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Isolated *Ficus* trees deliver dual conservation and development benefits in a rural landscape

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ABSTRACT

Many of the world's rural populations are dependent on the local provision of economically and medicinally important plant resources. However, increasing land-use intensity is depleting these resources, reducing human welfare, and thereby constraining development. Here we investigate a low cost strategy to manage the availability of valuable plant resources, facilitated by the use of isolated *Ficus* trees as restoration nuclei. We surveyed the plants growing under 207 isolated trees in Assam, India, and categorized them according to their local human-uses. We found that *Ficus* trees were associated with double the density of important high-grade timber, firewood, human food, livestock fodder, and medicinal plants compared to non-*Ficus* trees. Management practices were also important in determining the density of valuable plants, with grazing pressure and land-use intensity significantly affecting densities in most categories. Community management practices that conserve isolated *Ficus* trees, and restrict livestock grazing and high-intensity land-use in their vicinity, can promote plant growth and the provision of important local resources.

Keywords: Assam - Community management - Conservation - Development - *Ficus* - Human-uses - India - Regeneration

INTRODUCTION

Dependence on ecosystem goods and services is common in rural areas across the globe (MEA 2005). In rural India, households are dependent on forest and private resources for timber, firewood, and medicinal products (Natarajan 1995; Heltberg et al. 2000; Phondani et al. 2013). However, increasing environmental degradation is causing a decline in the provision of ecosystem goods and services, exacerbating poverty and reducing human welfare (Maginnis and Jackson 2002; MEA 2005; TEEB 2010). In Meghalaya, India, for example, forest degradation has not only reduced the availability of firewood, but has also reduced the richness of medicinally important flora (Laloo et al. 2006). The decline in natural capital is particularly problematic as modern substitutes are beyond the means of the poorest households (Gadgil 1993; TEEB 2010). Hence this process also serves to increase the marginalisation of stigmatised social groups (Heltberg et al. 2000).

It is therefore important to increase the availability of subsistence and economically important ecological goods and services in rural areas (MEA 2005; Chokkalingam et al. 2006; Rey Benayas et al. 2009). Various authors have suggested forest plantations, direct seeding, and natural succession as strategies to increase tree cover and eco-service provision (Lamb et al. 2005; Chazdon 2008; Rey Benayas et al. 2009; Hall et al. 2011). However, government sponsored schemes have achieved limited or mixed success (Dewees 1995; Nibbering 1999; Dudley et al. 2005; van 't Veld et al. 2006; Wuethrich 2008; Le et al. 2012), while private tree planting initiatives are constrained by insufficient access to resources such as labour, land, and finance (Arnold et al. 2006; Gebreegziabher and van Kooten 2013). One novel solution may be the use of isolated trees as the foci of vegetation restoration, taking advantage of the natural process of seed dispersal (Toh et al. 2002; Manning et al. 2006). As fruit-bearing tree species are likely to be more attractive to frugivorous seed dispersers, *Ficus* trees, many of which have extremely large crop sizes, may provide particularly useful nuclei in the regeneration of economically important flora (Shanahan et al. 2001; Howe and Miriti 2004; Caughlin et al. 2012).

Furthermore, in some regions, *Ficus* trees have enhanced cultural status through their associations with major religions, local faiths, or traditional belief systems (Gaultier 1996; Huabin 2003; Wilson and Wilson 2013). *Ficus* trees are used as sites of worship in many faiths, and taboos on cutting down large *Ficus* trees have been reported from several sites across Asia (Horowitz 1998; Long and Zhou 2001; Wilson and Wilson 2013). The cultural standing of *Ficus* trees may be instrumental in conserving their populations in rural landscapes by lowering mortality from direct felling, potentially increasing their importance as food sources for frugivores and restoration sites for plants.

Cultural considerations centered on religious, spiritual, and aesthetic values also mean that *Ficus* trees are commonly found on public land: along roads, in markets, in town squares, and at temple sites (Barua et al. in review; [*XX*] et al. in review). In addition, land tenure may affect livestock grazing pressure and the likelihood of human clearance. Therefore the provision of useful plant resources may also be influenced by the precise locations of isolated *Ficus* trees.

