Scoping Study for Biodiversity Airborne Campaigns
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Biodiversity

• Scoping studies for potential biodiversity field campaigns that:
  
  – identify the **key scientific questions** to be addressed should the campaign be carried out

  – develop an **initial study design and implementation concept**
• Plans for potential field campaigns should include:

  – *in situ surface sensors* that complement the airborne measurements (the airborne measurements must be the central focus and core observations of the campaign)

  – the **ER-2 aircraft** outfitted with at least two of the following three imaging spectrometers **PRISM**, **AVIRIS-NG**, and **HyTES**, along with the **LVIS** lidar

  – **relevant satellite datasets** from NASA and other sources (e.g., radars, other thermal infrared sensors, other lidars, etc.).
Key science questions should address one or both of:

- The **distribution and/or abundance of components of biodiversity** (focusing on one or more of ecosystems, species, and genes) and the **drivers and mechanisms of change** in the distribution and/or abundance of these components of biodiversity (ecosystems, species and genes)

- The **impacts of changing biodiversity** on the wider Earth System, e.g., the feedbacks from biodiversity to climate and/or other aspects of the Earth system
ABoVE will employ the facility version of NASA's Land, Vegetation, and Ice Sensor (aka the Laser Vegetation Imaging Sensor or LVIS).

LVIS is an airborne, scanning laser altimeter which, when combined with aircraft position and attitude knowledge, produces topographic maps with dm accuracy and vertical height and structure measurements [Blair 1999]. LVIS is a pulsed laser altimeter and measures range by timing a short (<10 ns duration) pulse of laser light between the instrument and the target surface. The entire time history of the outgoing and return laser pulses is digitised using a single detector, digitiser and timing clock, and unambiguously describes the range to the surface as well as the vertical distribution of surfaces within each laser footprint.

The LVIS system operates at altitudes up to 10 km AGL and has a 12° potential field-of-view (PFOV) within which footprints can be randomly spaced across track (Fig. 10). Scanning is performed using galvanometer-driven scan mirrors that control the pointing of both the laser and the telescope instantaneous field-of-view (FOV). Scan mirrors are positioned in a stepped pattern, stopping to fire the laser and integrate the return signal at each beam location. This raster scan pattern efficiently covers 100% of the area within the data swath. Footprint sizes from 1 to 80 m are possible, determined by the AGL altitude of the airplane and the focal length of a diverging lens in the output path [Blair 1999].

An LVIS flight over the Sequoia National Forest in southeast California was flown at 6 km AGL operating at 400 Hz. A total of 35 across-track footprints were generated, 25 m Fig 11 (a) Ground topography and (b) height within each footprint measured by LVIS in the Patapsco River, MD region. Laser footprints are ~20 m apart with increased density in areas of swath overlap [Blair 1999]. Fig 10. The LVIS transmit beam is scanned perpendicular to the aircraft flight path. Data on the surface below these swaths are collected, and a DEM and map can be generated from them. LVIS has a scan angle of about 12°, and can cover 2 km swaths of surface from an altitude of 10 km.
Observing Biodiversity From Space workshop series

- 2 workshops on terrestrial biodiversity in December 2014 and July 2015
- Outlining urgent policy needs and fundamental science questions
- Quantifying massive data gap
- Limitations of existing in-situ networks and satellites
- Maturity of airborne VSWIR algorithms
- Vision for a Global Biodiversity Observatory supported by a spectroscopic satellite mission
- RFIs to the NRC Decadal Survey
- Marine biodiversity workshop in June 2016
Observing Biodiversity From Space workshop series

The data gap
**Observing Biodiversity From Space** workshop series

<table>
<thead>
<tr>
<th>Trait</th>
<th>Trait definition</th>
<th>Trait functions</th>
<th>Trait role (refs)</th>
<th>Remote observation (refs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf mass per area (LMA) (g m⁻²)</td>
<td>The dry mass of a leaf divided by its one-sided area measured when fresh. The reciprocal is specific leaf area (SLA).</td>
<td>A primary axis of the global leaf economics spectrum</td>
<td>49, 66, 67</td>
<td>34, 35, 68–70</td>
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<tr>
<td>Nitrogen (N) (%)</td>
<td>Concentration of elemental nitrogen in a leaf or canopy.</td>
<td>Important for photosynthesis and other metabolic processes as a constituent of plant enzymes.</td>
<td>67, 71, 72</td>
<td>34, 35, 73–75</td>
</tr>
<tr>
<td>Non-structural carbohydrates (NSC) (%)</td>
<td>Direct products of photosynthesis (sugars and starches), not yet incorporated into plant structural components and thus readily assimilable.</td>
<td>Useful as an indicator of tolerance to environment stress</td>
<td>76</td>
<td>77</td>
</tr>
<tr>
<td>Chlorophyll (mg g⁻¹)</td>
<td>Green pigments.</td>
<td>Responsible for capturing light in the process of photosynthesis.</td>
<td>78, 79</td>
<td>35, 80, 81</td>
</tr>
<tr>
<td>Carotenoids (mg g⁻¹)</td>
<td>Orange and yellow pigments.</td>
<td>Involved in the xanthophyll cycle for dissipating excess energy and avoiding oxygen radical damage under stress conditions (drought, chilling, low nutrients).</td>
<td>82, 83</td>
<td>31, 35</td>
</tr>
<tr>
<td>Lignin (%)</td>
<td>A complex organic polymer.</td>
<td>Provides mechanical support and a barrier against pests and pathogens; negatively correlated with tree growth rate and microbial decomposition.</td>
<td>84, 85</td>
<td>32, 35, 73, 86</td>
</tr>
</tbody>
</table>
Conceptual framework for selecting regions

- Gradients that capture ranges of:
  - **Organism sizes** from microscopic phytoplankton to large canopy trees *(need to understand scaling)*
  - **Alpha diversity** from agricultural monocultures to highly diverse rainforests; species-poor mid-ocean gyres to diverse upwelling regions *(are algorithms robust across diversity gradients?)*
  - **Ecosystem structure** including the degree of fragmentation due to human-disturbance
What are the patterns, causes, and consequences of plant functional biodiversity?
What are the dominant controls on the distribution of plant functional traits and their diversity within biomes?

Is it abiotic environment, evolutionary contingencies, biotic context, or historical human influences? (yes)
How will the projected loss of plant functional diversity affect Earth system functioning through changes in carbon, water, and nutrient cycling?
How do the distribution and diversity of animal, plant, and fungal species vary with plant functional composition and diversity?
Scoping study timeline

- First workshop (March 2017)
- Present at NASA biodiversity meeting (May) and ESA (August)
- Post written draft on cce.nasa.gov and advertise for comments (August)
- Final workshop (Fall 2018)
- Final report to Woody Turner (Feb 2018)