

Phylogenetic beta diversity as a tool in biodiversity conservation and monitoring

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Ecological Society of America Symposium -
"From microbial to conservation biology:
Exploring phylogenetic beta diversity as a
theoretical tool uniting disciplines"

overview

Other talks in this symposium have addressed how **phylogenetic beta diversity** helps to reveal

“mechanisms driving spatial variation”, the “influence of factors on composition” etc.

I will discuss how this understanding of **phylogenetic beta diversity** patterns opens the door to applications in biodiversity monitoring and assessment

overview

- Phylogenetic beta diversity developed with explicit links to PD (phylogenetic diversity) calculations
 - a kind of PD dissimilarity
- This link to PD highlights the idea of feature diversity, and this link helps us to address monitoring and assessment
 - If **unimodal response of evolutionary features** to gradients, then the ED method provides the needed calculus of biodiversity gains and losses
- We plan to use this approach as part of a global biodiversity observation network GEO BON

GEO BON: a global Biodiversity Observation Network

GEO Biodiversity Observation Network is a new global partnership to help collect, manage, analyse & report data relating to the status of the world's biodiversity



GEO BON: a global Biodiversity Observation Network

Key challenges for GEO BON include finding effective ways to better observe and monitor at the level of genetic and phylogenetic variation.

Loss of evolutionary history is a major concern within the broader biodiversity crisis.

Recently highlighted as the loss of “**eVosystem services**”

Faith, D.P., S. Magallón, A.P. Hendry, E. Conti, T. Yahara, and M.J. Donoghue. (2010). Evosystem Services: an evolutionary perspective on the links between biodiversity and human-well-being. *Current Opinion in Environmental Sustainability*.

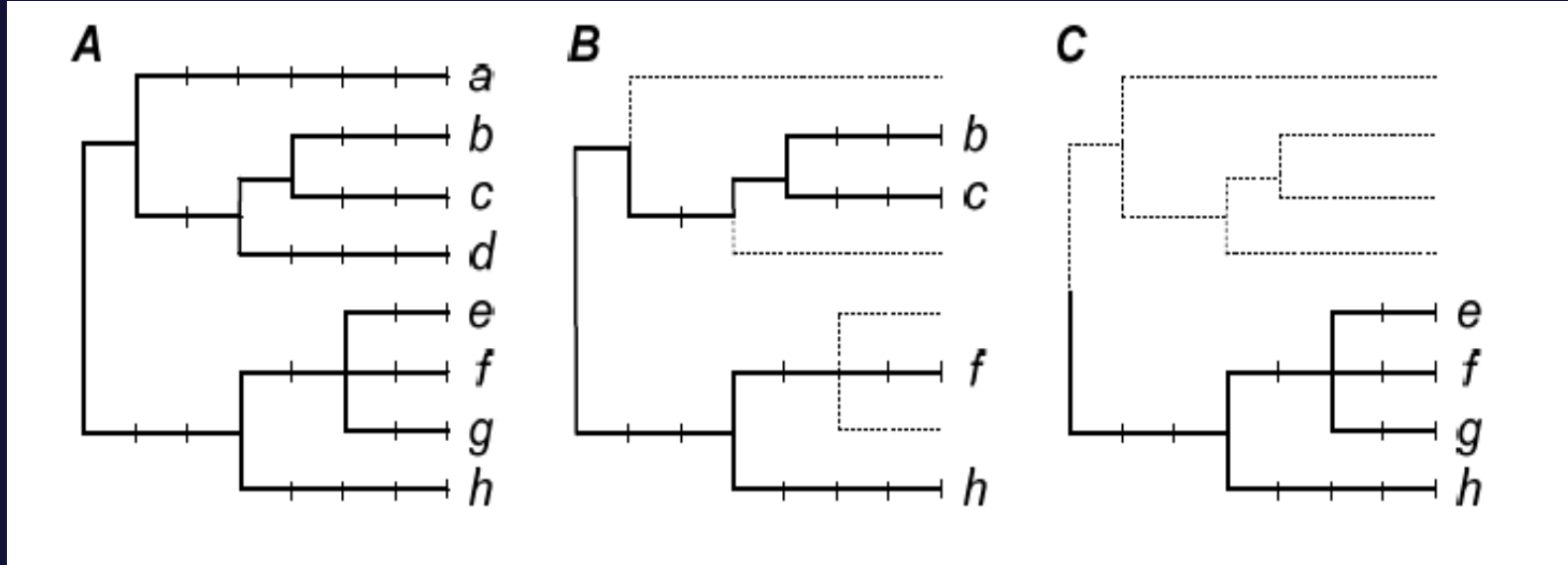
Two strategies for monitoring phylogenetic diversity

Repeated observations, over time, of:

- 1) Specific phylogenetic components of interest, in selected target groups.
- 2) changes in land/water condition (e.g. using remote sensing), integrated with phylogenetic beta diversity models as the “lens” to infer loss of phylogenetic diversity.

PD – phylogenetic diversity

Faith 1992



Phylogenetic ecology - take any conventional species-level index and re-express as a PD-based measure

Richness = total PD

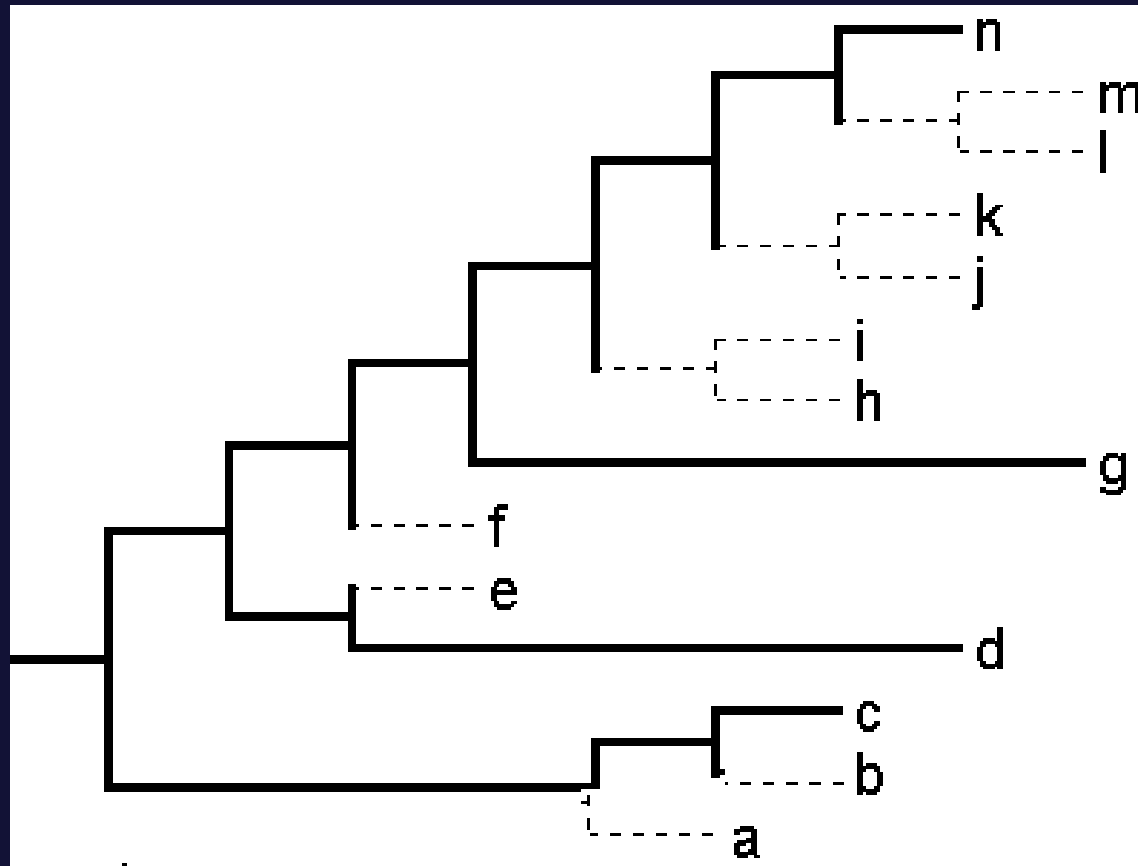
Expected diversity = expected PD

PD-Complementarity (gains & losses)

