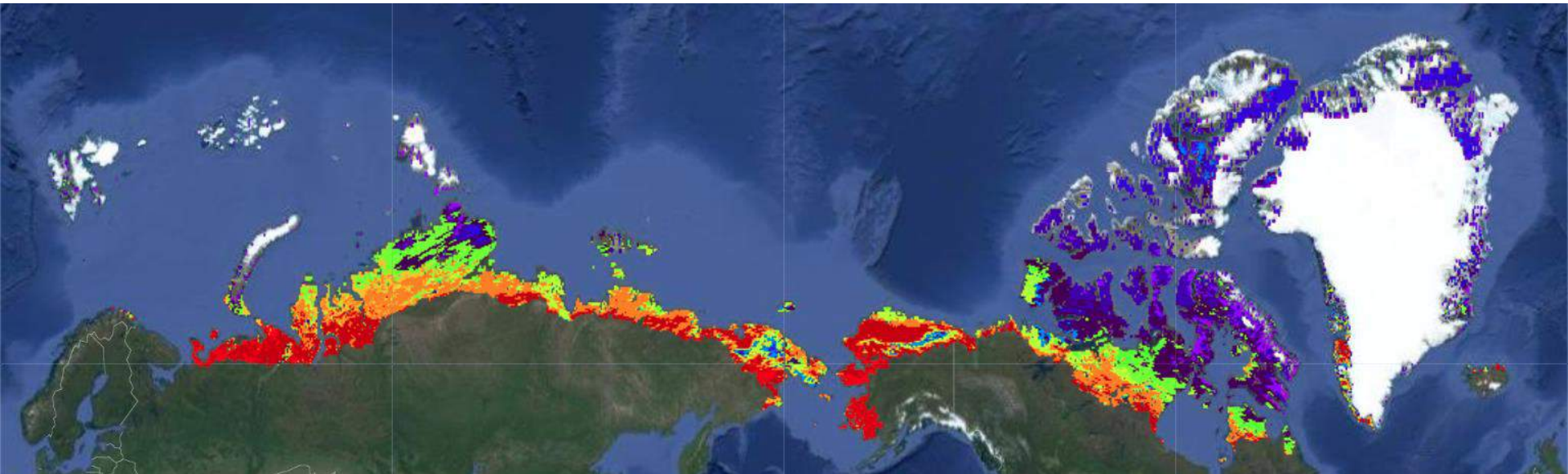
Project
ROSES 2016 A.50 GEO
PI: Howard Epstein
University of Virginia

Ecosystem Functional Diversity of the Circumpolar Arctic Tundra

H. Epstein[1], **A. Armstrong[1]**, D. Alcaraz-Segura[2], B. Cazorla[3], A. Castro[3], M. Raynolds[4], Q. Yu[5]

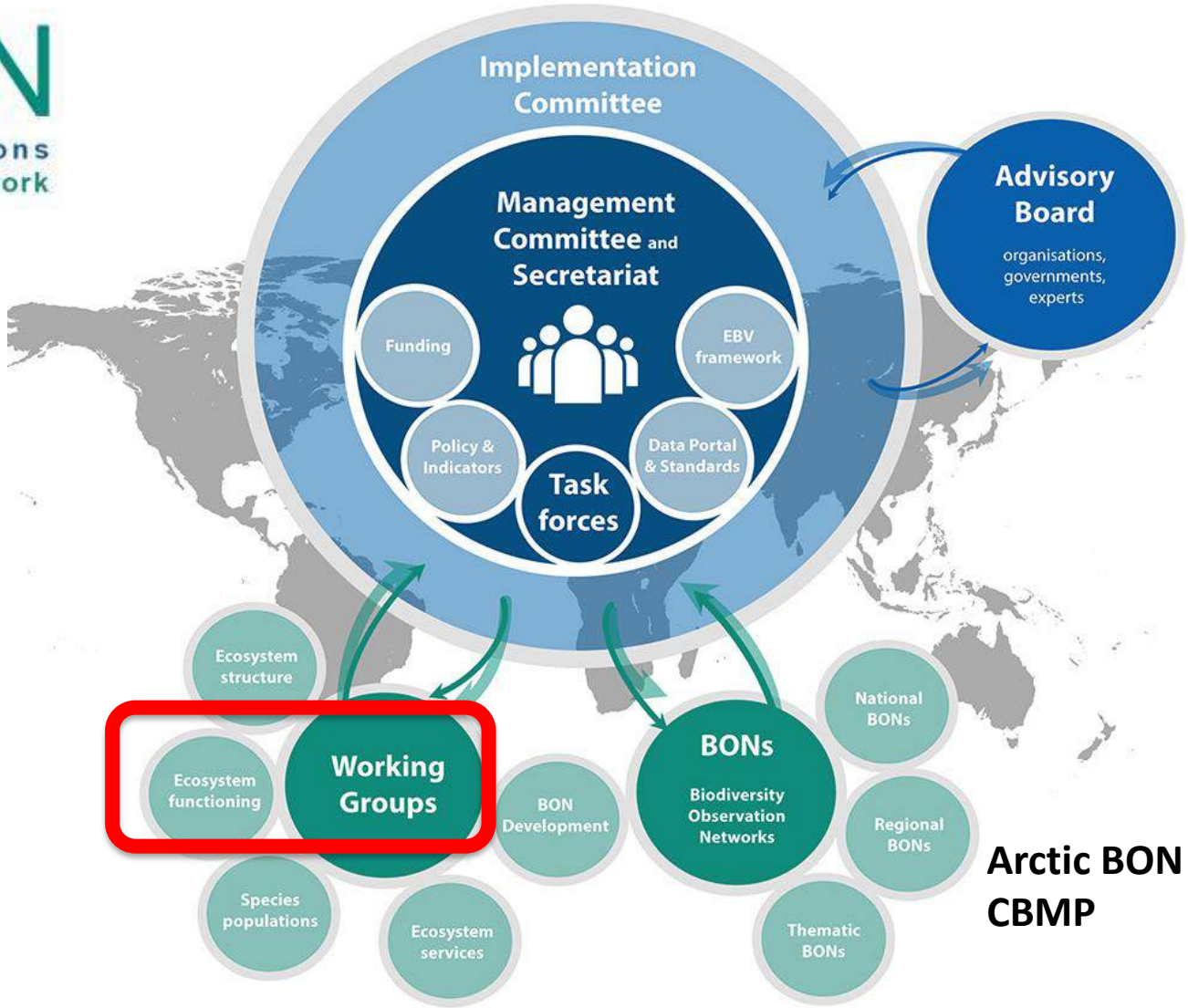
1 University of Virginia, 2 University of Granada, 3 University of Almeria, 4 University of Alaska Fairbanks, 5 George Washington University



One of several NASA Ecological Forecasting / Biodiversity projects supporting the GEO-BON Work Programme

GEO BON
Group on Earth Observations
Biodiversity Observation Network

A global system of harmonized observations is needed to inform scientists and policy-makers



Arctic BON
CBMP

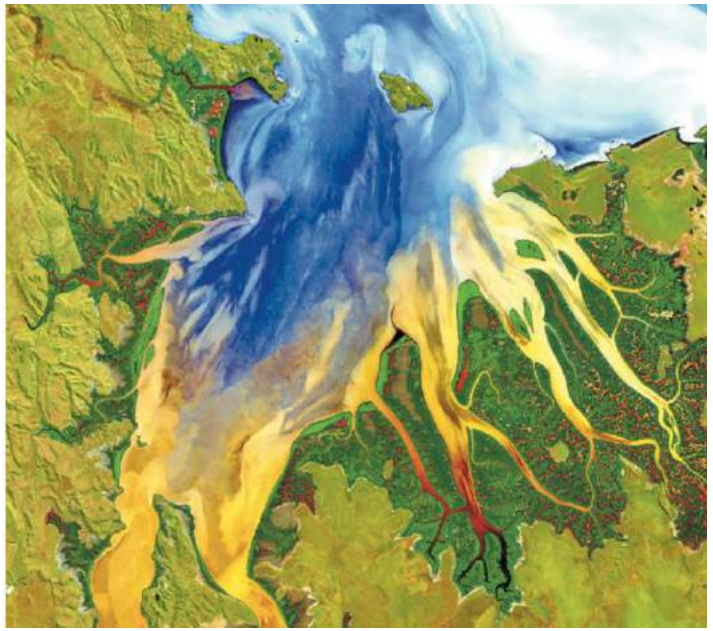
Essential Biodiversity Variables (EBVs)

www.sciencemag.org SCIENCE VOL 339 18 JANUARY 2013
ECOLOGY Published by AAAS POLICYFORUM

