



# Lifemapper

## Phylogeography and MetaCommunity

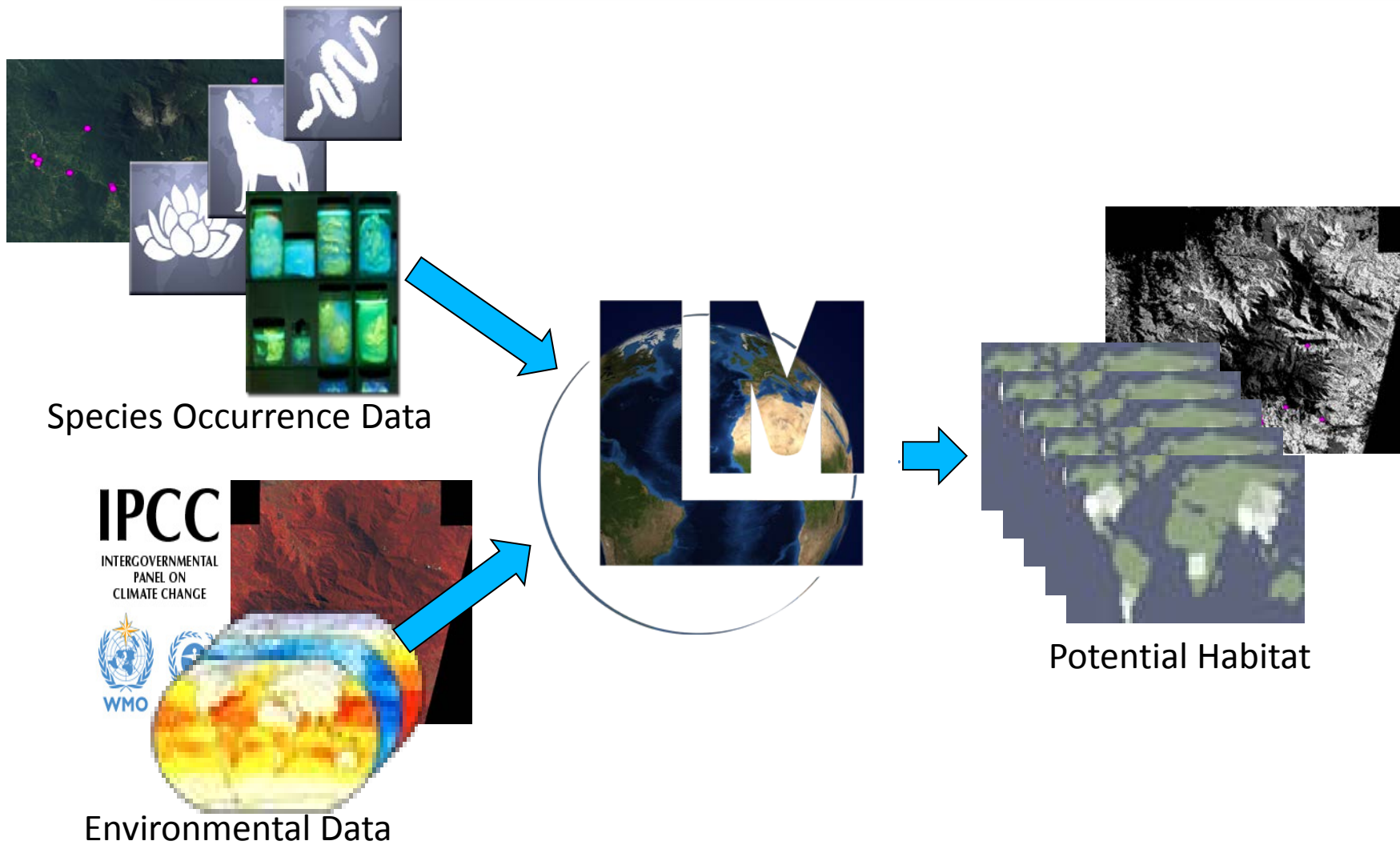


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CJ Grady  
Informatics, Biodiversity Institute, KU



