



2014

ECOLOGICAL FORECASTING

NASA Earth Science  
Applied Sciences Program



# ***Ecological Forecasting: 2014 Annual Summary***

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*<http://AppliedSciences.NASA.gov>*

## **I. Introduction**

The ESD Applied Sciences Program promotes efforts to discover and demonstrate innovative and practical uses of Earth observations. The Program funds applied science projects to enable near-term uses of Earth observations, formulate new applications, integrate Earth observations and related products in practitioners' decision making, and transfer the applications to long-term users. The projects are carried out in partnership with public- and private-sector organizations to achieve sustained use and benefits from the Earth observations.

The Applied Sciences Program's applications themes are currently focused on four of the nine Societal Benefit Areas of the interagency U.S. Group on Earth Observations: Health (including Air Quality), Disasters, Ecological Forecasting, and Water Resources.<sup>1</sup> The Program includes climate-related influences and impacts within each of these themes.

The Ecological Forecasting Applications area combines satellite observations and many types of models to build capacity for forecasting changes in living systems. Natural resource managers, working on land and in the oceans, are a primary user community along with all those involved in the conservation and sustainable use of ecosystems in the United States and abroad.

## **II. Overview of 2014**

Ecological Forecasting managed an active portfolio of projects in 2014. A dozen feasibility projects got underway while a mix of nine projects from the DECISIONS 2008, NPP Science Team, and Climate and Biological Response (BioClim) programs either neared completion or concluded. The applications area continued its support of mission applications. Ecological Forecasting also participated in several U.S. and international initiatives involving conservation and protected area management.

This report presents some of the achievements, challenges, and activities for the Ecological Forecasting Applications area over the past year. It also includes a brief outlook for 2015. The appendix includes individual project summaries with 2014 accomplishments and, as applicable, plans for the coming year.

## **III. Major Accomplishments**

Funding went out in early 2014 for 12 projects selected for one year of feasibility activities under the Ecological Forecasting for Conservation and Natural Resource Management solicitation. These projects brought together satellite remote sensing, ecological models and other types of models, and biological observations to promote conservation and sustainable ecosystem management. An exciting element of this program was that at least some of the required biological observations had to originate from crowdsourcing initiatives. Harnessing the power of the crowd through observations of interested observers, both professional and amateur, to develop time series of

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<sup>1</sup> The nine USGEO SBAs are Agriculture, Climate, Disasters, Ecological Forecasting, Energy, Health, Oceans, Water Resources, and Weather.

biological data broke new ground programmatically. The goal is to increase the number of *in situ* observations (currently a limiting factor in modeling changes to ecosystems and necessary to make forecasts). An added benefit is wider engagement of the public through participation in NASA Applied Sciences activities. These 12 projects completed their feasibility phase at the end of November and submitted reports and plans to NASA. These reports and plans documented their results in demonstrating the feasibility of their proposed efforts and offered a plan for a full three-year follow-on implementation project. Full projects are to culminate in the transition of tools developed by the project to end users for sustained application. A review panel in January 2015 will use these project reports/plans to select those projects that will receive an additional three years of funding for implementation.

Three projects wrapped up in 2014. They improved detection of heat stress on coral reefs around the world, developed a system for integrating animal movement data with remote sensing and modeled products to provide environmental context for the movements, and explored the ability of new VIIRS instrument products to replace older MODIS products. Details are below.

Frank Muller-Karger (University of South Florida) and his academia-government team used a variety of satellite sea surface temperature data sets to improve the spatial resolution of global NOAA Coral Reef Watch operational products from 50km to 5km, with even higher spatial resolution 1km products available for the Gulf of Mexico, Florida, and Caribbean regions. NOAA Coral Reef Watch products include: sea surface temperature anomalies, coral bleaching hotspots, degree heating weeks, and bleaching alert areas that point out coral reefs around the world susceptible to bleaching and other injuries due to water temperature changes. They are available for use by marine ecosystem managers everywhere via the Web.

Gil Bohrer (Ohio State University) and team developed a tool called the Environmental Data Automated Track Annotation system (Env-DATA) to provide the environmental context for animal movement data held in the Movebank archive. Env-DATA enables direct comparisons of more than 3,000 variables from remote sensing archives and weather model reanalyses with telemetry tracks of animal movement. A number of U.S. government and other users have adopted the tools from this project, including groups involved in population management for the endangered California condor.

Ramakrishna Nemani (NASA Ames Research Center) and his team received Applied Sciences funding to test the ability for a suite of Applied Sciences projects to transition from using MODIS instrument data to data from the new VIIRS instrument. The project focused on vegetation indices and uncovered a number of hurdles to overcome in applications projects' switching from MODIS to VIIRS products. In doing so, it has provided helpful direction for the new Science Investigator-led Processing Systems to pursue.

#### **IV. Assessment**

The overarching challenge for the NASA Applied Sciences Program is to support projects that develop products of value to the external community, i.e., our partners. The ultimate test of this utility is the transfer of the NASA-funded products to sustainable use by partners in the partners' operational management and decision support frameworks. Transferring a NASA-funded product (the outcome of a NASA Applied Sciences project) into long-term use by a partner is very challenging and involves close coordination among NASA, the NASA-funded investigator, and the end-user partner from the inception of the project. The Ecological Forecasting associates have become quite proficient over the past years in monitoring and guiding individual projects throughout their life cycles—so necessary to promote successful transfers. The associates are a major asset to this applications area. Biweekly conference calls have proven very helpful in keeping all program management personnel on the same page.

The mission applications representatives are also strong contributors to the applications area—indeed the entire Applied Sciences Program. They support the integration of applications into the development cycles of missions for which the Ecological Forecasting program manager serves as applications lead. Over the past year, they have spread the word about the applications potential of the *ICESat-2*, *PACE*, and *HyspIRI* missions through applications traceability matrices, mission applications whitepapers, special sessions at meetings, workshops, membership on mission science teams, etc. Each of these three missions supports elements of Ecological Forecasting. The mission applications representatives continue to target communities with an interest in designing Ecological Forecasting projects to prepare for products from new missions. Monthly calls link applications area program management to mission applications reps. These representatives are instrumental in bringing applications into mission life cycles at an earlier point than ever.

#### **V. Project Portfolio**

In 2014, the Ecological Forecasting applications area continued its transition from a series of productive and long-running DECISIONS and BioClim projects to the Ecological Forecasting for Conservation and Natural Resource Management “feasibility to decisions” projects. As the remaining DECISIONS and BioClim projects conclude over the course of 2015, it will be necessary to rejuvenate the portfolio with another call for proposals via either an amendment to the ROSES 2015 solicitation or a new appendix in the ROSES 2016 solicitation.

#### **VI. Program Management**

Investigators from both the NASA Biodiversity and Ecological Forecasting programs met at the annual joint team meeting in May 2014. Bringing together investigators working across the research to applications continuum has been valuable. Basic researchers gain insights into the potential to extend the benefits of their research to the operational community while those building applications access the latest thinking in their fields. Joint project proposals have resulted from team meeting conversations. Getting ready for the next NRC Earth Science and Applications Decadal Survey was the theme for the 2014 meeting. Participants divided into three breakout groups (terrestrial research,

terrestrial applications, and marine) and assembled key Decadal Survey questions and topics for these areas.

