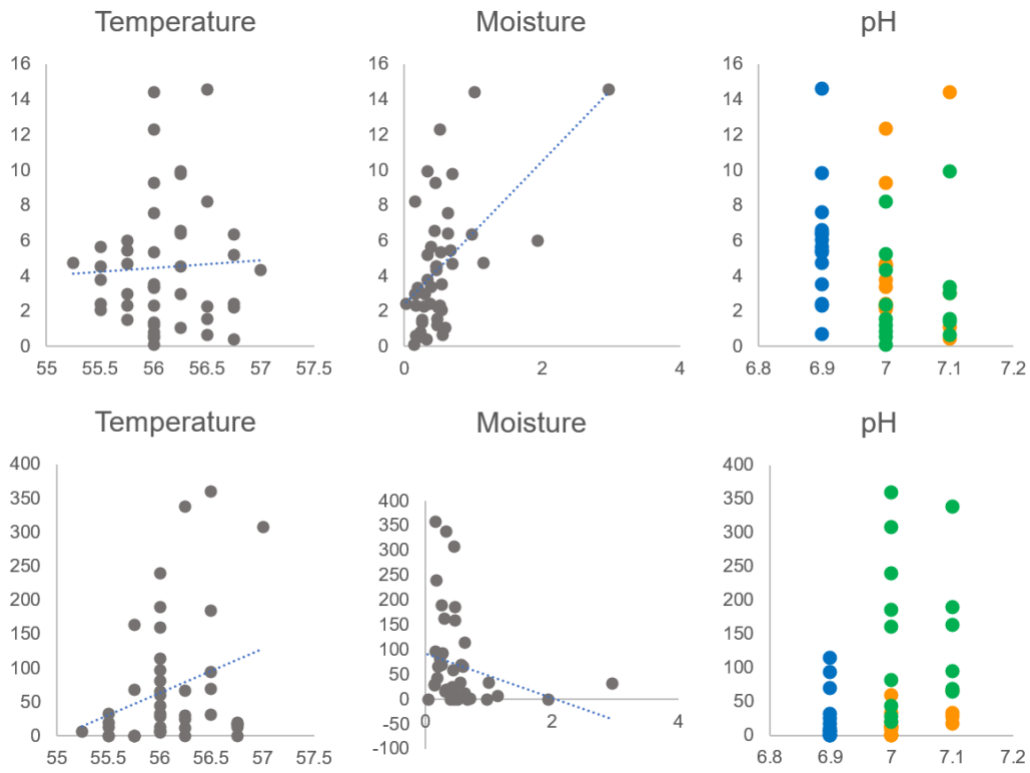


Figure 17. Top three panels show the relationship between decomposition rate and temperature, moisture, and pH. Bottom three panels show the relationship between productivity and temperature, moisture, and pH.

Discussion

These findings show that over time, restored sites, *active* and *passive*, can develop similarly no matter the type of restoration. In the case of Wild Basin, active restoration simply sped up the process of the restoration but after 30 years the passive site has attained a mostly similar function to that of the actively restored site with the exception of species richness. There are three main ideas to consider through my findings, 1. Because it has been so long since the original restoration time could be an influencing factor and the similarity in function and structure, 2. equally possible is that there may not be a difference between active and passive restoration in the long-term, only short term, and 3. the island model played a role in success of the sites. The island model suggests that a small area of a site can be restored and in turn the areas around it will regenerate through normal processes from wildlife (Holl 2004). This method is typically used when restorations face cost limitations.

Although my study covered a narrow area these same concepts can be applied to a larger scale study looking to test different restoration methods over a longer period of time (Garcia and Martinez 2012). Most importantly my study shows that visually all of

the sites currently look the same but considering all factors that it takes to make a successful ecosystem we can now say that the success of each site differs. This research is just a baseline for additional testing in the future at Wild Basin. It would be best if the measurements could be taken once a year to keep track of changes over time. Most analysis such as the ANPP show greater significance over time and would benefit from future analysis. These results will be shared with land managers at Wild Basin and the Balcones Canyonland Preserve and can be used to inform future restoration projects. This research was helpful in determining that the ecosystem function and structure of the active and passively restored sites in the Wild Basin Wilderness preserve was improved. The restoration was helpful to both the active and passive site in order to improve the land and limit the chance of contaminating Bee creek. In any case there is a need to monitor restoration sites in order to determine the amount of internal recruitment taking place (Robinson, 1994). Following the steps taken in this experiment can aid in determining if other restored landfills have a successful ecosystem. It is important to not only focus on diversity and species composition but look at the entire community to determine if the system is successful.