# Lifemapper

## LmSDM: Species Distribution Modelling

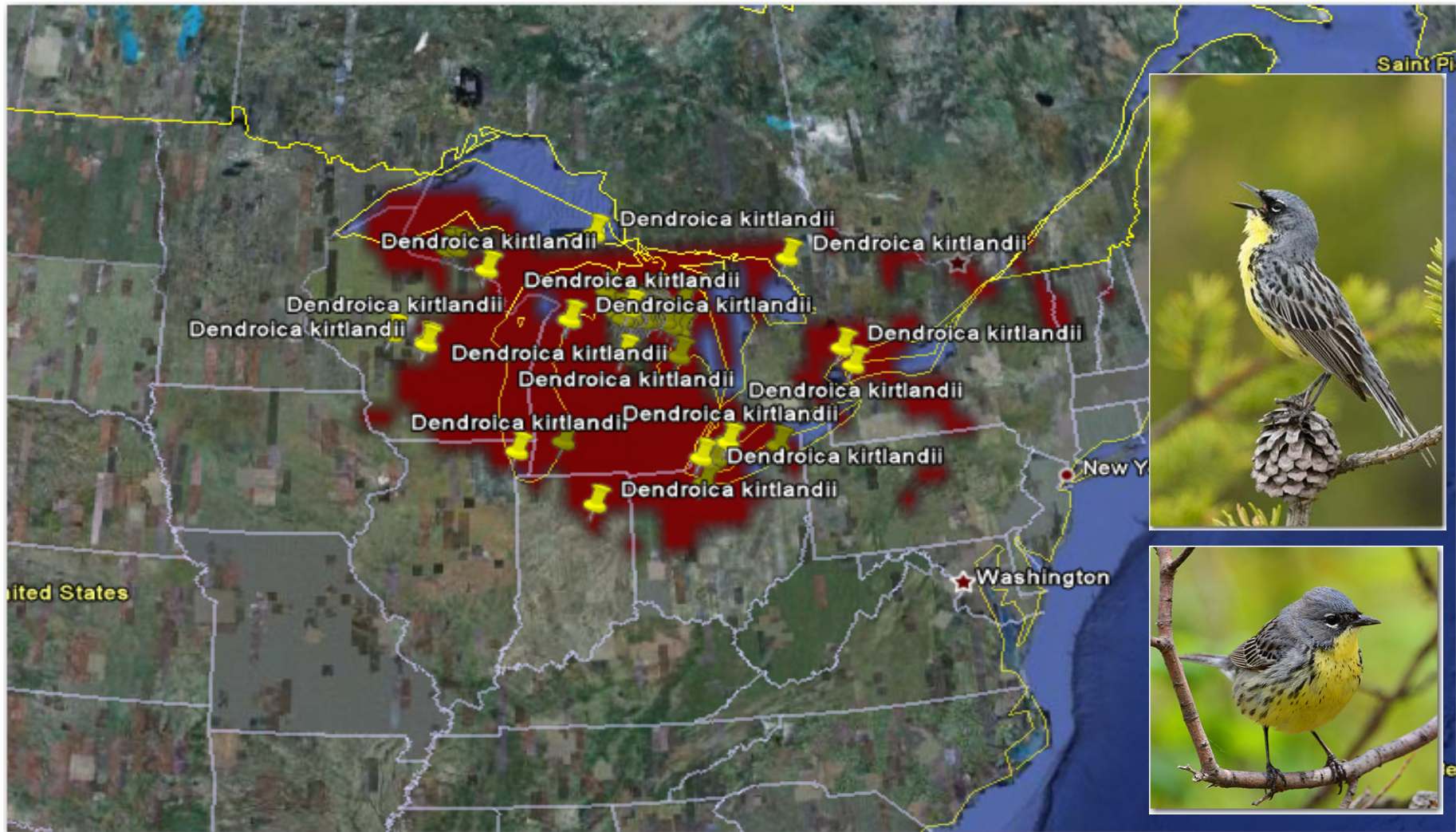






# Lifemapper

## Kirtland's Warbler Range





# Lifemapper

## Lifemapper Qgis plugin

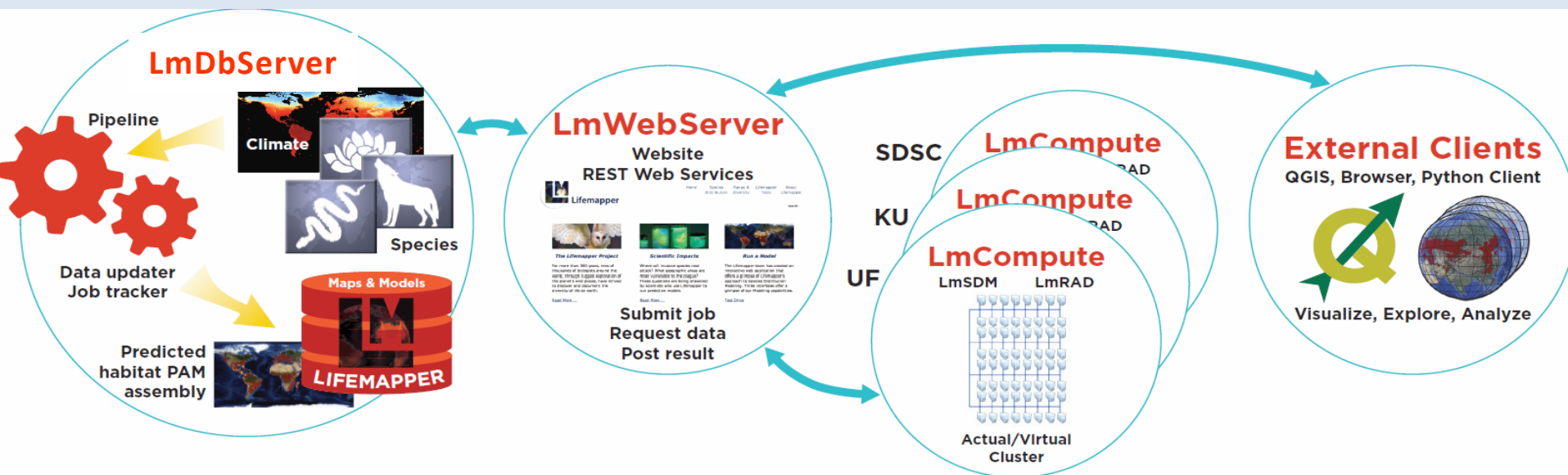
The screenshot displays the QGIS software interface with the Lifemapper plugin active. The menu bar includes Project, Edit, View, Layer, Settings, Plugins, Vector, Raster, Database, Web, Lifemapper, Processing, and Help. The Lifemapper menu is open, showing options: Sign In, LmRAD: Range and Diversity, LmSDM: Species Distribution Modeling (highlighted), Upload Layer, Change Workspace, and Sign Out. A sub-menu for LmSDM is also open, listing: New Experiment, Build Environmental Layer Set, List Experiments, and Current Experiment.

The Layers panel on the left shows two layers for *Peropteryx Trinitatis Pr...*. The top layer is checked and has a legend with a color scale from 0.000000 (green) to 0.498959 (red). The bottom layer is unchecked and has the same legend. The map view shows a map of South America with a color-coded overlay representing the species distribution model, with higher values (red) concentrated in the northern and central regions.



