The “bee –side” of pollination: wild ecosystems

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Ecosystem services and pollination

Ecosystem services: ecosystem functions that provide benefits to humans; i.e. a human beneficiary (current or **future**) must be explicit (Egoh et al. 2007).

- Social-cultural *values* (social motivations that can determine the importance of an ecosystem service):

1) Altruistic motives (to future generations and within the current generation).
2) Recognition of the intrinsic value of non-human species and ecosystems.
3) Social responsibility, (moral gratification by contributing to a worthy cause).

- Monetary *value*, may comprise:

1) Direct use values (human use of biodiversity, either consumptive - extractive, or a nonextractive use).
2) Indirect use value (derives from regulation services provided by biodiversity).
3) Option value (the importance that people give to a safe future -the future availability of ecosystem services).
4) Existence value (satisfaction of knowing that an ecosystem or species persists).

Ecosystem services and pollination

Biodiversity patterns: species and habitats, among other elements, can be important to people and may provide vital services as provision of food, among others.

Ecological processes, such as **pollination**, supporting biodiversity patterns that can sustain ecosystem services.

The importance of pollination

Crop plant species: insect pollination, mostly by bees, is necessary for 75% of all crop plants for human food worldwide (15 – 30% of food production).

Proportion of agricultural crops depending on pollinators is increasing (> 300%) -> commercial hives availability could constrain production.

Global annual economic value of insect pollination (2005) ≈ € 153 billion.

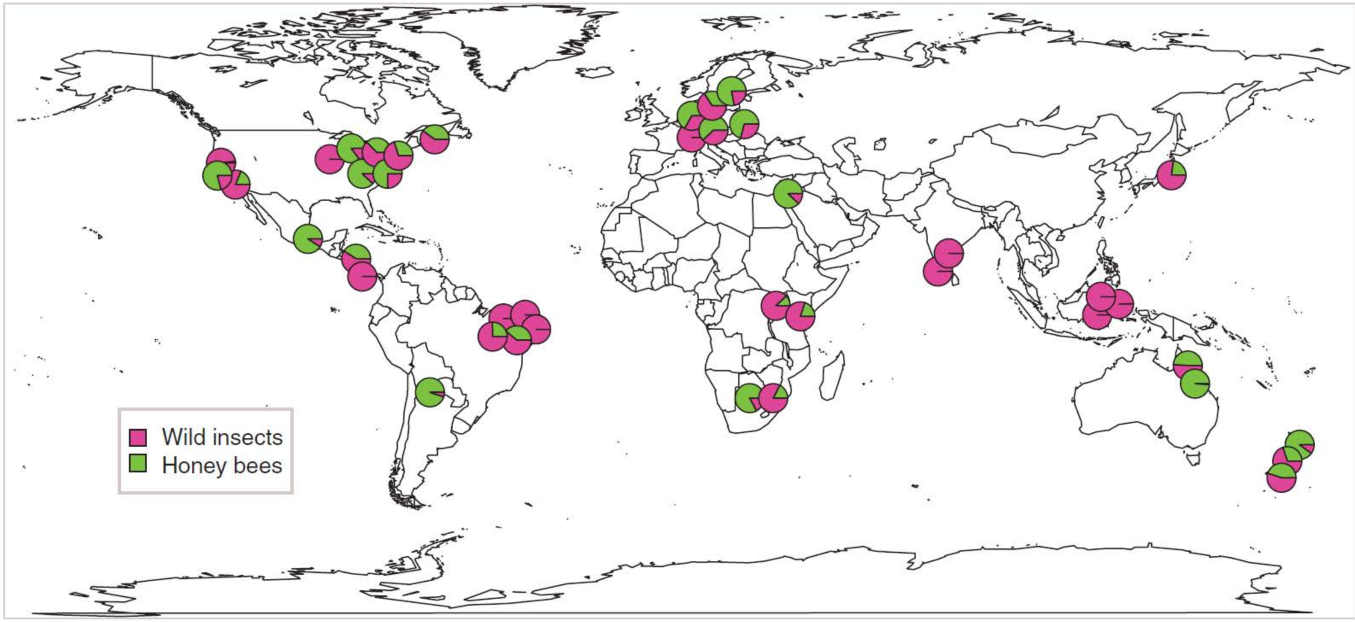
Wild bee species can be the unique agents for pollination of some crops, or be more effective pollinators than honey bees (Klein et al. 2003, 2007), or support pollination at conditions where honey bees are absent (Brittain et al. 2012).

