

2019 NPS FUTURE PARK LEADERS OF EMERGING CHANGE INTERNSHIP PROGRAM



PI ACCOMPLISHMENT REPORT

DECEMBER 31, 2019

Submitted by the University of Washington
Principal Investigator: Lisa J. Graumlich

Introduction:

The University of Washington was proud to partner with the National Park Service (NPS) in co-sponsoring the NPS Future Park Leaders of Emerging Change (FPL) Internship Program for a fifth year in the summer of 2019. The FPL is a competitive internship program in which high-achieving undergraduate and graduate students conduct rigorous and innovative projects to address high priority climate change management challenges in NPS park and program offices. The FPL is an approved Direct Hire Authority: interns who successfully complete the FPL and the requirements of their academic degree program are eligible for noncompetitive hiring within the U.S. Department of Interior.

The UW housed the FPL program website and application system, hired the interns as UW employees so that they were covered by liability insurance, and ensured their compensation. NPS solicited the parks for project proposals, selected the projects, and then conducted the review, interviewing, and selection of the interns.

NPS selected the following ten internship project proposals submitted by:

- Biscayne National Park, Florida
- Congaree National Park, South Carolina
- Golden Gate National Recreation Area, California
- Katahdin Woods and Waters National Monument, Maine
- Mount Rainier National Park, Washington
- Night Skies and Natural Sounds, Colorado
- Organ Pipe Cactus National Monument, Arizona
- Saguaro National Park, Arizona
- Voyageurs National Park, Minnesota

Recruitment:

The University of Washington and the NPS Climate Change Response Program (CCRP) distributed the program announcement widely including using email listservs to reach faculty advisors and students, posting it on various environmental organizations' websites, sending materials to conferences with UW College of the Environment advising representatives, and networking with federal agencies and educational institutions.

The UW launched the call for student applications on the FPL website <http://futureparkleaders.org/>.

The University of Washington sent the announcement to:

- Past FPL interns from academic institutions throughout the United States

- Past reviewers from academic institutions, federal agencies, and non-profit groups throughout the United States; these were reviewers who had served with an earlier NPS fellowship program.
- A list of organizations and academic institutions across the United States who serve under-represented minorities (i.e., Historically Black Colleges and Universities, Hispanic serving institutions, tribal academic institutions).
- The UW Office of Minority Affairs
- All College of the Environment advisors, sent out by the UW College of the Environment Dean of Academic Affairs and Diversity
- All UW academic advisors across the campus with emphasis on the College of Arts and Sciences
- Colleagues of the Dean of the UW College of the Environment

In addition, the program announcement was posted on the National Council for Science and Environment (NCSE), Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), and Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS) websites.

One of the UW College of the Environment Academic Affairs staff distributed the program announcement at the annual SACNAS conference to interested students and advisors. Emails were also sent to the university academic advisors whose names were collected from a previous SACNAS conference.

Materials were distributed at the annual American Indian Science and Engineering Society (AISES) conference in Spokane, WA.

JISAO (the Joint Institute for the Study of the Atmosphere and Ocean) in the College of the Environment runs a summer internship program with a focus on increasing diversity in STEM fields. They shared their contact list for faculty and advisors at colleges and universities across the United States including Morehouse College, Howard University and University of Puerto Rico.

Recruitment done by NPS was impacted by the shut-down of the federal government for several weeks during the open-application period when their staff could not work. The UW continued to respond to students' questions about the program and the application process including a number of inquiries about the possible impact on the internships from the government shut-down. Fortunately, our colleagues at NPS returned to work about the same time as the application deadline and the program proceeded as planned.

Summer 2019:

We received 203 applications from graduate students, upper-level undergraduate students (juniors and seniors), and recent graduates. The CCRP from NPS convened ten separate panels consisting of (at minimum) the park/program supervisor and a representative from the CCRP to review anywhere from 20-50 student applications for each project. They conducted interviews by phone or in-person with the top two to four candidates and then made the awards to the selected interns by mid-March, 2019. The interns were selected from universities all across the United States and they represented a diversity of age (18-33 years) and gender (62% female). The 2019 cohort identified as 27% minority or multi-racial background (an increase from 8% in 2018).

During their summer internship, students were temporary hourly employees of EarthLab in the UW College of the Environment. The UW FPL program manager initiated and provided oversight to the hiring process, ensuring that the interns smoothly navigated the process and completed their onboarding tasks and training as required. They also updated the FPL Internship Handbook to reflect the most current UW policies and procedures regarding timesheets, benefits, safety requirements and training, best practices in conducting field work, and more.

NPS and the UW collaborated to provide project supervisors and interns with an orientation to the both the FPL Initiative and to the UW's employment benefits and requirements by conducting two separate webinars: Supervisor Orientation, and Student Orientation. The program manager collected interns' health insurance information/documentation, and helped troubleshoot some thorny issues that arose, including securing the UW Diving Board's certification of the Biscayne National Park project intern, and the question of interns' liability coverage when driving government vehicles. They provided on-going support throughout the summer on issues including human resource questions, timesheet reporting, health or injury concerns, housing, and project-related costs and travel. Interns received reimbursements through EarthLab for their housing, travel, and other project-related expenses.

EarthLab provided logistical support to the annual FPL Professional Development Symposium held August 6-9, 2019 in Fort Collins, CO. The program manager organized the interns' lodging, the symposium catering, and all intern travel to and from the gathering. EarthLab processed the interns' travel reimbursement requests, and handled payments to the various symposium vendors.

The FPL interns completed their projects between May and September of 2019. Both interns and their NPS supervisors provided very positive feedback regarding their interactions with the online application and reviewer systems, and especially with the wide-ranging support provided by the UW over the course of the summer.

Financials:

The budget for the Summer 2019 FPL program was \$196,857 which included funds carried forward from 2018 plus a NPS supplement of \$12,287. All funds were expended as projected. Please see attached budget spreadsheet for details.

Conclusion:

The summer of 2019 concludes the UW's nine-year partnership with our colleagues at the NPS CCRP including Cat Hoffman, Melanie Wood, Larry Perez, and many others over the years. It has been exciting to be part of the evolution of a program that began as fellowships for graduate students, to becoming a paid internship with Direct Hire Authority for both undergraduate and graduate students. Students who have participated in this program have gone on to serve in federal government and academic positions around the United States where they are contributing in significant ways to the work of climate change and the challenging environmental problems of our day. We at the UW are grateful for the opportunity we have had to help support the education and development of the next generation of scientists and researchers, and to begin to foster increasing diversity and inclusion in environmental field

UW EarthLab

Sponsor: *National Park Service*

PI Name: *Lisa Graumlich*

NPS Future Park Leaders of Emerging Change Initiative				
Summary of Expenditures 2019 Summer Internships: 10/1/18 - 9/26/19				
11/26/19		RATES 2018-19	Months FTE/ Total Hours	Total
01 SALARIES AND WAGES				
01-10 Faculty/Postdoc			0.00	\$0.00
Total Faculty/Postdoc:				\$0.00
01-60 Classified Staff				\$0.00
Finance Specialist	Denneen Chambers			\$1,763.00
Total Faculty/Postdoc:				\$1,763.00
01-70 Professional Staff				
Business Intelligence Analyst	Spencer, Davina	\$8,837.00	0.20	\$1,757.35
Program Administrator	Karpov, Adrienne	\$7,344.00	3.25	\$23,716.00
EarthLab Administrator	Mary Dwyer			\$1,143.00
Assoc. Dean, Administration	Stephanie Harrington	\$16,250.00	no cost	\$0.00
Total Professional Staff:				\$26,616
01-80 Hourly				
Internship Salaries (for 10 internship positions)		Rate :	No. of Interns:	\$0.00
(based on 12 weeks/40 hrs. per week/\$16 per hr = \$7680)		\$7,680.00	10.00	\$74,412.00
Total Hourly:				\$74,560.00
TOTAL SALARIES AND WAGES:				\$102,939

