A.7 BIODIVERSITY

NOTICE: Amended March 27, 2020. In Subsections 2.1 and 3.5, the requirement to combine observations from the ISS has been diminished from three to at least two of the four instruments mentioned. New text is bold and deleted text is struck through. The due dates are also changed. Notices of intent are now requested by May 27, 2020, and proposals are now due June 25, 2020.

Proposers must use Earth Science division templates for the required Summary table of work effort and current and pending support sections of the proposal, see Subsection 3.5.

1. Scope of Program

Biodiversity is the variety of life on Earth at all levels of organization. It encompasses ecosystems, communities of organisms, single species, and the genes carried by organisms. Biodiversity is the cumulative result of life's responses, by means of evolution, to the changing conditions of our dynamic planet. It encapsulates life's evolutionary history. Biodiversity provides all life, including humanity, with a tremendous resource of opportunities to survive and thrive on our evolving planet. And while elements of biodiversity drive many Earth system processes, life's variety or biodiversity is in itself a characteristic that underpins numerous, if not all, of these processes.

Myriad efforts tracking changes in biodiversity record significant declines throughout its levels of organization and across multiple taxa. Scientific consensus now posits that current biodiversity loss is on a par with the major extinction events documented in Earth's geologic record. Losses in species and reductions in the ranges and abundances of individual taxa are largely the result of human action. Ironically, reductions in the goods, services, and other benefits we derive from biodiversity undermine humanity's life support system.

This situation demands that greater attention be paid to biodiversity. Where on Earth is biodiversity located, in what numbers, and how and why are these changing over time? Remote sensing has an essential role to play in answering these questions. The combination of newly available instruments and advances in the practical and theoretical means of pairing biologically relevant datasets offer the possibility for new insights.

The NASA Biological Diversity Program focuses on understanding the composition of life on Earth and how it changes over time. This includes documenting and identifying factors that determine the distribution, abundance, movement, demographics, physical or genetic characteristics, behavior, and/or physiology of organisms on Earth. The program supports the development of remote sensing tools, techniques, and associated models that enable this understanding. The program also seeks to increase knowledge of how biodiversity drives the wider Earth System.

Research supported by this program combines observations from satellites, airborne platforms, and *in-situ* sensors to explore biodiversity patterns in terrestrial, freshwater, marine, and airborne ecosystems. NASA's macroscopic observations illuminate patterns of biodiversity through direct identification of ecosystems and certain species.

Understanding the processes behind these patterns along with the detection of finer-scale patterns typically requires either the direct integration of remote sensing observations with *in-situ* sensor data gathered across spatial and temporal scales or the application of various types of quantitative or qualitative modeling. This integration of observations across scales continues to be a major theoretical and technological challenge for the program.

2. Description of Solicited Research

This program element seeks two types of proposals. The first type asks proposers to combine measurements from selected instruments aboard the International Space Station and *in-situ* biodiversity observations (see subsection 3.2 for examples) to further understanding of the composition of life on Earth and how it changes over time (subsection 2.1).

The second type seeks proposals that combine satellite remote sensing (see subsection 3.1 for a description) and *in-situ* biodiversity observations (see subsection 3.2 for examples) to further understanding of the operational and/or the theoretical implications of combining observations at different spatial scales to further understanding of the composition of life on Earth and how it changes over time (subsection 2.2).

2.1 Combining Space Station and *In-Situ* Observations for Biodiversity Understanding

The International Space Station (hereinafter ISS) operates a suite of instruments that are extraordinarily powerful and complementary for characterizing life on Earth. As of this writing, the ISS carries a multispectral thermal infrared radiometer (the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station or ECOSTRESS); a full-waveform vegetation lidar (the Global Ecosystem Dynamics Investigation or GEDI); a trio of high-resolution spectrometers, one of which infers photosynthesis more accurately than any spaceborne measurement to date through solar-induced fluorescence (the Orbiting Carbon Observatory-3 or OCO-3); and a visible to near-infrared imaging spectrometer (the DLR Earth Sensing Imaging Spectrometer or DESIS).

This program element ~~requests~~ **requires that** proposals combine ~~ing~~ observations from ~~three~~ **at least two** of the four ISS instruments mentioned above. This combination of ISS observations must also be used in conjunction with *in-situ* biodiversity observations (see subsection 3.2). **[Amended March 27, 2020]**

More information about the four ISS instruments relevant to this section of the program element may be found at the following websites:

- ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) https://ecostress.jpl.nasa.gov
- Global Ecosystem Dynamics Investigation (GEDI) https://gedi.umd.edu
- Orbiting Carbon Observatory-3 (OCO-3) https://ocov3.jpl.nasa.gov
- DLR Earth Sensing Imaging Spectrometer (DESIS) https://www.nasa.gov/mission_pages/station/research/experiments/explorer/Investigation.html?#id=1778 (for information about access to DESIS and other commercial data please go to: https://earthdata.nasa.gov/esds/small-satellite-data-buy-program)

