THE GHOST OF INVASIONS PAST: soil legacies of invasive plant species

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Consequences of soil impacts: FOUR CASES

- Invader-modified soil -

--- Native soil ---

Removal
CASE 1: RECOVERY

Removal

- Invader-modified soil -  --- Native soil ---

Recovery
CASE 1: RECOVERY
Suding and Royale, 2008
Komatsu et al, 2008
Artichoke thistle, Orange County

Invaded areas, rhizosphere:
4-100x Carbon-processing microbial enzymes

Four yrs after herbicide:
1/4-2x further increase

4x Needlegrass (Nassella pulchra) cover (to 5%)
When native species don’t recover -> legacies?

Mean change in abundance (95% CI), herbicide control 355 invasive species removal projects (n= 45, 18)

- 70% (-60 to -95%) Invasive

+9% (+20 to -17%) Natives

Kettenring and Reinhardt (2011)
CASE 2: LEGACIES

- Invader-modified soil -

--- Native soil ---

Removal

Re-invasion

Legacy persists
CASE 2: LEGACIES
Nutrient pools
CASE 2: LEGACIES
Marchante et al, 2008
Acacia longifolia, Portugal

After 2.5 years:
- 30% microbial biomass
- 60% N cycling

After 4 years:
- 35% Soil C and N
CASE 2: LEGACIES
Microbial community
Native (Gnaphalium): ↓30% nonnative-conditioned soil

Invasive Italian thistle (Carduus): ↓8% native soil communities

Nonnative-conditioned soil: ↓33% mycorrhizal density
CASE 3: NEGATIVE FEEDBACKS

- Invader-modified soil -

--- Native soil ---

Time

Recovery

Positive feedback

Negative feedback

Recovery
CASE 3: NEGATIVE FEEDBACKS
Nijer et al 2007
Chinese tallow, Texas

Invaded (own) soil inoculum:
↓42% biomass (vs native soil)

↑48% fungi-killed soil
CASE 3: NEGATIVE FEEDBACKS
Stein et al, in prep
Medusahead, Sierra Foothills

Medusahead: ↓ 33% MH-conditioned soil

Needlegrass (Nassella): ↓ 51% MH-conditioned soil

Avena fatua: ↓ 12% MH-conditioned soil
CASE 4: OTHER LEGACIES

Removal

Invader as Passenger

Other legacy (landuse, pollution)

Modified soil

Native soil

Re-invasion

Legacy persists
CASE 4: OTHER LEGACIES
Mangla et al, in prep
Artichoke thistle, Orange County

Grazing + Erosion

Artichoke thistle 1998

Herbicde Control

Needlegrass 2008

Black mustard 2008

Stop Grazing

(+)
Dispersal
Native seed limitation
Invasive propagule pressure
Restoration in the face of soil legacies

- Transitional plantings (Herron et al 2001)
- Host-specific mycorrhizae (Klironomos et al 2011)
- Less susceptible natives (Jordon et al 2008)
- Topsoil removal (Holzel and Otte 2003)
Many unknowns

Of species listed as “High” concern in Cal-IPC inventory:

- 46% Soil effects
- 11% Microbial feedbacks
Generalities

Time and invader density increase severity: get them early!

Species that impact nutrient pools and microbial composition likely to have longer-lasting legacies.

Positive feedbacks likely the exception rather than rule.

View in the larger context of other constraints: land-use, climate change, seed limitation.
Thanks