	Estimates	Actuals
03 OTHER CONTRACTUAL SERVICES		
UW Temporary Services Salary (Gabrielle Denby, Fiscal Specialist)		\$741.24
Recruitment/Advertising costs	\$5,000.00	\$125.00
Intern Housing Stipend (Julia Larson)	\$0.00	\$1,161.00
Medical Tests for Biscayne N.P. Intern		\$1,752.00
Background Checks	\$820.00	\$425.00
Refreshments for 3-Day annual symposium	\$300.00	\$444.41
TOTAL OTHER CONTRACTUAL SERVICES:		\$4,648.65

04 TRAVEL				
<i>(Lodging, meals, and airfare/travel, based on previous years' costs)</i>				
Intern travel to Symposium (based on est. to Ft. Collins, CO)	\$1,400.00	No. of travelers:	10.00	\$12,069.81
Intern project-supported travel (to project duty station, project-related)	\$1,100.00		3.00	\$8,734.42
UW Staff travel to attend Symposium	\$1,100.00		2.00	\$0.00
Intern Housing Stipend Fund (see chart below)				\$8,643.00
TOTAL TRAVEL:			\$29,447.23	

05 SUPPLIES AND MATERIALS				
JUMP Application System (student applications/review system)				\$4,932.48
Food and Snacks for Symposium				\$52.40
SACNAS Job Posting				\$137.63
2018 program charges covered in 2019				\$220.00
TOTAL SUPPLIES AND MATERIALS:			\$5,342.51	

07 RETIREMENT & BENEFITS (FRINGE)				
FY 2019 rates				
Faculty/Postdocs (01-10)	26.10%			\$0.00
Graduate RA's (01-30)	17.30%			\$0.00
Classified (01-60)	40.50%			\$714.02
Professional Staff (01-70)*	34.10%			\$8,862.78
Hourly (01-80)	20.90%			\$15,583.04
TOTAL RETIREMENT & BENEFITS:			\$25,160	

*Professional Staff rates changed 7/1/19 to 32.1%
<http://finance.uw.edu/fr/fringe-benefit-load-rate>

08 STUDENT AID/ TUITION				
tuition not subject to IDC				
TOTAL STUDENT AID/ TUITION (not subject to IDC):			\$0.00	

Total Direct Costs (TDC): \$167,537.58
Less costs not subject to IDC: \$0.00
Modified Total Direct Cost (MTDC) Base: \$167,537.58

25 INDIRECT COSTS				
CESU Rate:	17.5%			\$29,319
TOTAL INDIRECT COSTS:			\$29,319	

TOTAL PROJECT COSTS: \$196,857

Attachment A: Project Summaries

The following pages provide brief summaries for each 2019 FPL project. Detailed reports and additional materials are available upon request to Climate_Change@nps.gov.

Project Summary	Page
Biscayne NP, Amelia May	7
Congaree NP, Shea McCarthy	11
Golden Gate NRA, Leah Campbell	15
Katahdin Woods and Waters NM, Fernando Casal	17
Mount Rainier NP, Rachel Fricke	19
Natural Sounds and Night Skies Division, Julia Larson	22
Olmsted Center for Landscape Preservation, Erika Welch	24
Organ Pipe Cactus NM, Claudia Silver	26
Saguaro NP, Jessie Pearl	29
Voyageurs NP, Ashley Wilson	31

Cataloguing Coral Disease in Biscayne Bay

By: Amelia May

Abstract:

After the onset of stony coral tissue loss disease in Biscayne National Park, little reconnaissance of injured reefs has been conducted. A new protocol for assessing damage to corals on a reef is developed and set into practice. This new protocol allows for data to be collected in a way such that multiple agencies tracking similar information can use this data.

Problem Statement:

Following the outbreak of stony coral tissue loss disease in the Florida reef tract, multiple jurisdictions responded with conservation efforts. These experimental efforts were largely uncoordinated, and based on very little knowledge of the disease, and more importantly, the state of the reef following the disease. Data records for the endemic zone, where the disease has already passed through, is sparse and inconsistent. This poses a problem for researchers trying to compile data.

Project objectives:

The purpose of this project was to begin a cataloguing system to tract endemic reefs for the purpose of future conservation and restoration. Creating a standardized system for surveying reefs was a primary goal. This survey was designed to include stony coral tissue loss disease prevalence, along with bleaching trends and presence of other coral diseases. By quantifying the prevalence of the tissue loss disease, conclusions can be made about what areas should be targeted for restoration purposes. Focuses include finding individual corals that would be healthy candidates for reproduction or fragmentation, which will be done by using size data for healthy 'susceptible' coral species. Additionally, the survey can begin to identify reef areas which have potential for out-planting of young corals by comparing prevalence of the disease and health of coral populations post-disease. This project also allowed for collaboration between other research teams, included marine debris cleanup, lionfish culling, and BACI fish and benthic life surveys.

Approach and Methods:

The data sheet utilized by this project was created by modifying a previously used datasheet to include bleaching characteristics and presence of other coral diseases. Data was collected via roving diver survey. These surveys were opportunistic throughout Biscayne National Park but did represent a variety of reef habitats. The diver was tasked with identifying coral species and recording them with the corresponding four-letter field ID code found on the data sheet. The diver was not constricted by a specific area search, and did not mark distances or areas size surveyed. The diver recorded the total time surveyed, as well as the coordinates for the location of each individual survey. The diver was encouraged to take photographs of species exhibiting the disease, as well as comment on any anomalous findings on the reef. Coordinates were analyzed against a Google Maps program to determine the habitat that was surveyed at

each site. Data analysis included prevalence of the tissue loss disease in both susceptible and non-susceptible species, range of habitats surveyed, and in the future, health of the reef surveyed. Surveys and analysis will be continued to help build an understanding of reef health following a disease event.

Results of the Internship:

A total of 37 surveys were conducted in Biscayne National Park. This data was recorded for further analysis by future interns or personnel at the park. Some preliminary analysis of data found that even 5 years after the outbreak of the disease, prevalence in susceptible species is still high, especially in corals which are affected quickly by the disease. This is problematic for restoration efforts for susceptible species, as corals should be disease free when taking spawn or fragments for reproduction efforts. Despite this, healthy susceptible corals recorded are important for restoration efforts as they have seemingly survived this disease outbreak. It was also found out of 11 'non-susceptible' species, nearly half showed stony coral tissue loss disease. The species that showed disease had relatively high prevalence percentages, which does not bode well for local reefs. This data collection method can now be used for future interns and surveys. The data collected can also be added to databases of outside agencies researching the disease. These survey data provide a snapshot of coral life, post disease outbreak, that will allow conservationists to pinpoint candidates for future projects.

Recommendations:

Allow the intern or individual time to process their dive clearance from the employing agency far before the start of the internship. Allow access to a flexible schedule where the intern can join multiple dive teams in order to access a multitude of reef types. If possible, have the intern compare their data to data at a previous season or significantly different weather pattern than their data was collected (eg. Winter data vs summer data). Plan as much as possible for the intern to partake in outside-park activities in order to collect data from different reef areas. Comparing a 5 year endemic reef to a 3 year endemic reef may allow for information or trends about the disease presence after the initial infection. To increase sample size, train other workers in coral identification a prerequisite for the survey and have them join the intern. Equip all surveyors with a camera, and discrete instructions on picture taking so that, if necessary, the intern can cross reference survey data to photographic evidence.

