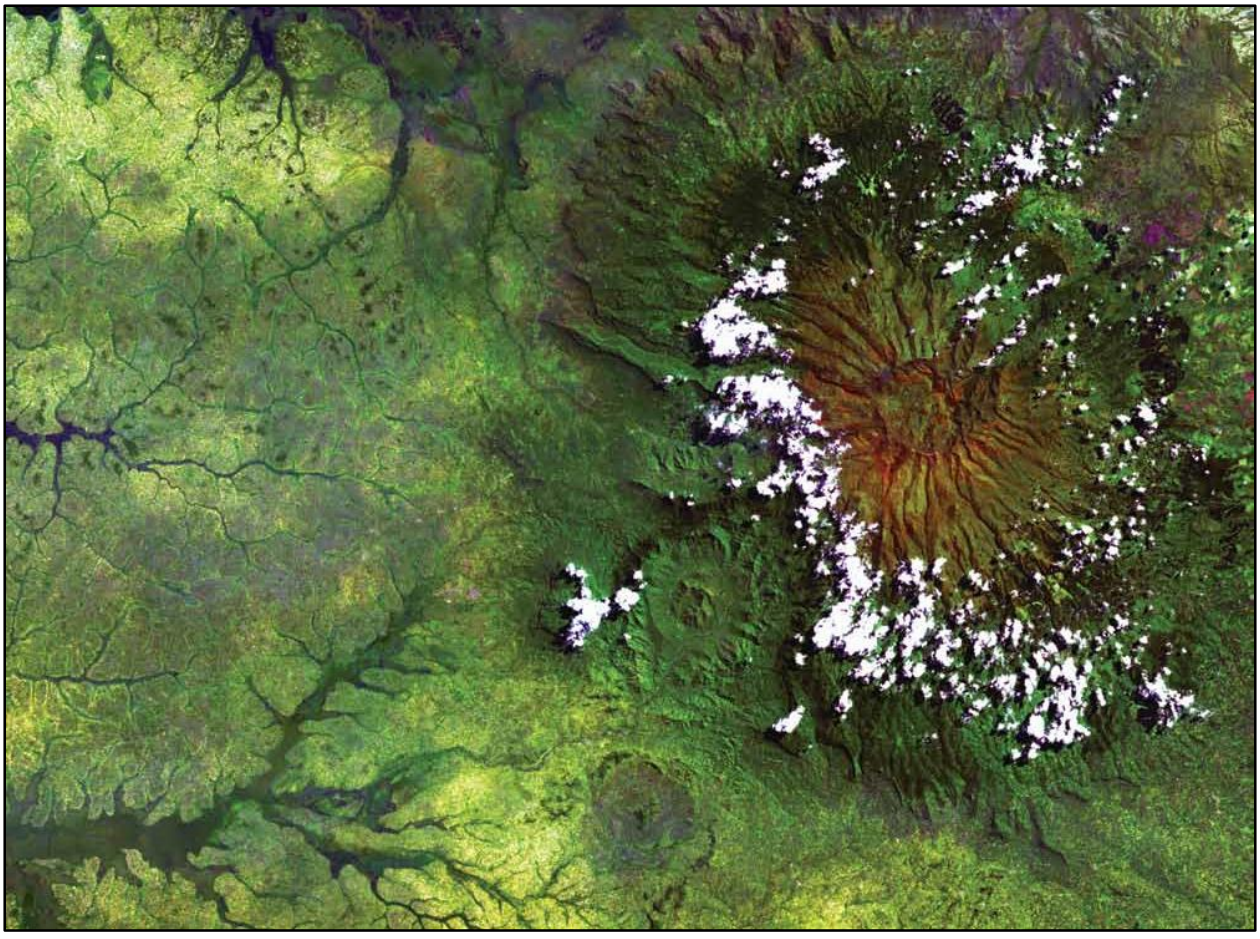
DEVELOP National Program

Ecological Forecasting Project Proposals

Spring 2015



Proposals Snapshot

1. Arizona Ecological Forecasting II: Coupling Unmanned Aerial Systems with Landsat 8 Imagery to Refine, Evaluate and Compare Risk Assessments for Invasive Plants in the Critical Wetland Habitat of Havasu National Wildlife Refuge (Fort Collins)
This project will incorporate high- resolution small Unmanned Aerial System (sUAS) data in concert with a time series analysis of Landsat 8 OLI/TIRS data and species distribution modeling to map invasive species within Topock Marsh, Havasu National Wildlife Refuge (NWR), Project outputs will be evaluated for inclusion in invasive species risk assessments, and further facilitate existing plans for the Conservation Opportunity Area (COA) within the Refuge.

2. Montana Ecological Forecasting: Utilizing NASA Earth Observations and Lidar to Forecast Goshawk Nesting and Post Fledgling Habitat, and the Effects of Climate Change on Boreal Forest Health (Goddard)
The goal of this project is to understand effects of climate change on National Forests, using the Goshawk as a bio indicator. This project will specifically characterize Goshawk nesting and post fledgling habitat characteristics in the Lewis and Clark National Forest and determine the ideal environment for goshawk persistence, by using field data combined with remote sensing data. This data will be used to create a goshawk nesting habitat plan, which will aid in finding goshawk nests to monitor population dynamics. Historical nesting location data and remote sensing data will also be used to identify how forest change has affected Goshawk nesting patterns, in order to predict future effects of climate change on the boreal forest ecosystem.

3. Louisiana Ecological Forecasting: Utilizing NASA Earth Observations to Aid the Louisiana Department of Wildlife and Fisheries and Ducks Unlimited, Inc in Quantifying Rates of Change in Select Habitats within the Catahoula Lake Area (Stennis)
This project will create a time series of remotely-sensing land-cover types and document current waterfowl habitat extent and habitat-specific rates of change in and around Catahoula Lake, LA. The team will use those rates of change to predict future habitat-type expansion and decline by extrapolating from preexisting baseline data.

