Metapopulation capacity with self-colonization:

Finding the best patches in fragmented habitats

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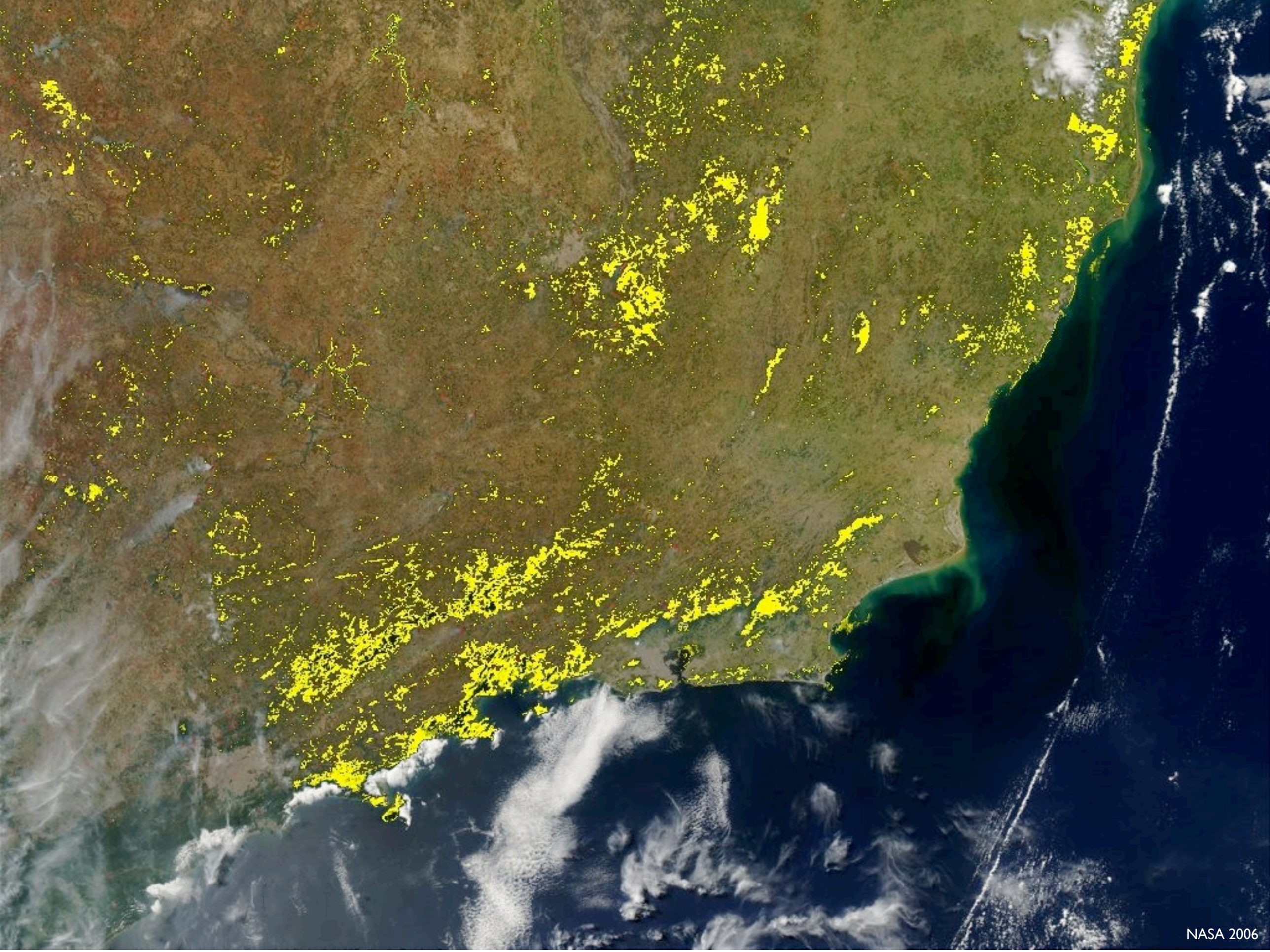
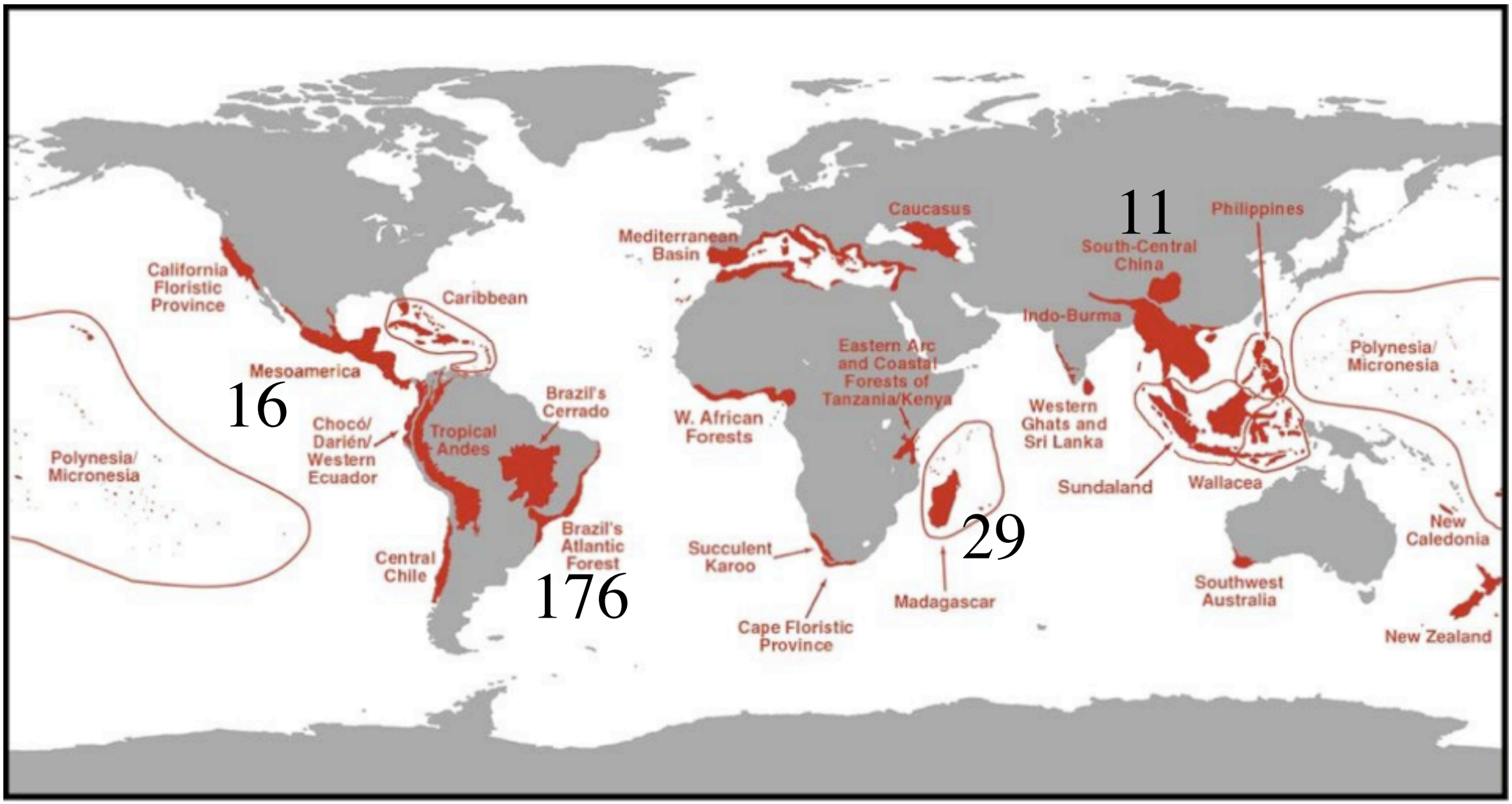

