Coupling pollination services to agriculture in fragmented landscapes under climate change

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INTRODUCTION

- Pollinators are considered essential for offering fundamental ecosystem services to agricultural landscapes (Daily 1997).
- Bees are considered the most important taxon offering this service. (Klein *et al.* 2007).
- However, human-induced activities and climate change can have a strong effect on diminishing pollinator diversity and distribution, hence pollination services to important crops.
- The distance at which a crop is located from the forest in the tropics, is known to affect social bees pollination services (Apidae), because forest offers vital resources for bees (Klein et al. 2003).
- Bees visitation is reduced by half at 668 m distance to forests (Ricketts et al. 2008). Beyond 1507 m from forests bees diversity is reduced by half (Ricketts *et al.* 2008).

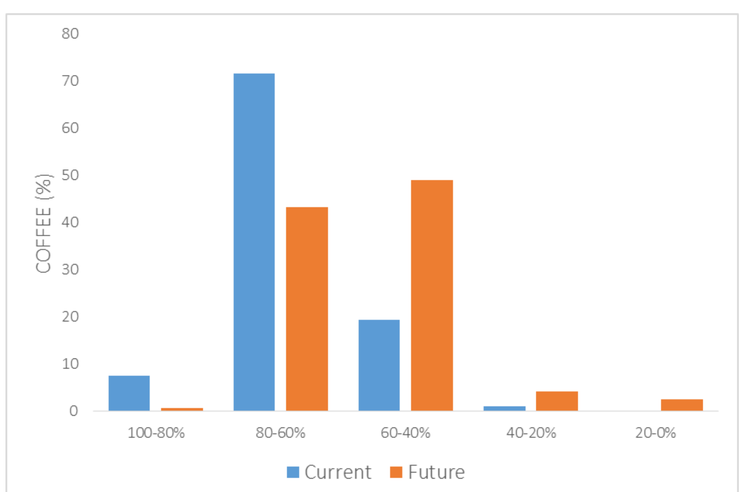
OBJECTIVES

- Evaluate the impacts of climate change on the geographical distribution of bee species, important coffee pollinators in Central America.
- Identify areas in where shifts in distribution of bee species may affect coffee pollination, taking into account (i) changes in pollinator distribution ranges, (ii) changes in future coffee suitability, and (iii) presence of nearby forests to support pollinators communities.

METHODS

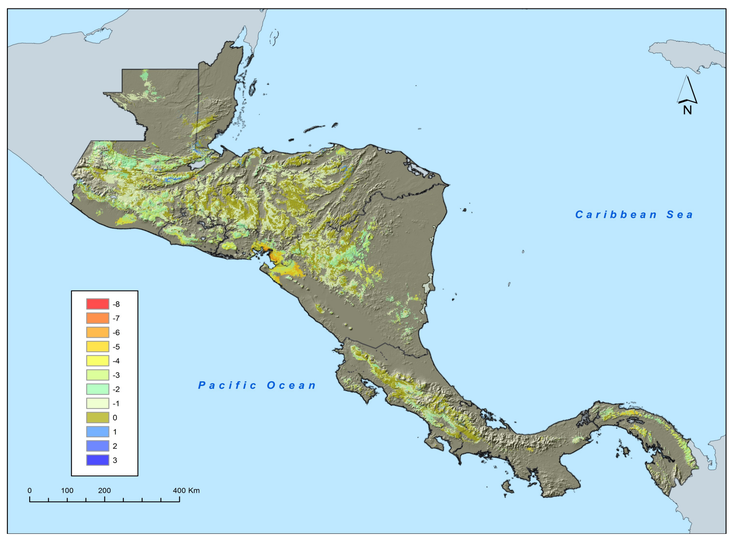
We used a potential suitability model (Maxent) to simulate current and future (19 GCM´s under mid-global warming levels from CMIP5, indicating mean climate conditions for 2040-2060) scenarios of coffee and bees distribution ranges. We modelled distribution of 13 bee species known as coffee pollinators in Central America. Distance to forests was also used as a factor conditioning bees and pollination services.

RESULTS



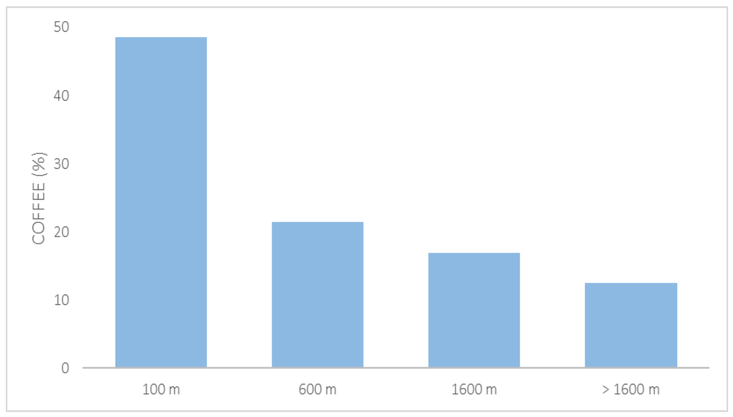
a

Figure 1. Fraction of currently coffee suitable areas and bee diversity (as fraction of total (13) bees simulated under current and future climate contitions **(a).** Changes in the number of bee species under future climate scenarios (mean change across 19 GCMs) in currently suitable cofffee areas **(b)**.



b

- Larger fractions of coffee suitable areas are in relatively high bee diversity areas. Future bee diversity decreases in currently suitable coffee areas. (Fig. 1a).
- Currently suitable coffee areas with reduction/increase in bee species occur mostly in all Central American countries/Guatemala and Honduras (Fig. 1b). Significantly large areas maintain the number of bee species under future climate conditions.



