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EFFECTS OF GARDEN TYPE AND DISTANCE FROM BUSH ON ADVENTIVE TREES IN DOMESTIC GARDENS

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(with three text-figures and two tables)

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Gardens are both a source of plant species that invade native vegetation (bush) and are places that native species can invade. We test the hypotheses that the richness of adventive exotic and native trees in suburban gardens declines with distance from the bush, and that the type of garden strongly influences the establishment of adventive trees. The adventive woody species in front gardens of houses on randomly selected streets in three Hobart suburbs were observed from the street, along with garden type. Distance from the bush boundary was measured from maps. Most taxa occurred less frequently with increasing distance from the bush and garden type was associated with the occurrence of several taxa. Distance and garden type had no effect on the exotic *Pittosporum undulatum*, possibly because it is rare in native vegetation due to its fire sensitivity but is both attractive to many gardeners and well-dispersed by birds between gardens.
Key Words: ***Acacia, Bursaria, Cotoneaster*, dispersal, eucalypts, *Dodonaea, Exocarpos*, *Pittosporum undulatum*, suburban gardens.**

INTRODUCTION

Over half of the world's population live in urban areas (Giles-Corti *et al.* 2016). Much of these urban areas, especially in richer countries, are devoted to private gardens (Loram *et al.* 2007), often located adjacent to remnants of natural vegetation. Gardens provide habitat for fauna, the species composition of which varies by garden characteristics (e.g., Daniels & Kirkpatrick 2006a, Smith *et al*. 2006). Gardens are also a source of weeds that invade adjacent natural vegetation (Groves *et al.* 2005, Alston & Richardson 2006, Ivey-Law & Kirkpatrick 2015, Guo *et al.* 2019). However, these weeds appear to be as often dispersed from natural vegetation to gardens as they are from gardens to natural vegetation (Zagorski *et al.* 2004). Plants native to natural vegetation in urban areas may also be able to colonise gardens from natural vegetation or from remnant individuals that have survived urban development.

The probability of adventives from natural vegetation is likely to decrease with distance from the interface of bush with suburbia, given the reverse-J dispersal curves typical of plants (Vittoz & Engler 2007). Individual survivors of suburbanisation are also likely to decrease in density with distance as well, as old trees are successively removed (Kirkpatrick *et al.* 2011 and 2013). The probability of survival of adventives in gardens is likely to be largely a function of the preferences and activities of gardeners. The variability of preferences and activities (Kirkpatrick *et al.* 2012, van Heezik *et al.* 2013) can result in adjacent gardens that markedly differ in their species composition and structure (Thompson *et al.* 2003, Kirkpatrick *et al.* 2009), even within small distances. Distinct garden types have been recognised in Hobart, Tasmania (Daniels & Kirkpatrick 2006b, Kirkpatrick *et al.* 2007), as have strong relationships between the attitudes of gardeners and the type of garden (Zagorski *et al.* 2004). Gardeners who prefer exotic species and who spend much time weeding their gardens are likely to remove any native adventives, whereas those who prefer natives or avoid weeding are less likely to remove native adventives (Zagorski *et al.* 2004). Thus, we can expect that garden type will affect the success of adventives.

This paper tests whether adventive native and exotic tree species in gardens are associated with native vegetation, the degree to which there is distance decay in their distributions in gardens and whether there is variation in their incidence by garden type.

METHODS

Three inner Hobart city suburbs of West Hobart, Sandy Bay and North Hobart (fig. 1) were sampled by selection of sections of streets and roads with similar block sizes and socioeconomic status to provide varying distances from native vegetation, which largely consisted of dry eucalypt forest and woodland. Two hundred and nine gardens were used in the analyses.

Distance from native vegetation to each front garden was measured using the tool in LISTmap. Presence or absence of the following species in the section of the garden visible from the street was recorded: *Pittosporum undulatum* Vent. (Sweet Pittosporum), *Cotoneaster* spp., *Exocarpos cupressiformis* Labill. (Cherry Ballart), *Dodonaea viscosa* Jacq. (Hopbush), *Bursaria spinosa.* Cav. (Sweet Bursaria), *Acacia dealbata* Link. (Silver Wattle), *Acacia melanoxylon*

