Savannas from space:

Informing landscape conservation with remote sensing

Jody Vogeler [1],

David Bunn [2], Steve Filippelli [1], Derek Fedak [1],

[1] Colorado State University

[2] UBC

SSNM 2025 -
Species-Habitat Relationships & Biodiversity Patterns

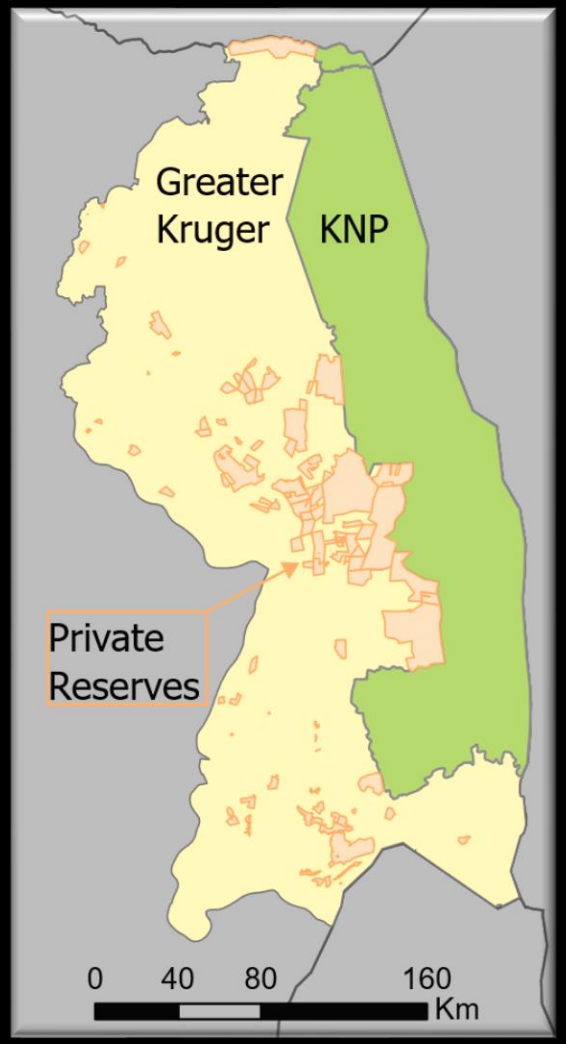
SSNM 2025 –

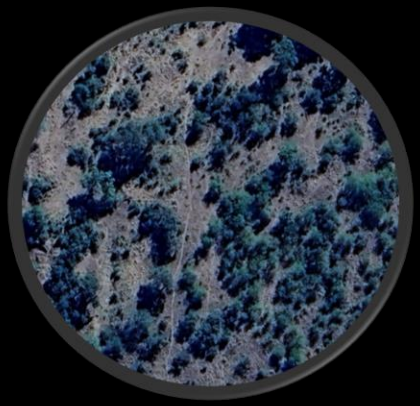
Vegetation Structure & Landscape Configurations

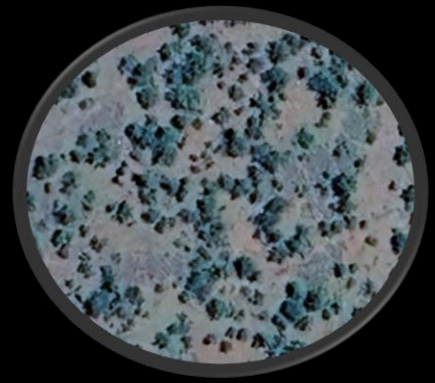
SSNM 2025 –

Ecosystem Dynamics & Resilience

How do we Translate Research into Conservation Tools?







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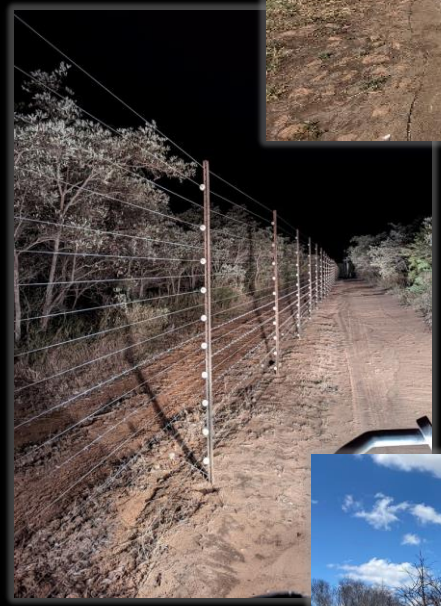
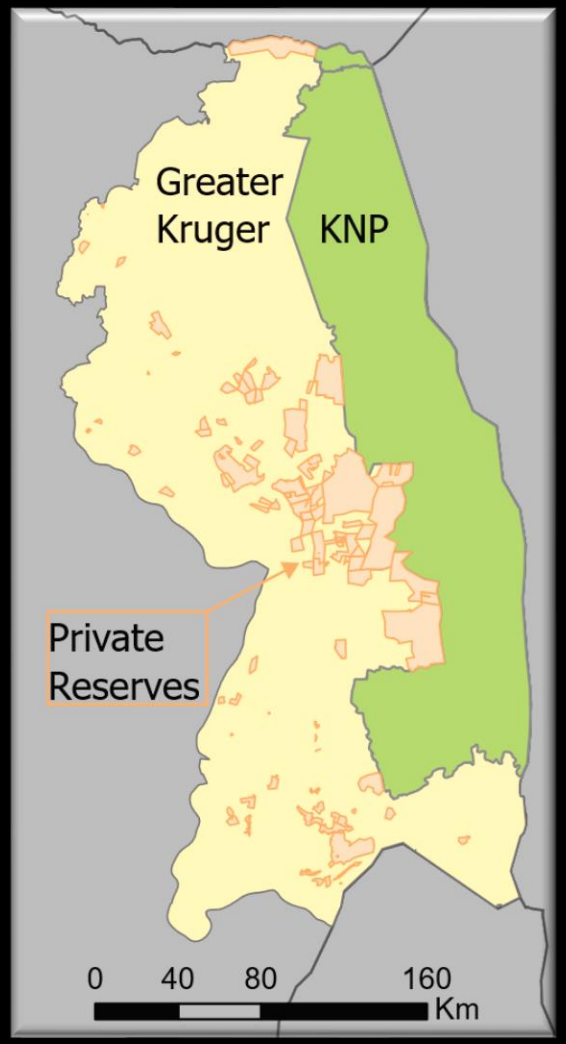


Rewilding & Adaptive Management Strategies

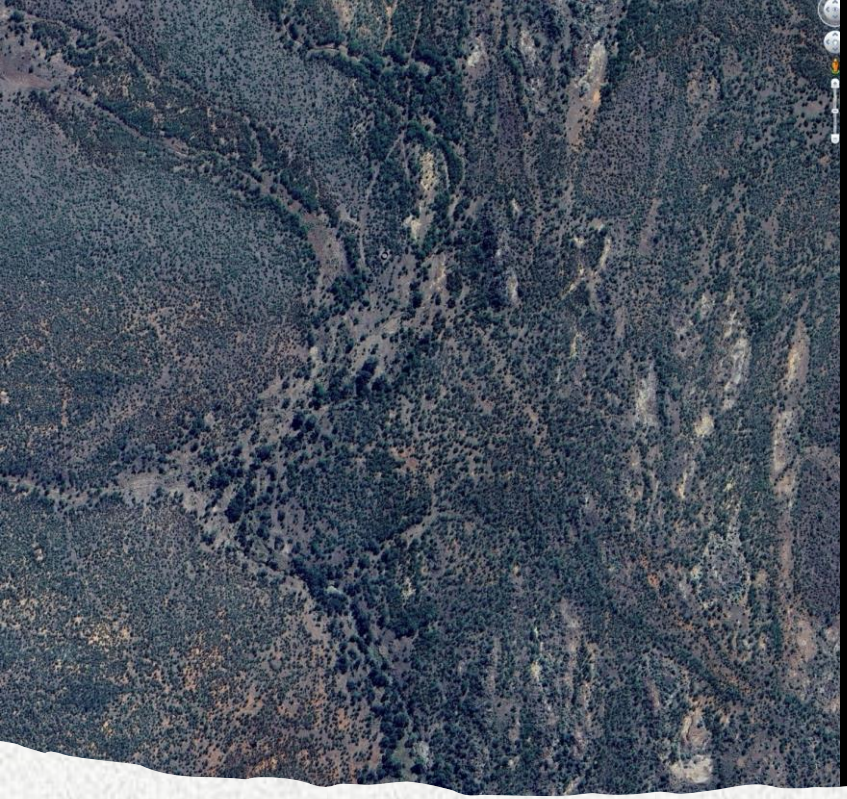


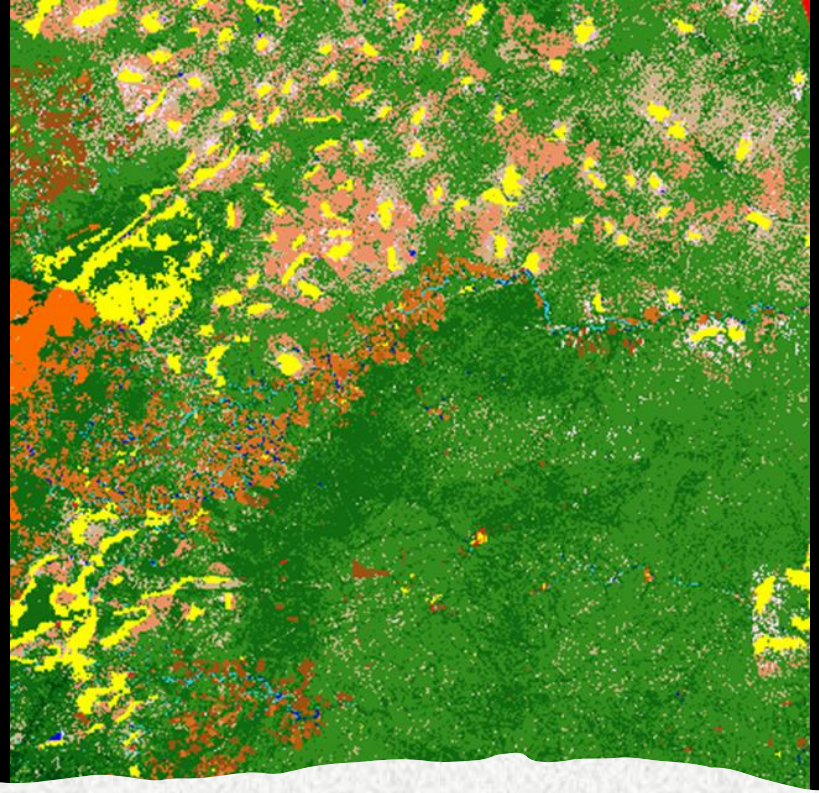
Patterns & drivers of tree mortality

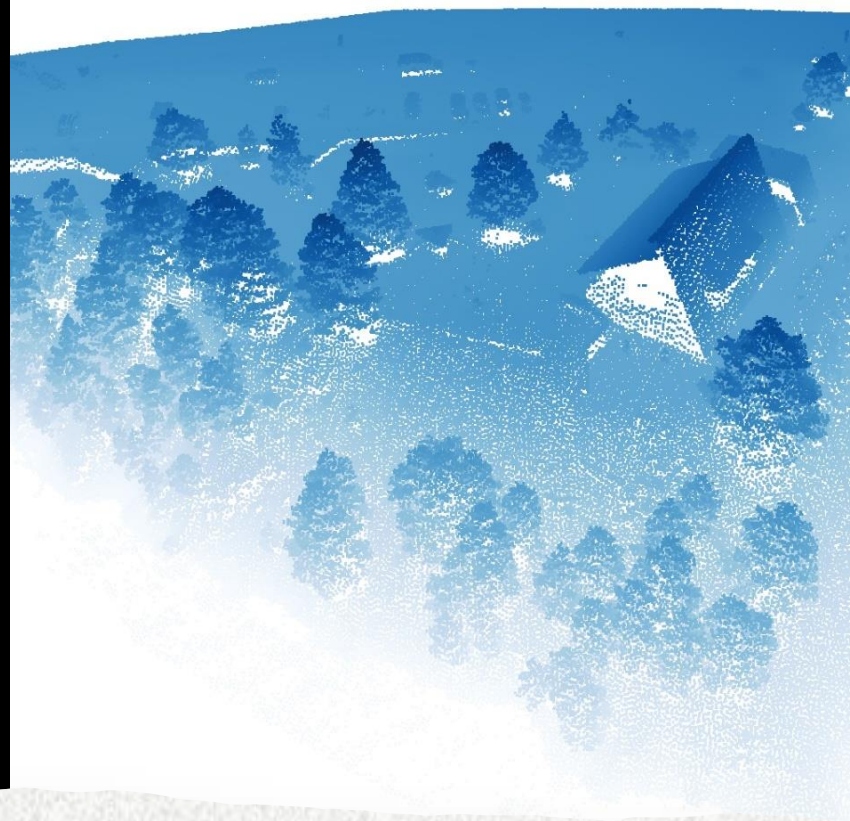
Increasing urbanization pressures along protected area borders


How do we create management & conservation relevant tools?