Essential Biodiversity Variables

H. M. Pereira,[1*†] S. Ferrier,[2] M. Walters,[3] G. N. Geller,[4] R. H. G. Jongman,[5] R. J. Scholes,[3] M. W. Bruford,[6] N. Brummitt,[7] S. H. M. Butchart,[8] A. C. Cardoso,[9] N. C. Coops,[10] E. Dulloo,[11] D. P. Faith,[12] J. Freyhof,[13] R. D. Gregory,[14] C. Heip,[15] R. Höft,[16] G. Hurtt,[17] W. Jetz,[18] D. S. Karp,[19] M. A. McGeoch,[20] D. Obura,[21] Y. Onoda,[22] N. Pettorelli,[23] B. Reyers,[24] R. Sayre,[25] J. P. W. Scharlemann,[26,27] S. N. Stuart,[28] E. Turak,[29] M. Walpole,[26] M. Wegmann[30]

- Minimum set of essential measures that capture main biodiversity dimensions: composition, structure, and ***function***
- Inform biodiversity status
- Sensitive to biodiversity change

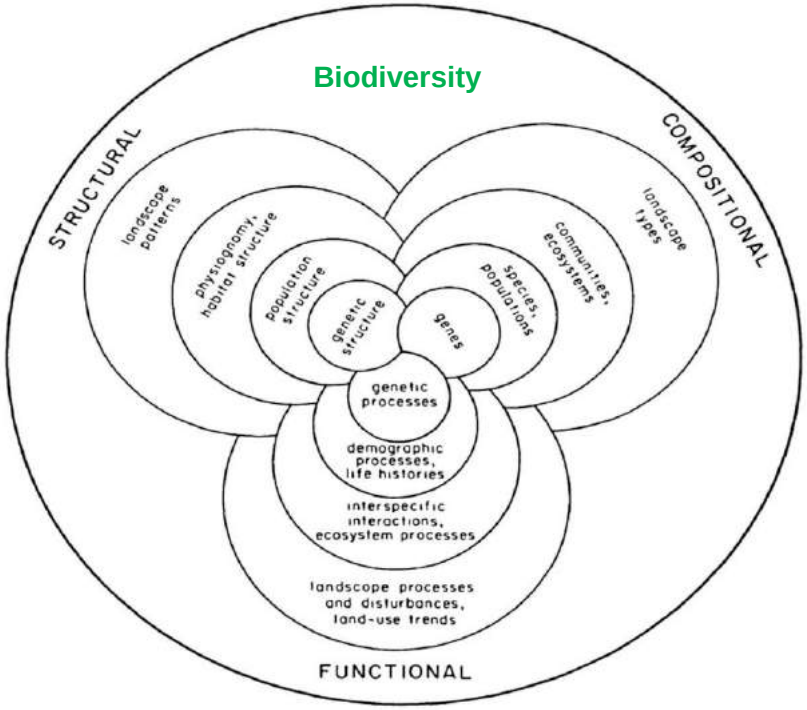


2015 | VOL 523 | NATURE | 403

Agree on biodiversity metrics to track from space

Ecologists and space agencies must forge a global monitoring strategy, say **Andrew K. Skidmore, Nathalie Pettorelli** and colleagues.

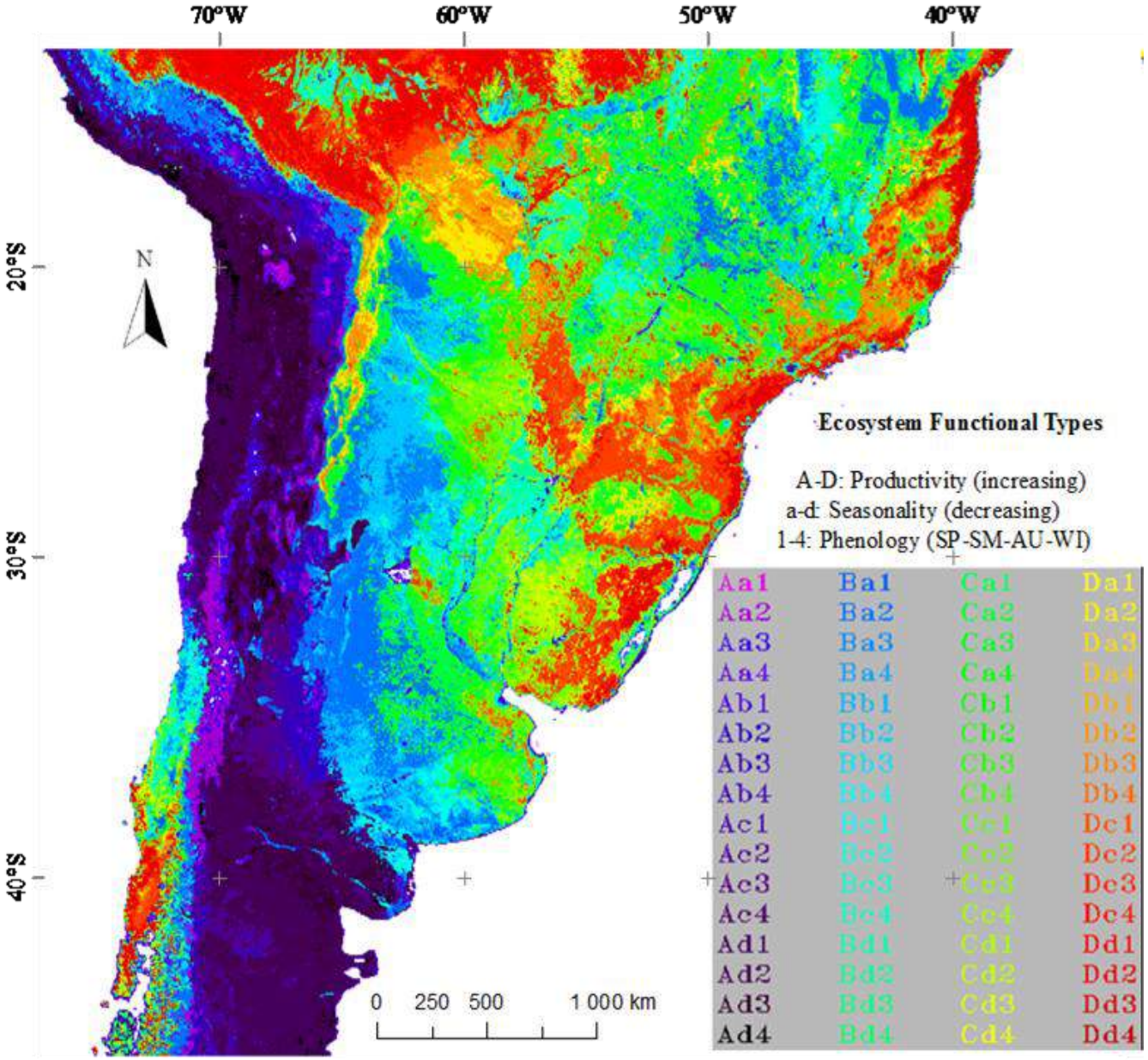
Project Background



- Biodiversity hierarchy can be assessed along three dimensions: composition, structure, and **function** (Noss, 1990)
- Primary production (carbon cycling) dynamics are integrative descriptors of ecosystem function and an **Essential Biodiversity Variable** candidate of GEO-BON (Pereira et al., 2013; Skidmore et al., 2015)
- **Ecosystem Functional Diversity** based on dynamics of primary productivity can be assessed by means of **Ecosystem Functional Types (EFTs)**, patches of the land surface that process energy and matter in similar ways and potentially show coordinated responses to environmental factors (Valentini,1999; Paruelo et al. 2001).
- Our goal is to develop an **Ecosystem Functional Diversity** set of products for the **Circumpolar Arctic**

Not a completely new idea…

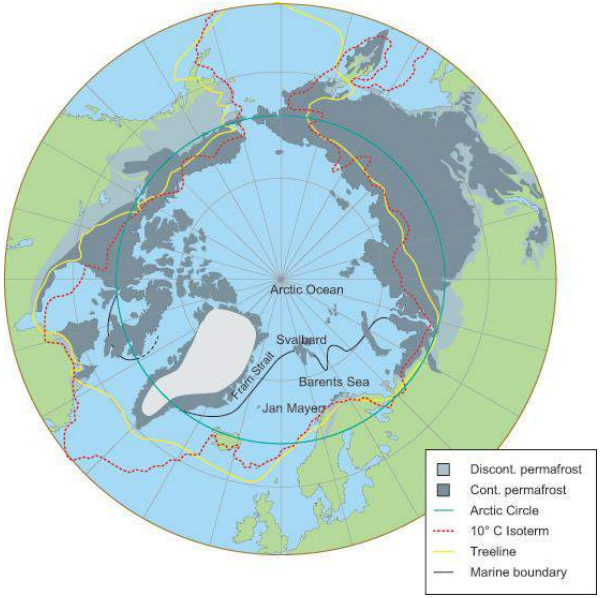
- Denotes areas of functional similarity
- Agnostic to vegetation composition or structure