NASA 2006

Range Data



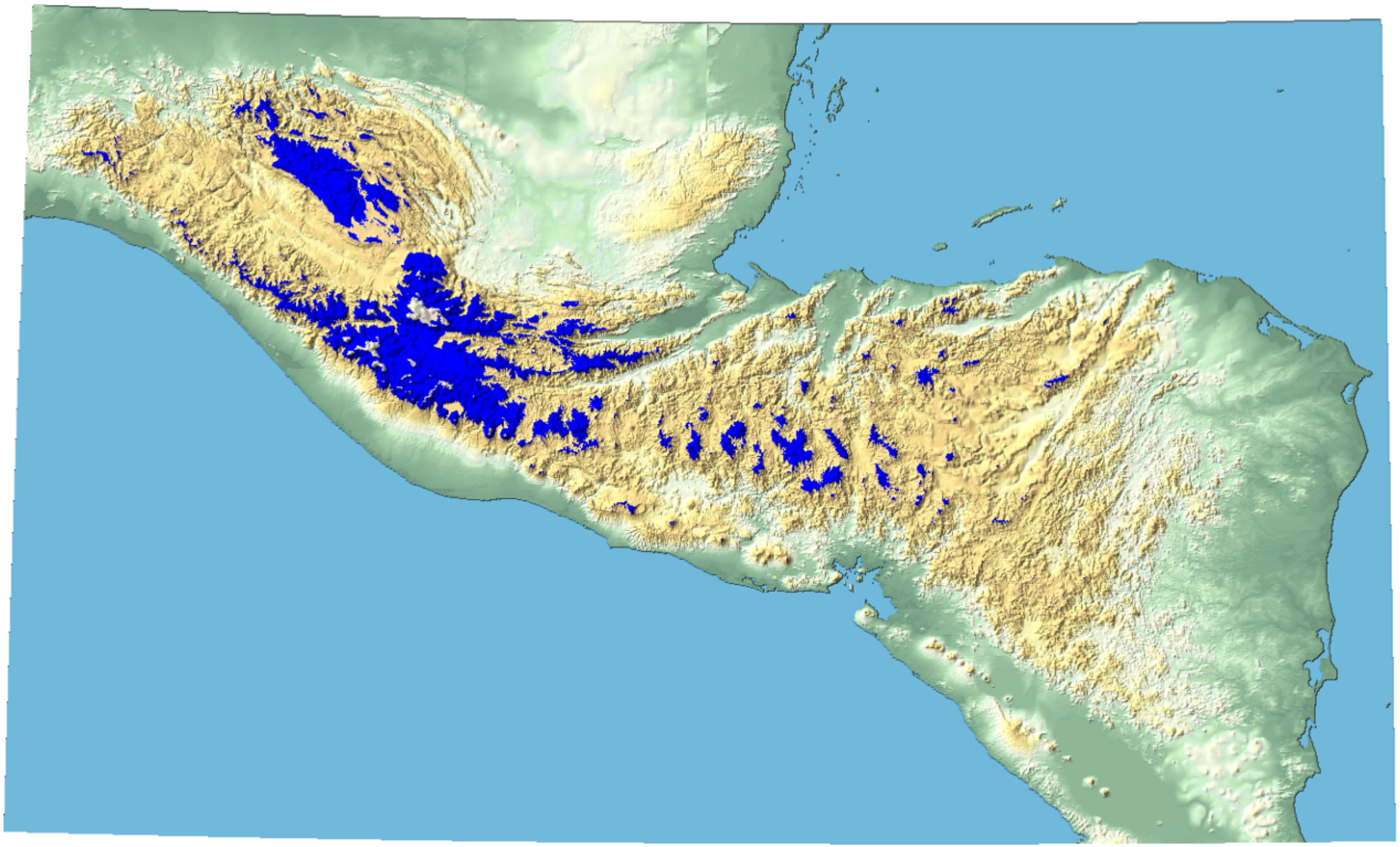
Myers et al 2000

“Guide book” range

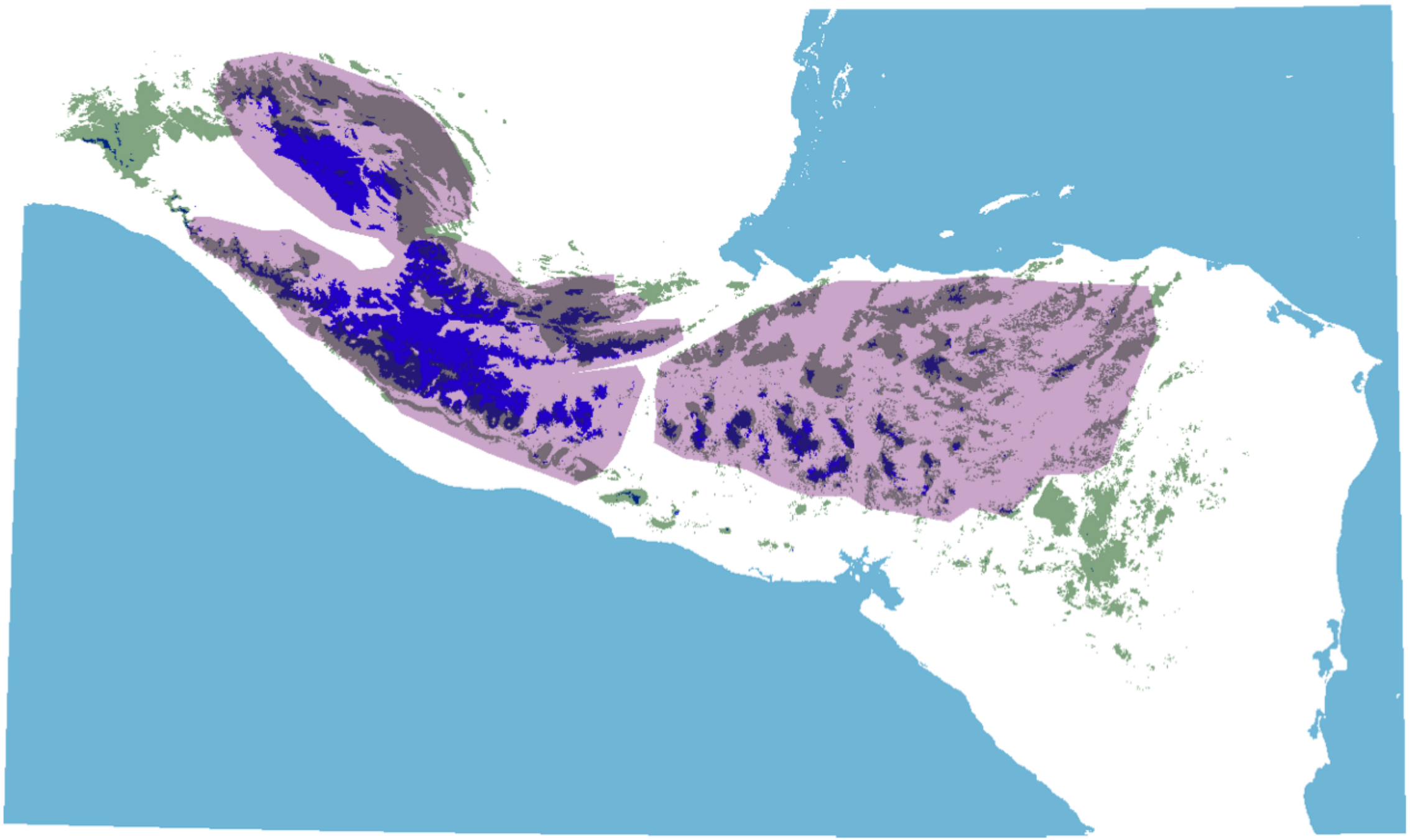
Black-throated Jay (*Cyanolyca pumilo*)

