A. Current and Recent Projects

Last five years:

USGS Ecosystems Mission Area: United States - Mexico 1944 Water Treaty Research & Monitoring in the Colorado River Delta

- A1. <u>Minute 319</u>: Pulse Flow to the Colorado River Delta (the river forms the US-Mexico Border and then meanders through Baja & Sonora, Mexico, to the Sea of Cortez). <u>Role</u>: My role was to lead the remote sensing component of this USGS project; this role included measuring and bi-monthly remote monitoring of the Colorado River Delta ecosystems following the Spring 2014 Pulse Flows using remote sensing observations with shared ground-based information from the Delta Science Team. <u>Start & End Dates</u>: FY2014-FY2017. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), Land Management (Land Remote Sensing Program). <u>One sentence description</u>: With USGS/NASA satellite imagery, the Colorado River Delta's riparian vegetation was measured using metrics of greenup and water use that I created specifically for the riparian species and their evapotranspiration (ET) rates in this arid/semi-arid region south of Yuma, Arizona; time-series measurements from 2000 through 2017 using four vegetation indices from Landsat and the Moderate Resolution Imaging Spectrometer (MODIS) Terra and Aqua were used to provide results prior to the 2014 pulse flows and after the pulse flows through 2017, the end of the Minute 319 study, for comparison to see if the added environmental flows had impact on vegetation health. <u>Time</u>: N/A.
- A2. Minute 323: Measuring and monitoring of restoration sites and unrestored areas in the Colorado River Delta. Role: My role is to lead the remote sensing component of this USGS project; this role includes measuring and bi-monthly remote monitoring of the riparian ecosystem greenness and water use using primarily satellite imagery from Landsat for seven unrestored riparian reaches and more than a dozen restoration sites in the corridor of the Colorado River Delta. Start & End Dates: FY2018-FY2027. Funding Source: USGS Ecosystems Mission Area (EMA), Land Management (Land Remote Sensing Program). One sentence description: This project allowed me to apply my novel remote sensing algorithm for measuring ET (and vegetation greenness) to the unrestored reaches and the restoration sites, which are two metrics used in the Adaptive Management Plan and used to inform policy- and management-decisions regarding the utility of targeted water deliveries to native riparian sites and the successfulness of active restoration under different management and planting schemes; key contributions, published in three journals and two federal reports resulting from this study, showed for the first time, declines in the unrestored vegetation health over two decades (2000–2019), declines in trends between VI, ET and drought indices in riparian corridors, and increases in restoration site health which highlights the success of restoration and improved native vegetation habitat (2010-2021). Time: 30%.

USGS Ecosystems Mission Area: Biological Threats & Invasive Species Program

A3. <u>Invasive Species - Tamarisk</u>: Tamarisk Beetle Dispersion Model. <u>Role</u>: My role was to lead this USGS project; this role included measuring the rate of the tamarisk beetle (*Diorhabda* spp.) movement and track their spread / extent through riparian corridors using satellite remote sensing measurements of defoliation events on the Virgin and Lower Colorado Rivers. <u>Start & End Dates</u>: FY2015-FY2016. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), Invasive Species Program. <u>One sentence description</u>: This project allowed me to document the landcover extent and rate of movement of the tamarisk defoliating beetle, *Diorhabda* spp., southward, the number of defoliation episodes occurring in one year, and the length of the defoliation periods; a key contribution to the

literature from this study was that for the first time, my methods documented how fast the beetles moved through the riparian corridor. <u>Time</u>: N/A.