How do we create management & conservation relevant tools?
Remote Sensing + Field Data & Local Knowledge = Spatial Planning Tools
(Also useful for advancing research across multiple scales)







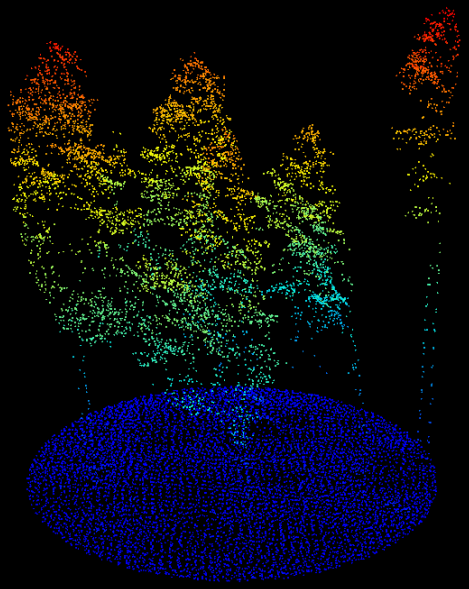
What is the right “tool” for the job?

- Spatial resolution and extent
- Temporal resolution and extent
- Sensitivity to focal features or change
- Data accessibility (open-source)

What is the right “tool” for the job?
- Tradeoffs -

Consistency across space & time

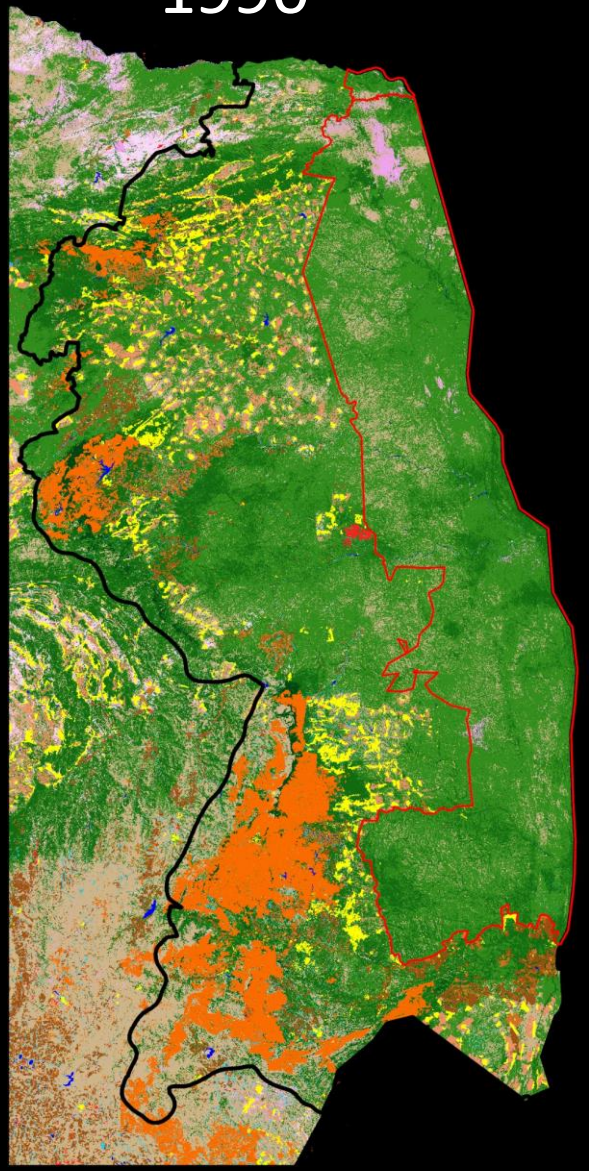
Spatial resolution and mapping detail vs. open-source data with ease of repeatability through time



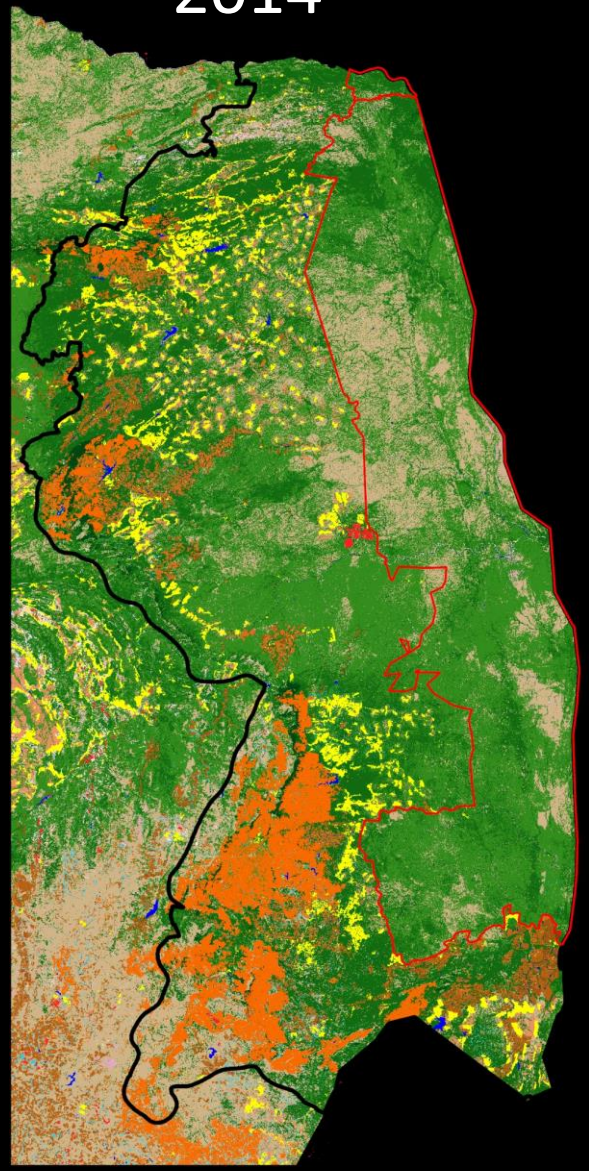
Small spatial coverage & limited accessibility

South Africa Land Cover Land Use Mapping Program

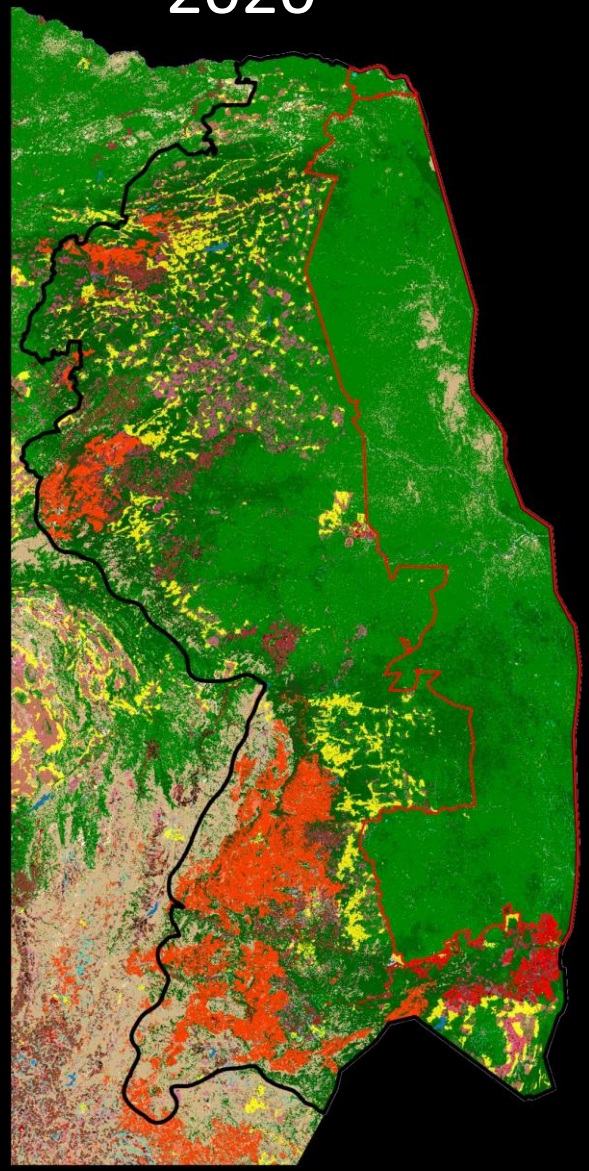
1990

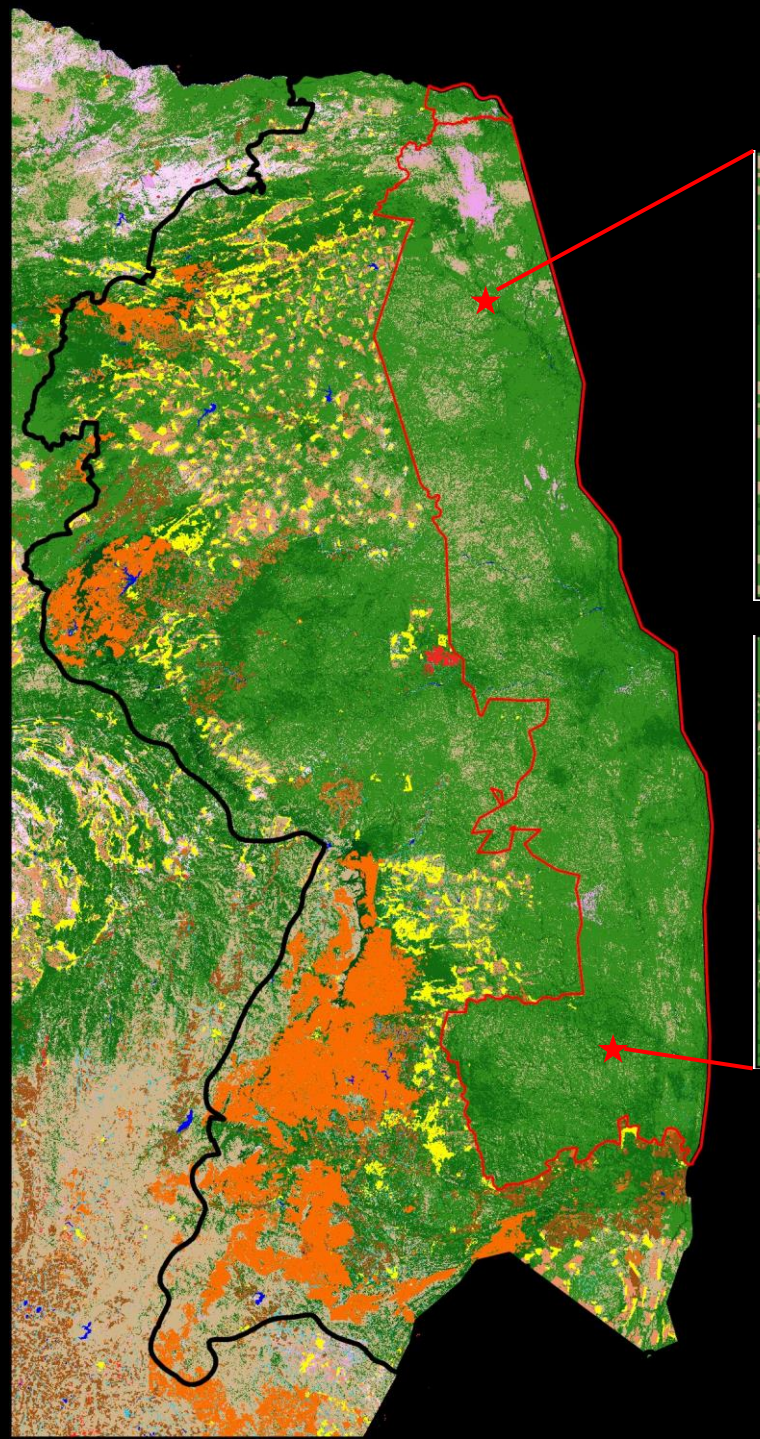


2014



2020





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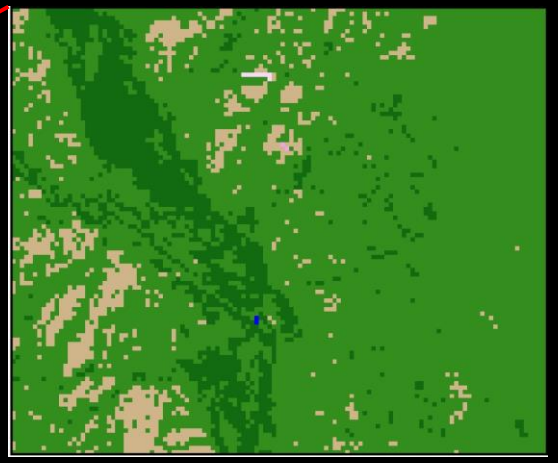