4. Colombia Ecological Forecasting III: Utilizing NASA Earth Observations to Enhance the Conservation Efforts of Colombia's Most Endangered Primate, the Cotton-top Tamarin (Saginus oedipus) (UGA)
The overarching goal of this project is to strengthen and support Proyecto Tití by incorporating the use of NASA Earth observations into their conservation program. This study aims to use results from the previous terms to systematically assess forest connectivity and habitat distribution for the remaining departments within the historic range of the Cotton-top tamarin.

5. Ocmulgee River Ecological Forecasting: Utilizing NASA's Earth Observations for Forecasting Land Use Change and Wildlife Disturbances along the Ocmulgee River Corridor (UGA)
The goal of this project is to produce an up to date time series analysis illustrating and quantifying land use change in the Ocmulgee River corridor. Results of the time series will then be used to understand the effects of changing conditions on the wildlife and fisheries with a focus on endangered native species. This will provide the partners with information regarding threats to habitat and allow for ecological forecasting. Additionally, the team will explore the use of close-range unmanned aerial systems (UAS) coupled with NASA Earth observations for wildlife management.

Partners Snapshot

State Partners

- Georgia Department of Natural Resources (Partner/End-User)
- Louisiana Department of Wildlife and Fisheries (LDWF) (End User)

Federal Partners

- National Forest Service: (End-user, Partner)
- USGS, Fort Collins Science Center (Boundary Organization)
- US Fish and Wildlife Service (USFWS) Havasu National Wildlife Refuge (End-user)

International Partners

- Fundación Proyecto Tití (End-User)
- Proyecto Tití (Partner)

NGO Partners (Non-Profit & For-Profit)

- National Parks Conservation Association (Potential End-User)
- Disney's Animal Kingdom (Boundary Organization)
- Ducks Unlimited, Inc. (End User)

Academic Partner

- Colorado State University, Natural Resource Ecology Laboratory (Partner)
- Oulu University Researchers: (End-user/Boundary Organization)

Letters of Support

UGA Ocmulgee River Eco – Dan Forster, Georgia Dept of Natural Resources
UGA Colombia Eco – Dr. Anne Savage, Disney Animal Kingdom

Project Proposals

1. Arizona Ecological Forecasting II (Fort Collins)

Coupling Unmanned Aerial Systems with Landsat 8 Imagery to Refine, Evaluate and Compare Risk Assessments for Invasive Plants in the Critical Wetland Habitat of Havasu National Wildlife Refuge.

Objective:

This project will incorporate high- resolution small Unmanned Aerial System (sUAS) data in concert with a time series analysis of Landsat 8 OLI/TIRS data and species distribution modeling to map invasive species within Topock Marsh, Havasu National Wildlife Refuge (NWR), Project outputs will be evaluated for inclusion in invasive species risk assessments, and further facilitate existing plans for the Conservation Opportunity Area (COA) within the Refuge.

Community Concern:

Havasu NWR was established to protect wildlife species in danger of extinction after the creation of the Hoover Dam in 1936, which depleted critical riparian forest habitat along the Colorado River. Invasive plant species pose a threat to the protection of this area as they compete with native vegetation that provide important habitat and forage for wildlife, especially waterfowl. Furthermore, invasive plant species affect ecosystem function, including altering sediment loads and flow patterns of the Colorado River. Some of the most concerning invasive plant species in the 4,000- acre Topock Marsh of Havasu NWR include *Tamarix* spp., Phragmites (*Phragmites australis*) and Eurasian watermilfoil (*Myriophyllum spicatum*). Detection of invasive plants is a high priority for land managers, who seek to effectively and efficiently control and eradicate these problematic species.

End-Users/Partners/Boundary Organizations:

US Geological Survey (USGS) Fort Collins Science Center (Boundary Organization, POC: Dr. Leanne Hanson, Biologist)
US Fish and Wildlife Service (USFWS) Havasu National Wildlife Refuge (End-user, POC: Linda Miller, Refuge Manager)
Natural Resource Ecology Laboratory, Colorado State University (Partner, POC: Nick Young, Research Scientist)
US Geological Survey Fort Collins Science Center (Boundary Organization, POC: Dr. Catherine Jarnevich, Research Ecologist)

The partners and end-users listed are a mixture of existing and new NASA DEVELOP collaborators. A series of meetings with USGS partners and end-users revealed the potential for a strong collaboration around ongoing research at Havasu NWR regarding invasive species. Dr. Hanson (USGS) has expressed strong enthusiasm about the continuation of the project into the Spring term, and has scheduled a meeting in December 2014 to provide additional data for the DEVELOP team and discuss details for how the term's results will be incorporated into the decision support system being developed by the USGS team.

Decision Making Process:

Mapping invasive plants has become a high priority for land managers, but agencies often lack adequate budgets for conducting field assessments – which are time and labor intensive. Remote sensing provides an efficient tool for conducting such work, but limited background in remote sensing analysis severely hinders the incorporation of such powerful applications into management planning and action. Outputs produced by this project will help quantify the extent of invasive species within the Refuge. This will be done through novel techniques with the inclusion of sUAS imagery, which to the team's knowledge have yet to be applied. Additionally,

this work will provide spatial information that will facilitate the development of management strategies such as the Refuge's Comprehensive Conservation Plan.

Ongoing assessment of aquatic resources at Topock Marsh began in 2010, after initial construction to improve water management capabilities and habitat resulted in below-average water depths. A key goal of this assessment includes understanding the establishment and propagation of invasive species, which negatively impacts water quality and aquatic biota. Early detection and mapping of invasive species are essential to effective management strategies. Quantitative assessments of invasive plant species distribution have not been conducted. Traditional ground survey techniques commonly employed are time consuming and costly, especially over large geographic areas with difficult sampling terrain like Topock Marsh.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	OLI/TIRS	Spectral vegetation indices, Brightness Temperature
Space Shuttle	SRTM V2	Elevation, Slope, Aspect, Compound Topographic Index

NASA Earth Observations to be Highlighted:
This project explores a unique methodology that has not been attempted; incorporating high-resolution orthorectified sUAS data with Landsat 8 imagery and species distribution modeling to map invasive plant species. This approach seeks to assist refuge management by using the best available science to determine more effective water management strategies. The team will apply the new OLI/TIRS sensors aboard the Landsat 8 platform to assist in mapping the current distribution of invasive species in Topock Marsh, Havasu National Wildlife Refuge. Integrating a time series analysis of Landsat 8-derived vegetation indices with novel sUAS detection methods and ancillary geospatial datasets will provide a time- and cost-effective strategy for conducting invasive species risk assessments in the study area as well as comparing appropriate technologies to address land management questions. The project will also use the new SRTM V2 data to produce topographic grids of the study area.