Project Deliverables, see attached:

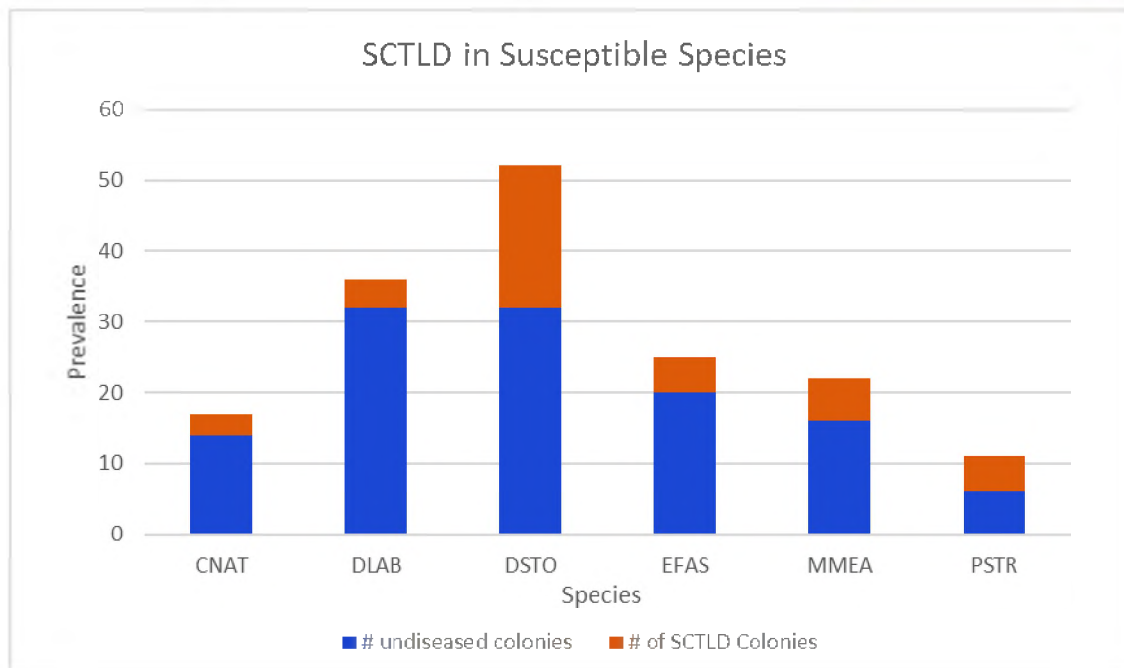
- Data sheet for roving diver survey

- Graphs showing trends based on analyzed data

- *Database showing all collected data (at supervisor discretion)

Observer:		SITE:		Latitude:	
DATE:		Time Surveyed:		Longitude:	
SPECIES	Diseased		Non-Diseased <10 cm	Non-Diseased 10-30 cm	Non-Diseased >30 cm
CNAT	Other:	SCTLD:			
DLAB	Other:	SCTLD:			
DSTO	Other:	SCTLD:			
EFAS	Other:	SCTLD:			
MMEA	Other:	SCTLD:			
PSTR	Other:	SCTLD:			
ALAM	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
DCYL	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
FFRA	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
MALI	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
MANG	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
MAUR	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
MCAV	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
MFER	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
MLAM	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
OANN	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
OFAV	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
OFRA	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
PCLI	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
SINT	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N
SSID	Present: Y or N	SCTLD:	Disease Other:	P PB BL:	Present: Y or N

Species	Count of SurveyID	Count of SCLTD#	% of SCLTD
ALAM	33	16	48%
DCYL	33	0	0%
FFRA	33	0	0%
MALI	33	5	15%
MANG	33	0	0%
MAUR	33	8	24%
MFER	33	0	0%
MLAM	33	0	0%
PCLI	33	1	3%
SINT	33	27	82%
SSID	33	33	100%



Bacterial Water Quality Monitoring as Citizen Science Congaree National Park

Shea McCarthy

Future Park Leaders of Emerging Change Intern, 2019

I. Overview

Congaree National Park (CONG) has the largest intact old-growth bottomland forest, with swampland and floodplains that are regularly flooded by rivers and creeks. Park staff, volunteers, and visitors are regularly put in contact with recreational waters, and there are concerns of fecal bacterial contamination in park waters. To benefit water quality, maintain ecological significance, and protect human health, this summer internship project was based on creating and implementing a bacterial water quality monitoring program that can continually be executed as citizen science.

II. Problem Statement

Multiple river and creek systems run through Congaree National Park and the land also regularly receives runoff and waters from neighboring rivers. CONG waters have great ecological significance and greatly contribute to visitor experience. Due to the importance of water quality to the park, improvement of water quality monitoring is in the top 20% of priorities for the CONG five-year strategic plan. There are specifically concerns with bacterial contamination due to upstream industrial, residential, and agricultural wastes as well as from a non-native mammal population in the park.¹ Bacterial contamination in recreational waters of CONG are a concern for both water quality degradation and human health. Specifically, the risk of fecal coliform bacteria contamination can cause serious illness in humans.²

III. Objectives

The overall objective of this summer internship project was to develop and establish a bacterial water quality monitoring program in Congaree National Park. Due to staffing and resource limitations, there was currently no regular water quality monitoring being conducted directly by the park and of the recent water quality testing done by other groups in and around the park, none included bacterial parameters. This developed program regularly tests for total coliform and E. coli bacteria concentrations at multiple sites within CONG, mainly along Cedar

Creek which is an ecologically significant waterway, but is also listed as an impaired water. Sample testing results are documented to monitor changes in bacteria concentrations and how they are related to factors such as precipitation events or seasonal changes.

In order to bypass the issue of staffing limitations and create a sustainable program that can be continued in the park, this water quality monitoring program was developed and executed as a citizen science project. CONG has a large and enthusiastic base of volunteers that are regularly involved with park projects. Executing this monitoring program as citizen science and allowing for volunteer participations creates potential for this project to continue following the completion of the summer internship. To make this possible, project objectives also included creating and compiling documents to guideline the continuation of bacterial water quality monitoring.

IV. Approach

In order to create and execute this project, the intern completed extensive background research regarding relevant water quality monitoring projects, methodology for water sampling and bacteria testing, and the development of citizen science programs. Throughout the internship, several rounds of water sample collection and bacteria concentration testing were completed to practice and optimize the methodology. There was also partnership with USGS staff throughout the project as they collected samples for a molecular source tracking project in tandem with sample collection for this bacteria concentration testing. USGS partners also provided literature for similar bacteria testing projects to reference for laboratory methodology. Bacteria testing was completed in the park's Learning Center using the IDEXX Colilert system which includes two nutrient indicators that give quantifiable concentrations of both coliform bacteria and *E. coli* in water samples. This method is relatively simple and does not require extensive laboratory experience, which makes it accessible to citizen scientists.

The developed plan was edited and revised in collaboration with the internship supervisor and other park staff based on resources, funding, and volunteer availability. The intern executed volunteer training sessions in which participants were given background information about the project and were guided through water sample collection, bacteria testing, best laboratory practices, and sample results reading. With the completion of the volunteer training program, citizen scientists are informed and prepared enough to conduct bacterial water quality monitoring for this program.

V. Results

Following the volunteer training sessions, feedback and conversation with participants showed significant interest in the continuation of the program. There has also been additional interest voiced by other park volunteers that want to be involved in the future. Based on these experiences and feedback, a revised program plan and a training manual document have been created for the use of park staff and volunteers to conduct additional volunteer trainings and citizen science sampling events.

Sample results from bacteria testing give most probable number (MPN) results which quantify the most probable number of colony forming bacteria in a 100 mL sample. This test gives concentrations for both total coliform bacteria and *E. coli*.³ The South Carolina Department of Health and Environmental Control (SCDHEC) provides a standard for *E. coli* in freshwaters to not exceed 349/100 mL in a single sample.⁴ A few sites exceeded this standard and most sites came close to it at least once. The highest bacteria concentration results were almost always found directly after a precipitation event. Sample results also showed that high concentrations of total coliform bacteria were not indicative of higher *E. coli* concentrations and therefore cannot be predictive of *E. coli*. For each sampling event, the Cedar Creek water level as measured by the USGS static gage was noted in order to compare water level to bacteria concentrations.⁵ It is important to monitor this association, as it could show that precipitation events are predictive of harmful bacteria levels in this area.

VI. Recommendations

With the use of the developed program plan, it is highly recommended that Congaree National Park continue monitoring bacterial water quality with the use of these documents. The program plan outlines the resources, scheduling, and planning required for sampling events and the necessary steps to complete them. The training manual provided outlines the expectations for participants and step by step instructions needed to complete a sampling event.

With the continuation of sample collection, park staff or a volunteer with computer access at the park should continue to record sample results in a document, created by the intern, that includes each sampling event and its bacteria concentration results. This document is stored internally to the park to be monitored by park staff and information can be shared with volunteers and visitors. This information should continue to be monitored to seek patterns of bacterial contamination in repeated sample sites for a better understanding of bacteria

concentrations and potential health risks. This information will also allow for additional analysis of bacteria concentrations as they are related to precipitation events and seasonal changes. Based on research from previous projects and the efficiency of the program, it is recommended that bacterial water quality monitoring be conducted at 3-5 sites on Cedar Creek and other tributary systems at a frequency of about every 1-2 months. During the late Spring and Summer months, however, it is suggested that sampling be completed at least once a month as recreation along Cedar Creek is more common.