Original extent of wet forest

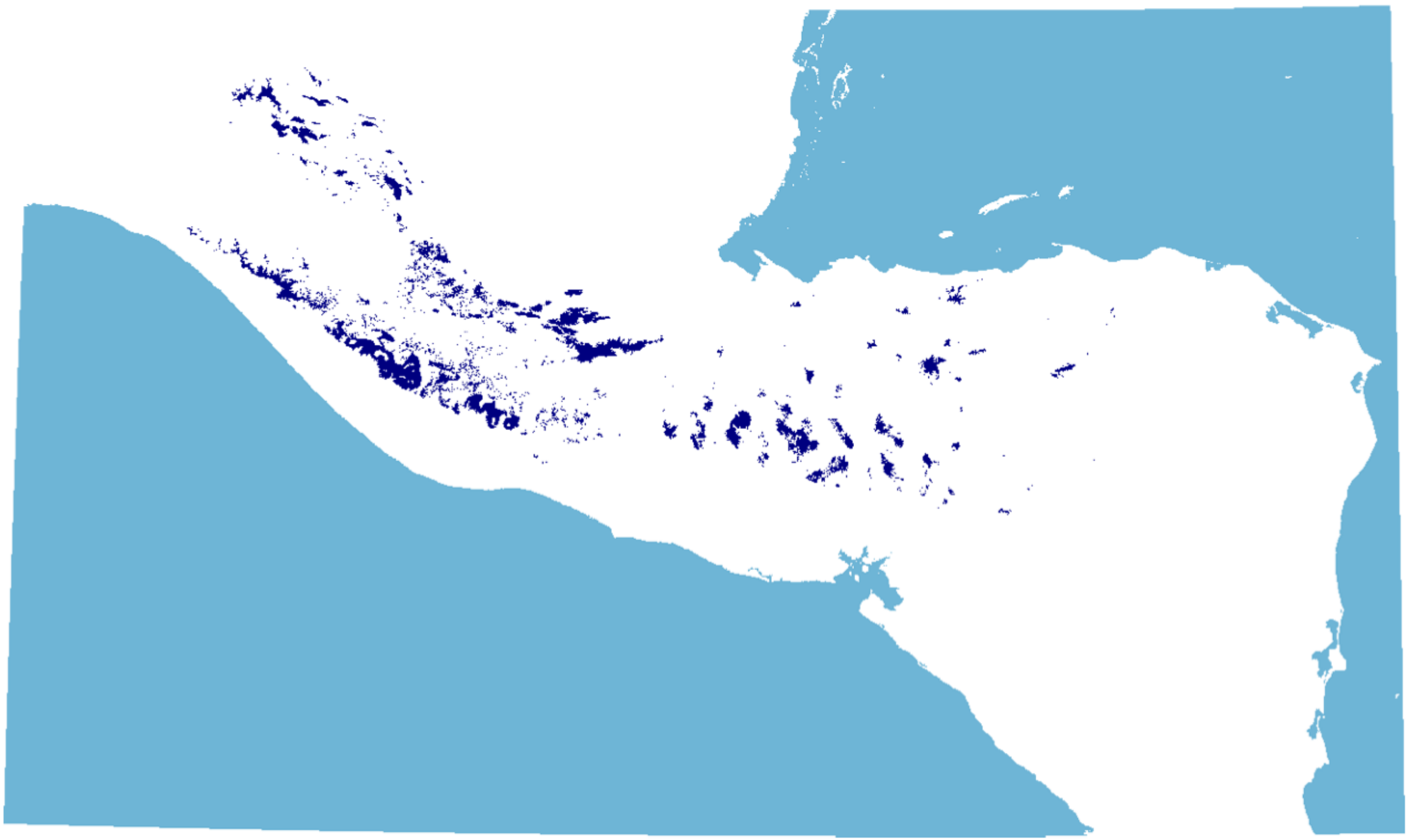
Species-specific elevation range



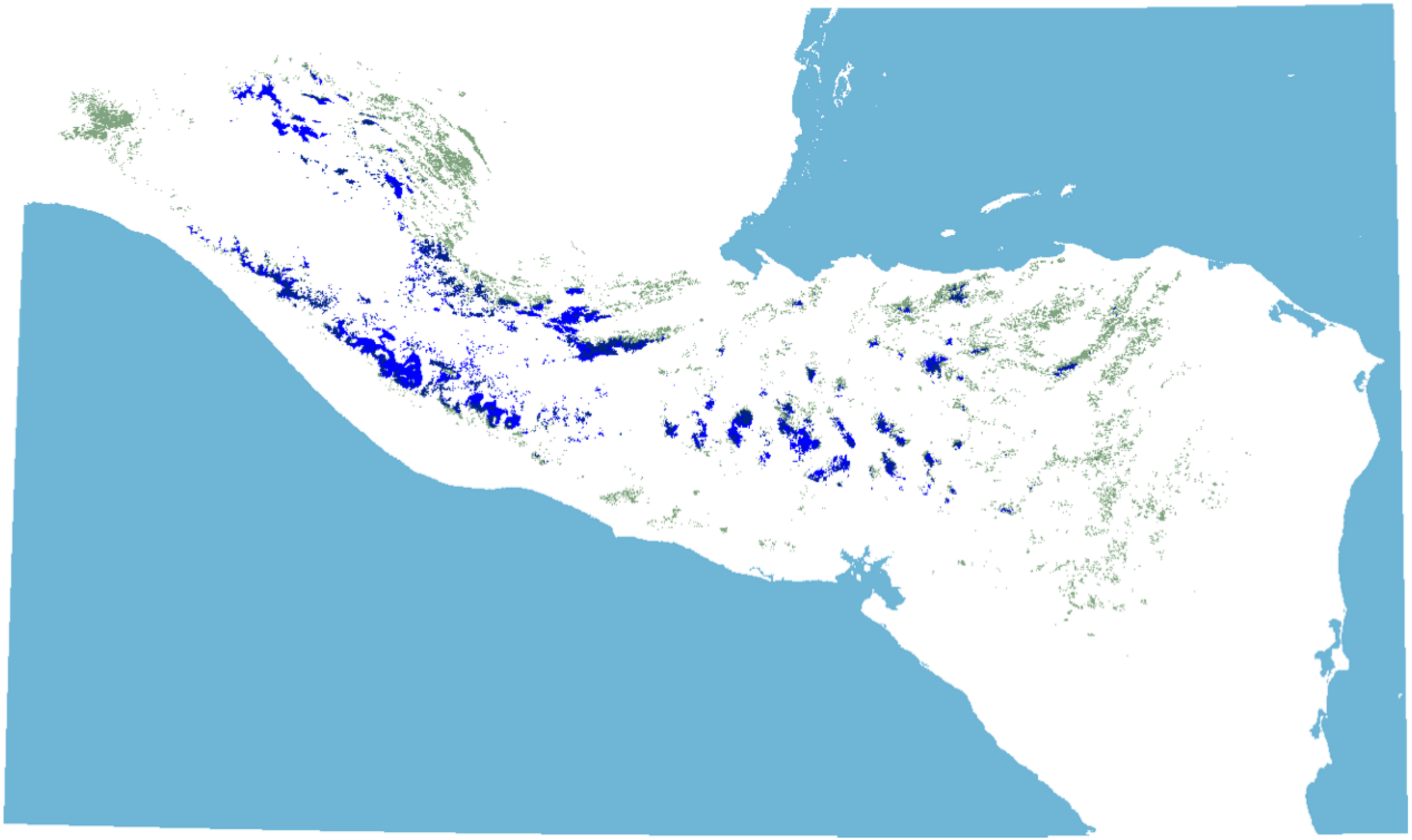
All three layers



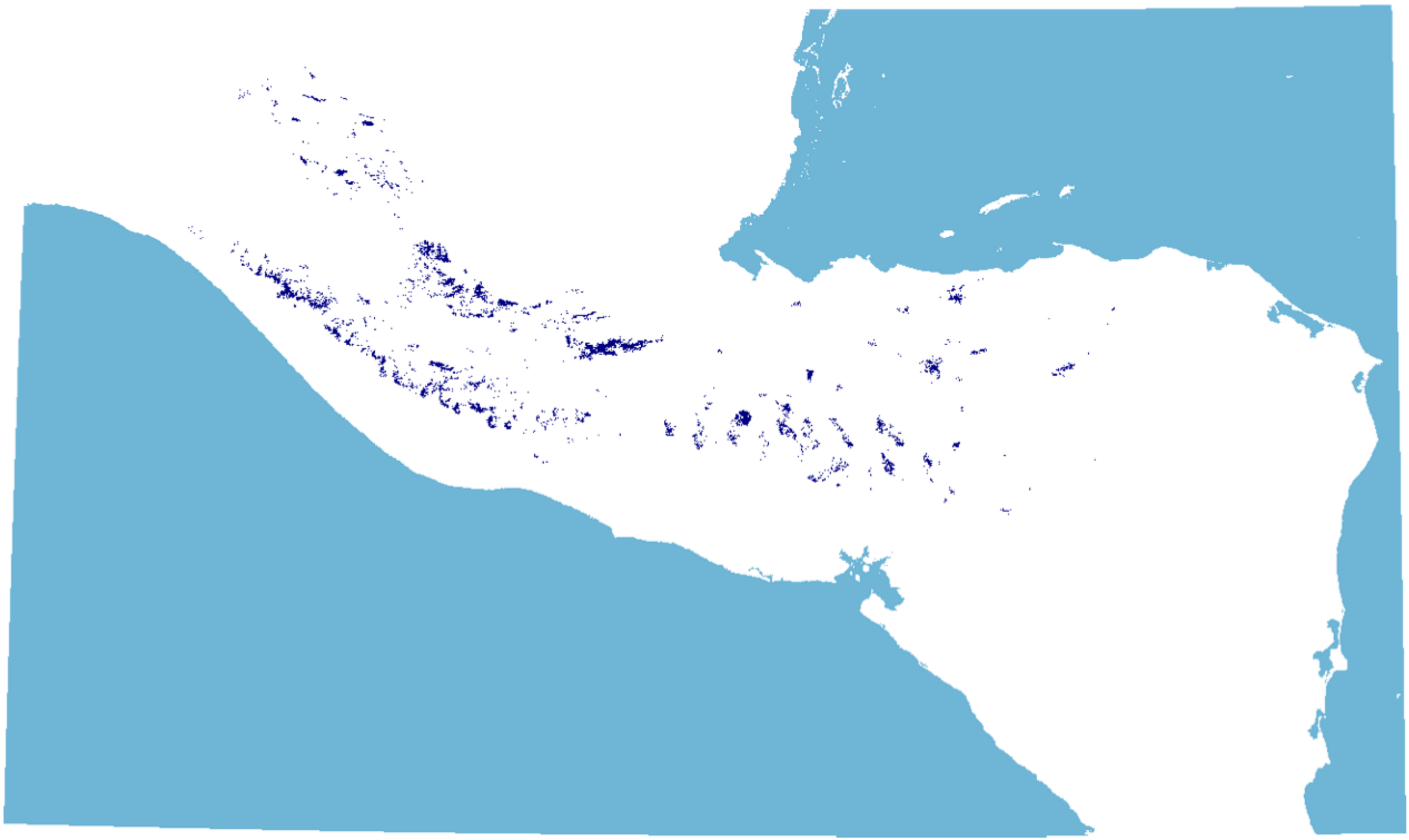
Intersection = Original Range



Remaining extent of wet forest



Intersection = Remaining Range



Black-throated Jay

- original range
- remaining range

Metapopulation dynamics

- individuals persist via interpatch migration which offsets local extinction (Levins 1969)

$$\frac{\mathrm{d}p_i(t)}{\mathrm{d}t} = (\text{Colonization rate}_i)[1\text{-}p_i(t)] - (\text{Extinction rate}_i)\ p_i(t)$$

- spatially explicit models (Hanski 1994)

$$\frac{\mathrm{d}p_i(t)}{\mathrm{d}t} = \left(C \sum_{i \neq j}^{n} p_j\ e^{-\alpha D_{ij}}\ A_j \right) [1 - p_i(t)] - \left(\frac{E}{{A_i}^x} \right) p_i(t)$$

Method 1: Metapopulation Capacity

- "metapopulation capacity is the leading eigenvalue of an appropriate 'landscape' matrix" (Hanski & Ovaskainen 2000), *with* self-colonization

$$m_{ij} = \begin{cases} e^{-\alpha D_{ij}} A_j A_i^{0.5} & j \neq i \\ A_j A_i^{0.5} & j = i \end{cases}$$

Method 2: Abandonment Rate

- initial rate of decrease of patch occupancy (population "contracts" after fragmentation) from a fully-occupied range with a rescue effect

