Citable ideas

Mutualism & general facts

- Obligate mutualisms are more common in the trophics, facultative mutualisms are more common in the temprate areas. That doesn't mean they are less important. Just more flexible. Reasons might be related to costly phenology during winter for example (May 1982)
- Population dynamic models of mutualism there is an explosion of positive feedback and runaway in the populations (May 1982), that is related to invasion meldown (Simberloff et al. 1999)

Global change

- Mutualistic interactions are generally affected negatively by global change (Tylianakis et al. 2008)
- Global change (temperature increasses) disrupt plant pollinator networks by making phenologies missmatch or spatial distributions change and local abbundances (Memmott et al. 2007; Hegland et al. 2009)
- Habitat fragmentation, habitat modification and other neggative impact references are in (Tylianakis et al. 2008)
- Effects of defaunation

Invasive species & mutualisms

- Pollination is a key proces fior the establishment of invasive species and the community assemby (Sargent and Ackerly 2008)
- Successful invasive species tend to be super-generalists (Richardson et al. 2000; Vilà et al. 2009)
  - Non suitable pollinators limit the spread of alien species, those that can have pollinators are more likely to necome invasive (suggested by Richardson et al. 2000)
  - Often alien species require efficient symbionts (pollinators, seed dispersers, mycorrhiza) to become invasive (Richardson et al. 2000)
- From the competitive point of view more diverse communities should be less prone to invasion, from the mutalistic more diverse facilitates invasion. More diverse native can have more diverse invasive species (Richardson et al. 2000)

- Invaders use efficiently available pollinators (Richardson et al. 2000)
- Invasive plants affect the others trough two mechanisms (Bjerknes et al. 2007):
  - Effects on pollinator populations: Positive for example by supporting pollinators with more resources, especially in different times as the natives. Neggative as for example being toxic for pollinator larvae
  - Effects on pollinator behaviour:

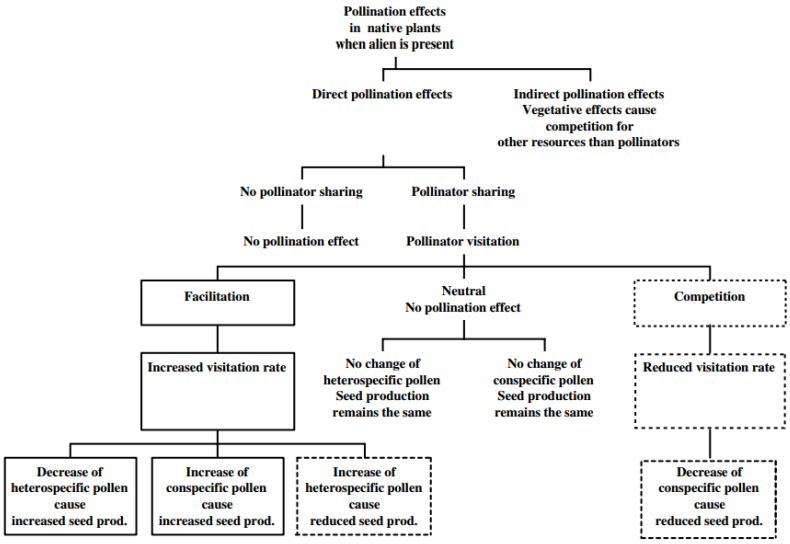

Fig. 1 – Changes in pollinator behavior (visitation rate and quality of visits) and direct pollination effects in native plants caused by alien plant introductions on a local scale. Positive effects are in boxes with full borders, negative effects are in boxes with dashed borders.

Figure 1: Effects of changes in pollinator behavior

- There is evidence that native plants that have similar traits (morphological at least) to invaders might have a receive less visits than before (Carolina Laura Morales and Traveset 2009), there is also evidence that they dont (Vilà et al. 2009)
- Invaded communities receiver more pollination visits in total(Vilà et al. 2009)
- Invasive species don't induce overall changes in network structure (connectance, plant linkage level, and nestedness) (Vilà et al. 2009), but that might depend on the degree of invasion (Aizen, Morales, and Morales 2008)
- Aizen, Morales, and Morales (2008) found that although total connenctance is maintained, links get transfered between native generalists to invasive