# Lifemapper

## Component Design

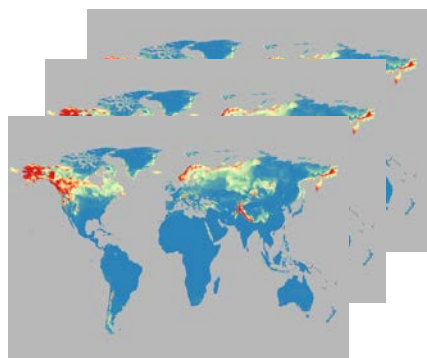






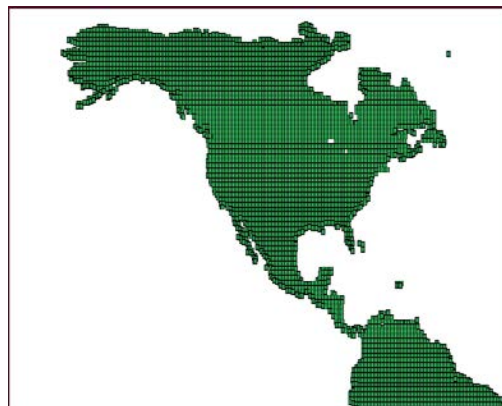
# Lifemapper

## LmRAD: Presence Absence Matrix (PAM)



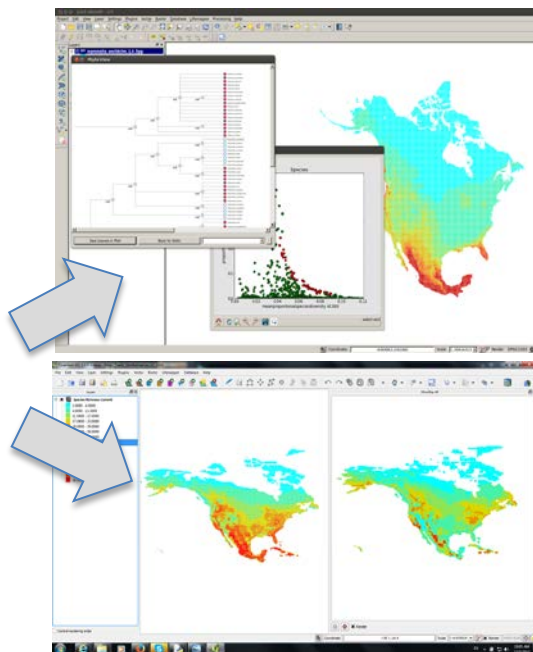
Species

Sites



M =

0	0	0	0	1	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	1	0	0	0	1	0	1
1	0	1	0	1	0	0	0	0	1	0	1	0
1	0	0	1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	1	0	1
0	0	1	0	0	1	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	1	0	0	0	0
0	1	0	0	0	0	0	1	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0



Multi-species analyses and visualizations



# Lifemapper

It's that moment they told us about when matrix algebra would save our lives

$$\begin{pmatrix} a_{11} & a_{12} & \dots & \\ a_{21} & a_{22} & & \\ \vdots & & & \\ & & & a_{nm} \end{pmatrix} * \begin{pmatrix} b_{11} & b_{12} & \dots & \\ b_{21} & b_{22} & & \\ \vdots & & & \\ & & & b_{mj} \end{pmatrix} = \begin{pmatrix} \sum_{k=1}^m a_{1k} * b_{k1} & \sum_{k=1}^m a_{1k} * b_{k2} & \dots & \sum_{k=1}^m a_{1k} * b_{kj} \\ \sum_{k=1}^m a_{2k} * b_{k1} & \sum_{k=1}^m a_{2k} * b_{k2} & & \\ & \vdots & & \\ \sum_{k=1}^m a_{nk} * b_{k1} & \sum_{k=1}^m a_{nk} * b_{k2} & & \sum_{k=1}^m a_{nk} * b_{kj} \end{pmatrix}$$



