Dynamics of ecosystem services driven by changes in land-use intensity in mountains

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ES dynamics and land intensification

- Tradeoffs between ES occur in space and time (Anderson et al., 2009; Raudsepp-Hearne et al., 2010)
- Understanding temporal dimension of multiple ES in a landscape (Bennett et al., 2009)

- Land intensification
  - A major change in land management in the last 50 years
  - Rapid increases in agricultural yields but decreases in biodiversity (Lambin et al., 2000)
  - Major consequences on ES (Tscharntke et al., 2005)
  - Knowledge is still limited on these consequences (Swift et al., 2004)
Stylized models

- Previous stylized models of ES supply as a function of land management
  - applied in global or regional ES assessments (Burkhard et al., 2009; Schneiders et al., 2012)
- Example (by Braat and Ten Brink, 2008 and De Groot et al., 2010)
  - variations of four types of ES
  - along gradient of land-use intensity with 6 classes
Objective

- Analyzing how temporal changes in land-use intensity influence the supply of multiple ES and the tradeoffs among them, using mountain landscapes as examples
  - review case studies of ecosystem services dynamics in mountain landscapes
  - summarize their findings in a stylized model of ES supply and tradeoffs along a gradient of land-use intensity
Method

- Search in ISI Web of Knowledge
  - papers quantifying multiple ecosystem services
  - in mountainous landscapes
  - at two or more times.

- Only 18 selected publications, after rejecting studies with:
  - No quantitative data,
  - No described land-use change,
  - Small spatial scales (e.g. forest plot)
  - One single ecosystem service
A typology of land uses needed for comparing cases. Differentiation between land uses dominated either by trees or grass (as in de Groot et al., 2010)
Results

- Case studies classified into 3 groups of land intensification ("stories")
  - Story 1: Agricultural intensification (n=4)
  - Story 2: Forest intensification (n=3)
  - Story 3: Extensification (n=11)
- The stories reported similar temporal dynamics in ES
Story 1: Agricultural intensification

- Conversion of natural or semi-natural ecosystems to croplands or pastures
- Often driven by food demand
- Often in developing countries
- Similar to the first phase of the forest transition framework
- “Agricultural frontiers”
Story 1: Agricultural intensification

Temporal evolution of land-use intensity

Temporal evolution of ecosystem services

- Food
- Timber
- Other prod
- Soil, water
- Carbon
- Spiritual
- Recreation
- Heritage
Story 2: Forest intensification

- Expansion of forest plantations, often intensively managed
- Examples in Chile, Ecuador, China
- Drivers: forest or environmental policies, wood market, carbon demand

Second phase??
Story 2: Forest intensification

**Temporal evolution of land-use intensity**

- Forest intensification
  - Grass: G0, G1, G2, G3, G4
  - Tree: T0, T1, T2, T3, T4

**Temporal evolution of ecosystem services**

- Food
- Timber
- Soil, water
- Carbon
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- Recreation
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Story 3: Extensification

- Abandonment, rewilding and transformation to multifunctional landscapes
- Drivers: More demand for regulation and cultural services (water, recreation, landscape beauty), less demand for food (agricultural and trade policies)
- Mostly in industrialized countries
**Story 3: Extensification**

- **Temporal evolution of land-use intensity**
  - Extensification
    - Grass: G0, G1, G2, G3, G4
    - Tree: T0, T1, T2, T3, T4

- **Temporal evolution of ecosystem services**
  - Food
  - Other prod
  - Soil, water
  - Carbon
  - Spiritual
  - Recreation
  - Heritage
Evolution of ES in:
- Food
- Timber
- Other products
- Soil/Water
- Carbon
- Spiritual
- Recreation
- Heritage

- Tree-dominated land
- Grass-dominated land
- All land uses
Evolution of ES in:
- Tree-dominanted land
- Grass-dominanted land
- All land uses

Changes in land-use intensity:
AI: Agricultural intensification
Evolution of ES in:
- Tree-dominated land
- Grass-dominant land
- All land uses

Changes in land-use intensity:
- AI: Agricultural intensification
- FI: Forest intensification
- E: Extensification

(a) Food
(b) Timber
(c) Other products
(d) Soil/Water
(e) Carbon
(f) Spiritual
(g) Recreation
(h) Heritage
Conclusions

- Most common trade-offs:
  - Increases in desired ES following intensification (food or timber) and declines in other ES

- Limitations
  - Few studies, diverse approaches, different ES

- Simple stylized model
  - Can be used in global modeling works
  - Communication tool on trade-offs
  - Starting point in specific studies: what explains divergence from the simple model?
  - Could be tested in non-mountain areas

- Issue of scale and landscape heterogeneity
  - E.g., agricultural intensification in some places may coincide with, if not encourage, rewilding in others
Thank you!