Ancillary Datasets:
Occurrence data points of invasive species in Havasu NWR (USFWS, USGS, and potentially collected by Amanda West, Steve Chignell, and Nick Young during the October 2014 site visit)
High-resolution, orthorectified imagery from Raven RQ-11a model small Unmanned Aircraft Systems (sUASs owned and operated by USGS)
Water surface, water quality, and water depth datasets, United States Geological Survey (USGS)

Models:
Maximum Entropy (Maxent) Species Distribution Model (POC: Dr. Catherine Jarnevich, USGS Research Ecologist)

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Current Invasive Species Distribution Maps	Invasive emergent vegetation management and monitoring practices within the Havasu National Wildlife Refuge	Field surveys
Risk Assessment Map	Invasive emergent vegetation management and monitoring practices within the Havasu National Wildlife Refuge	Field surveys

Current Invasive Species Distribution Maps - Quantification of invasive species distribution will provide important data for project partners and end-users to better understand the health and function of Topock Marsh under various hydrologic conditions and areas in need of immediate mitigation.

Risk Assessment Map - Model output including maps of the current suitable habitat for multiple invasive species in Topock Marsh will act as an important decision support tool for ongoing management and monitoring efforts in the Havasu National Wildlife Refuge. Additionally, results of this project may be incorporated in the planning and drafting of the Havasu National Wildlife Refuge's Comprehensive Conservation Plan.

Project Details:

National Application Areas Addressed: Ecological Forecasting, Water Resources
Source of Project Idea: A series of meetings with USGS partners/end-users revealed the potential for a strong collaboration around existing research going on at Havasu National Wildlife Refuge. Through the novel integration of sUAS data, Landsat 8 imagery and species distribution modeling, this project builds on existing work at the Fort Collins DEVELOP node, by providing important risk assessment tools for addressing invasive emergent vegetation. Unique to this project is the integration of high resolution sUAS data, which has not been attempted in this type of remote sensing-based risk assessment work. Additionally, this project applies invasion risk assessment to a new ecosystem, focusing on sensitive wetland areas, which has not been conducted by the USGS-CSU DEVELOP node to date.

Advisors: Dr. Paul Evangelista (Natural Resource Ecology Lab (NREL), CSU), Nick Young (NREL, CSU), Dr. Melinda Laituri (Department of Ecosystem Science and Sustainability (ESS), CSU)
# of Participants Requested: 4
Project Timeline: 2 Terms: 2014 Fall (Start) to 2015 Spring (Completion)
Study Location: Havasu National Wildlife Refuge, Arizona
Period being Studied: April 2013 – April 2014

Previous Related DEVELOP Work:

Arizona Ecological Forecasting: Using Landsat 8 OLI and TIRS to Enhance Invasion Risk Assessment of *Tamarix* spp. in Topock Marsh, Havasu National Wildlife Refuge - Fall 2014 (USGS-CSU)

Alaska Ecological Forecasting: Modeling Current and Future Invasion Vulnerability for Critical Habitat in Interior Alaska: Applying Novel Modeling Techniques for Invasive Species Risk Assessment in the Yukon Flats National Wildlife Refuge - Summer 2014 (USGS-CSU)

Ethiopia Ecological Forecasting: Mapping Distribution and Forecasting Invasion of Mesquite (*Prosopis juliflora*) in Ethiopia's Afar Region - Spring 2014 (USGS-CSU)

Great Dismal Swamp Ecological Forecasting: Mapping Invasive Phragmites with Maxent and NASA Earth Observations in Great Dismal Swamp National Wildlife Refuge, Virginia - Summer 2013 (Langley Research Center)

Multi-Term Objectives:

- **Term 1** – Phase one of this two-term project focused on quantifying and mapping the extent of invasive *Tamarix* spp. within the Havasu National Wildlife Refuge through novel species distribution modeling techniques and indices derived from Landsat 8 imagery. The outcome of this project provided spatial information to facilitate the development of management strategies like the Refuge's Comprehensive Conservation Plan.

- **Term 2 (Proposed Term)** – Phase two of this two-term project will include coupling object-based classification of sUAS imagery with indices and species distribution models developed using Landsat 8 imagery. There is also the potential to test phase one modeling procedures with other invasive emergent vegetation present in Topock Marsh, such as Phragmites (*Phragmites australis*) and Eurasian watermilfoil (*Myriophyllum spicatum*).

2. Montana Ecological Forecasting (Goddard)

Utilizing NASA Earth Observations and Lidar to Forecast Goshawk Nesting and Post Fledgling (PF) Habitat, and the Effects of Climate Change on Boreal Forest Health

Objective

The ultimate goal of this project is to understand effects of climate change on National Forests, using the Goshawk as a bio indicator. This project will specifically characterize Goshawk nesting and post fledgling habitat characteristics in the Lewis and Clark National Forest and determine the ideal environment for goshawk persistence, by using field data combined with remote sensing data. This data will be used to create a goshawk nesting habitat plan, which will aid in finding goshawk nests to monitor population dynamics. Historical nesting location data and remote sensing data will also be used to identify how forest change has affected Goshawk nesting patterns, in order to predict future effects of climate change on the boreal forest ecosystem.