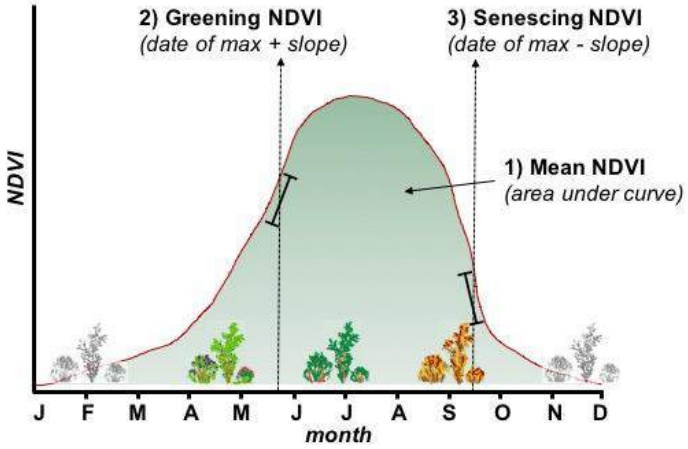


Alcaraz-Segura et al. 2013

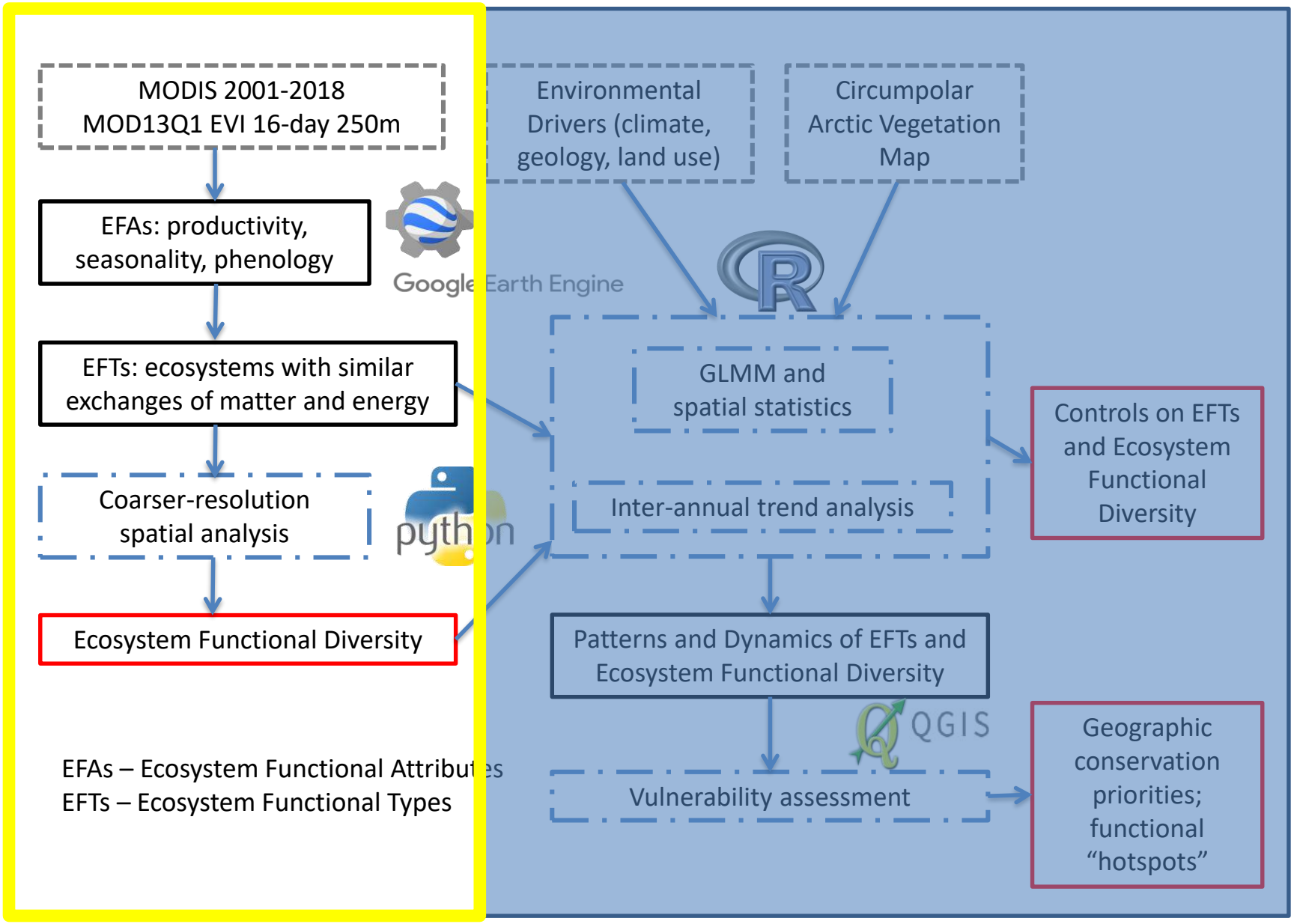
Project Goals

1. To **develop** and **implement** a processing stream for the production of EFTs and Ecosystem Functional Diversity variables for the circumpolar Arctic Tundra
2. To **evaluate** the environmental and human controls on the spatial patterns of EFTs and EF-Diversity with respect to climatic, topographic/geological, and land use gradients
3. To **analyze** the relationships between vegetation composition and EFTs and EF-Diversity for the Arctic Tundra biome
4. To **assess** the inter-annual dynamics of EFTs and EF-Diversity throughout the Arctic tundra over the past 17+ years
5. To **assess** the conservation priority (e.g. vulnerability) of current and potential protected areas within the Arctic Tundra biome, based on properties of Ecosystem Functional Diversity (e.g. functional richness, rareness) and their inter-annual dynamics.





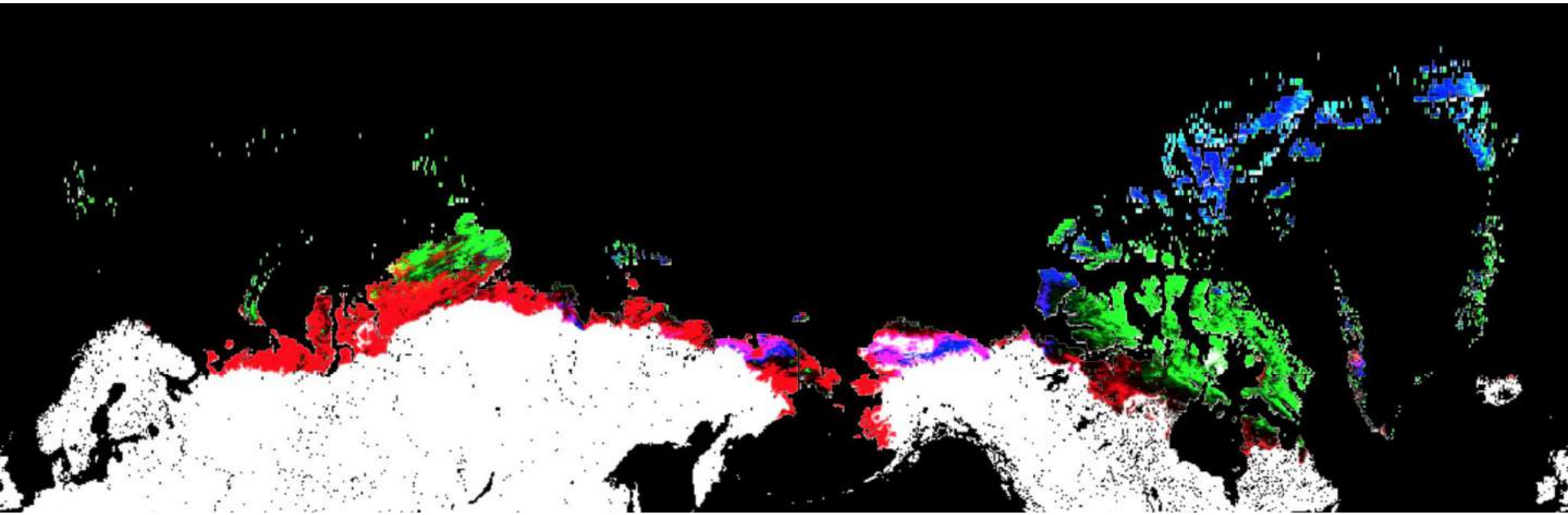
Methodological Framework



Ecosystem Functional Attributes

What attributes of the seasonal NDVI curve represent the most important modes of variability in the dataset?