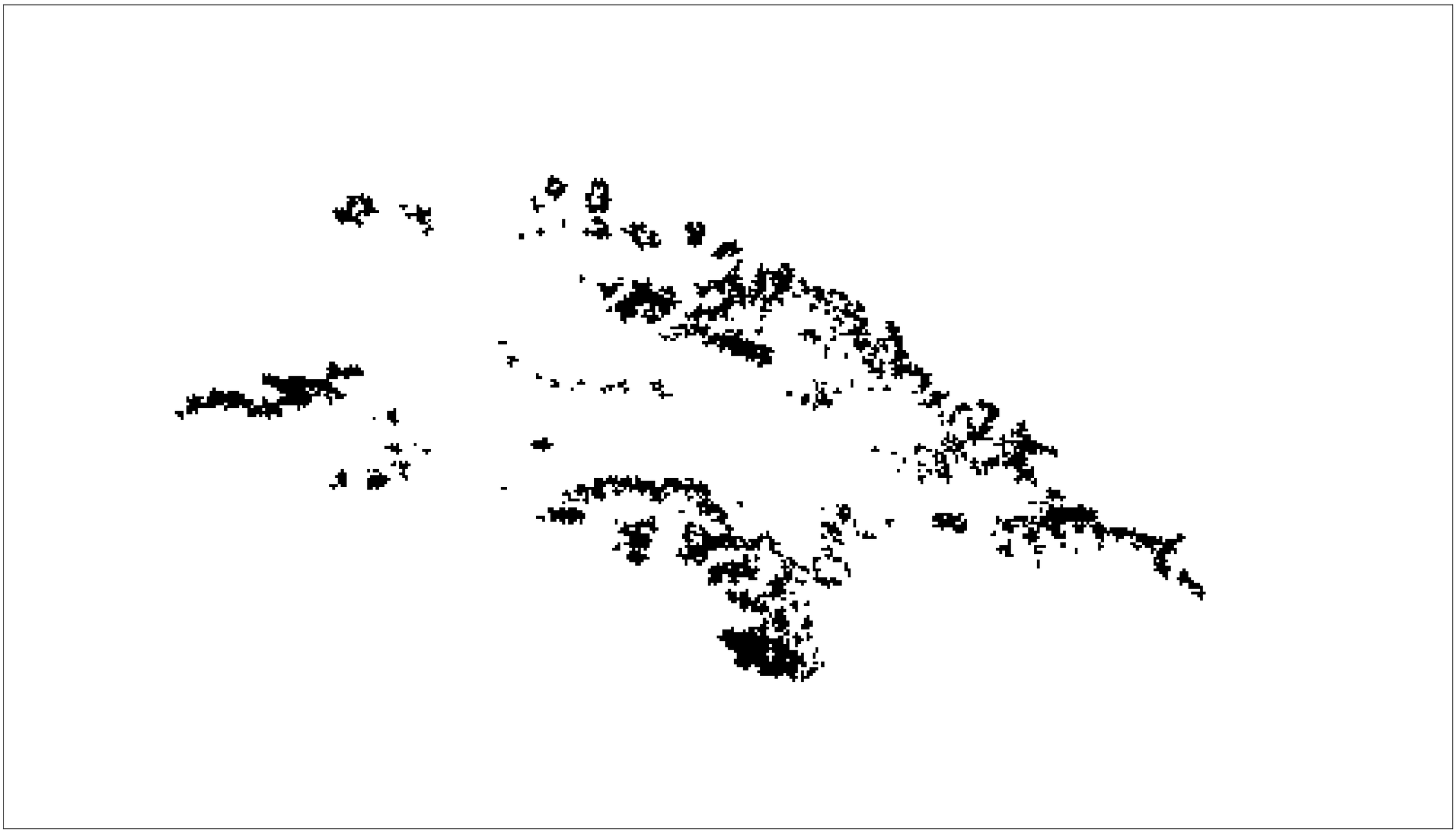
$$\delta_i = Ext_i \frac{Ext_i}{Col_i + Ext_i}$$

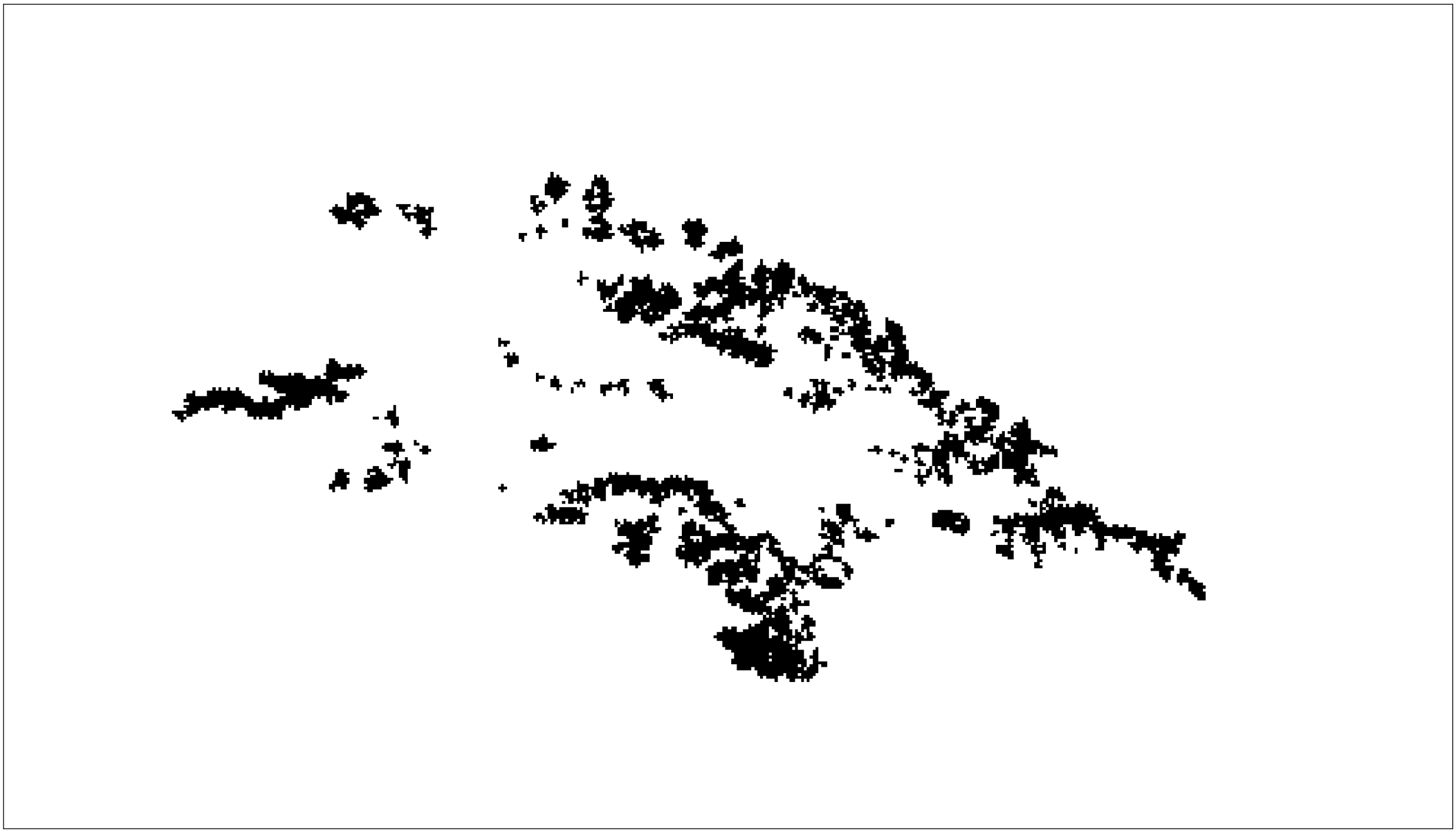
$$\Delta = \sum \delta_i$$

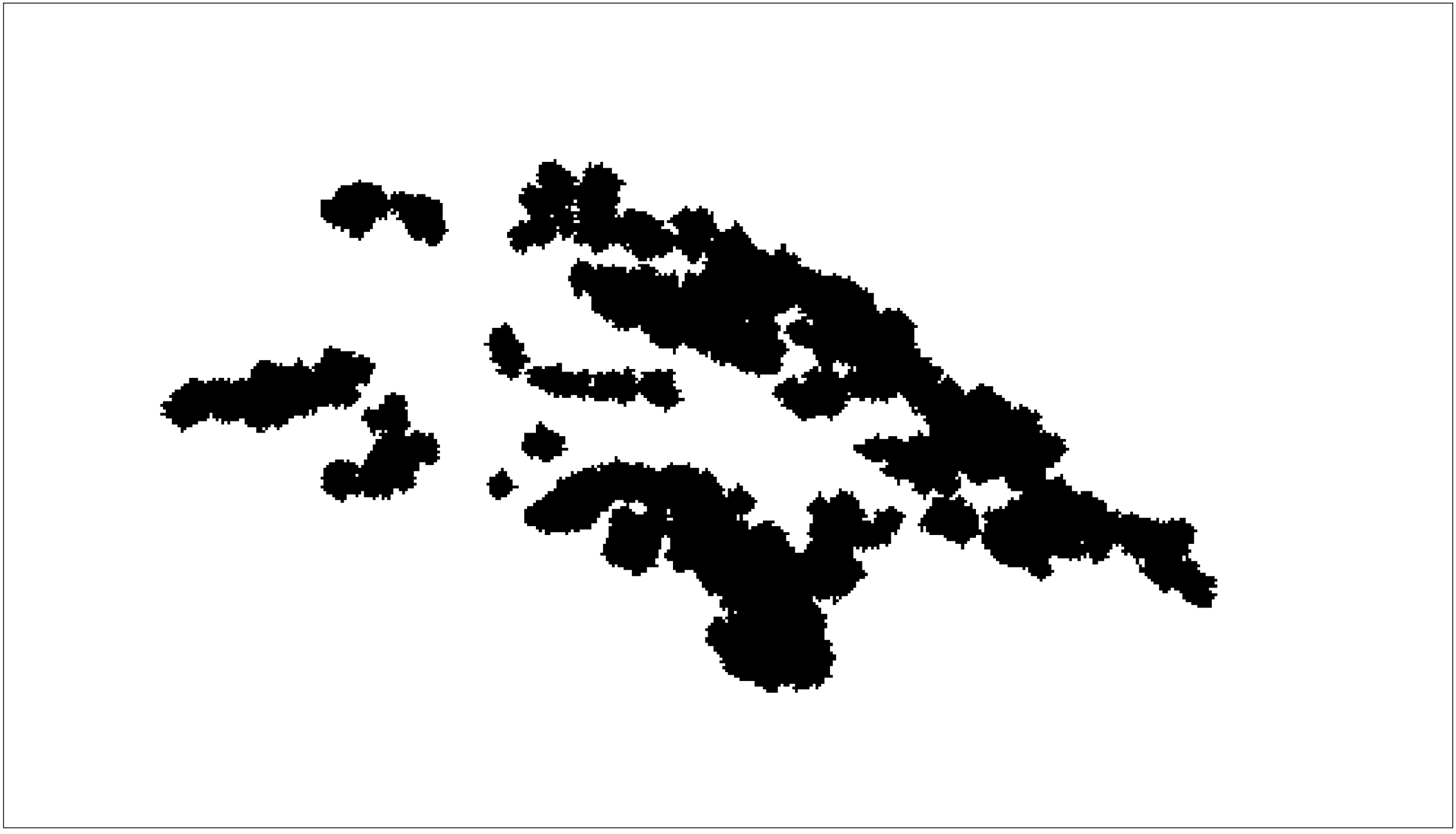
$$Ext_i = \frac{E}{A_i^{0.5}} \qquad Col_i = C \sum_{j \neq i} e^{-\alpha D_{ij}} A_j p_j(t)$$