- A4. <u>Invasive Species Tamarisk</u>: Tamarisk Science to Inform Management Actions. <u>Role</u>: My role was to lead the remote sensing component of this USGS project; this role included using satellite measurements of riparian corridor plant health and landscape impacts from tamarisk beetle defoliation events to track changes in water use at the river-reach level and to determine if a shortwave infrared hyperspectral algorithm can be used to distinguish plant litter from soils in these dryland riparian landscapes. <u>Start & End Dates</u>: FY2017-FY2019. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), Invasive Species Program. <u>One sentence description</u>: This project allowed me to (i) distinguish defoliated tamarisk from both green vegetation and background soils using novel remote sensing methods including my own hyperspectral Cellulose Absorption Index, and (ii) evaluate beetle–tamarisk interactions with USGS/NASA satellite imagery on 13 river systems, with vegetation indices (VIs) used as indicators of the extent of defoliation and ET; a key contribution to the literature from this study was that for the first time, my methods documented that ET before beetle release (2000–2006) was higher compared to post-release (2007–2015) for a net reduction of 61 mm/year in ET a key finding because expectations were that the beetle would save up to 460 mm/year in ET. <u>Time</u>: N/A.
- A5. Invasive Species Tamarisk: Southwestern Tamarisk in the Upper and Lower Colorado River Basins: Challenges and Opportunities for Riparian Zone Management. <u>Role</u>: My role was to lead the remote sensing component of this USGS project; this role included acquiring and measuring two decades of riparian vegetation greenup and ET using satellite imagery fusion methods for tamarisk-invaded riparian corridors of select southwestern U.S. riparian zones and populating a prototype online data server for the end user community to evaluate change in areas of interest. <u>Start & End Dates</u>: FY2020. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), USGS Biological Threats & Invasive Species Program. <u>One sentence description</u>: This project allowed me to (i) determine an annualized ET using novel remote sensing methods from my own phenology assessment metric, and (ii) evaluate the riparian ecosystem on the Lower Colorado River (LCR, AC/CA border) for relationships between VIs, ET and drought indices; key contributions to the literature from this study were that for the first time, my methods documented declines in vegetation health over two decades (2000– 2020) from a loss in healthy canopy cover, indicating a deterioration of wildlife habitat, and that declining trends exist between VI, ET and drought indices in riparian corridors. <u>Time</u>: N/A.
- A6. Invasive Species Tamarisk: Salt Cedar Science and Tools to Support Successful Resource Management Action. <u>Role</u>: My role is to lead the remote sensing component of this USGS project; this role includes (i) the development of novel remote sensing algorithms for water use and a USGS/NASA imagery fusion approach for the measurement of riparian vegetation trends in southwestern U.S. riparian corridors, and (ii) population of the prototype online data server for the end user community to evaluate change in selected areas of interest. <u>Start & End Dates</u>: FY2021-FY2023. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), USGS Biological Threats & Invasive Species Program. <u>One sentence description</u>: This project allowed me to delineate riparian vegetation and restoration sites, adjacent agricultural lands, urban areas, and upland plant communities for all major rivers and streams in the Lower Colorado River Basin; two key contributions to the literature from this study (thus far) are the success of Reclamation's restoration sites in the LCR, indicating their importance for resource managers, and novel relationships between ET, VIs and drought indices in riparian corridors. <u>Time</u>: 30%.

Evapotranspiration and Groundwater Flux at Southwestern Uranium Mill Tailings Sites

A7. <u>Phytoremediation at Uranium Mill Tailings Sites</u>: Effects of Changes in Saltcedar Evapotranspiration on Groundwater Flow and Contaminant Transport at a Southwestern Uranium Mill Tailings Site

Using Unmanned Aircraft Systems at UMTRCA Sites in NM and UT. This project was a joint award between the USGS-SBSC, DOE Legacy Mine Program and the University of Arizona. <u>Role</u>: My role was to lead the remote sensing component of this USGS project; this role included acquiring Unmanned Aircraft Systems (UAS) / drone data over phytoremediation UMTRCA Sites in NM and UT that were selected by partners from the DOE Legacy Mine Program. <u>Start & End Dates</u>: FY2015-FY2017. <u>Funding Source</u>: USGS Unmanned Aircraft Systems (UAS) Program, Land Remote Sensing, and UAS pilots from USGS Flagstaff Remote Sensing Science Consortium Research (FRSSC) group. <u>One sentence description</u>: This project allowed me to (i) create a static map using the multi-band UAS imagery for discriminating live from defoliated tamarisk, and from other riparian species, on sites where phytoremediation is used by DOE and on a riparian nature preserve with only native species; a key contribution to the literature from this study was the successful creation of ET maps by vegetation community. <u>Time</u>: N/A.