2.2 Scale

Life on Earth scales spatially by many orders of magnitude from the molecular scale of DNA and RNA to that of the global biome. NASA is a space agency. It makes observations from space-based platforms ranging in spatial extent from global to landscape and in grain (or pixel) sizes from 100s of kilometers (i.e., GRACE gravity maps) to 10s of meters (i.e., Landsat pixels; note: certain commercial satellite imagery ranges into sub-meter grain sizes). These observations are gathered at time steps that range in temporal scale from monthly to daily to even sub-hourly. In turn, biological phenomena scale across the orders of organization of biodiversity: biome, ecosystems, communities of organisms, single species, and the genes carried by organisms. NASA seeks to relate its satellite remote sensing products to biological phenomena to answer questions such as: how do we best link observations at disparate scales for specific applications? how do these observations relate to each other? To answer these and related questions, this subsection of the program element seeks to achieve two related but distinct goals:

1) To enhance our operational or technological ability to combine observations from satellite remote sensing (see subsection 3.1) with *in-situ* observations of biodiversity on the ground, in the water, and in the air (see subsection 3.2) for the purpose of advancing understanding of the composition of life on Earth and how it changes over time.

   The goal of this first topic is practical: to improve our ability to integrate observations made by different platforms covering different spatial extents at different grain sizes. NASA seeks to develop and enhance observational and model-based techniques that will allow us to use cross-scale information to advance understanding of the composition of life on Earth and how it changes over time. This includes documenting and identifying factors that determine the distribution, abundance, movement, demographics, physical or genetic characteristics, behavior, and/or physiology of organisms on Earth.

2) To advance our theoretical understanding with regard to how life scales spatially through the mechanism of combining satellite remote sensing with *in-situ* observations on the ground, in the water, and in the air. This work should build upon the rich literature over the past century from D'Arcy Wentworth Thompson to Geoffrey West, along with a number of others, regarding scaling rules for life. Efforts proposed may range from molecules to organisms to biomes. Whatever their inspiration, proposals must employ a combination of both satellite remote sensing (see subsection 3.1) and *in-situ* biodiversity observations (see subsection 3.2).

   The goal of this second topic is to increase theoretical knowledge of patterns and processes, which underpin our ability to advance understanding of the composition of life on Earth and how it changes over time, which includes documenting and identifying factors that determine the distribution, abundance, movement, demographics, physical or genetic characteristics, behavior, and/or physiology of organisms on Earth. NASA seeks refinement and further elaboration of the scaling rules of life: why life scales as it appears to scale.

Proposals may address one or both of the scale topics discussed above in this subsection. While these two topics are intimately connected, proposers are alerted that attempts to advance both technological ability and theoretical understanding within the same proposal may prove quite challenging and, as such, might constitute a “bridge too far” given the time and funding available for selected projects. Thus, choosing one or the other topic could result in a more focused and intelligible proposal. Nevertheless, fortune does, on occasion, favor the bold. While grander syntheses are welcome, they must still accord with the funding and time limits of the program element.

3. Important General Information for this Program Element

3.1 Relevant Satellite Remote Sensing

For the purposes of this program element, "satellite remote sensing" includes: measurements (i.e., data and information products) from NASA on-orbit satellites (including the ISS); simulated measurements from planned NASA satellites; measurements from commercial, foreign, and other U.S. Government satellites; outputs and predictive capabilities from models associated with NASA products; NASA algorithms; NASA visualizations; and other NASA geospatial products, including airborne products. The use of non-NASA satellite products is welcome - although, as this is a NASA solicitation, proposals must include specific NASA satellite remote sensing products in the overall mix of data products proposed. Satellite remote sensing data should be explicitly named within the proposal. The proposal will be evaluated as to how essential these data are to achieving the proposal’s goals.

Observations from suborbital airborne sensors may be included in proposals responding to this program element. That said, the use of suborbital airborne sensors should be clearly justified, scientifically complementary to, and, ideally, generate products coincident with the data from the ISS, other satellite, and *in-situ* observations forming the focus of this program element. Proposed suborbital airborne activities, for which NASA funding is sought, must fit within the funding limits of this program element and must also include a complete “includes-all-costs” cost estimate for the suborbital activities, including a full flight cost estimate (aircraft and instrument), data integration and analysis costs, etc. For proposed flights of NASA suborbital airborne platforms, a flight request should be submitted to the NASA Airborne Science Program at https://airbornescience.nasa.gov. NASA flight requests should result in that part of the "includes-all-costs" cost estimate focused on the use of the NASA suborbital airborne platform itself.

NASA has arrangements with certain commercial providers of satellite imagery allowing access to their commercial imagery by NASA-funded investigators. To learn more about this imagery, including DESIS imagery, and to determine the possibility of tasking certain commercial satellites, please visit https://earthdata.nasa.gov/esds/small-satellite-data-buy-program.

3.2 Relevant *in-situ* Biodiversity Observations

Examples of *in-situ* biodiversity observations include - but are not limited to - survey and census results, tracks of animal movement or other behavioral data from Global Positioning System tags or other biologging and biotelemetry devices, camera trap

imagery, information from acoustic sensors, various types of citizen science collections, and outputs from environmental DNA (eDNA). These observations may come from terrestrial, freshwater, marine, or airborne sources. The proposal will also be evaluated as to how essential these observations are to achieving the proposal's goals.