# Lifemapper

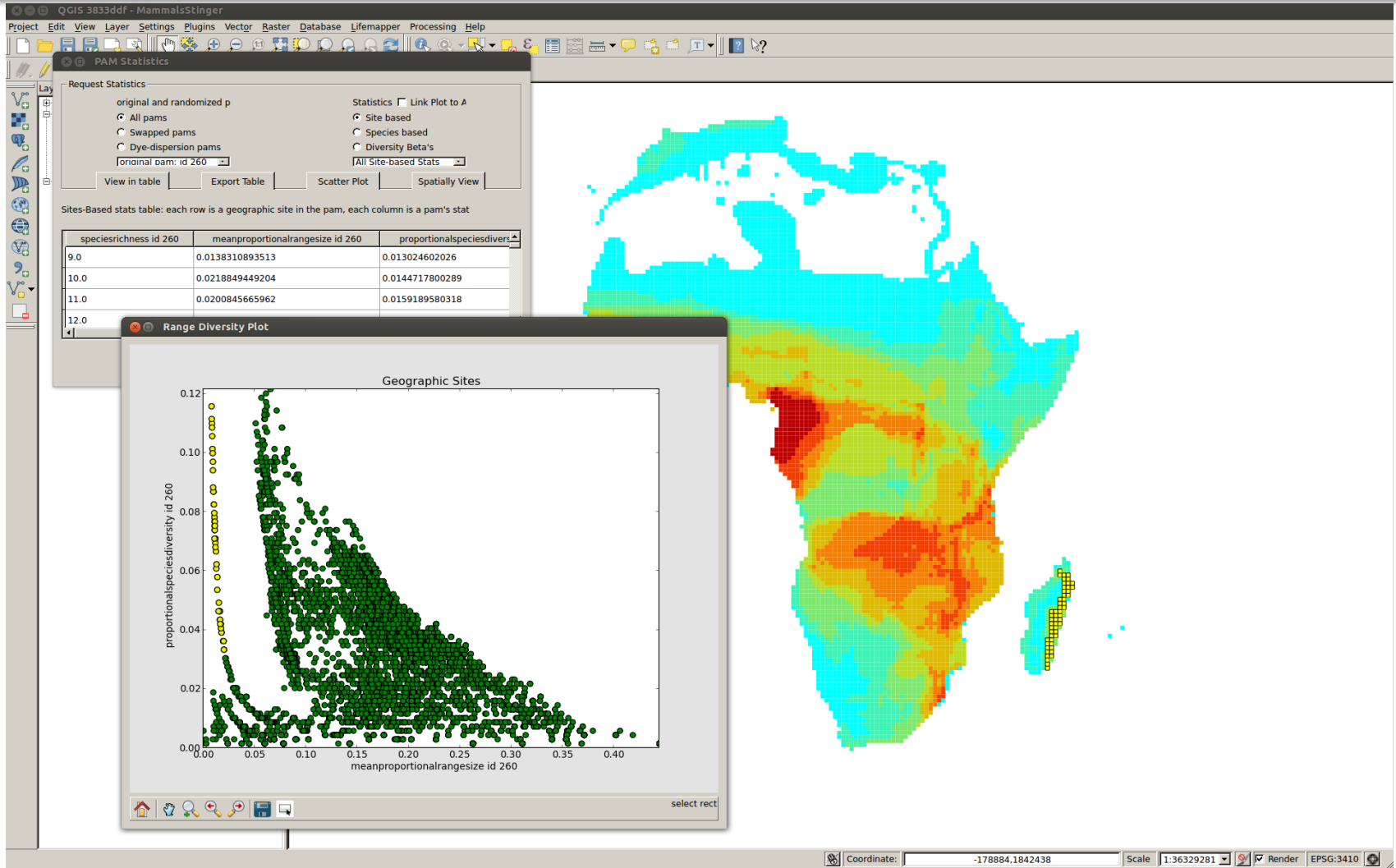
	NAME	ALGEBRAIC DEFINITION	LINEAR ALGEBRA
1	Whittaker's multiplicative beta	$\beta_w = \frac{1}{\bar{\omega}^*}$	$\beta_w = \frac{SN}{\text{Trace}(\mathbf{\Omega})}$
2	Lande's additive beta	$\beta_A = S(1 - 1/\beta_w)$	$\beta_A = S[1 - \frac{\text{Trace}(\mathbf{\Omega})}{SN}]$
3	Legendre's beta	$\beta_L = SS(\mathbf{X}) = SN / \beta_w - \left( \sum_{j=1}^S \omega_j^2 \right) / N$	$\beta_L = \text{Trace}(\mathbf{\Omega}) - \mathbf{\Phi}^T \mathbf{1}_N$
4	Range-richness of a species	$\psi_i = \sum_{j=1}^N \delta_{i,j} \alpha_j$	$\boldsymbol{\Psi} = \mathbf{X}\boldsymbol{\alpha} = \mathbf{\Omega}\mathbf{1}_S$
5	Per-site range size of a locality	$\phi_j = \sum_{i=1}^S \delta_{i,j} \omega_i$	$\boldsymbol{\Phi}^T = \boldsymbol{\omega}^T \mathbf{X} = \mathbf{1}_N^T \mathbf{A}$
6	Matrix of covariance of composition of sites	$\Sigma_{sites}(j, k) = \frac{1}{S} \sum_{i=1}^S \delta_{j,i} \delta_{k,i} - \frac{\alpha_j \alpha_k}{S^2}$	$\Sigma_{sites} = \frac{1}{S} \mathbf{A} - \boldsymbol{\alpha}^* (\boldsymbol{\alpha}^*)^T$
7	Matrix of covariance of ranges of species	$\Sigma_{sps}(h, i) = \frac{1}{N} \sum_{j=1}^N \delta_{i,j} \delta_{h,j} - \frac{\omega_i \omega_h}{N^2}$	$\Sigma_{species} = \frac{1}{N} \mathbf{\Omega} - \boldsymbol{\omega}^* (\boldsymbol{\omega}^*)^T$
8	Mean composition covariance	$\alpha_j^* = \frac{\tau_j}{\bar{\varphi}^* - \beta_w^{-1}}$	$\bar{\boldsymbol{\tau}} = \frac{1}{NS} \boldsymbol{\Phi} - \beta_w^{-1} \boldsymbol{\alpha}^*$
9	Mean range covariance	$\omega_i^* = \frac{\bar{\rho}_i}{\bar{\psi}^* - \beta_w^{-1}}$	$\bar{\boldsymbol{\rho}} = \frac{1}{NS} \boldsymbol{\Psi} - \beta_w^{-1} \boldsymbol{\omega}^*$
10	Schluter sites-composition covariance	$V_{sites} = \frac{\bar{\varphi}^* - S / \beta_w^2}{1 / \beta_w - \bar{\varphi}^* / N}$	$V_{sites} = \frac{\mathbf{1}^T \Sigma_{sites} \mathbf{1}}{\text{Trace}(\Sigma_{sites})}$
11	Schluter species-ranges covariance	$V_{sps} = \frac{\bar{\psi}^* - N / \beta_w^2}{1 / \beta_w - \bar{\psi}^* / S}$	$V_{sps} = \frac{\mathbf{1}^T \Sigma_{sps} \mathbf{1}}{\text{Trace}(\Sigma_{sps})}$
12	Wright & Reeves' nestedness	$N_c = \frac{1}{2} \sum_{j=1}^S \omega_j (\omega_j - 1)$ $= \frac{1}{2} (N\bar{\omega} - \frac{S}{N} \frac{1}{\beta_w})$	$N_c = \frac{1}{2} (N\boldsymbol{\Phi}^T \mathbf{1} - \frac{S}{N} \frac{1}{\beta_w})$
13	Stone & Roberts C-score	$C = \frac{2}{S(S-1)} \left[ \sum_{i=1}^S \sum_{h < i} (\omega_i - \omega_{i,h})(\omega_h - \omega_{i,h}) \right]$	$C' = \mathbf{1}^T \left[ \left( \frac{NS}{\beta_w} \right)^2 - 2\boldsymbol{\omega}^T \boldsymbol{\Psi} - \mathbf{\Omega} \odot \right]$





