Ecological tree-planting and pasture conversion costs on the southern Atherton Tablelands

Acknowledgements
This report was compiled by Amanda Freeman from contributions by Carla Catterall, Kylie Freebody, David Hudson and Cath Moran. Some information is based on preliminary trials and further research is required to improve the data.

Acknowledgement of the Rainforest Aboriginal Peoples of the Wet Tropics
The Wet Tropics Management Authority acknowledges Rainforest Aboriginal Peoples as the first sovereign nations and Traditional Owners of the Wet Tropics and pays respect to their Elders, past, present and emerging. The Wet Tropics Management Authority recognises Rainforest Aboriginal Peoples' ongoing and essential connections to the Wet Tropics rainforests and their rights and responsibilities under traditional law and custom. The Wet Tropics Management Authority supports the active roles of Rainforest Aboriginal Peoples in the ongoing management and governance of the Wet Tropics World Heritage Area.

Attribution
Wet Tropics Management Authority (2020). Ecological tree-planting and pasture conversion costs on the southern Atherton Tablelands. Cairns, Australia. Available at http://www.treat.net.au/resources/index.html.

Background

The southern Atherton Tablelands has been a focus of rainforest revegetation efforts in the Wet Tropics region for over three decades. Rainforest revegetation on the Tablelands provides many conservation benefits including habitat connectivity and enhancement at elevations where increasing vegetation cover can buffer and expand climate refugia. A substantial increase in rainforest cover on the Atherton Tablelands is therefore a priority for conservation management in the region. Most revegetation efforts to date have used direct tree-planting methods and the cost of these is an obstacle to larger-scale reforestation. Emerging methods to convert disused pasture to forest by catalysing and managing naturally regenerating vegetation avoid the cost of tree-planting and may be cheaper to implement (Catterall & Harrison 2006, Catterall 2019).

Comparing the costs of revegetation projects is problematic. There are many site-specific variables such as topography, access, ground cover and water availability that affect the cost and duration of projects. Despite this, experienced practitioners on the Atherton Tablelands are adept at calculating expected project costs based on their previous experience with similar projects and sites. However, practitioners' organisations include community groups, government, and private businesses so their project costs, particularly labour, are not necessarily directly comparable. Determining comparable costs for revegetation activities is necessary both when assessing alternative methods (Moran *et al.* 2017) and when developing larger-scale, multi-agency project budgets, such as for the Queensland Land Restoration Fund (LRF).

Sources of information and costs

This report summarises published information on rainforest revegetation costs on the southern Atherton Tablelands and imputes their current value (RBA inflation calculator: https://www.rba.gov.au/calculator/annualDecimal.html). It focuses on revegetation undertaken primarily for its biodiversity benefits and does not include studies that have costed comparatively low-density plantings designed principally for cost-effective forestry or carbon capture (e.g. van Oosterzee *et al.* 2020). Unpublished data on revegetation costs, provided to assist with costing a potential LRF proposal, is collated.

The estimated direct costs of establishing vegetation cover on disused pasture with moderately easy terrain and access are compared for ecological tree-planting and pasture conversion methods within the same project site at D. Hudson's Upper Barron property Cloudland Nature Refuge. The property is on basaltic soil, at approximately 850m elevation, and experiences an annual rainfall of about 2,000 mm. The revegetation plots are adjacent to old-growth rainforest.

Ecological tree-planting methods

Ecological tree-planting utilises direct planting of a high density and diversity of seedlings and methods are well-established for the Atherton Tablelands (refer to Moran *et al*. 2017).

Catterall & Harrison (2006) reported the costs of vegetation-focused projects in the Wet Tropics region funded through the Natural Heritage Trust (NHT) 1 program. Though not restricted to the Atherton Tablelands, many projects were located there. Over a reported area of 644 ha, the overall unit cost of 49 vegetation reinstatement projects implemented between 1995-2002 was $25,600/ha (approx. $34K present value; Table 1).

