NASA Science Mission Directorate
Research Opportunities in Space and Earth Sciences – 2022
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A.4 Terrestrial Ecology

The National Aeronautics and Space Administration (NASA) solicited one-year proposals for Scoping Studies for the Next Terrestrial Ecology Field Campaign within the NASA Earth Science Division Research and Analysis Program. The due date for proposals was January 11, 2023.

NASA's Terrestrial Ecology Program has a long and rich history of successfully mounting intensive field campaigns. These field campaigns have been aimed at exploiting the synergistic benefits of multidisciplinary science focused on a specific science question or set of science questions. These science questions are addressed using satellite and airborne remote sensing observations in combination with surface and near-surface measurements of smaller scale features and processes. Such field experiments use an integrative modeling framework to synthesize and scale the results across space and time. NASA Terrestrial Ecology field campaigns focus the community's attention on (a) answering big science questions targeted on important regions or biomes; (b) enabling more effective interpretation and analysis of space-based measurements; (c) fostering collaborative interactions and building new relationships within the scientific community; (d) providing valuable opportunities for training and educating the next generation of scientists; and (e) leaving a legacy data set of great value for future research.

This opportunity requested scoping studies that will (1) identify the scientific questions, (2) develop an initial study design; (3) and propose an implementation concept for a new NASA Terrestrial Ecology field campaign that could be implemented on a six- to nine-year time frame. This solicitation offers resources to facilitate such planning and provides an opportunity to design a major, yet logistically feasible, initiative that advances the Terrestrial Ecology Program's research goals and makes use of NASA's unique capabilities to mount well-coordinated projects that use satellite and airborne remote sensing as a central element. NASA may decline to proceed with further development of a field campaign concept.

A total of five proposals were received, and two have been selected for funding. The total funding to be provided for these investigations is approximately $500,000 over one year. The two selected investigations are listed below. The Principal Investigator, institution, investigation title, and abstract are provided.

Elsa Ordway/University of California, Los Angeles
A Scoping Study for the NASA Tropical Terrestrial Ecology Campaign
22-TE22-0006

Tropical forests are under increasing pressure from climate change and land-use change and are already showing evidence of varying responses given the large heterogeneity in ecosystem diversity, structure, and function. Tropical forests will likely respond to changes in temperature and precipitation in many ways, including changes in carbon flux

dynamics, water cycling, and species composition shifts with globally important consequences. However, the generalizability of different tropical forest responses in space and time remains highly uncertain. We propose a scoping study to evaluate how tropical forests on different continents vary in their vulnerability and resilience to land-use and climate change for the next Terrestrial Ecology Field Campaign, with the following science objectives:

1. Quantifying similarities and differences within and among tropical regions in forest composition, structure, function, and biogeochemical cycling,
2. Advancing understanding of the vulnerability and resilience of tropical forest ecosystems to global change across the tropics, and
3. Providing the scientific and regionally specific basis for informed decision-making to guide societal responses to climate change mitigation and adaptation and biodiversity conservation at local to international levels.

Evaluating how tropical ecosystems will vary in their response to climate and land-use change requires a campaign spanning multiple scales and multiple continents. This campaign will be composed of modeling and satellite remote sensing efforts conducted pan-tropically, with a network of smaller field and airborne campaigns that are distributed across targeted tropical forest ecosystems. We will scope the feasibility of addressing the above science objectives across a variety of tropical forest ecosystems to identify sites for potential ground and airborne campaigns that span important axes of variation within and across continents, including climate, elevation, geologic, and disturbance gradients. Remote sensing data critical to this campaign include lidar, imaging spectroscopy, thermal, and radar data, making this effort closely aligned with current and future spaceborne missions, including GEDI, NISAR, and SBG.