We investigated key ecosystem functional attributes (characteristics of the seasonal NDVI curve) using a Principal Components Analysis (PCA) on the 16-day composite NDVI data.



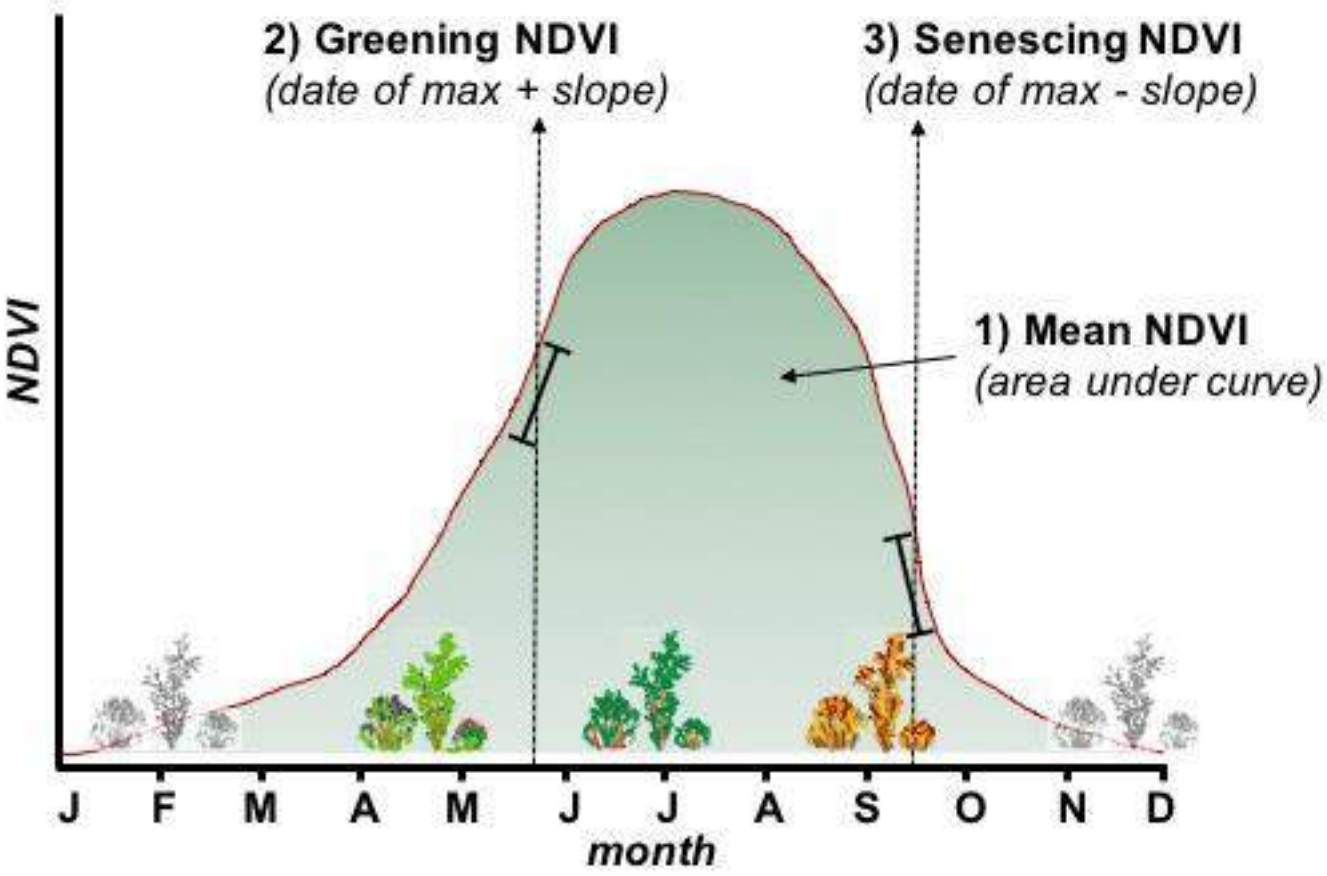
RGB image of PCs 1-3. Red is PC1, Green is PC2, Blue is PC3.

Subsequent correlations of PCs with numerous NDVI metrics revealed 3 key EFAs for our study domain.

Ecosystem Functional Types

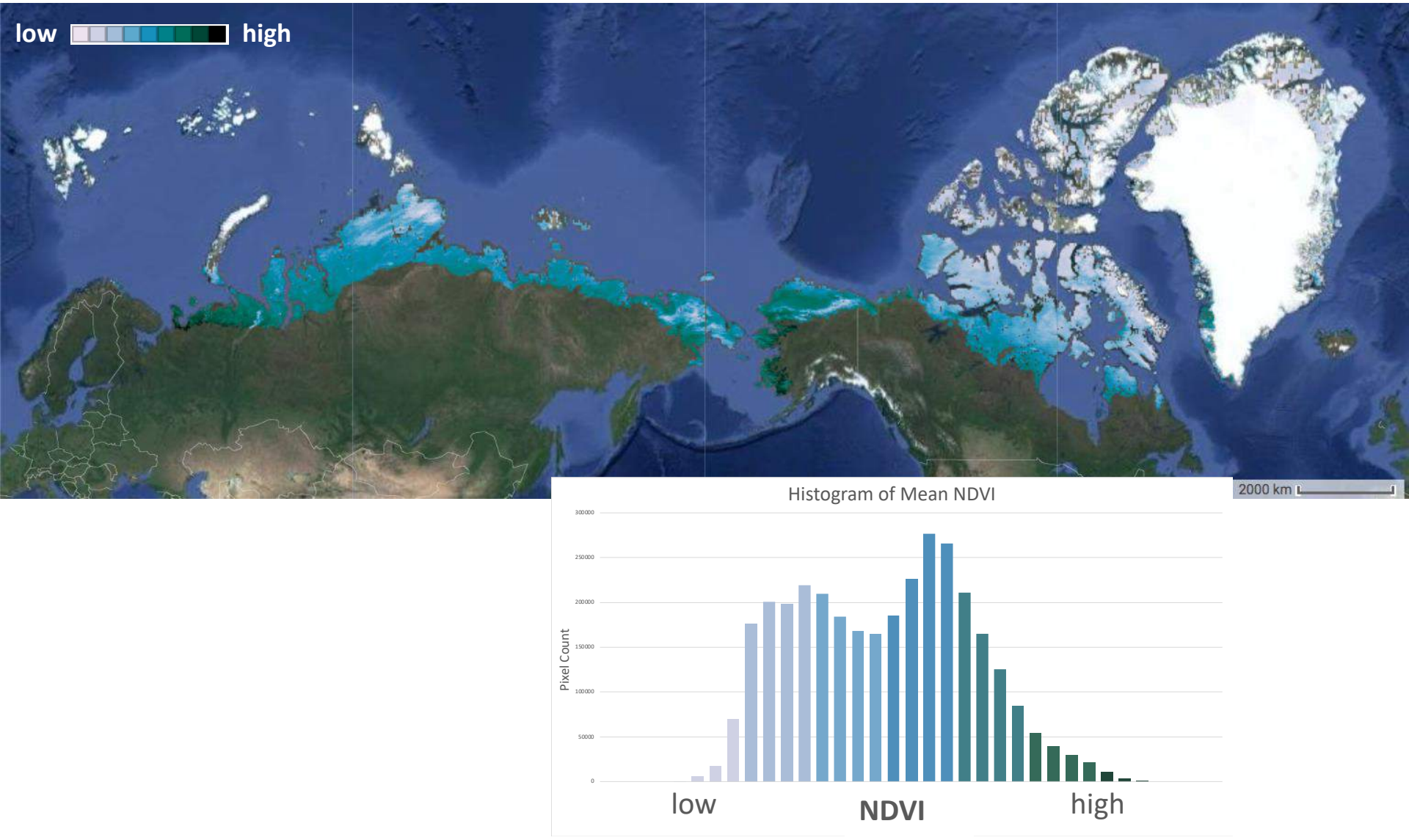
- **EFTs**: Patches of the land-surface with similar dynamics of matter and/or energy exchanges between the biota and the physical environment (Paruelo et al. 2001, Alcaraz-Segura et al. 2006).