In this study, we sought to discover whether isolated trees increase the local availability of natural goods and services. Specifically, we aimed to test: 1) whether economically or medicinally valuable plant species grew under isolated trees; 2) whether isolated *Ficus* trees are associated with (i.e. surrounded by) more valuable plants than other common isolated trees; and 3) how land management practices affected the density of valuable plants growing under isolated trees.

METHODS

The study was conducted from October 2012 to June 2013 in the Golaghat District of Assam, North-east India. The study area was a ≈250 km^2 region bounded by Kaziranga National Park at N26 34.394 E93 15.433, the city of Jorhat at N26 46.198 E94 12.678, and the town of Golaghat at N26 27.819 E93 54.978. The elevational range of the study area is 30–100 m above sea level, and the mean annual rainfall in the region is 1,500–2,500 mm, most of which falls in the May to August monsoon (Shrivastava and Heinen 2007). The annual temperature range varies from a mean minimum of 5°C to a mean maximum of 35°C (Barua and Sharma 1999). The original habitat of moist subtropical deciduous forest was largely cleared for commercial tea production in 1840 (Shrivastava and Heinen 2007). The landscape is an agricultural mosaic, with a heterogeneous assortment of small-holder rice cultivation, tea estates, and village home gardens, with a population density of 302 people per square kilometre (GOI 2011).

We surveyed 207 mature isolated trees, of which 103 were *Ficus* trees, and 104 were non-*Ficus* trees. To select trees, we would stop after driving or walking for 500 m, measure any *Ficus* trees present, and select the three largest non-*Ficus* trees in the area for measurement. In all cases, focal trees had to be a minimum of 30 m from the nearest *Ficus* tree or non-*Ficu*s tree. We repeated this sampling process until we had over 100 focal trees of each type.

We recorded the species of each of these 207 focal trees and measured the diameter at breast height (DBH) with a tape measure, estimated the maximum tree height with a clinometer, and estimated the canopy area by measuring the canopy diameter at ground level along two axes, and then calculating the area using the formula for an ellipse (Table 1). We also recorded the grazing intensity of the area under the canopy by consulting local landowners and observing grazing damage. Specifically, local landowners were asked how many animals and what species of livestock grazed the site, and how often livestock grazed in the area. We also looked for grazed stems and bite marks on the plants around focal trees to corroborate these reports. Although wild Asian Elephant (*Elephas maximus*) and several species of deer (Cervidae) inhabited the area, the overwhelming majority of grazing pressure came from domestic animals, and in particular, goats and cattle. We ranked grazing intensity using a three point scale where 0 is very little evidence of grazing; 1 is some livestock occasionally graze the site; and 2 is large numbers of livestock frequently graze the site. The human land-use of the area under the canopy was also recorded from observations using a similar three point scale (where 0 is very little human land-use; 1 is some human land-use, such as a village home garden or livestock grazing area; and 2 is intense human land-use, in cases where a road, house, or paddy field are present under the canopy). Finally, the land tenure at each focal tree's growing location was recorded as being under either private or public ownership, which was determined through consultation with nearby households.

At each focal tree, we identified and measured the height of plants growing under the canopy. We restricted our measurements to trees, shrubs, vines, and forbs of 20–200 cm in height, and identified the species found following several sources (Kanjilal et al. 1934–1940; Bora and Kumar 2003; Sarma et al. 2010). To classify the plant species into human-use groups, we identified important local uses of natural resources through consultation with local households and regional plant use publications (Dutta 2006; Laloo et al. 2006), which produced six groups: high-grade timber, low-grade timber, firewood, human food, livestock fodder, and medicinal resources. Plants with multiple uses (60 of 91, 66%) were placed in several groups.