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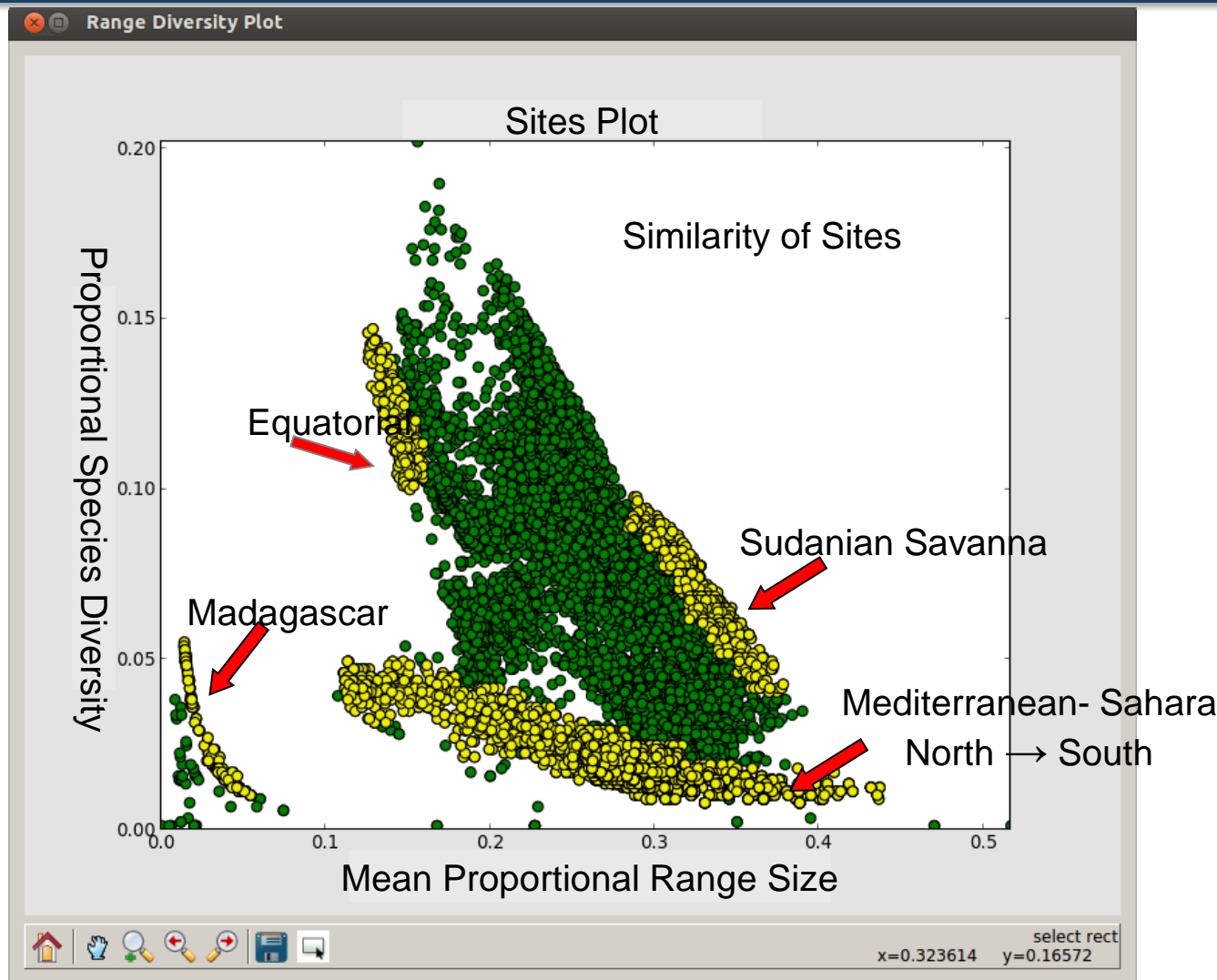
Covariance in interactive plot show biogeographic patterns





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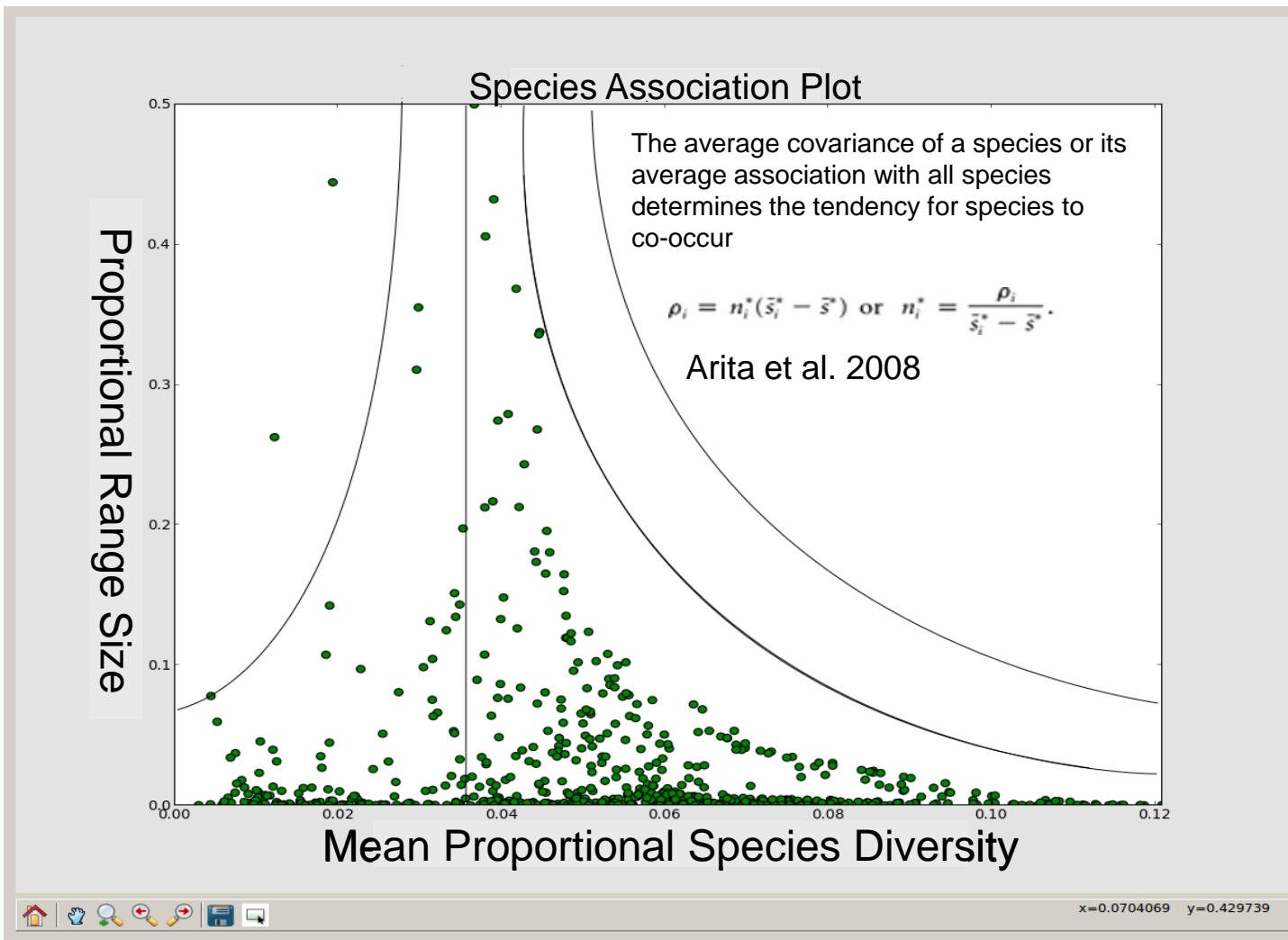
## Similarity of Sites