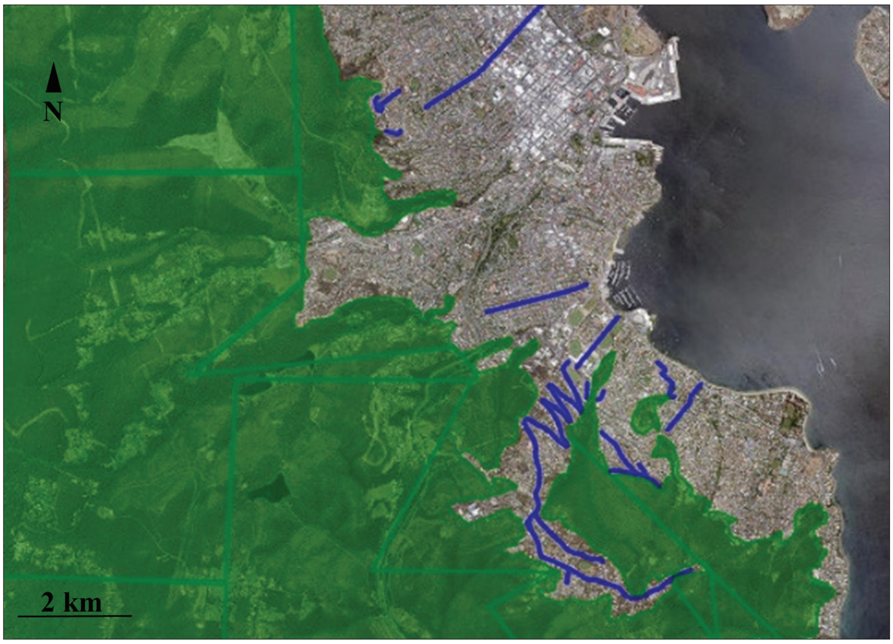

FIGURE 1 – Location of the streets in the city of Hobart, Tasmania, Australia within which front gardens were sampled (marked in blue) with respect to the natural vegetation boundary (marked in green). Location of top right-hand corner of map: 42°52'31"S 147°22'3"E.

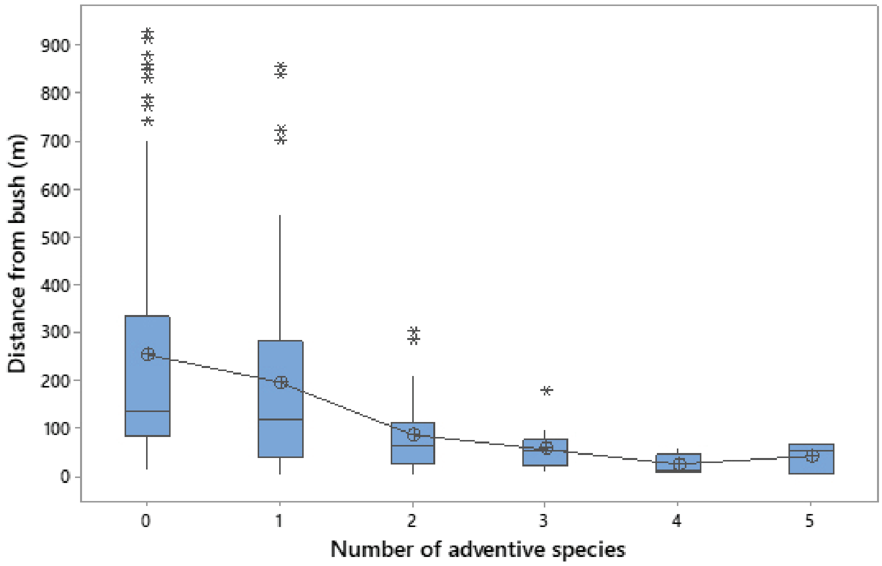

FIGURE 2 – Number of adventive species by distance from bush. The boxes contain 50% of the observations, the whiskers and outliers above and below 25% each. The median is a horizontal line. Lines connect the means.