- We derived our EFTs from our **EFA analysis of the seasonal curve of NDVI:**



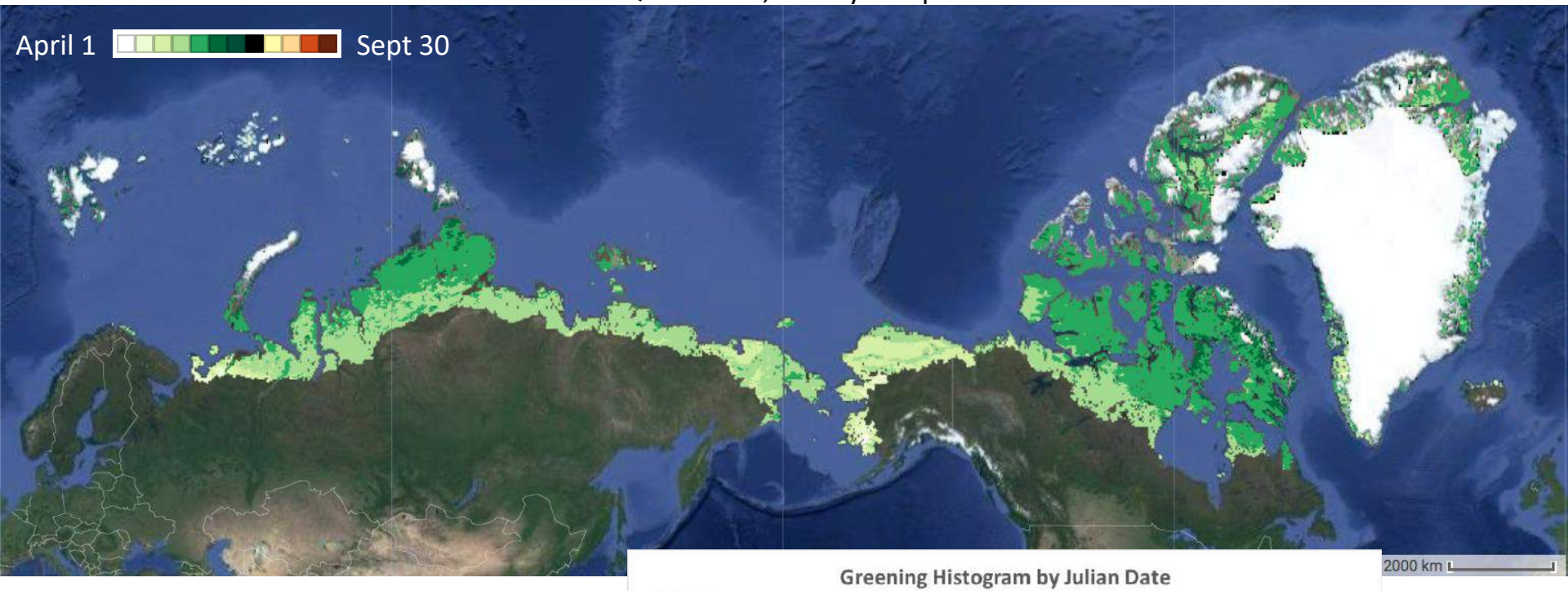
Circumpolar Arctic Tundra Mean NDVI 2001-2018