The *Hyperspectral Infrared Imager (HyspIRI)* is a mission concept called for in the 2007 NRC Earth Science Decadal Survey. This mission would combine a visible through shortwave infrared imaging spectrometer with a multispectral thermal infrared sensor—a powerful instrument combination for ecosystem understanding. Two *HyspIRI* events in 2014 addressed the needs of the communities in the NASA Applied Sciences Program. In June, NASA GSFC hosted its annual *HyspIRI* Data Products Symposium. This year's symposium addressed how *HyspIRI* could support NASA's Sustainable Land Imaging (SLI) activities. In addition, it featured applications-oriented talks on ecosystems studies, public health, and disasters. There was also a series of talks on automated processing of low-latency products—of interest to several applications. The final day of the symposium was dedicated to coastal ecosystem talks.

The annual *HyspIRI* Science and Applications Workshop took place in Pasadena, California, in October. Talks included an Applied Sciences update from Lawrence Friedl and, as usual, a wide range of applications presentations cutting across the Applied Sciences applications areas. There was also a session on the ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) activity. ECOSTRESS was selected in 2014 through the Earth Venture–Instrument solicitation. It will fly a multispectral thermal instrument aboard the International Space Station and is leveraging much technology maturation work done for the *HyspIRI* thermal infrared sensor. One of three key science questions for ECOSTRESS is an applications question: Can agricultural vulnerability be reduced through advanced monitoring of agricultural water consumptive use and improved drought estimation?

## **VII. Community Leadership**

In November 2014, the applications area played a large role in the World Parks Congress in Sydney, Australia. The World Parks Congress occurs every 10 years and brings together environment ministers, government parks administrators, NGO conservation biologists, indigenous peoples residing in and around protected landscapes, and nature lovers from around the world. This year's congress included more than 6,000 participants from over 170 countries. NASA Applied Sciences highlighted ways in which satellite remote sensing can support the management of parks and other protected areas through talks, press events, hyperwall presentations, a NASA booth, blogs, and the release of a new book *Sanctuary* by the Institute for Global Environmental Strategies. *Sanctuary* features satellite imagery of parks alongside ground images, with case studies reflecting the themes of the congress. Examples featured in these talks, events, and materials often came from Ecological Forecasting projects.

Publications arising from the applications area in 2014 included a paper in the journal *Conservation Biology* by Robert Rose *et al.* entitled “Ten Ways Remote Sensing Can Contribute to Conservation.” The paper resulted from a NASA-sponsored workshop in 2013 that brought together 30 participants from the terrestrial and marine conservation

and remote sensing communities to discuss the leading challenges in conservation for remote sensing to tackle. The journal *Science* published a Perspectives piece in October 2014 by the Ecological Forecasting program manager on “Sensing Biodiversity.” The paper makes the case for building networks of satellite, airborne, and *in situ* sensors to manage our changing global biodiversity and stem its loss.

### **VIII. International Activities**

The Ecological Forecasting application area’s Gary Geller was a leader in the renewal of the Group on Earth Observations Biodiversity Observation Network (GEO BON) in 2014. GEO BON called a new chair, vice chair, and Executive Director and initiated a reorganized governance structure built upon a Management Committee, Implementation Committee, and Advisory Board. Gary had been a key player in designing this new structure. He also spent much of 2014 preparing for his departure to Geneva, Switzerland, to serve on the GEO Secretariat. His tour will begin in 2015.

The applications area, along with NOAA and the Bureau of Ocean Energy Management (BOEM), conducted a review panel to select projects proposed in response to an interagency solicitation under the auspices of the National Oceanographic Partnership Program. The solicitation called for demonstration projects to test the potential for a U.S. Marine Biodiversity Observation Network (Marine BON)—an element of GEO BON. Three demonstration projects were selected for funding, with additional support for one project coming from Shell Oil Company. These projects got underway in the second half of 2014.

In May, the Ecological Forecasting program manager gave a talk at a Zoological Society of London symposium on Remote Sensing for Conservation. The applications area played a key role in organizing this symposium. There is a growing awareness worldwide of the ability of remote sensing to offer new solutions to longstanding conservation and natural resource management challenges.

### **IX. Looking Ahead**

The year 2015 will be an active one for the Ecological Forecasting Applications area. The Ecological Forecasting for Conservation and Natural Resource Management projects are entering their implementation phase, bringing together crowdsourced biological observations, satellite remote sensing, and ecological models. They will help demonstrate the potential of citizen-provided data sets to provide urgently needed *in situ* information for generating ecological forecasts. Without this *in situ* information, the utility of NASA satellite imagery for forecasts is limited. GEO BON is entering a new phase after its 2014 reset. It has much on its plate but its renewed management and energy along with an exciting range of products should carry it far over the coming year. Stay tuned for a new solicitation in this applications area. There are a number of new topics and compelling questions around which to organize a solicitation. The applications area has a growing global reputation as a source of innovative remote sensing solutions for the conservation and sustainable use of our natural world and its resources.

## X. Appendix

### Ecological Forecasting Project Highlights from 2014

**Project:** Merging Satellite and Numerical Model Data in the California Current to Create Forecasts of Harmful Algal Blooms

Principal investigator: Clarissa Anderson, University of California at Santa Cruz

Project year: 1 (feasibility)

Year-end ARL: 6

Description: This project introduces a method for predicting the spatial distribution of harmful algal bloom (HAB) and toxin (domoic acid) load likelihoods in the coastal region of the California Current System using a unique blend of numerical models (ROMS), ecological forecast models (GLM HAB) of target phytoplankton taxon (*Pseudo-nitzschia*) and gap-filled satellite ocean color imagery (MODIS with DINEOF). The project utilizes the distributed databases established by the Central and Northern California Ocean Observing System (CeNCOOS) for data management, interface with end users, and communication with regional partners. The project is developing a forecasting system and analysis tool in partnership with the NOAA National Ocean Service (NOS) and the National Weather Service (NWS) as a test bed for transferring results to an operational center to complement existing regional HAB forecasting systems.

End users: NOAA National Ocean Service (NOS)

Data sources, models, technology: *Aqua*/MODIS, VIIRS, ROMS, HABMAP, Jellywatch and Marine Mammal Center crowdsourced data

Major accomplishments in CY 2014:

- Applied DINEOF to 2009 MODISA ocean color imagery to assess in hindcast mode the feasibility of the merged (gap-filled) satellite-ROMS-GLM HAB model approach.
- Transitioned approach to the CeNCOOS computing environment to produce nowcasts and forecasts on the CeNCOOS website for targeted end users (beta version).
- Launched a feedback survey to the CeNCOOS community and made the forecasts public to a wide group of science and management end users.
- Quantified overall performance of the models using observational time series of both *Pseudo-nitzschia* abundance and domoic acid for 2014 (showed good coherence and model skill).
- Modified a popular citizen science website for beachcombers that would allow them to easily record observations of marine mammal strandings in order to verify offshore model results of toxic events with crowdsourced data.

