The drivers of restoration success: a global meta-analysis for forest structures and biodiversity

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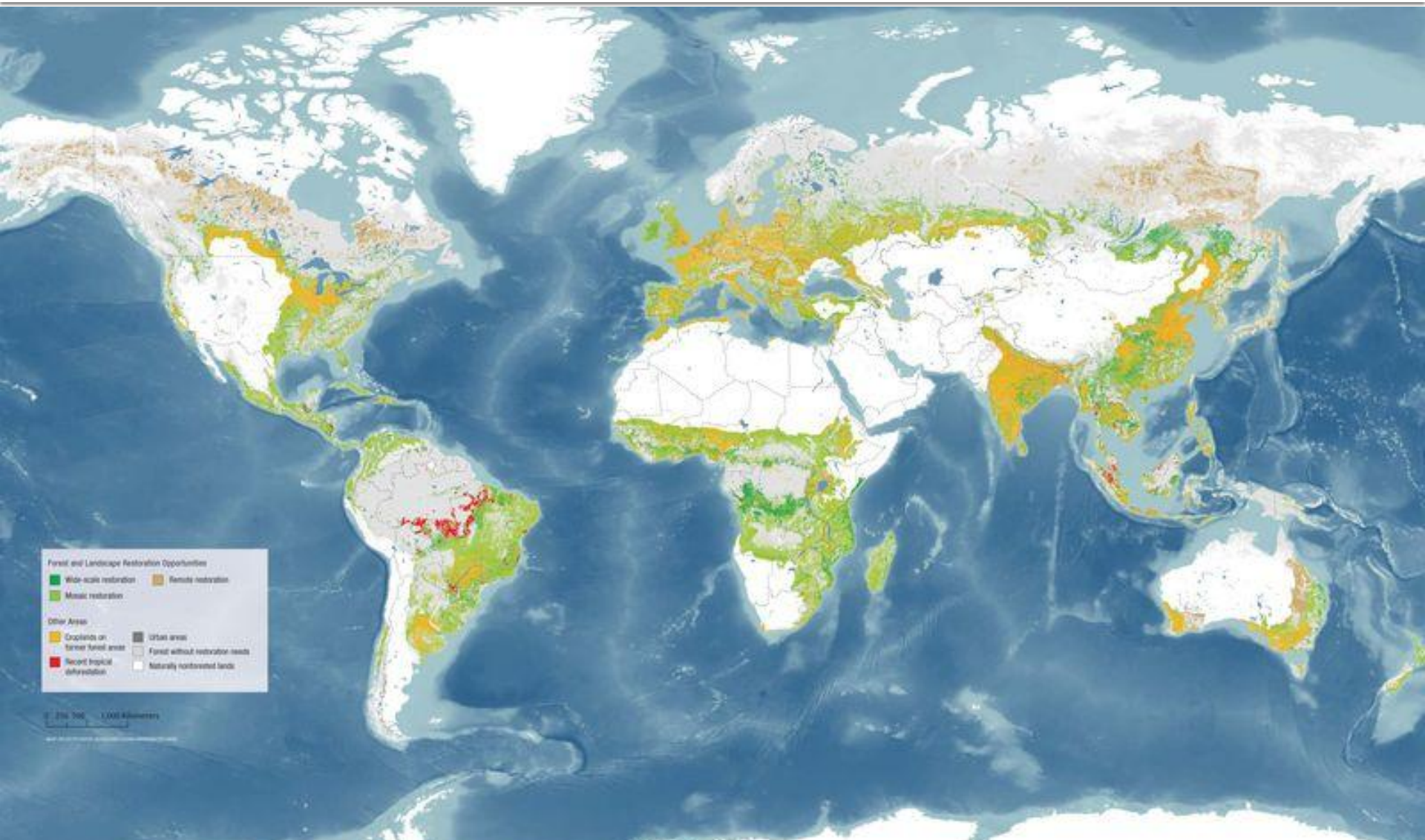
Recovery of forest land is a global priority