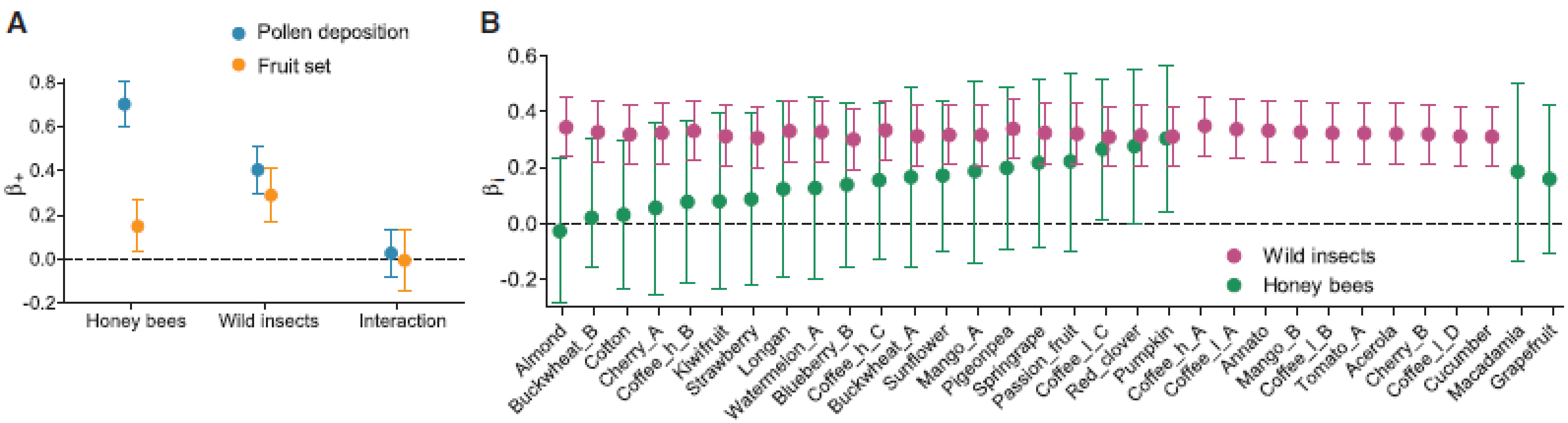
Wild plant species: about 80% are dependent on insect pollination for fruit and seed set.

Aditional ecosytem service "valuation“: maintenance of genetic flux and genetic diversity.