- Obtained and analyzed historical marine mammal stranding data (2007-2014) with respect to HAB monitoring and model data to assess their coherence.
- Strengthened partnership with NOS and established a Phase 2 plan with NOS and NWS.

Plans or expectations for 2015:

- Create Forecast & Analysis Tool for applying guidelines to validation and forecast analysis. In Year 2, the UCSC group will work with NCCOS to establish the precise nature of the final forecast product and the most appropriate destination for dissemination, whether via CO-OPs product pages and/or Listserves, and/or NWS dissemination systems.
- Transfer HAB forecast product to CeNCOOS data portal for interactive displays and time series searches by end users.
- Establish best-practice DINEOF methods for CCS and application of new Chl algorithms to be run at NOAA CoastWatch and disseminated to NOS/NWS.
- Address the first steps required to implement routines for integrating ocean color data, hydrodynamic models, and ecological models on NOAA developmental computer(s) in routine demonstrations.

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**Project:** A Tool Using Satellite Telemetry and Remotely Sensed Environmental Data to Provide Near Real-time Predictions of Whale Occurrence in the California Current System to Reduce Anthropogenic Impacts

Principal investigator: Helen Bailey, University of Maryland Center for Environmental Science

Project year: 4

Year-end ARL: 6

Description: The project goal is to reduce whale ship strikes and entanglements by providing near real-time predictions of whale occurrence.

End users: NOAA NMFS Southwest Regional Office

Data sources, models, technology: SSH, SST, chlorophyll-a, net primary productivity (*Topex/Poseidon, Jason, SeaWinds, MODIS, AMSR-E, SeaWiFS*)

Major accomplishments in CY 2014:

- Developed automated framework for near real-time tool.
- Associated humpback whale “hot spots” with high chlorophyll a concentrations.
- Determined that blue whale occurrence is significantly related to SST, chlorophyll-a concentration, Ekman Upwelling, meridional wind strength, and water depth.

- Continued to fully engage NOAA; NOAA will make recommendation to Coast Guard on shipping lanes based on newly published work on blue whales.
- Estimated gray whale speeds; the data will be used to refine existing NOAA state-space model.
- Continued progress on humpback and gray whale models.
- Completed an analysis of blue whale core areas; published it in *PLOS ONE*.

Plans or expectations for 2015:

- Refine blue whale habitat-based occurrence and density model to improve accuracy of predictions.
- Complete blue whale habitat-based foraging model.
- Complete analysis of humpback whale habitat use and foraging areas.
- Demonstrate near real-time tool to partner at NOAA NMFS.
- Deliver final report.

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**Project:** Discovering Relationships between Climate and Animal Migration with New Tools for Linking Animal Movement Tracks with Weather and Land Surface Data

Principal investigator: Gil Bohrer, Ohio State University

Project year: 3 (final)

Year-end ARL: 9

Description: To facilitate understanding of how birds and other highly mobile animals respond to environmental factors, this project is developing a variety of analytical and visualization tools, as well as environmental databases from MODIS, *TRMM*, and other sensors. These databases and tools, called Env-DATA, are used to enhance the online Movebank service.

End users: National Park Service, USFWS, USGS, U.S. Navy, researchers

Data sources, models, technology: ASTER, MODIS, SRTM, *TRMM*

Major accomplishments in CY 2014:

- Completed development of Env-DATA system and related tools providing access to more than 3,000 variables from remote sensing data archives and global weather model reanalyses.
- System used by more than 20 government and academic users.
- Env-DATA and Movebank tools adopted as the work procedure by all California condor population management groups. Movebank is the intermediary data system.
- Expanded use of project-developed tools by other groups at USGS.

- Organized Symposium on Animal Movement and the Environment, May 2014, in Raleigh, North Carolina.
- Eleven manuscripts published in 2014.
- Completed project in September 2014.

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**Project:** Forecasting Coastal Habitat Distributions through Fusion of Earth Observations, Process Models, and Citizen Science: A Climate Change Adaptation Tool for the NOAA National Estuarine Research Reserve System

Principal investigator: Kristin Byrd, USGS

Project year: 1 (feasibility)

Year-end ARL: 4

Description: Estuarine managers need ecological forecasting tools to prepare for the potential impacts of future climate change. In partnership with the NOAA National Estuarine Research Reserve System (NERRS), this project will integrate Earth to *in situ* observations with a model of tidal marsh elevations to forecast spatially explicit coastal habitat response to sea level rise, a key NERRS concern. The project will focus feasibility research on a brackish marsh, Rush Ranch, one of two sites in the San Francisco Bay NERR.

End users: NOAA NERRS

Data sources, models, technology: vegetation biomass: *Landsat 8* and World View-2. Total suspended sediment: *Landsat 8*, PRISM, and World View-2

Major accomplishments in CY 2014:

- Completed collection of biomass data for marsh vegetation biomass maps.
- Produced a biomass model and map with *Landsat 8* with error suitable for use in the Marsh Equilibrium Model. Overall RMSE = 208 g/m<sup>2</sup>.
- Produced Total Suspended Solids (TSS) models and maps with *Landsat 8*, World View-2 and PRISM with error suitable for use in the Marsh Equilibrium Model. Overall RMSE varied among sensors from 3.38 mg/L (*Landsat 8*), 8.33 mg/L (World View-2), and 7.28 mg/L (PRISM).
- Tested integration of remote sensing data from *Landsat 8* with the Marsh Equilibrium Model, Vegetation Distribution Model, and Habitat Suitability model for three sites in Suisun Marsh; identified technical integration issues related to proper extraction of spatial data used for model inputs.
- Identified method for correcting LiDAR DEMs for vegetation height that provides DEM accuracy suitable for use in the Vegetation Distribution Model (RMSE < 10 cm).

- Organized and ran initial test of citizen science activity, which will enable citizen scientists to collect water turbidity data to be used to validate the TSS map.
- Completed interviews with NERRS staff and coastal managers on decision-making activities and needs to improve decisions and how remote sensing and models will improve decision-making activities.
- Prepared fact sheet on project that was distributed widely to NOAA NERRS staff that summarizes project and seeks end user contribution to Phase II NASA proposal.

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**Project:** Using NASA Resources to Inform Climate and Land Use Adaptation: Ecological Forecasting, Vulnerability Assessment, and Evaluation of Management Options across Two U.S. DOI Landscape Conservation Cooperatives (LCCs)

Principal investigator: Andrew Hansen, Montana State University

Project year: 3

Year-end ARL: 4

Description: The project is using TOPS models and products, *Landsat* imagery, and other data to demonstrate the steps of a climate adaptation strategy in two LCCs. The project intends to support decision making at national parks, LCCs, and similar organizations through the development of future climate and land use scenarios, ecological vulnerability assessments, and management adaptation strategies.