Restoration initiatives are widespread and billions of dollars have been spent

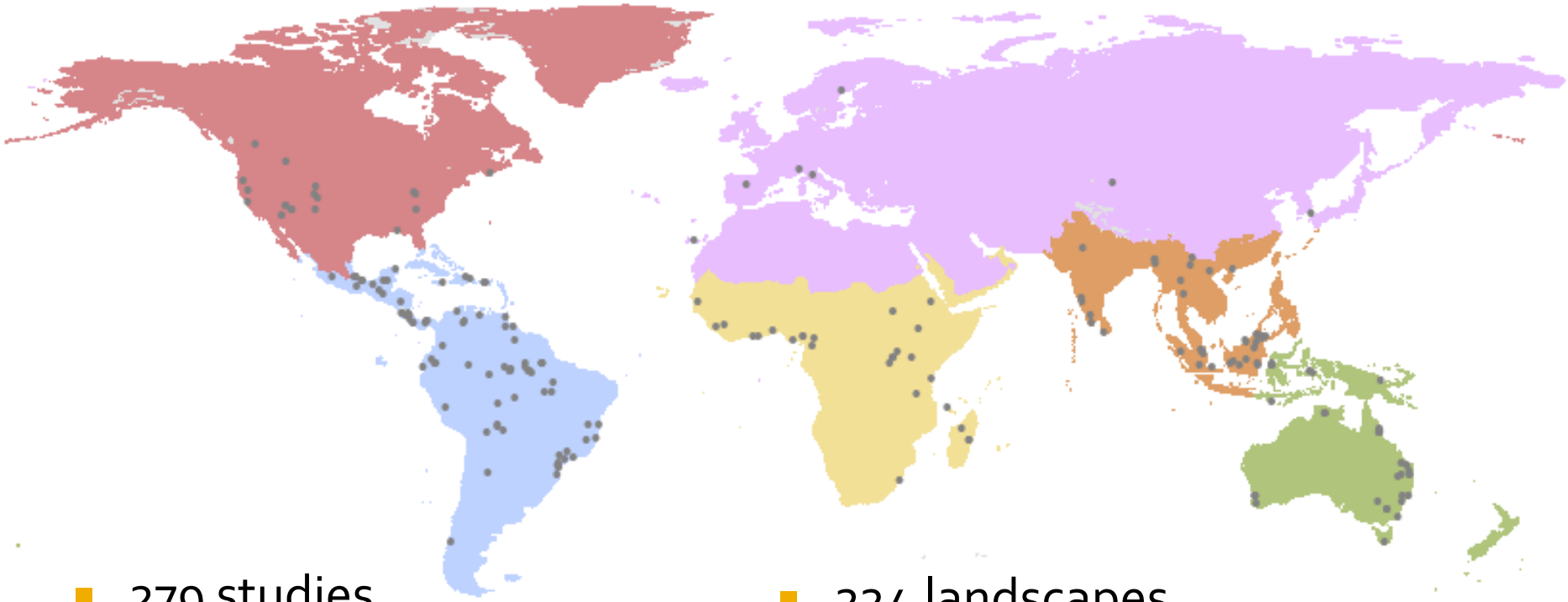
Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead

Katharine N. Suding 2011

The drivers underpinning the restoration success remain unclear.

What are the main drivers of restoration success for forest structures and biodiversity?

Global meta-analysis – most comprehensive dataset for forest restoration success to date



- 279 studies
- 53 countries
- 6 of 7 geographic regions
- 224 landscapes
- 4,772 quantitative comparisons between reference and disturbed

Extensive analysis of all recorded studies compiled by seven key reviews on restoration

Criteria:

i) conducted in forest ecosystems

ii) multiple sampling sites to measure forest structures/ biodiversity

iii) old-growth forests as reference to the disturbed system

- Disturbed systems - restored forests or degraded lands

- **Biodiversity** - mammals, birds, herpetofauna, invertebrates, plants
- **Forest structures** - litter, density, cover, biomass, height