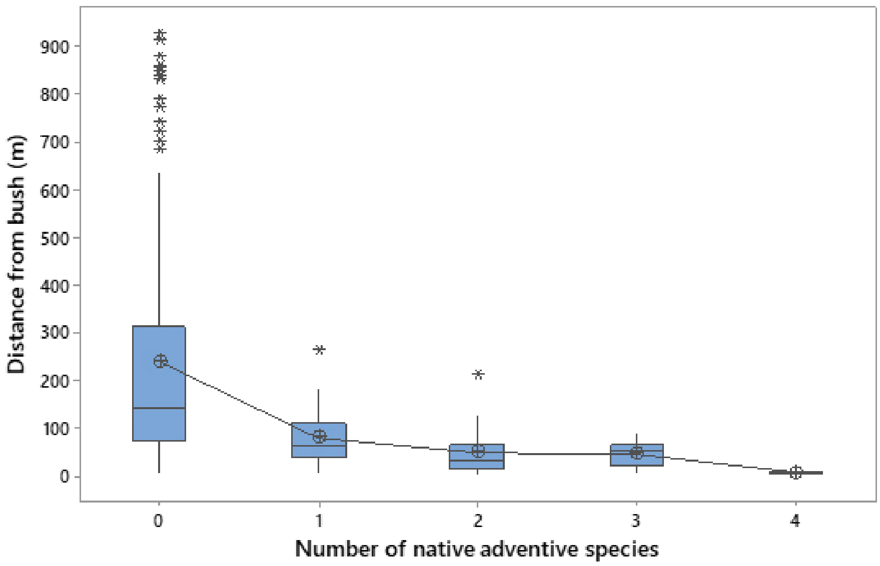

FIGURE 3 – Number of native adventive species by distance from bush. The boxes contain 50% of the observations, the whiskers and outliers above and below 25 % each. The median is a horizontal line. Lines connect the means.

R.Br. (Blackwood), *Acacia mearnsii* De Wild. (Black Wattle), *Eucalyptus pulchella* Desf. (White Peppermint) and *Eucalyptus viminalis* Labill. (White Gum). The first two were examples of non-native trees, and the remainder were trees native to adjacent bushland. Of these native trees, *Exocarpos* and *Acacia* seed can be transported by birds, with the remaining species having seed that is normally weakly dispersed by wind close to its source, with almost all seed from eucalypts deposited within twice tree height. *Exocarpos*, *Acacia* and *Dodonaea* have persistent soil seed stores (Bezemer *et al.* 2013). Garden type, as defined by Daniels and Kirkpatrick (2006b), was recorded.

One-way ANOVA, using Welch's test to account for non-equal variances, was used to test the relationship between distance from the bush and the presence/absence of individual taxa. ANOVA, assuming equal variances was used to determine the relationship between garden types (complex flower gardens, exotic shrub gardens, minimal input exotic gardens, shrub and bush tree gardens, simple native gardens, and woodland garden) and each of adventives per garden, native adventives per garden and the distance from native vegetation. Tukey's test was used to determine the significance of individual differences between garden types. Chi squared was used to determine if the frequency of adventive taxa varied between garden types. All statistical analyses were undertaken in Minitab version 18 (https://www.g2.com/).

RESULTS

The numbers of adventive species, and native adventive species, in gardens declined strongly with distance from native vegetation (figs 2, 3), with all observed native adventives being within 300 m of the bush (fig. 3). Gardens with native adventives were, on average, much closer to native vegetation than those without native adventives (64 m cf. 293 m) (table 1). The nearest native species to the bush boundary was *Bursaria spinosa*, followed in order by *Exocarpos cupressiformis*, *Eucalyptus pulchella*, *Acacia mearnsii*, *Dodonaea viscosa*, *A. dealbata*, *E. viminalis* and *A. melanoxylon* (table 1). The exotic, *Cotoneaster*, although significantly concentrated near the bush boundary, had a greater mean distance than any of the native species (table 1). The other exotic, *Pittosporum undulatum*, was ubiquitous (table 1).

There was no difference between garden types in their mean distance from the bush boundary or the mean species richness of all adventives (table 2). However, the mean native adventive species richness of the simple native garden was greater than that of the exotic shrub garden and the woodland garden (table 2). The highest percentage frequency of both all adventives and native adventives was in the shrub and bush tree garden and the least in the complex flower garden (table 2). *E. viminalis* was significantly differentiated between garden types, its percentage frequency being highest in the shrub and bush tree garden and least in the exotic shrub garden (table 2).

DISCUSSION

The lack of significant differentiation between garden types in mean distance from the bush boundary gives us confidence that our analysis of the effects of both garden type and distance from bush are not substantially biased by variation in the location of garden types.

The distance from the bush boundary to where a species is found may be influenced by patterns of dispersal of their disseminules from natural vegetation, dispersal from remnant bush trees in gardens or dispersal from trees that have previously invaded gardens from the bush or other gardens. Inter-garden migration seems likely to have

TABLE 1 – Mean distances from natural vegetation of gardens with and without taxa of adventive tree species and all local native species

Taxon	**Distance (m)**		**F**	**P (Welch's test)**
	Present	Absent		
Pittosporum undulatum	196	186	0.07	0.787
Cotoneaster species	115	218	15.08	<0.001
Acacia melanoxylon	85	195	23.06	<0.001
Eucalyptus viminalis	78	203	35.84	<0.001
All local native species	64	239	69.25	<0.001
Acacia dealbata	52	194	50.98	<0.001
Dodonaea viscosa	50	205	57.35	<0.001
Acacia mearnsii	44	192	45.36	<0.001
Eucalyptus pulchella	34	197	82.47	<0.001
Exocarpos cupressiformis	27	196	96.50	<0.001
Bursaria spinosa	24	195	92.81	<0.001

