WATER AND WETLANDS

NASA Bioreach field campaign for assessing the capabilities of remote sensing blue Africa

A project to understand biodiversity and habitat change across the estuaries in the Western Cape is yielding results. Article by Heidi van Deventer, Anthony Campbell, Laven Naidoo, Atticus Stovall, Kyle Smith, Pati Thakali, Elhadi Adam, Daniel Jensen, Abigail Barenblitt, Lola Fatoyinbo.

Estuaries, together with inland wetlands, are considered the most threatened ecosystem in South Africa (Skowno et al., 2019). Less than 43% of habitat maps out of the 290 estuarine functional zones (EFZs) and less than 10 of the 42 micro-estuaries have been digitised by various ecologists in the country to date (Van Deventer et al., in review). The images of several space-borne, remote sensing instruments, including RapidEye, Sentinel-1 and -2, and WorldView has proven useful to distinguish some wetland vegetation communities in the country, however, the use of different Light Detection and Radar (LiDAR) and hyperspectral images at higher spatial resolutions, remains to be assessed.

The National Aeronautics and Space Administration (NASA) funded an aerial campaign of four instruments integrated on two airborne platforms (outlined in Table 1) to capture biodiversity in the Western Cape in 2023. The NASA BioSCape campaign resulted from discussions that commenced over seven years ago. With the primary focus on assessing biodiversity of the Greater Cape Floristic Region, the campaign consisted of 19 sub-projects, each with a particular focus on various realms and biomes. One of these is the NASA BioReach subproject, led by Dr Anthony Campbell from NASA Goddard Space Flight Centre and the University of Maryland, Baltimore County. The aim of the NASA BioReach project was to understand biodiversity and habitat change across the estuaries in the Western Cape.

The NASA Bioreach project collaborates with 23 South African institutions, ranging from science councils to universities and the South African National Parks (SANParks) conservation agency. In May 2023, a workshop was held with initial discussions and planning for the fieldwork campaign later in the year (see Figure 1).

Figure 1. Participants at the NASA BioSCape Applications Workshop at Houw Hoek Hotel, Grabouw, Western Cape, South Africa, 22-26 May 2023 (from Forbes et al., 2023).

Table 1: Table with the airborne sensors that form part of the NASA Bioscape campaign

Instrument/ platform	Time-frame	Platform	Spectral Range (# bands)	Application	URL
Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG)	2023	Gulfstream	380-2 510 nm (426)	Land cover classification; plant functional type and trait maps	https://www.jpl.nasa.gov/missions/airborne-visible-infrared-imaging-spectrometer-next-generation-aviris-ng
Portable Remote Imaging Spectrometer (PRISM)	2023	Gulfstream	350-1 050 nm (3)	Bathymetry and submerged aquatic vegetation	https://airbornescience.nasa.gov/instrument/PRISM
Hyperspectral Thermal Emissions Spectrometer (HyTES)	2023	Gulfstream	7 500-12 000 nm (256)	Land surface temperature	https://airbornescience.nasa.gov/instrument/HyTES
Land, Vegetation and Ice Sensor (LVIS)	2023	Gulfstream	1 064 nm (Waveform)	Hydrogeomorphic characterisation and vegetation structure	https://airbornescience.nasa.gov/instrument/LVIS

Between October and November 2023, the fieldwork campaigns were undertaken in several estuaries at the time of the sensor's overflight. The first week was spent in and around Sedgefield in the Western Cape, followed by the second phase at Langebaan on the West Coast. Plots were sampled within the blue carbon habitats, including salt marshes and seagrasses (e.g. Figure 2 and 3), while adjacent ecotonal freshwater ecosystems were also explored. 'An ecotone is a transition area between two biological communities (Senft, 2009), where two communities meet and integrate (Pearl et al., 2011)' according to Wikipedia (2024). Ecotones are crucial for estuarine habitats and contribute to habitat function and integrity. In each plot the plant species composition and vegetation height recorded, and sediment cores were periodically taken to assess the ecological condition and carbon storage of the biodiversity types. The outputs are currently being processed while the team is waiting for the aerial data to be pre-processed and released. Thereafter, the habitat mapping and analysis will be done, with several papers planned as follow-up work to assess the variation in the characteristics and ecological condition of the ecosystem types.

The vegetation survey was done at four of the Garden Route estuaries: the Knysna Estuarine Bay, Swartvlei, the Touws Estuary and Wilderness Lakes (Figures 4-7). Surveys started at low tide in the intertidal zone, and subsequently shifted with the tides, and would soon end up in the reeds and supratidal vegetation bordering the lakes and estuaries. Swartvlei and other less readily accessible locations in the estuary were accessed by boat. Stands of ***Phragmites australis,*** which towered over the team and made passage difficult, were also surveyed, and at Rondvlei the Sawgrass left its mark in the form of tattered measuring tapes, and plots of spiny rush (***Juncus spp.***) which lived up to their name puncturing shirts and piercing pant legs. Though the marsh vegetation is less than hospitable to humans it is critical to the function of the local ecosystem as it reduces flooding and sequesters carbon.