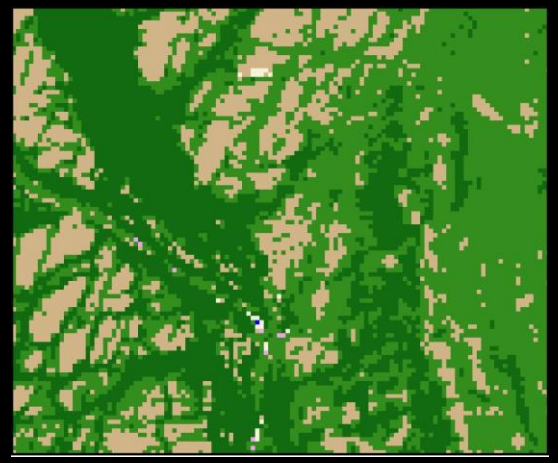

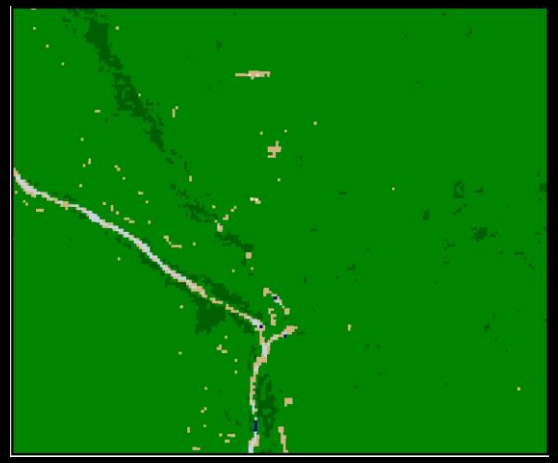

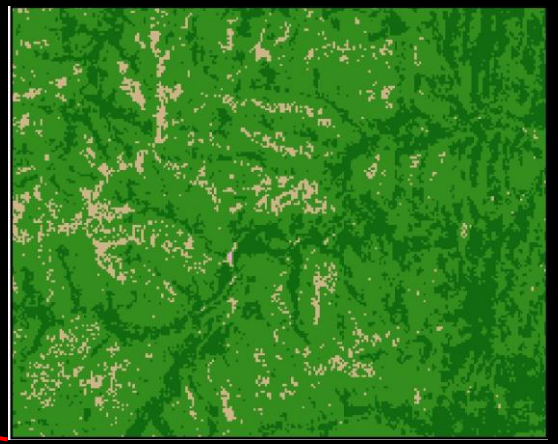

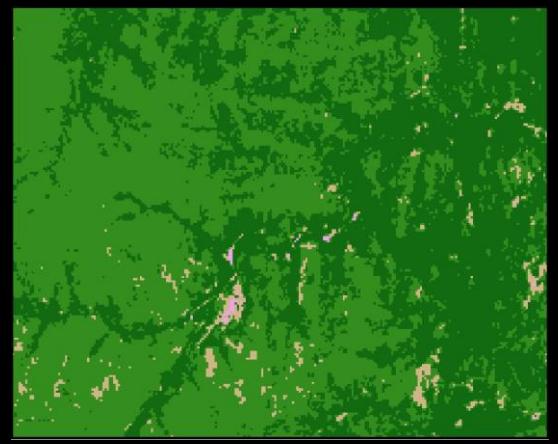

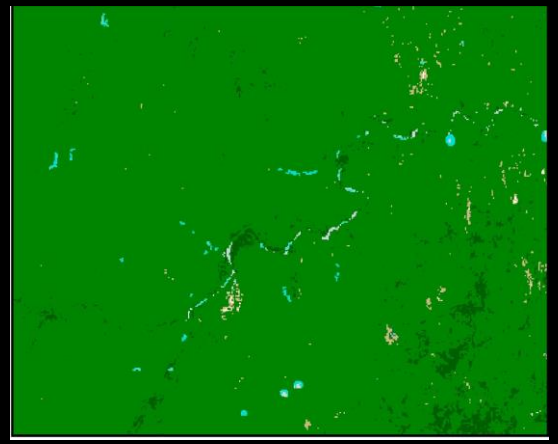

Trading vegetation detail for spatial and temporal extents

Inset Legend

- Thicket /Dense bush
- Woodlan/Open bush
- Low shrubland
- Grasslands
- Waterbodies
- Wetlands

Remote Sensing of GKNP Savannas

Applied Vegetation Science **17** (2014) 172–184

Savanna woody vegetation classification – now in 3-D

Jolene T. Fisher, Barend F.N. Erasmus, Ed T.F. Witkowski, Jan van Aardt, Konrad J. Wessels & Gregory P. Asner

KOEDOE - African Protected Area Conservation and Science
ISSN: (Online) 2071-0771, (Print) 0075-6458
Page 1 of 6 Short Communication

Woody cover mapping in the savanna ecosystem of the Kruger National Park using Sentinel-1 C-Band time series data

Marcel Urban[I]; Kai Heckel[I]; Christian Berger[I]; Patrick Schratz[II, III]; Izak P.J. Smit[IV, V]; Tercia Strydom[IV]; Jussi Baade[VI]; Christiane Schmullius[I]

Spatial patterning among savanna trees in high-resolution, spatially extensive data

A. Carla Staver[a,1], Gregory P. Asner[b], Ignacio Rodriguez-Iturbe[c,1], Simon A. Levin[d], and Izak P.J. Smit[e,f]

Remote Sensing of Environment 284 (2023) 113369
Contents lists available at ScienceDirect
Remote Sensing of Environment
journal homepage: www.elsevier.com/locate/rse

Quantifying the sensitivity of L-Band SAR to a decade of vegetation structure changes in savannas

Konrad Wessels [a,*], Xiaoxuan Li [a], Alexandre Bouvet [b], Renaud Mathieu [c], Russell Main [d], Laven Naidoo [e], Barend Erasmus [f], Gregory P. Asner [g]

Ecological Indicators 170 (2025) 113061
Contents lists available at ScienceDirect
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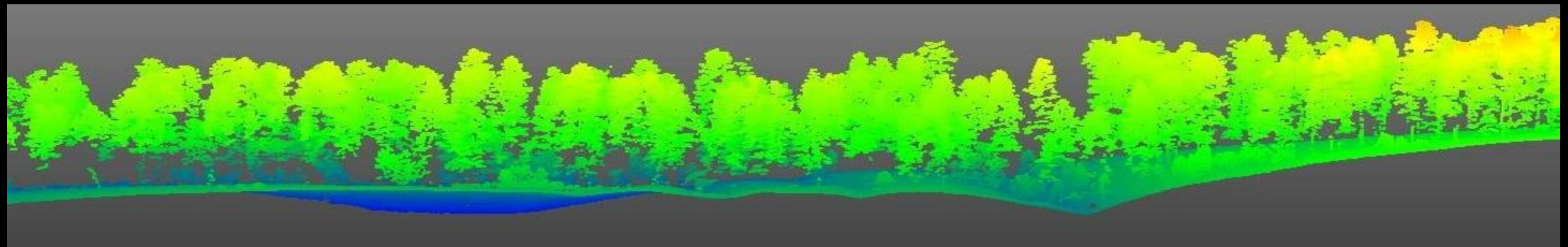
Original Articles

Consistent patterns of LiDAR-derived measures of savanna vegetation complexity between wet and dry seasons

Zhengyang Wang [a,b,*], Jenia Singh [a], Andrew B. Davies [a,*]

SAR-TO-LIDAR MAPPING FOR TREE VOLUME PREDICTION IN THE KRUGER NATIONAL PARK

[†]H.C. Myburgh, [†]J.C. Olivier, [*]R. Mathieu, [‡]K. Wessels, [†]B. Leblon, [**]G. Asner, [*‡]J. Buckley*



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[1]70 (2025) 113061

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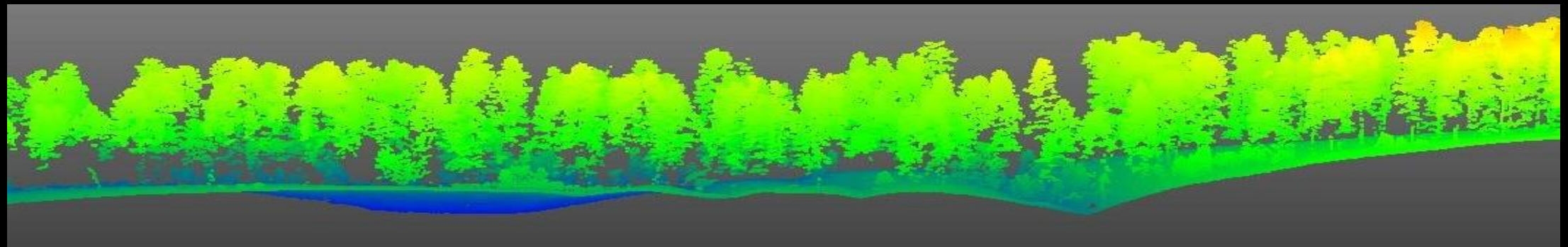
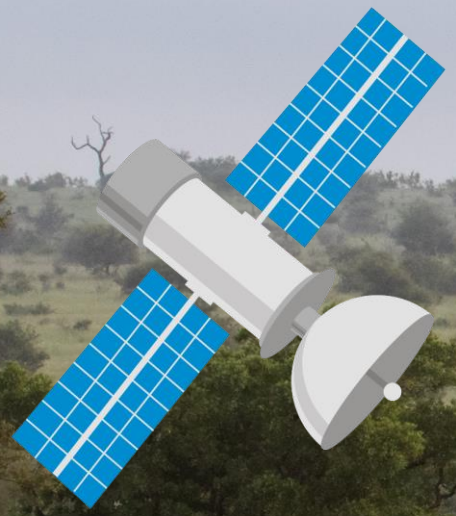
Characterizing Savanna Vegetation Structure with Airborne LiDAR

Scaling up Airborne LiDAR with Synthetic Aperture Radar (SAR) Data




How can we continue to advance spatial tools for conservation planning in GKNP?



Applying NASA Earth Observation Data to Conservation Management in the Greater Kruger National Park Region

Colorado State University

NASA

Remote Sensing for Informing Conservation

End-User Engagement

Identify Critical Data Gaps for Planning/Monitoring Programs

Consider Available Remote Sensing Data to Meet Needs

Remote Sensing for Informing Conservation

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Remote Sensing for Informing Conservation

