The unseen costs of agricultural expansion across a rainforest landscape: depauperate pollinator communities and reduced yield in isolated crops.

Thesis submitted by
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I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Abstract

Biotic pollination services are an essential component of agricultural landscapes; approximately three quarters of the world's crop species use biotic pollen vectors to initiate or enhance fruit and seed production (Roubik 1995, Nabhan & Buchmann 1997, Kenmore & Krell 1998). Biotic pollination services are in decline, necessitating maintenance of either landscape elements required by pollinating species or the development of new ways to enhance currently managed species or potential new ones (Allen-Wardell *et al* 1998, Heard 1999).

In this empirical study I have surveyed the potential pollinators and measured fruit productivity within a tropical horticultural crop (*Annona squamosa* x *A. cherimola* cultivar (cu.) 'Hillary White': custard apple) across a northern Australian tropical landscape comprised of a matrix of agricultural land and remnant rainforest patches. I tested the relationship between floral visitor species richness and abundance and two variables; distance that a custard apple orchard was located from naturally occurring rainforest and rainfall. I also tested for a relationship between fruit productivity (initiation) and the distance a custard apple crop was located from naturally occurring rainforest.

Unfortunately, due to the absence of replication of the variable 'orchard distance from naturally occurring rainforest', all conclusions must be seen as relationships between measured floral visitor and fruit production variables and orchard location in the landscape. The mechanism/s driving these patterns could be a number of factors associated with the landscape gradient such as north-south gradient, rainfall decline or

distance that the orchard was located from naturally occurring rainforest and it will take further empirical study to qualify the most important ones. For simplicity here I have retained the variable ‘distance from naturally occurring rainforest’ or ‘crop isolation’ in the thesis as it was the variable that determined the selection of sites.

I found 19 species of floral visitors (18 beetles and 1 thrip) to female custard apple flowers; 16 of which are potentially new records for custard apple pollination. Species richness and abundance declined exponentially with distance that a crop was located to naturally occurring rainforest indicating that these floral visitors rely, at least in part, on rainforest resources in the landscape. This is some of the first evidence published (see Blanche & Cunningham 2005) of an effect of crop isolation from native habitat (landscape structure) on a pollinator assemblage other than social bees.

Fruit productivity showed the same relationship; flowers were pollen limited in all orchards but there was an exponential decline in productivity with crop isolation indicating that pollen limitation was more pronounced in orchards isolated from naturally occurring rainforest. Empirical evidence for an effect of landscape structure on pollinator assemblages and resultant fruit production has also been found in tropical crop species such as *Macadamia tetraphylla* (Macadamia nut), in southeastern Australia and *Coffea arabica* (Coffee) in Central Sulawesi, Indonesia (Heard & Exley 1994, Klein *et al* 2003).

I propose from this evidence that the configuration of landscape elements, such as remnant native rainforest, across an agricultural landscape must be considered in

proposals to expand crop areas. Ignoring these elements including threshold distances between pollinator ‘sources’ and crop plants will be detrimental and costly to growers and ultimately may jeopardise the sustainability of agricultural crops.

I have also shown in this research that current hand-pollination practises essential to custard apple growers for producing a viable crop may not be ideal. Custard apple growers’ hand-pollinate female custard apple flowers using pollen sourced from either ‘Hillary White’ or ‘African Pride’ cultivar trees. I found that flowers hand-pollinated using cu. ‘African Pride’ produced larger and more symmetrical fruit (better fruit quality) than those hand-pollinated using cu. ‘Hillary White’. These parameters of a fruit are important to growers because larger and more symmetrical fruit are more valuable on the market. The difference in fruit quality was not associated with a decline in fruit quantity in flowers pollinated using cu. ‘African Pride’.

Hand-pollination is a incredibly time consuming practise and any progression in traditional hand-pollination techniques that improves fruit production either through an increase in fruit quantity or quality is likely to be embraced by custard apple growers.

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