- A8. <u>Applied Studies at Uranium Mill Tailings Sites</u>: Effects of Changes in Evapotranspiration on Ground Water at Southwestern Uranium Mill Tailings Sites. This project was awarded to the contractor of the DOE Legacy Mine Program at DOE with collaboration with USGS-SBSC. <u>Role</u>: My role was to scale ET from previously created UAS maps over phytoremediation UMTRCA Sites to USGS/NASA satellite products for the purpose of acquiring spatiotemporal information for the phytoremediation riparian sites. <u>Start & End Dates</u>: FY2018-FY2019. <u>One sentence description</u>: This project allowed us to (i) correlate ET flux estimates in the riparian growth on tailings sites with groundwater flux with a very high degree of accuracy; a key contribution to the literature from this study were the implications for managing groundwater contaminants using ET:GW dynamics. <u>Time</u>: N/A.
- A9. <u>Calibration of Evapotranspiration Estimates in a Semi-arid Sagebrush Steppe</u>: Creation of a revised ET algorithm for arid shrublands adjacent to Southwestern Uranium Mill Tailings Sites. This project was awarded to the contractor of the DOE Legacy Mine Program at DOE to collaborate with USGS-SBSC. <u>Role</u>: My role was to produce a revised ET algorithm using validation data from a large weighing lysimeter and satellite VIs. <u>Start & End Dates</u>: FY2019-FY2021. <u>One sentence description</u>: This project allowed us to (i) estimate vadose-zone ET at DOE waste disposal sites in the SW deserts; a key contribution to the literature from this study was the first VI-ET algorithm calibrated in a semi-arid upland plant community using field-scale lysimeters to accurately estimate spatially-explicit ET for monitoring and modeling efforts for studying recharge on flow and contaminant transport in underlying aquifers. <u>Time</u>: N/A.

USGS-FWS Science Support Partnership (SSP)

- A10. Population trends, extinction risk, and conservation guidelines for Ferruginous Pygmy-Owls in the Sonoran Desert. An assessment of abundance trends of pygmy-owls in northern Mexico across 17 years (2000-2016). Role: My role was to use myriad sources of satellite VIs at various plot scales to acquire fractional land cover and corresponding spatiotemporal trends across 14 watershed regions in the Borderlands region. Start & End Dates: FY2016-FY2018. Funding Source: USGS-FWS, Science Support Partnership (SSP), USGS Ecosystems Mission Area (EMA), Invasive Species Program. One sentence description: This project allowed us to evaluate the influence of temperature, precipitation, land-use and land-cover change, spatial variation in local habitat quality, and interactions among these factors on occupancy dynamics; a key contribution to the literature from this study was a federal report for wildlife managers focused on 1) protecting high-quality habitat, 2) enhancing and creating habitat (e.g., nest-cavity augmentation, riparian restoration), 3) reducing deleterious changes in land use and land cover, and 4) increasing landscape connectivity through both passive (e.g., landscape planning and restoration) and active (e.g., facilitated dispersal, translocations) techniques to enhance recovery prospects for pygmy-owls. Time: N/A.
- A11. <u>High-resolution Transboundary Vegetation Community Dynamic Map of the Sonoran and Mojave</u> <u>Desert Ecoregion to Support Critical Landscape Conservation Planning and Land Management</u>

<u>Needs</u>. <u>Role</u>: My role is to lead the Borderlands Mapping project and coordinate the roles of the USFWS and University of Arizona partners/co-PIs and lead the research teams of ground-truthing and remote sensing data collection; this role includes the preparation, presentation and dissemination of all products. <u>Start & End Dates</u>: FY2020-FY2022. <u>Funding Source</u>: USGS-FWS, Science Support Partnership (SSP), USGS Ecosystems Mission Area (EMA), Biological Threats & Invasive Species Program. <u>One sentence description</u>: This project allows for the analyzation of vegetation dynamics and phenological phenomena presented by the different plant communities, including using shifts in vegetation indices (VIs) measured from myriad sensors to capture the onset of greenup, peak summer growing season and senescent periods and discriminate plant communities based on shifts in phenology depicted by the different plant types. <u>Time</u>: 30%.