The importance of pollination

Garibaldi et al. 2013

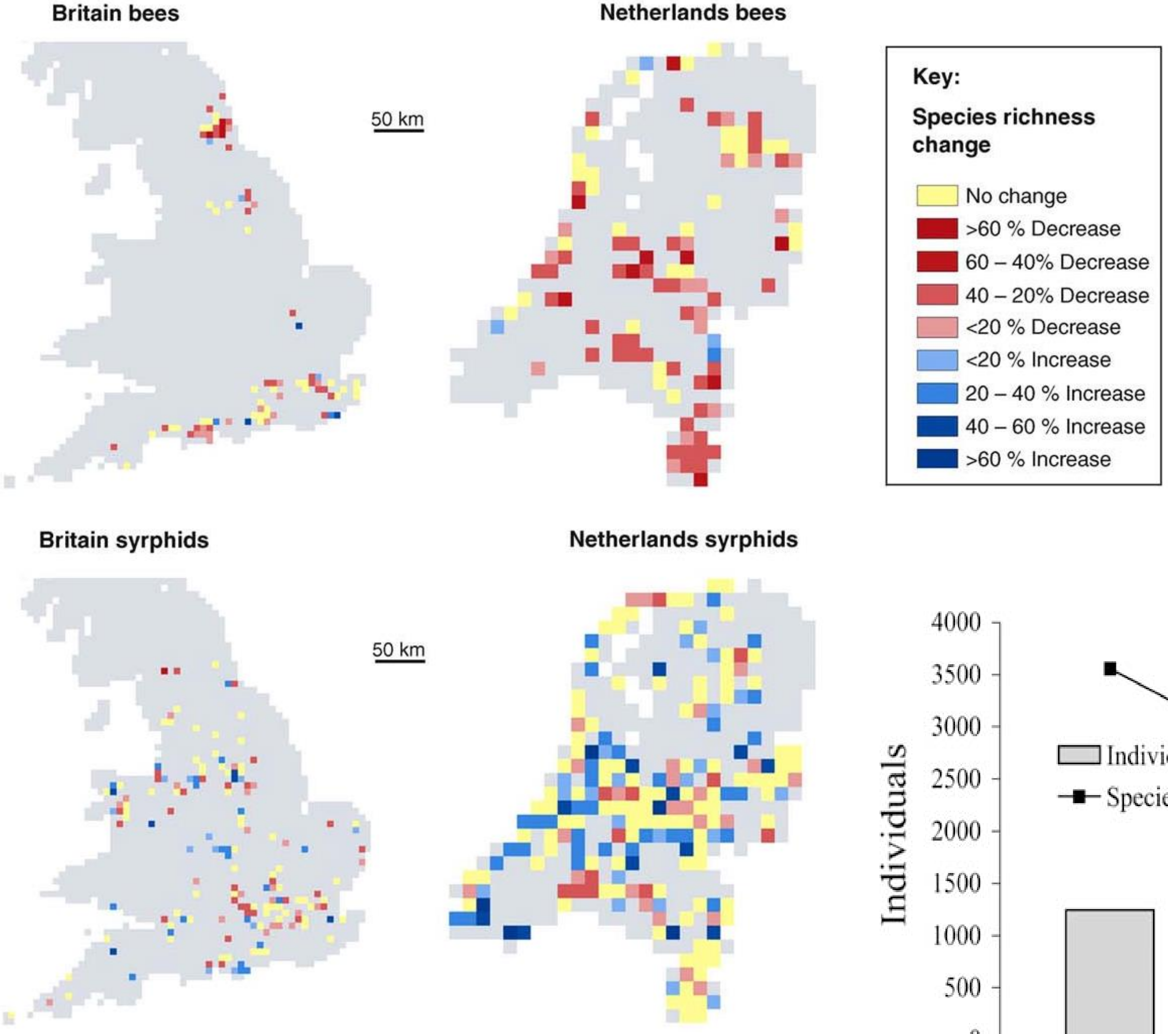




The importance of pollination

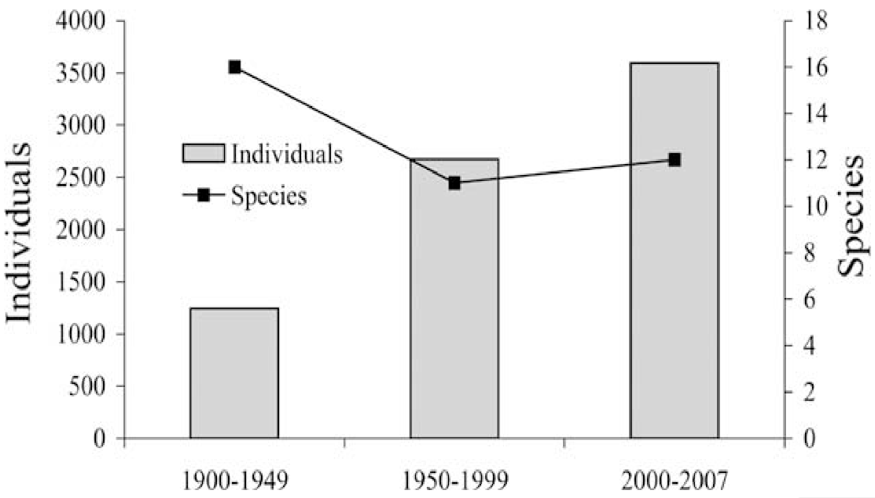
Prosopis tamarugo – Centris tamarugalis

Pollinators decline



Potts et al. 2010

Grixti et al. 2009



Pollinators decline

Pollinator losses seem to be biased towards species with particular life history traits:

✓dietary and habitat specialists among pollinators.

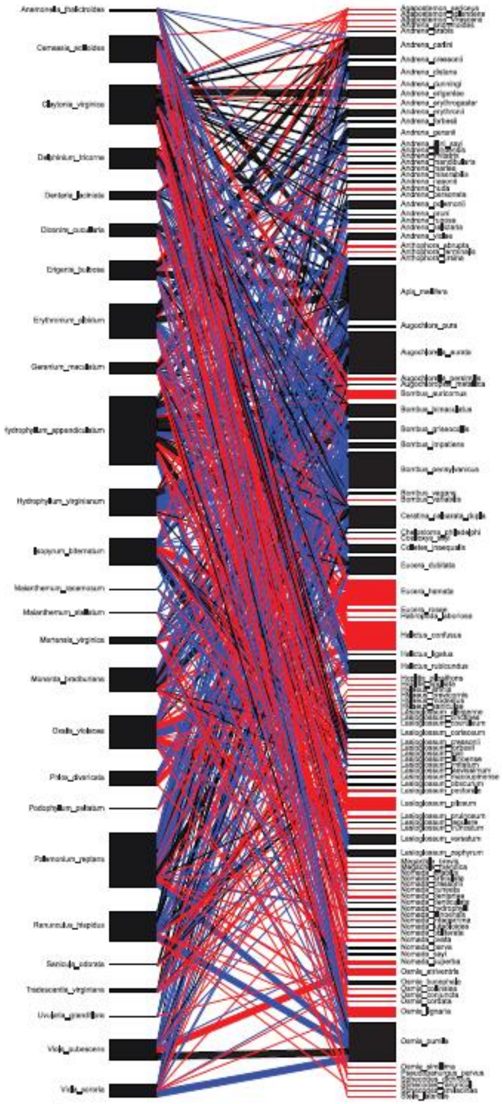
✓bumblebees with narrow pollen specialization.