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Uncertainty Assessments

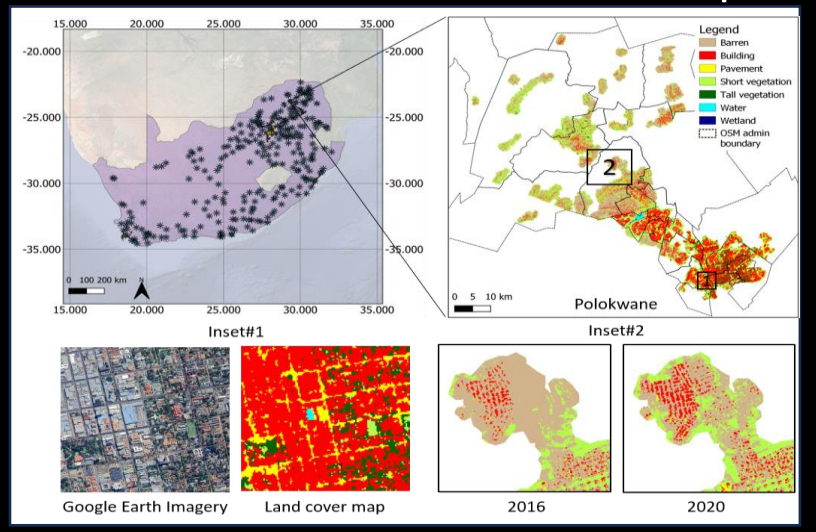
Consider Data/Tool Accessibility

Training and Hand-Off Support for End-User Integration

Project Goals and Outputs

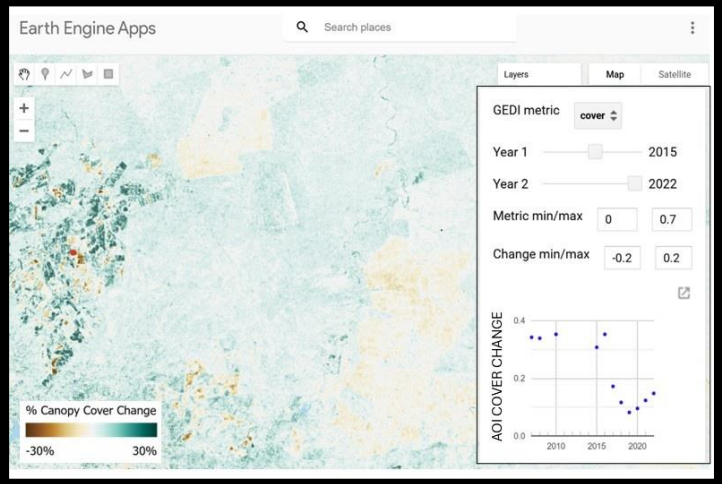
Characterize Woody Vegetation Structure

Urbanization Patterns & Landscapes

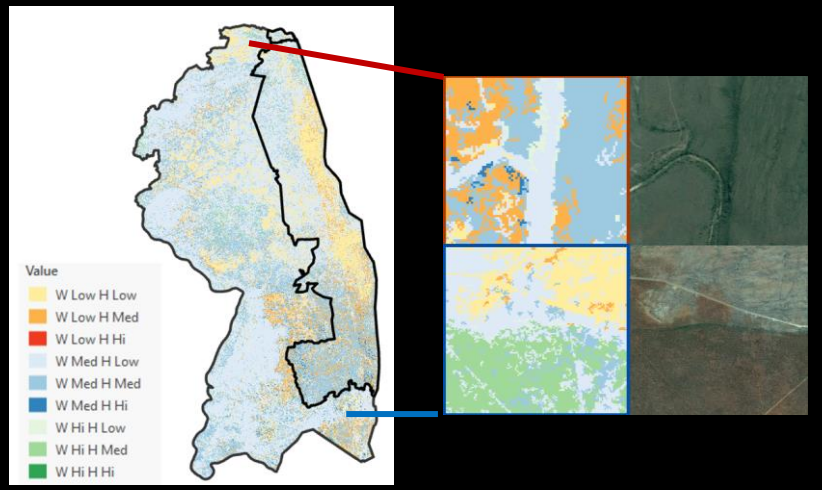


Wildlife Habitat & Connectivity

Monitoring & Conservation Planning Tools



Herbaceous Biomass & Patch Classes



Project Goals and Outputs

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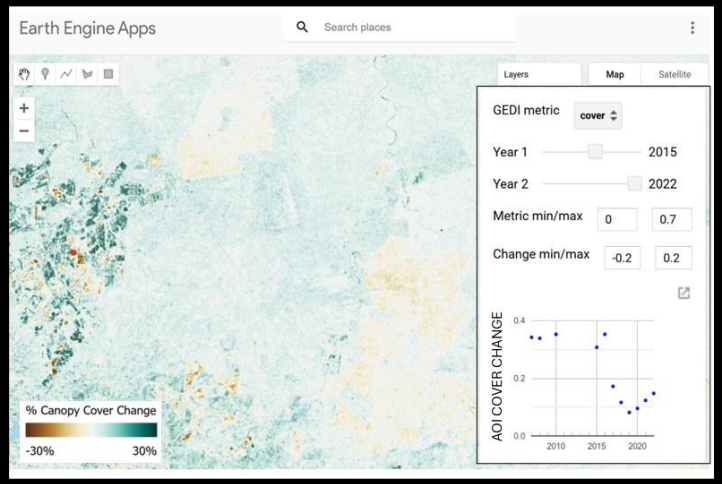
Monitoring & Conservation Planning Tools



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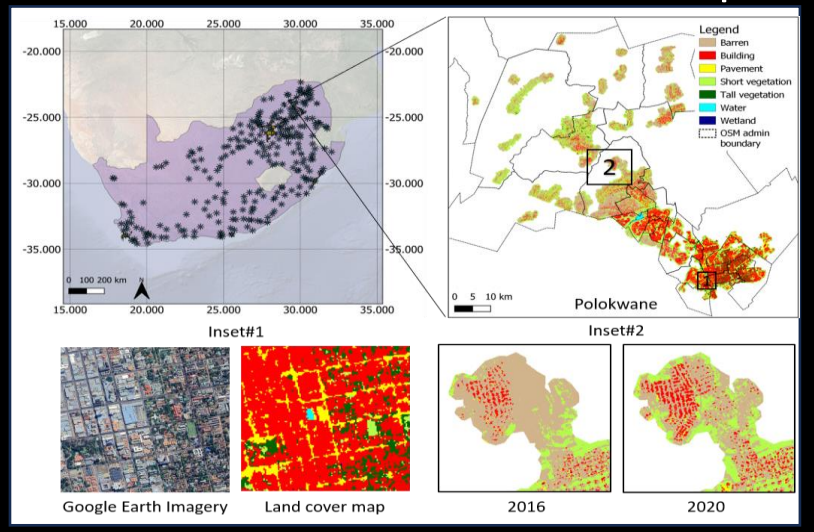

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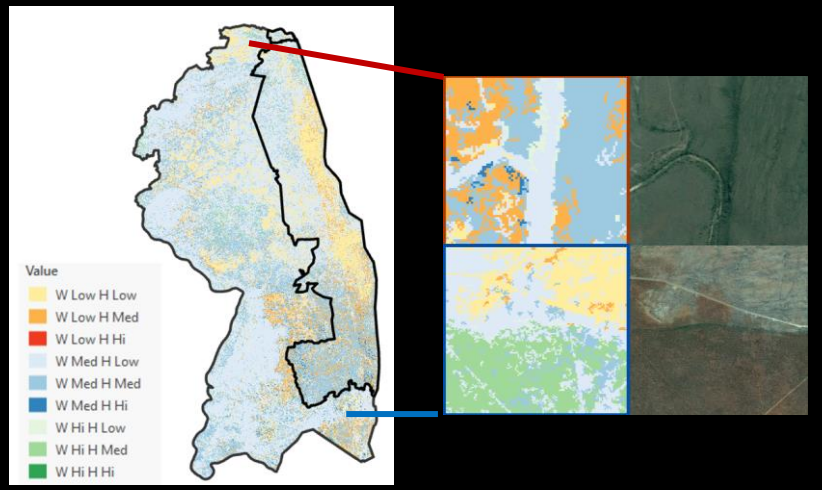

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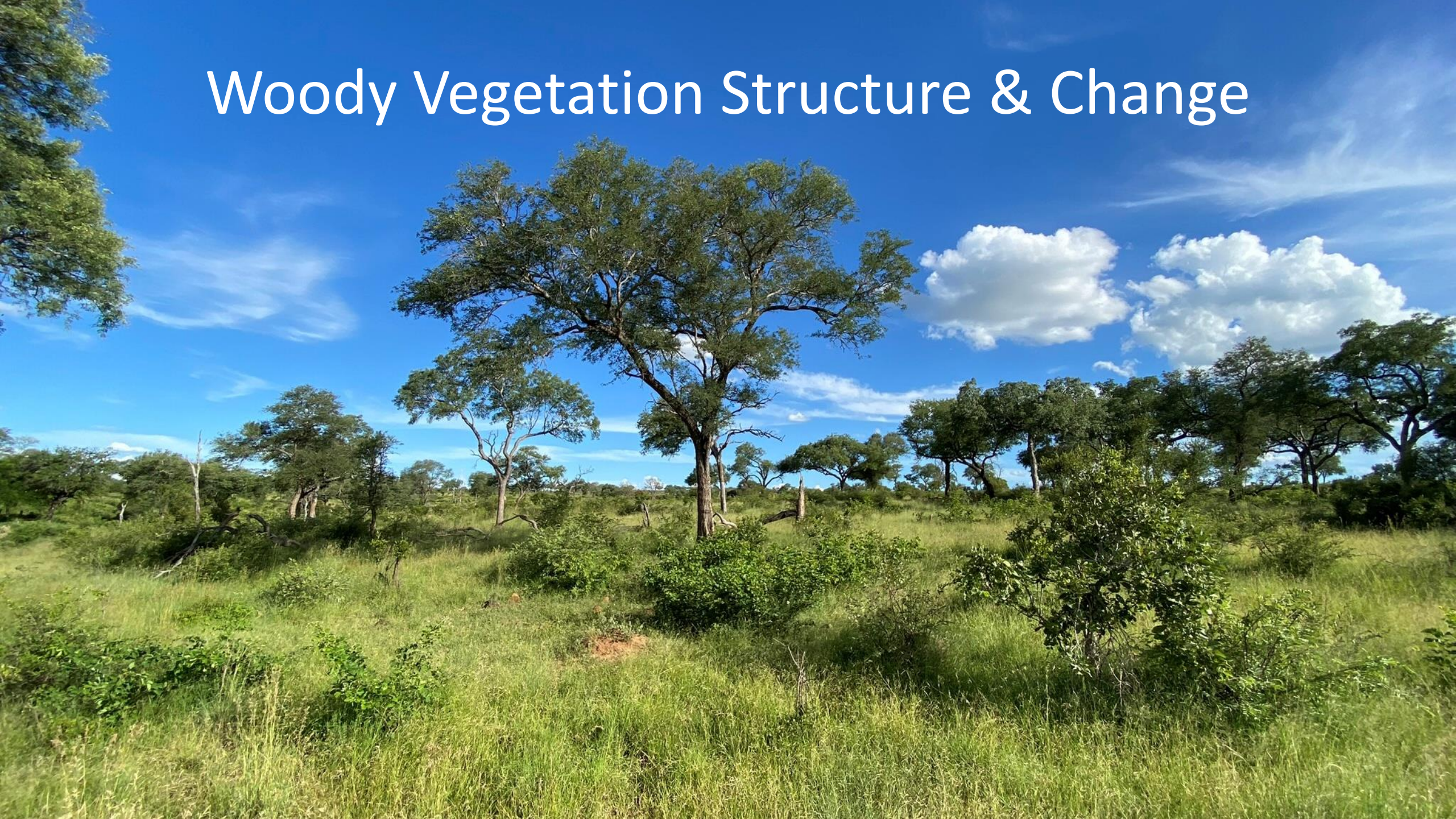