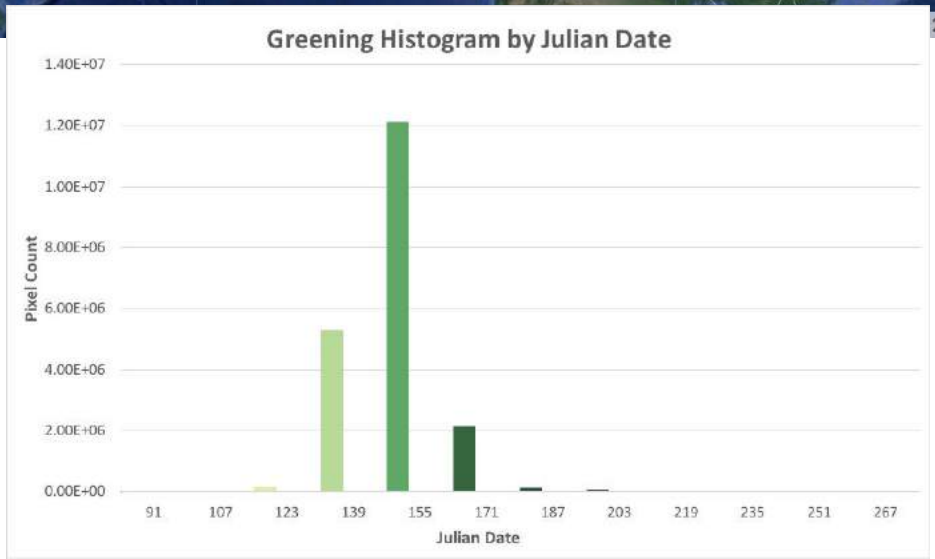
MODIS 13Q1 – 250m , 16-day composite



Circumpolar Arctic Tundra Date of Green-up 2001-2017

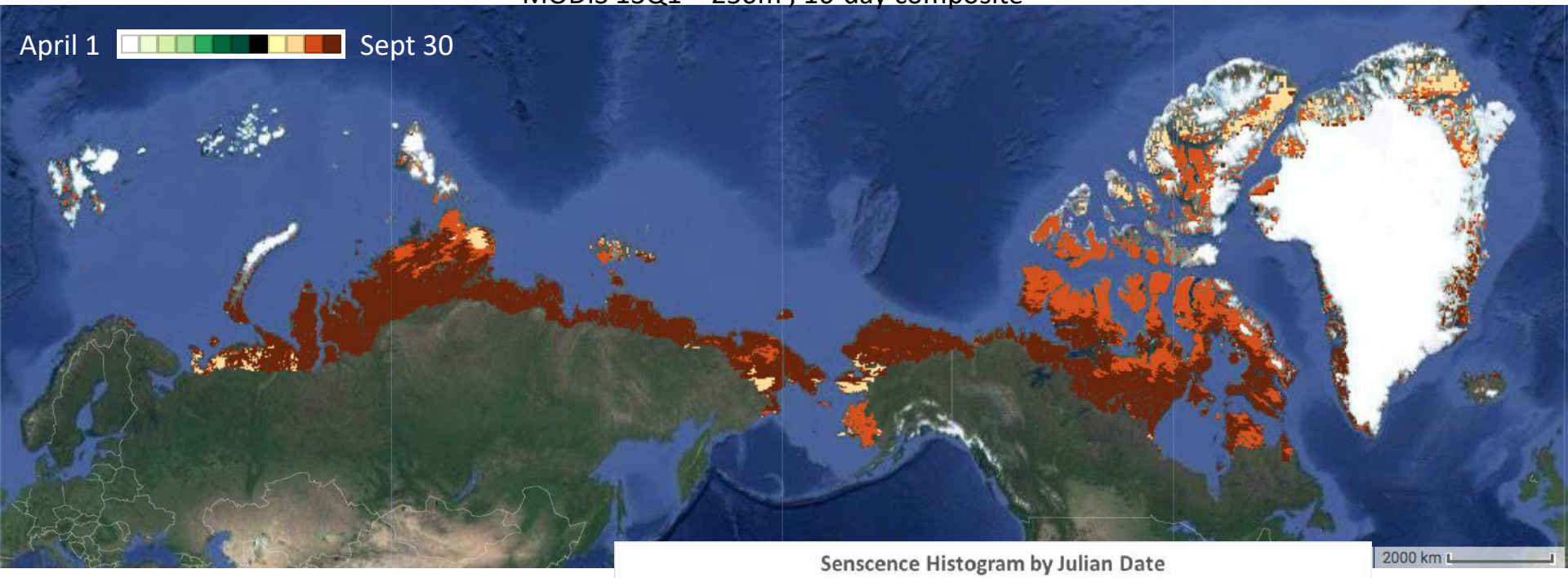
MODIS 13Q1 – 250m , 16-day composite

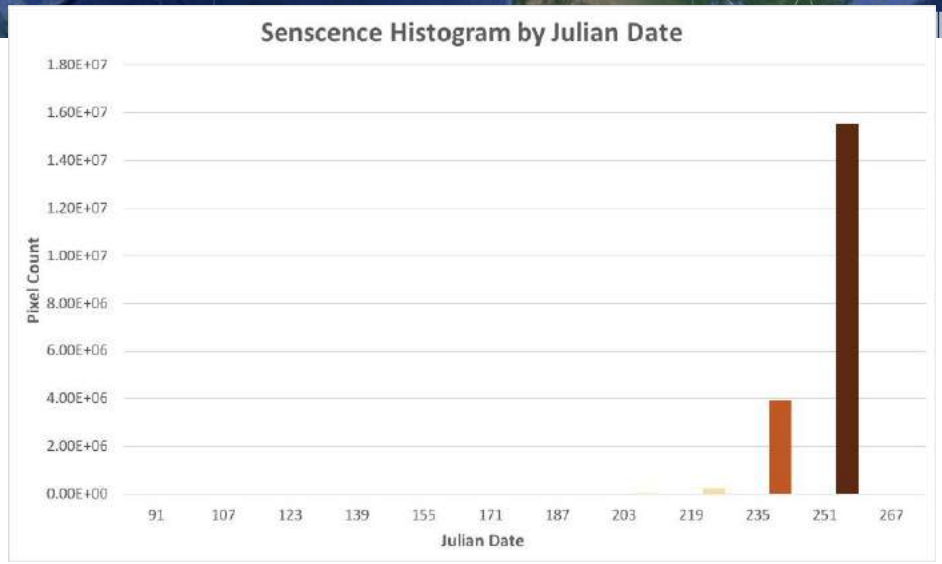




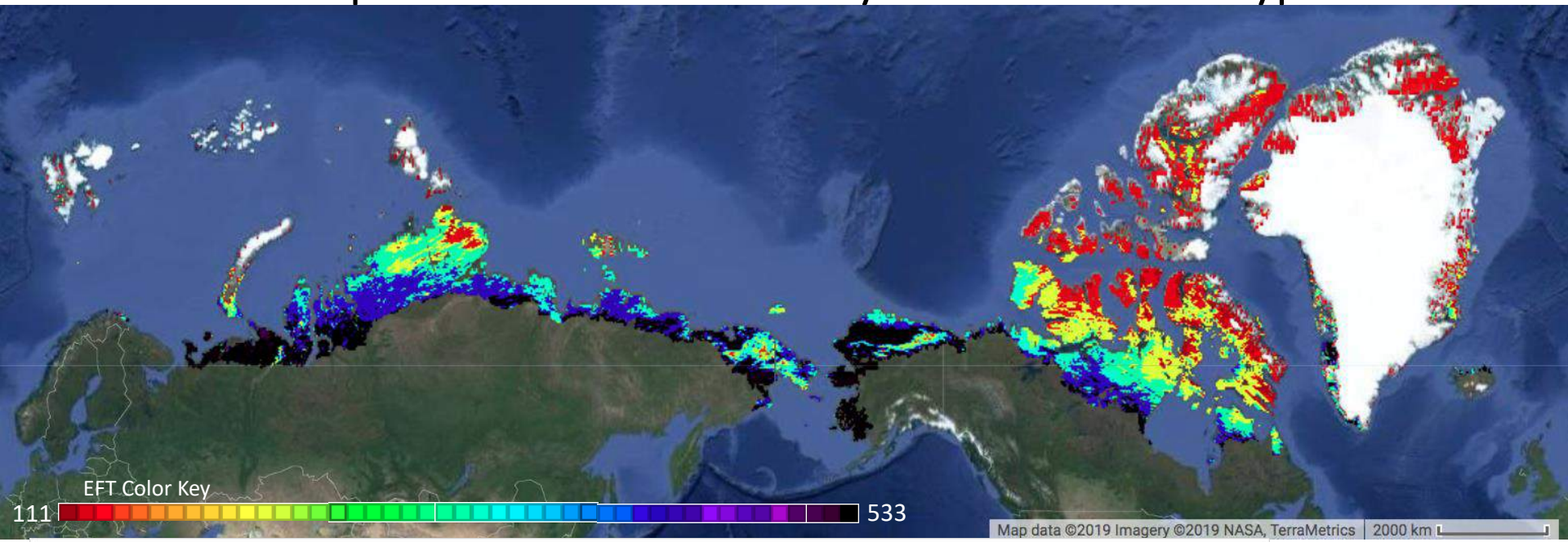
Circumpolar Arctic Tundra Date of Senescence 2001-2017