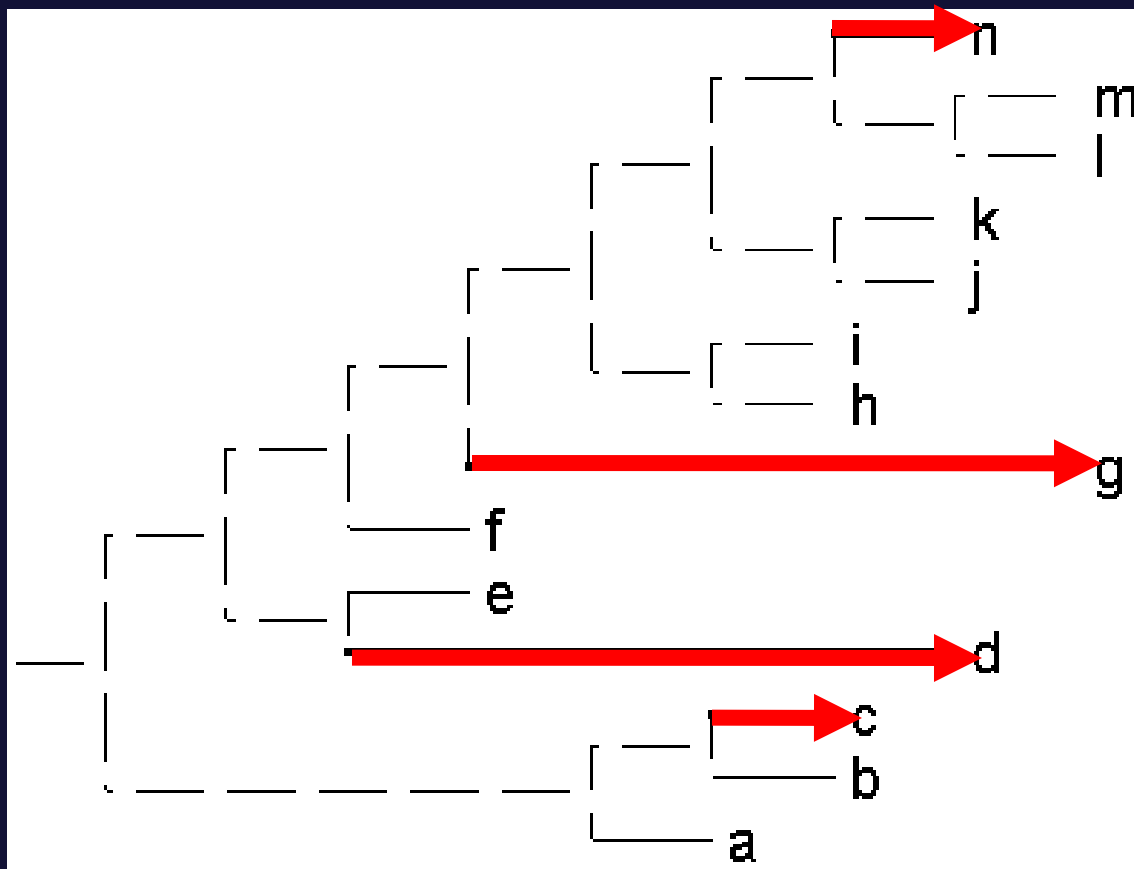
PD-Endemism (e.g. Faith et al 2004)

PD-Dissimilarity between communities (PBD)

The total PD represented by an area
(dark branches)

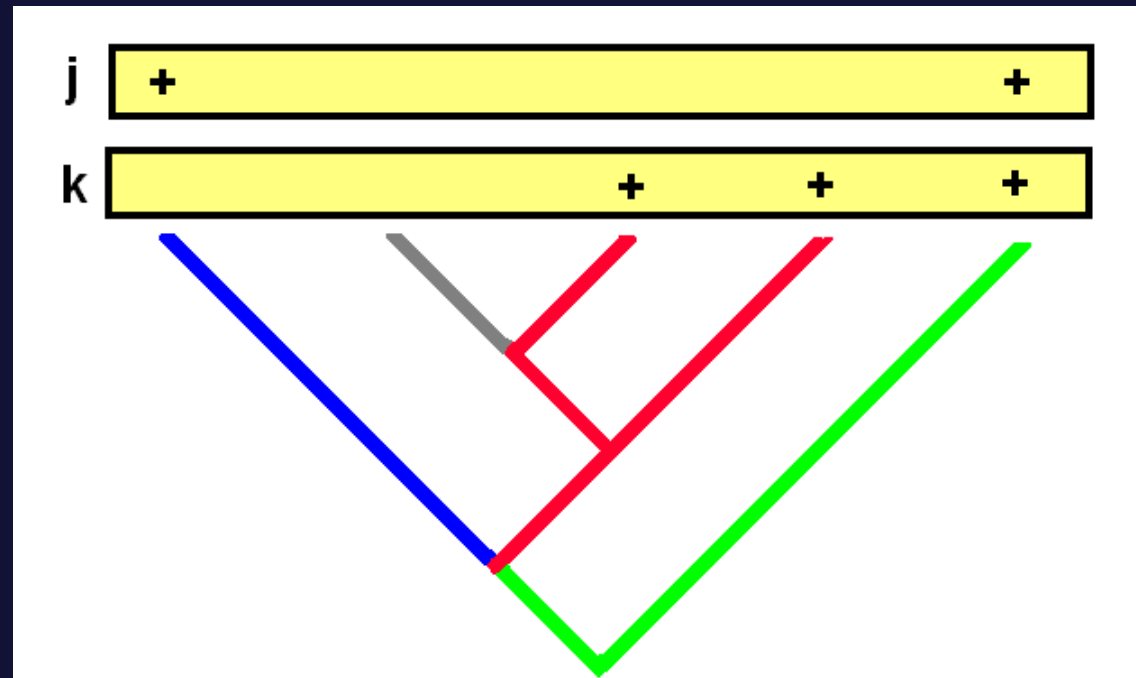


The PD-complementarity of that same area



That compares the branch lengths/features represented by an area to those already represented by a set.
We also can compare two areas

$$\text{PD Dissimilarity} = \frac{B + C}{2A + B + C}$$

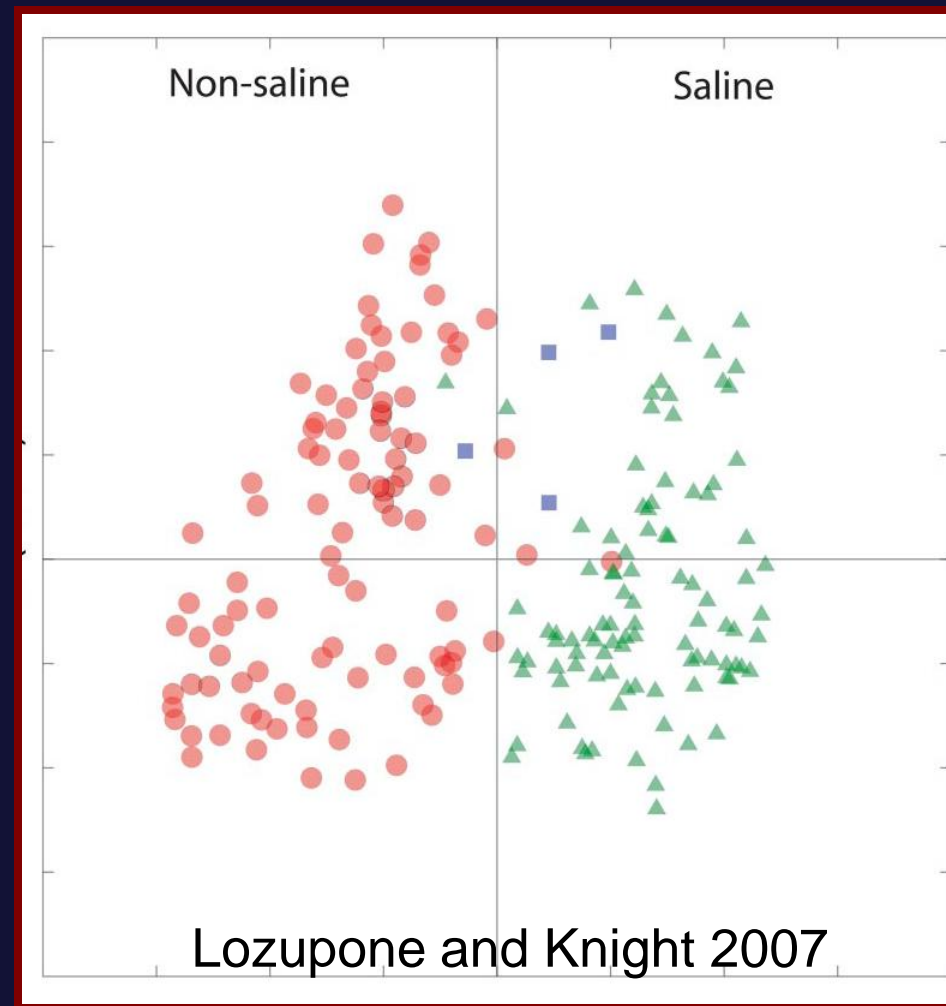


See
Lozupone et al 2005
Ferrier et al 2007

j and k dissimilar if there
is lots of red and blue

These dissimilarities can be calculated for all pairs of sample sites.

exciting examples include microbial ecology work using UniFrac (Lozupone and colleagues), where ordinations reveal key environmental factors/gradients e.g. global scale bacteria



Monitoring and conservation assessments require information for *all* sites in the region.