We calculated the density of plants growing under each focal tree for each human-use group. To compare the difference in mean plant densities between *Ficus* and non-*Ficus* trees, we carried out a MANOVA with Pillai's Trace and follow-up univariate contrasts, using the human-use groups as independent variables. To identify the land management practices that affected plant densities, we used a MANOVA with Pillai's Trace and Bonferroni post hoc tests, as two of the independent variables had three groups. The independent variables were grazing intensity, land-use intensity, and land ownership. All analyses were conducted in IBM SPSS Statistics 21 (IBM 2012).

RESULTS

The *Ficus* focal trees were large (Figure 1), hemi-epiphytic species, comprising 26 *F. benghalensis*, which has large fruit (mean diameter=182 mm, n=62), with the rest small-fruited species (mean diameter=131 mm, n=47), comprising 57 *F. religiosa*, 13 *F. rumphii*, 5 *F. microcarpa*, and 3 *F. benjamina*. The canopies of *Ficus* trees were less light permeable that the majority of non-*Ficus* trees, which comprised 28 species, the most common of which were *Mangifera indica* (12 individuals) and *Albizia saman* (11 individuals) (see Table S1 for the full list).

We recorded 7,078 individual plants, representing 117 species, growing under the 207 focal trees. Of these, 91 were identified to species level, and only seven had no locally identified human-use. Twenty-six species were identified as being a good resource for high-grade timber, 16 for low-grade timber, 34 for firewood, 39 for human food, 32 for livestock fodder, and 59 for medicinal products (see Table S2).

Ficus trees were associated with higher mean plant densities in each human-use category than were non-*Ficus* trees (Table 2). Indeed, the type of focal tree had a significant effect on the density of valuable plants growing under the tree canopy

($V=0.6$, $F_{(6,200)}=50.92$, $p<0.001$). Follow-up univariate contrasts confirmed that significant differences existed between the densities of plants growing under *Ficus* versus non-*Ficus* trees in all usage categories (Table 3).

Land-use practices also had a negative effect on the densities of valuable plants, where more intense human land-uses were linked to lower densities of valuable plants. Grazing intensity also had a negative effect, as did interactions between grazing and land-use, and land-use and ownership (Table 4). Ownership alone, and grazing and ownership did not have an effect at the $p>0.05$ confidence level.

Bonferroni post hoc tests indicated that grazing had a negative effect on the densities of high-grade timber, low-grade timber, firewood, and human food plants (all $p<0.05$). However, there was no difference in livestock fodder ($p>0.3$ for all) or medicinal ($p>0.1$ for all) plant densities between areas subject to low, medium, and high grazing pressure. The tests also indicated that land-use intensity was significant at all levels for high-grade timber, low-grade timber, and firewood plants (all $p<0.05$). Land-use intensity did not have an effect for human food between medium and high land-use intensities ($p<0.05$), and for medicinal plants between low and medium land-use intensities ($p<0.1$). For livestock fodder, the post hoc tests were only significant between low and high land-use intensities ($p<0.02$).

DISCUSSION

Our results demonstrate the important role of isolated *Ficus* trees in the regeneration of locally important plant species. The densities of plants growing under *Ficus* trees were significantly higher than under non-*Ficus* trees in all economic and medicinal human-use categories. In some case, the average densities of plants were two-

(firewood, human food, livestock fodder, medicinal resources) or almost three- (high-grade timber) times higher under *Ficus* trees than under non-*Ficus* trees.

It appears likely that the higher densities of valuable plants growing under *Ficus* trees is a consequence of *Ficus* trees supporting higher plant densities *per se*, as has been demonstrated in studies from the Neotropics (Slocum 2001; Guevara et al. 2004). However, the exact reasons for a higher density of useful plants growing under *Ficus* trees compared to non-*Ficus* trees are hard to disentangle. Mature hemi-epiphytic *Ficus* trees have larger fruit crops than most other plant species (Kinnaird et al. 1996), and so may attract a wider range and higher abundance of frugivores, which in turn would generate a greater density of seed rain (Guevara et al. 2004; Cole et al. 2010). However, *Ficus* trees also ameliorate environmental conditions under their canopies, with humidity, light, temperature, and soil nutrient levels more closely representing closed forest than the conditions commonly found under many non-*Ficus* trees in disturbed landscapes (Dhanya et al. 2013). Given the larger DBH sizes of *Ficus* trees compared to non-*Ficus* trees, the higher densities may also be a result of their longer growth histories, which would provide more time for plants to become established under *Ficus* canopies. However, *Ficus* trees do grow exceptionally quickly, and their unusual life histories render conventional tree aging techniques invalid. In the absence of further evidence, it seems reasonable to assume that some combination of greater seed rain and ameliorated growing conditions may explain the higher densities of plants growing under *Ficus* trees compared to non-*Ficus* trees, most of which are also valued by the local community for subsistence and the provision of commercial goods.