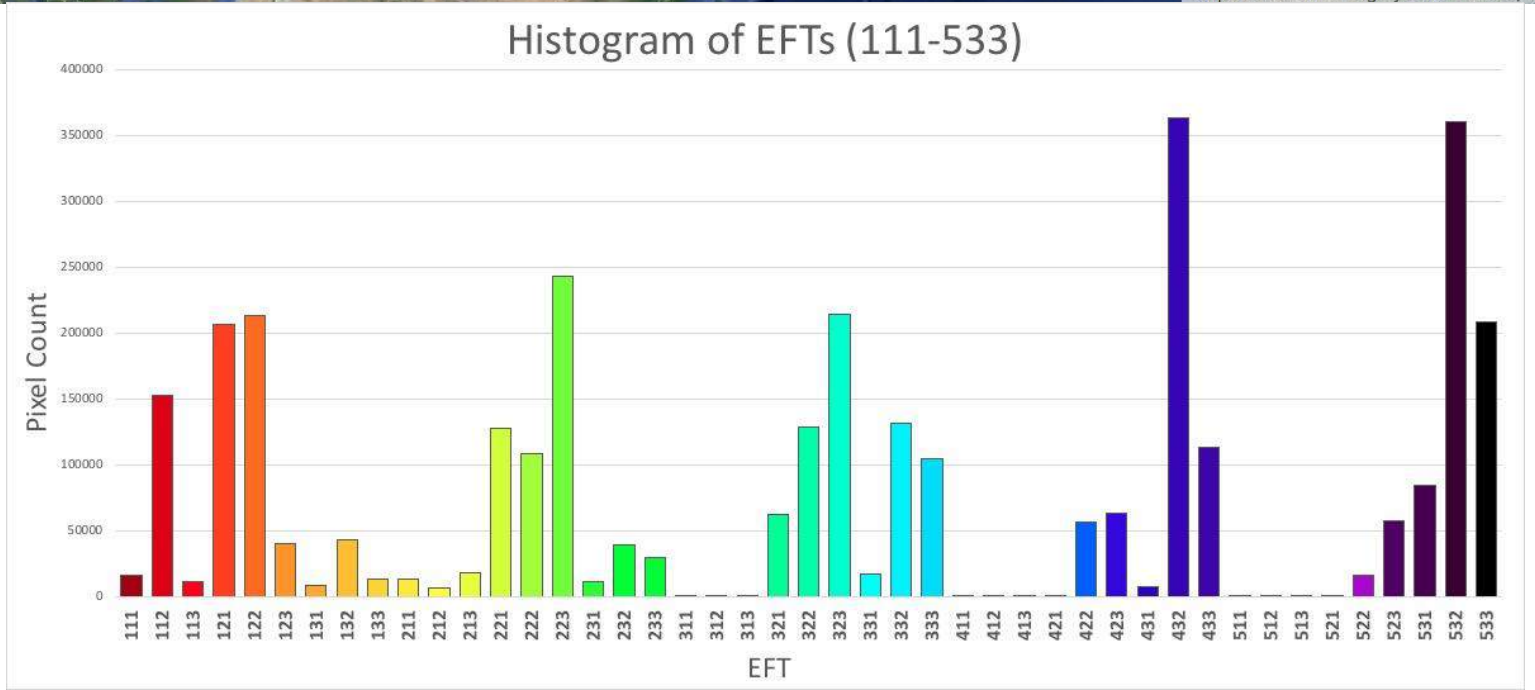
MODIS 13Q1 – 250m , 16-day composite





Circumpolar Arctic Tundra Ecosystem Functional Types



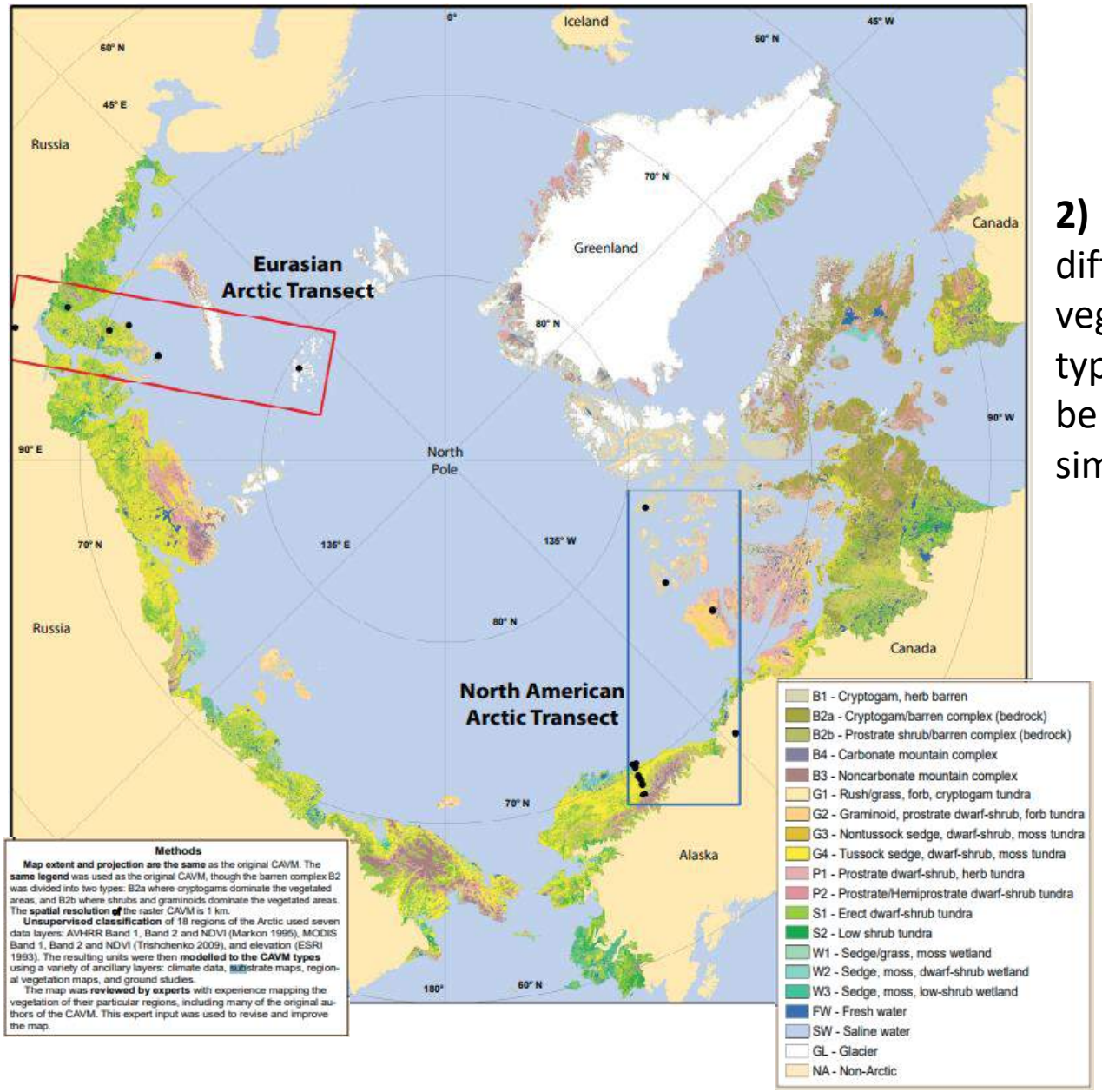


Key

NDVI	
100	low
200	mid-low
300	mid
400	mid-high
500	high
Greening	
30	Early
20	Mid
10	Late
Browning	
1	Early
2	Mid
3	Late

Using the new raster version of the **Circumpolar Arctic Vegetation Map** we can:

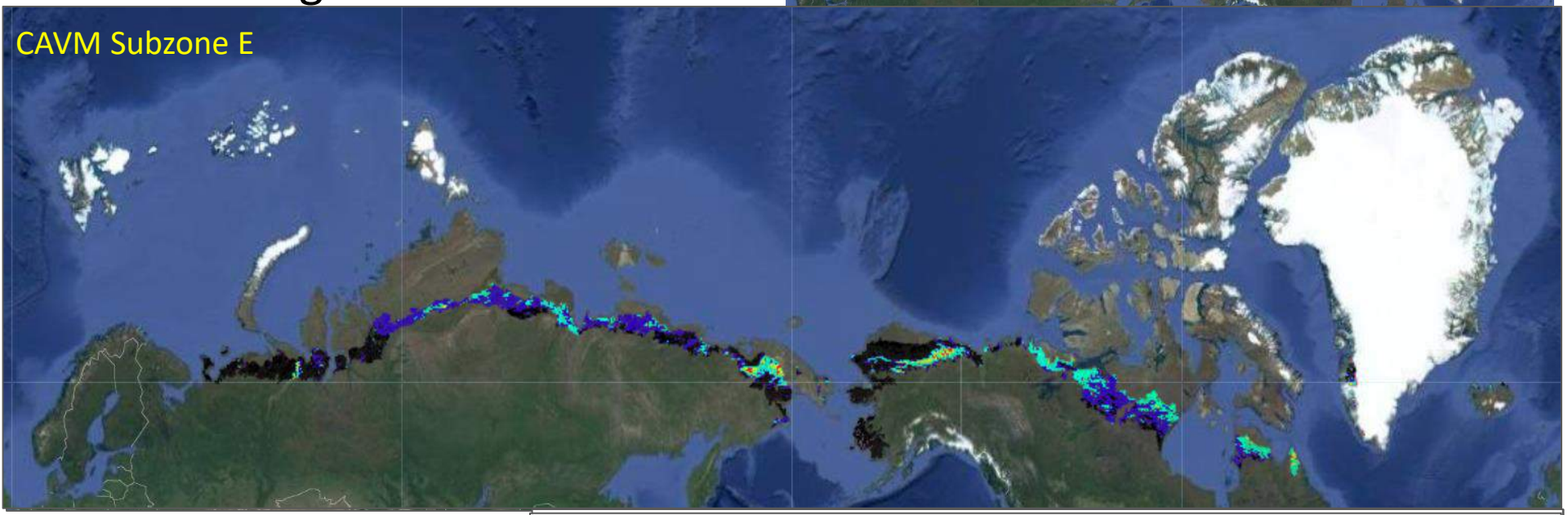
1) Identify the functional diversity within vegetation types