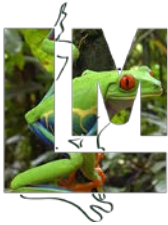




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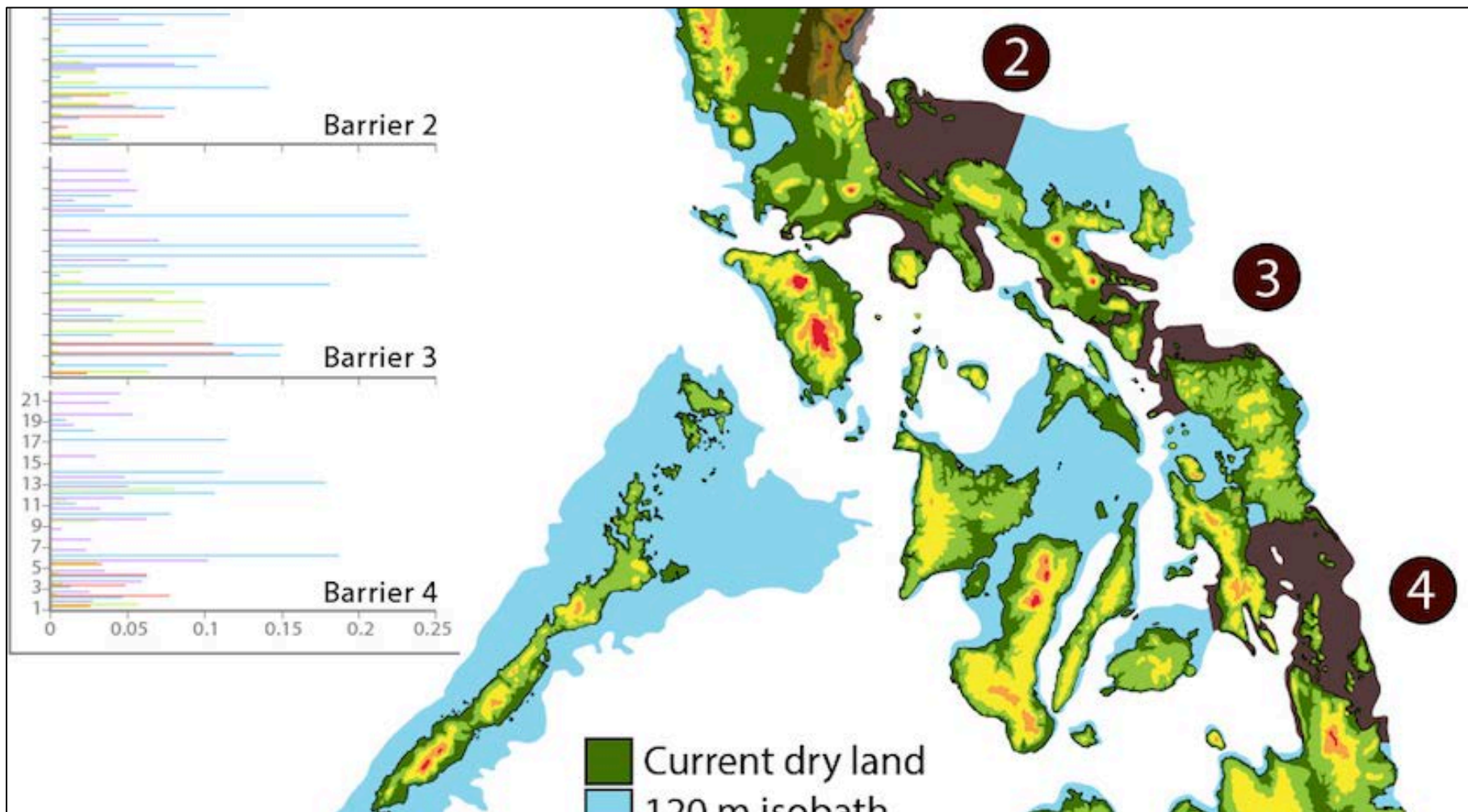
## Degree of Co-Occurrence