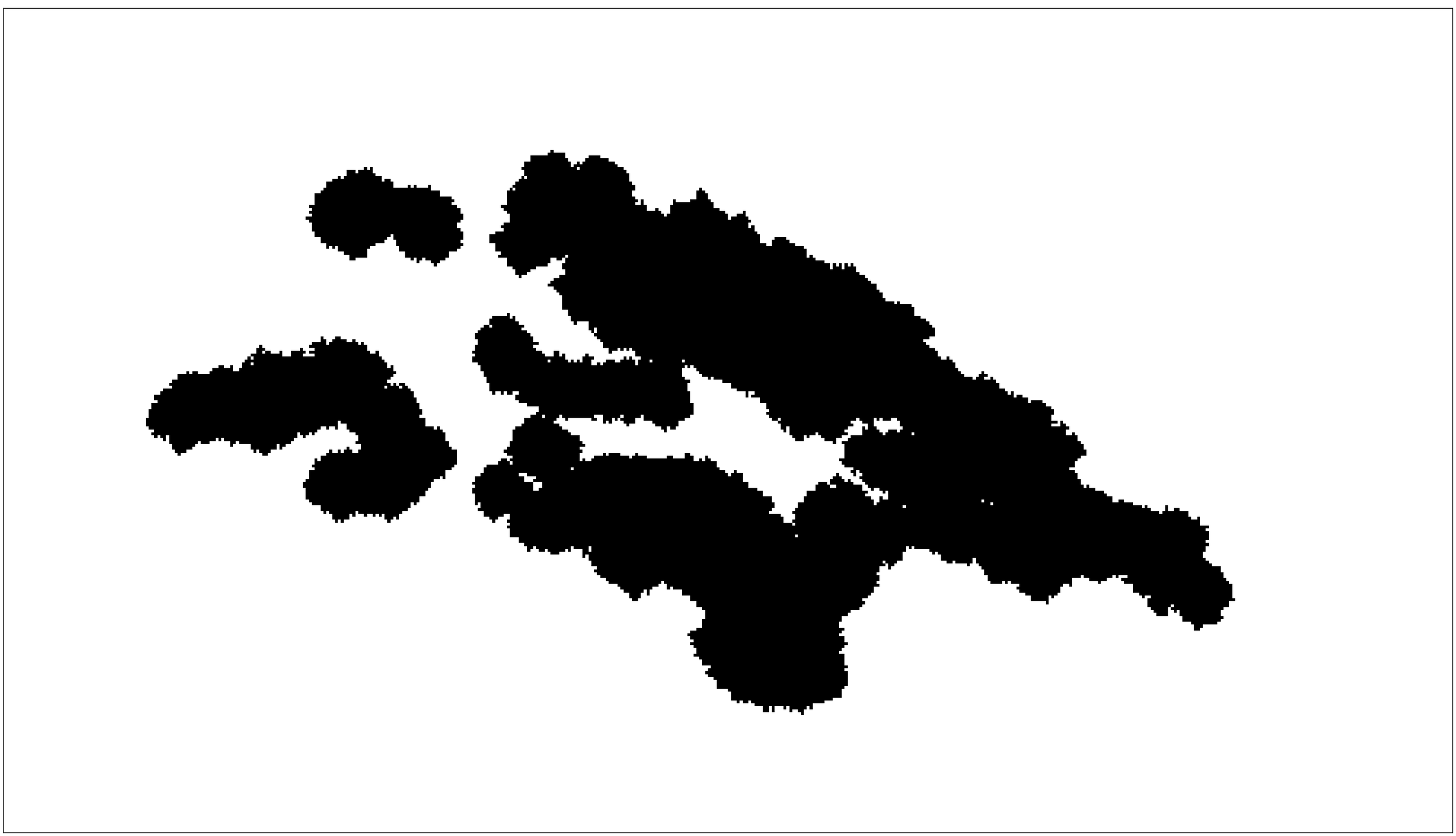
“Reverse” Fragmentation simulation

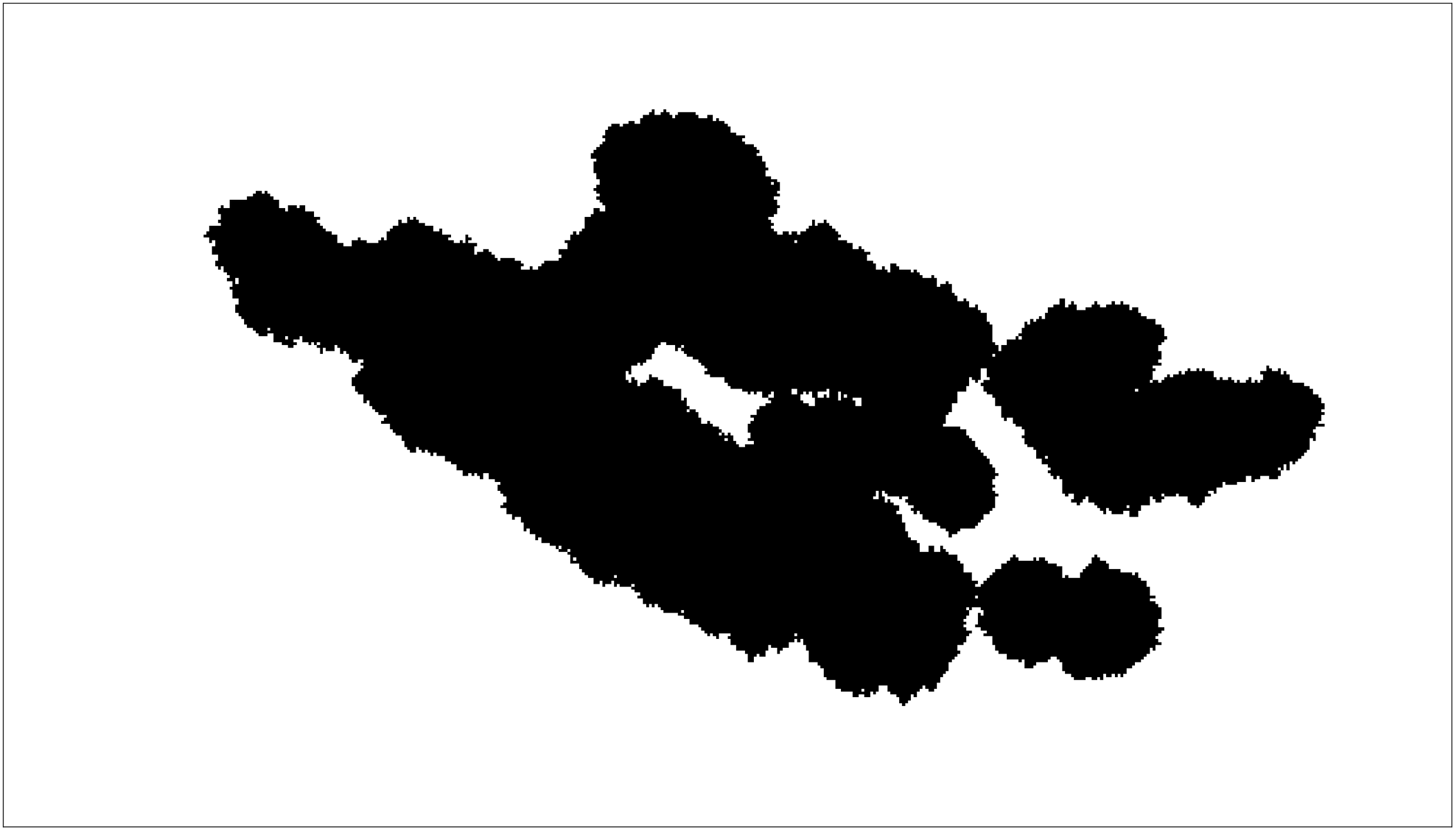
Pink-headed Warbler (*Ergaticus versicolor*)