Hunt (2008) investigated the cost of ecological tree-planting by the organisation Trees for the Evelyn and Atherton Tablelands (TREAT) as part of research on the potential value of such plantings in emerging carbon markets. The source of cost data was detailed TREAT records and included cash costs and labour costs, including an imputed cost of volunteer labour. A unit cost of $64,835/ha was calculated (approx. $85K present value; Table 1) according with the higher end of NHT project costs. Hunt (2008) concluded that, at that stage, payments for sequestered carbon could only defray a small proportion of tree-planting costs and were an insufficient incentive to stimulate rainforest revegetation.

A decade later that situation had not changed. Reporting on a 1.6 ha biodiverse carbon farming pilot project, Moran *et al.* (2019) found that under current conditions of low carbon prices and high audit costs, income from the amount of carbon sequestered could not cover the costs of participating in the carbon farming scheme. The unit cost of establishing the pilot project, including maintenance for three years, was calculated as $27,800/ha. However, this did not include volunteer labour for planting or volunteers' vehicle use. For the purposes of this report, these additional vehicle and mileage costs for the 2017 project were included at an additional $8,200/ha giving a total present value cost of $37,100/ha (Table 1). This accords reasonably well with the present value of average-cost NHT 1 projects and the typical unit cost of "around $30 K/ha" (present value $31,200) reported in Moran *et al*. (2017) if the same imputed in-kind contributions are added (Table 1).

Though there is wide variation in project costs that must be borne in mind (Catterall & Harrison 2006, Moran 2017, Table 1) there is never-the-less reasonable agreement between the different published costs of "average" ecological tree-planting projects on the southern Atherton Tablelands. A present value of $34–39K/ha is derived when imputed volunteer in-kind costs are included. The current direct costs of straight-forward Tablelands Regional Council (TRC) ecological plantings on disused pasture are similarly priced at $37K/ha; though complicated sites with woody weeds and difficult access may cost as much as $55K per hectare (K. Freebody pers. comm.).

Pasture conversion methods

Widely known as "bush regeneration", assisted regeneration techniques for advanced regrowth and disturbed remnant forest are well-established (Kanowski & Catterall 2007). On the Atherton Tablelands, however, natural succession on disused land is often stalled by dense pasture grasses that can persist for many years. Trials of pasture conversion methods that facilitate early stage succession on such sites are underway.

Pasture conversion methods as applied on the Atherton Tablelands have involved spraying to suppress exotic grasses and managing the resultant regenerating vegetation. In contrast to ecological tree-planting methods, such natural regeneration methods have been little used or tested on the Atherton Tablelands. However, as such passive methods generally avoid the major costs associated with tree-planting, they have the potential to significantly expand the area over which vegetation cover can be reinstated at lower unit cost (Catterall & Harrison 2006, Catterall 2019).

Whereas weed control is typically a substantial component of ecological tree-planting project costs, pasture conversion methods may need to accept weedy regrowth as a component of novel regenerating ecosystems that nevertheless have significant habitat value (Catterall 2019). The outcomes of such natural regeneration are uncertain, and it may take many years until native rainforest vegetation re-establishes on a site. However, two pasture conversion projects on the southern Atherton Tablelands the "Kickstart Pasture Conversion Trials" (Elgar *et al*. 2014; Catterall 2019) and the "Cloudland Expanded Kickstart Natural Regeneration Project" (D. Hudson pers. comm.), are demonstrating that vegetation cover can be promoted.

The Kickstart Pasture Conversion Trial, begun in 2012, provided bird perches to enhance seed dispersal and controlled pasture grasses which out-compete native tree recruits. The cost of establishing vegetation cover in the Kickstart plots has been estimated as "in the order of $12,000/ha" over the first five years (Catterall *et al*. 2018) but detailed costs have not yet been published.

The Cloudland Expanded Kickstart Natural Regeneration Project, begun in early 2018, incorporates approximately 0.5ha of tree islands within a 3.0 ha regeneration site. Grass is controlled across the area by spraying on an "as needed" basis. The cost of establishing vegetation cover in the Cloudland Expanded Kickstart plot, including the tree islands, has been calculated as $7,300/ha for the first two years of the project (D. Hudson pers. comm.).