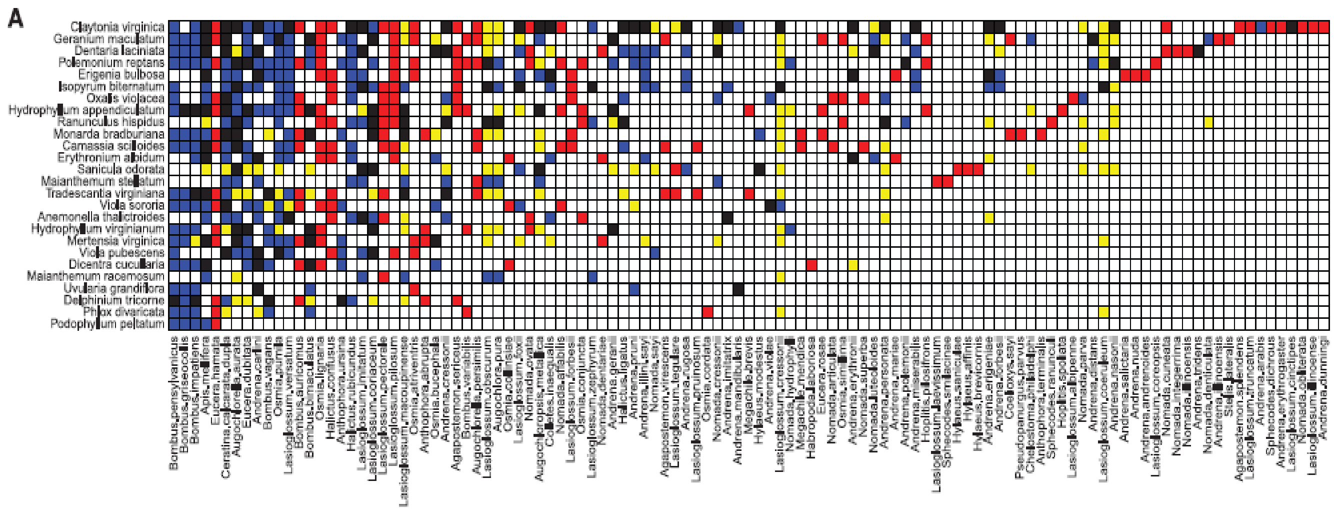
✓small solitary bees

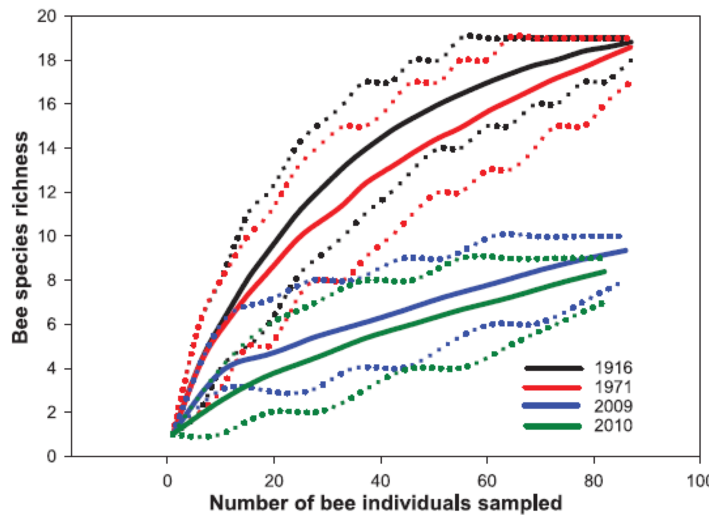
Loss of pollinators can disrupt pollen transfer and greatly reduce or completely eliminate seed production, contributing a demographic collapse.

Of the plants that have been studied, 62-73% have shown pollination limitation (Potts et al. 2010).