VII. Deliverables

The aforementioned deliverables from this internship program are separately attached. Among these documents are a research summary of relevant topics, a bacterial water quality monitoring program plan, a volunteer training manual, and a results table from Summer sampling events.

VIII. Works Cited

1. National Park Service. (2019, May 30). Congaree National Park. Retrieved July 2019, from National Park Service: <https://www.nps.gov/cong/index.htm>
2. CDC. (2014, December 1). Escherichia coli. Retrieved from Centers for Disease Control and Prevention: <https://www.cdc.gov/ecoli/general/index.html>
3. IDEXX. (n.d.). Colilert. Retrieved from IDEXX: <https://www.idexx.com/en/water/water-products-services/colilert/>
4. South Carolina Department of Health and Environmental Control. (2014). R.61-68 Water Classifications & Standards. Columbia, SC: SCDHEC.
5. US Geological Survey. (2019). USGS 02169672 Cedar Creek at Congaree NP Near Gadsden, SC. Retrieved from National Water Information System: Web Interface: <https://waterdata.usgs.gov/nwis/uv?02169672>

SHORELINE CHANGE MONITORING PROTOCOL AND SOPS at GOLDEN GATE NATIONAL RECREATION AREA

Overview

I developed a formal monitoring protocol and SOPs to guide the collection and analysis of topographic data to inform coastal adaptation planning in light of sea level rise and increasing flood risk at Golden Gate NRA. Data was collected from two priority sites in Marin County to establish baseline conditions.

Problem Statement

Coastal parks are increasingly threatened by sea level rise and climate change-driven flooding, which poses a threat to park infrastructure, facilities, and natural resources. These challenges are particularly acute at Golden Gate NRA, where the park's nine miles of sandy beach typically abuts semi-urban development and draws some of the largest crowds in the national park system. This limits the potential of landward migration of park infrastructure and ecosystems and restricts the use of other traditional adaptation strategies, particularly at some of the park's more remote sites.

Objectives

In response to the park's pressing coastal challenges, coupled with the relative lack of information about some of these sites, a 2017 Resource Stewardship Strategy identified the development of a beach geomorphology monitoring program for Marin County beaches as a high priority activity. Marin County was chosen given that these beaches are considered some of the most vulnerable communities in the Bay Area to sea level rise and climate change-driven flooding. Stinson Beach, specifically, was also identified as a priority site in the park's Climate Action Plan and has been the focus of county-level climate change adaptation planning efforts.

Developing a comprehensive monitoring program would help the park gather consistent, reliable data on shoreline position and seasonal and annual variation in beach width. This, in turn, would provide valuable information on shoreline migration, erosion rates, and coastal sediment supply in order to help the park effectively manage coastal sites and engage in climate change adaptation efforts. Specific objectives included assessing the park's existing monitoring efforts, becoming familiar with similar protocols from other parks, and formalizing a monitoring protocol and standard operating procedures (SOPs) that incorporates best practices, but also meets park needs and accommodates existing resources.

Approach

The first step of the project was data collection, in which I was introduced to the technology, different surveying techniques, and the park's existing, ad hoc monitoring protocol. Once I developed an understanding of our current approach, I was able to review similar protocols and SOPs from within the park system and the USGS to refine and formalize that approach. This new approach was tested out by collecting pilot data at Stinson Beach. Data was collected using real-time kinematic surveying by walking with a GPS-retrofitted backpack to collect high-precision elevation and position data across the beach and along any prominent morphological features.

After data collection, I used existing Muir Beach data to develop analysis techniques and products for both Muir and Stinson Beaches that would be both useful and usable by the park and partner organizations. Using Excel, ArcGIS, and specialized survey software, I developed plots and maps showing landward shoreline migration, cross-sectional beach morphology, and elevation loss, as well as templates to aid future analysis. Finally, I put all of this information onto paper in the form of a monitoring protocol and SOPs.

Results

The primary product of this project was a protocol and SOPs that incorporate best practices from other monitoring programs, but places monitoring firmly in the context of Marin County and Golden Gate NRA. The protocol outlines the conceptual framework, overarching objectives, and sampling and analysis design of the monitoring program. It is meant to be a more permanent document that can broadly guide monitoring efforts and inform any future changes in response to new questions or management challenges. The SOPs provides step-by-step instructions for mission planning, conducting the survey, analysis and reporting, and data management. These are to ensure that data is collected and managed in a formal, reliable manner year-to-year to ensure consistency between surveys and facilitate inter-annual comparisons of data.

Field work and analysis also provided preliminary information on the geomorphic processes underway at these beaches. We see widespread and extensive beach loss and landward shoreline migration at Muir Beach over the winter, despite it not being a particularly stormy year. At Stinson Beach, we see that the beach is far more regular across its length and width, but that there are places where the dunes are unstable, and the erosion is more rapid.

Recommendations

Near Term

- Test out the protocol and SOPs in the field during the Fall 2019 surveys. Refine the documentation as needed.
- Prepare the protocol for publishing on the Inventory and Monitoring Program site and go through the necessary review process. Most of the necessary information is there but may need to be reorganized or reframed to fit I&M guidelines. Having it published will help others coastal parks develop their own monitoring programs based on GGNRA's work.

Intermediate Term

- Work with the County on an information-sharing protocol to ensure that analysis and reporting is done in a way that is most useful for them. Ensure that this information is used during any potential future dune restoration work.
- Present this information at the next Stinson Summit meeting to ensure that the information is usable by park staff and partners. Ensure that those working on the parking lot improvement project, in particular, have access to and utilize this information in their planning process.

Longer Term

- As technology improves and needs potentially evolve with greater data availability, investigate other possible collection and analysis methods. The most obvious avenues for protocol improvement include incorporating data collection with UAVs (drones) or ATVs to increase efficiency.

Deliverables

1. Final protocol and SOPs draft
2. Muir Beach Survey Area Site Map
3. Muir Beach Survey Map (May 2019)
4. Muir Beach Shoreline Change Spreadsheet and Plots (2012-2019)
5. Rodeo Beach Survey Area Site Map
6. Stinson Beach Survey Area Site Map
7. Stinson Beach Survey Map (July 2019)
8. Stinson Beach Profiles Spreadsheet and Plots (2019)
9. Staff Meeting Project Presentation (July 2019)
10. FPL Symposium Presentation (August 2019)
11. Photos

Future Park Leaders of Emerging Change 2019
Katahdin Woods and Waters National Monument
NPS Northeast Region Archaeology Program
June 11 – August 24, 2019
Fernando Casal

**Modeling Indigenous Subsistence, Archaeology, and Cultural Significance for the East Branch of the
Penobscot River ahead of Timber Management to Reduce Wildfire Severity**

Report Cover Sheet

Overview

The objective of this internship was to construct a model on ArcGIS Pro 2.3.2 to predict the spatial distribution of archaeologically and culturally sensitive resources within the bounds of Katahdin Woods and Waters National Monument ahead of proposed timber management plans, and included a data collection component.

Problem statement

KAWW, located in northern Maine, is majority forested and experiences periodic wildfires. The monument will develop a forest management plan to mitigate the severity of future fires, however this plan must be cognizant of potential impacts on archaeologically and culturally sensitive resources in the monument. The land within KAWW is part of the original homeland of the Penobscot Indians and contains the Penobscot River, an important part of their origin story. As KAWW is one of the newest NPS units, an organized data base for the monument does not exist, complicating the process of constructing a useful predictive model.

Objectives

To account for the impacts the forest management plan will have on cultural resources in the monument, a predictive model for the spatial distribution of cultural resources within the monument will be developed. Constructing this model involves data collection from historical, archaeological, geological, ecological, and ethnographic data.