Acknowledgements

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Literature Cited

Arbingast, SA, Kennamer LG, Ryan RH, et al. 1976. Atlas of Texas. University of Texas. Bur. Bus. Res., Austin

Bayliss, C and Langley K. 2003. Nuclear decommissioning, waste management, and environmental

Brown D. 1954. Methods of survey-and measuring vegetation Bull. 42. Commonwealth Bur. of Pastures and Field Crops. Hurle, Berks, England. 233

Brunclíková L. 2017. Recyclable waste as a marker of everyday life routines. Archaeologies of waste; encounters with the unwanted, 1st ed.,Oxbow Books, Oxford; Philadelphia. 100-120.

Callaway JC. 2005. The challenge of restoring functioning salt marsh ecosystems. J Coast

Camill P, McKone MJ, Sturges ST, et al. 2004. Community –and ecosystem –level changes in a species – rich tall grass prairie restoration. Ecological society of America. 14(6):1680- 1964

Cardinale BJ, Wright JP, Cadotte MW, Carroll IT, Hector A, Srivastava DS, Loreau M, Weis JJ.

2006. Effects of biodiversity on the functioning of trophic groups and ecosystems. Nature 433, 989–99210.

Carr JT. 1967. The climate and physiography of Texas. Tex. Water Devel. Board Rep. 53.

Coleman DC, Crossley Jr. AD, and Hendrix PF. 2004. Fundamentals of soil ecology 2e. Burlington, MA: Elsevier Academic Press

Collum B. 2017. Nuclear facilities: a designer's guide. Woodhead Publishing.

Corvellec H and Hultman J. 2013. Waste management companies: Critical urban infrastructural services that design the sociomateriality of waste. In Campos M. & Hall C. (Eds.), Organising.

Eriksen T. 2016. Waste. Overheating: an anthropology of accelerated change. 105-116.

Fowler NL and Dunlap DW. 1986. Grassland vegetation of the eastern Edwards Plateau. University of Texas. 146-156

Garcia D and Martinez A. 2012. Species richness matters for the quality of ecosystem services: a test using seed dispersal by frugivorous birds. Proceedings Biological Science. 279(1740):3106-3113.

Gaudinski J, Trumbore S, Davidson E, Zheng S .2000. Soil carbon cycling in a temperate forest: radiocarbon-based estimates of residence times, sequestration rates and partitioning of fluxes. Biogeochemistry. 51: 33-69

Giusti L. 2009. A review of waste management practices and their impact on human health. Science Direct. 29(8). 2227-2239

Gould FW. 1969. Texas plants: A checklist and ecological summary. Texas Agric. Exp. Sta. Bull. MP-585.

Gornish ES, Lennox MS, Lewis D, et al. 2017. Comparing herbaceous plant communities in active and passive riparian restoration. *PLoS ONE*. 12(4): e0176338.

Högberg A. 2017. Waste, very much a social practice. In Sosna D. & Brunclíková L. Eds.,

Hunter ML .2002. Fundamentals of Conservation Biology, 2nd edn. Blackwell Science, Oxford.

Karberg NJ, Scott NA and Giardina CP. 2008. Methods for Estimating Litter Decomposition. US Forest Service. 8:103-111

Korhonen L, Korhonen KT, Rautiainen M, Stenberg P. 2006. Estimation of forest canopy cover: a comparison of field measurement techniques. Silva Fennica 40(4): 577–588.

Lauenroth WK, Hunt HW, Swift DM, Singh JS. 1986. Estimating aboveground net primary
production in grasslands: a simulation approach. Ecological Modeling 33:297–314.

Loreau M., et al. 2001. Biodiversity and ecosystem functioning: current knowledge and future
challenges. Science 294:804–808

Magurran AE. 1988. Ecological diversity and its measurement. Princeton Univ. Press, Princeton, N.J.

Mahler D and Walther J. 1987. The process of habitat restoration: with specific application to the upper Glen Rose geologicc formation of Central Texas.

Maugh TH. 1979. Burial is the last resort of hazardous wastes: solidification may reduce leaching problem, but new rules, financial requirements may make disposal in landfills prohibitively expensive. Science. 204:1295-1298.