End users: Greater Yellowstone Whitebark Pine Subcommittee, Yellowstone National Park, Grand Teton National Park, Rocky Mountain National Park, Great Smoky Mountain National Park, Shenandoah National Park, Delaware Water Gap National Recreation Area, Great Northern LCC, Appalachian LCC, DOI North Central Climate Science Center, NPS Intermountain Region Climate Change Program

Data sources, models, technology: NASA multi-platform sensor data, NASA TOPS; *Landsat*

Major accomplishments in CY 2014

- Completed ecological hindcasting and forecasting of climate, ecosystem process, and tree species and communities under climate change scenarios.
- Used hindcasts and forecasts as a basis for assessing vulnerability of land facets, tree species, and vegetation communities under land use and climate change.
- Worked closely with resource managers to develop and evaluate alternate management approaches for whitebark pine in Greater Yellowstone.
- Identified strategy for transferring decision support to federal agencies.
- Published 18 scientific papers on results from the project.

- Completed the first draft of a book on climate adaptation planning in wildland ecosystems and negotiating with Island Press as a publisher.
- Conducted major symposium on climate adaptation planning in wildland ecosystems at the annual meeting of the Society for Conservation Biology.

Plans or expectations for 2015:

- Complete all major project tasks.
- Publish book on climate adaptation planning in wildland ecosystems.
- Publish additional scientific papers.
- Demonstrate climate adaptation planning for whitebark pine in the Rocky Mountains and for eastern hemlock in the Appalachians.
- Conduct final vegetation management workshops with stakeholders in the Rockies and in the Appalachians.
- Transfer decision support products to the Great Northern LCC, the North Central Climate Science Center, and the NPS I&M program.

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**Project:** The Effects of Extreme Climate Events on Avian Demographics: The Role of Habitat Refugia in Mitigating Climate Change

Principal investigator: Patricia Heglund, U.S. Fish and Wildlife Service

Project year: 3

Year-end ARL: 5

Description: Using MODIS, *Landsat*, and other data, this project seeks to predict the effects of extreme climate and weather events on bird demographics, as well as quantify the role of national wildlife refuges and national forests as refugia for waterfowl and forest birds, respectively. During extreme events, such as droughts and cold snaps, it hopes to identify management actions to enhance this refuge function.

End users: USFWS, USFS, the Nature Conservancy

Data sources, models, technology: MODIS, SRTM, AVHRR, AMSR-E, *Landsat*

Major accomplishments in CY 2014:

- Developed a draft Web interface for downloading mapped weather data (19 variables) for North America for the period 1980-2013 (<http://silvis.forest.wisc.edu/data/BIOCLIM-Climate-Data-Access>). This stems from user requests for data from practitioners at workshops we held and NASA Science Team meetings.
- Projected changes in spring onset and false springs for the conterminous United States under two emissions scenarios until 2100.

- Analyzed velocity of shifting distribution patterns of 200+ bird species to illuminate current/predicted future location of weather refugia.
- Completed proof-of-concept that geographically extensive bird data collected once annually is able to characterize bird response to extreme weather detected at geographically local and intensively sampled sites.
- Completed comparison of seven downscaled or interpolated published weather data sources.
- M.S. thesis was successfully defended by Ana Maria Venegas, “Effects of extreme weather events on bird productivity in the Northeastern United States.”
- Have three manuscripts well into review, with three others in preparation, which demonstrate a) how weather is related to changes in bird distribution b) projects how spring onset will change through time, or c) how well different existing weather data sets characterize extreme event values.
- Hired additional post-doc who is working on analysis of USFWS refuges as weather refugia during current, historic, and predicted future extreme weather.

Plans or expectations for 2015:

- Refine and expand the Web interface for serving weather data—this will be accomplished with the help of additional of temporary staffing from GIS graduate students.
- Analyze waterfowl response to drought.
- Determine for passerine species the magnitude of movement versus productivity decline in response to extreme events.
- Analyze and develop maps of predicted future extreme event patterns for the United States from GCM output.
- Implement Web-based interface for making maps available to user groups.
- Conduct a workshop to facilitate tech transfer in fall/winter of 2015-16.
- A key staff member has had a significant change in circumstances, and has reduced effort to 50 percent. We have requested a no-cost extension of one year, and anticipate continuing analyses and transition of products to end users during 2016.

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**Project:** Snow, Montane Wildflowers, and Citizen Scientists

Principal investigator: Janneke Hille Ris Lambers, University of Washington

Project year: 1 (feasibility)

Year-end ARL: 2

Description: This project combines MODIS-based images of snow covered area, citizen science observations, and models to generate spatially explicit seasonal forecasts of snow disappearance date and peak wildflower phenology to aid decision making by the National Park Service. The project team focused its one-year feasibility efforts in Mt.

Rainier National Park, using downscaled MODIS-based fractional snow covered area to map snow disappearance, which can be used to predict the timing of peak wildflower season.

End users: National Park Service

Data sources, models, technology: MODIS and MODSCAG

Major accomplishments in CY 2014:

- Determined that the MODSCAG and *Landsat 7* products accurately capture total snow extent.
- Developed downscale algorithm to downscale MODSCAG products from 500 meters to 30 meters.
- Determined that the timing of peak flowering of 10 focal species is tightly correlated with the timing of snowmelt.
- Developed a baseline operational forecasting system of seasonal snow disappearance date and peak wildflower season. This system was based on the SNOW-17 snow model.

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**Project:** Avian Abundance Estimation across the Pacific Flyway for Full Life-Cycle Conservation Planning (implementation phase)

Principal investigator: Steve Kelling, Cornell Lab of Ornithology

Project year: 1 (feasibility)

Year-end ARL: 4

Description: Many species are moving targets for conservation work: they move across broad spatial extents occupying different habitats and occurring in different densities at different times of year. To make informed decisions on when to make habitat available, land managers require accurate spatial and temporal information about species' abundance to direct conservation action.

End users: The Nature Conservancy of California, land managers, climate forecasters, species distribution modelers

Data sources, models, technology: eBird citizen science data, MODIS and *Landsat* land products, species distribution models, etc.

Major accomplishments in CY 2014:

- The Nature Conservancy of California (TNC) has developed BirdReturns, a project that works with rice farmers in California's Central Valley to create flooded habitat for migrating water birds at the time and places when needed.
- A reverse auction process was used to incentivize farmers to flood fields later in the spring migration and earlier in the fall to coincide with migration. In 2014 twenty thousand acres of additional wetlands were made available.
- During the project's feasibility stage, we validated the ability of the models to consistently estimate abundance across multiple species and at different times of year, creating the information required by TNC to make informed decisions on how to spend scarce conservation dollars on targeted population needs.

Plans or expectations for 2015:

- Develop a decision support tool (DST), initially for BirdReturns, but adaptable to other projects.
- The DST will provide precise knowledge of the temporal and spatial variation in bird abundance using eBird data.
- The DST will provide estimates of distributions and relative abundances of focal bird species to partners as GIS data layers that will be accompanied by spatially explicit information about the robustness of these estimates, all of which can be used interactively by end users to explore different management scenarios.