TABLE 2 – The percentage frequency of adventive taxa in gardens and gardens of different types, mean richness (number) of adventives and mean distance from natural vegetation

	CF	ES	MIE	SBT	SN	W	All	P
N	16	39	63	19	38	34	208	
All	31.25	48.72	52.38	**78.95**	65.79	50.00	55.55	**0.044**
All Native	12.50	17.95	25.40	**63.16**	44.74	17.65	28.71	**0.001**
Cotoneaster spp.	18.75	17.95	31.75	21.05	34.21	38.24	28.71	0.297
Pittosporum undulatum	6.25	28.21	20.63	26.32	10.53	23.53	20.10	0.212
Eucalyptus viminalis	6.25	0.00	12.70	**31.58**	18.42	5.88	11.48	**0.003**
Acacia melanoxylon	0.00	0.00	9.52	21.05	5.26	0.00	5.19	-
Eucalyptus pulchella	0.00	7.69	1.59	10.53	10.53	2.94	4.76	-
Exocarpos cupressiformis	0.00	5.13	3.17	5.26	7.89	2.94	4.76	-
Acacia dealbata		0.00	2.56	6.35	5.26	7.89	0.00	4.33
Bursaria spinosa	0.00	0.00	3.17	0.00	13.16	2.94	3.46	-
Acacia mearnsii		0.00	0.00	0.00	5.26	7.89	2.94	2.60
Mean richness of natives	0.19AB	0.28B	0.41AB	0.84AB	**0.89A**	0.29B	0.48	**0.003**
Mean richness of adventives	0.44	0.74	0.94	1.32	1.34	0.91	0.94	0.057
Mean distance (m)	192	233	185	135	130	236	205	0.227

P = probability (Chi Square likelihood ratio for taxa, ANOVA for others, ANOVA means with same letter (A or B) in a row are identical at P > 0.05). Bold indicates the highest value in a row in which there is significant differentiation. CF = complex flower, ES = exotic shrub, MIE = minimum input exotic, SBT = shrub and bush trees, SN = simple native, W = woodland.

dominated in the distribution of *Pittosporum undulatum*, a species native to mainland eastern Australia, which is rare in the bush because of its fire sensitivity (Gleadow & Ashton 1981). *Pittosporum undulatum* is tolerant of dry conditions, is dispersed by native and exotic birds (Gleadow & Ashton 1981) and is an attractive small tree with highly scented flowers and dense glossy foliage, making it less likely to be removed by weeding than less attractive plants. The other exotic taxon we observed was *Cotoneaster*, which is dispersed by birds from the bush to gardens and vice-versa, as well as between gardens (Zacharek 1990, Zagorski *et al.* 2004). The concentration of *Cotoneaster* near the bush boundary, despite a widespread occurrence, indicates dispersal from the bush, which can occur up to 400 m through the agency of native birds (Zacharek 1990).

The close proximity of the native adventive species to the bush boundary suggests a strong role of dispersal from the bush. However, in many cases the species may have persisted on suburban blocks that were not totally cleared before house construction. The species with the highest mean distances from the bush are trees that were previously widespread in the study area, but they are no more widespread than many of those with lesser mean distances. Different species of *Eucalyptus* and *Acacia* have a wide range of mean distances, despite little variation in seed dispersal mechanisms between congeners, suggesting that their pre-suburbanisation patterns of distribution may have played a role in determining their present distributions in gardens.

The concentration of native and total adventives and *E. viminalis* in shrub and bush tree gardens and simple native gardens is likely to reflect the nativist values of the gardeners, as well as their tendency to leave the garden to itself (Zagorski *et al.* 2004). The low percentage frequency of both all adventives and native adventives in complex flower gardens reflects the intensity of weeding of this garden type, combined with a preference for exotics and herbs (Zagorski *et al.* 2004). The exotic shrub gardens and woodland gardens that have lesser native adventive species richness than the simple native gardens are also well-weeded. The woodland gardener does incorporate the less straggly of native trees into their rich palette, while local natives are generally not planted by exotic shrub gardeners (Daniels & Kirkpatrick 2006b).

We conclude that there is highly likely to be dispersal of trees from bush into gardens, that this dispersal is concentrated close to natural vegetation, and that the type of garden is associated with variation in the propensity of adventive trees to establish. It may be possible to increase the conservation and amenity values of at least some gardens by informing the gardeners about the values of the native species that are likely to colonise their gardens. For example, *Exocarpos cupressiformis* is an attractive small tree that has bird-dispersed fruits with arils that are eaten by many animals, including humans. It is also apparent that concentrating efforts to control the exotic *Cotoneaster* species in gardens and bush close to the boundary is highly desirable.

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