Community Concern:

Goshawks are a top-tier predator and an old growth forest health indicator species, and found in boreal forests around the world. Goshawk breeding activity has fluctuated with climate, which is common in many other areas of the country. Eastern Montana, however, is currently experiencing a dramatic mountain pine beetle infestation that is destroying large tracts of forest that goshawks rely upon for nesting, hunting and rearing their young. In addition, habitat destruction and amplified weather variation can prove fatal to Goshawks, as well as their prey, having a cascading effect through trophic levels. This project looks to provide further insight into a number of factors that are currently acting upon goshawks such as temperature and habitat destruction, to identify, forecast, and remedy habitat devastation due to climate change and mountain pine beetle kill. These top tier predators are also indirectly affected by the lower trophic levels of the forest, which allows them to serve as a bio-indicator of ecosystem health, as well as being important to maintaining ecosystem balance. There is currently a lack of significant data and understanding of how climate change is affecting Goshawks and their habitats, boreal forests, which are found in many regions around the world. Using a combination of remote sensing, *in situ* data, and population dynamics information, a comprehensive model of the essential factors this species needs to fulfill its life history can be built. These results will allow for the creation of a dynamic and well-suited management plan and habitat suitability forecasting. This understanding of forest dynamics and goshawk response will help us understand possible effects of climate change on goshawks and how those may affect the forest ecosystem as a whole.

End-Users/Partners/Boundary Organizations:

National Forest Service: (End-user, partner, POC: Nate Bickford, Researcher and Prof)
Oulu University Researchers: (End-user, boundary organization, POC: Nate Bickford, collaborator)

Partner Interaction: Nate Bickford, Professor at University of Great Falls in Montana, is leading this research on Goshawk habitat and using this species as a bio-indicator for climate change. He works primarily in the Lewis and Clark National Forest in Montana, and works with the US Forest

Service on conservation strategy. This project will be used by Dr. Bickford to gage how the forest has changed in the past, how Goshawk nesting patterns have responded to these changes, and how future climate change may affect the health of the forest and this top tier predator. This information will help guide conservation strategies, and understand the implications of future climate change.

In addition, Dr. Bickford collaborates with researchers at Oulu University in Finland, who are doing similar research in boreal forests in that region. These forests are very similar to the ones in Montana, but are closer to the Arctic Circle and may experience the effects of climate change sooner. They will be able to apply the methods from this project to model habitat suitability for Goshawks in their study region, which also has Lidar and optical imagery available, and be able to predict how climate change will affect these large tracts of boreal forests on an ecosystem level.

Decision Making Process:
Currently the US Forest Service is not using remote sensing to identify or forecast goshawk habitat. The tools used now are some basic topographical data and forest type, along with a large amount of fieldwork. dThis type of analysis tells us very little about climate change issues. In addition, there is little understanding how past climate change and habitat destruction has affected the nesting and post-fledging habitat distributions of Goshawks. Goshawk nesting surveys have been carried out since 2006, and although parameters such as canopy density and tree height are known to influence nesting patterns, there are no maps that show these parameters to guide surveys and research efforts.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 7, 8	ETM+, OLI	Land cover, land use change, beetle deforestation
Airborne Platform	Lidar	Canopy structure, topography
Aqua / Terra	MODIS	NDVI, surface temperature

NASA Earth Observations to be Highlighted:
Landsat 7 and 8 multispectral imagery and Aqua and Terra MODIS will be used to create land cover maps to quantify forest change to understand how forest change is affecting nesting patterns of Goshawks.

Ancillary Datasets:
Goshawk nest and post fledging habitat locations, Nate Bickford
Ground truth vegetation data, Nate Bickford
Prey densities from habitat areas, Nate Bickford
Lidar, Nate Bickford

Models:
Habitat suitability model – to be developed as part of project

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacts	Current Partner Tool/Method
Habitat Suitability Model	What forest characteristics best predict goshawk nest and PF habitat? If habitats are predicted and no goshawks	None

	are found, what has changed in the forest, which will allow us to see subtle changes in forest that are due to climate change?	
Goshawk Habitat Maps	Locating Goshawk nests can be very difficult, and this will guide researchers where to look	Topographic maps
Land cover change maps	Conservation strategy	Mostly ground observation

Habitat Suitability Model – Lidar data will be used to derive canopy structure and metrics such as forest density, tree height, and canopy cover will be used to determine suitable habitat for Goshawk nesting and post-fledging sites. The researchers at Oulu University in Finland will be able to implement this in their study forest.

Goshawk Habitat Maps – using the Habitat Suitability Model, maps will be derived showing potential Goshawk habitat. This map will aid researchers to find Goshawk locations, as well as identify what changes in the forest are affecting the species.

Land Cover Change Maps – Landsat and MODIS data will be used to derive land cover maps over time, and a land cover change map will be derived to understand how forest distributions have changed. This map can be used for conservation, as well as understanding how Goshawk nesting sites have moved in response to land cover change.

Project Details:
National Application Areas Addressed: Ecological Forecasting
Source of Project Idea: Goddard DEVELOP Center Lead attended a talk at GSFC given by the potential project partner, who is seeking NASA collaborators.

Advisor: Dr. Ross Nelson (NASA GSFC)
# of Participants Requested: 3
Project Timeline: 1 Term: 2015 Spring
Study Location: Montana
Period being Studied: 2006 - present

Notes: Nesting and post-fledging surveys have been carried out by Nate Bickford and his team in the Lewis and Clark National Forest in Montana since 2006. He has identified forest density, tree height, and canopy cover parameters that are ideal for Goshawk nesting and post-fledging sites, but does not have a way to extrapolate to identify these ideal conditions across the entire forest. This lack of data makes it extremely difficult to locate nests, and the use of Lidar and NASA Earth observations can create these maps to show suitable nesting habitat distributions. This research and habitat suitability model could then be applied to other study locations where there is Goshawk research ongoing, including Alaska and Finland.

3. Louisiana Ecological Forecasting (Stennis)

Utilizing NASA Earth Observations to Aid the Louisiana Department of Wildlife and Fisheries and Ducks Unlimited, Inc. in Quantifying Rates of Change in Select Habitats within the Catahoula Lake Area

Objective:
This project will create a time series of remotely-sensing land-cover types and document current waterfowl habitat extent and habitat-specific rates of change in and around Catahoula Lake,

LA. The team will use those rates of change to predict future habitat-type expansion and decline by extrapolating from preexisting baseline data.