Land management practices were statistically important in determining plant densities. The significantly lower plant densities around focal trees situated in higher land-use intensities for three categories suggests that land-use planning decisions have a high impact on the local provision of economically important plants. The cultivation of human food plants in residential areas may have increased the supply of their seeds in high land-use areas, which may help explain the absence of a difference between human food plants densities at medium and high land-use sites (Shrivastava and Heinen 2007). The sacredness of *Ficus* trees in Assam may have also had an influence on land-use around them. 15% of *Ficus* trees in the study area are reported to have shrines associated with them, or to grow at temple sites (Barua et al. in review), which customarily have cleared compounds that are devoid of vegetation. Although this means that some *Ficus* trees may be unsuitable restoration nuclei, the conservation of these trees for religious reasons should help augment the overall *Ficus* population size in the landscape (Caughlin et al. 2012).

Grazing by domestic animals is recognized as a major constraint to vegetation restoration in many areas of the tropics, including Assam (Harvey et al. 2011; Holl and Aide 2011; Murgueitio et al. 2011; Bhatta 2011; Barnes et al. 2014). Here, the existence of differences in plant densities between low, medium, and high grazing pressures in four human-use categories suggests that managing grazing pressure would produce higher densities of economically important plants. While excluding livestock entirely from the area under isolated *Ficus* trees would be the most effective strategy, these results indicate that other management plans, which recognize the trade-off between the need for grazing space and the local provision of valuable plants, would also work (Chakravarty-Kaul 2013). Suitable alternatives might be to selectively exclude certain domestic animals, such as goats, or to only allow grazing for short periods in a monthly cycle (Fischer et al. 2009). One challenge to implementing such a system may involve land-ownership issues. Interestingly, the results indicate that land tenure was not a statistical predictor of plant density, suggesting that similar densities are found on public and private land. However, the lack of interaction with grazing suggests that livestock graze the area under focal trees at a similar intensity regardless of ownership, presenting a potential problem in regulating grazing under focal trees on public land (Francis et al. 2013).

With 59 species, the richness of medicinally important plants found under isolated trees in the study was comparable to the richness reported in sacred groves in other states of North-east India (Laloo et al. 2006). As the focal trees in this study provide a much smaller area for plants to grow, yet are of comparable richness to the larger sacred groves, a micro-site strategy may be effective in conserving the resources needed to treat a broad range of illnesses, and helps explain how the use of traditional medicines has persisted following deforestation. The local presence of these medicinal resources is likely to be very useful to local households, who have a detailed understanding of how to use them, and who do not have access to modern health care facilities (Phondani et al. 2013).

The recognition of the role isolated trees, and especially isolated *Ficus* trees, play in regenerating economically and medicinally important plants in rural areas is important from both a conservation and development perspective. If land planning and grazing management initiatives are implemented around these trees, biodiversity metrics and indicators are likely to improve at a local scale, while landscape connectivity is likely to improve at a regional scale. Furthermore, if the areas under isolated *Ficus* trees are well managed, they are likely to provide important resources for local households over long timescales, aligning conservation and development objectives through community resource management (Hutton and Leader-Williams 2003; Adams et al. 2004; Martin et al. 2009). As the cost of reducing grazing and vegetation clearance under *Ficus* trees is low (Barnes et al. 2014), and as *Ficus* trees occur in rural landscapes across the tropics (Slocum 2001; Guevara et al. 2004; Eshiamwata et al. 2006; Caughlin et al. 2012), the conservation of *Ficus* trees and the communities associated with them could yield low-cost improvements to human welfare on a global scale.