Meta-analysis and model selection

- **8 drivers of restoration success:**

Local

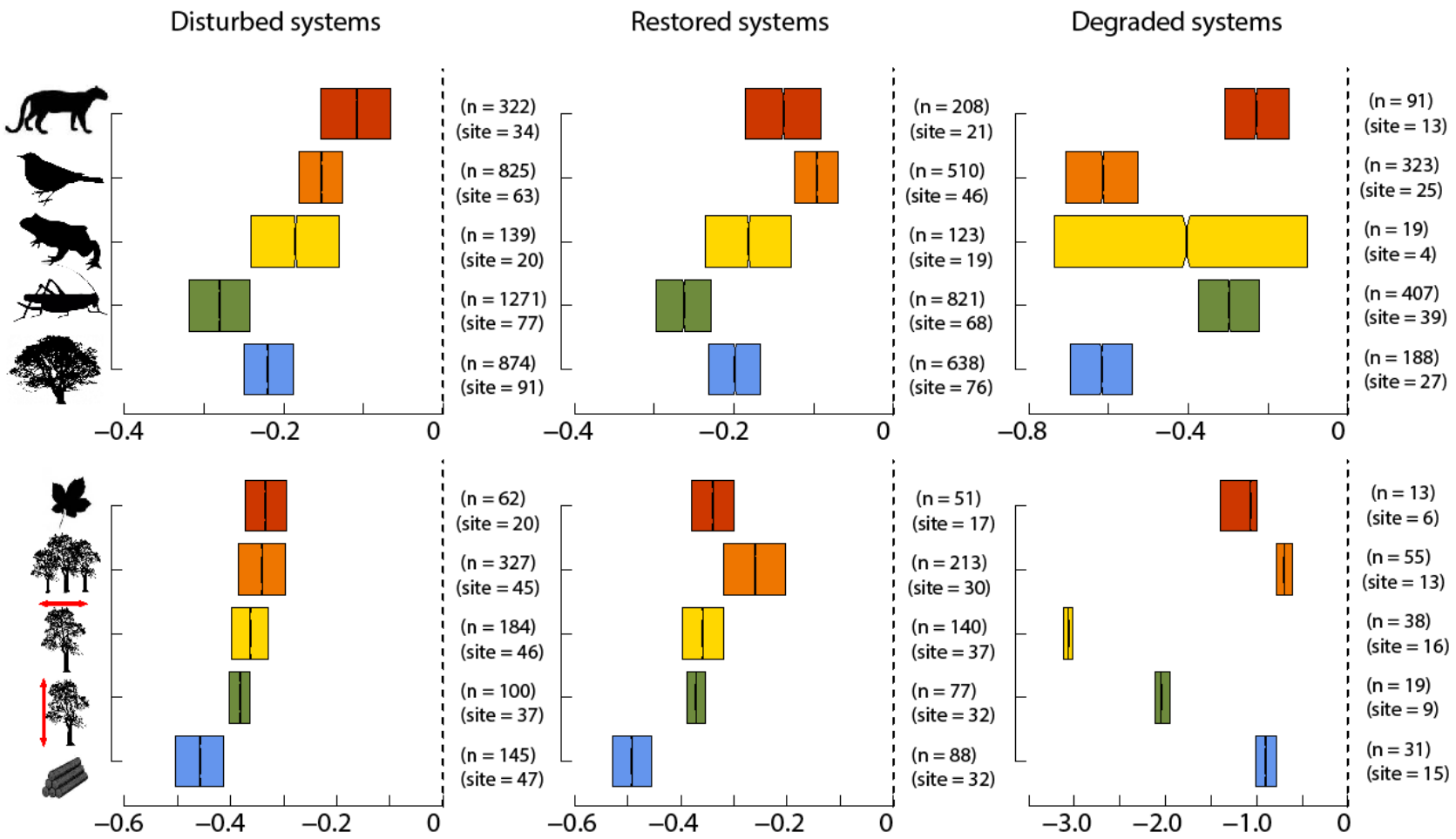
(i) disturbance type or restoration conversion class
(ii) time under disturbance or since restoration took place
(iii) restoration activity or land use

Landscape

(i) mean size of forest patches
(ii) mean isolation of forest patches
(iii) largest patch size
(iv) forest cover
(v) edge/area ratio

- 10,000 bootstraps (1 comparison per landscape)

Restored enhanced >113% of biodiversity and 183% of forest structures to degraded systems