Morrison ML, Marcot BG, Mannan RW.1999. Wildlife–habitat relationships: concepts and applications. J Mammal 80(4):1382–1385

O'Dell RE and Claassen VP. 2011. Serpentine: the evolution and ecology of a model system. University of California Press.

Önal H. 1997. Trade-off between structural diversity and economic objectives in forest management. Oxford journals. 79(3):1001-1012

Paletto, A and Tosi, V. 2012. Forest canopy cover and canopy closure: comparison of assessment techniques. European Journal of Forest Research. 128:265-272

Palmer MA and Filoso S. 2009. Restoration of ecosystem services for environmental markets. Science 325:575-576.

Passell HD. 2000. Recovery of bird species in minimally restored Indonesian thin strips mines. Restoration ecology. 8:112- 118.

Purcell AH, Friedrich C, Resh VH. 2002. An assessment of a small urban stream restoration project in northern California. Restoration ecology. 7:298-308

Robinson GR and Handel SN. 1993. Forest restoration on a closed landfill: rapid addition of new species by bird dispersal. Conservation biology. 7(2):271-278.

Schmid B, Balvanera P, Cardinale BJ, Godbold J, Pfisterer AB, Raffaelli D, Solan M, Srivastava DS. 2009. Consequences of species loss for ecosystem functioning: meta-analyses of data from biodiversity experiments. Oxford University Press. 14–29

(SER) Society for Ecological Restoration. 2004. The SER international primer on ecological restoration.

Shaw RB, Volman KC, Smeins FE. 1980. Modern pollen rain and vegetation on the Edwards Plateau, Texas. Palynology, 4:205-213.

Sheoran V, Sheoran AS, Poonia, P. 2010. Soil reclamation of abandoned mine land by Singh JS, Lauenroth WK, and Steinhorst RK. 1975. Review and assessment of various techniques for estimating net aerial primary production in grasslands from harvest data. Botanical Review. 41:181–232.

Smeins FE and Fuhlendorf. 1997. Biology and ecology of Ashe juniper. Texas Natural Resources Server.

Thornthwaite CW. 1948. An approach toward a rational classification of climate. Geogr. Rev., 38:55-94.

Weitzman ML. 1992.On Diversity. Quarterly Journal of Economics. 107:363- 406.
Whitney, M.I., 1952, Some zone marker fossils of the Glen Rose Formation of central Texas: Journal of Paleontology,v. 26, no. 1, p. 65–73

Worm B. 2015. Silent spring in the ocean. Proceedings of the National Academy of Sciences of the United States of America,112(38), 11752-11753.

Appendix J: Signage Manufactured or Purchased by Travis County TNR for Wild Basin Wilderness Preserve in FY 2019

Table 12. Signage Manufactured or Purchased by Travis County TNR for Wild Basin Wilderness Preserve in FY 2019

Type	Quantity	Dimensions	Status
Highway Sign	2	24” X 72”	Installed by TXDOT
Main entrance sign metal panel	1	36" X 72"	delivered but needs redoing
Main entrance top line, routed in wood backing	1	left 47.5" x 76"; right 40.5" x 76"; 1.5 in. thick	Not manufactured (needs scraping and repainting)
Main entrance icons	1	6" x 6"	on hold (not made)
Main entrance bottom board sign	1	6" height	on hold (not made)
Preserve Closed	2	6" height	installed
Call sheriff	1	Preferred 3' x 6" (to fit on gate arm)	installed
BCP sign	3	Same	delivered
Large "rules" signs	2	30" x 36" or larger	installed
Fragile area sign for creek	2	24" x 18"	delivered
Bus loading (NEW)	1	12" x 18"	delivered
Do not leave valuables, etc.	5	12" x 18"	installed
Security cameras in use	3	11' x 17" or 12" x 18"	installed
Delivery and handicapped parking	2	12" X 18"	installed
No bus turnaround	1	12" x 18"	delivered
Speed limit	3	24" X 18"	installed
No smoking icon and words	5	24" x 24"	installed
No pets	4	12" x 18"	installed
Daylight hours	3	24" x 24"	installed
Parallel parking	1	12" x 18"	delivered
Not accessible trail sign	2	24" x 24" or larger	installed
Trail to Falls Steep Grade	1	12" x 12"	delivered
Trail to Creek steep grade	1	12" x 12"	delivered
steep grades	1	12" x 12"	delivered
Preserve Full	1	6" height x 18"	delivered
Back gate sign	1	36" x 30"	delivered
Visitor Center sign	1	12" x 12"	installed