We can use a special regression (“GDM”) to predict PD-dissimilarities from environmental distances (Ferrier et al 2007)

Myobatrachid frogs (150 669 records, 0.01 degree sites) Classification based on predicted PD dissimilarities

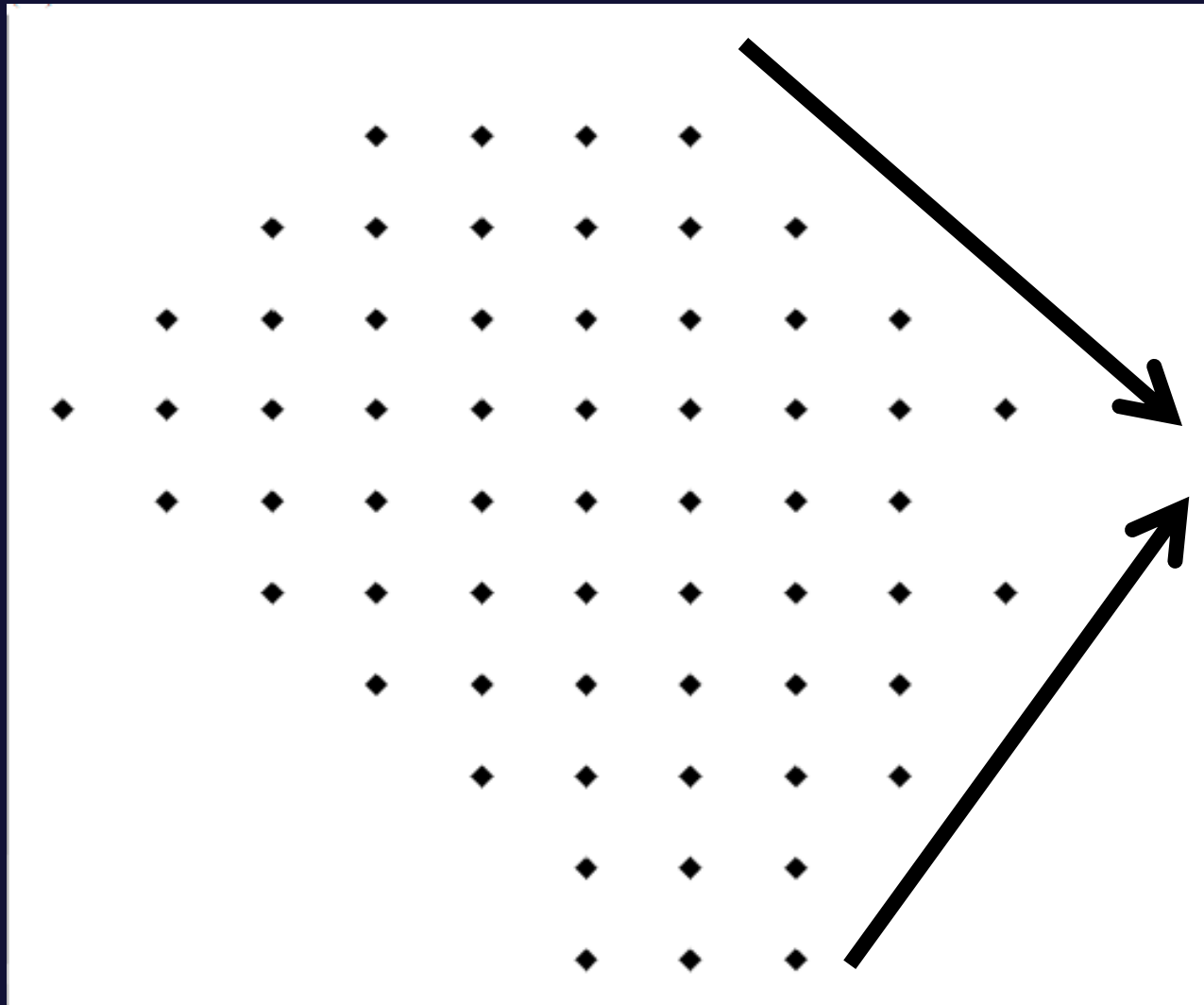


Williams, Ferrier, Rosauer, Faith et al. Report for Department of the Environment, Water, Heritage and the Arts; for further information, contact Dan Rosauer

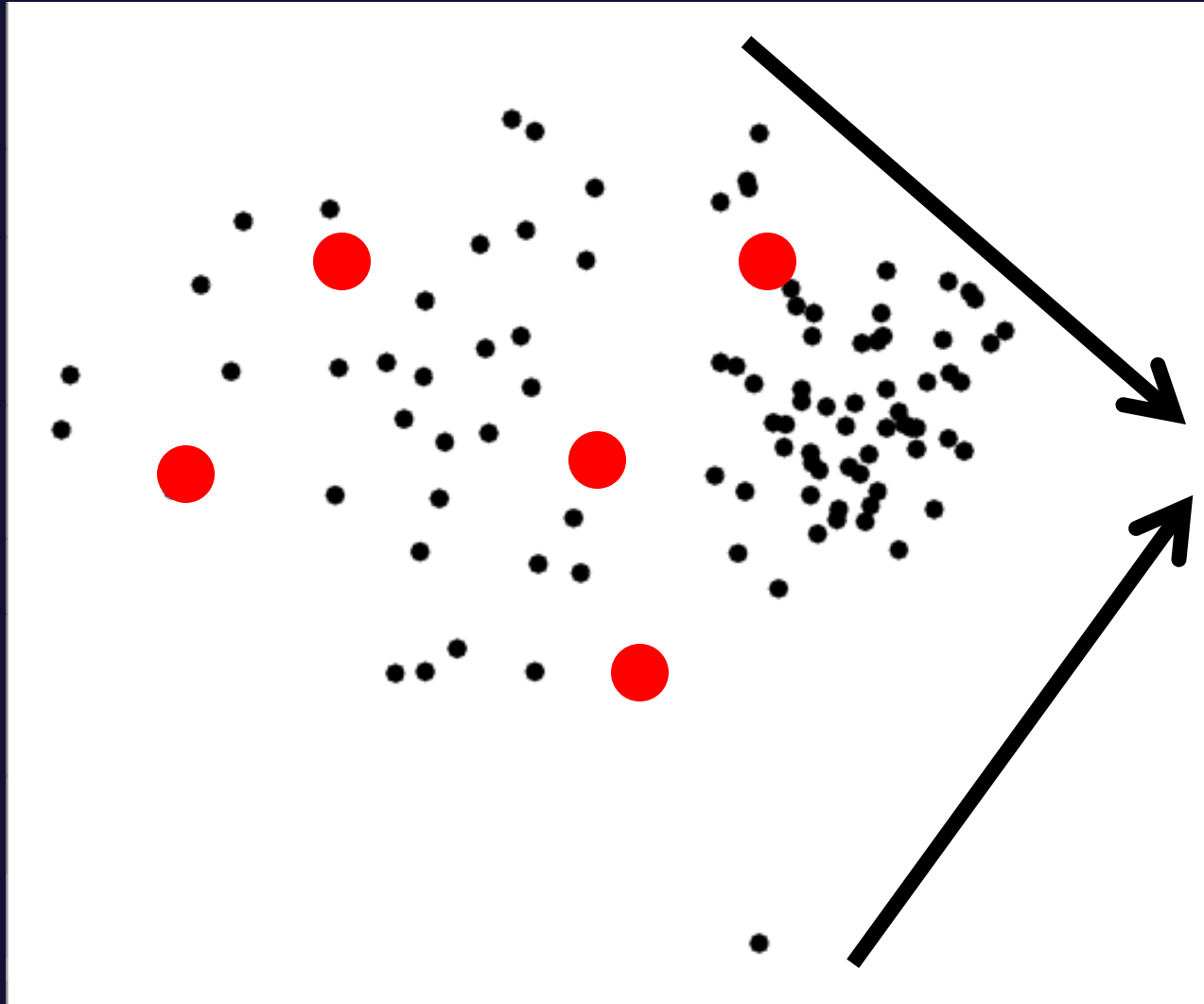
We have continental coverage, but how do we best use this to talk about change in phylogenetic diversity?