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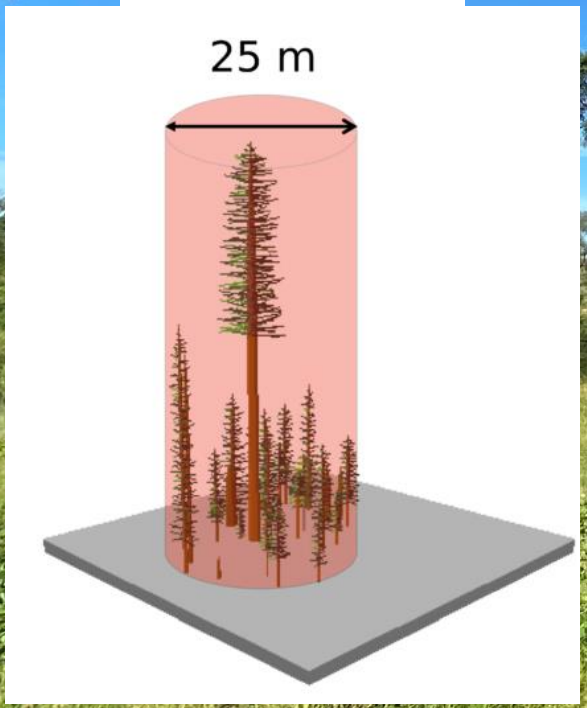
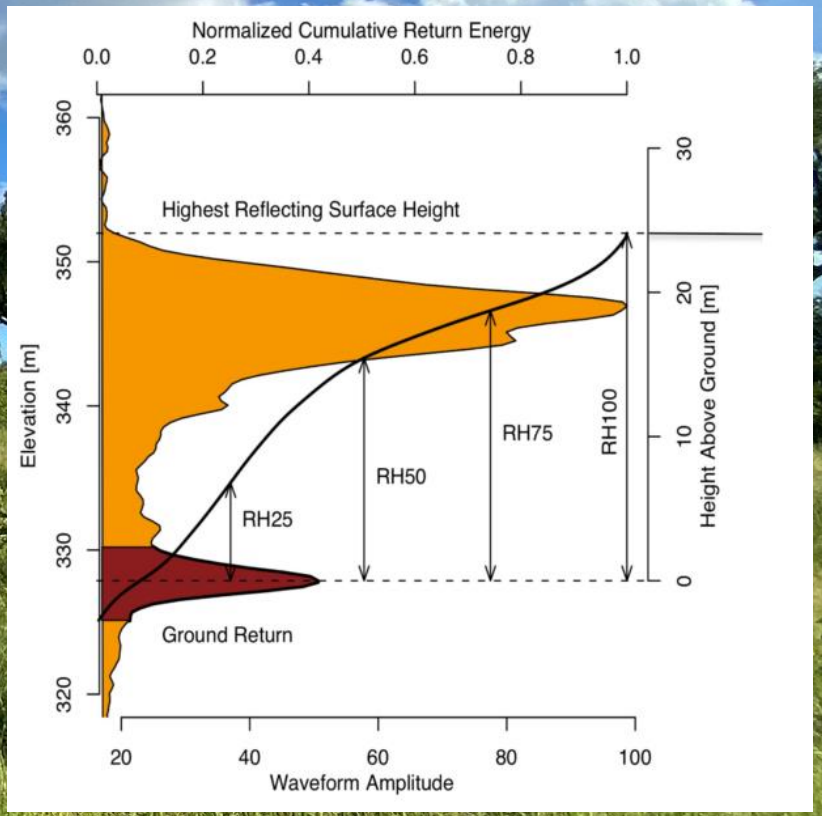
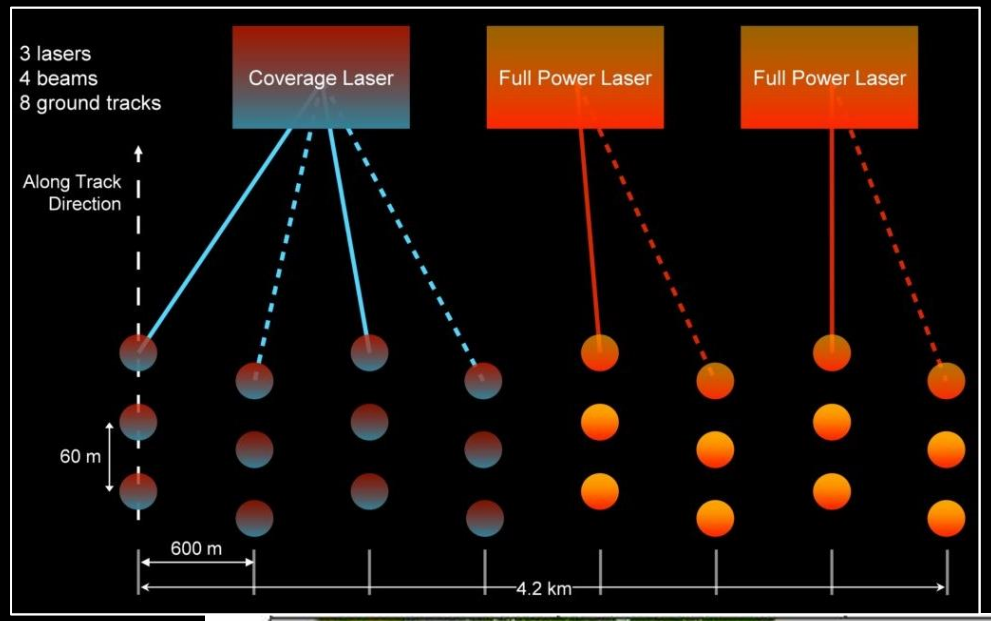
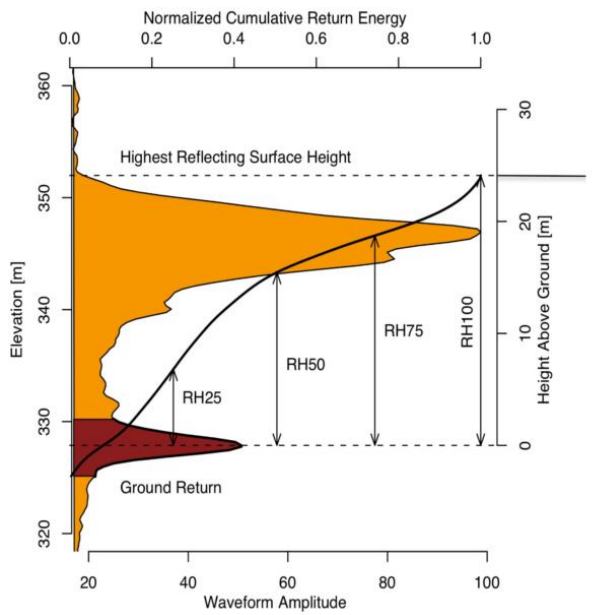
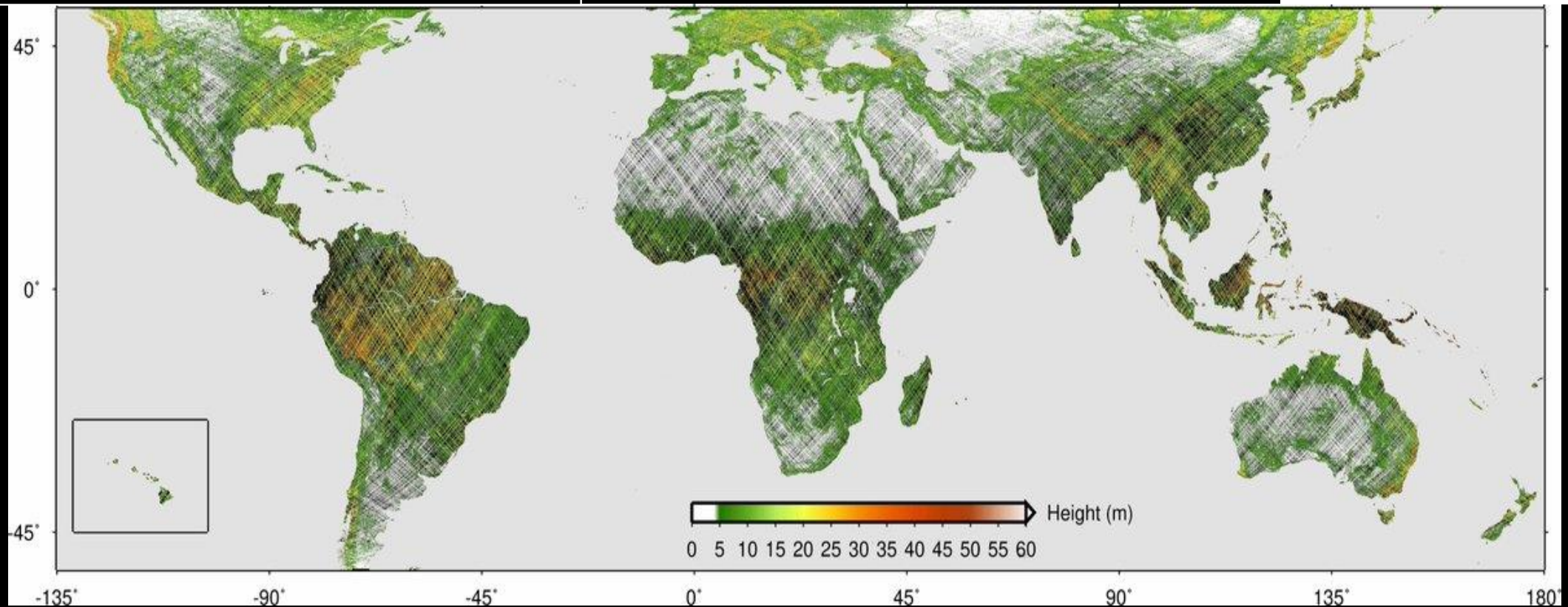






GEDI: Structure Sampling Tool





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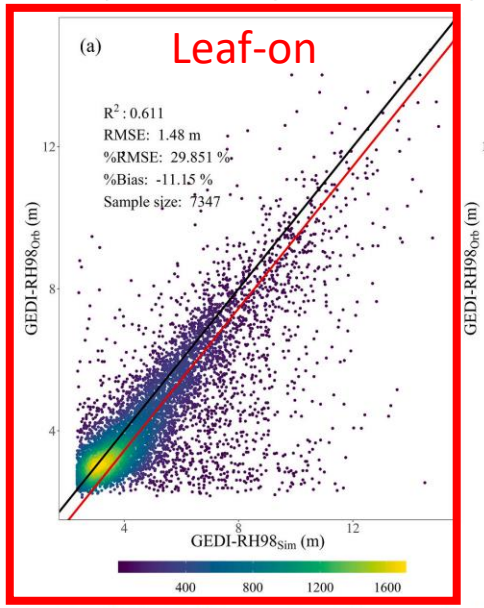
First validation of GEDI canopy heights in African savannas

Xiaoxuan Li [a], Konrad Wessels [a,*], John Armston [b], Steven Hancock [c], Renaud Mathieu [d], Russell Main [e], Laven Naidoo [f], Barend Erasmus [g], Robert Scholes [h]



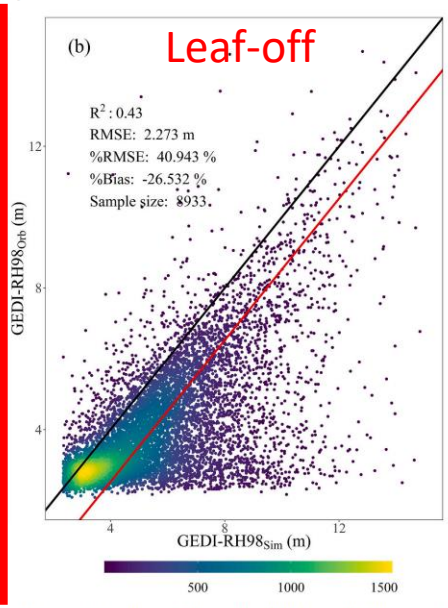
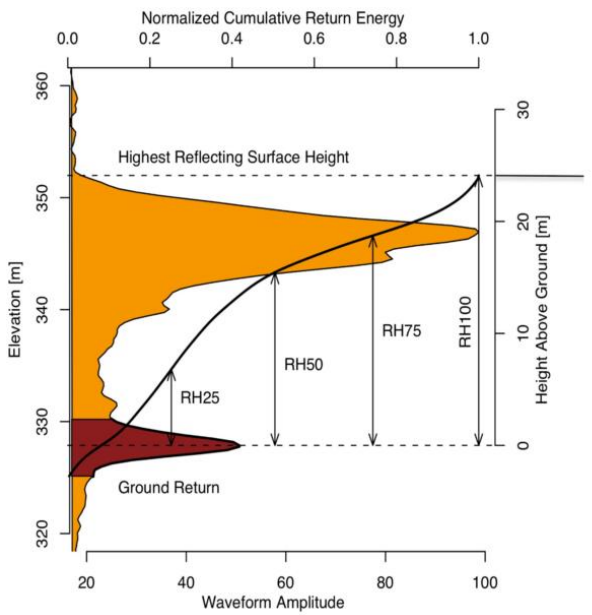
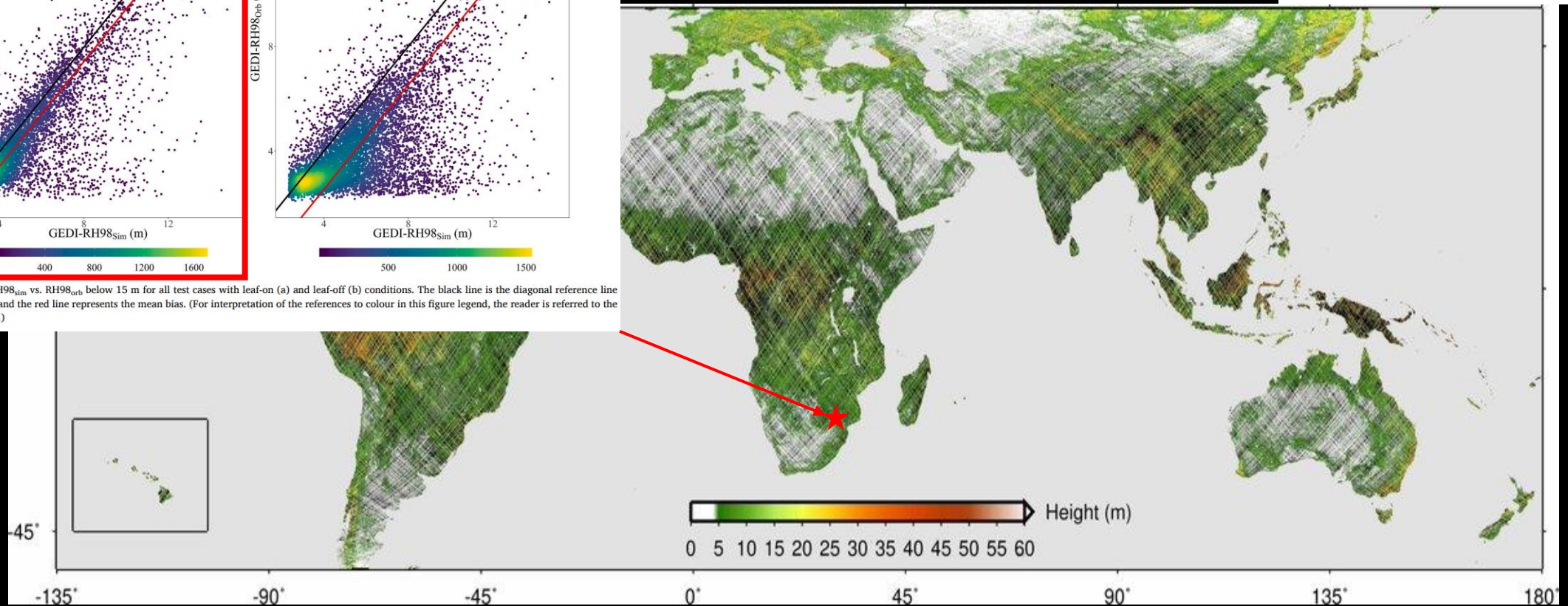