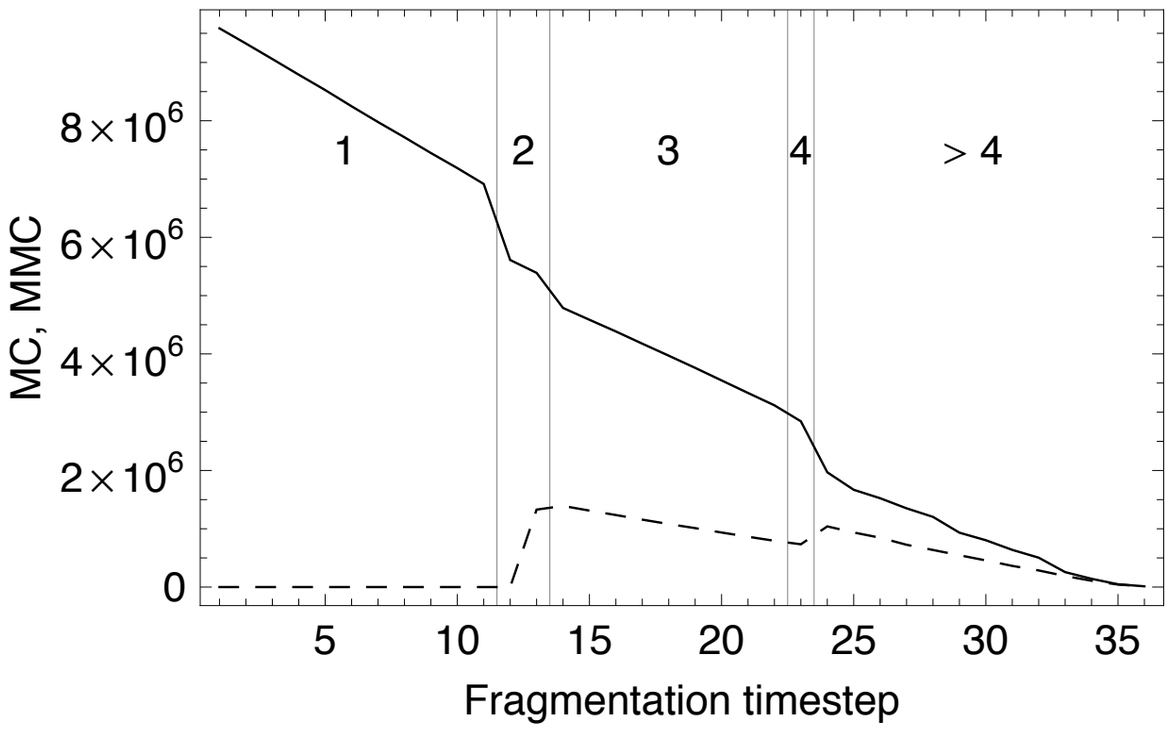


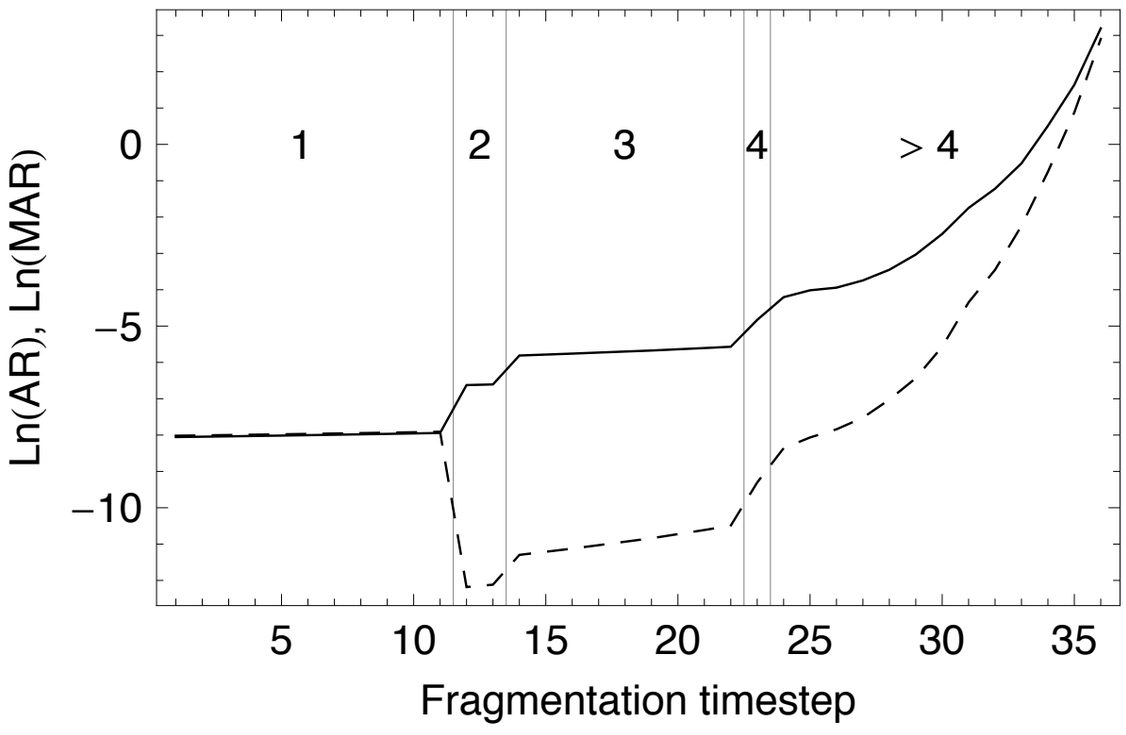






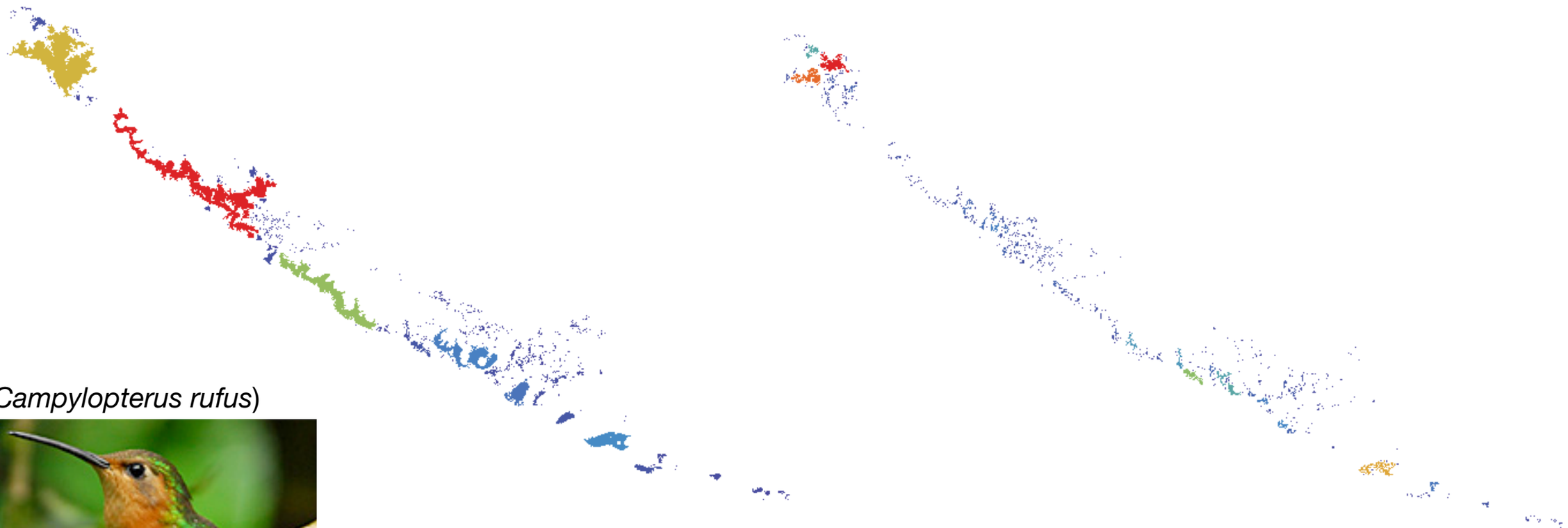
How our metrics differ





We can compare fragmentation (over time)

Rufous Sabrewing (LC)

