Biodiversity Survey of the Cape (BioSCape)

Adam M. Wilson, Erin Hestir, Jasper A. Slingsby
## NASA Field Campaigns

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Campaign Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-1991</td>
<td>OTTER</td>
<td>First campaign to use the AVIRIS hyperspectral sensor to study the ecology of western coniferous forests</td>
</tr>
<tr>
<td>1999-2001</td>
<td>SAFARI (Southern African Regional Science Initiative)</td>
<td>Biogenic, pyrogenic, and anthropogenic emissions</td>
</tr>
<tr>
<td>2011-2016</td>
<td>HyspIRI</td>
<td>Preparatory airborne campaigns to support several terrestrial and marine ecological studies</td>
</tr>
<tr>
<td>2015-2025</td>
<td>ABOVE (Arctic-Boreal Vulnerability Experiment)</td>
<td>10-year field campaign to understand the socio-ecological implications of environmental change in Alaska and Northwestern Canada</td>
</tr>
<tr>
<td>2016</td>
<td>CORAL (Coral Reef Airborne Laboratory)</td>
<td>Globally-extensive airborne imaging spectroscopy survey of coral reefs around the world.</td>
</tr>
<tr>
<td>2021-2024</td>
<td>BioSCape (Biodiversity Survey of the Cape)</td>
<td></td>
</tr>
</tbody>
</table>
“Extremely high levels of endemism and species turnover, fynbos is made up of dissimilar local communities that are species-rich but relatively poor in rare species.”

Latimer (2005) 10.1126/science.1115576
Digitally accessible biodiversity data density

Occurrence Record Counts (2021)

GBIF.org
Greater Cape Floristic Region (GCFR) of South Africa

- **Approximately 90,000 km²**
- **Outstanding Biodiversity**
  - ~1% of Africa’s area
  - ~9,000 vascular plants
  - ~20% of Africa’s plants
  - 65% endemic
  - ~2.5% of the world’s plants endemic

**Socio-ecological complexity**
- Climate Change
- Urban Migration

**7 Terrestrial Biomes**
- Agulhas
- Fynbos
- Namaqua
- Southern Benguela
- Southwestern Cape
- Succulent Karoo

**4 Marine Biomes**

**Important Freshwater Ecosystems**
BioSCape Timeline

2015
• NASA Call for Biodiversity Scoping Proposals

2016-2018
• Stakeholder meetings
• Scoping Proposal Development

2020
• BioSCape Selected for Funding

2021
• ROSES call for Science Team
• Workshop
  • Proposals in Review
• Science team selected

2022
• Co-design implementation plan, flight paths, and field logistics.
• NSF projects?

2023
• Field Campaign

2024+
• Analysis and Publication
BioSCape Team

Conservation authorities

Intro Organization Technology Next Steps
BioScape Science Themes

- **Distribution and abundance of biodiversity**
  - Direct Observation of Indicator Species
  - Inferred distributions through RS-informed distribution modeling
  - Taxonomic Diversity / Functional Diversity

- **Role of biodiversity in ecosystem functions**
  - Biodiversity & ecosystem resilience.
  - Relationships between biodiversity and the nitrogen, hydrologic, & carbon-cycles

- **Feedbacks between global change, biodiversity change, & ecosystem services**
  - Hydrologic variability and biodiversity and ecosystem function
  - Feedbacks climate & wildfire

**Terrestrial, Freshwater, & Marine**

**Global and Regional Relevance**

**Intro**

**Organization**

**Technology**

**Next Steps**
Socio-ecological Processes

Land Use
Alien Species
Climate Change
Groundwater Extraction
Atmospheric Composition
Sea Chemistry
Currents
Fishing
Freshwater Flows
Pollution

Biodiversity Distribution & Abundance
Community Processes
Biotic functional traits
Ecosystem Function
Ecosystem Services
Regional Processes

adapted from Slingsby, et. al. (2014)
Platform & Sensor Technology

NASA G3 and G5 Research Aircraft 3 imaging spectrometers and LiDaR

Nearly complete spectral coverage + Lidar

<table>
<thead>
<tr>
<th>UV</th>
<th>VIS</th>
<th>NIR</th>
<th>SWIR</th>
<th>TIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIRIS-NG</td>
<td>480 Bands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRISM</td>
<td>246 Bands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESIS</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Landsat-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MODIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentinel-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentinel-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wavelength (nm)

HyTES 256 Bands

Ecostress

ASTER

Landsat-8

Intro  Organization  Technology  Next Steps
Reflectance from UV through Shortwave Infrared (UV-SWIR) capture canopy-level physical and biological characteristics

Size and arrangement of leaves within a canopy or cellular structure within leaves

Water with Algae
Coarse Snow
Deciduous Tree
Mineral

H₂O, OH, MgOH, CO₃, MgOH, ALOH
Lignin, cellulose, proteins
Pigments

Dust
Floating algae
Snow grain size

Pigments

Structure

H₂O

OH, H₂O

Wavelength (μm)

0.5 1 1.5 2 2.5

Remote Sensing of Environment
Volume 257, May 2021, 112349

NASAs surface biology and geology designated observable: A perspective on surface imaging algorithms

Leaf reflectance spectra captures the evolutionary history of seed plants.

