The Impact of Local Plant Density on Plant-Pollinator Interactions and Plant Reproduction in a Fragmented Landscape: A Comparative Approach

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DECLARATION

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged.

[redacted]

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ABSTRACT

In the study of the "fragmentation paradigm" researchers variously measure parameters such as isolation, connectivity, patch size or population size, at different spatial and temporal scales. All of these aspects have been implicated (both positively and negatively) in shaping species' responses and interactions to fragmentation. Clarity is required here however, about the relative importance of ecological factors that can influence species' resilience and persistence. In addition, studies are often zoologically inclined. A problem with plant-based studies has been the bias towards herbaceous temperate species that exist in European landscapes, which have experienced Pleistocene glacial episodes and subsequent agrestral activities. The utility of ecological work from these ecosystems to for example, Australian ecosystems requires close scrutiny.

The study of plant and pollinator responses to fragmented and altered landscapes in the last two decades has shown that the landscape context and time since fragmentation is important in shaping species persistence and resilience. Furthermore, local density effects may in fact be more influential on plant performance than currently assumed. This study focuses upon the effects of local patch density (sparse versus dense) on floral visitation and plant fecundity within naturally occurring populations in a fragmented landscape occurring on the New England Tablelands in New South Wales, Australia.

In this thesis, I use three plant species with different breeding systems and floral morphology as vehicles for examining the impacts of local density on floral visitation rates, fecundity and offspring fitness; *Dillwynia sieberi* (Fabaceae), an obligate outcrossing shrub, *Wahlenbergia luteola* (Campanulaceae), a facultative outcrossing herb and *Thesium australe* (Santalaceae) a hemiparasitic herb which displays high levels of selfing. Fruit: flower ratios, seed: fruit ratios, and components of offspring fitness such as seed weight and germinability were included as performance indicators in this study.

Thesium australe lacks obvious visitors, but cryptic species such as thrips (Thysanoptera) may contribute to pollination. A diverse assemblage of native bees was observed visiting both *W. luteola* and *D. sieberi*; the introduced honeybee *Apis mellifera* was a common visitor to *D. sieberi* but was not observed on *W. luteola* flowers. Hoverflies (Syrphidae) were also regular visitors to *W. luteola*. For these two plant species, density was an important influence on floral visitation rates, particularly for *W. luteola* where dense patches consistently received significantly higher visitation rates than sparse. This

pattern, although less obvious, was also observed for visitation to *D. sieberi*. Intra-specific visitor behaviour on *D. sieberi* individuals was also influenced by density.

The lack of visitors to *T. australe* may be promoting inbreeding depression. High levels of autogamous fruit production were observed for the strongly self-compatible *T. australe*, thus conferring reproductive assurance in a system where an apparent lack of visitors precludes outcrossing. However, a high incidence of partial seed fill and a lack of germinability, which are characteristic of inbreeding depression, were observed in these populations. There was little suggestion that fecundity or fitness was density-related in *T. australe* populations. However, viability was slightly higher in seed from dense plots, which may indicate an influence of underlying environmental or genetic effects.

Wahlenbergia luteola is self-compatible, and its protandrous condition coupled with negligible pollen limitation in this system appears to release it from any negative effects, which may be associated with density–dependent visitation. Seed and seedlings from both densities performed equally as well in germination and glasshouse experiments, but significant site differences for these factors were manifest. For the obligate outcrossing *D. sieberi*, FR: FL ratios were significantly higher in dense compared with sparse individuals, but this relationship did not extend to seed production (S: FR), which was similar between densities. There was evidence to suggest that density-induced intra-plant behaviour influenced the proportion of 1- and 2-seeded fruit production in *D. sieberi* (the flowers of which produced two ovules). The mean mass of seed from 1-seeded fruits was greater than that from 2-seeded fruits, and heavier seeds produced larger offspring in glasshouse experiments. This suggests that visitor behaviour may exert some influence on offspring fitness and that this can be shaped by density.

There is little doubt that visitation can be influenced by density in these systems however, the extent to which this influences reproductive output and offspring fitness for both *W. luteola* and *D. sieberi* was difficult to ascertain. To conclude unequivocally that density-dependent visitation is *not* a differential driver of reproductive success for these species would be shortsighted, especially considering the aforementioned results obtained for *D. sieberi*; other factors may be clouding what was anticipated to be a relatively clear relationship. Compared with the facultative outcrossing *T. australe* and *W. luteola*, the obligate outcrossing *D. sieberi* showed the greatest utility for measuring density-related visitation and subsequent reproductive responses. Furthermore, the utility of the indicators used to assay responses varied greatly depending on the species, and it is recommended that a suite of indicators be used to adequately interpret results.

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List of Abbreviations

GENERAL

FR: FL	Fruit to flower ratio; the number of fruits that arose per flower.
S: FR	Seed to fruit ratio; the number of seeds that arose per fruit
SW: FR	Seed weight to fruit ratio (surrogate for S: FR)
P:O	Pollen to ovule ratio; the number of pollen grains per ovule
HBs	Introduced honeybees, *Apis mellifera*
NBs	Australian native bees collectively
FP	Focal Plant
NN	Near Neighbour; nearest conspecifics to a focal plant
NND	Near Neighbour Distance (from the focal plant)
SC	Self-Compatible
SI	Self-Incompatible

STUDY SITES

ABR	Aberfoyle Rd
BM	Black Mountain Cemetery
MOR	Moray
OAR	Old Armidale Road
POW	Powalgarh
UNE	University of New England

CHEMICALS

FAA	Formalin: Acetic acid: Alcohol (fixative)
GA_3	Gibberellic Acid (plant hormone)
TTC	2,3,5-triphenyl-2H-tetrazolium chloride