Conclusion

The importance of isolated trees for conserving biodiversity has only recently been recognized (Manning et al. 2006; Fischer et al. 2010). Here we demonstrate that the conservation of isolated trees may also help to improve the livelihoods of rural households through the provision of a wide range of economic and medicinal resources. If 'bottom-up' community-led initiatives could successfully encourage the conservation of isolated *Ficus* trees, restricting land-use and controlling livestock grazing in their vicinity, they are likely to achieve both conservation and development benefits.

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Tables

Table 1. Characteristics of isolated *Ficus* and non-*Ficus* focal trees surveyed in Assam, India, from October 2012 to June 2013. DBH is diameter at breast height. Values for DBH, height, and canopy area are mean ± standard error. Different superscript letters denote significantly different means at $p<0.05$ following ANOVA. Codes for land tenure are PU=public land ownership, PR=private land ownership. Codes for land-use intensity and grazing intensity are H=high, M=medium, L=low. The percentages indicate the proportion of *Ficus* and non-*Ficus* focal trees that were recorded in each land tenure, land-use intensity, and grazing intensity category.

Characteristic	***Ficus***	**Non-*Ficus***
Total no. of individuals surveyed	103	104
Total no. of species surveyed	5	28
Land tenure	PU=71%; PR=29%	PU=44%; PR=56%
Land-use intensity	H=59%; M=36%; L=5%	H=44%; M=54%; L=2%
Grazing intensity	H=50%; M=46%; L=5%	H=39%; M=56%; L=5%
DBH (m)	1.38±0.07 ^{a}	0.54±0.03 ^{b}
Height (m)	24.38±0.74 ^{a}	18.43±0.59 ^{b}
Canopy area (m^2)	424.11±35.31 ^{a}	130.79±16.86 ^{b}

Table 2. Densities of plants in each human-use category under 103 isolated *Ficus* and 104 non-*Ficus* focal trees in Assam, India. Values are means±standard error, with the range in parentheses. Significance levels are annotated by asterisks: *=p<0.05; **= p<0.01; ***= p<0.001.

Focal tree type	High-grade timber	Low-grade timber	Firewood	Human food	Livestock fodder	Medicinal resource
Ficus tree (n=103)	0.018±0.0036*** (0–0.26)	0.0089±0.0017** (0–0.09)	0.027±0.0047*** (0–0.37)	0.02±0.0036** (0–0.28)	0.0052±0.0014* (0–0.09)	0.044±0.0063** (0–0.33)
Non-*Ficus* tree (n=104)	0.0067±0.0013 (0–0.08)	0.0051±0.0009 (0–0.04)	0.011±0.0018 (0–0.1)	0.009±0.0013 (0–0.08)	0.0024±0.0005 (0–0.03)	0.022±0.0048 (0–0.44)

Table 3. Follow-up ANOVA contrasts of differences between the densities of plants growing under 103 *Ficus* versus 104 non-*Ficus* trees in all human-usage categories, Assam, India. All differences were significant at the p<0.05 level.

Human-use category	F	d.f.	*P*
High-grade timber	12.53	1, 205	<0.001
Low-grade timber	5.9	1, 205	<0.05
Firewood	16.93	1, 205	<0.001
Human food	11.81	1, 205	<0.01
Livestock fodder	5.64	1, 205	<0.05
Medicinal resource	11.23	1, 205	<0.01

Table 4. MANOVA results with Pillai's Trace (V), on the affect of land management practices on the density of valuable plants growing under all 207 focal trees, Assam, India.

Management practice	**V**	**F**	**d.f.**	***p***
Grazing intensity	0.13	2.25	12, 376	<0.001
Land-use intensity	0.18	3.02	12, 376	<0.001
Ownership	0.038	1.22	6, 187	0.300
Grazing*Land-use	0.29	3.34	18, 567	<0.001
Grazing*Ownership	0.094	1.55	12, 376	0.094
Land-use*Ownership	0.140	2.31	12, 376	<0.01

Figures

Figure 1. An isolated *Ficus* tree in Assam, India.