Community Concern:

Catahoula Lake, located in east central Louisiana, is known to be an important location within the Mississippi Flyway where, each year, waterfowl winter by the tens of thousands. Catahoula Lake occupies approximately 30,000 acres; 20,000 acres make up the lake, while the surrounding 10,000 acres are predominantly hardwood trees. Today, much of the historic lake area is being overrun by encroaching woody vegetation such as Willow, Swamp Privet, and Water Elm. These woody species have no benefit to waterfowl and shade out the beneficial, moist-soil wetland plants that naturally grow at Catahoula Lake. This has led to a drastic reduction in the amount of available forage for waterfowl and makes Catahoula Lake a less attractive wintering location for most waterfowl species. In addition, it has been noted by partner organizations that the vegetative composition of the area has been changing in recent decades. Thus, it is necessary to ensure proper management by capturing the current vegetative composition and to determine rates of change by comparing to preexisting baseline datasets.

End-Users/Partners/Boundary Organizations:

Louisiana Department of Wildlife and Fisheries (LDWF) (End User, POC: Dr. Larry Reynolds, Waterfowl Study Leader)

Ducks Unlimited, Inc. (End User, POCs: Dr. Dale James, Conservation Planning Manager; Jerry Holden, Director of Conservation Programs in Louisiana)

The Louisiana Department of Wildlife and Fisheries and Ducks Unlimited, Inc. have teamed up to devise a management strategy that will help eliminate and mitigate the potentially destructive encroachment of woody vegetation. Email and phone communication with both groups was initiated in December 2013 by DEVELOP SSC and both organizations have expressed sincere interest in partnering with DEVELOP on this project. They have offered assistance and guidance as needed throughout the project's lifecycle, along with access to their previous work relating to Catahoula Lake. It is anticipated that project results and methods will be handed off in person at the SSC Spring 2015 Close-out. Project results will allow partner organizations to make better informed management decisions by providing them with up-to-date information on woody vegetation extent and predicted changes to specific habitat types.

Decision Making Process:

The Louisiana Department of Wildlife and Fisheries and Ducks Unlimited, Inc. have teamed up to devise a management strategy that will help eliminate and mitigate the potentially destructive encroachment of woody vegetation. In order to facilitate a management plan, the current extent of encroaching woody vegetation needs to be quantified and stratified into classes of relative density and cover species. This will allow decision makers to prioritize their mechanical and chemical treatment efforts to minimize the time and costs and to maximize benefits. Partner agencies have previously created woody-stem vegetation density classifications from 2004 *Satellite Pour l'Observation de la Terre* (SPOT) 5 data and 1987-2003 change in woody vegetation using Landsat 5 Thematic Mapper (TM) classifications. However, no recent or follow-on work has been completed or is planned by either organization.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	OLI	Spectral vegetation indices, land cover classification, woody stem density
Landsat 5	TM	Spectral vegetation indices, land cover classification,

		woody stem density
Terra	ASTER	Spectral vegetation indices, land cover classification, woody stem density
ER-2	AVIRIS	Spectral vegetation indices, land cover classification, woody stem density

NASA Earth Observations to be Highlighted:
This project seeks to highlight the use of: 1) Landsat 8 Operational Land Imager (OLI) data to create current woody geospatial vegetation cover density indicator products; and 2) Landsat 5 TM and Landsat 8 OLI data to create time series and change products for various cover types. Project results will be used to calculate and document habitat-specific rates of change and use those calculated rates to predict future habitat type expansion or decline. This project will also investigate the use of Landsat 8's panchromatic band to pan-sharpen scenes to 15m spatial resolution, as a means to improve the spatial resolution and utility of the Landsat-based products of interest to the end-users. If available for the study area and study period, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) data will also be explored to created higher resolution and high-specificity products.

Ancillary Datasets:
2004 SPOT 5 woody stem density classification – provided by partners
1987-2003 Landsat 5 TM change in woody vegetation – provided by partners
USDA – National Agricultural Imagery Program (NAIP) aerial imagery
NOAA – Coastal Change Analysis Program (CCAP) Regional Land Cover
USGS – National Land Cover Database (NLCD)

Models:
IDRISI Land Change Modeler for ArcGIS – Clark Labs (POC: Christine Rains, JPL DEVELOP)

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Current woody-stem vegetation density classification	Target areas for mechanical and chemical treatment efforts	2004 SPOT 5 classifications
Time series of woody vegetation extent	Target areas for mechanical and chemical treatment efforts	1987-2003 Landsat 5 TM change detection
Rates of change in woody vegetation cover	Future target areas for mechanical and chemical treatment efforts	1987-2003 Landsat 5 TM change detection
Predictions of future habitat expansion or decline	Future target areas for mechanical and chemical treatment efforts	No method currently used

Current Woody-Stem Vegetation Density Classification – Current extent of woody-stem vegetation will be quantified using pan-sharpened Landsat 8 OLI data. If available, ASTER and AVIRIS data may also be used for creating current extent maps.

Time Series of Woody Vegetation Extent – Time series and change analysis of woody vegetation from 2004 – 2014 will be conducted using Landsat 5 TM and Landsat 8 OLI data. Use of ASTER and AVIRIS data, if available, will also be explored.

Rates of Change in Woody Vegetation Cover – Using 2004-2014 time series and available baseline data, rates of change in select cover types will be calculated. These rates of change will allow partner agencies to predict future woody vegetation encroachment into Catahoula Lake.

Predictions of Future Habitat Expansion or Decline – Using rates of change for specific habitat and cover types from the 2004-2014 time series, future expansion or decline will be forecasted for woody and non woody-stem vegetation.