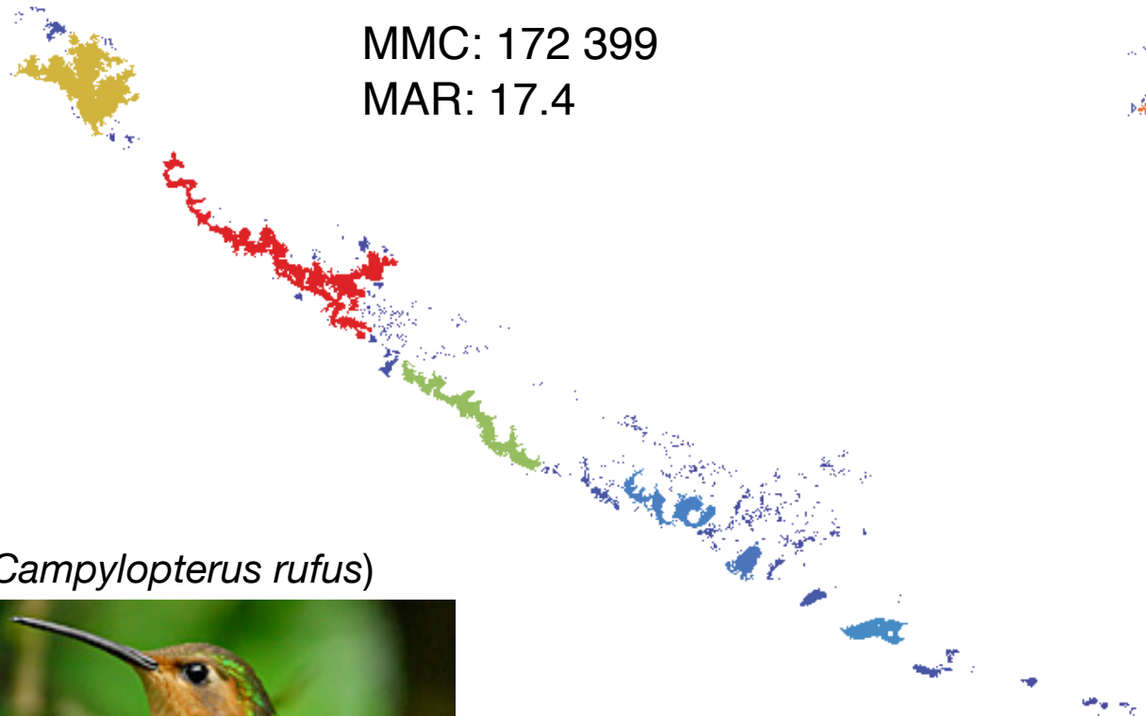


(*Campylopterus rufus*)

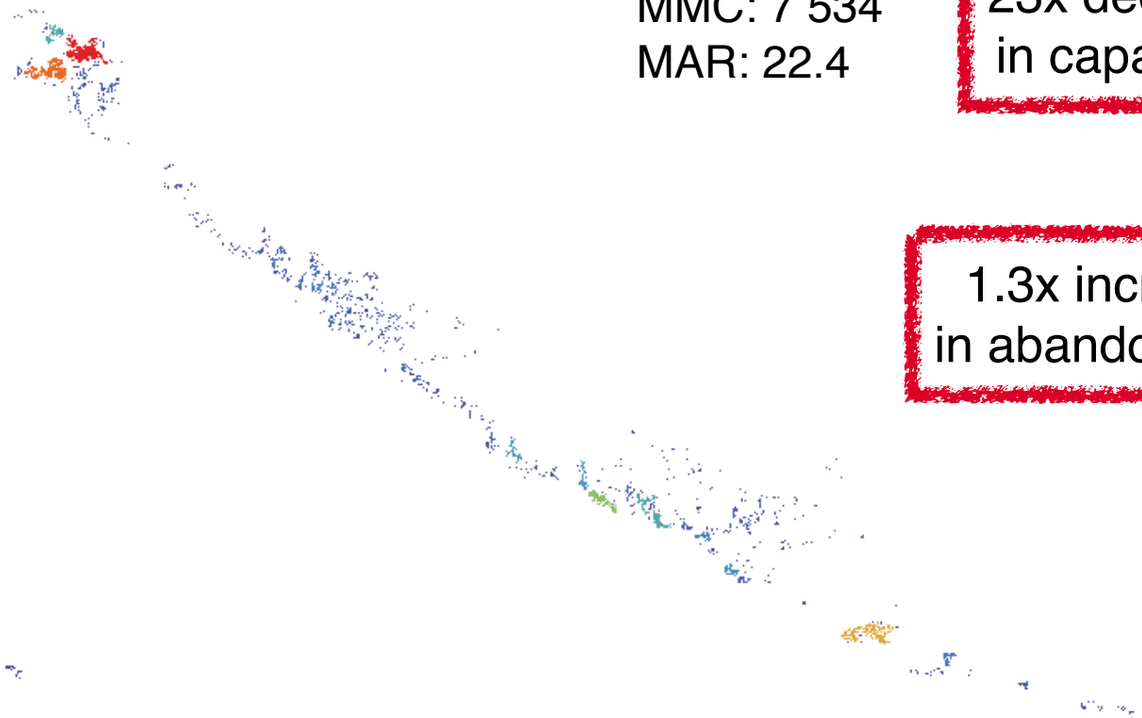
...at the landscape level

Rufous Sabrewing (LC)

MMC: 172 399
MAR: 17.4



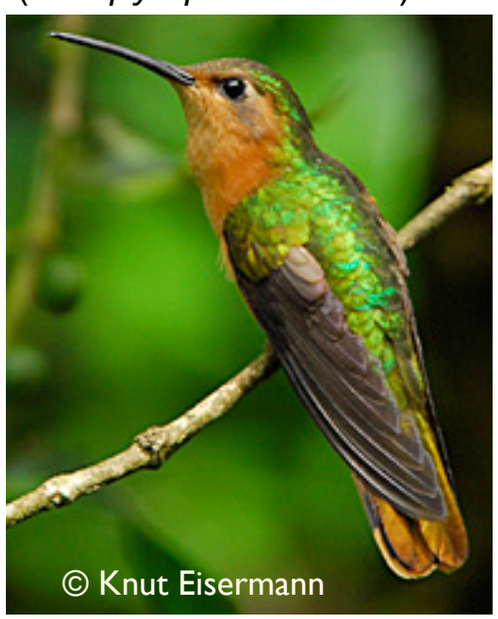
MMC: 7 534
MAR: 22.4



23x decline in capacity

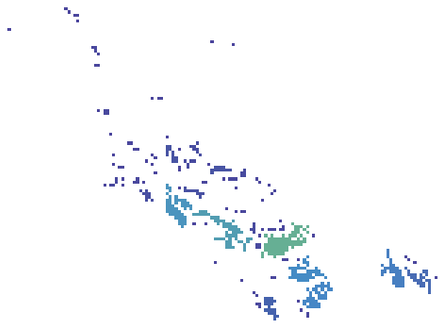
1.3x increase in abandonment

(*Campylopterus rufus*)

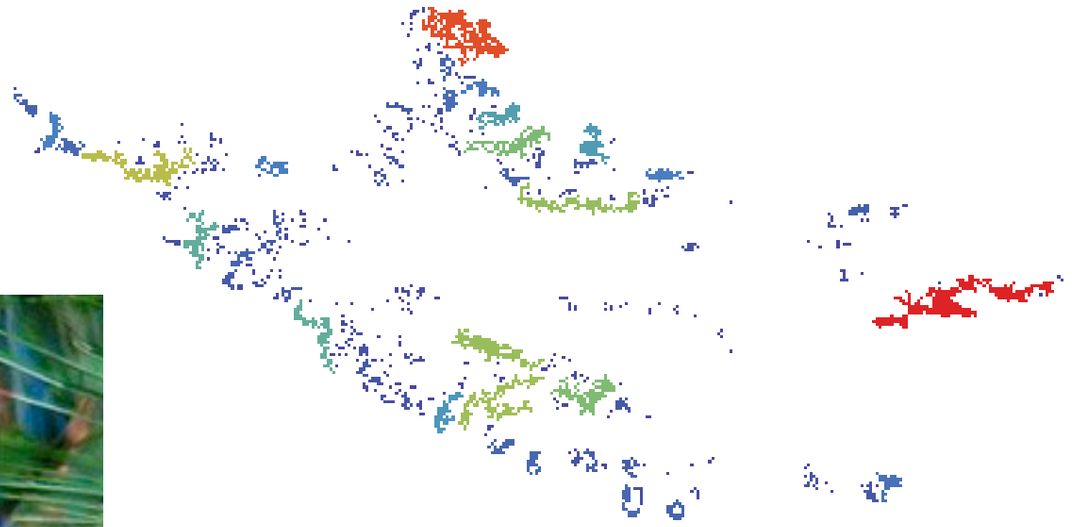


...at the patch level

Pink-headed Warbler (VU)



(*Ergaticus versicolor*)

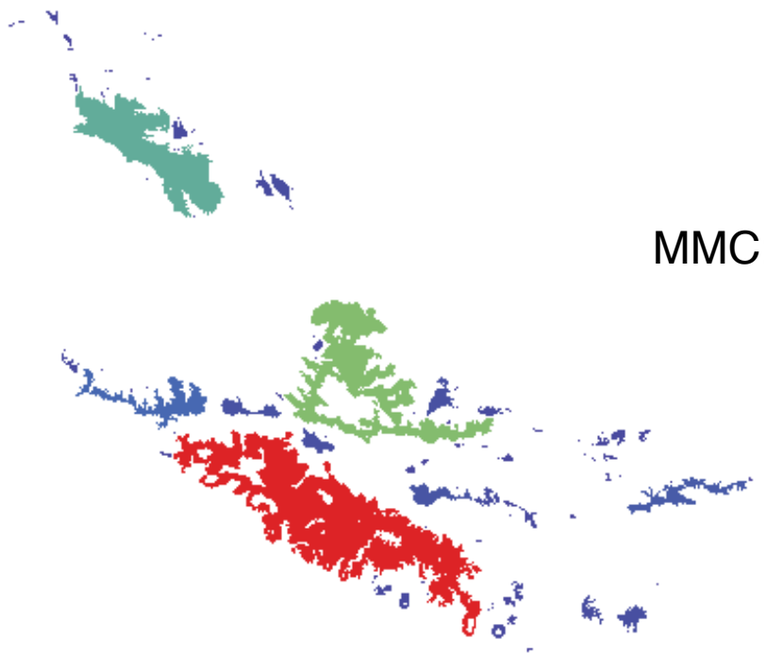


Can IUCN listings be more objective?