3.3 Scope of Submissions

A proposal must only address a topic described in either subsection 2.1 or subsection 2.2, i.e., a single proposal should not attempt to address topics from both of these subsections. However, an investigator may submit more than one proposal.

Proposals may focus on organisms in terrestrial, freshwater, marine, or airborne ecosystems - or some combination of terrestrial, freshwater, marine, and airborne ecosystems.

Proposals that do not focus on the overarching goal of advancing the use of satellite remote sensing in conjunction with *in-situ* biodiversity observations for understanding the composition of life on Earth and how it changes over time are discouraged. Encouraged topics include documenting and identifying the factors that determine the distribution, abundance, movement, demographics, physical or genetic characteristics, behavior, and/or physiology of organisms on Earth.

Also discouraged are proposals largely focused on topics central to other NASA Earth Science Division programs including biogeochemistry (e.g., the cycling of carbon or nitrogen), land cover and land use change, and the water cycle. Such proposals may be deemed non-responsive to this program element.

All proposals to this program element must be rooted in hypothesis-based research. A very important aspect of proposals to this program element will be identification of the scientific question(s) and issues to be addressed by the research. Proposals should describe:

- the current state of the science,
- the potential for a significant scientific advance, and
- the central and critical role for NASA satellite remote sensing.

Successful proposals may well arise from the assembly of teams of researchers with cross-sensor and cross-disciplinary skills.

Proposals must accord with the funding and time limits of the program element. Proposals with budgets or schedules that exceed guidance below (see section 4 Summary of Key Information) may be deemed non-responsive and may not be submitted for peer review.

3.4 NASA Biological Diversity and Ecological Forecasting Team Meeting

Funded Principal Investigators are expected to attend the annual NASA Biological Diversity and Ecological Forecasting Team Meeting (generally held each spring in the Washington, DC area) during each year of their award. Thus, proposals should budget for all costs needed for transportation, lodging, and per diem to attend these meetings.

3.5 Checklist of Solicitation-Specific Requirements

Proposers should check to determine whether their proposal meets the requirements of this program element, listed below.

- Is the proposed work aimed at understanding the composition of life on Earth and how it changes over time, which includes documenting and identifying the factors that determine the distribution, abundance, movement, demographics, physical or genetic characteristics, behavior, and/or physiology of organisms on Earth?
- The proposed work should not focus on a topic discouraged under this program element that is central to other NASA Earth Science Division programs including biogeochemistry (e.g., the cycling of carbon or nitrogen), land cover and land use change, and the water cycle?
- Does the proposal explicitly include a research hypothesis that will advance the understanding of the composition of life on Earth and how it changes over time?
- Does the proposal describe the current state of the science, the potential for a significant scientific advance, and the central and critical role for NASA satellite remote sensing?
- Does the proposed work include use of both NASA satellite remote sensing (subsection 3.1) and *in-situ* biodiversity observations (subsection 3.2)? Are these observations explicitly named? Are they integral to addressing the proposed hypothesis(-es)?
- Do any proposed suborbital airborne activities, for which NASA funding is sought, fit within the funding limits of this program element and is there a complete "includes-all-costs" cost estimate for the suborbital activities, including a full flight cost estimate (aircraft and instrument), data integration and analysis costs, etc.?
- Does the proposal accord with the funding and time limits of the program element?
- Has the team included budget for attending the NASA Biological Diversity and Ecological Forecasting annual team meeting?
- For proposals to subsection 2.1: does the proposal include ~~three~~ **at least two** of the four ISS instruments? Are the instruments explicitly named? Are they integral to addressing the proposed hypothesis(-es)? **[Amended March 27, 2020]**
- Does the proposal only address a topic described in either subsection 2.1 or subsection 2.2 and not in both?
- Does the proposal include all of the required sections listed in Table 1 of the *ROSES Summary of Solicitation*?
- Does the proposal adhere to formatting requirements (e.g., regarding font size, line spacing, and margins) in the *ROSES Summary of Solicitation*?
- Is the budget consistent with instructions from ROSES? (https://science.nasa.gov/researchers/sara/how-to-guide/nspires-CSlabor/)
- Are the required Summary table of work effort and current and pending support sections of the proposal based on the Earth Science division templates? (https://science.nasa.gov/researchers/templates-for-earth-science-division-appendix-a-roses-proposals)

4. Summary of Key Information

Expected annual total program budget for all new awards funded through this solicitation	$2,200,000 per year
Number of new awards pending adequate proposals of merit	7 to 15
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA.
Due date for Proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	7 months after submission of proposal
Page limit for the central Scientific/Technical section of proposal	15 pp.; see also Table 1 of ROSES and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section IV and Table 1 of *the ROSES Summary of Solicitation* and Section 3 of the *NASA Guidebook for Proposers*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of the *ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH20ZDA001N-BIODIV
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