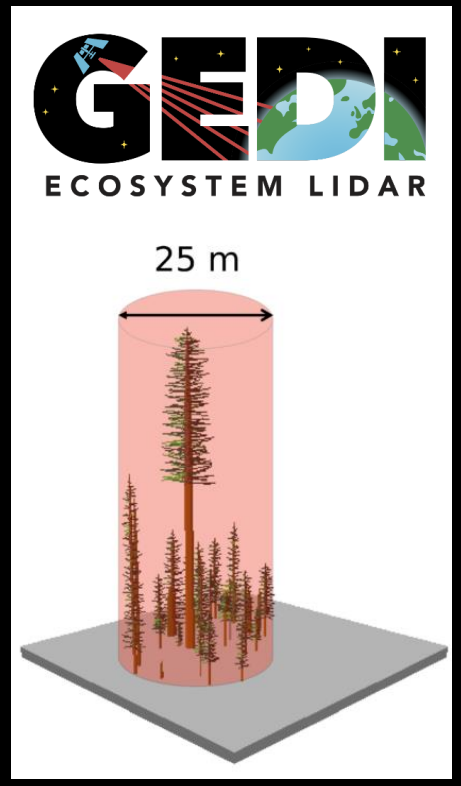
Fig. 9. Density plots of $RH98_{sim}$ vs. $RH98_{orb}$ below 15 m for all test cases with leaf-on (a) and leaf-off (b) conditions. The black line is the diagonal reference line (slope = 1, intercept = 0) and the red line represents the mean bias. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

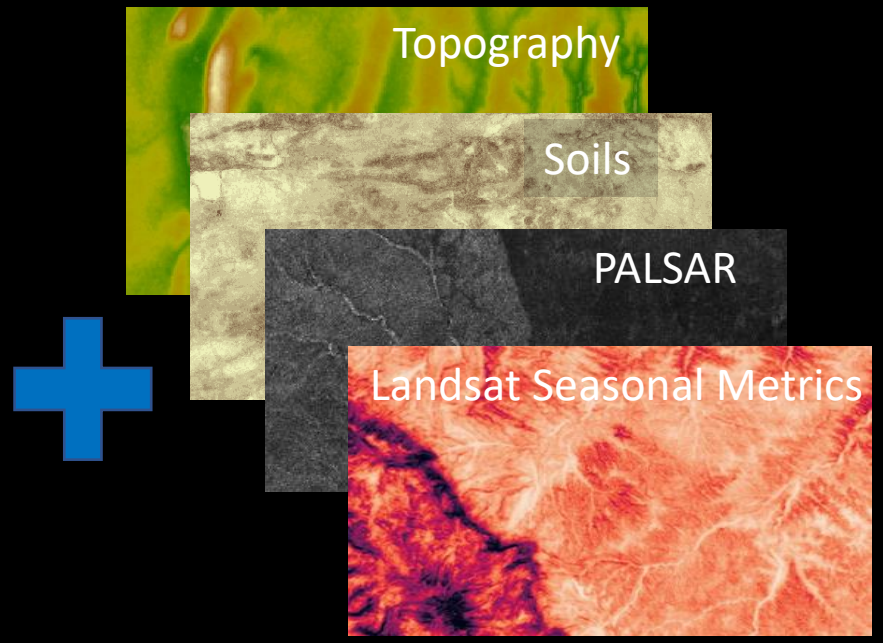
GEDI: Structure Sampling Tool





Random Forest Modeling Framework

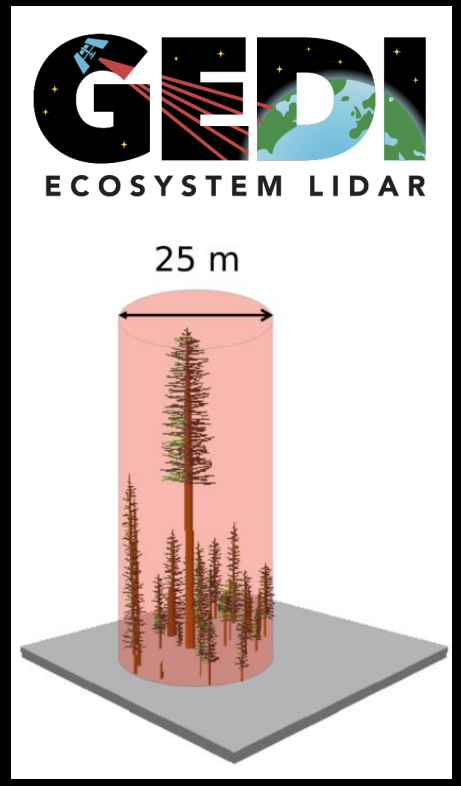




High Quality Leaf-on Footprints Only

Sample sampling of footprints

Random Forest Modeling Framework



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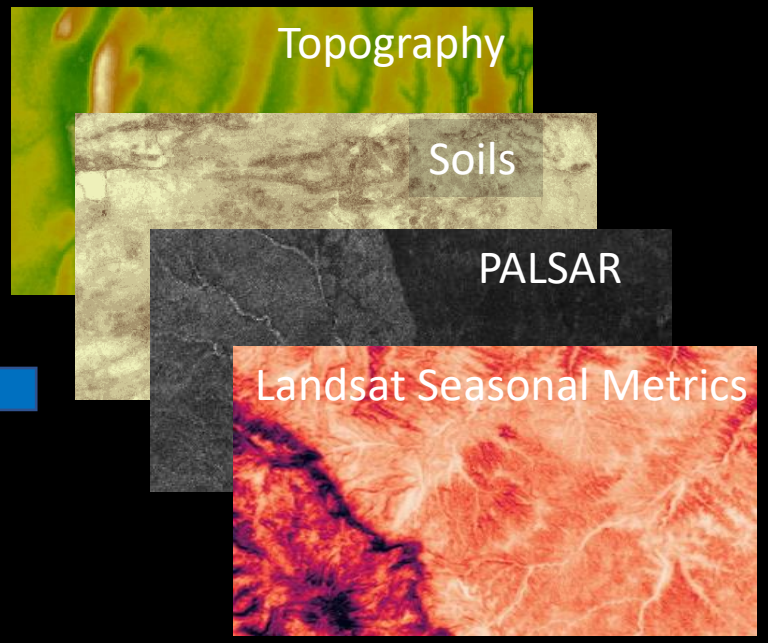
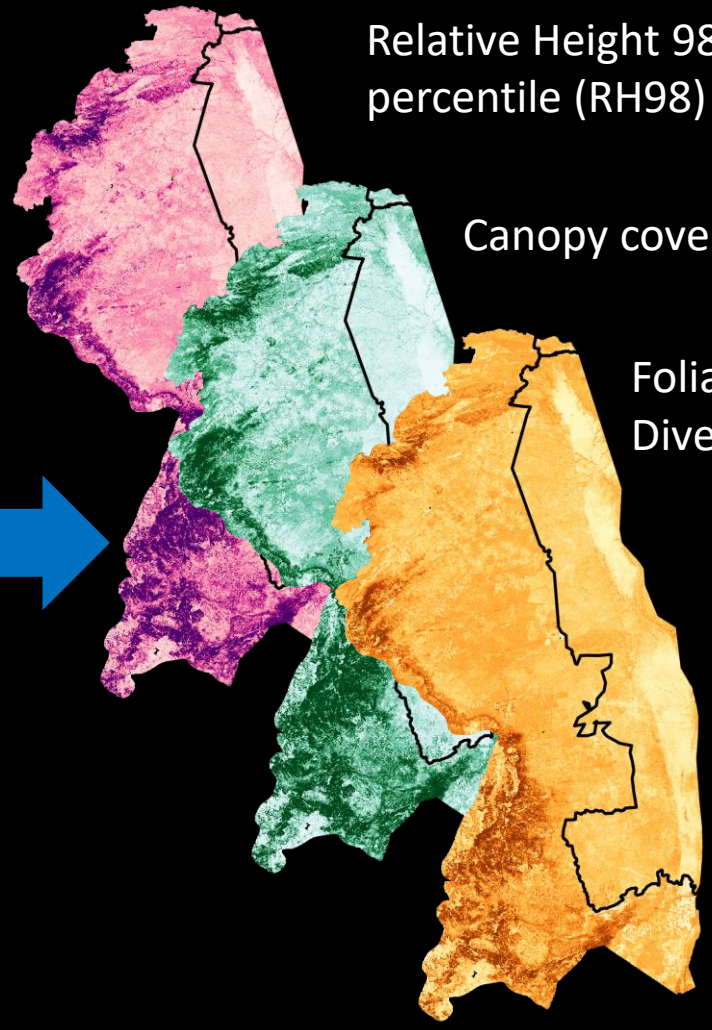




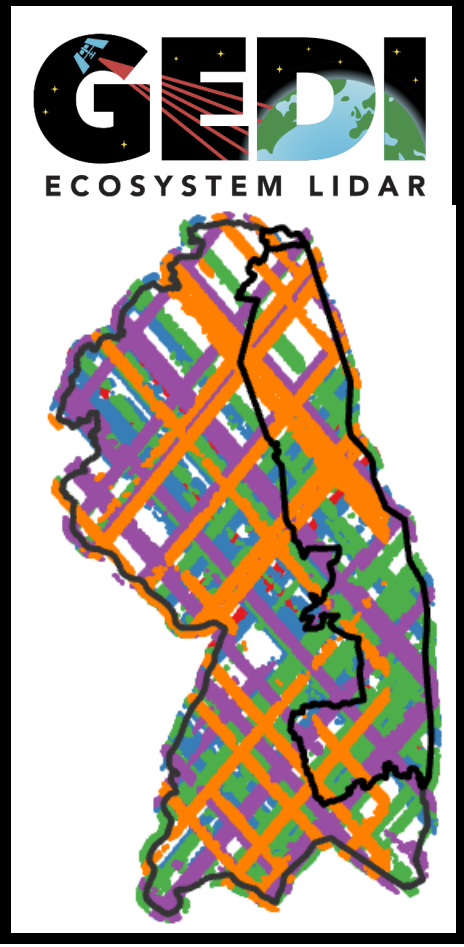
Relative Height 98th percentile (RH98)

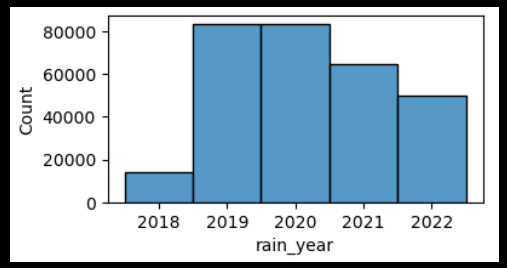
Canopy cover (COVER)

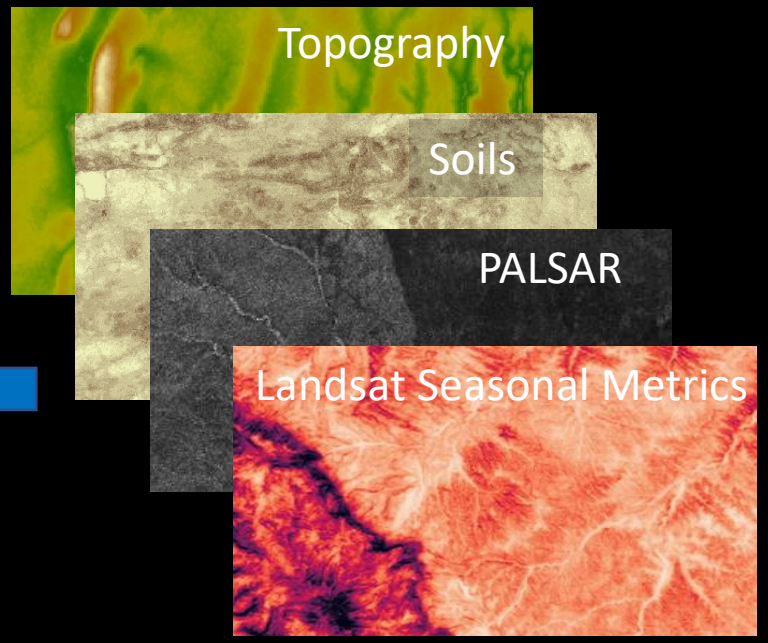
Foliage Height Diversity (FHD)