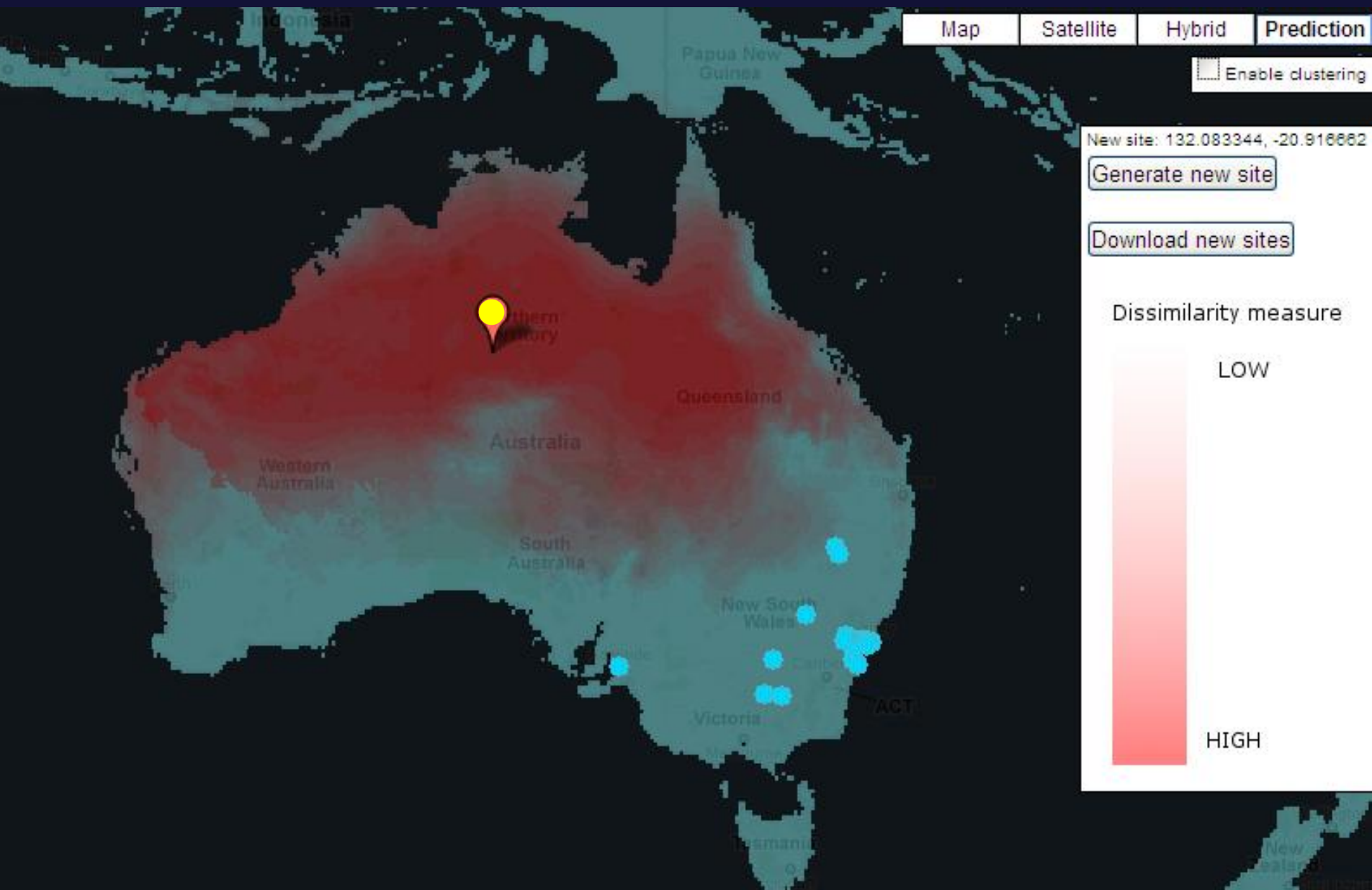
- use the classification of dissimilarities
 - but loses information
- Ferrier et al 2004 indices – what portion of the habitat type found in a given place is intact over the whole region? “effective area of similar habitat”
 - but perhaps does not really assess degree of representation of biodiversity, nor gains and losses
- Faith and Walker’s ED (“environmental diversity”) method.
 - but controversial; hard to calculate?

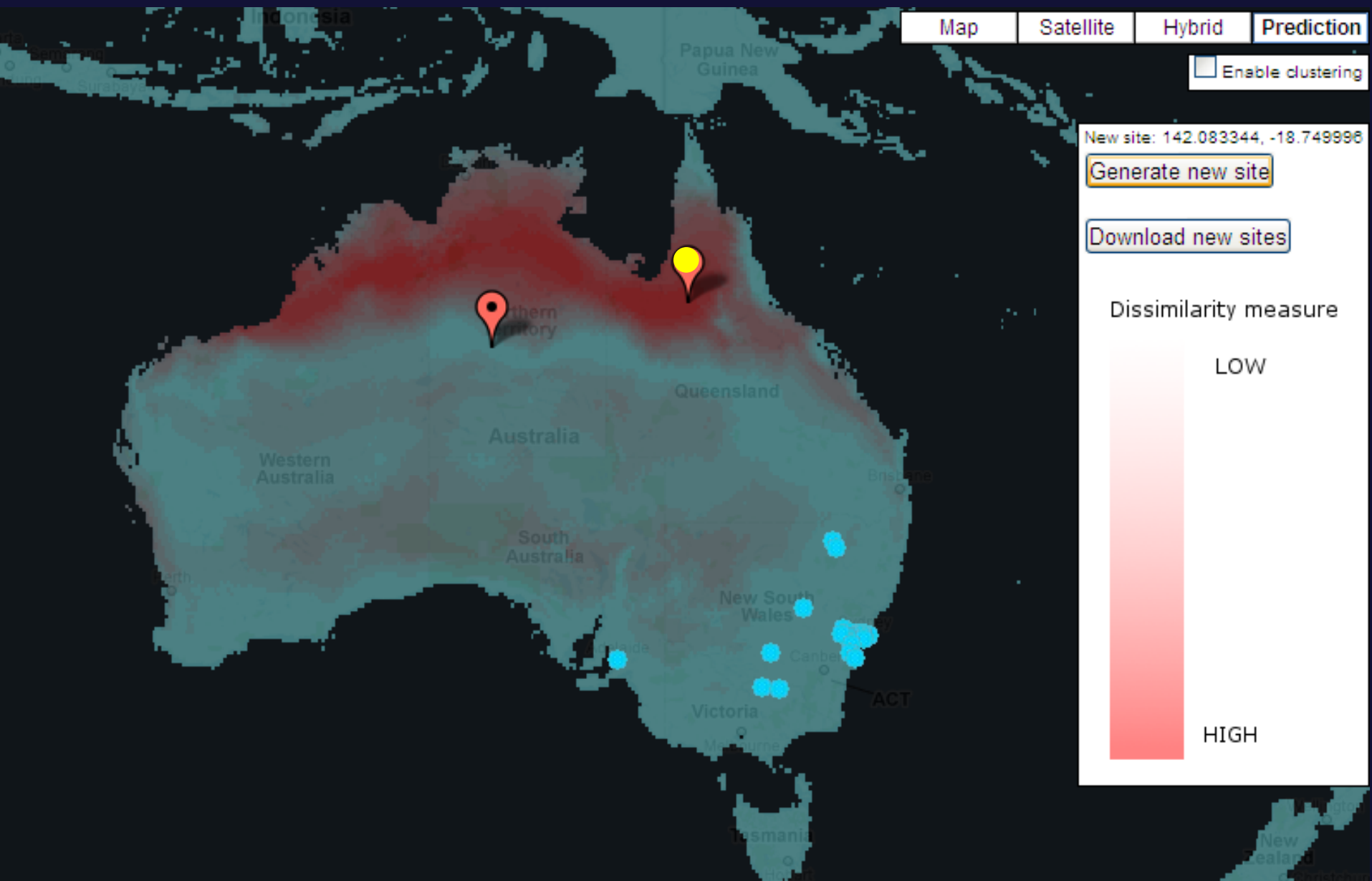
An environmental space
filled with “demand points”