Much of the GIS data in existence for KAWW is not up to NPS standards, meaning it is either imprecise or is lacking metadata entirely. Creating data needed the model involves writing metadata, digitizing historic or printed maps, and following up on entities creating data for the monument. This internship later developed a data collection component, a compilation of all relevant documents, data, and contacts.

As KAWW develops as an NPS unit, it is important to have this baseline data to inform future development of the predictive model and other research. As KAWW acquires better internet connectivity and IT assistance, identifying these gaps in data are an important step towards facilitating future continuation of this work.

Data collection and methodology

Collection of historic data for the model involved travel to the Millinocket Memorial Library in Millinocket, ME; Lumbermen's Museum in Patten, ME; University of Maine at Orono Maine Library and Special Collections in Orono, ME, and the book collection at the NPS Northeast Region Archaeology Program. To assess existing data and reports, and to identify comparable research, I spoke to staff at Acadia National Park Headquarters.

Results of the internship

The model constructed during this internship is a simple buffer and raster calculator model, combining buffer zones around all waterbodies within the monument. While this is more inclusive than the current model used for the state, there is still more work to be done. Alongside this, detailed data for lakes, ponds, rivers, and streams was collected and clipped to the boundary of the park. Metadata as of 8/24/2019 only exists for the LiDAR derived products, so the data used in the model is not up to NPS standards. The reports used to inform buffer sizes are historical reports, or from archaeological reports from private contractors or avocational sources. Therefore it is important to note that this model is not quantitative.

A spreadsheet with all reports and documents accessed, their locations, GIS data and storage information, and relevant contacts was compiled as part of the internship as a rudimentary baseline inventory for KAWW. While this work is preliminary, this research revealed that there is a density of sites along the river unexpected for this part of Maine. As part of a conversation with Art Spiess, State Historic Preservation Officer, (August 15, 2019) it was stated that there are an expected 1 or 2 sites per kilometer along the Seboeis river tract.

Recommendations

The model constructed for the monument only includes proximity to water as the main variable, although next steps must include slope (derived from DEM) to select out the floodplains of the three main linear water features of the monument (East Branch of the Penobscot, Seboeis, and Wassataquoik). As of now, the model is similar to the one used within the state of Maine, including only proximity to water as a variable. According to Spiess and Smith (2016), this accounts for up to 90% of archaeological sites in the state. However, these are found archaeological sites, and the model does not use GIS.

As the vegetation habitat map from MNAP comes out, selecting out for preferred vegetation communities or vegetation communities created out of a response to indigenous land use must be considered. To consider habitation during the Paleoindian period, a comprehensive soil map with distinct sand classifications should be used to identify early post-glaciation sites. Continued conversation with Chris Sockalexis is needed to continue modeling work generally, and ground truthing should commence once a model that includes these variables is constructed.

Deliverables and works cited

All deliverables and cited documents detailed on spreadsheet sent to NE Region with documents, GIS data, and contacts. Model is restricted information.

Evaluating Future Water Supply Scenarios in Mount Rainier National Park

Rachel M. Fricke, Future Park Leader of Emerging Change

Overview

Mount Rainier National Park (MORA)'s water supply primarily depends on surface streams in which summer flows are expected to decline due to climate change. Here, I calculated a series of future water availability and use metrics to inform management recommendations for increased storage capacity and exploration of alternative water sources.

Problem Statement

MORA's most drought-sensitive water supply systems rely entirely on intakes located above barriers on snowmelt-fed surface streams. Throughout the Northwest, climate change is expected to drive declines in snowpack and shift peak runoff earlier, which may limit water availability late in the summer (Mote et al. 2018). Park managers saw a preview of what future conditions may look like in water year 2015 when, following a historically low snowpack and warm temperatures, by August flow had ceased into some intake reservoirs (Mote et al. 2015). These observations, coupled with projected increases in park visitation due to rising air temperatures, have motivated an assessment of the park's future water supplies (Fischelli et al. 2015).

Objectives

The water systems of highest concern in MORA include White River, Stevens Canyon, Ohanapecosh – all of which are supplied by surface streams – and Sunrise, which is supplied by Frozen Lake reservoir. Here, my objectives were to (i) collate and analyze all existing visitation and water use data for these systems, (ii) estimate future mean monthly discharge at water supply intake locations under different emissions scenarios, and (iii) provide recommendations to park management for immediate and long-term infrastructure adaptations to address current and anticipated changes in hydrological norms.

Methods (200 words)

Annual and monthly visitation by water system was estimated by collating data from highway counters and entrance stations in areas served by systems of interest. As Stevens Canyon primarily serves facilities at the Grove of the Patriarchs trailhead, I used the limited trailhead data available for this location – from May – to calculate relative visitation to trailheads for which we have summer-long visitation data, and then extrapolated this proportion across the summer to estimate monthly visitation totals.

I estimated monthly discharge in the 2040s and 2080s under very rapid economic growth (A1B) and rapid introduction of resource-efficient technologies (B1) emissions scenarios using existing basin-wide streamflow projections for the Cowlitz and White River watersheds (Hamlet et al. 2013). Basin streamflow projections were scaled to the White River, Stevens Canyon, and Ohanapecosh water supply intake sub-basins by relative drainage area proportion. In addition, I also scaled streamflow projections for the previously abandoned Laughingwater Creek intake, which used to supplement Ohanapecosh's water supply.

Results (200 words)

Though visitation is generally increasing across all analyzed water systems, water use has slightly declined over the past decade at all locations except Stevens Canyon. By the 2080s, all four current and former intake basins are projected to shift from a historical annual flow regime of snowmelt-dominant runoff to a rainfall driven regime in which peak runoff coincides with winter

storms in December in January. The disparity between historical and future flows is most evident in June and July under the A1B emissions scenario in the 2080s, where mean monthly discharge is projected at 50% or less compared to historic measures across all intake locations. Notably, the formerly abandoned Laughingwater Creek intake receives significantly more discharge than the current intake for Ohanapecosh, suggesting that this location may be a more reliable intake location long-term.

Recommendations (200 words)

Given the projected declines in mid to late summer flow facing MORA's surface streams and steadily increasing visitation, a prudent first step in climate adaptation is expanding the storage capacity of these water supply systems. In some cases, storage tanks are potentially historical structures, which may warrant construction of new tanks.

Water use has declined at most systems in spite of visitation increases, and this is likely due to incremental improvements in system efficiency (e.g. installation of low-flow toilets, looping water through hot water heaters to limit waste). However, water use continues to rise at Stevens Canyon, and this is the only site without low-flow toilets which reduce water use from 4 to 1.6 gal. per flush. Thus, an additional preliminary action item should be updating the facilities on this particular system to improve water use efficiency.

As Laughingwater Creek receives significantly more discharge than the existing Ohanapecosh intake, the park plans to beta-test reinstalling the Laughingwater Creek intake to supplement Ohanapecosh's water supplies – though the long-term viability of this site is unknown based on the dynamic nature of Laughingwater canyon. Lastly, efforts are underway to explore groundwater options which, if viable, may serve as a redundant rather than replacement water source.

Deliverables

1. MORA Management Team Presentation
2. Poster, to be presented by Supervisor at Northwest Climate Conference
3. Natural Resource Report, *In Prep*

References

- Fischelli, N.A., Schuurman, G.W., Monahan, W.B., & Ziesler, P.S. (2015). Protected area tourism in a changing climate: will visitation at US national parks warm up or overheat? *PLOS ONE*, doi: 10.1371/journal.pone.0128226.
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- Mote, P.W., Li, S., Lettenmaier, D.P., Xiao, M., & Engel, R. (2018). Dramatic declines in snowpack in the western U.S. *Nature npj Climate and Atmospheric Science*, doi:10.1038/s41612-018-0012-1.
- Mote, P.W., Rupp, D.E., Li, S., Sharp D.J., Otto, F., Uhe, P.F., et al. (2016). Perspectives on the causes of exceptionally low 2015 snowpack in the western United States. *Geophysical Research Letters*, 43(1), 10980–10988.

Acknowledgments

Data, figures, or summary information were downloaded from the Columbia Basin Climate Change Scenarios Project website at <http://warm.atmos.washington.edu/2860/>. These materials were produced by the Climate Impacts Group at the University of Washington in collaboration

with the WA State Department of Ecology, Bonneville Power Administration, Northwest Power and Conservation Council, Oregon Water Resources Department, and the B.C. Ministry of the Environment.

