The ecological basis of invasive species management

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Components of ecology

- Ecosystem
- Community
- Population (individuals and modules)
- Physiological
- Evolutionary (genetic)
- Human

- Synthesis through models within and between the levels

- Landscape ecology as an integrating framework

- Disturbance and vegetation dynamics in applied ecology

Autoecology of the target invasive species

Life cycle of the species:

- **Flower set**
- **Pollination**
- **Seed set**
- **Seed dispersal**
- **Dormancy and germination**
- **Seedling establishment**
- **Growth to reproductive maturity**
- ***Versus vegetative reproduction (e.g. layering)***

Versus potentially limiting environmental factors:

- Climate (tolerance limits, phenology etc.)
- Substrate
- Competition (shade etc.)
- Predators/pests versus dispersers
- Pathogens
- Disturbance

Which factor limits which stage of life cycle?

Complications: interactions, unusual events (e.g. late frost), the “realised niche” (species response will vary amongst habitats)

Which life cycle stage X factor most limits rate of potential population growth? - transition matrix models

Ecology of the invaded ecosystem

Why was it vulnerable to invasion?

- **Historical biogeography**
- **Current management/disturbance**
- **Is it vulnerable to a broad spectrum of invaders, or just to particular species?**
  - the invader X invaded interaction

Ecology of the invaded ecosystem

- Was it vulnerable just once (in the past) or will it remain vulnerable in the future?
- Thus the risk of the “Sisyphus effect”: King of Corinth and his stone, its two versions

Sisyphus - 1

Sisyphus - 2

How to manage?

- **Utilise natural ecological processes rather than imposing entirely artificial interventions, e.g. self-thinning?**

What to manage?

- **The ecosystem, the community, the population of the invasive species or some combination**

Where to manage?

- **At what spatial scale: plot by plot, farm by farm, or across the whole landscape? - intensity of management versus time spent on negotiation with stakeholders etc.**

Time scales

- **Manage for longer-term objectives, e.g. target habitats and vegetation cover**
- **Understanding of natural secondary succession pathways in this environment will indicate the trajectories by which this may be reached**
- **“Site-capture” then slow succession *versus* instant restoration of target habitat**
- **But “climax theory” is dead; beware the lack of convergence in succession**
- **Mature vegetation may not be especially stable, resistant or resilient to invasion**
- **Beware the long lag-phase of many invasions – problems may only become clear a long time in the future**

More on succession

- **Successional mechanisms may help: facilitation, inhibition, etc.**
- **E.g. promote establishment of fast-growing ground-cover or tall-growing pioneer tree species: may help inhibition of invasives before becoming senescent and allowing further succession**
- **Planting has huge costs: can we promote natural regeneration of the desired plant species, without promoting it of the invasive? E.g. promoting bird versus wind versus human seed dispersal input**
- **Can fertilizing help recovery of native vegetation? – most invasives are more competitive in high resource conditions, so adding fertilizing risks making the invasion worse**