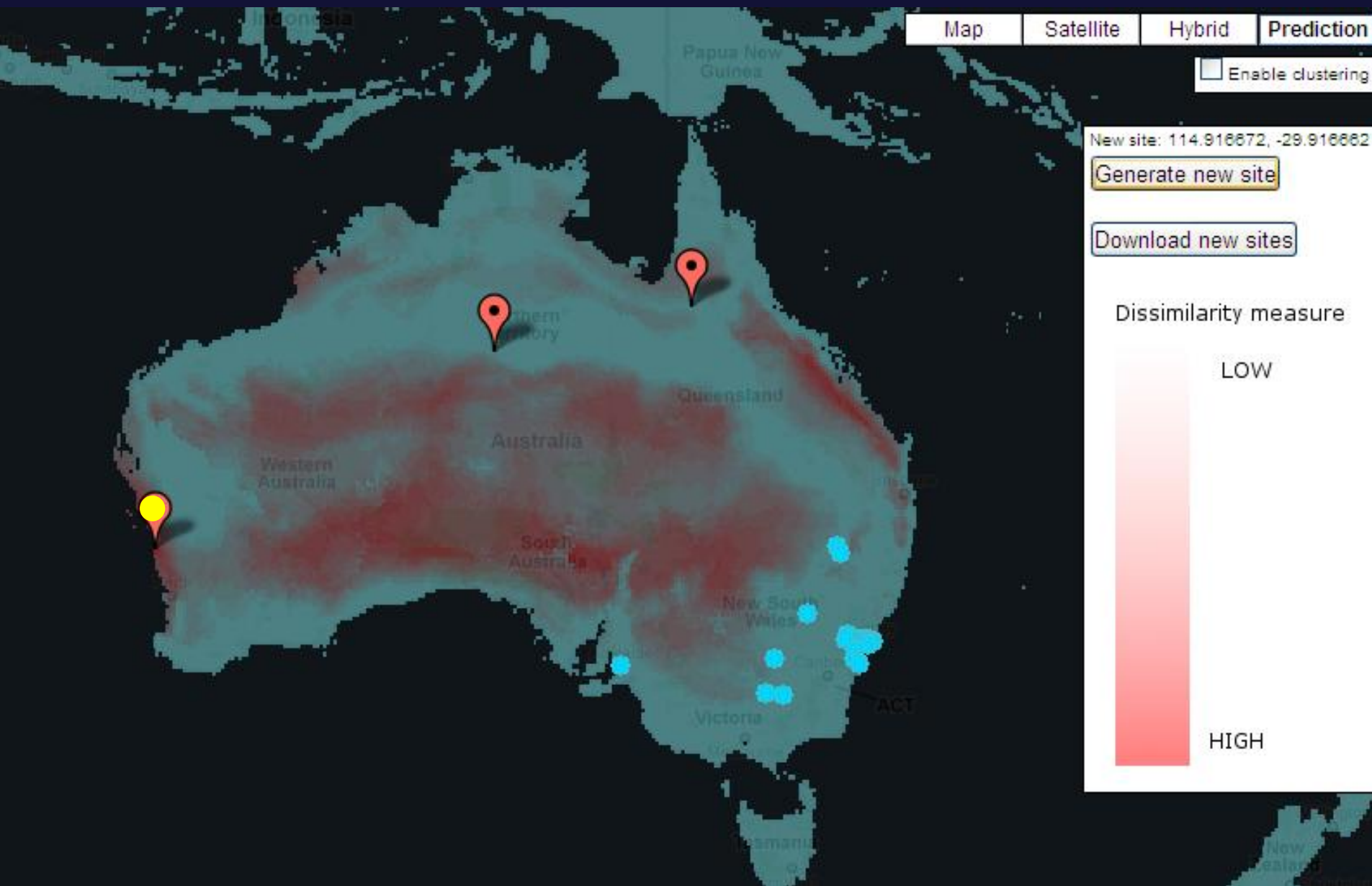


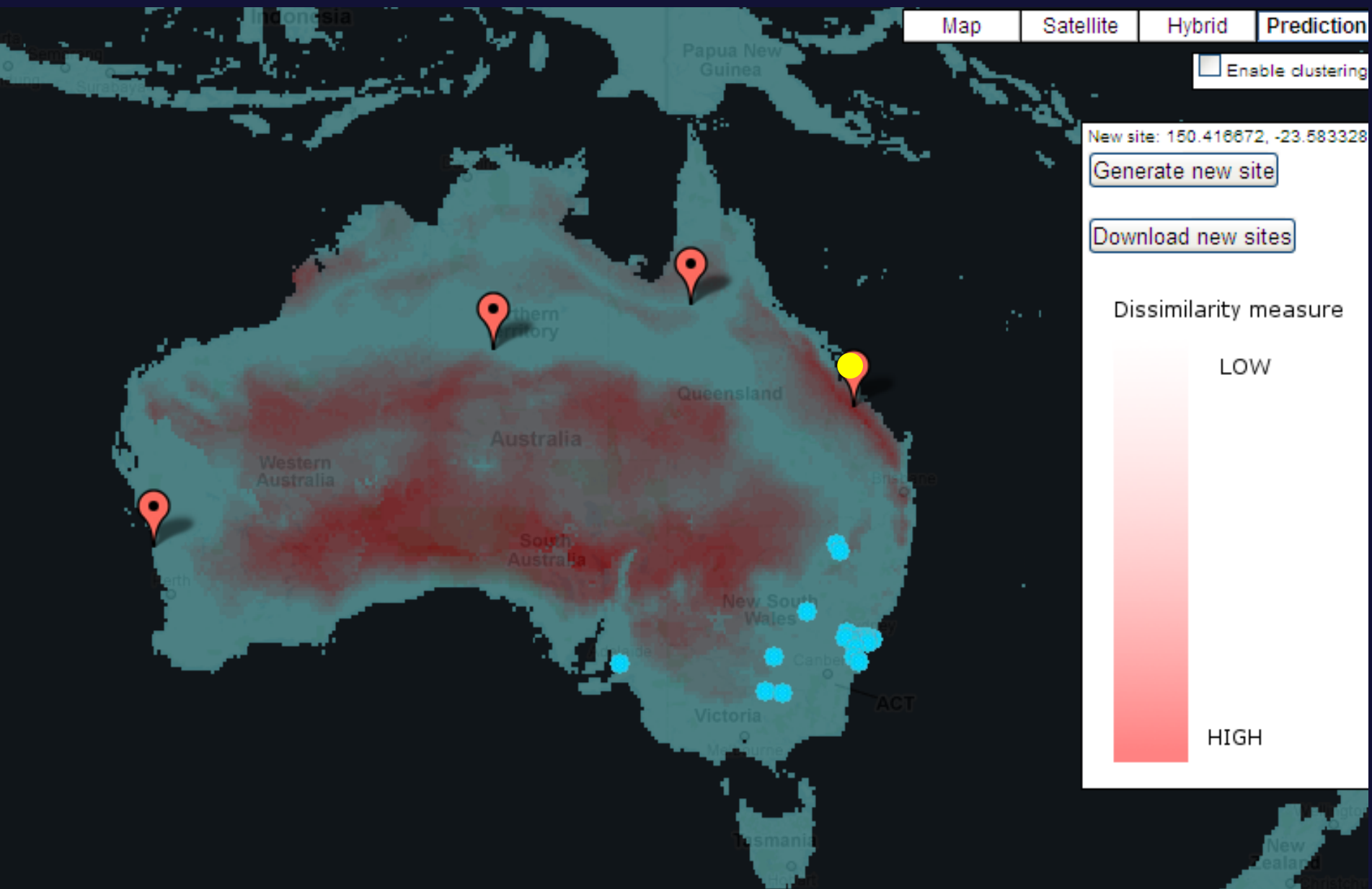
The environmental space showing sites + 5 best ED sites (red)
These 5 sites minimise sum of distances of demand points to
their nearest selected site