A Blueprint for Sustainable Park Friendly LED Lighting

Overview

Develop a blueprint to help parks achieve park friendly intelligent outdoor LED lighting.

Problem Statement

Outdoor LED lights are quickly being adopted for use in national park units however not all LED lights are suitable for park purposes and what factors make an LED light suitable are unclear.

While infrastructure upgrades are being made to parks in the form of outdoor LED lights, the benefits of intelligent light controllers ought to be considered, and how those types of controller could be extended to other Internet of Things initiatives.

Objectives of the Project

Write a guiding document that describes the various aspects of outdoor LED lights, controllers, and sensors as they relate to various park objectives including environmental leadership, sustainability, and wildlife, ecosystem, and night sky protection. This document should include the benefits, challenges, and costs of using various technologies and provide actionable advice to park units looking to install outdoor LED lights. In addition, the document should provide guidance on how intelligent light controllers and other Internet of Things initiatives could be used to meet park objectives.

Approach

A combination of research using primary and secondary sources alongside interviews with lighting, Internet of Things, and smart city industry experts was used to develop a written toolkit to help park units select park friendly outdoor LED lighting

Results

The use of LED lights outdoors is recommended for parks units, however selecting the appropriate LEDs will require specialized knowledge or tools. The Smart Outdoor LED Lighting for the National Park Service toolkit produced during this internship can be used as a starting point to help park employees acquire the necessary knowledge to select park friendly LEDs. Intelligent connected controllers will likely benefit many parks and a pilot project in Colter Bay in Grand Tetons National Park is currently underway to test the long term viability of such a project. Research indicated that Internet of Things initiatives exist that could help with almost any park objective and that parks in Africa are currently using such systems.

Recommendations

I would recommend the Natural Sounds and Night Skies Division review the toolkit that I produced to ensure it complies with their guiding principles then proceed with testing the usability of the toolkit with several national park units.

To move forward with Internet of Things initiatives in parks I would recommend continuing to work with cloud connected street light controllers and vendors, adding other types of sensors to the controller networks and testing their usefulness in meeting park objectives.

Deliverables

Project Folder

<https://drive.google.com/open?id=1UWuHBaxt9nisahh2II9Pas11tgQBqSHj>

Title: Smart Outdoor LED Lighting for the National Park Service

File Name: Smart Outdoor LED Lighting for the National Park Service.docx

Link: https://drive.google.com/open?id=1jy5pX_-sjJuUI31H05CmdLSJNhRbxbwy

Description: A document containing a toolkit for using outdoor LED lights and the Internet of Things in National Park Units

Title: Connected Lighting Research

File Name: connected_lighting_research.xlsx

Link: <https://drive.google.com/open?id=19jUxIVUDadSHZTizOHttrdXYSMJxtVVy>

Description: Spreadsheet containing multiple tabs that contain the data and research presented in the Smart Outdoor LED Lighting for the National Park Service document

Works Cited

Works cited are cited in the relevant deliverable

Erika Welch
Olmsted Center for Landscape Preservation
Future Parks Leader Intern, Summer 2019

Cultural Landscape Vulnerability Assessment

Salem Maritime National Historic Site

George Washington Birthplace National Monument

Overview:

Cultural landscapes are anthropogenic settings within the natural world that reveal the relationship between people and land. The histories and stories revealed within these landscapes are being threatened by climate change. In order to protect cultural landscapes from climate change impacts, park managers must understand the vulnerability of their resources.

Problem Statement:

Cultural landscape vulnerability assessments are part of an initiative to help parks manage climate change. This assessment evaluates the vulnerability of George Washington Birthplace National Monument and Salem Maritime National Historic Site. George Washington National Monument is exposed to severe erosion and vegetation decline. An increase in local sea level, as well as an increase in severity and frequency of extreme weather events will intensify erosion at the park boundaries. Salem Maritime National Historic Site is also threatened by local sea level rise. Increased flooding from sea level rise and storm surge threatens key structures in the park.

Objective:

The vulnerability assessment identifies and evaluates cultural landscapes to understand the importance, significance, condition, and integrity of the landscape characteristics. Climate change impacts are likely to degrade the integrity and significance of these landscapes. The vulnerability assessment looks at previous and potential exposure and sensitivity to climate change stressors for individual features and characteristics. Based on results from cultural resources, vulnerability of landscapes and their characteristics are determined. The purpose of the vulnerability assessment is to help park managers and staff prioritize which resources need attention for maintenance and conservation in respect to funding use and time. The vulnerability assessment recommends which practices and actions are most suitable for resource protection against climate change impacts. Preliminary methods and results from the work at George Washington Birthplace and Salem Maritime Historic Site will serve as a guide to inform future cultural landscape vulnerability assessments, which will allow for climate vulnerability to be incorporated into the Cultural Landscapes Inventory (CLI) and Cultural Landscape Reports (CLR).

Methods:

The CLI and the National Register of Historic Places is used to determine potential impacts to the condition and integrity of cultural landscapes from climate change. Once cultural resources were identified and located, each park is evaluated for key climate change stressors. These stressors may vary for each site, as they are based on landscape conditions, location, historical data, and climate change projections. Stressors in both sites include: Sea level rise,

flooding/storm surge, coastal erosion, and change in temperature, change in precipitation, and change in ground water.

Once key stressors were identified, the exposure and sensitivity to that stressor was assessed. Exposure was evaluated through ArcGIS mapping and site visits. Cultural resources within sites are tallied in excel if they overlap with any climate change stressor. During park visits exposure is evaluated and tallied based on its proximity to key climate change stressors. Sensitivity was evaluated on site visits and utilizes expert knowledge. How a feature will react to the climate change impact if exposed reveals the score in which it receives. Sensitivity scores are assigned based on qualitative numbers, and therefore do not have a mapping component. Vulnerability for each resource across a landscape is determined by multiplying the exposure score and the sensitivity score.

Results:

For George Washington Birthplace, the most vulnerable features are their buildings and structures and their vegetation. The least vulnerable features are their views and vistas, small scale features, and circulation. The majority of the landscape has minimal to low vulnerability, leaving 20% of the landscape to have moderate to high vulnerability. George Washington Birthplace elevation will protect many of the cultural and natural features. In time, higher sea levels and storm surges will increase flooding at the site and exacerbate coastal erosion.

At Salem Maritime the most vulnerable features are spatial organization, buildings and structures, and views and vistas. The least vulnerable features are vegetation, small scale features, and circulation. The majority of the landscape has minimal to low vulnerability, leaving 31% of the landscape to have moderate to high vulnerability. Impacts in Salem have the potential to be far more damaging to the historic significance than George Washington Birthplace. Salem Maritime can alleviate climate change impacts by enhancing their resiliency, while also minimizing major alterations to their landscape.

Recommendations:

Adaptation methods shall not alter the history or intention of the park but preserve it for future generations. It is recommended softscapes and green infrastructure are used, rather than hardscapes and gray infrastructure to reduce potential loss of significance or integrity. George Washington Birthplace and Salem Maritime National Historic Site have similar recommendations, with Salem Maritime requiring more than George Washington Birthplace. Some examples of green infrastructure are salt marsh restoration and invasive species removal. Softscape examples include geotextiles, beach re-nourishment, increasing permeability of the surface, and flood vents. Hardscape and gray infrastructure recommendations include jetties, breakwaters, or sea walls. Hardscapes/gray infrastructure are recommended for sites that are at greater risk of climate change impacts and loss of historic features.

A combination of both green and gray infrastructure is recommended for Salem Maritime National Historic Site. The park is attempting to raise Derby Wharf to 2-feet above the high tide line, a project that could potentially cost \$20 to \$50 million. Some of the building and resources throughout the site can be raised to endure flooding. Raising the wharf and structures will only prolong the lifetime of the landscape. In the future, Salem would need to consider relocation or retreat to a less vulnerable site.