Canopy emissivity and land and water surface temperature with HyTES

Temperature a driver for plant microclimates

Example: notable differences in thermal environments of C3 and C4 plants

Susan Meerdink et al. 2019 Remote Sensing of Environment

Christopher Still et al. 2014 Global Ecol & Biogeography
Sensor Integration

Imagery processed to Surface Reflectance on a common grid (identified by science team).

<table>
<thead>
<tr>
<th>Type</th>
<th>Instrument</th>
<th>n spectral bands</th>
<th>Spectral Res (nm)</th>
<th>Swath width (km)</th>
<th>Spatial res (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D Structure</td>
<td>LVIS</td>
<td>1</td>
<td>1</td>
<td>2 - 3</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Reflectance</td>
<td>PRISM</td>
<td>608</td>
<td>2.83</td>
<td>5 - 8</td>
<td>8 - 13</td>
</tr>
<tr>
<td>Reflectance</td>
<td>AVIRIS-NG</td>
<td>480</td>
<td>5</td>
<td>6 - 10</td>
<td>9 - 14</td>
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<tr>
<td>Thermal</td>
<td>HyTES</td>
<td>256</td>
<td>17.6</td>
<td>10 - 16</td>
<td>12 - 20</td>
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Intro
Organization
Technology
Next Steps
Funding Opportunities

**NASA Biological Diversity** (Woody Turner & Keith Gaddis)
- Biodiversity and Ecological Forecasting ROSES Call for Proposals
- ≈$2m / year supporting 10-27 awards
- *Proposals in review*

**South African National Space Agency** (Stewart Bernard)
- New Earth Observation Frontiers (NEOFrontiers) Funding Framework
  - 2021 Deadline Passed, future calls possible

**US National Science Foundation**
- Division of Environmental Biology (NSF 21-504, no deadline)
  - Biodiversity on a Changing Planet (BoCP)
  - Also: Systematics and Biodiversity Science, Evolutionary Processes, Population and Community Ecology, Ecosystem Science
- Macrosystems Biology and NEON-Enabled Science (MSB-NES)
  - NSF 20-506, second Monday in November, annually
- Division of Ocean Sciences (Biological Oceanography)
  - Open call (no deadline)
Biodiversity on a Changing Planet (BoCP)

Integrative approach to understand biodiversity from a functional perspective with the use of new technology and team science approaches.

Functional Perspective: the roles that organisms play within populations, communities, and ecosystems in ecological and evolutionary processes and patterns (including species generation, loss, reorganization, and maintenance.)

Emergent properties at all levels of biological organization and functions not directly under selective pressure.

Deadline: March 25, 2022

Learn more at bioscape.io/project
OR

Expected funding from NSF:
3-year $500k
5-year $2.5m

Expected funding from NRF:
Up to two 3-year ZAR1.8M ($120k)
Up to two 5-year ZAR10.0M (~$670k) projects
Diversity, Equity, and Inclusion

From the ROSES RFP:

3.2 South African Partnerships

NASA strongly encourages proposals to contain partnerships with South African organizations and individuals to ensure the relevance of proposed GCFR research to South Africa’s people and ecosystems. All things being equal, South African partnerships will make for a stronger, more highly-rated proposal.

3.6 Inclusion

Inclusion is a core NASA value. By fostering an atmosphere of inclusion and respect for all, we value the strengths afforded by both our commonalities and differences with an aim to fully engage and utilize talents, ideas, and perspectives. Projects that offer an opportunity to tap the nation’s diverse talent pool and increase participation in Earth science and remote sensing are encouraged. NASA is interested in increasing the diversity of race, ethnicity, gender, ability, and career stage in science teams.
Parachute science: when scientists, often from wealthier nations, visit a location, collect data, and publish results with minimal engagement with the local scientists and/or decision-makers.

BioSCape as an example to brainstorm and co-design strategies to enhance scientific engagement.
All data freely available soon after collection
Join the mailing list at bioscope.io/contact
Look for the workshop at AGU

There are several ways to get involved in the field campaign, from subscribing to our email list to proposing a project to NASA.

- Subscribe to the email list here to get emails about this project as it develops.
- Fill out the form below to be included in a list of potential collaborators.
- If you are a US-based researcher, consider applying for a NASA grant to work on the project. Details here.
- Contact the Science Team at bioscope[AT]wilsonlab.io to discuss conducting an affiliate project to use the airborne data collected by this field campaign.
BioSCape Team

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Conservation authorities

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Izak Smit
Stefanie Freitag-Ronaldson
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Andrew Turner
Thank you! BioSCape.io

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Join the mailing list!