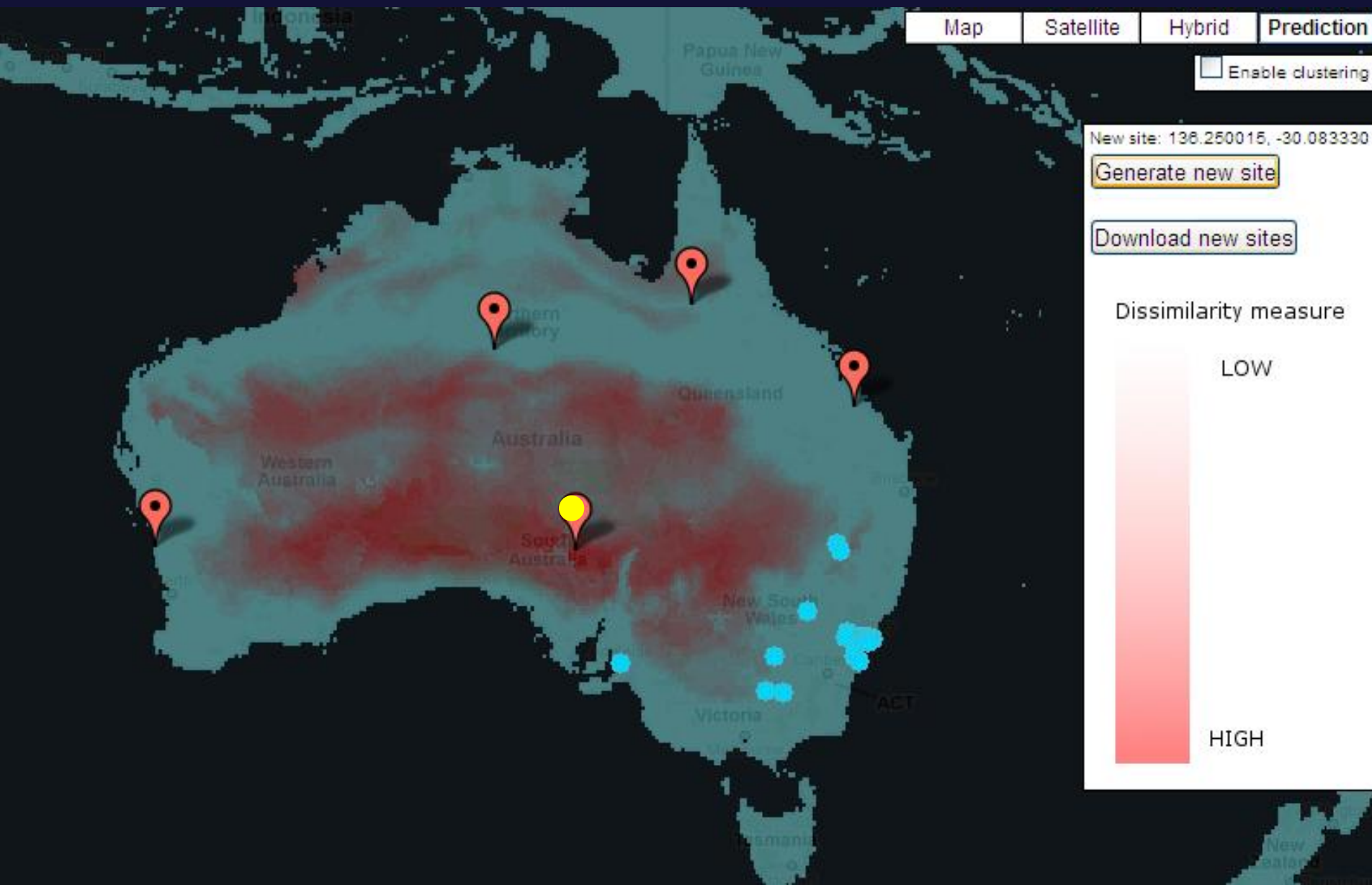


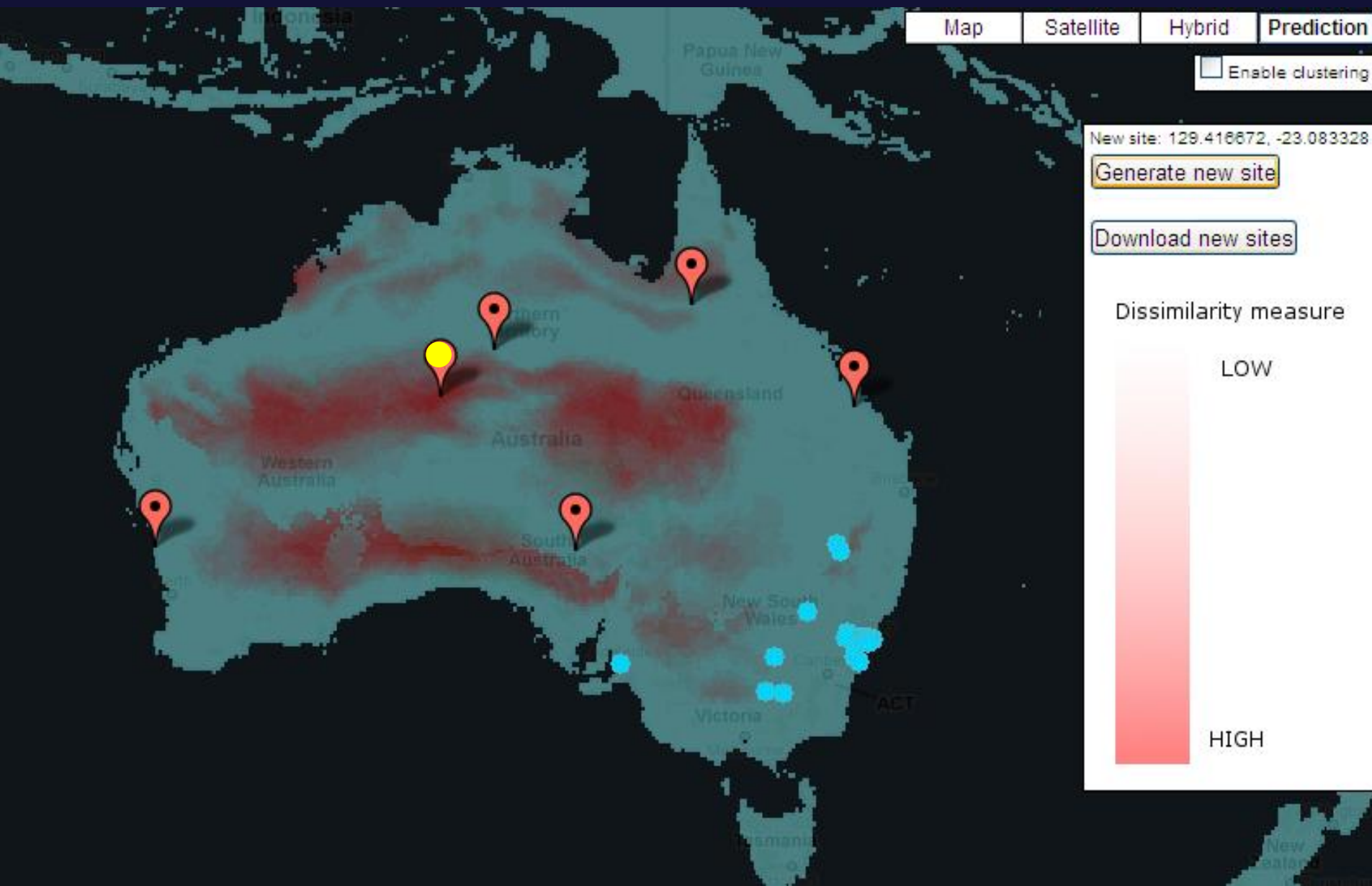


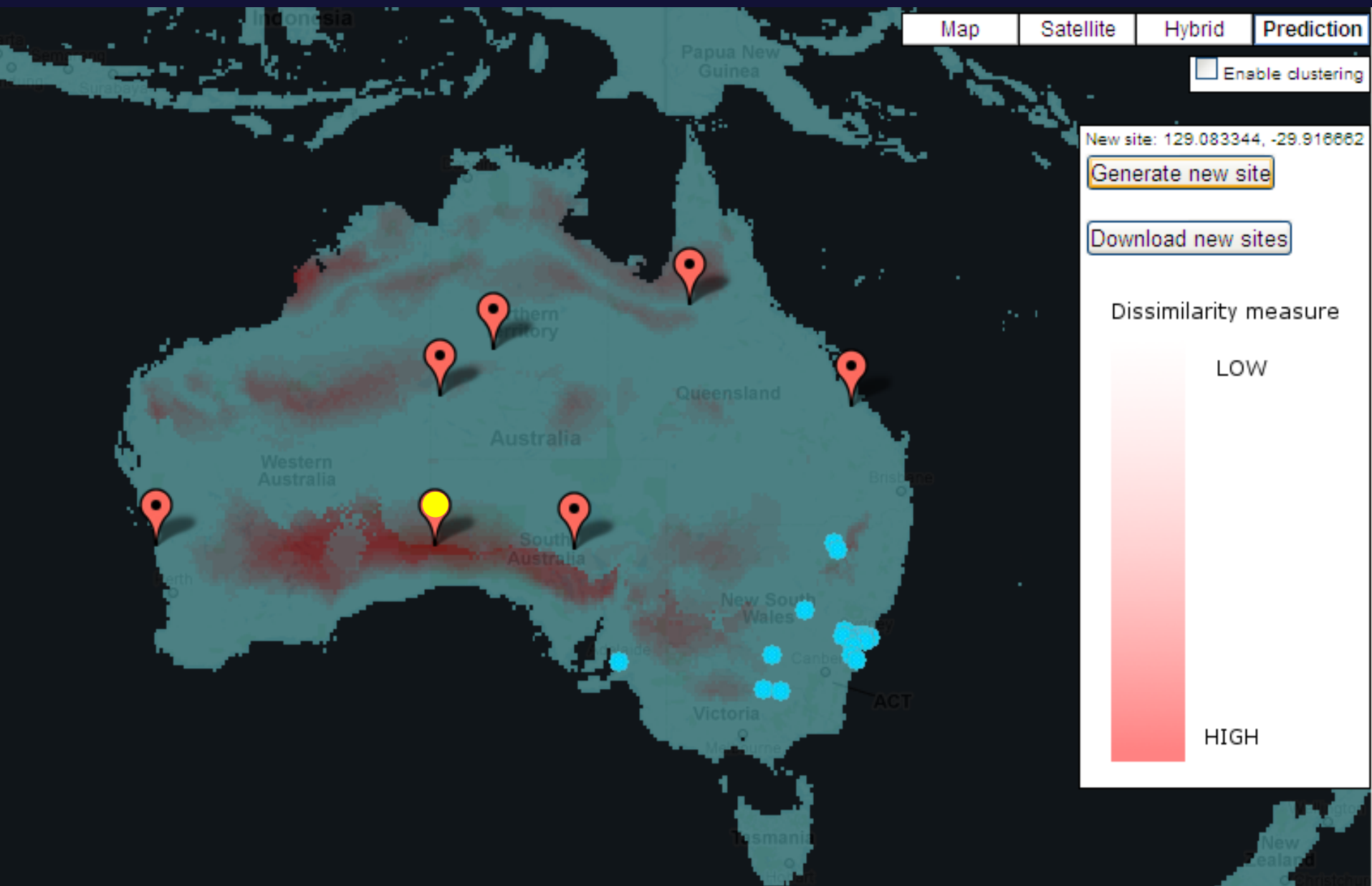


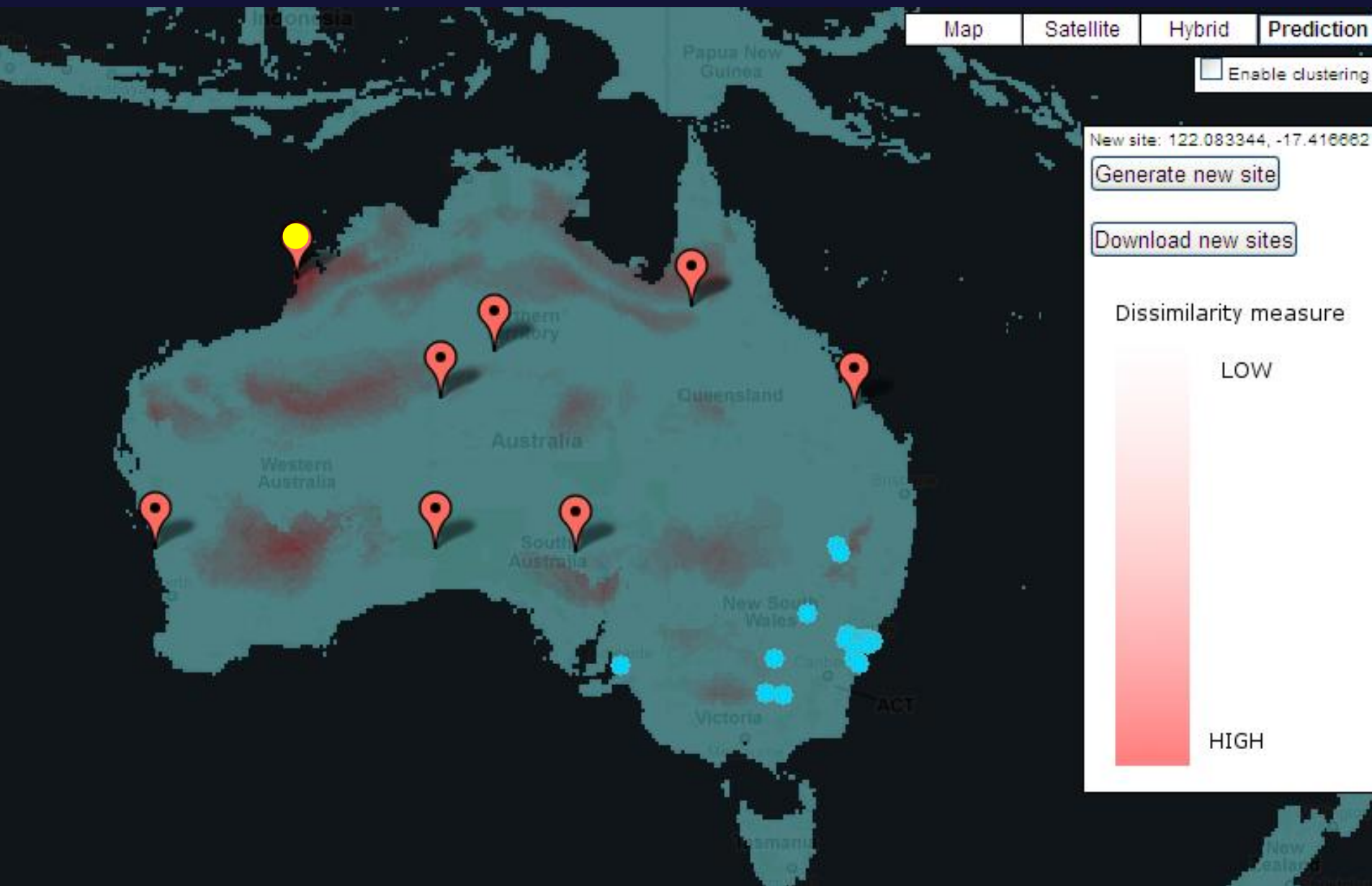