Table S1. A list of the non-*Ficus* focal trees included in this study, from Assam, India. The number of individual trees analysed per species is recorded in the second column.

Species	Number studied
Adenanthera pavonina L.	1
Albizia lucidior (Steud.) I.C.Nielsen	1
Albizia procera (Roxb.) Benth.	4
Albizia saman (Jacq.) Merr.	11
Alstonia scholaris (L.) R.Br.	6
Artocarpus heterophyllus Lam.	6
Artocarpus lakoocha Roxb.	7
Bombax ceiba L.	2
Carallia brachiata (Lour.) Merr.	1
Cassia fistula L.	7
Dillenia indica L.	3
Dysoxylum binectariferum Hook f. ex. Bedd.	2
Gmelina arborea Roxb.	6
Heliotropium indicum L.	1
Lagerstroemia speciosa (L.) Pers.	4
Litsea monopetala (Roxb.) Pers.	1
Magnolia mannii (King) Figlar	2
Mangifera indica L.	12
Mesua ferrea L.	1
Murraya koenigii (L.) Spreng.	1

Neolamarckia cadamba (Roxb.) Bosser	3
Pongamia pinnata (L.) Pierre	5
Premna bengalensis C.B.Clarke	3
Spondias mombin L.	1
Spondias pinnata (L.f.) Kurz	2
Syzygium cumini (L.) Skeels	5
Tetrameles nudiflora R.Br.	3
Toona ciliata M.Roem.	3

Table S2. Taxonomic list of plants recorded under the focal trees in Assam, India, and their published human uses. A tick denotes an important human use. Abbreviations for mature growth form are: BT=big tree; ST=small tree; S=shrub; V=vine; F=forb. A threshold of 20 m height at maturity was used to differentiate big trees from small trees. In two cases the scientific name of the plant could not be determined, but its local human use was still recorded.

Scientific name	**Family**	**Growth form**	**Timber**	**Low-quality wood**	**Firewood**	**Human food**	**Animal fodder**	**Medicinal**
Spondias mombin L.	Anacardiaceae	BT	✔	✖	✔	✔	✖	✖
Spondias pinnata (L.f.) Kurz	Anacardiaceae	BT	✖	✖	✖	✖	✖	✔
Mangifera indica L.	Anacardiaceae	BT	✖	✔	✔	✔	✔	✔
Annona squamosa L.	Annonaceae	ST	✖	✖	✖	✔	✔	✖
Artabotrys hexapetalus (L.f.) Bhandari	Annonaceae	S	✖	✖	✖	✖	✖	✖
Alstonia scholaris (L.) R.Br.	Apocynaceae	BT	✖	✔	✔	✖	✖	✔
Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don	Apocynaceae	F	✖	✖	✖	✖	✖	✔
Asparagus racemosus Willd.	Asparagaceae	F	✖	✖	✖	✔	✖	✔