Pollination networks modifications







Burckle et al. 2010

Pollinators decline - hypotheses

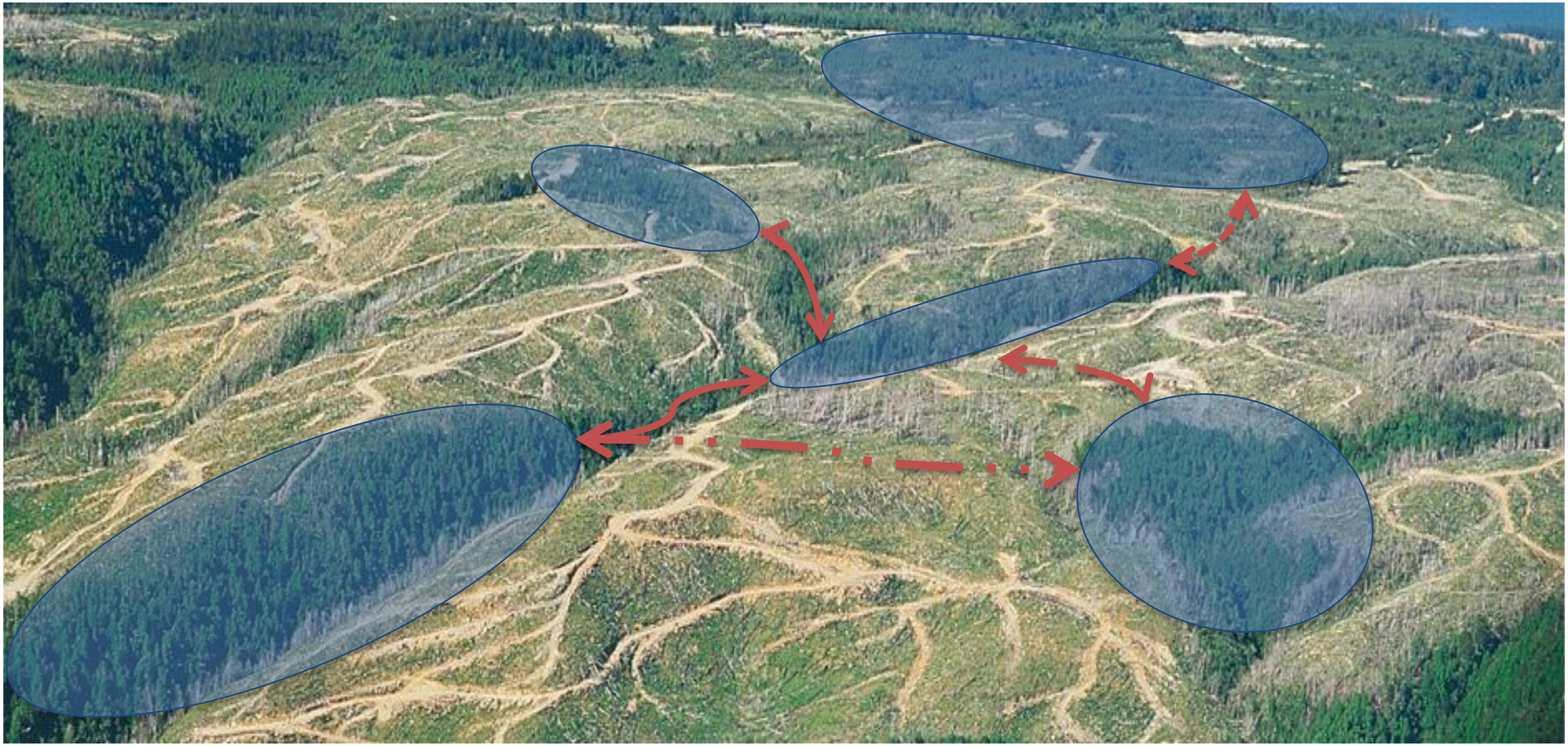
- Habitat loss and fragmentation
- Alien species
- Decreased resource diversity
- Pesticides use
- Climate change

