USING BIG DATA TO PREDICT RESTORATION POTENTIAL

Andrew R. Marshall, Marion Pfeifer, et al.
Talk Overview

FoRCE
(1) Lianas vs. trees
(2) Restoration planning
[pilots, methods, and intentions]
Why Restore?

Forest Restoration
- TFs: Half lost; One third degraded
- 1 Trillion Trees Campaign
- Bonn Challenge: 350 Mha by 2030

(1) Lianas vs. trees
- Threatening global C sink?
- Neotropics:
  - Liana:tree biomass ↑ 4.6%/yr
  - Tree cover ↑ 50-80%/yr
  - Net carbon uptake ↓ 76%/yr
- But lianas have value
- Big data needed...

“One of the greatest challenges for ecologists this century” (Duncan & Chapman 2003)

Schnitzer, Phillips, van der Heijden, various
Cutting Pilot

- Cutting $\rightarrow$ $\uparrow$ biomass
- Growth $\downarrow$ all size classes
- Net biomass $\uparrow$ 6× faster rate

Pantropical Review

- Impact $\sim$ equivalent across tropics
- Bias: elevation; Neotropics; two pathways? ...
• UY Priming → ARC (& RT/WLT)
• Africa → Australia → upscaling
• Lianas vs. recovery & climate
• Plots / photos / satellite
• Cut some lianas

SO WHAT?
• Extent of impact?
• Threshold response / drivers?
• Can we minimise liana cutting?
Australian Lianas
(should we cut?)

Meremia peltata, Cook’s glory vine
(Convolvulaceae, native)

Cat’s claw creeper (exotic)
FoRCE Plot (0.4ha)

- **Stratification:** (a) climate; (b) degradation
- **Management:** Liana cutting; BACI design
- **SEEKING:** (a) PhDs / postdoc; (b) Collaborators; (c) Asian / Tropical American Sites
(2) FoRCE: Science → Practice

Restoration Planning:
• Seed germination/planting
• Restoration planning
Landscape Restoration Planning

Govts & donors need to set priorities...

Our Approach
(1) Plot data (9 projects)
(2) Estimate biomass & deficit
(3) Method → cost → cost-effectiveness → RESTORATION POTENTIAL
Cost Effectiveness → Restoration potential

Figure 4. (a) Relative priority for reforestation to meet 30% vegetation restoration targets across Australia, assuming a carbon market as per scenario 11 (priority set 2).

Carwadine et al 2015 Bioscience; Gourevitch et al 2016 Env Res Letters
Step 1: Veg plots → Biomass → Biomass deficit
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- 1,012 plots 0.09ha (0.025-1.0ha)
- ~50,000 stems
- Climate gradient, elev 270-2,400m
• AGC: elevation/PET; elephants; slope

• Tree shape varies with elevation

• Dbh > height >> species

• Carbon estimate using height: $174.6 \pm 32.2$ t ha$^{-1}$

• Carbon estimate using diameter alone: $229.6 \pm 37.0$ t ha$^{-1}$

→ 50t ha$^{-1}$ overestimate !!

Biomass calculation

- Diameter (all stems)
- Height (~10%; d:h models)
- Wood density (~40%; open vs. closed canopy)

→ Three allometric equations

Spectral upscaling

- Recent plots only
- Rapideye 5m → 20m pixel
- Beta logistic regression

Step 2: Veg plots → Biomass → Biomass deficit
Maximum biomass

- Estimate of former biomass (e.g. Gourevitch et al 2016)
- Closed canopy plot biomass (min plot size 0.1ha)
- Biomass-climate [76.2%D]: MWD (-); elevation (∩); slope (-); seasonality (+); temp range (-)
- Upscaling 100m

Biomass deficit

- Maximum biomass MINUS current biomass
- Basic restoration potential

Step 2: Veg plots → Biomass → Biomass deficit
Step 3: Restoration Potential

i.e. Likely **biomass gain** (and carbon sequestration) that could be achieved and its variability and **cost-effectiveness** across the region and landcover classes...

\[
AGC_\$_i = \frac{(\Delta AGC_i \times p)}{\$_i}
\]

**AGC$_\$ = Carbon sequestration per US$ (kg.US$^{-1})**

**ΔAGC = expected change in carbon**

**p = expected probability of success $ = expected cost in US$**

5-year and 50-year scenarios
Components of Cost-effectiveness:
1. Expected change in AGC

- Biomass deficit
- Pattern of biomass recovery estimated (Poorter et al 2016 Nature)
- AGC = AGB ÷ 2
- Intervention needed where biomass loss >70-80% (Hanski 2011 Ambio)...

- Mean recovery: ~50 years
- Variation: MWD; rainfall; seasonality (Poorter et al 2016)
Components of Cost-effectiveness:

2. Probability of Success

Scenarios: Pessimistic (25%), Realistic (50%) and Optimistic (75%) [donors]

Range elsewhere: 20-96%, Felix Finkbeiner, pers. comm.

UNKNOWN: Variation between methods? Assume biomass gain quicker for planting in first 5 years, but biomass equal after 50 years (Shoo et al. 2016)
# Components of Cost-eff: 3. Cost per ha

Which method?

<table>
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<th>Restoration method</th>
<th>No action</th>
<th>Vine cutting</th>
<th>Herb/shrub cutting *</th>
<th>Exotic tree removal</th>
<th>Firebreak cutting</th>
<th>Grass cutting **</th>
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Components of CE: 3. Cost per ha

- Land purchase
- Community engagement (agriculture)
- Community engagement (50% <3km)
- Seeds/nurseries
- Equipment
- Labour
- Transport per distance
- Management
- Admin
- Security
Example Cost Calculations
(PENDING FE PAPER 😊)

Vine cutting
• Tanzania: US$5.45/ha/year (Marshall et al 2017) [no admin]
• West Africa: US$1-4/ha (Bongers et al 2002) [no admin?]
• Bolivia & Brazil: $11/ha (range $1–16; various) [no admin?]
• Reforest Africa: **US69.47/ha/yr → US$347.35/5 yr**

Tree planting
• 44x more expensive (Marshall et al 2017) [no admin]
• Uganda: US$1200/ha/5yr (Omeja et al 2009) [admin costs?]
• Reforest Afr: US$1,297.64 (€1/tree) then $69.47/yr
  → **US$1,644.99/5 yr → 4.7x more expensive**
• Plant for the Planet €1/tree; others US$1-2/tree (US$0.30 – $50)
• Australia: $30,000 vs $5,000 [$0-$10,000] (weed control)
  → 6x more expensive (Catterall & Kanowski 2010)
Waves of Evolution in African Forest Conservation

Latham 2014 PhD
(and in prep)
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Save Forests We Will

www.force-experiment.com

SEE LEAFLETS!

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