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**Project:** EcoCast: Improving Ecological and Economic Sustainability of Marine Fisheries Using Remotely Sensed Oceanographic Data

Principal investigator: Rebecca Lewison, San Diego State University

Project year: 1 (feasibility)

Year-end ARL: 3

Description: The goal is to evaluate the applicability of EcoCast, a near real-time, multi-species fisheries decision support tool. The project's objective is to develop a flexible and responsive application that will enhance conservation of protected and non-target species, while maintaining sustainability and profitability of the fishery.

End users: NOAA NMFS and California drift gillnet fishery

Data sources, models, technology: SSH, Eddy kinetic energy, Ekman upwelling, SST, Chl-a, depth, slope, *Topex/Poseidon*, *Jason 1*, *Jason 2*, AVHRR, *Aqua*/MODIS, SeaWiifs, SeaWinds/QuikSCAT

Major accomplishments in CY 2014:

- Identified three bycatch and one target species as focal species for the initial EcoCast model: leatherback sea turtles, California sea lions, and blue sharks (bycatch species) and swordfish (primary target species).
- For each species, fishery observer data was sourced from NOAA's Southwest Fisheries Science Center, and tracking data was sourced from the Tagging of Pelagic Predators Project ([www.topp.org](http://www.topp.org)).
- Remotely sensed satellite data was sourced from a number of different products using Xtractomatic, a set of free R software routines created by our team that allow access of environmental data served by the NOAA's Environmental Research Division.
- Generalized additive mixed models (GAMMs) were constructed to analyze the statistical correlation between the oceanographic parameters and animal presence/absence.
- Feasibility has been established and the project has been formally recognized by management, industry, and the fisheries' governing body as a priority moving forward.

Plans or expectations for 2015:

- Refine and evaluate Phase I models, integrating Earth observation data to identify other potential essential ocean variables, and quantitatively evaluate EcoCast output.
- Predict bycatch and catch in near-real time scenarios as a function of species risk (as set by managers), and model error (bootstrapping multiple model runs).
- Attend the Pacific Fisheries Management Council meetings to present our results and solicit feedback from fishers, industry, managers, and regulators.

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**Project:** Projecting Effects of Climate Change on River Habitats and Salmonid Fishes: Integrating Remote Sensing, Genomics, and Demography to Inform Conservation

Principal investigator: Gordon Luikart, University of Montana

Project year: 1 (feasibility)

Year-end ARL: 3

Description: This project links remote-sensing mapping of freshwater habitats with genetic and demographic data, as well as spatially explicit hydrological and thermal model outputs to assess the vulnerability of salmonid populations in current and projected climate conditions. Incorporating these new measures of habitat quality will enhance an existing decision support tool, the Riverscape Analysis Project.

End users: USGS, NOAA, USFWS, Columbia River Inter-Tribal Fisheries, Idaho Department of Fish and Game, Montana Fish Wildlife and Parks, Wild Fish Conservancy, Wild Salmon Center

Data sources, models, technology: AMSR-E fractional cover of water and free/thaw dynamics, MODIS NPP, *Landsat*

Major accomplishments in CY 2014:

- Hosted a workshop with leading experts in salmonid conservation to identify key decision support system (DSS) components.
- Developed an improved methodological framework for conducting climate change vulnerability assessments by including adaptive capacity.
- Provided evidence of a strong correlation between climate and genetic diversity in threatened bull trout and steelhead populations.
- Performed pilot climate change vulnerability assessments in bull trout and steelhead populations.
- Created prototype, Web-based DSS to integrate tools and remotely sensed habitat and climate data sets, along with genetic and demographic data sets, for salmonid conservation.

Plans or expectations for 2015:

- Conduct end-user workshops to refine data and tool design.
- Add additional remotely sensed and modeled climatic, habitat, and hatchery data to the DSS (e.g., MODIS Global Flood Mapping data).
- Integrate new NOAA human footprint data into the DSS.
- Compile genetic data for multiple species through crowdsourced and other sources and integrate online.

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**Project:** Bayesian Data-Model Synthesis for Biological Conservation and Management in Antarctica

Principal investigator: Heather Lynch, Stony Brook University

Project year: 1 (feasibility)

Year-end ARL: 7

Description: This project is developing a browser-based decision support mapping and analysis tool that integrates multiple streams of remote sensing data with field counts and citizen survey reports to calculate the current distribution and abundance of the Adelie penguin. This species is a key indicator species used to assess the impacts of fishing and climate change on the Southern Ocean ecosystem.

End users: Oceanites, Inc., Southern Ocean Observing System, Antarctic Treaty System

Data sources, models, technology: *Landsat*

Major accomplishments in CY 2014:

- Completed and verified a continent-wide survey of Adelie penguin distribution, including eight colonies previously unknown and unreported.
- Developed a statistical methodology for ground-based and satellite data assimilation and population modeling.
- Created an interactive, browser-based geospatial decision support application.

Plans or expectations for 2015:

- Mine the record of *Landsat* satellite observations over Antarctica, starting from 1984.
- Develop a radiative transfer model to improve the physics of the penguin breeding areas retrieval algorithm.
- Complete a Dynamic Bayesian Network (DBN) assimilation of ground-based observations of penguin distribution and abundance with the complete satellite record, and use the DBN to predict species presence and population size for any space/time assemblage.
- Expand the work to include three other Antarctic penguin species: Emperor, Gentoo and Chinstrap.
- Incorporate eBird observations into the DSS.
- Present results at the Scientific Committee for Antarctic Research.

\* \* \*

**Project:** Using the USGS Resource for Advanced Modeling to Connect Climate Drivers to Biological Responses

Principal investigator: Jeff Morisette, U.S. Geological Survey

Project year: 3

Year-end ARL: 7

Description: The project is enhancing the decision support tools of the Resource for Advanced Modeling (RAM) facility at the USGS Fort Collins Science Center. The project team developed a package called the Software for Assisted Habitat Modeling (SAHM) within the open-source VisTrails scientific workflow tool.

End users: USGS RAM, field ecologists, land managers, climate forecasters, habitat modelers

Data sources, models, technology: MODIS and *Landsat* land products, gridded historical and projected climate data, etc.

Major accomplishments in CY 2014:

- Continued improvements on VisTrails:SAHM into RAM to enhance the tools available to field ecologists, land managers, climate forecasters, and habitat modelers.
- Supported programmers at the North Central Climate Science Center; expanded on the year 2 work of having VisTrails:SAHM software to take advantage of multiple processors to explore supercomputers at NASA Ames, USGS Denver, and Amazon cloud (with the objective of further reducing processing times from days to hours, yielding quicker model calculations that allow analysis of “what if” scenarios for various ecological questions and future climate projections).
- Institutionalized SAHM training at DOI every six months, see <http://pubs.usgs.gov/fs/2014/3007/>.
- Worked with NASA Ames to generate summary layers from the NASA NEX CMIP5 data (e.g., quarterly rainfall, annual maximum temperature, etc.)
- Worked with NYU on SAHM:VisTrails module to display predictor response curves, to explore interactions between predictors and compare predictors across modeling techniques.