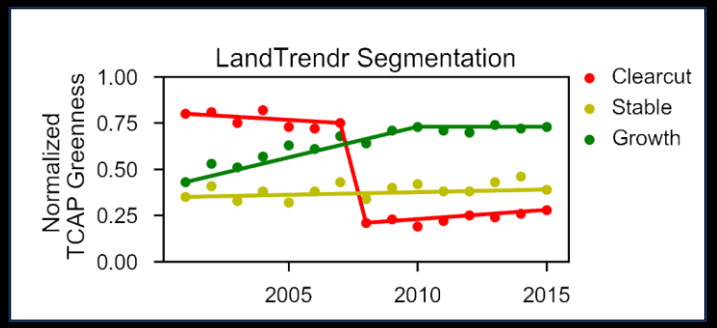
30 m resolutions

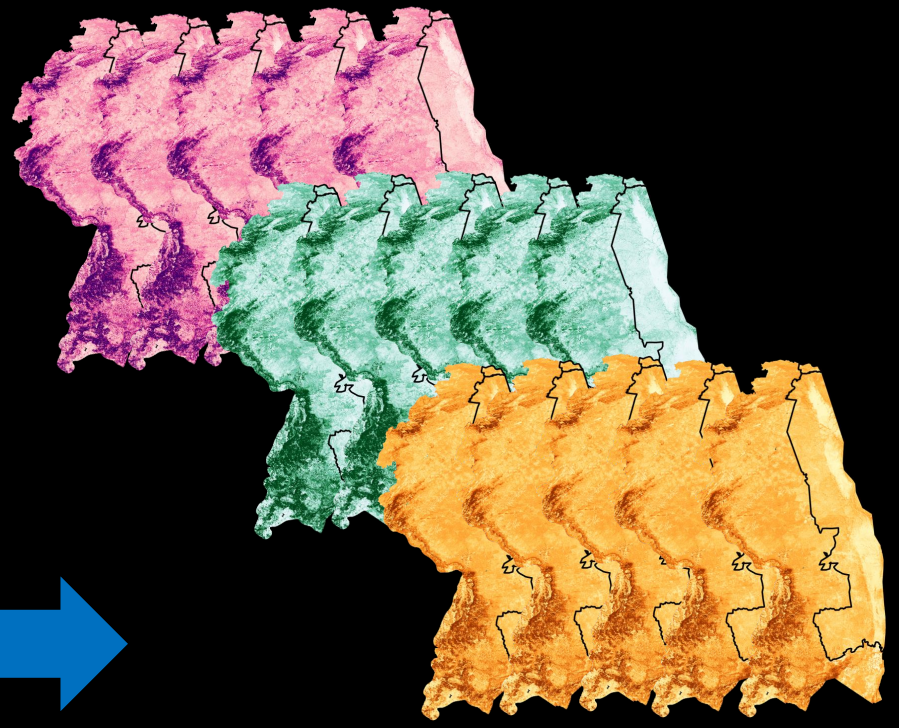
Random Forest Modeling Framework





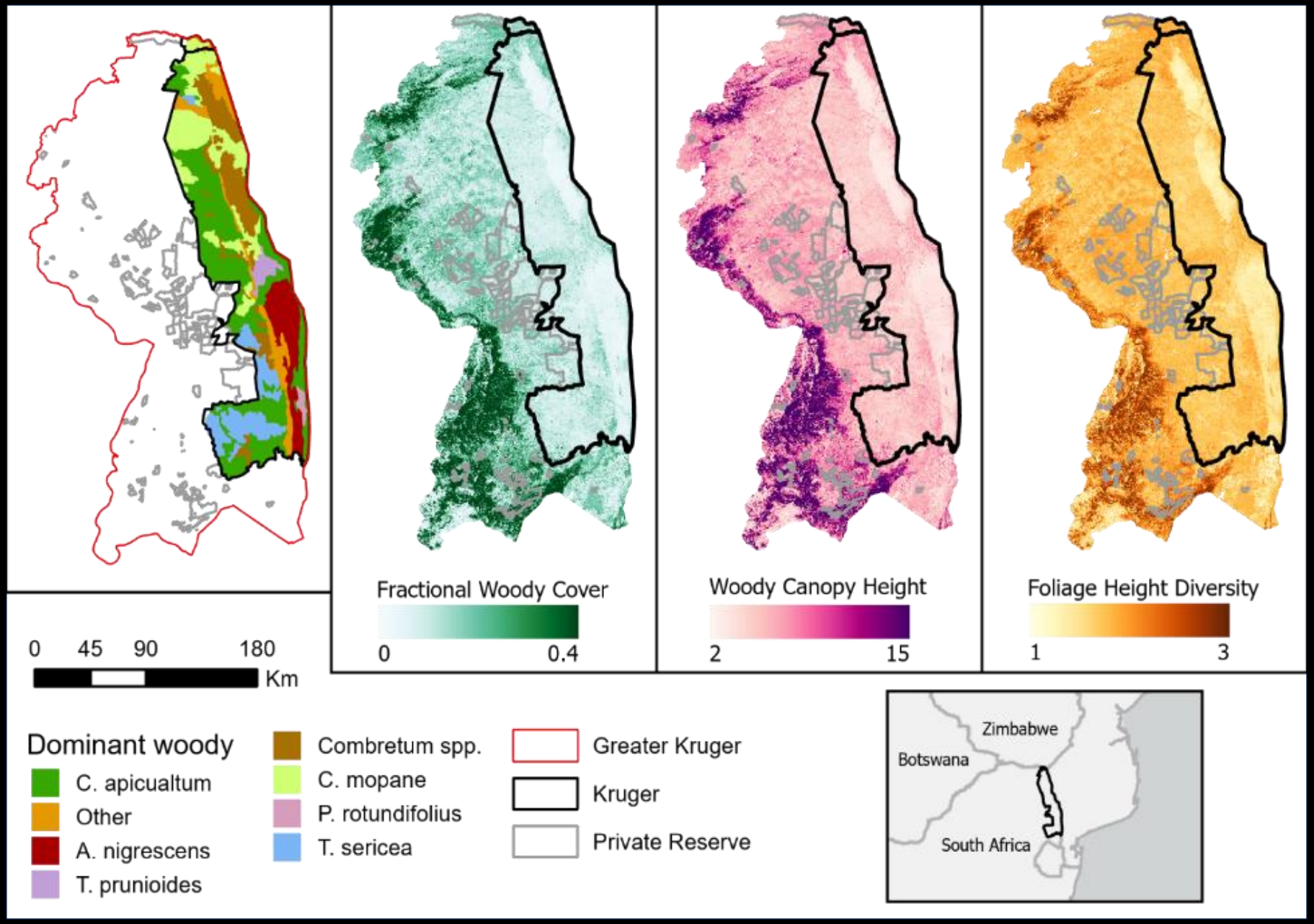


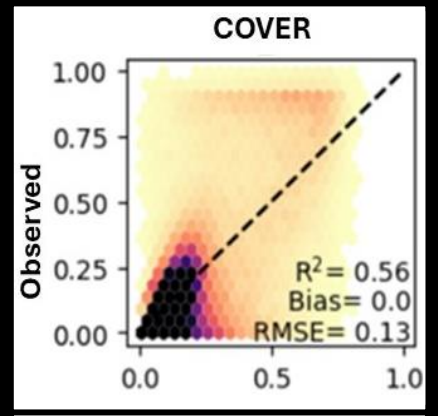


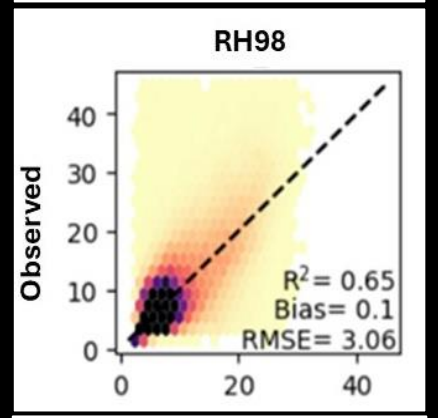


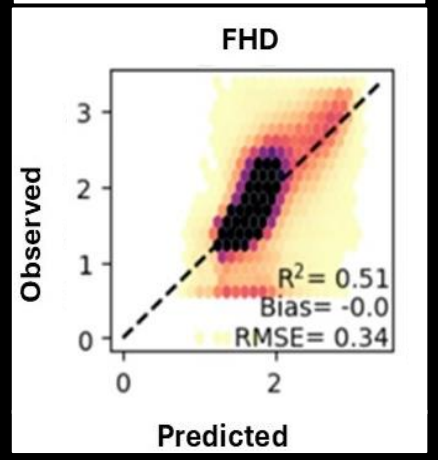
2007-2010, 2015-present

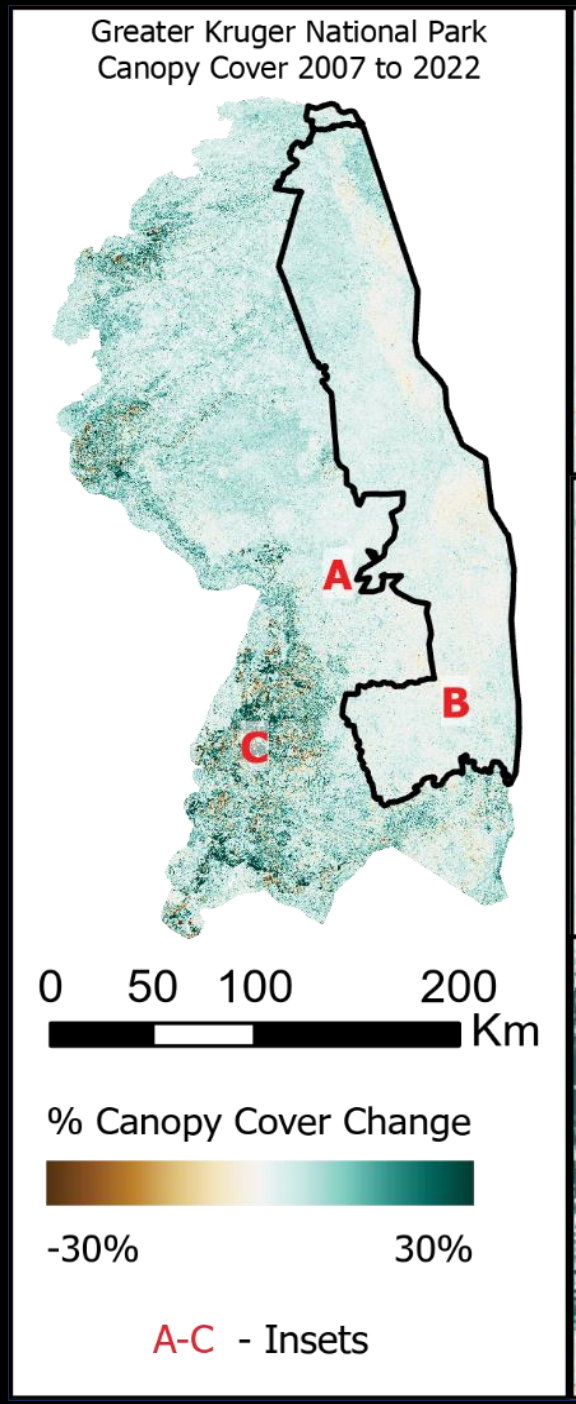
Annual structure map products to support monitoring change & better match timing of field-data collections through time

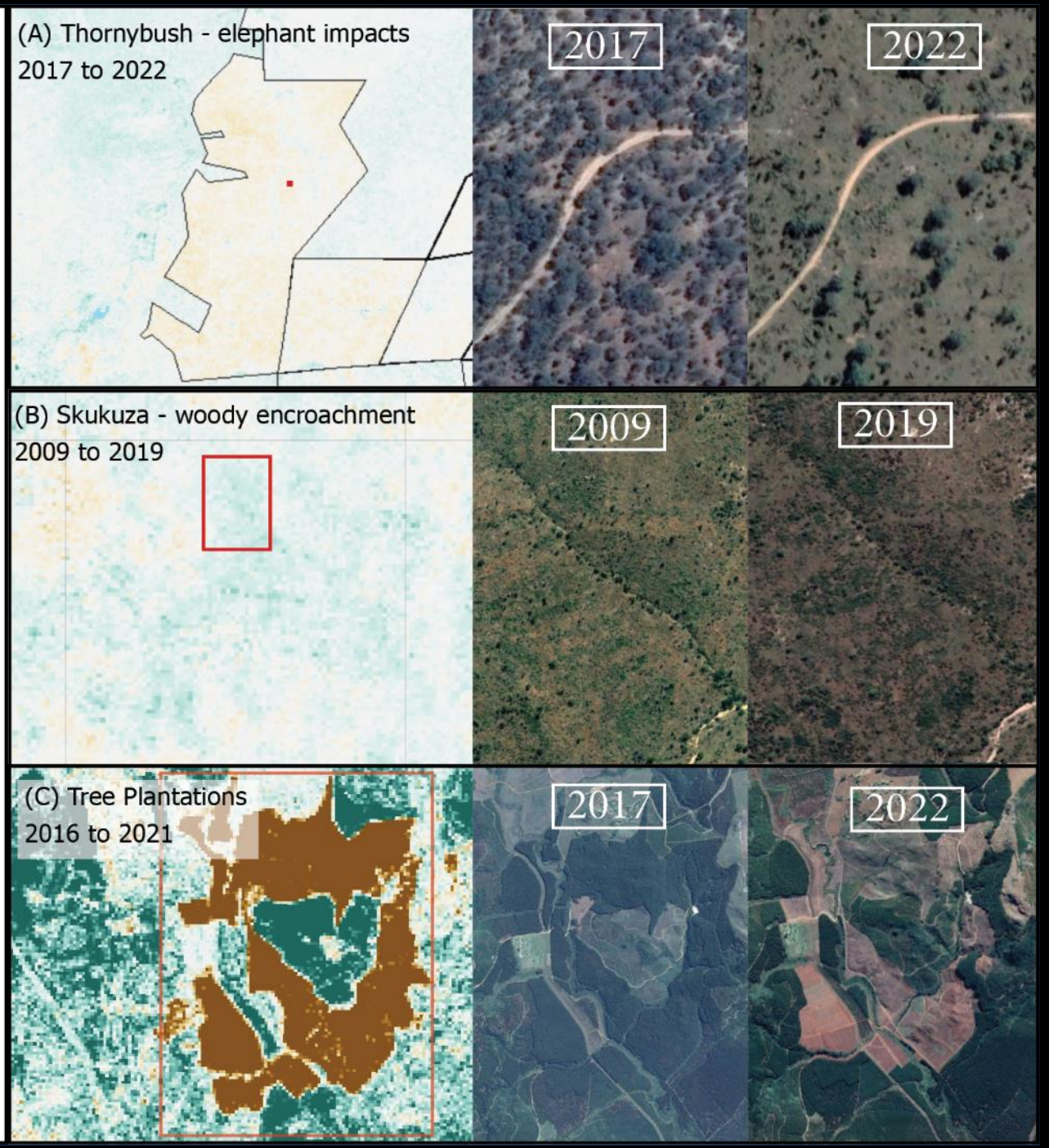

Fractional Woody Cover
0
0.4
Woody Canopy Height
2
15
Foliage Height Diversity
1
3
0 45 90 180
Km
Dominant woody
C. apicaltum
Other
A. nigrescens
T. prunioides
Combretum spp.
C. mopane
P. rotundifolius
T. sericea
Greater Kruger
Kruger
Private Reserve
Zimbabwe
Botswana
South Africa