Oroxylum indicum (L.) Kurz	Bignoniaceae	ST	✖	✖	✖	✖	✖	✔
Cordia fragrantissima Kurz	Boraginaceae	ST	✔	✖	✔	✖	✖	✖
Canarium bengalense Roxb.	Burseraceae	ST	✖	✖	✖	✖	✖	✖
Senna tora (L.) Roxb.	Caesalpiniaceae	F	✖	✖	✖	✖	✖	✔
Senna alata (L.) Roxb.	Caesalpiniaceae	F	✖	✖	✖	✖	✖	✖
Senna sophera (L.) Roxb.	Caesalpiniaceae	F	✖	✖	✖	✖	✖	✔
Cassia fistula L.	Caesalpiniaceae	ST	✔	✖	✔	✔	✔	✔
Caesalpinia cucullata Roxb.	Caesalpiniaceae	V	✖	✖	✖	✖	✖	✔
Cannabis sativa L.	Cannabinaceae	F	✖	✖	✖	✖	✖	✔
Carica papaya L.	Caricaceae	ST	✖	✖	✔	✔	✔	✖
Terminalia catappa L.	Combretaceae	BT	✔	✖	✔	✖	✔	✔
Tagetes erecta L.	Compositae (*nom. alt.* Asteraeae)	F	✖	✖	✖	✖	✖	✔
Dillenia indica L.	Dilleniaceae	ST	✔	✔	✔	✔	✔	✔
Shorea robusta Gaertn.	Dipterocarpaceae	BT	✔	✖	✔	✖	✖	✔
Vatica lanceaefolia Bl.	Dipterocarpaceae	F	✔	✔	✖	✖	✖	✖
Macaranga indica Wight	Elaeocarpaceae	ST	✖	✖	✖	✖	✖	✔
Elaeocarpus floribundus Blume	Elaeocarpaceae	ST	✖	✖	✖	✔	✔	✖
Mallotus albus (Roxb. ex Jack) Müll. Arg.	Euphorbiaceae	ST	✖	✖	✖	✖	✖	✔
Jatropha curcas L.	Euphorbiaceae	S	✖	✖	✖	✖	✖	✔
Exacum tetragonum Roxb.	Gentianaceae	F	✖	✖	✖	✖	✖	✔
Premna bengalensis C.B.Clarke	Lamiaceae	BT	✖	✖	✖	✔	✖	✔
Gmelina arborea Roxb.	Lamiaceae	BT	✔	✖	✔	✔	✔	✔
Callicarpa arborea Roxb.	Lamiaceae	ST	✖	✖	✖	✔	✔	✔
Clerodendrum infortunatum L.	Lamiaceae	S	✖	✖	✖	✖	✖	✔
Vitex negundo L.	Lamiaceae	S	✖	✖	✖	✖	✖	✔

Ocimum basilicum L.	Lamiaceae	F	✖	✖	✖	✔	✔	✔
Litsea monopetala (Roxb.) Pers.	Lauraceae	ST	✖	✔	✔	✖	✔	✔
Phoebe goalparensis Hutch.	Lauraceae	ST	✔	✖	✖	✖	✖	✖
Lagerstroemia speciosa (L.) Pers.	Lythraceae	BT	✔	✖	✖	✖	✖	✔
Magnolia mannii (King) Figlar	Magnoliaceae	ST	✔	✖	✔	✔	✖	✖
Magnolia griffithii Hook.f. & Thomson	Magnoliaceae	ST	✔	✖	✔	✖	✖	✖
Magnolia champaca (L.) Baill. ex Pierre	Magnoliaceae	BT	✔	✖	✔	✖	✖	✔
Hibiscus rosa-sinensis L.	Malvaceae	S	✖	✖	✖	✖	✖	✔
Heliotropium indicum L.	Malvaceae	F	✖	✖	✖	✖	✖	✔
Bombax ceiba L.	Malvaceae	BT	✖	✔	✔	✖	✖	✔
Urena lobata L.	Malvaceae	S	✖	✖	✖	✖	✖	✔
Melastoma malabathricum L.	Melastomaceae	S	✖	✖	✖	✖	✖	✖
Dysoxylum binectariferum Hook f. ex. Bedd.	Meliaceae	BT	✔	✔	✔	✖	✖	✖
Toona ciliata M.Roem.	Meliaceae	BT	✔	✖	✖	✖	✖	✖
Albizia procera (Roxb.) Benth.	Mimosaceae	BT	✔	✖	✔	✖	✖	✖
Albizia lucidior (Steud.) I.C.Nielsen	Mimosaceae	ST	✔	✖	✔	✖	✖	✖
Albizia saman (Jacq.) Merr.	Mimosaceae	BT	✖	✔	✔	✖	✖	✖
Parkia timoriana (DC.) Merr.	Mimosaceae	BT	✖	✔	✔	✖	✖	✖
Artocarpus lakoocha Roxb.	Moraceae	BT	✔	✔	✔	✔	✔	✖
Artocarpus heterophyllus Lam.	Moraceae	ST	✔	✔	✔	✔	✔	✔
Ficus racemosa L.	Moraceae	BT	✖	✖	✖	✔	✔	✔
Ficus religiosa L.	Moraceae	BT	✖	✔	✔	✖	✔	✔