Plans or expectations for 2015:

- Continue to improve technical aspects of SAHM.
- Finalize methodology to produce summaries from NASA NEX CMIP5 data, which will allow ecological impact modelers to utilize and evaluate CMIP5 climate model output.
- Develop strategy and workflow to utilize USGS Denver supercomputer.
- Publish paper and operationalize NYU’s enhanced response curve display module.

\* \* \*

**Project:** A Decision Support System for Ecosystem-based Management of Tropical Coral Reef Environments

Principal investigator: Frank Muller-Karger, University of South Florida

Project year: 5 (final)

Year-end ARL: 9

Description: This project is applying MODIS, AVHRR, and other Earth observations to enhance the NOAA Coral Reef Watch decision support system with higher resolution products.

End users: NOAA Coral Reef Watch, park rangers, coral reef managers, natural resource managers, etc.

Data sources, models, technology: MODIS, AVHRR, GOES

Major accomplishments in CY 2014:

- Developed, tested, and operationally deployed new 5-km resolution global NOAA Coral Reef Watch (CRW) products. Products deployed sustainably through NOAA NESDIS CRW Program: <http://coralreefwatch.noaa.gov/satellite/index.php>. Products are more sensitive than original 50 km products because of much higher temporal resolution achieved by blending global geostationary and polar orbiter data.
- Developed, tested, and operationally deployed new 1-km resolution regional (Western Caribbean/Gulf of Mexico) products using AVHRR and MODIS. Developed prototype cold water stress index (cold spot) for the Florida Keys. 1 km data to be deployed via CONABIO Web page (Mexico).
- Completed user surveys for NOAA Coral Reef Watch products. About half of 245 respondents are using the 5 and 1 km data.
- UNEP WCMC incorporated the NASA Coral Reef Millennium Map: <http://data.unep-wcmc.org/datasets/13>.
- Publications: seven peer-reviewed manuscripts (likely more over the next few years).

The sustainability of the products and DSS lies in the funding and longevity of the NOAA CRW and CONABIO programs. Government and nonprofit institutions such as the Florida Department of Environmental Protection Coral Reef Conservation Program, Mote Marine Laboratory, and the Nature Conservancy (through the Bleach Watch and Florida Reef Resilience Programs, respectively) have already incorporated the new high-spatial resolution CRW thermal stress products into their routine planning and management efforts. CONABIO will be operationalizing the Western Caribbean 1-km MODIS-derived thermal products.

\* \* \*

**Project:** Extending the Terrestrial Observation and Prediction System (TOPS) to *Suomi NPP* Applications

Principal investigator: Rama Nemani, NASA Ames Research Center

Project year: 3 (final)

Year-end ARL: 1 (feasibility study only)

Description: This project seeks to understand the errors and uncertainties associated with transitioning from MODIS data use to VIIRS data use with reference to Applied Sciences Program projects. It also seeks to integrate *Suomi NPP* data and products into

existing applications by conveying the errors and uncertainties associated with such a transition. The project planned to utilize TOPS and the NASA Earth Exchange (NEX) to engage federal, state, tribal, and local partners in the *Suomi NPP* mission by providing a platform for creating high-level products and rapid prototyping of applications. Though early versions of the data were used with TOPS on NEX, the premature state of vegetation index products from the *Suomi NPP* mission required the postponement of demonstration to end users.

End users: NOAA, National Park Service, California Department of Water Resources

Data sources, models, technology: MODIS and VIIRS land products

Major accomplishments in CY 2014:

- Cooperation between the NOAA Center for Satellite Applications and Research and NASA Land Product Evaluation and Test Element (PEATE) teams led to the resolution of many of the initial issues with VIIRS product generation and, by the end of this project's term, were supplying a "Collection 1.1" of VIIRS land products through a previously existing NASA data portal.
- The lack of a top-of-canopy NDVI Environmental Data Record (EDR) in the NOAA requirements prevents many applications from using existing workflows to utilize VIIRS data provided by NOAA.
- The accuracy and precision of the top-of-canopy EVI appear to be acceptable in the provisional product made available by NASA's Land PEATE.
- Discrepancies in statistics observed in the top-of-canopy VIIRS EVI relative to MODIS products imply potential issues with automatic adoption of MODIS-based algorithms for use in applications.
- Many hurdles remain for using VIIRS EDRs in existing workflows because of formatting and geo-registration issues. It will be important for the new Science Investigator-Led Processing System being developed by NASA for VIIRS vegetation products to specifically address these hurdles.

\* \* \*

**Project:** System for Mapping and Predicting Species of Concern (SMAP-SOC)

Principal investigator: John Olson, Desert Research Institute

Project year: 1 (feasibility)

Year-end ARL: 5

Description: This project combines Earth Observations of hydrology, vegetation, and surface thermal conditions with observations of species occurrences from both traditional and environmental DNA (eDNA) methods to model distributions of freshwater

species of concern. These models can then be applied to all stream reaches to provide BLM natural resource managers with maps of predicted distributions.

End users: U.S. Bureau of Land Management

Data sources, models, technology: MODIS, *Landsat*, empirical water chemistry models

Major accomplishments in CY 2014:

- Demonstrated feasibility of application using a *Didymosphenia geminata*, an invasive diatom, as the example organism.
- Successfully developed eDNA collection and assay techniques that detected *D. geminata* > 80 percent of the time from a single sample, a 30-point increase over traditional methods.
- Developed and tested methods allowing public to collect samples of suspected *D. geminata* blooms and preserve them for genetic identification.
- Developed species distribution models that predicted *D. geminata* occurrences with > 93 percent accuracy using measurements of evapotranspiration and temperature from MODIS and vegetation type from *Landsat*.
- Applied models to all stream reaches in Rocky Mountains, producing maps of probability of *D. geminata* occurrences suitable for management use.

Plans or expectations for 2015:

- Collect samples and develop genetic markers for six additional species (broad and humpback whitefish, Artic grayling, least cisco, burbot, and northern pike) found in Alaska.
- Assemble additional Earth observation data for evaluation as predictors, including SAR data indicating winter refugia for fish, snow cover (MODIS), and ground and soil water storage from *SMAP* and *GRACE*.
- Develop and test prototype interface for application.

\* \* \*

**Project:** Adaptive Ecosystem Climatology

Principal investigator: Bradley Penta, Naval Research Laboratory

Project year: 1 (feasibility)

Year-end ARL: 5

Description: This project aims to develop an Adaptive Ecosystem Climatology (AEC) to provide a flexible, online tool for ecoforecasting applications that will meld observations collected by amateur observers (crowdsourcing), Earth-observing satellites, archived *in situ* data, and output from a state-of-the-art, data assimilative, coupled bio-optical-physical ocean model system. The AEC mitigates the shortcomings of the components

and combines their strengths to enhance decision-making activities of our end-user, partner organizations (NOAA, BOEM, and EPA).