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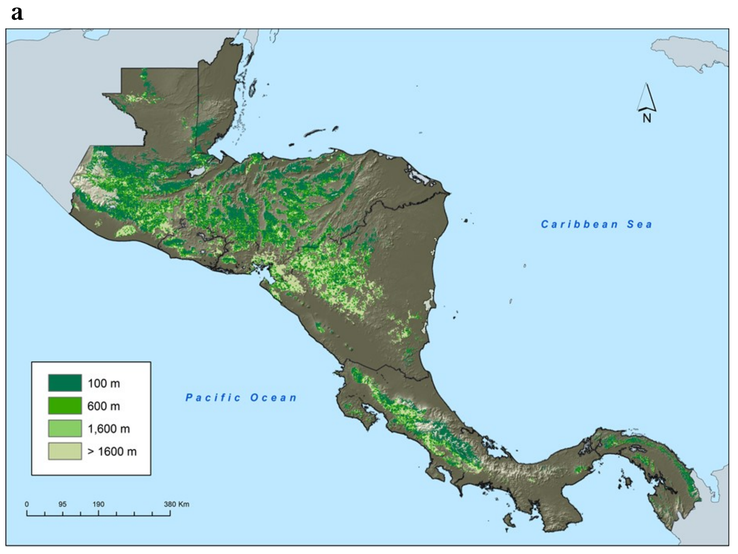

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Figure 2. Fraction of currently coffee suitable areas and distance to forests (forest cover data for 2012 from Hansen *et al.* 2013) **(a).** Distance of currently suitable coffee areas to forests **(b)**.

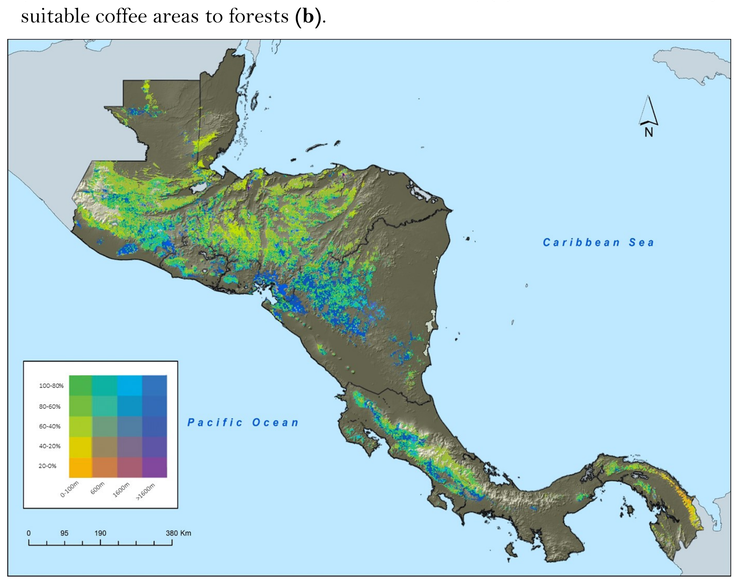

Figure 3. Coffee suitable areas across bee diversity (fraction of total (13) bee species) and distance to forests (m) gradients under current bee diversity.

- A large fraction (>80%) of coffee suitable areas are close to forests (>600m) and half of the area (48%) is within 100m of forests. Less than 15% of coffee suitable areas have no forests supporting bee communities (>1600 m) (Fig.2a). Coffee suitable areas with largest/shortest distances to forests are located in Nicaragua/Honduras (Fig.2b).
- High bee diversity areas closer to forests (light green) occur in Honduras Guatemala and Costa Rica (Fig. 3)
- Areas suitable for high bee diversity could be compromised due to forests too distant to sustain bee diversity and/or visitation (dark blue and purple areas) in most of Nicaragua and over specific areas in other countries (Fig 3).

CONCLUSIONS

- Central America has a large fraction of coffee suitable areas with relatively high bee diversity within distance to forests that can support bee communities.
- Coffee suitable areas further from forests with high bee diversity would benefit from forests restoration near coffee fields to support pollination services (i.e. over most of Nicaragua).
- Future climate change scenarios indicate a potential reduction in bee diversity, generalized over the region, indicating a potential reduction in pollination services for coffee.
- Our results indicate the need to study different pollinator diversity thresholds and its effect on coffee productivity and possible crop management mechanisms to offset potential losses due to climate change and pollinators.

Future Work

- Assess changes in coffee suitability under future climate conditions combined with changes in bee species diversity in order to assess whether future suitable coffee areas will potentially benefit from pollination services.
- Assess whether future suitable coffee areas will require forest restoration to support pollination services.
- Assess potential changes in forest cover limiting or enhancing pollination services under future climate scenarios.

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