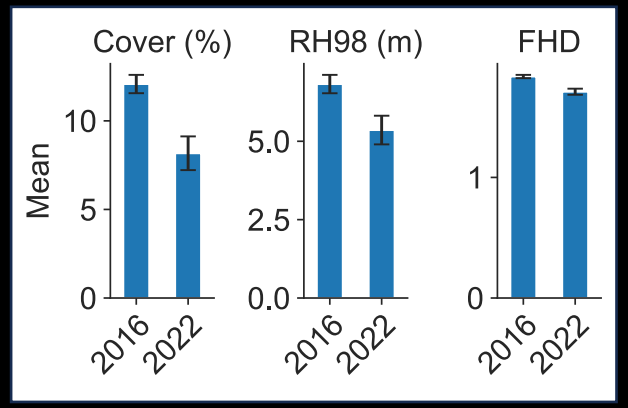

COVER
Observed
1.00
0.75
0.50
0.25
0.00
0.0
0.5
1.0
R^2= 0.56
Bias= 0.0
RMSE= 0.13

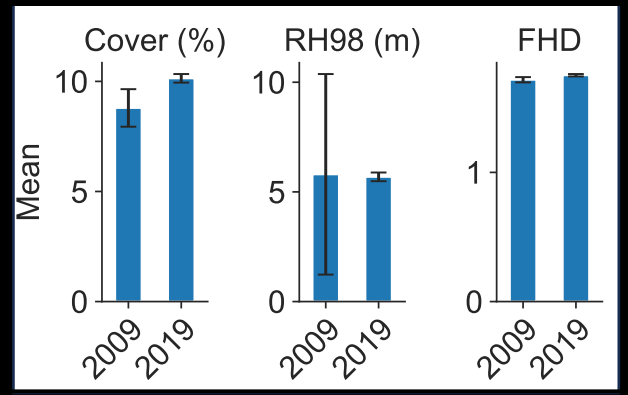

RH98
Observed
40
30
20
10
0
0
20
40
R^2= 0.65
Bias= 0.1
RMSE= 3.06

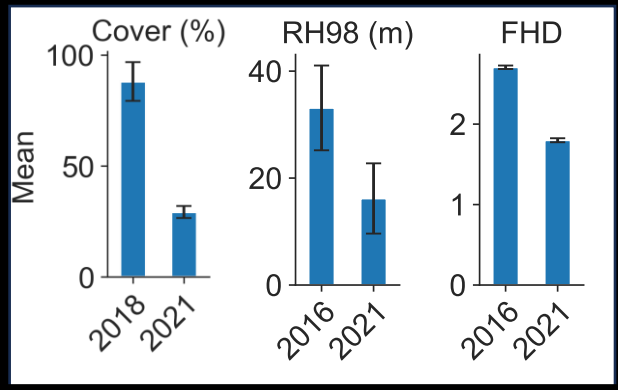

FHD
Observed
3
2
1
0
0
2
Predicted
R^2= 0.51
Bias= -0.0
RMSE= 0.34


Greater Kruger National Park
Canopy Cover 2007 to 2022
A
B
C
0 50 100 200
Km
% Canopy Cover Change
-30%
30%
A-C - Insets

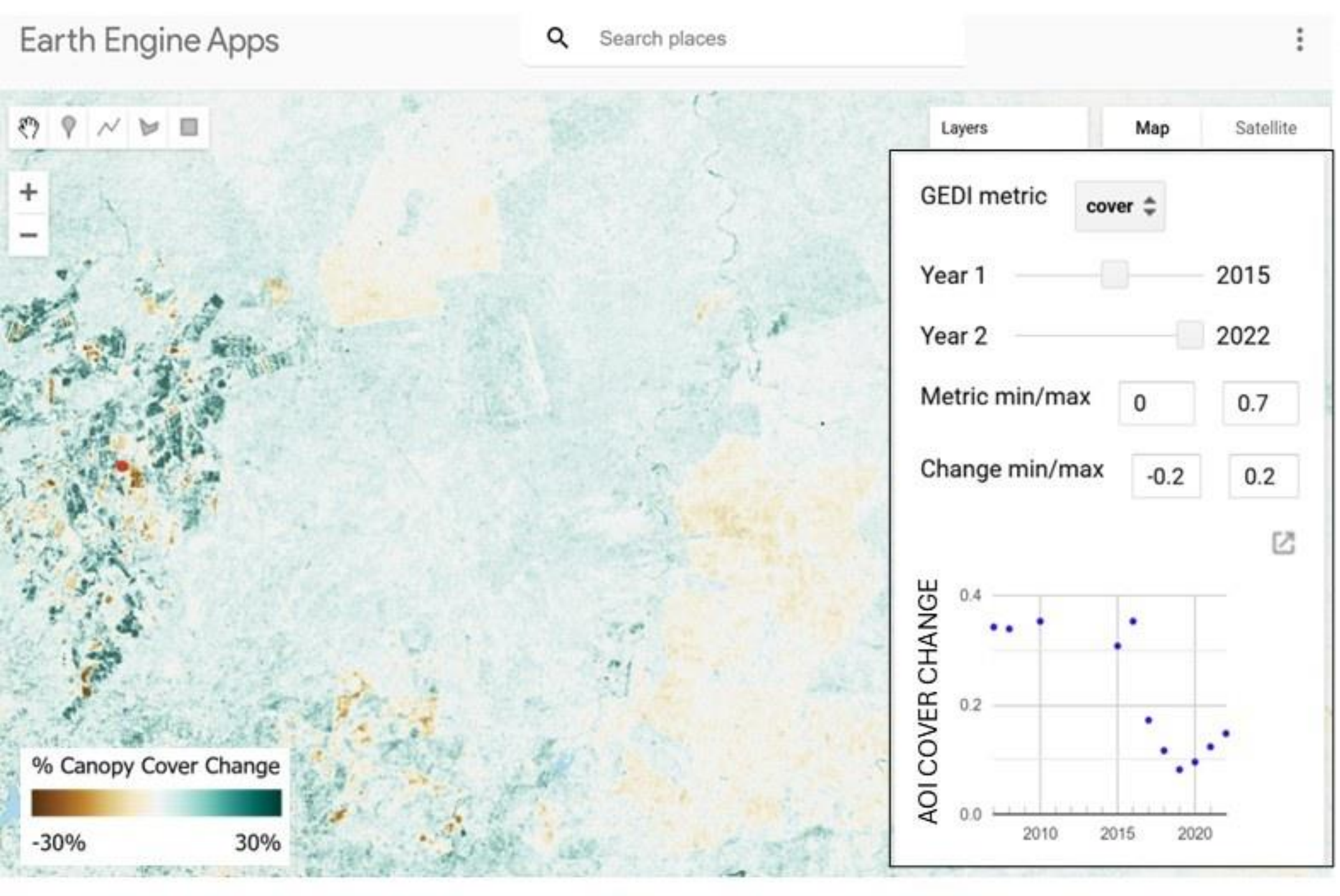

(A) Thornybush - elephant impacts
2017 to 2022
2017
2022
(B) Skukuza - woody encroachment
2009 to 2019
2009
2019
(C) Tree Plantations
2016 to 2021
2017
2022


Cover (%)
RH98 (m)
FHD
Mean
10
5
0
5.0
2.5
0.0
1
0
2016
2022


Cover (%)
RH98 (m)
FHD
Mean
10
5
0
1
2009
2019


Cover (%)
RH98 (m)
FHD
Mean
100
50
0
40
20
2
1
2018
2021
2016

Wildlife Occupancy & Habitat Connectivity

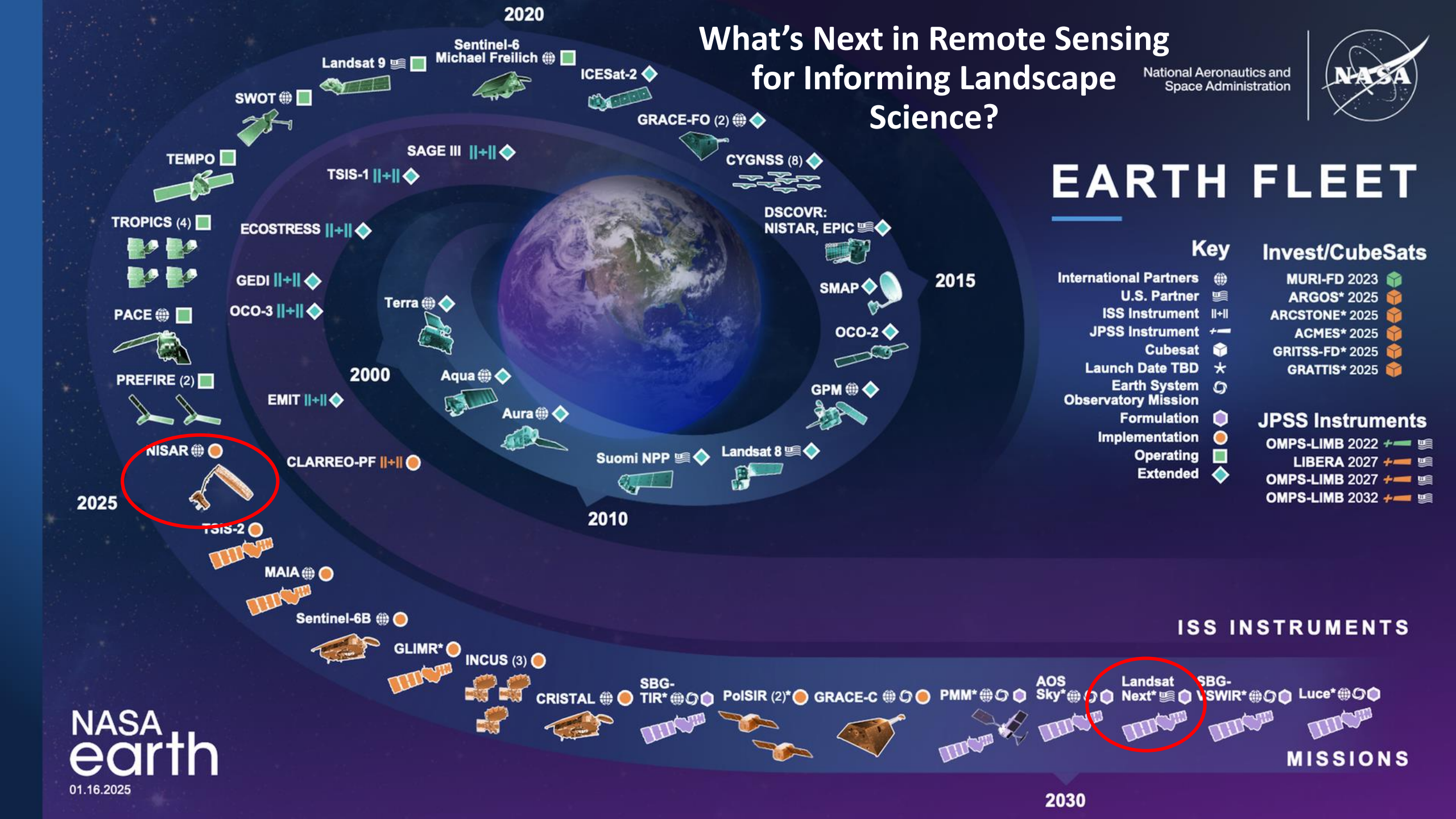


Will also provide tutorials and an update package to keep spatial products up to date.

What's Next in Remote Sensing for Informing Conservation Science?

What's Next in Remote Sensing for Informing Landscape Science?

National Aeronautics and Space Administration



NASA Earth Science to Action

Goal: Bridge the gap between data producers and end-users to accelerate and advance the impact of NASA's Earth science to benefit humankind.

BIOLOGICAL DIVERSITY & ECOLOGICAL CONSERVATION

Thank You:

Project Team
Local Partners
Local Field Guides
NASA Funding