End users: NOAA, BOEM, EPA, Gulf of Mexico (GOM) Alliance, NOAA Southeast Fisheries Science Center, NOAA NCDDC, NOAA Atlantic Oceanographic and Meteorological Lab, Gulf States Marine Fisheries Comm., Mississippi River/GOM Watershed Nutrient Task Force

Data sources, models, technology: SeaWiFS, *Aqua*/MODIS, MERIS, and VIIRS. Products include SST, chlorophyll concentration, phytoplankton absorption coefficient, suspended particulate matter, diffuse attenuation coefficient, and euphotic depth

Major accomplishments in CY 2014:

- Compiled GOM Earth observation (1997-2013) and model reanalysis runs from 1979-2013, ocean model climatology and historical *in situ* data.
- Coefficient of variation product produced for both chlorophyll and sea surface temperature.
- Prototype GUI developed for Web-based decision-support tool.
- Developed a prototype program working with St. Stanislaus High School in Bay St. Louis, Mississippi, for the collection, reporting, and utilization of crowdsourced observations.
- Three “static” climatology products, Earth observation, Navy Coastal Ocean Model-Carbon, Silicate, and Nitrogen Ecosystem (NCOM-COSiNE), and AEC-optimal interpolator, were integrated into NOAA’s Ocean NOMADS portal ([http://ecowatch.ncddc.noaa.gov/thredds/catalog\\_aec\\_climo.html](http://ecowatch.ncddc.noaa.gov/thredds/catalog_aec_climo.html)) and are being used by partner organizations.

Plans or expectations for 2015 (if funded):

- Implement a better mass transport for river discharge and incorporate river nutrient flux inputs, both of which are critical in the vicinity of large rivers like the Mississippi.
- Re-run the long-term NCOM-COSiNE model for the Gulf of Mexico applying the refinements determined in Phase 1 and re-compute the multivariate statistics and model metrics for use in the assimilation scheme.
- Begin deployment of the AEC for the U.S. West Coast and combine the ecosystem model with the circulation model and start calibrating for the U.S. East Coast.

\* \* \*

**Project:** Monitoring and Forecasting Chimpanzee Habitat Health in Africa to Inform Conservation Actions and Strategies, and Measure Success

Principal investigator: Lilian Pintea, Jane Goodall Institute  
Project year: 1 (feasibility)

Year-end ARL: 3

Description: This project applies 30-meter resolution *Landsat* data with a habitat suitability model and a model forecasting future land use change, enhanced by crowd-sourced field data collected by local communities and protected area rangers using mobile smartphones and tablets, to annually monitor and forecast chimpanzee habitat health in Africa.

End users: Jane Goodall Institute

Data sources, models, technology: *Landsat*, MAXENT, Random Forests, DINAMICA EGO, Android smartphones and tables, Open Data Kit (ODK) mobile data collection app

Major accomplishments in CY 2014:

- Completed chimpanzee habitat suitability models, which predict distribution and estimate the current habitat health status of the chimpanzee in East and Central Africa at 30-meter resolution.
- Completed forecasting model, which predicts future chimpanzee habitat health until 2030, taking into account business-as-usual scenarios of land cover and land use change occurring between 2000 and 2012.
- Scaled-up community-based crowdsourced data collections in Africa using Android mobile devices and ODK app and demonstrated that crowdsourced efforts could be an important source of data for the development and validation of species distribution, land cover change and habitat health models.

Plans or expectations for 2015:

- Complete technical needs analysis for data and model integration (ARL 4).
- Assembly and first meeting of three proposed institutional arrangements: Technical Advisory Group, Coordination Unit, and Steering Committee (ARL 4).
- Integration of components into functioning DSS prototype hosted on a local server (ARL 5).

\* \* \*

**Project:** Management and Conservation of Atlantic Bluefin Tuna and Other Highly Migratory Fish in the Gulf of Mexico under IPCC Climate Change Scenarios: A Study Using Regional Climate and Habitat Models

Principal investigator: Mitchell A. Roffer, Roffer's Ocean Fishing Forecasting Service, Inc.

Project year: 4

Year-end ARL: 9

Description: The project focuses on enhancing the management of multiple important highly migratory pelagic fish species in the Gulf of Mexico and surrounding waters, with particular focus on Atlantic bluefin tuna (*Thunnus thynnus*) and other highly migratory tunas and billfishes in the Gulf of Mexico area for spawning and larvae, and the north Atlantic Ocean including the Gulf of Mexico for adults. Applying Earth observations, the study projects a habitat model using IPCC climate change scenarios to assess possible effects of climate change on spawning habitat and fish population dynamics.

End users: NOAA NMFS SEFSC, University of Miami, and University of South Florida. Additional partners include the University of Southern Mississippi, University of South Carolina, NOAA NMFS offices, international partners in Mexico (CONABIO) and Spain (Spanish Institute of Oceanography), and the International Commission for the Conservation of Atlantic Tunas

Data sources, models, technology: MODIS and VIIRS (SST, ocean color), AVHRR (IR SST), Altimetry, SeaWifs, Metop\_a and b, CZCS and Meris

Major accomplishments in CY 2014:

- NOAA NMFS is using satellite data/results from the project in stock assessments.
- Completed habitat models and species/species guilds work for the Gulf of Mexico.
- Provided daily satellite ocean oceanographic analyses to NOAA research vessel for an ichthyoplankton cruise in the western and northern Gulf of Mexico.
- Downscaled IPCC-AR5 model projections for the GOM and Caribbean Sea: shows reductions in the Loop and Caribbean currents in the 21st century similar to AMOC.
- Developed habitat suitability models for adults and larvae; linked with downscaled climate model output to define temporal and/or spatial shifts in spawning and feeding habitats for bluefin tuna and other billfish.
- NOAA is actively processing satellite data and evaluating options for sustainability.

Plans or expectations for 2015:

- Provide real-time daily oceanographic analyses to the research vessel during the two-month SEAMAP research cruise in the spring.
- Provide post-cruise analyses after fish identifications returned.
- Complete habitat models for each species of interest, at the larval and adult stages.
- Provide forecasts of habitat expansion, contraction, or shifts for the next 100 years, at decadal intervals, for a range of CO2 emission scenarios derived from a downscaled biogeochemical model.
- Quantify changes in species distribution, species dominance, and levels of interaction between species across the Gulf of Mexico, through to the end of the 21st century.
- Complete training and transfer of tools, programs, and models to NOAA.
- Deliver final report.

\* \* \*

**Project:** Bringing Wildlife Management into Focus: Integrating Camera Traps, Remote Sensing and Citizen Science to Improve Population Modeling

Principal investigator: Phil Townsend, University of Wisconsin at Madison

Project year: 1 (feasibility)

Year-end ARL: 4

Description: This project will link animal populations and remote sensing data derived from MODIS and *Landsat* imagery to model spatio-temporal patterns of animal occupancy statewide. Spatially explicit models of occupancy and abundance will be developed for specific animal populations including black bear, grey wolf, bobcat, and beaver, improving the population and management models that the Wisconsin Department of Natural Resources currently uses for decision making.

End users: Wisconsin Department of Natural Resources

Data sources, models, technology: MODIS phenology, *Landsat*

Major accomplishments in CY 2014:

- Deployed and operated 79 cameras across the state of Wisconsin.
- Developed the Snapshot Wisconsin Web portal for the crowdsourcing of animal identification in trailcam images.
- Linked camera trap locational data to MODIS imagery, land cover, and climate observations.