The team collected both above and below ground measurements, including soil cores, terrestrial laser scans, and spectral reflectance. The Analytical Spectral Device FieldSpec4 was provided by Prof Elhadi Adam from the University of the Witwatersrand (WITS; see Figure 8). The field spectrometer, manufactured by Malvern Panalytical, measures radiance and reflectance across the electromagnetic spectrum from 300 nm to 2 500 nm allowing us to relate ground measurements directly to the sensors flying overhead.

LiDAR technology was utilised in two forms for this project both on the ground with a Terrestrial Laser Scanner (TLS; Figure 9) and LVIS in the air. LiDAR can be used to determine the elevation of the ground and height of vegetation based on the time it takes for light to transit back to the sensor. In our study the TLS scans will be coupled with plot measurements and aerial LiDAR to understand how vegetation structure affects biodiversity in these low stature coastal environments.

Figure 2: Dr Anthony Campbell on the right, and Mr Pati Thakali (WITS) on the left, doing a transect in the submerged macrophytes or seagrasses at Sedgefield.

Figure 3: Close-up photograph of Zostera capensis *as a submerged macrophyte, which is a threatened species in the country.*

Figure 4: Field validation of inland water habitats at Sedgefield. From left to right: Mr Kyle Smith (SANParks), Dr Anthony Campbell (Goddard Space Flight Center, USA), Dr Atticus Stovall (Goddard Space Flight Center; University of Maryland, USA), Mr Pati Thakali (University of the Witwatersrand), Mr Petri Oberholster (volunteer from University of the Free State) and Ms Larize Nel (volunteer).

Figure 5: Beautiful view from the Sedgefield Estuary looking inland, showing the Zostera capensis *patches that are small in extent as a blue carbon habitat and therefore challenging to map with coarse-scale satellite images. The landscape shows the transition to coastal dunes with terrestrial vegetation on both sides of the estuary.*

*Figure 6: The homogeneity of the salt marsh in the front (*Juncus spp.*) and the reeds (*Phragmites australis*) at Swartvlei at the time of the field campaign. Submerged macrophytes are visible between the lake water on the far right.*

Figure 7: Narrow patches of salt marsh vegetation co-occur with terrestrial vegetation at Swartvlei, which makes it very challenging for space-borne sensors, with a medium spatial resolution to accurately delineate and monitor these vegetation communities.

Figure 8: Fieldwork sampling at Langebaan using the field spectrometer (on the far right). From left to right: Dr Keith Gaddis (NASA Headquarters), Dr Woody Turner (NASA Headquarters), Dr Lola Fatoyinbo (NASA Goddard Space Flight Center), Dr Daniel Jensen (JPL-Caltec), Abigail Barenblitt (NASA Goddard Space Flight Center), Mr Pati Thakali (WITS), Dr Anthony Campbell (NASA Goddard Space Flight Center, USA), Danielle Wood (MIT), Dr Laven Naidoo (GCRO) and Prof Elhadi Adam (WITS).

Figure 9: Dr Atticus Stovall collecting 3D data with a terrestrial laser scanner for mapping wetland topography and vegetation structure in the tidal estuary ecosystem.

The knowledge exchange between the researchers from the different countries, and between the researchers and other organisations, has enriched the understanding of the systems, while also offering increased creativity in new approaches. Subsequently, meetings have been held every two weeks in 2024 with the expanded team, which facilitated the refinement of the knowledge gaps and research approach towards the outputs. The intention is that the outputs will provide a greater understanding of the fragmented distribution and structure of blue carbon biodiversity in the estuaries of South Africa and can serve as a reference record to map and monitor changes in these systems.

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Participating and funding organisations

References:

- Forbes, C., Cardoso, A., Wilson, A., Slingsby, J., Hestir, E., 2023. BioSCape Applications Workshop Report, December 2023. https://drive.google.com/file/d/1njyvLYYO9a4v4iJDk_pKokg4M_uSPKdT/view
- Pearl, S. E.; Berg, L.R.; Martin, D.W. 2011. Biology. Belmont, California: Brooks/Cole.
- Senft, A. 2009. Species Diversity Patterns at Ecotones (PDF). University of North Carolina. Archived from the original (Master's thesis) on 2011-09-30. Retrieved 2011-01-07.
- Skowno, A.L.; Poole, C.J.; Raimondo, D.C.; Sink, K.J.; Van Deventer, H.; Van Niekerk, L.; Harris, L.R.; Smith-Adao, L.B.; Tolley, K.A.; Zengeya, T.A.; Foden, W.B.; Midgley, G.F. & Driver, A. 2019. National Biodiversity Assessment 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report. South African National Biodiversity Institute, an entity of the Department of Environment, Forestry and Fisheries, Pretoria. http://hdl.handle.net/20.500.12143/6362.
- Van Deventer, H.; Apleni, P.; Adams, J.B.; Riddin, T.; Whitfield, E.; Machite, A.; Van Niekerk, L.; Madasa, A. in review. Mapping changes in South African estuarine ecosystem functional groups using Landsat and Sentinel images of 1990, 2014, 2018 and 2020
- Wikipedia 2024. https://bit.ly/3ARIIQP