# Lifemapper

## Phylogenetic Diversity Across Transition Zones

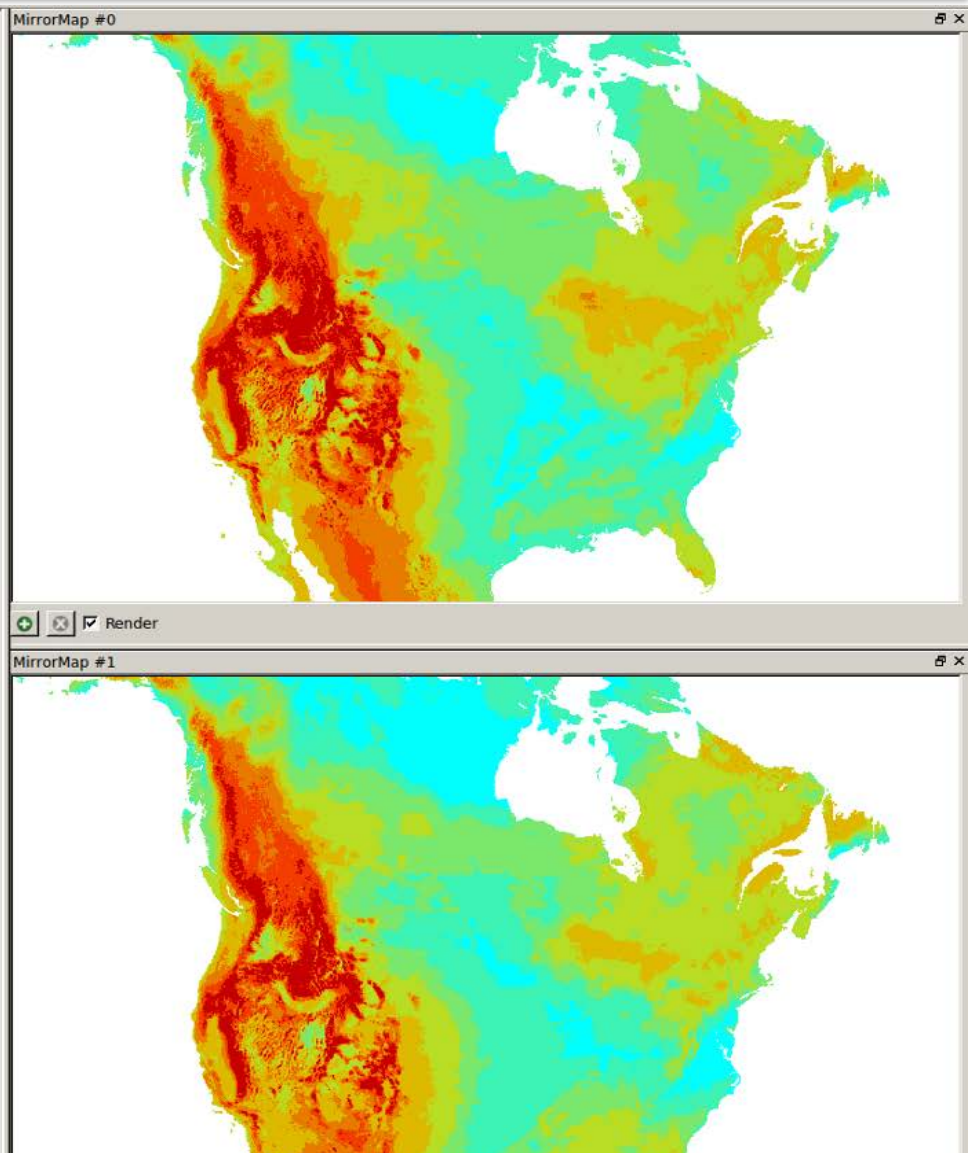
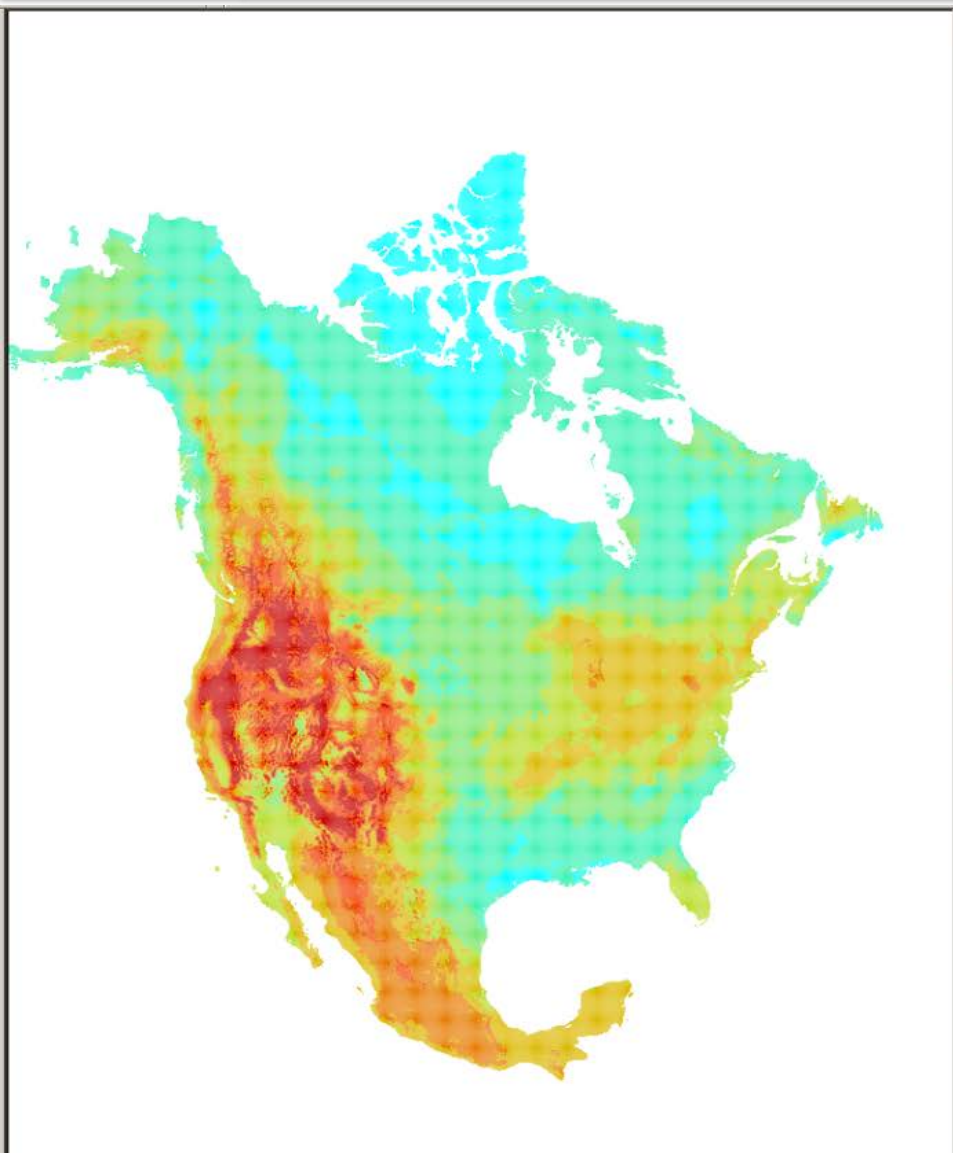