Project Details:
National Application Area Addressed: Ecological Forecasting
Source of Project Idea: This project idea arose during conversations between Jason Jones and Jerry Holden with Ducks Unlimited, Inc. Initial contact was made by Jason as he was researching how different organizations assess project performance and metrics for the Applied Sciences and Technology Project Office at SSC. The topic of DEVELOP arose, and Jason inquired about the potential for collaboration and asked Jerry if he had any ideas for potential projects. Jerry mentioned the previous work that LDWF and Ducks Unlimited, Inc had done with Catahoula Lake vegetation mapping and suggested that a continuation of that work would be very beneficial to both organizations. Jerry Holden then put Jason and SSC Center Lead, Ross Reahard, in touch with Dr. Dale James of Ducks Unlimited, Inc. and Larry Reynolds with LDWF. Subsequent conversations lead to the development of this proposed project.

Advisors: Joe Spruce (NASA SSC Primary Science Advisor and Mentor), James "Doc" Smoot (NASA SSC Secondary Science Advisor), Dr. Kenton Ross (NASA DEVELOP National Science Advisor, LaRC)
# of Participants Requested: 4
Project Timeline: 1 Term: Spring 2015
Study Location: Catahoula Lake, Louisiana
Period being Studied: 2004 – present (2015)

Previous Related DEVELOP Work:
Southeast Louisiana Ecological Forecasting
Utilizing NASA EOS to Aid the National Wildlife Federation in Analyzing Wetland Gain and Loss in Wetland Restoration Project Areas in Southeast Louisiana
Fall 2012 (SSC)

4. Colombia Ecological Forecasting III (UGA)

Utilizing NASA Earth Observations to Enhance the Conservation Efforts of Colombia's Most Endangered Primate, the Cotton-top Tamarin (*Saguinus oedipus*)

Objective:
The overarching goal of this project is to strengthen and support Proyecto Tití, a Colombia-based conservation program, by incorporating the use of NASA Earth observations into their conservation program. This study aims to use results from the previous terms to systematically assess forest connectivity and habitat distribution for the remaining departments within the historic range of the Cotton-top tamarin.

Community Concern:
Proyecto Tití is committed to protecting the cotton-top tamarin (*Saguinus oedipus*), one of the most threatened primates in the world. This species is listed as critically endangered by the

International Union for Conservation of Nature (IUCN) Red List, with roughly 6,000 individuals remaining in the wild. Colombia is among the top ten countries to suffer significant loss of forested habitat with a 0.5% annual rate of destruction and the status of tamarin forest habitat has been designated as critically endangered throughout a significant portion of Colombia. A study by Miller et al. (2004) documented a 31% decrease in forested habitat between the years 1990 and 2000 within the tamarins' historic distribution. This decrease was due to conversion of tropical forest habitat to agricultural uses and urban development, extraction of forest resources for firewood and lumber, and logging on both private and protected areas. The rate of habitat destruction continues at an unprecedented rate in Colombia and the creation of small isolated forest remnants is prevalent throughout much of the distribution of the cotton-top tamarin. Cotton-top tamarins have a localized distribution within northwest Colombia (departments of Antioquia, Atlántico, Bolívar, Chocó, Cordoba, Sucre), making them highly vulnerable to the effects of habitat destruction.

End-Users/Partners/Boundary Organizations:
Disney's Animal Kingdom (Boundary Organization, POC: Dr. Anne Savage, Conservation Director, Disney's Animals, Science & Environment, Walt Disney Parks and Resorts)
Fundación Proyecto Tití (End-User, POC: Rosamira Guillen, Executive Director)
Proyecto Tití (Partner, POC: Dr. Anne Savage, Executive Director)

Contact with the partner was previously established and project ideas have been discussed with Dr. Anne Savage, Executive Director of Proyecto Tití and Conservation Director for Disney's Animals, Science & Environment, Walt Disney Parks and Resorts, and with the field team in Colombia led by Rosamira Guillen, Executive Director of the Colombian NGO, Fundación Proyecto Tití. They are interested in partnering with NASA DEVELOP to create end-products that will benefit conservation efforts initiated by Proyecto Tití and Disney. At the close of the term, the UGA node will present the partner with methods, quantitative information, and maps to enhance their on-going efforts and assist local resource managers in prioritizing critical habitats at risk. The decision support tool created by this project will provide the partner with novel information gleaned from NASA Earth science data and GIS modeling techniques.

Letters of Support: Dr. Anne Savage, Conservation Director, Disney's Animals, Science & Environment, Walt Disney Parks and Resorts

Decision Making Process:
Proyecto Tití has been actively involved in studying wild Cotton-top tamarins for many years at field sites in Colosó and Santa Catalina in Colombia. Their field research is focused on population surveys, demography and group composition, reproductive behavior, habitat, and community conservation. In 2004, they used Landsat 4, 5, and 7 to create an unsupervised land cover classification of the historic range of the tamarin for habitat assessment. They have integrated end-products derived from Landsat 8 into their presentations that were developed by the summer 2014 DEVELOP team at UGA.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	OLI	Land cover / vegetation indices

NASA Earth Observations to be Highlighted:
The Operational Land Imager (OLI) on Landsat 8 is a push broom scanner designed to collect electromagnetic radiation reflected from Earth's surface across nine broad spectral bands. This

new sensor and up-to-date imagery provide the most relevant and useful data to assess the remaining tamarin habitat and identify areas to focus reforestation efforts.

Ancillary Datasets:
Field Transect GPS Data provided by Proyecto Tití

Models:
Edge Density Python Script (POC: Tom Prebyl, Warnell School of Forestry and Natural Resources at the University of Georgia), Cotton-top Tamarin Suitability Forest Model (POC: Colombia Eco Forecasting Team Fall 2014, NASA DEVELOP)

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Historic Range Connectivity Assessment	Identify areas where reforestation and conservation should be focused to improve connectivity	None

Historic Range Connectivity Assessment – The team will provide a series of map products and landscape metric analyses for the departments of Córdoba, Magdalena, Chocó, and Antioquia in Colombia within the historic range of the Cotton-top tamarin. The end-products will quantitatively support priority areas for land acquisition, reforestation, and assessing forest connectivity. The project partners in Colombia have the ability to ground truth the locations the DEVELOP team identifies as priority areas for protection and restoration. If deemed suitable, partners can purchase the land and maintain it as protected habitat.