2) Identify different vegetation types that may be functioning similarly

Circumpolar Arctic Tundra Ecosystem Functional Types by CAVM Vegetation Subzones

Circumpolar Arctic Tundra Ecosystem Functional Types by CAVM Vegetation Subzones



Map Color Key

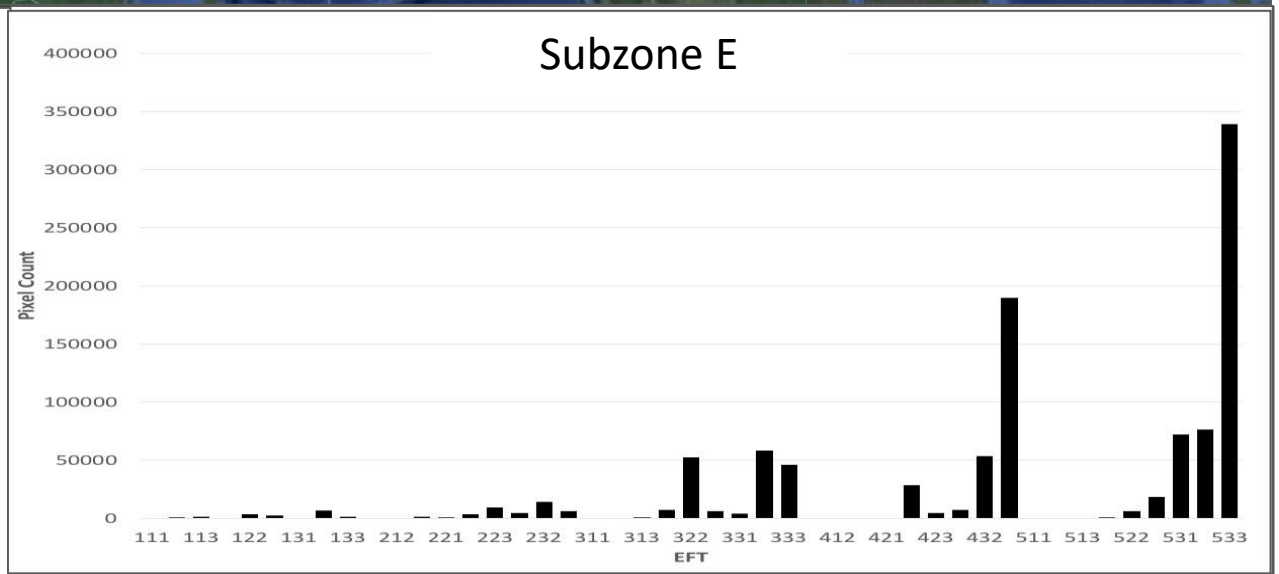
111 — 223

231 — 413

413 — 533

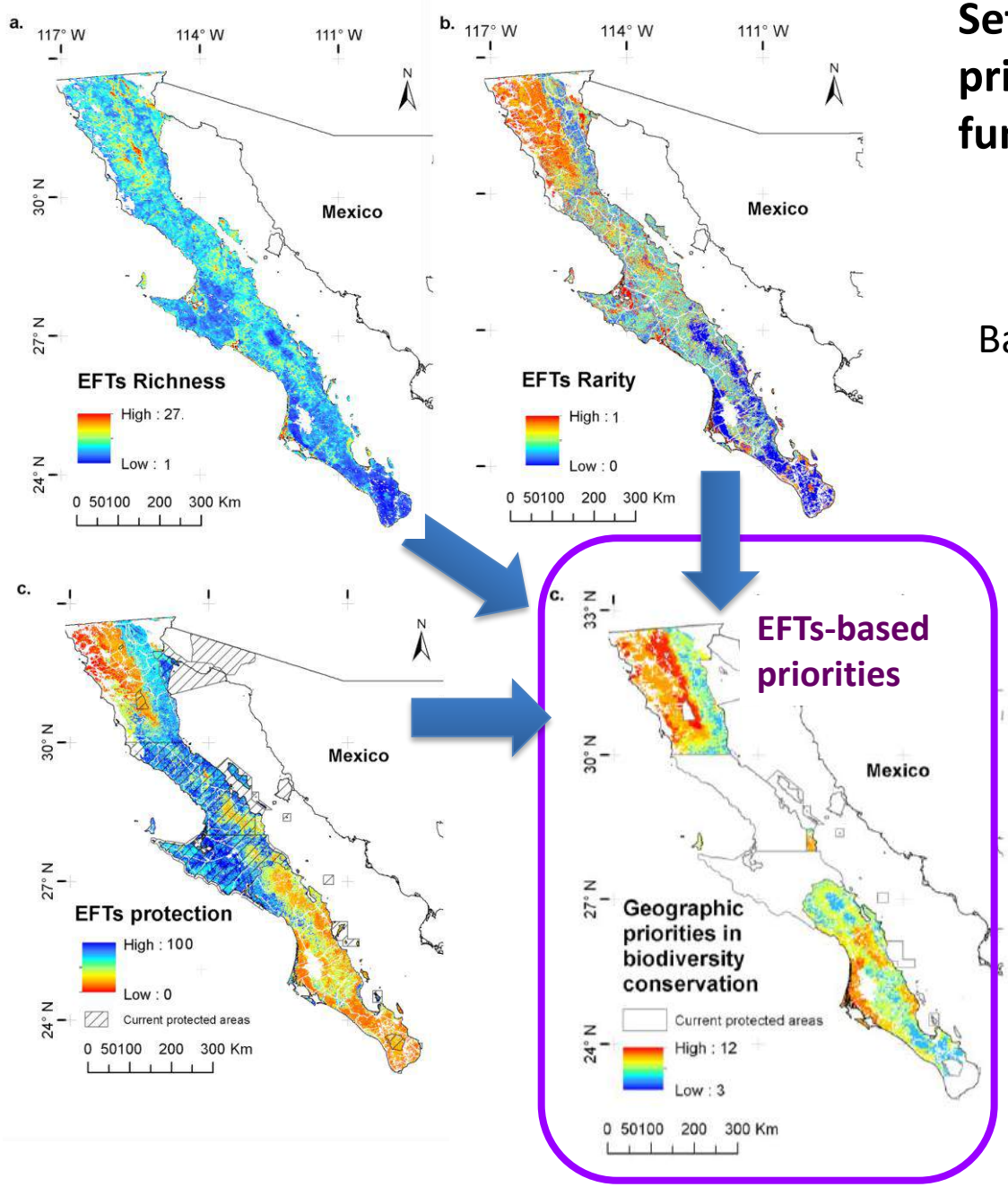
EFT Number Key

NDVI		Greening		Browning	
100	low	30	Early	1	Early
200	mid-low	20	Mid	2	Mid
300	mid	10	Late	3	Late
400	mid-high				
500	high				



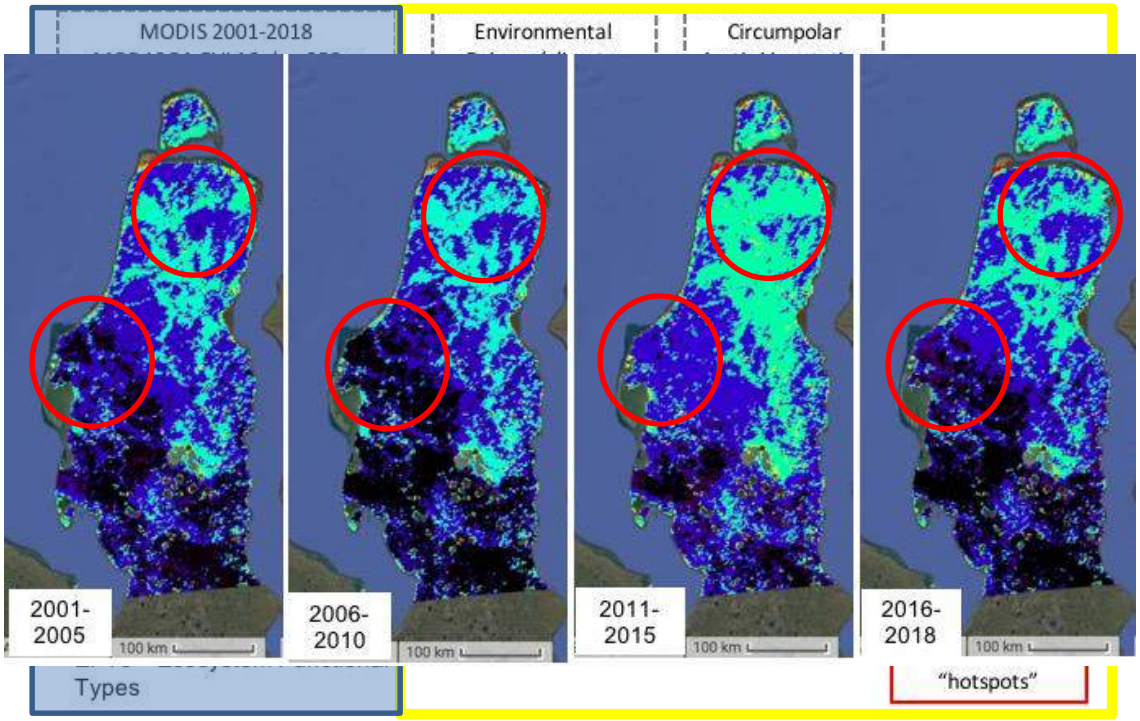
Setting geographic conservation priorities for ecosystem functional diversity using EFTs

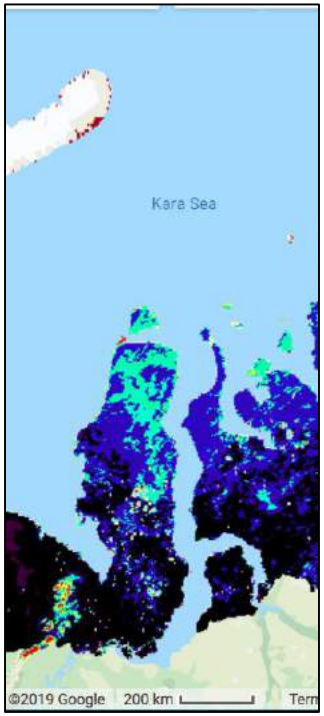
Baja California (México)



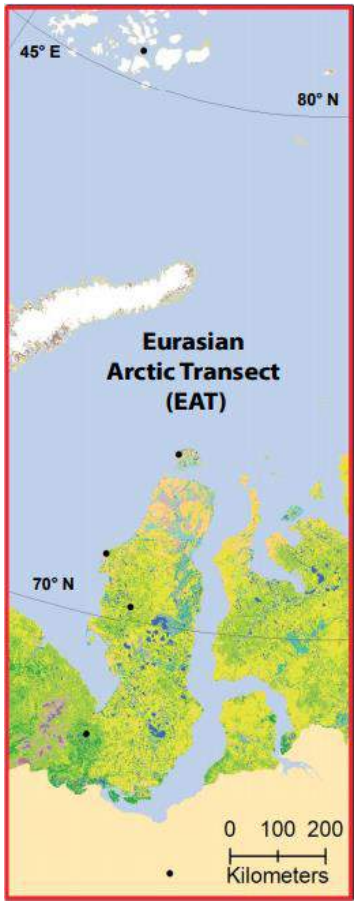
Next Steps…

1) Compare EFTs with vegetation types within CAVM Subzones
2) Calculate and derive EFT diversity and distribution metrics
3) Environmental and land use controls on EFT distribution
4) Comparing patterns and dynamics of functional diversity using EFTs
5) Interannual and other temporal EFT dynamics





EFT



CAVM