Navajo Nation

A12. <u>Riparian Ecosystem Evapotranspiration and Consumptive Use Analysis for Navajo Nation (NN)</u> <u>Lands within the Little Colorado River Watershed in Arizona</u>. <u>Role</u>: My role is to lead the project and coordinate activities under the Technical Assistance Agreement (TAA) so that consumptive use estimates for riparian lands within the Little Colorado Watershed are produced for use by the NN Attorney General and Natural Resources Department for management and policy-decisions. <u>Start &</u> <u>End Dates</u>: FY2021-FY2022. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), Biological Threats & Invasive Species Program. <u>One sentence description</u>: This project allows me to (i) provide an estimate of river and stream vegetation, riparian greenness and phenology, on the NN, (ii) acquire data inputs necessary to estimate actual ET for riparian plant communities by height class (grasses, shrubs, trees) using Landsat OLI (30m) data from 2013-2021, and (iii) produce actual estimates of ET and consumptive water use for delineated regions of interest on the NN. <u>Time</u>: 10%.

USGS EarthMap

A13. <u>A Drought Data Explorer for the Colorado River Basin: Integrated and Dynamic Web-Based Delivery</u> of Actionable Information. This idea stemmed from an EarthMap Use Case created by SBSC Terrestrial Dryland Ecosystems (TDE) scientists involved in drought & climate change research in drylands with the focus being an EarthMap product and/or database of drought impact on Colorado Basin ecosystems. <u>Role</u>: My role is to provide guidance, knowledge and experience from creating the Riparian Data Explorer for application to the Drought Data Explorer by assisting with technical design ideas, information, end-user interest and exchanges, and sharing of data I've produced, such as from Data Releases, as well as assisting with stakeholder lists and outreach tasks. <u>Start & End</u> <u>Dates</u>: FY2021. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), RMR Earthmap. <u>One</u> <u>sentence description</u>: The Drought Data Explorer project is developing computing and information management workflows and tools to connect scientists and stakeholders in the Colorado River Basin. <u>Time</u>: N/A.

https://usgs.maps.arcgis.com/apps/Shortlist/index.html?appid=953fe75a426a4fea95d804382687b8d8

A14. Evapotranspiration Estimates for Riparian Vegetation Along the Lower Colorado River. Science findings from several Nagler et al. studies were used for an EarthMap Presentation for the Colorado River Basin Pilot Study. <u>Role</u>: My role is to share data collected from the riparian regions of the Lower Colorado River Basin to broaden the EarthMap vision. <u>Start & End Dates</u>: FY2021. <u>Funding Source</u>: USGS Ecosystems Mission Area (EMA), RMR Earthmap. <u>One sentence description</u>: This project uses a compilation of my research findings on riparian vegetation health and ET which showed declines in unrestored reaches of the Lower Colorado River and its delta; a key contribution to the literature will include the Rocky Mountain Region (RMR) 2020 Science Exchange Circular

(USGS OFR), A Collection of Science Findings from the Colorado River Basin Pilot. <u>Time</u>: N/A. <u>https://usgs.maps.arcgis.com/apps/Shortlist/index.html?appid=953fe75a426a4fea95d804382687b8d8</u>

Data Explorer for Dynamic Mapping & Monitoring for Researchers, Stakeholders, & Partners