Five main drivers of restoration success

Model	π_i	k	w_i	site	n
PLANTS					
Time (-) + Isolation (-)	21.66	4	0.14	76	677
INVERTEBRATES					
Patch Size (-)	14.09	3	0.16	47	769
BIRDS					
Restored/Land activity	21.27	8	0.20	49	590
MAMMALS					
Null	44.99	2	0.19	19	247
HERPETOFAUNA					
Null	57.41	2	0.26	14	96
COVER					
Time	35.65	3	0.18	39	124
LITTER					
Time (-) + Isolation (-)	26.82	4	0.20	17	48
DENSITY					
Isolation (-)	20.24	3	0.13	37	282
BIOMASS					
Edge/area ratio (+)	35.46	3	0.15	38	111
HEIGHT					
Null	96.18	2	0.11	30	59

- Time under disturbance or since restoration took place (time)
- Restoration/Land activity
- Isolation of forest patches
- Size of forest patches
- Edge/area ratio

Several factors can influence ecological restoration – we identified five main drivers

- **Time** - plants, cover, litter

- High levels of complexity requires long periods of time

  (Dunn 2004; Curran et al. 2014)

- A simple **conversion of agriculture into passively or actively restored lands** can assist the return of bird species

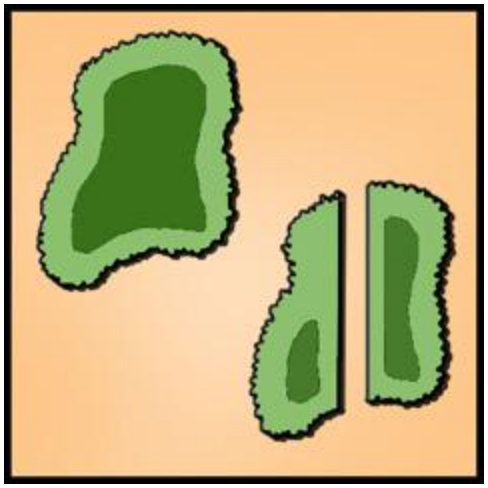
Drivers operating at the landscape scale also influence restoration success

- Passive recovery of secondary forests tends to spread outwards from existing forests (Helmer et al. 2008)

- Low dispersal capacity in the matrix, but **enlarging forests** allow this group colonize new habitats

- Besides the increase in size of forests, it is critical to **reduce the irregular shape of forests**

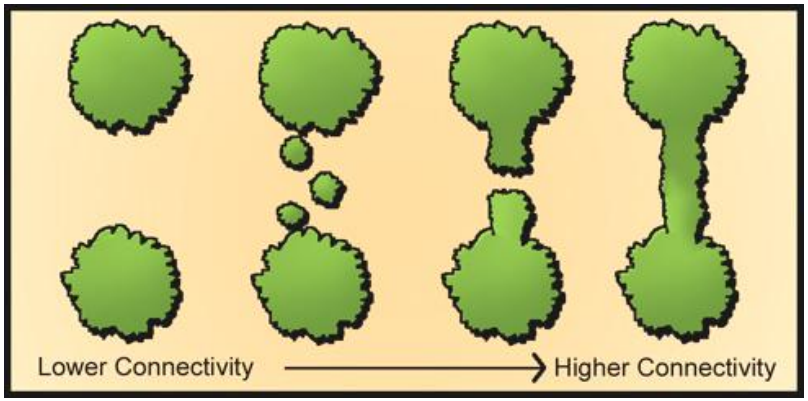
- Increasing edge effects has led to lower biomass (Berenguer et al. 2014)



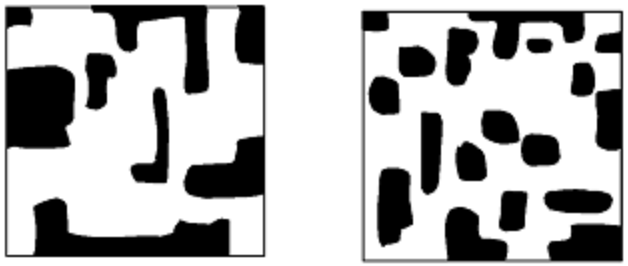
An increase in the isolation tends to enhance plants, litter and density

- This result in fact reflects a **fragmentation process**

- Forest cover and size were strongly positively related to isolation



In our data set



- Increase in forest fragmentation leads to denser understories and higher number of fast-growing pioneer tree species

(Murcia 1995)

Synthesis of main recommendations