Ficus microcarpa L.	Moraceae	BT	✖	✖	✖	✖	✔	✔
Ficus benghalensis L.	Moraceae	BT	✖	✖	✖	✖	✔	✔
Morus alba L.	Moraceae	ST	✖	✖	✔	✔	✔	✔
Syzygium cumini (L.) Skeels	Myrtaceae	BT	✔	✖	✔	✔	✖	✔
Psidium guajava L.	Myrtaceae	ST	✖	✖	✔	✔	✔	✔
Nymphaea nouchali Burm.f.	Nymphaceaea	F	✖	✖	✖	✖	✖	✖
Nyctanthes arbor-tristis L.	Oleaceae	S	✖	✖	✖	✔	✔	✔
Pongamia pinnata (L.) Pierre	Papilionaceae	ST	✖	✖	✔	✖	✖	✔
Glycyrrhiza glabra L.	Papilionaceae	F	✖	✖	✖	✔	✖	✔
Passiflora foetida L.	Passifloraceae	V	✖	✖	✖	✔	✔	✖
Baccaurea ramiflora Lour.	Phyllanthaceae	BT	✖	✖	✖	✔	✔	✖
Carallia brachiata (Lour.) Merr.	Rhizophoraceae	ST	✔	✖	✔	✔	✔	✔
Prunus armeniaca L.	Rosaceae	ST	✖	✖	✖	✔	✔	✖
Prunus domestica L.	Rosaceae	ST	✖	✖	✖	✔	✔	✖
Psilanthus bengalensis (Roxb. ex Schult.) J.-F.Leroy	Rubiaceae	S	✖	✖	✖	✔	✖	✔
Coffea arabica L.	Rubiaceae	S	✖	✖	✖	✔	✖	✔
Neolamarckia cadamba (Roxb.) Bosser	Rubiaceae	BT	✔	✔	✖	✖	✖	✖
Catunaregam spinosa (Thunb.) Tirveng.	Rubiaceae	S	✖	✖	✖	✖	✖	✖
Murraya koenigii (L.) Spreng.	Rutaccae	ST	✖	✔	✔	✔	✖	✔
Citrus medica L.	Rutaccae	ST	✖	✖	✖	✔	✖	✔
Citrus reticulata Blanco	Rutaccae	ST	✖	✖	✖	✔	✔	✖
Citrus maxima (Burm.) Osbeck	Rutaceae	ST	✖	✖	✔	✔	✔	✔
Flacourtia jangomas (Lour.) Raeusch.	Salicaceae	ST	✔	✖	✔	✔	✔	✔
Salix tetrasperma Roxb.	Salicaceae	ST	✔	✖	✔	✖	✖	✖

Santalum album L.	Santalaceae	ST	✔	✖	✖	✖	✖	✔
Solanum torvum Sw.	Solanaceae	F	✖	✖	✖	✔	✖	✔
Solanum melongena L.	Solanaceae	F	✖	✖	✖	✔	✔	✔
Datura stramonium L.	Solanaceae	F	✖	✖	✖	✖	✖	✔
Tetrameles nudiflora R. Br.	Tetramelaceae	BT	✖	✔	✔	✖	✖	✖
Camellia sinensis (L.) Kuntze	Theaceae	S	✖	✖	✖	✔	✖	✖
Pyrenaria barringtoniaefolia Seem.	Theaceae	S	✖	✖	✔	✔	✔	✖
Aquilaria malaccensis Lam.	Tymelaeaceae	BT	✔	✖	✖	✖	✖	✔
Unknown	Unknown	-	✖	✖	✖	✔	✖	✖
Lantana camara L.	Verbenaceae	V	✖	✖	✖	✖	✖	✔
Unknown	Verbenaceae	-	✖	✖	✖	✖	✖	✖
Leea indica (Burm. f.) Merr.	Vitaceae	S	✖	✖	✖	✖	✖	✔