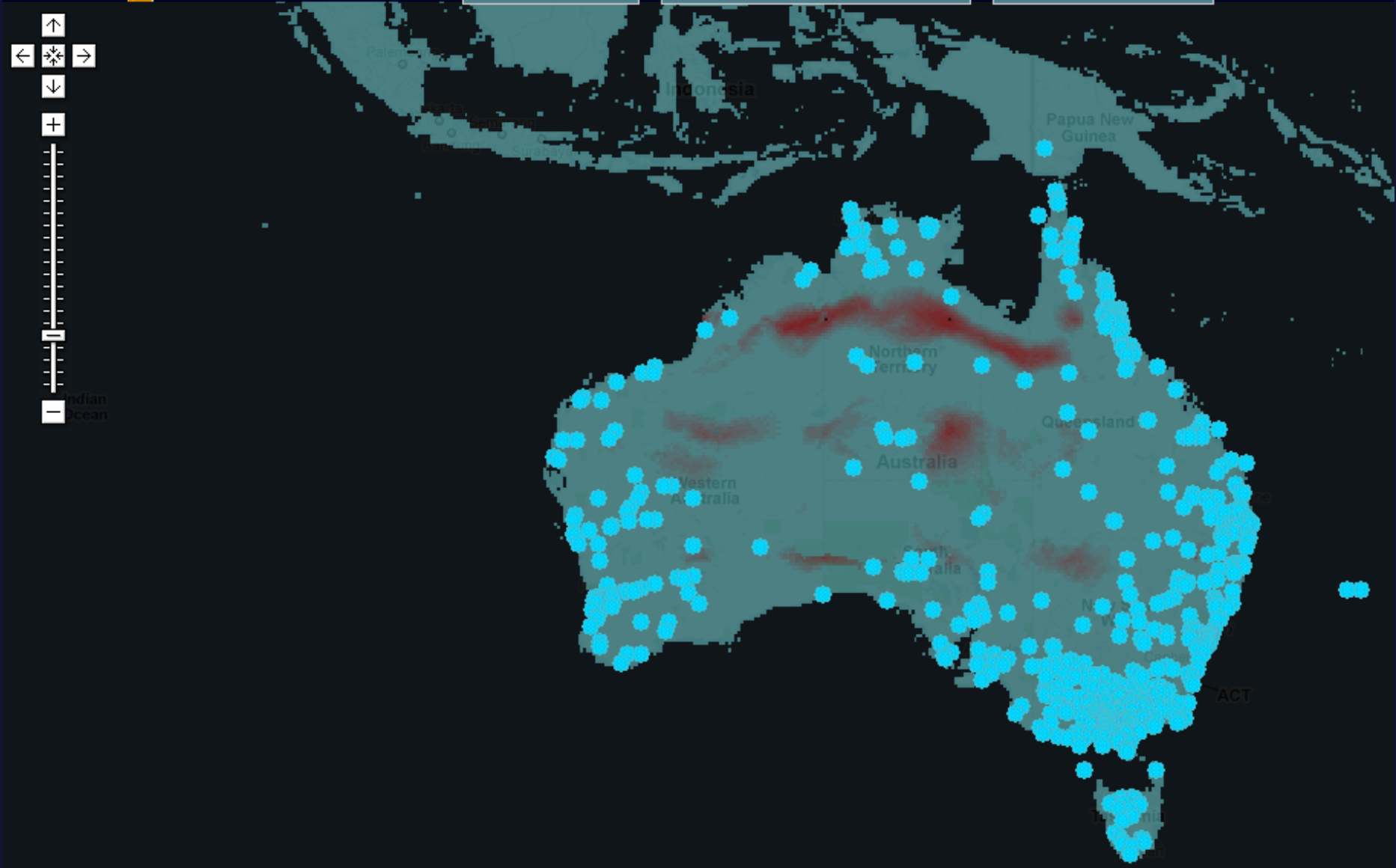




Start a new map

Add more species to this map

Use an Analysis Tool



ED method has been controversial

Poorly applied, miss-interpreted....