Assessing Erosion Risk for Cultural Resource Management Claudia Silver Organ Pipe Cactus National Monument

Overview:

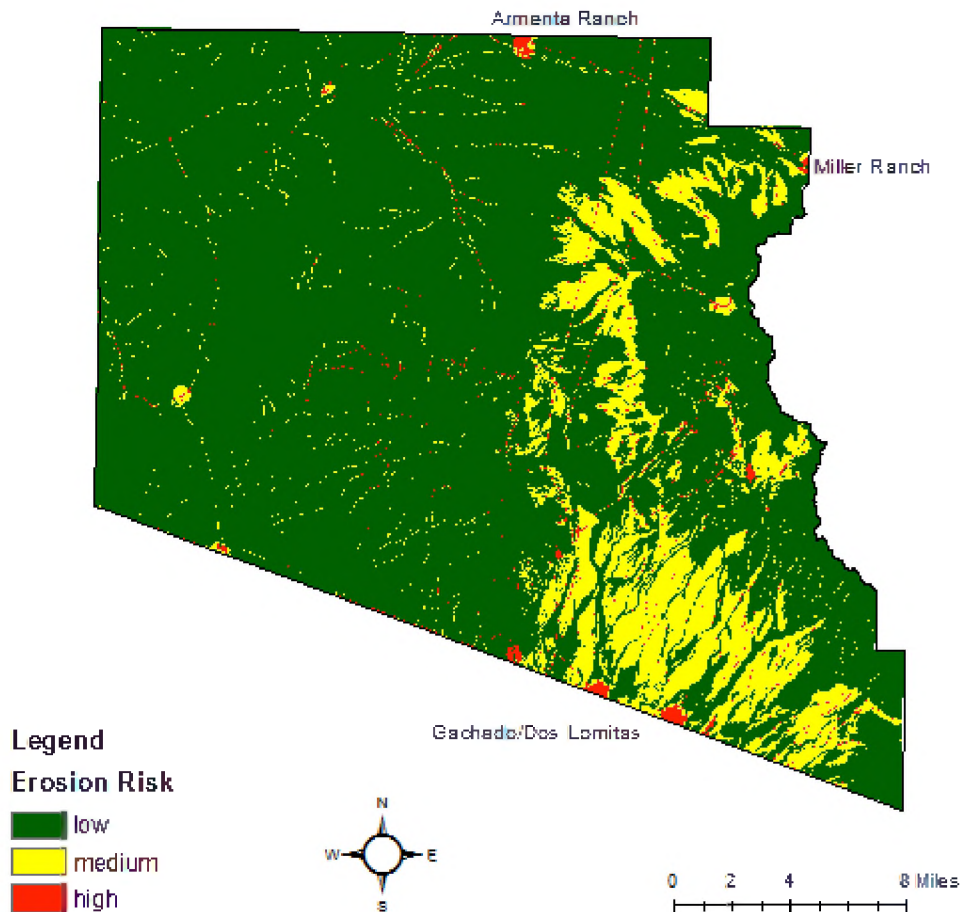
Problem Statement: Currently, the ORPI cultural resources program has surveyed approximately 7% of the monument for archaeological resources. Climate change in the Sonoran Desert is causing a continued increase in the severity and frequency of monsoon and hurricane-related flooding events, as seen in several recent erosional events in the Monument's recent history. Climate change-induced landscape changes, most importantly erosion, will adversely affect known and as-of-yet undocumented sites in the region by damaging both the artifacts and their context.

Objectives of the Project: The goal of this project was to do an analysis of water-based erosion of the park to determine which areas are most at risk of major erosion events. These are the areas that should be a priority for future surveying so that these sites may be documented in advance of substantial erosion events.

Approach/Method Used to Accomplish the Objective: This project used a predictive modeling technique to determine which culturally sensitive sites in ORPI are most susceptible to erosion. The project utilizes both external and internal data, including weather data from ORPI's Environmental Modeling Program, in an ArcGIS predictive model. The erosion analysis uses a geospatial, deductive predictive model technique to determine which areas of the park are most likely to experience erosion. Geospatial predictive modeling is rooted in the principle that distribution of events are affected by spatial factors. The predictive model uses the presence and value of specific attributes related to water-based erosion to deduct which areas have a high probability of an erosion event. A congregation of various erosion factors points to a higher erosion risk. Sites identified as having a high erosion risk were then compared to high-erosion sites identified in a 1996 ORPI historic erosion restoration report. Based on these results, specific recommendations were made to identify which areas should be a high priority for cultural resources inventory in the near future.

Results of the Internship:

Erosion Risk Reclassified



The results of the erosion analysis show that most of ORPI has a low risk risk for sudden erosion events caused by heavy precipitation. Areas that do not have a substantial history of human habitation are relatively safe, while those within grazing areas and those adjacent to washes are the most susceptible to increased erosion impacts. As seen in places like Armenta Ranch, areas that are within the grazing ranges are most susceptible to erosion events because of their weak soil and proximity to buildings, roads, and washes in their range. Thus, grazing ranges act as hotspots for erosion activity. Miller Ranch, Armenta Ranch, and the Gachado/Blankenship areas are most susceptible to erosion based on the analysis and should be the priority for comprehensive surveying. Areas near roads and UVRs, in addition to other grazing areas like Alamo Ranch, Quitobaquito, Bates Well Ranch, and Pozo Nuevo should have second priority.

Recommendations:

This report recommends that areas around ranches and major washes are the priority for surveying. The table below shows the erosion areas with the highest priority.

High Priority Areas	Armenta Ranch, Dos Lomitas, Gachado, Miller Ranch
Middle Priority Areas	Alamo Canyon, Bates Well Ranch, Quitobaquito, Pozo Nuevo, other areas near roads, UVRs, and washes
Low Priority Areas	The rest of ORPI

It is also recommended that both sudden erosion events and areas with recurrent erosion are documented. Date of a major erosion incident, degree of precipitation, and proximity to features should be included in the standard condition assessment documentation. This data can be used for better erosion management and erosion risk predictions. There should be future statistical analysis on how accurately the factors used in this model predict erosion.

Since there was limited time to design and complete the project, there are a few steps I was not able to complete. To expand upon the model, recommendations include: adding more years to the averaged rain gradient, doing a predictive model for the winter monsoons, and including new geospatial data on border wall structures. The rain gradient and border wall additions will provide more precise, updated results and winter monsoon addition may show different surveying priorities later in the year.

Deliverables: Report on Assessing Erosion Risk for Cultural Resource Management at Organ Pipe Cactus National Monument

Jessie K Pearl, PhD
2019 Saguaro National Park FPL Intern

Contextualizing Recent Snowpack Trends of Saguaro National Park

Saguaro National Park (SNP) is home to a unique “sky island” mountain range (the Rincon Mountains) that reaches over 2400 meters with a temperate climate zone at high elevation. This project looked at recent trends of snow amount in SNP, the climatological drivers of snow, and the effects of snow on water resources at SNP.

Problem Statement

SNP ecosystems are dependent upon the melting snowpack at high elevations to maintain water supplies during the dry spring and summer. Recent climate change is altering the amount of snow accumulation and the timing of snow melt. Prior to this study, a synoptic record of snow did not exist due to the remote and rugged topography of the area. Without these records, it is difficult to understand the magnitude of changes to SNP’s hydrologic cycle and impacts of snow amount on SNP ecosystems.

Project Objectives

The overarching objective of this project was to gain a better understanding of where water comes from, particularly during the dry season between the winter snow and summer monsoon rains, and how climate change may alter the timing and availability of the water resources at SNP. A principal project goal was to generate and analyze a long-term record of snowpack variability in the Rincon Mountains from newly developed remote sensing estimates of snow coverage and snow water equivalent. Using these new estimations of snow, our aim was to complete an analysis on the climatological controls on snow amount and assess the impact of changing snow amount on low elevation water resources. To better contextualize recent trends in snowpack, the project aimed to lengthen the records of snow and winter precipitation past the satellite era through proxy-based reconstructions. Additionally, this project continued prior research on low elevation water sources to determine the relationship of water presence in bedrock pools to the local geology.