Pollinators decline - hypotheses

Habitat loss and fragmentation

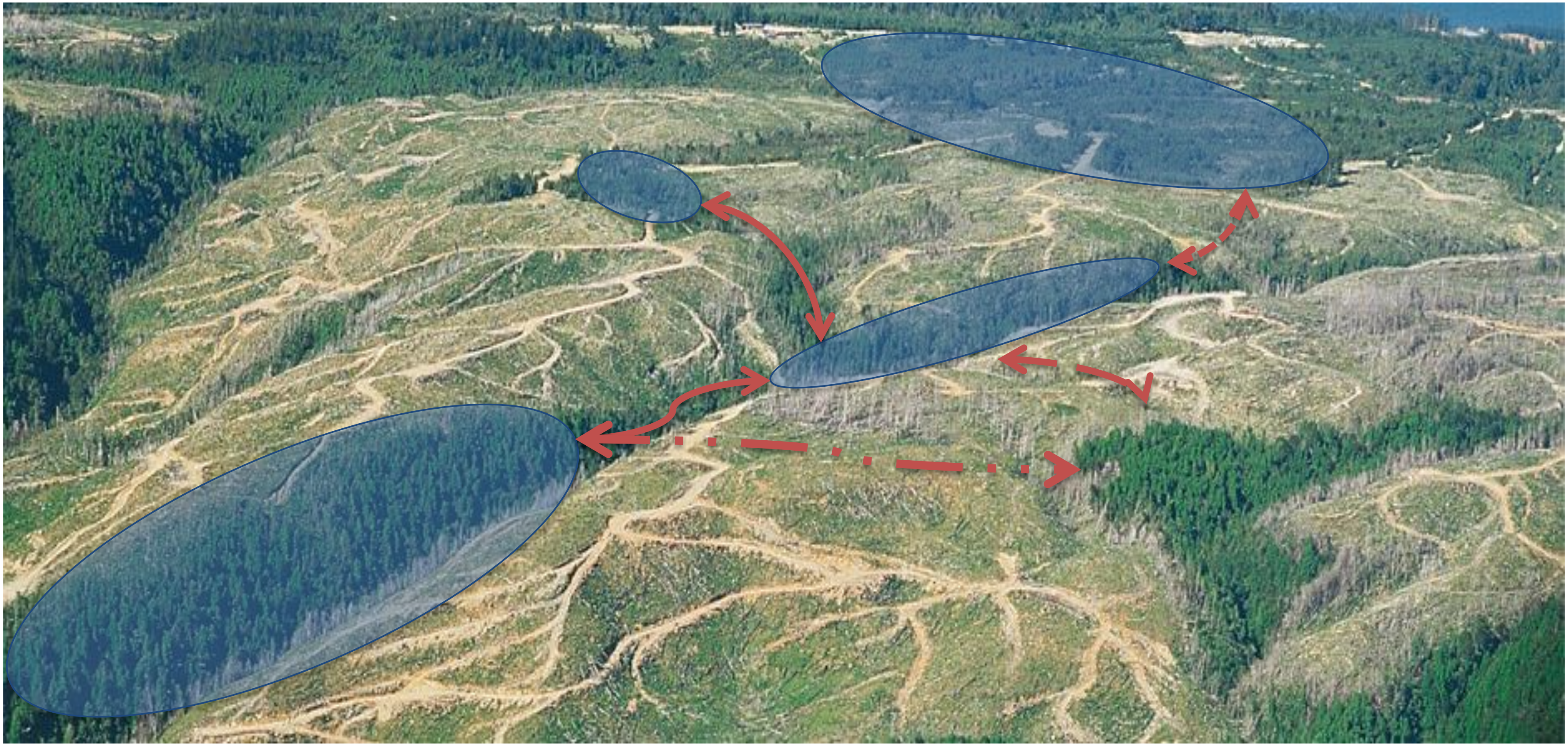
Pollinators decline - hypotheses

<u>Habitat loss and fragmentation</u>



Pollinators decline - hypotheses

<u>Habitat loss and fragmentation</u>



Pollinators decline - hypotheses

Habitat loss and fragmentation

Generally considered as the most important factors in pollinator declines.

Pollen is often limited in fragmented landscapes.

Landscape disturbance may affect plant abundance, density and health (influencing the light, water and nutrients received) -> reduced amount of pollen available and/or plant attractiveness (altering number and size of flowers - reward availability).

Abundance, distribution and diversity of pollinators may be reduced by landscape disturbance -> reduced pollination rates and seed production.

Disturbance may restrict pollinators movements (functional connectivity): patches, matrix, corridors may affect animal movement decisions -> reduced effectiveness in pollen transfer.

Most wild bees are **soil nesting** -> impervious surfaces (pavements) are common component of expanding urban areas

Wild bees wood nesting can be heavily affected by deforestation.

Pollinators decline - hypotheses

Habitat loss and fragmentation

Pollinators decline - hypotheses

Alien species

Arrival of propagules of alien species- > invasion usually triggered mostly by human-related disturbances and/or enemy-free spaces.

Aliens can modify basic quantitative parameters of pollination webs: strength of interactions, distribution of asymmetries (Aizen et al. 2008).

The effect of aliens on the distribution of interactions could depend on the extent of invasion (Aizen et al. 2008).

Generalist aliens could become central nodes in highly invaded webs that might increase nestedness and persistence of many species but modifying network architecture (Aizen et al. 2008).

Invasive plants may exhibit high densities and/or exuberant flower displays.

Groups of introduced species could interacting more with each other than expected. If these interactions conform the main core of webs, facilitation between alien species may become apparent.

Pollinators decline - hypotheses

<u>Decreased resource diversity</u>

- Flower resources: pollen, nectar, species richness, phenology, floral display, etc.
- Nests: nesting substrates, nesting sites, nesting materials.
- Patches: size, resources predictability and richness, distance between patches.
- Habitat: landscape configuration, habitat shape, connectivity, aggregation, heterogeneity.