Science Themes
1. Biogeochemical cycles and carbon dynamics
2. Ecosystem structure, function, and diversity
3. Social-ecological systems
4. Climate feedbacks and interactions

To achieve the objectives of this campaign, a coordinated team of field ecologists, earth system scientists, satellite and airborne remote sensing scientists, and modelers is essential. This effort will prioritize capacity building, equitable engagement with international collaborators, and education and training, with outcomes that have the potential to guide future policy in a critically important and underserved region of the world. Given the scale of impact of a tropical campaign, the research community deserves the opportunity to gather for a scoping study. Scoping efforts will involve several modes of community engagement with a variety of stakeholders in the U.S. and internationally. These include various town halls, a large community workshop, site visits, a virtual community town hall to provide updates and solicit feedback, and regular Working Group meetings co-led by researchers from the global North and South. We have already begun engagement with the international tropical ecology research and

stakeholder community in an effort to obtain early feedback. We will emphasize equitable and inclusive practices throughout all scoping activities.

Sasha Reed/U.S. Geological Survey
Adaptation and Response In Drylands (ARID) Experiment
22-TE22-0003

We propose a scoping study to identify key scientific questions, develop an initial study design, and provide an implementation concept for the next NASA Terrestrial Ecology field campaign focused on improving our understanding and predictive capacity for Earth's drylands. Dryland ecosystems represent the planet's largest terrestrial biome, making up over 40% of the land surface and supporting more than two billion people. Defined by their aridity, these ecosystems provide critical services, including large agricultural yields, abundant energy and mineral resources, and regulation of Earth's climate and biogeochemical cycles. Dryland systems also show dramatic responses to global change, with frequent observations of plant mortality events, shifts in productivity and plant community assemblage, and losses of biodiversity and ecosystem services in the face of increasing drought and temperature. Despite their global importance and high vulnerability to change, our scalable understanding and capacity to forecast dryland dynamics, as well as impacts to ecosystems and society, is notably poor.

Recent advances in airborne and spaceborne remote sensing for the first time provide the appropriate observations to scale dryland water, carbon, and energy cycles across the globe. Airborne instruments such as AVIRIS-NG, HYTES, and LVIS, missions aboard the space station (e.g., GEDI, EMIT, ECOSTRESS), and free-flying polar orbiting and geostationary satellites (e.g., VIIRS, Landsat, SWOT, SMAP, ICESAT-2, and by the end of the decade, the Designated Observables), provide unprecedented opportunity to address the role of drylands in the Earth system. Thus, here we propose scoping the Adaptation and Response in Drylands (ARID) field experiment to engage with the science and applications community to envision NASA's next field campaign. We describe activities for an interdisciplinary project that addresses critical scientific uncertainties in dryland systems by integrating satellite and airborne remote sensing with observations from ground-based research and modeling. The proposed core-study area includes the drylands of the western United States (from Mexico to Canadian border) and an additional 3-5 international 'rotational' sites that could include the Miombo woodlands in southern Africa, the Cerrado in Brazil, and the Northern Territories of Australia. The work tackles numerous 2017 Decadal Survey questions and contributes to several operational and planned NASA Earth observing missions. Due to drylands' high spatial and temporal heterogeneity, vast spatial expanse, and rapid rates of change, satellite data are key to an accurate understanding of dryland trajectories under global change.

Our scoping effort provides a framework for engaging with the scientific community and stakeholders to improve an actionable understanding of drylands, focused on quantification and forecasting for 1) drivers of change, 2) responses of ecosystems, 3) consequences of altered structure and function for ecosystem services and human

systems, and 4) knowledge and tools to support decisions, management, and mitigation and adaptation efforts. We identify high-impact scientific questions which, as refined during the scoping study, advance terrestrial ecology, biogeochemistry, remote sensing, and a host of related fields. We stress that drylands represent a critical set of systems that due to their global importance, responsiveness to perturbation, and poor representation in models induce large uncertainties in our understanding of anthropogenic change and feedbacks. Fortunately, existing and emerging in situ and NASA remote sensing tools offer unprecedented opportunity to address these knowledge gaps with benefits for science, societies, and economies in drylands and globally.