Project Details:
National Application Area Addressed: Ecological Forecasting
Source of Project Idea: Caren Remillard, current UGA Center Lead, was introduced to Dr. Anne Savage through a former colleague at Emory University's Yerkes National Primate Research Center. After the initial meeting they determined that NASA Earth observation-driven modeling could provide important decision support tools to an on-the-ground partner.

Advisors: Dr. Marguerite Madden (University of Georgia, Geography Department), Dr. Nathan Nibbelink (University of Georgia, Warnell School of Forestry and Natural Resources), Dr. Thomas Jordan (University of Georgia, Geography Department), Steve Padgett-Vasquez (University of Georgia, Integrative Conservation and Geography Department)
# of Participants Requested: 4
Project Timeline: 3 Terms: 2014 Summer to 2015 Spring
Study Location: Northwestern Colombia within the historic distribution of the Cotton-top tamarin
Period being Studied: 2014

Previous Related DEVELOP Work:
Colombia Ecological Forecasting I and II
Utilizing NASA Earth Observations to Enhance the Conservation Efforts of Colombia's Most Endangered Primate, the Cotton-top Tamarin (*Saguinus oedipus*)
Summer and Fall 2014 (UGA)

Multi-Term Objectives:

- **Term 1** – During the first term, the team created a current land use/land cover map of the historic range of the Cotton-top tamarin from Landsat 8 imagery and a series of change detection maps dating from 1991 to 2014. A habitat suitability map was produced based on image classification and ground data to determine current Cotton-top tamarin habitat distribution. Finally, outreach tools were developed for the local community to spread awareness of habitat loss.
- **Terms 2** – The team performed a suitable habitat connectivity assessment to identify areas to focus restoration and conservation efforts in the three northern departments of Atlantico, Bolivar, and Sucre within historic range of the Cotton-top tamarin. The team used land use/land cover classification maps constructed during the first term to examine forest connectivity and identify practical areas to implement reforestation.
- **Term 3 (Proposed Term)** – The team will continue the forest connectivity and habitat modeling performed in term 2 to the remaining departments of Córdoba, Magdalena, Chocó, and Antioquia. This will complete the habitat analysis for the historic range of Cotton-top tamarins. When the assessment is complete, project partners can use the information to purchase land with the most potential for conservation and reforestation, ultimately providing a more contiguous habitat for the Cotton-top tamarins and sympatric species.

5. Ocmulgee River Ecological Forecasting & Water Resources (UGA)

Utilizing NASA's Earth Observations for Forecasting Land Use Change and Wildlife Disturbances along the Ocmulgee River Corridor

Objective:

The goal of this project is to produce an up to date time series analysis illustrating and quantifying land use change in the Ocmulgee River corridor. Results of the time series will then be used to understand the effects of changing conditions on the wildlife and fisheries with a focus on endangered native species. This will provide the partners with information regarding threats to habitat and allow for ecological forecasting. Additionally, the team will explore the use of close-range unmanned aerial systems (UAS) coupled with NASA Earth observations for wildlife management.

Community Concern:

The Ocmulgee River corridor has exceptional conservation importance but is under increasing pressure from urban and suburban sprawl and the subdivision of large forested tracts. The corridor contains extensive bottomland hardwood swamps and other natural communities that support important plant and animal populations including Shortnose sturgeon and Atlantic sturgeon (both federally endangered), Robust redhorse, American shad, Striped bass and the state endangered Altamaha shiner. It serves as an important flyway habitat to millions of migratory birds, is home to the Central Georgia black bear and contains several archeological remnants of pre-European Native American villages. The Ocmulgee River corridor is also a tremendous recreational resource that provides hunting, fishing, boating, hiking, and wildlife viewing opportunities, and is described as a high-priority landscape feature in Georgia's 2005 Wildlife Action Plan. It was also identified in 2006 as one of six Georgia Department of Natural Resources (GA DNR) land priority conservation areas.

End-Users/Partners/Boundary Organizations:

Georgia Department of Natural Resources (Partner/End-User, POC: Dan Forster, Director of Wildlife Resources Division; Thomas Litts, Special Project Operations Manager)

National Parks Conservation Association (Potential End-User, POC: Dr. Chris Watson, Senior Program Manager)

Contact with Thomas Litts at the Georgia Department of Natural Resources (GA DNR) Wildlife Resources Division has been made and project ideas have been discussed between Mr. Litts, Dr. Marguerite Madden (Science Advisor), Peter Hawman (DEVELOP Young Professional), and Caren Remillard (DEVELOP UGA Center Lead). The GA DNR anticipates that the project will result in tools that could be used to assess threats, to identify opportunities (e.g. easement, land acquisition), to communicate with conservation partners and the public, and to target best-management practice efforts. The GA DNR is a local partner and the UGA node will deliver the end-products in person and provide methodologies and tutorials of the decision support tools. The GA DNR will participate actively in the project and provide input or direction as needed.

Letters of Support:
Georgia Department of Natural Resources, Wildlife Resources Division; Dan Forster

Decision Making Process:
The Georgia Department of Natural Resources (GA DNR), Wildlife Resources Division (WRD) is charged with conserving, enhancing and promoting Georgia's wildlife resources, including game and nongame animals, fish, and protected plants. It is comprised of three sections: Game Management, Fisheries Management, and Nongame Conservation. The GA DNR uses numerous decision and management tools to conserve state-owned and -operated lands. These range from statistical and spatial analysis to fish stocking and prescribed burns. GA DNR currently uses remotely sensed data to support management decisions, including National Agriculture Imagery Program imagery, LiDAR, side imaging sonar, digital elevation models, and products derived from satellite sensors. The GA DNR has personnel trained in GIS and remote sensing and will be able to take ownership and utilize the tools and products resulting from this DEVELOP project.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	OLI	Land use
Terra	ASTER	Land use and DEM

NASA Earth Observations to be Highlighted:
The Operational Land Imager (OLI) on Landsat 8 is a push broom scanner designed to collect electromagnetic radiation reflected from Earth's surface across nine broad spectral bands. This new sensor and up-to-date imagery provide the most relevant and useful data to assess land use/land cover. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) aboard Terra provides higher resolution imagery as well as digital elevation models.