Bees (Bumblebees; Jha & Kremen 2013) perceive and consider both landscape-scale and patch-scale resources.

Pollinators decline - hypotheses

Decreased resource diversity

Atriplex nummularia

Pollination in EIA

Should consider:

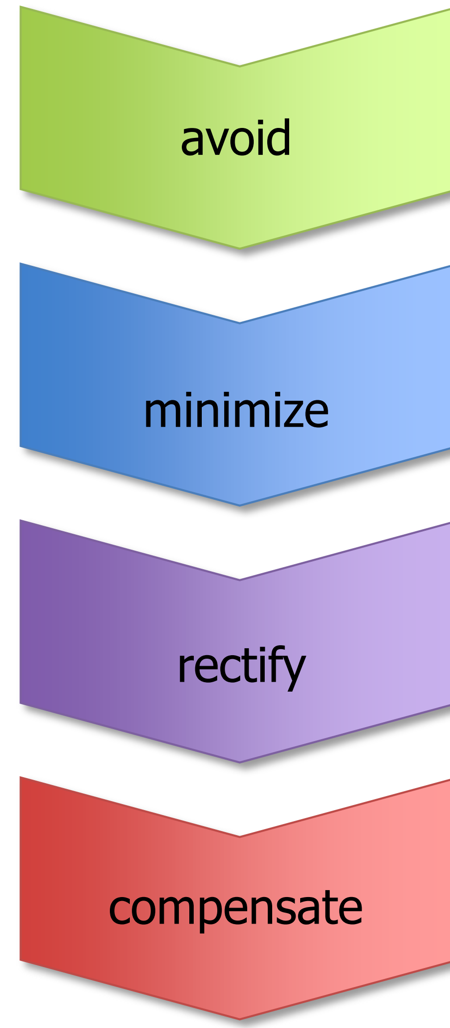
Mobile agent-based ecosystem services (MABES; Kremen et al. 2007): organisms that deliver services locally, but their behaviour, population biology and community dynamics are affected by the spatial distribution of resources at a larger, landscape scale.

- ❖ Have both direct (immediate) and indirect (via other ecosystem services) values

→ regulating and supporting roles.

- ❖ Managing should consider:

    - local scale (where services are delivered).
    - landscape scale.



Pollination in EIA

Should consider:

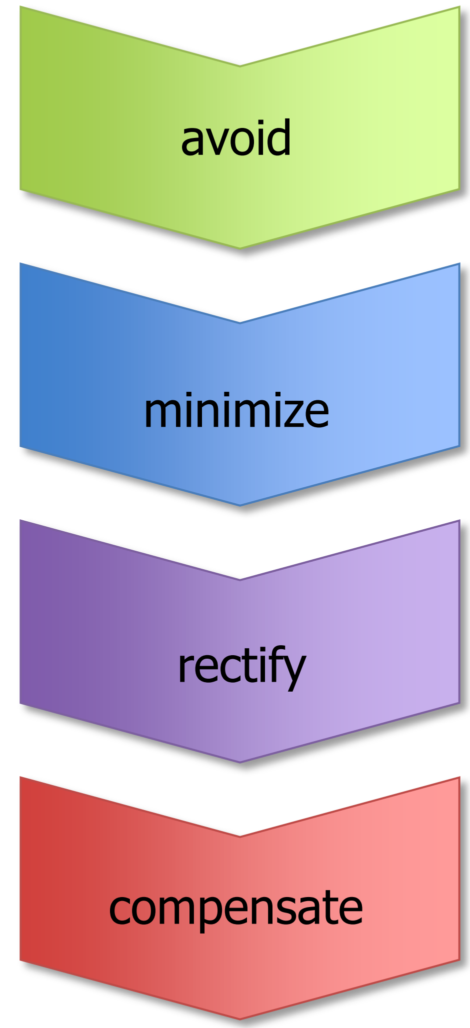
❖ Deliberate manipulation of nesting resources is a critical complement to floral resource management.

❖ Managing for bee nesting sites can include:

- providing patches of bare ground with soils of different textures.
- providing holes of different sizes drilled in to boards, fences or dead trees.
- providing standing dead trees and fallen branches.
- providing fields where tillage and flood irrigation are avoided.