Plans or expectations for 2015:

- Deploy 500 additional cameras throughout the state.
- Improve functionality of Snapshot Wisconsin crowdsourcing platform.
- Incorporate VIIRS data into phenological modeling effort.
- Continued integration of remote sensing data with wildlife distribution data for species modeling.

\* \* \*

**Project:** A Decision Support System for Monitoring, Reporting, and Forecasting the Ecological Conditions of the Appalachian National Scenic Trail

Principal investigator: Yeqiao Wang, University of Rhode Island

Project year: 5

Year-end ARL: 6

Description: The project team worked with the U.S. Park Service, Appalachian Trail Conservancy, USGS, and U.S. Forest Service to apply Earth observations, including MODIS data and TOPS models and data products, to an Appalachian Trail Decision Support System (DSS). The project team designed the DSS for monitoring, reporting, and forecasting ecological conditions. By integrating NASA *EOS* data and modeling products that link climate models and ecological models with *in situ* observations, the DSS provides critical information to improve effectiveness of decision making in land management and for biodiversity conservation.

End users: foresters, land managers, park rangers, fish and game officials, natural resource managers, trail users

Data sources, models, technology: MODIS, TOPS and products, *Landsat*

Major accomplishments in CY 2014:

- Demonstrated that NASA data products enabled the provision of multiple resolution, multiple scale perspectives to enhance decision making by natural resource managers.
- Linked USFS field-based monitoring of thousands of plots along the Trail with remote sensing data to inform ecosystem management, including MODIS soil moisture and vegetation indices. The DSS incorporates climate change scenarios as well as temperature and precipitation changes projected for the end of this century, which the team used to assess the potential effects on habitat and species in various areas.
- Demonstrated that the system could be used to target species whether invasive, native, rare, threatened, or endangered.
- Developed a smartphone app to extend the DSS functions and information to a broader scope of users.
- Prepared the user manual to provide the step-by-step instructions for effective use of the DSS.

Plans or expectations for 2015:

- Complete the final promotion of the capabilities of the decision support system.
- Have the system online in full operation.

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**Project:** A System to Forecast the Demographic and Genetic Viability of Salmonid Fish across Broad Regions under Changing Climates

Principal investigator: Seth Wenger, University of Georgia

Project year: 1 (feasibility)

Year-end ARL: 5

Description: Conservation management for salmonids, as for other taxa, often requires decisions on the allocation of scarce resources. Ideally, this conservation planning would be supported by population viability analyses (PVA), but until now there has been a lack of accessible, data-driven methods for PVA that can be used across broad spatial scales. This project is developing two new approaches to PVA: (1) ST-PVM, a statistical spatio-temporal demographic population viability model; and (2) CDMetaPOP, a flexible, individual-based model that can follow the genetic signature of hundreds of thousands of simulated individuals, providing estimates of demographic and genetic viability. These new methods fill a crucial gap, connecting population ecology and genetic approaches that rely on extensive field collections with landscape ecology methods that rely on broad-scale Earth observations. The resulting estimates of population viability will be incorporated into decision support systems of various state, federal, and non-governmental organizations.

End users: Trout Unlimited, U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management, Seattle City Light, and state agencies from Nevada, California, Utah and Montana (among others).

Data sources, models, technology: *Landsat* NDVI, *Landsat* NLCD, MODIS snow cover fraction, MODIS net primary productivity, NLDAS-2 and NASA Earth Exchange

Major accomplishments in CY 2014:

- Compiled a comprehensive, versatile database of fish collection records to meet project modeling needs, for end users/stakeholders' additional uses, and as a repository for future collections.
- Assembled all available in-stream temperature records for the Lahontan Basin from 14 state and federal agencies, and modeled stream temperatures at the 1-km scale across the basin using the methodology of the NorWeST project.
- Successfully developed and tested the ST-PVM model for 34 populations of Lahontan cutthroat trout (LCT), a federally threatened taxon.
- Successfully developed and tested CDMetaPOP for LCT in the Mary's Basin, Nevada. Also tested CDMetaPOP for other species of salmonids in Washington and Oregon.

Plans or expectations for 2015:

- Finalize modeling of LCT while expanding to other species and subspecies: redband trout, golden trout, and other cutthroat trout subspecies. Validate predictions using independent data sets and hindcasting.
- Estimate viability of LCT under climate change scenarios.
- Model alternative management scenarios for the Mary's River Basin.
- Improve our modeling platforms to cover multi-species modeling and species interactions.
- Test the relationship between annual riparian NDVI and population parameters.
- Continue expanding the fish database.

\* \* \*

## Abbreviations

AMSR-E: Advanced Microwave Scanning Radiometer - Earth Observing System  
ARL: Application Readiness Level  
ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer  
AVHRR: Advanced Very High Resolution Radiometer  
BioClim: Climate and Biological Response  
BLM: Bureau of Land Management  
BOEM: Bureau of Ocean Energy Management  
BON: Biodiversity Observation Network  
CeNCOOS: Central and Northern California Ocean Observing System  
DEM: Digital Elevation Model  
DINEOF: data interpolating empirical orthogonal function  
DSS: decision support system  
ECOSTRESS: ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station  
Env-DATA: Environmental Data Automated Track Annotation system  
GCM: General Circulation Model  
GIS: Geographic Information Systems  
GOES: Geostationary Operational Environmental Satellite  
GRACE: Gravity Recovery and Climate Experiment  
HAB: harmful algal bloom  
HypIRI: Hyperspectral Infrared Imager  
ICESat-2: Ice, Cloud, and land Elevation Satellite-2  
LCC: Landscape Conservation Cooperative  
LCT: Lahontan cutthroat trout  
LiDAR: Light Detection and Ranging  
MODIS: Moderate Resolution Imaging Spectroradiometer  
MODSCAG: MODIS Snow Covered-Area and Grain  
NDVI: Normalized Difference Vegetation Index  
NERRS: NOAA National Estuarine Research Reserve System  
NGO: nongovernmental organization  
NMFS: National Marine Fisheries Service  
NOAA: National Oceanic and Atmospheric Administration  
NOS: NOAA National Ocean Service  
NPS: National Park Service  
NRC: National Research Council  
NWS: National Weather Service  
PACE: Pre-Aerosol, Clouds, and ocean Ecosystem  
PRISM: Portable Remote Imaging SpectroMeter  
PVA: population viability analysis  
QuikSCAT: Quick Scatterometer  
ROMS: Regional Ocean Modeling System

SBA: Societal Benefit Area  
SLI: Sustainable Land Imaging  
SMAP: Soil Moisture Active Passive  
SRTM: Shuttle Radar Topography Mission  
SSH: sea surface height  
SST: sea surface temperature  
TOPS: Terrestrial Observation and Prediction System  
TRMM: Tropical Rainfall Measuring Mission  
USFS: United States Forest Service  
USFWS: United States Fish and Wildlife Service  
USGS: United States Geological Survey  
VIIRS: Visible Infrared Imaging Radiometer Suite

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