Regime shifts

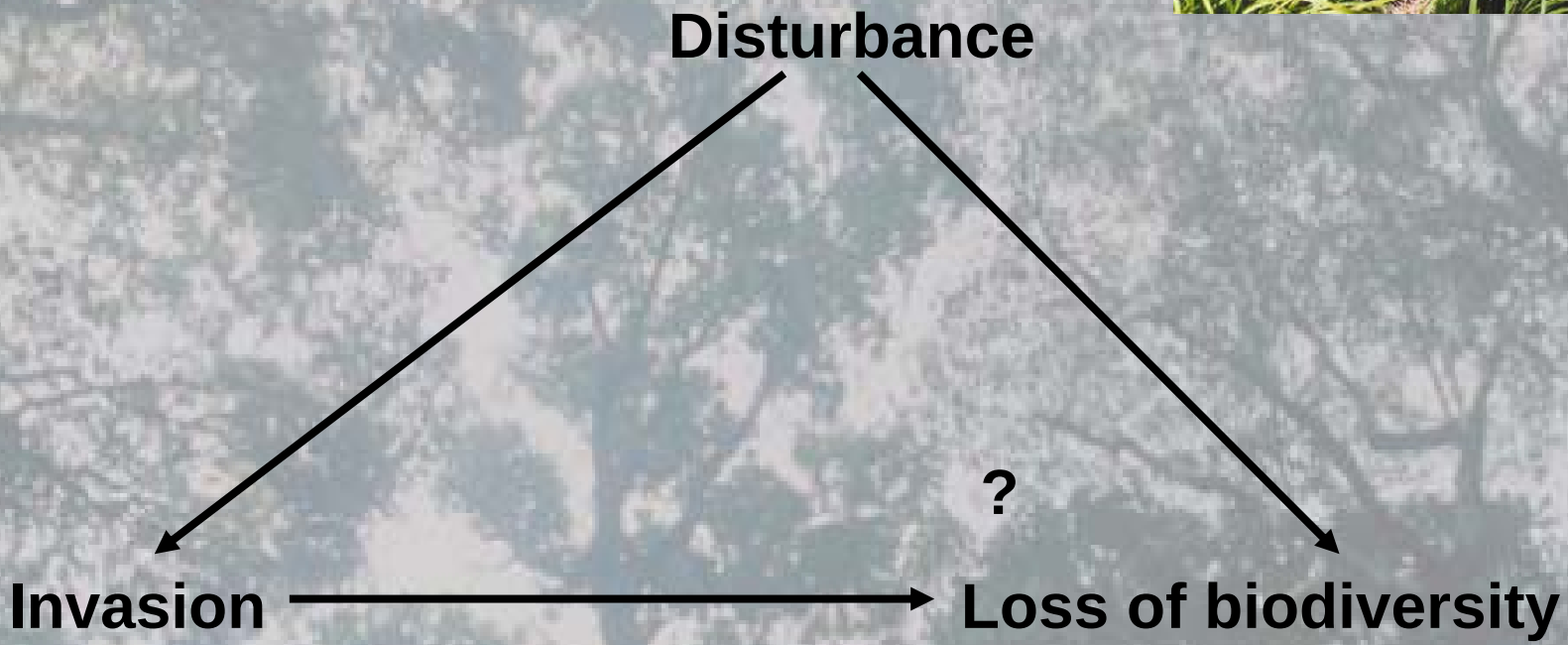
- Can you achieve regime shifts in the ecosysem?
- Even short of full eradication can you shift the system to a state where control is much easier?

Management of the disturbance regime

- E.g. fire, browsing, cutting, harvesting/thinning, crushing, chemical disturbance, specific predators, soil cultivation
- The key factor in the dynamics of many invasions
- Disturbance often increases ecosystem vulnerability to new or re-invasion
- So planned disturbance may give you short-term control, but at the cost of longer-term vulnerability
- What are the relative tolerances of: the invasive species; species that can potentially outcompete them; priority species (eg of conservation value)?
- Complexity of defining the disturbance regime: frequency, extent, intensity, (duration), specificity

Disturbance

- **Often a major contributory factor to occurrence of invasions**



Silviculture as managed disturbance

Alternative silvicultural systems vary in their combination of disturbance:

- **frequency versus intensity**
- **specificity of species and size**
- **spatial distribution**

Must compare response to disturbance of invasive versus current dominant and target species:

- **canopy trees**
- **understorey/shrubs**
- **ground layer plants**

Indices from Hill et al. (1995)

1. Time to first emergence
   - Time taken for the fastest growing seedling in a cohort to emerge above the canopy of the competing vegetation

2. Establishment/emergence ratio
   - Between the number of seedlings established in a given year and the number of those seedlings that survive to reach a given height

Assess for invasive and competing species under alternative silvicultural regimes

Landscape considerations

1. Identify functional units (“patches”)

- Prioritise and specify management between them
- E.g. promote expansion of vegetation patches that are most resistant to invasion, e.g. dense grass
- Create patch structure with scarification of brash

2. Identify the landscape properties of the invasion

- Depending on its dynamics, target control at: established seed source patches, immature individuals at the invasion front, founder individuals beyond the front

3. Habitat networks as routes for invasion; metapopulations in plants?

Climate change and habitat disturbance

- **Rapid shift in species' ranges**

- **Invasive species versus "exotic" or "non-native", e.g. beech?**

- **Species will go extinct unless they can migration and "invade"**