❖ Surrounding natural habitats – corridors (“Stepping stone plant individuals) – patch features

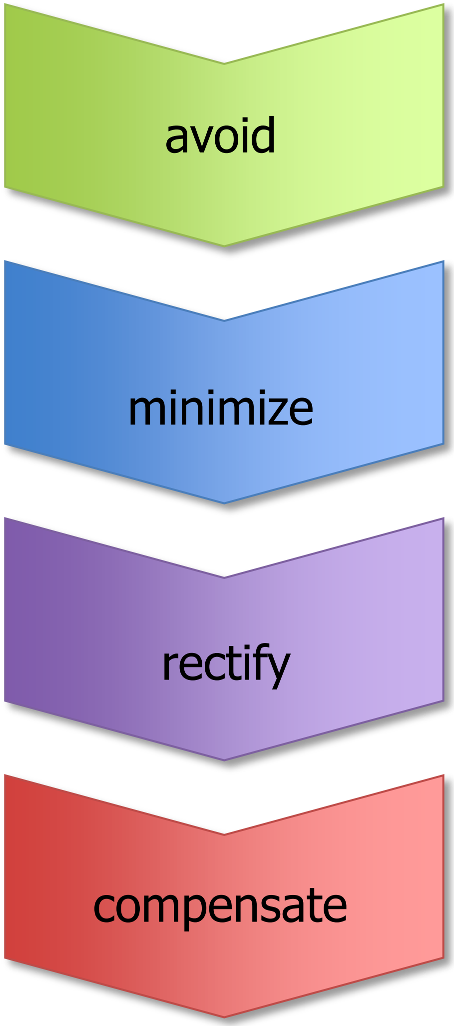
❖ Organic farming management – avoiding large monocultures.



Pollination in EIA

Should consider:

- Plant reproductive biology.
- Plant degree of specialization.
- Mass flowering.
- Keystone plants (bridging plants – framework plants).



Pollination in EIA

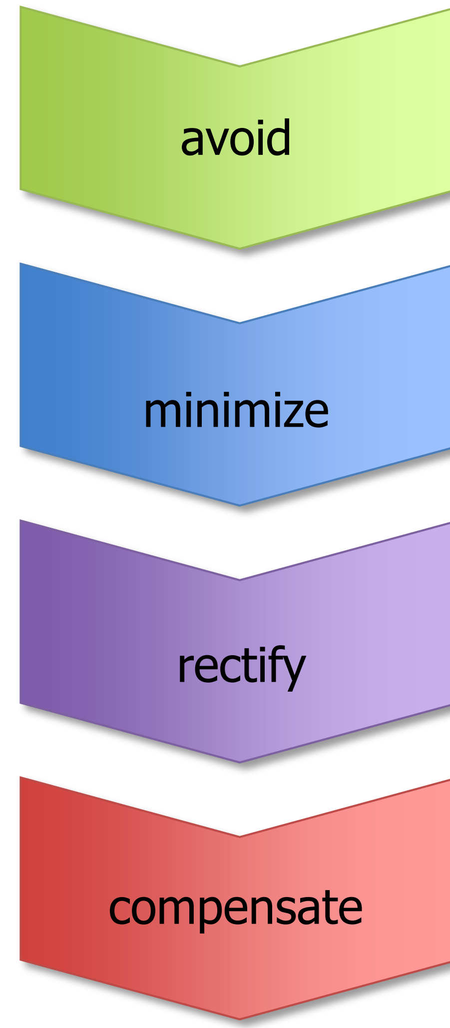
Should consider:

- Pollinator Functional Richness → Richness of pollinator species should increase mean (and reduce variance) fruit set due to complementary pollination, facilitation, or sampling effects among other mechanisms.

- Response Diversity → different pollinator species may be active at different environmental conditions.

- The overall structure of plant-pollinator networks might be robust to perturbations → nestedness and redundancy in interactions.

- Diversity → richness → abundance



Pollination in EIA

- ❖ Base line studies should consider interacting species.

- ❖ Restored networks showed less complexity and robustness than in natural habitats (see Menz et al. 2011).

- ❖ Plants used in restoration should sustain pollinators not only in a short term timescale.

- ❖ Managing of plant populations should consider their pollinators:

- plant populations no affected – pollinator populations affected
- reforesting in another place.

- ❖ Networks consisting mainly by specialist species could be more difficult to manage – restore.

- ❖ Pollinators with complex life cycles could be more difficult to manage – restore.

- ❖ EDUCATION AND DEBATE → social recognition and accurate valuation of wild pollinators as ecosystem service

Pollination in EIA

Constrains

- ❖ Monetary trade-offs: to preserve v/s to intervene.
- ❖ Specialists for carrying out robust base lines (locating nesting sites) – scientific and technical data availability.
- ❖ Monitoring and compliance efforts, developing criteria for both assessment and compliance.

Chilean situation

- 435 bee species -> 70% endemisms.
- 169 butterfly species (Rhopalocera); 12 hummingbird species; 11 bat species (only 1 nectarivorous).
- 16% of bee species are observed at flowering desert (*desierto florido*).
- Conservation status of pollinator species = unknown
- Regulations and policies concerning pollination = 0
- Measures included in EIA concerning pollination = none