- A15. Interactive Remote Sensing "Colorado River Delta" Data Explorer An Online Platform in Support of the Colorado River Delta Ecosystems. Role: My role has been to create data for the public end-users for all of my projects with approved USGS Data Releases and provide this data to the public (end users) through a searchable, interactive Data Explorer. I have partnered with the University of Arizona, Vegetation Index and Phenology (VIP) Lab which specializes in remote sensing and data analytics to build a processing pipeline based on the full record of USGS/NASA satellite sensors from the year 2000 to present, to create a prototype data server for my research output focused on ecosystems monitoring, change detection, and general spatial analyses, and to deploy the Data Explorer prototype for estimating land cover community, phenology changes, and ET (based on Nagler algorithms as well as thermal-based ET) of the region and associated changes with dynamic vegetation cover, especially pertinent to riparian woodland ecosystems. Start & End Dates: FY2018-Present. Funding Source: USGS Ecosystems Mission Area (EMA), Land Management and Invasive Species Programs. One sentence description: This project provides the processed and final ready-to-use VIs, greenness, phenology, and water use data and plotting tools for the full record of USGS/NASA satellite sensors from the year 2000 to present for end-users to query the Colorado River delta riparian ecosystem, its wetlands and estuary, as well as all active restoration sites. <u>Time</u>: N/A.
- A16. Interactive Remote Sensing "Riparian" Data Explorer Online Platform in Support of Riparian Ecosystems on the Lower Colorado Basin Rivers. Role: My role has been to create and provide data for the public (end users) through a searchable, interactive Data Explorer. Start & End Dates: FY2019-Present. Funding Source: USGS Ecosystems Mission Area (EMA), Land Management and Invasive Species Programs. One sentence description: This project is an extension of the Colorado River Delta Data Explorer and provides the processed and final ready-to-use VIs, greenness, phenology, and water use data and plotting tools for the full record of USGS/NASA satellite sensors from the year 2000 to present for end-users to query; this project requires the discrimination and delineation of riparian ecosystems for all rivers and streamside vegetation in Arizona and future work is required to further divide the native from the non-native species and to identify areas of detectable defoliation to monitor the impact of the tamarisk beetle (*Diorhabda* spp.). Time: N/A.
- A17. Interactive Remote Sensing "Borderland Avian Habitat" Data Explorer Online Platform in Support of the Borderlands Transboundary Vegetation Dynamic Maps in the Sonoran and Mojave Desert Ecoregions for Bird Conservation Region #33. Role: My role has been to create and provide data for the public (end users) through a searchable, interactive Data Explorer. Start & End Dates: FY2019-Present. Funding Source: USGS Ecosystems Mission Area (EMA), Invasive Species Programs. One sentence description: This project is an extension of the Riparian Data Explorer and provides the processed and final ready-to-use VIs, greenness, phenology, and water use data and plotting tools for the full record of USGS/NASA satellite sensors from the year 2000 to present for end-users to query; this project will create and provide a high-resolution reference map of vegetation community, to support land management and conservation planning in Sonoran and Mojave Desert ecosystems. Time: N/A.

A18. Interactive Remote Sensing "Little Colorado River Watershed" Data Explorer Online Platform in Support of the Navajo Nation's tributary and stream vegetation monitoring. Role: My role has been to create and provide data for the public (end users) through a searchable, interactive Data Explorer. Start & End Dates: FY2019-Present. Funding Source: USGS Ecosystems Mission Area (EMA), Invasive Species Programs. One sentence description: This is a nexus project of the Riparian Data Explorer and provides the processed and final ready-to-use VIs, greenness, phenology, and water use data and plotting tools for the full record of USGS/NASA satellite sensors from the year 2000 to present for end-users to query; this project requires the discrimination and delineation of riparian grasslands, shrubs, trees and wetlands along tributary streams and springs of the Little Colorado River Watershed, and future work is required to further divide the native from the nonnative species and to identify areas of detectable defoliation to monitor the impact of the tamarisk beetle (*Diorhabda* spp.). Time: N/A.