Ancillary Datasets:
- 2012 Side Scan Sound Navigation And Ranging (SONAR) image data and Ocmulgee River substrate layers, GA DNR
- Index of Biotic Integrity fish sample data, GA DNR
- Long term sport fish monitoring data, GA DNR
- National Pollutant Discharge Elimination System (NPDES), 303d, Soils, geology and other environmental layers, GA DNR
- Rare plant / animal / fish survey data, GA DNR
- Parcel data, GA DNR
- National Land Cover Data set (NLCD), Multi-Resolution Land Characteristics Consortium (MRLC)
- UAS data, DJI Phantom 2 Vision +

Models:

A logistic regression model will be used to measure the relationship between environmental factors and fish diversity and water quality. The UGA science advisors have experience with this type of statistical modelling and will assist participants.

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Current Land-use Map	Assessment of current land use	Most current land-use map is 2008
Land-use Time Series Analysis	Predict future land use change for management purposes	None
Threat and Opportunity Assessment	Quantitative results can be used to communicate and enhance management and conservation decisions for fisheries and wildlife	None

Current Land Use Map of Ocmulgee River Corridor - The team will use Landsat 8 OLI imagery to construct a current land use map of the areas surrounding the Ocmulgee River.

Land Use Time Series Analysis of Ocmulgee River Corridor – Using NLCD data sets for the years 2001, 2006, and 2011 and current Landsat 8 OLI imagery, the team will assess land use change. This analysis will display trends in land use change and help in the forecasting of future development impacting the Ocmulgee River and the surrounding ecosystems.

Threat and Opportunity Assessment – Using the time series analysis developed during the first term in conjunction with ancillary data listed above, the team will conduct statistical analyses examining the relationship between development and natural resources (e.g. fish presence/absence/diversity) to complete a threat and opportunity assessment. Project partners can use these results to support their decisions regarding corridor management.

Project Details:
National Application Areas Addressed: Ecological Forecasting, Water Resources
Source of Project Idea: Dr. Marguerite Madden and Thomas Litts have been working together for 25 years and are interested in collaborating to use NASA imagery for exploring and predicting land-use change around the Ocmulgee River.

Advisors: Dr. Marguerite Madden (University of Georgia, Center for Geospatial Research), Dr. Thomas Jordan (University of Georgia, Center for Geospatial Research)
# of Participants Requested: 4-5
Project Timeline: 2 Terms: Spring 2015 to Summer 2015
Study Location: Ocmulgee River, Central Georgia
Period being Studied: late 1990s to present

Multi-Term Objectives:

- **Term 1 (proposed)** – During this term, the team will utilize NLCD data sets for the years 2001, 2006, and 2011 and Landsat 8 imagery to create time series analysis of land use change affecting the Ocmulgee River corridor. Additionally the team will use the most current Landsat 8 imagery to assess the current land use in the study area.
- **Term 2** – During the second term, the team will use the land use classification results along with ancillary data provided by the GA DNR to assess the threat of urbanization has on the

resources found within and along the Ocmulgee River. Focusing on available habitat for keystone species such as the Black bear and Atlantic sturgeon.

Note: This is UGA's first collaborative DEVELOP project with the Georgia Department of Natural Resources.

Letters of Support

Project 4. Colombia Eco Forecasting (UGA)

February 4, 2014

Caren Remillard
NASA DEVELOP-UGA Center Lead
Graduate Research Assistant
Center for Geospatial Research
Department of Geography
University of Georgia
210 Field St., Rm 319
Athens, GA 30602

Dear Caren,

Thank you very much for your interest in partnering with Proyecto Titi and Disney in helping us to assess habitat availability for cotton-top tamarins. The conservation of this critically endangered species is a high priority in Colombia and Proyecto Titi continues to be a leader in assisting the Colombian government in bringing public attention to the plight of this charismatic species as well as helping to prioritize forest habitats for long-term protection.

We welcome the assistance of the NASA DEVELOP team in helping to provide important data on landscape metrics so that we may continue to select priority areas for conservation, create opportunities to connect forest patches, and examine the opportunities to purchase and reforest habitat adjacent to forested areas. We believe that this information will be critical in helping us to achieve our goal of establishing new protected areas for cotton-top tamarins and insure the survival of this species for future generations.

Sincerely,

Anne Savage

Anne Savage, Ph.D.
Conservation Director
Walt Disney Parks and Resorts

Project 5. Ocmulgee River Ecological Forecasting (UGA)

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
WILDLIFE RESOURCES DIVISION

MARK WILLIAMS
COMMISSIONER

DAN FORSTER
DIRECTOR

September 25, 2014

Caren Remillard
NASA DEVELOP-UGA Center Lead
Graduate Research Assistant
Center for Geospatial Research
Department of Geography
University of Georgia
210 Field St., Rm 319
Athens, Georgia 30602

Ms. Remillard,

We appreciate your interest in partnering with Wildlife Resources Division (WRD) to develop current land use maps, future land use projections and assess habitat threats and opportunities in the Ocmulgee River corridor between Juliette and Hawkinsville, Georgia. The Ocmulgee River corridor is one of six priority conservation areas in Georgia that provide critical habitat to a wide range of rare and sensitive species, as well as exceptional hunting, fishing, boating, hiking, wildlife viewing, and other recreational opportunities. The corridor is also experiencing increased pressure from urban/suburban development and subdivision of larger forested tracts. Products derived from the project will serve WRD and its partners well as we move forward to identify and implement conservation actions within the corridor.

Again, thank you for your interest helping to conserve Georgia's wildlife resources for future generations and we look forward to partnering with you on this project and others going forward. If you have any questions or require additional information please contact Thomas Litts at 706.557.3236.

Sincerely,

Dan Forster

DF:tl

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