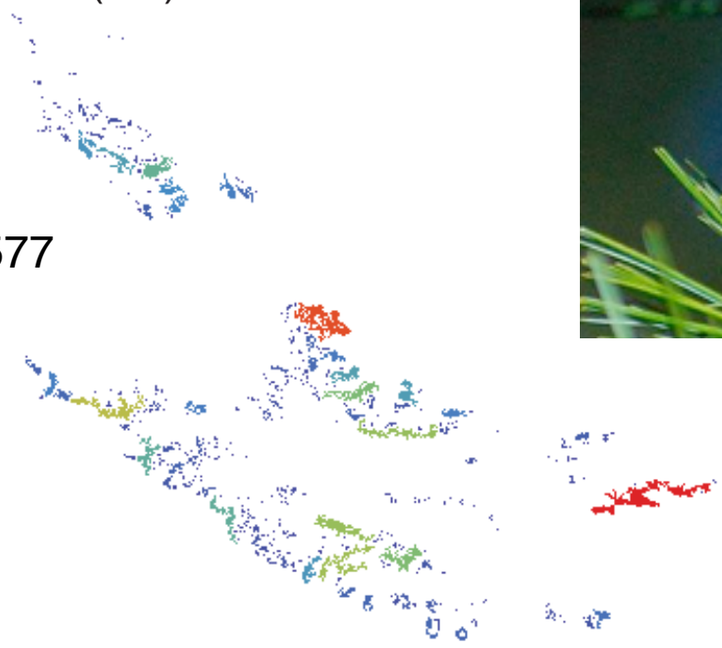
(*Ergaticus versicolor*)

Pink-headed Warbler (VU)

MMC: 476 264



MMC: 19 577

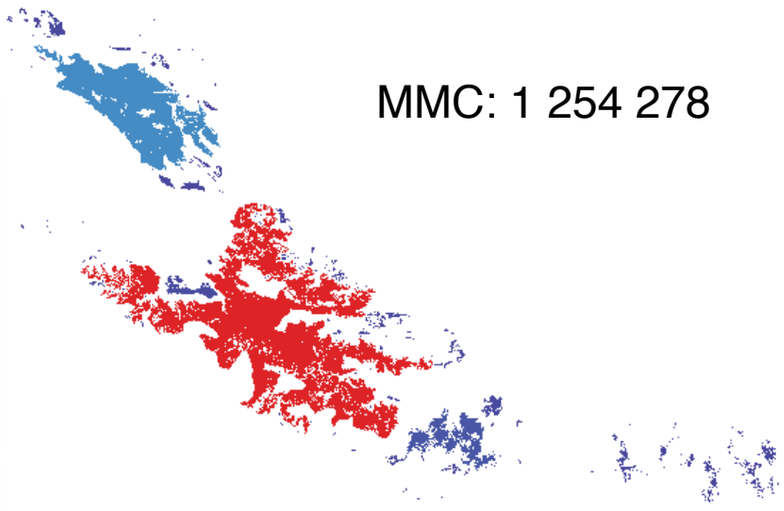


24x loss in capacity

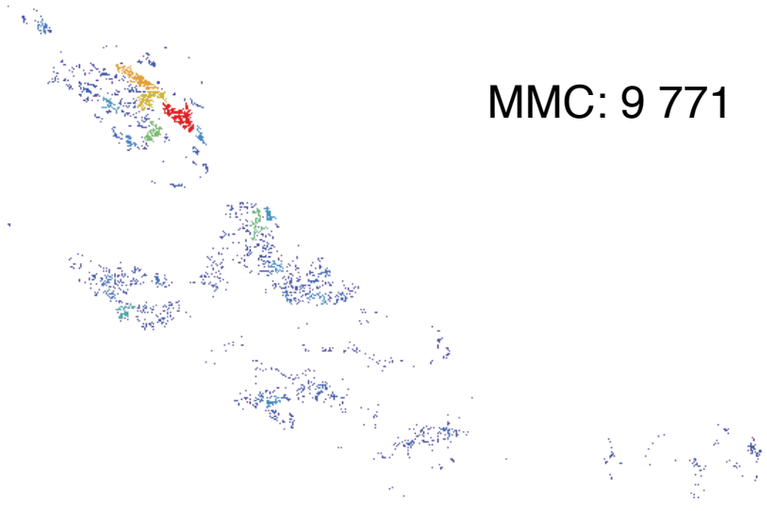
Black-capped Swallow (LC)

(*Notiochelidon pileata*)

MMC: 1 254 278



MMC: 9 771

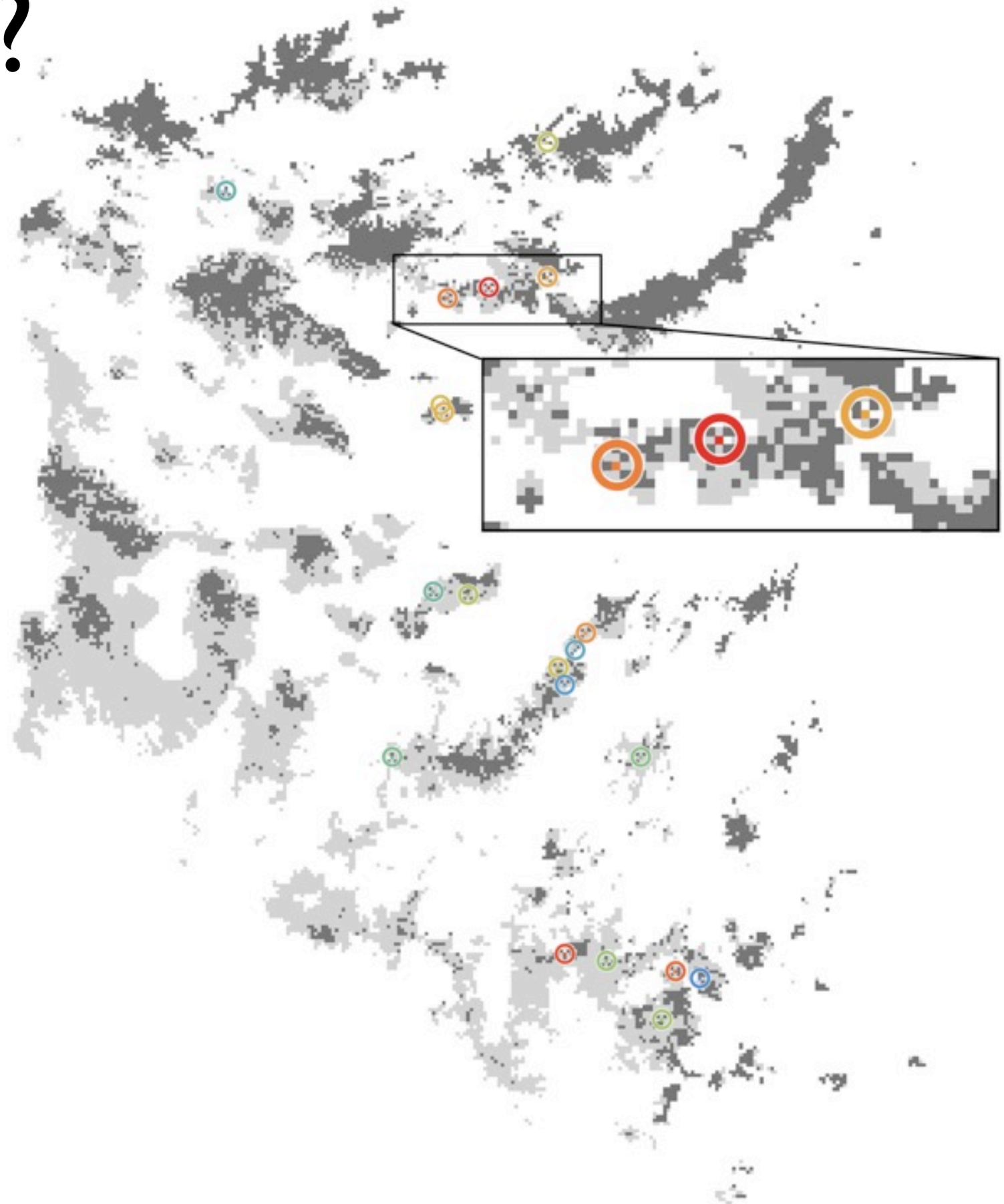


128x loss in capacity

Conclusions

- Modern data products and models allow for relatively consistent and sophisticated assessment of the impact of forest fragmentation
- While they may not replace current evaluation methods, these metrics force us to confront complex questions about how we assess extinction threat

Restoration?



Green-breasted Mountain-gem (*Lampornis sybillae*)

Simply the best...

Acknowledgements

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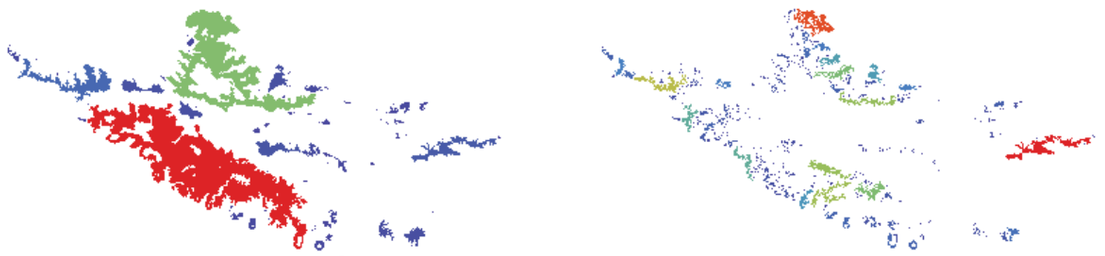
Questions?

NASA 2006

Rufous Sabrewing
172000 — 7500
17 — 22
LC

Pink-headed Warbler
476000 — 19500
4 — 18
VU



Black-throated Swallow
1254000 — 9800
12 — 35
LC