Approach

To address the snow data gap, we used a Google Earth Engine Script developed by a NASA Develop Project in 2017 to analyze satellite imagery for snow coverage amount since the early 1980s. We additionally modeled Snow Water Equivalent (SWE) by collaborating with the University of Arizona’s School of Natural Resources and the Environment “SnowView” (*in beta*) product. Data for the Rincon Mountains was extracted with permission from the products’ creator Patrick Broxton. We compared the resulting records of snow with other Snow Course and SNOWTEL sites proximal to the Rincon Mountains in Arizona. We compared the SWE time series with climate reanalysis products to determine the principal climate drivers of snow in the Rincon Mountains. We used stream flow data from the USGS outflow gauge in Rincon Creek and five years of water presence surveys in key drainages across the park to assess how snow influences downstream water sources. To extend the short records of snow we used both long temperature data sets and the early wood width of tree-rings sampled in the Rincon Mountains to reconstruct winter mean annual SWE and total winter precipitation. To determine source water of low elevation pools in the park, we sampled key pools for their water chemistry, isotopic ratios, and tritium.

Results and Future Work

The result of this internship was a comprehensive analysis of snow in the Rincon Mountains of SNP using two differently modeled estimations of snow cover and SWE. We show that snow in the Rincon Mountains depends on colder than normal winter air temperatures in addition to increased precipitation in the region. Additionally, Pacific Ocean temperatures from the antecedent fall influence the moisture availability, with warmer than normal ocean temperatures (an El Niño year) yielding more moisture. We see that anomalously low pressures in the North Pacific and Europe (or the Pacific North American pattern of variability) coeval with high snowpack years. We show that snowpack appears to have little relationship to low elevation stream gauge records but does appear to effect the amount of water in the principal drainages in the park during the driest time of year. We show that a reconstruction of Rincon Mountain SWE is possible back to 1896 when using Rincon Mountain temperatures and Douglas Fir tree-ring early wood width as predictors. We also skillfully reconstructed winter precipitation back to 1650 using the early wood the Douglas Fir tree-rings. The region has seen previous ‘snow droughts’ over the 400 year record, but the current snow drought of the past 30 years is accompanied by a massive temperature increase. Thus, temperature is the critical shift that will impact the timing of snow melt and amount of snow fall in the next decades.

I recommend that future water resources studies at SNP concentrate on better understanding the alluvium and shallow bedrock aquifers across the park. By compiling the current knowledge of principal streams, geohydrology of low elevation bedrock pools, and high elevation hydrology, this study could provide a comprehensive assessment of recent changes in water resources and identification of key physical mechanisms (including geology and climate) and that change water availability across the park. There is a trove of data from various projects over the years in addition to longer term monitoring data that have yet to be compared and contextualized. The results of will provide key updates to the Park staff and Resources department on many of the key questions regarding water, and its vulnerability, in a desert Park.

Deliverables

This document contains the following products and links that have been worked on this summer through the FPL internship:

- The report entitled “Contextualizing Recent Snowpack Trends of a Southeastern Arizona Mountain Range”
- The draft manuscript entitled “Geohydrology of perennial *tinajas* in the Sonoran Desert” , in preparation for submission to *Journal of Arid Environments*
- Links to a rough cuts of two videos that describes some of work I have down at Saguaro National Park this summer

Future Park Leaders of Emerging Change Cover Sheet

Ashley Wilson, 2019 Cohort

Voyageurs National Park, MN

Project title: Heart of the Continent Dark Skies Initiative

Overview: This project involves developing applications for International Dark-Sky Association (IDA) Certifications among Voyagers National Park (VOYA), Grand Portage National Monument, Boundary Waters Wilderness (USFS) and four provincial parks in Ontario, Canada in a region known as the Heart of the Continent (HOC) to recognize and promote stewardship of night skies.

Problem Statement: Public lands in northeast Minnesota and southwest Ontario, Canada comprise one of the largest expanses of green space in the center of North America. These lands provide vast areas of relatively natural night skies and the partnership has identified the preservation and promotion of this resource as a high priority. The biggest threat to night skies is light pollution from outdoor lighting; a pervasive threat with widespread impacts, including wildlife, visitor experience, cultural resources, wilderness character, energy efficiency, environmental sustainability, and public health and safety. Further, outdoor lighting is a major driver of climate change, contributing between 6- 8%.

Objectives:

The intern will be responsible for the following:

- Coordinate the development of and submission of applications for certification as an International Dark-Sky place for areas managed by the National Park Service, US Forest Service, and Ontario Provincial Parks in Canada.
- Develop briefing papers and presentations for national and international partners and stakeholders.
- Develop a Lighting Management Plan based on previous examples and protocols.
- Conduct education and outreach activities with community leaders about the importance of natural darkness and the impacts of light pollution.
- Produce education materials on the importance of naturally dark night skies and the impacts of light pollution for community outreach purposes.
- Project management to keep many moving parts and partners on track.
- Develop methods and organize the recording of sky quality measurements throughout all parks to verify the minimum sky quality meets IDA's requirements for certification.

Approach used to accomplish the objectives: The primary component that drives how parks obtain their certification stems from a fully developed and researched Lighting Management Plan. This document outlines all regulations and requirements parks must abide by when retrofitting and installing compliant lights. An extensive background assessment was completed to describe and define the six lighting principles that maximize lighting efficiency, mitigate negative effects on public health and wildlife, all the while balancing the need for safety at recreational areas. Once this document was completed, a light audit of all outdoor lighting at the parks' facilities was conducted to determine the conditions of the placement, quality, and utility of outdoor lights with regards to the requirements outlined in the Lighting Management Plan. The information provided by the Lighting Management Plan was transcribed for a general audience in order to communicate these concepts effectively. This information will be available on the official website for VOYA, as well as during public outreach and education events held at the park's visitor centers. Finally, the final application was developed, and contains the Lighting Management Plan, all sky quality data recorded by the Natural Sounds and Night Skies Division (NSNSD), outreach and leadership projects.

Results of the internship: At the beginning of the application process, any HOC unit with facility buildings did not meet the IDA's requirements of possessing 2/3 compliant lights. By engaging with leadership staff, the intern was able to strategically plan and utilize facilities operations to meet the 2/3 requirement by the end of 2019. Additionally, the intern organized and managed efforts to record night sky quality measurements throughout VOYA, Boundary Waters Canoe Area Wilderness, and several Canadian parks. Each unit is able to use this information to prove they meet the necessary measurements to apply for certification.

Another major component for applying for the certification is to raise awareness concerning light pollution, educate the public on appropriate uses of outdoor lighting, and engage with the local community on why celebrating and preserving the night sky is an important endeavor to this region. At the end of the internship, VOYA held two public forums to engage the public in a conversation regarding the process for Dark Sky Park certification. These events were highly successful, as visitors and local residents showed enthusiasm and interest in the certification process, and desired to continue conversations regarding implementation of effective outdoor lighting in their own communities.

197/200

Recommendations: VOYA will need to continue current efforts on installing compliant lights at their facilities. A recommendation guide has been developed to suggest how to update all lights in the park to meet compliance. Once the park obtains 2/3 compliant lights, VOYA can successfully submit their application for the IDA certification. Another requirement of the certification mandates park update 90% of their outdoor lights five years after certification is awarded, and 100% of outdoor lights must be dark-sky compliant ten years after obtaining certification.

Furthermore, the park will need to develop the Dark Skies Ranger program series to continue to engage and interact with visitors in the park regarding light pollution and its

relationship to the night sky. These events will spark interest and provide relevant information on all of the ways artificial light impacts visibility of the stars, public health, wildlife, as well as safety within the park. By providing these resources, the park should plan for increased use of visitation by visitors participating in Astro-tourism. Dark sky enthusiasts actively seek out certified parks to experience the night sky, and Voyageurs is optimally located to be attractive to new visitors in the eastern United States.

Deliverables: See attached:

- 1) Voyageurs National Park International Dark Sky Park Application
- 2) Educational materials will be put on VOYA's official website
- 3) Outline of the Night Sky Interpretative Program developed as an outreach activity to park visitors
- 4) PowerPoint presentation to introduce the Dark Sky Certification, effective uses of outdoor lighting, and benefits of efficient lighting to community members
- 5) Link to Outside Science (Inside Parks) video produced by Colorado State University, TBA