generalists, an increasse in connectance in invasors and a decreasse in natives

- Highly invaded networks exhibit weaker mutualism (i.e. less reciprocal interdependence) that less invaded webs (Aizen, Morales, and Morales 2008)
- Suggesting evidence that the impact of invading plants might be less worse than invading pollinators (Vilà et al. 2009) or complexes of invasive species when an invader facilitates further invaders; explained by Simberloff (2006) and proposed by Simberloff et al. (1999)
- Invasion meltdown (Simberloff 2006). Mutualistic invasive species enter an "autocatalytic" process, and accelerate their spread and impact on the ecosystem., an invasive seed disperser ant facilitates the recruitment of an invasive plant that interacts strongly with it (Prior et al. 2014); *Ficus* only became invasive in Florida and New Zealand after the introduction of their specific plant pollinator (Richardson et al. 2000)
- However J. M. Olesen, Eskildsen, and Venkatasamy (2002) didn't found invader complexes to be pervasive in oceanic islands. Instead, invaders get successfully assimilated by native super generalists
- A reason for a pollen pool: Visitation frequency is a surrogate of total interaction effect (Vázquez, Morris, and Jordano 2005), but that only takes into account immediate consequences of pollen deposition or seeds removal, not take into account fraction of outcrossed pollen or germination rate/defecated seeds. Relationship between visitation and effect is not linear. eg. infinite visitation doesn't lead to infinite benefit (saturation of polen). It can be bellshaped.
- Studies that explored the effects of invasions on network "stability" (in the broad sense): J. M. Olesen, Eskildsen, and Venkatasamy (2002), Aizen, Morales, and Morales (2008), Bartomeus, Vilà, and Santamaría (2008), Vilà et al. (2009)

Stability

- Coexistence stable states makes throphic networks less connected, less nested and more modular than intial parameters before equilibrium (Thébault and Fontaine 2010)
- Interaction diversity, nestedness, distributions and patterns of interaction strength, compartmentalization and degree distribution are structural network factors though to have an impact on stability (Tylianakis et al. 2010)

In mutualistic networks

- Asymetric networks (so that if a plant species depends strongly on an animal species, the animal depends weakly on the plant) facilitate coexistence (Bascompte, Jordano, and Olesen 2006)
- Coexistence stable states makes mutualistic networks more connected, more nested and less modular than intial parameters before equilibrium (Thébault and Fontaine 2010)
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Bascompte2006,Rooney2006,Okuyama2008,Thebault2010,Rohr2014,Sauve2014

Polen pool

- Mutualism facilitate plant reproduction, yet it is well recognised that mutualismns can be substantually altered if co-flowering species compete for the serviices of shared pollinators (Sargent and Ackerly 2008, **???**).
- Ine step further: Studies of pairwise interactions have shown that an alien plant can affect the pollination of a native plant, this effect being mediated by shared pollinators (Lopezaraiza-Mikel et al. 2007)
- Overall neggative effect of invasive species in native pollination services Reviewed by Carolina Laura Morales and Traveset (2009)
- Competition for pollinators is termed Interspecific Polen Transfer, which can be divided into heterospecific pollen deposition and conspecific polen loss (Carolina L. Morales and Traveset 2008)
- Ghazoul (2006) deals with apparent facilitation and competition in mutualistic networks
- Visitation is correlated with pollen transport, but there is a high proportion of pollinators (~25-35%) that don't carry conspecific pollen (Alarcón 2010). Pollen transport networks seem to be dominated by alien polen (Lopezaraiza-Mikel et al. 2007)
- Although there might be mechanisms to mitigate the impacts of alien polen (morphological differences on where each type of pollen is attached, individual pollinator fidelity and differnt flower phenologies), polen from invasive species was present in the majority of pollinators (Bartomeus, Bosch, and Vilà 2008)
- At high densities alien species negatively affect pollination visitation rates and seed output in natives (Muñoz and Cavieres 2008), however it might increasse it at low densities by attracting new pollinators to the community (Muñoz and Cavieres 2008)

- Invasive species co-opt pollinators from native ones (Pyšek et al. 2011)

Coexistence

- Alternatuve model to Garcia-Algarra et al. (2013) is Fishman and Hadany (2010)

Structure and invasions

- Invasions are more likely in less complex networks Romanuk et al. (2009)

Defaunation

- Defaunation can reduce polen transfer and plant densities (Nia and States 2011)

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