# Lifemapper

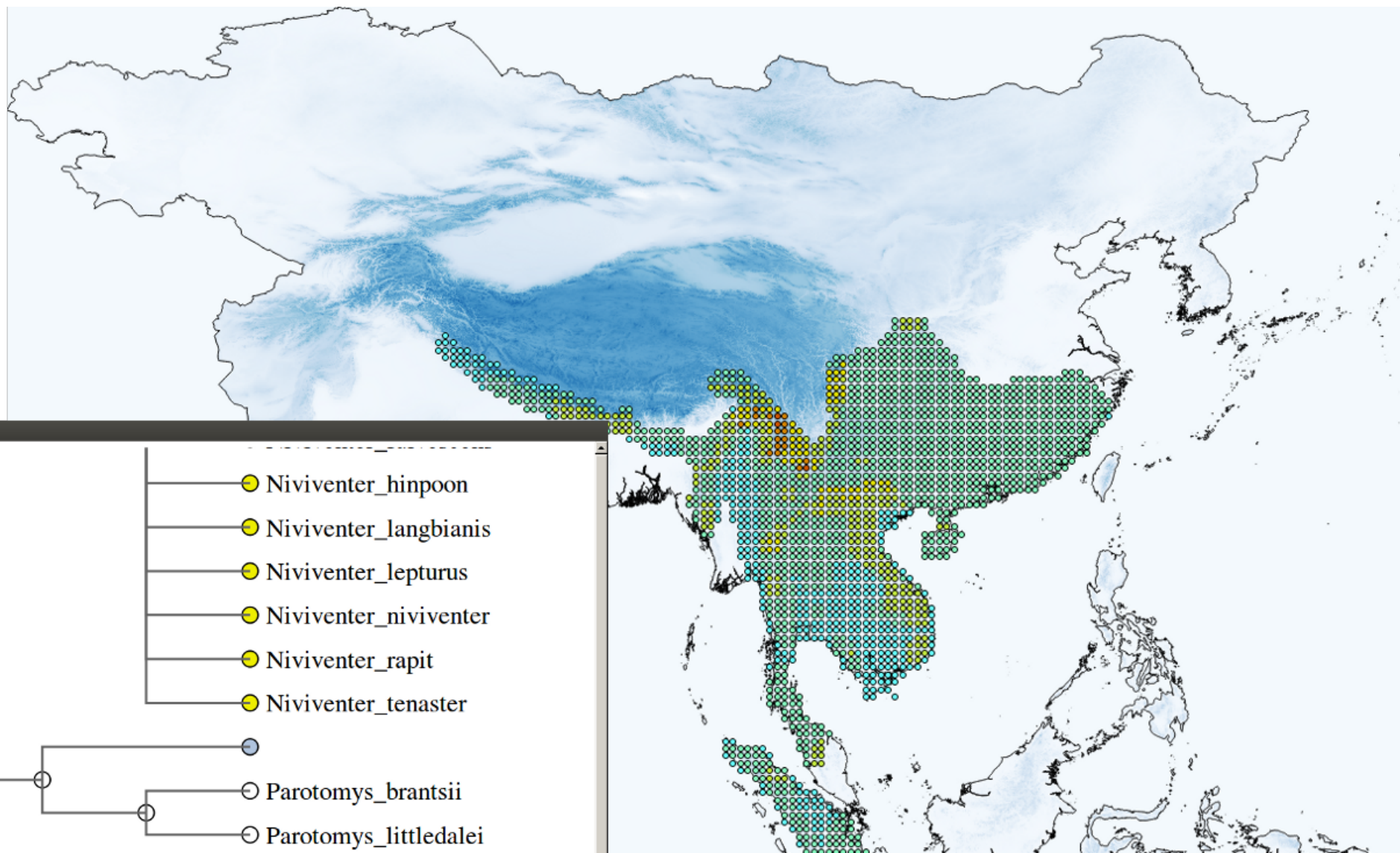
Using PAMs for Predicting Patterns of Diversity





# Lifemapper

## Mapping Diversity across a Species' Range



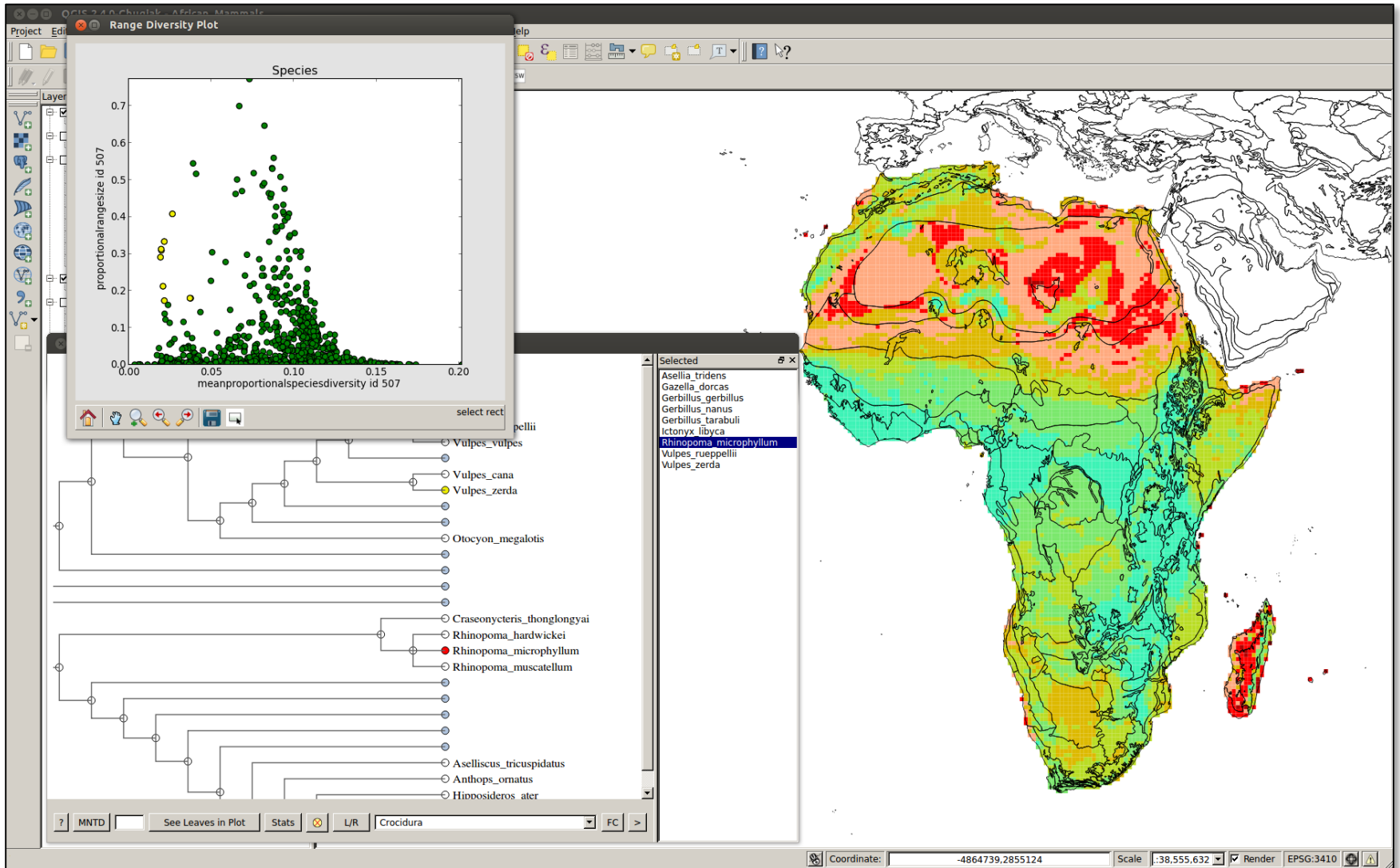






# Lifemapper

Grand Integration: Phylogeny, Biogeography, Diversity







# Lifemapper

Finish