Araújo et al 2001, 2003, 2004

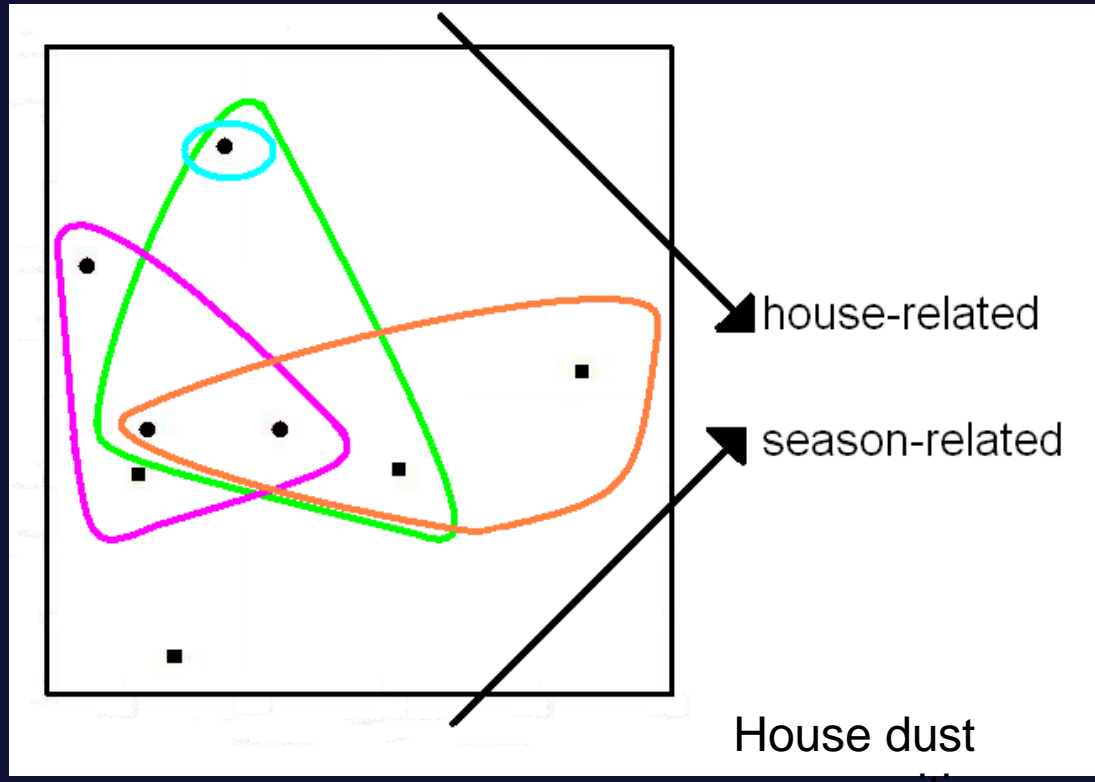
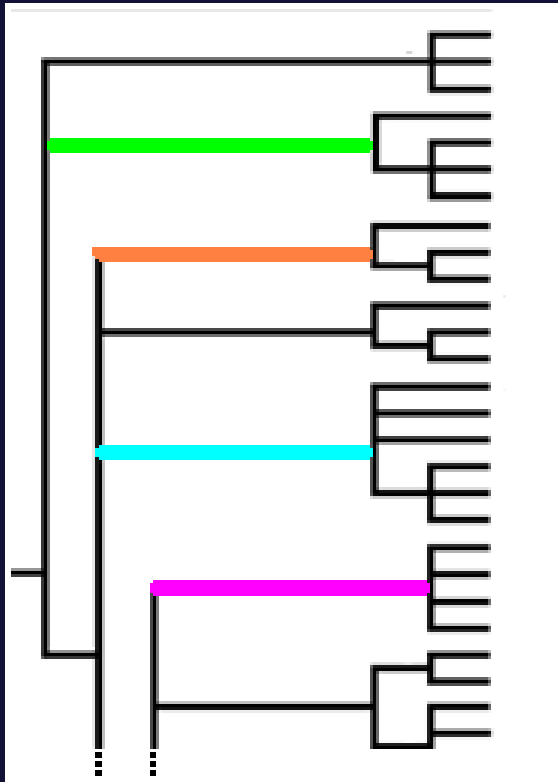
Hortal et al 2009; Arponen et al 2008

For discussion, see

Faith DP (2010) Attempted tests of the surrogacy value of the ED environmental diversity measures highlight the need for corroboration assessment of surrogacy hypotheses. *Ecological Indicators*

Key property motivates use of ED – under general unimodal response, number of features is maximised if and only if sites are selected under the ED p-median criterion

Phylogeny helps find important gradients, because even deeper branches have unimodal response to gradients

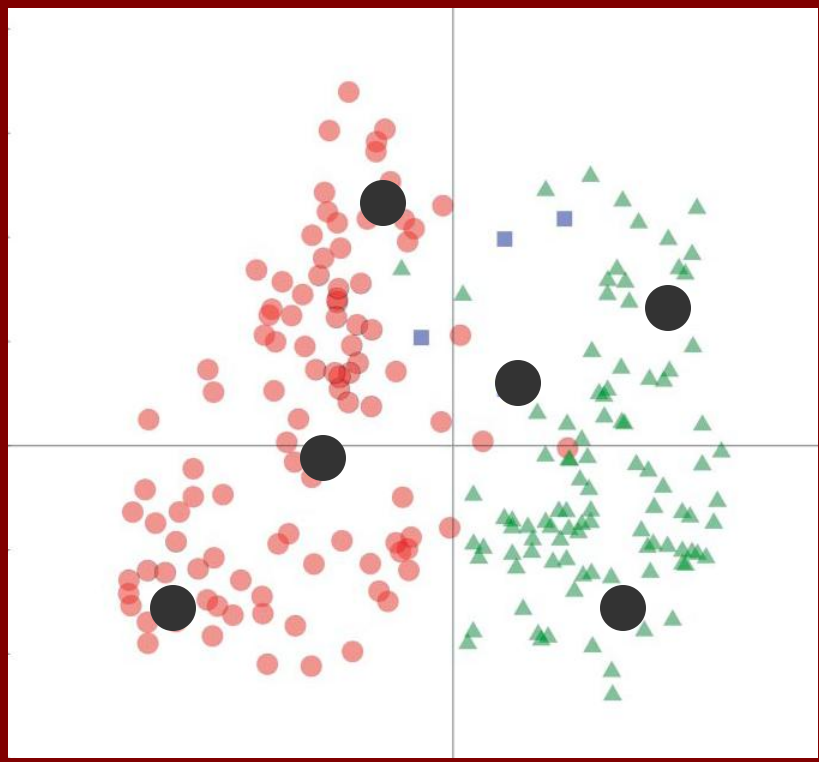


The key unimodal response exists - therefore ED is justified in theory as a way to calculate phylogenetic diversity change

Faith, D. P., C. A. Lozupone, D. Nipperess, R. Knight (2009)

A general model linking evolutionary features and environmental gradients supports broad applications of microbial ecology's phylogenetic beta diversity framework. *International Journal of Molecular Science*

The link from phylogenetic beta diversity to unimodal response of features/lineages motivates the use of ED



Using phylogenetic beta diversity and ED, phylogenetic information can be integrated into a “lens” for interpreting remotely sensed changes in land condition for GEO BON

but more work to be done..

Future work –

complete a demonstration study for GEO BON
using PBD and ED-estimated losses

extend the web-based software that uses ED to
add sites (survey gap analysis) to allow “lens”
assessments where sites are lost

provide the realistic ED options allowing
probabilities, richness models, etc. and
implement a shortcut continuous ED method

Phylogenetic
patterns

mapped climate,
terrain & substrate
data

THE LENS

Biodiversity distribution modelling –
Using phylogenetic beta diversity

Time series
of remotely
sensed land
condition/cover
observations

Use variants of ED to
estimate the status of
phylogenetic diversity