While the costs stated for maintaining biodiversity plantings are based on over three decades of practice involving projects at hundreds of sites, pasture conversion methods have been trialled at very few sites and for a much shorter time period. This makes their overall costs difficult to estimate. How long spraying will need to continue in these trial sites, to control pasture grasses and ensure ecological development, is conjecture. However, the practitioners involved predict 7-10 years will be needed before they can stop maintenance. If the maintenance costs incurred for the regeneration component of the Cloudland Expanded Kickstart project during the first years of the project are applied over a seven to ten year timeframe, the cost per hectare of the different techniques used can be

estimated and compared. By this method, regeneration by pasture conversion is expected to cost around $7-9K/ha compared to $34K/ha for ecological tree-planting (Table 2).

There has been little research in the Wet Tropics region comparing the outcomes for fauna of ecological tree-planting and pasture conversion methods. Preliminary results are promising; in the Kickstart Pasture Conversion Trial, bird communities in the early-stage conversion plots were found to be comparable to those in directly planted sites of a similar age (Freeman & Von Der Linden 2014).

Conclusions

Although there is a wide variation depending on scale and site-specific factors, the cost of an "average" ecological tree-planting on the Atherton Tablelands has remained essentially the same over 25 years. Methods continue to be refined but practitioners are unable to significantly reduce the costs of tree-planting without compromising results (Hunt 2008).

Tree-planting remains costly and therefore relatively small scale yet the need to reforest on a larger scale has become more urgent in a warming world. Emerging pasture conversion techniques that intervene to "kickstart" natural regeneration on disused pasture show promise as cheaper alternatives to tree-planting, conceivably facilitating vegetation establishment for as little as one quarter of the cost.

Table 1. Costs of reinstating vegetation cover on the Atherton Tablelands by ecological tree-planting (per hectare).

Project (s)			Cited cost	Cited cost (2019 value)	Source
NHT 1: 1995-2002 (includes NHT, proponent funds & in-kind contributions including volunteer labour)	Lower range $15-30 K (>5ha)	Higher range $30-60 K (<1ha)	Average cost $25,600	Average cost $34,300	Catterall & Harrison 2006
TREAT: to 2007 (3256 trees/ha; includes seedlings, fertiliser, herbicide in site preparation and weed control for three years, fencing and labour)	Cash costs $14,840 + Labour $49,995		$64,835	$84,900	Hunt 2008
Wet Tropics Uplands: 2017 (large variation in cost due to different methods depending on site conditions and among practitioners; establishment costs included but not volunteers' tree-planting labour or vehicle costs) **+ imputed volunteer labour and vehicle operating** ($8,200)		Higher range $50K	Typical cost $30,000	Typical cost $31,200 $39,400	Moran *et al*. 2017
Carbon Farming Pilot Project: 2017 (includes site preparation by contractor, seedlings, consumables e.g. water crystals, fertiliser and three years maintenance but not volunteers' tree-planting labour or vehicle costs) **+ imputed volunteer labour and vehicle operating** ($8,200)			$27,800	$28,900 $37,100	Moran *et al*. 2019

Table 2. Estimated costs of reinstating vegetation cover using tree-planting and pasture conversion methods at Cloudland, Atherton Tablelands.

Revegetation Method	Site preparation		Seedlings		Planting		Maintenance		$/ha (rounded)
Ecological tree-planting	initial and follow-up sprays	$1792	@$3.40/tree 3600 trees/ha (including replacements)	$12240	tree-planting labour	$10654	weed spraying - labour, equipment, materials @$3180/ha annually with 3 years maintenance	$9540	$34K
Pasture conversion	initial and follow-up sprays	$1792	NA	NA	NA	NA	maintenance (mainly grass selective) spraying - labour, equipment, materials @$750/ha annually with 7 years maintenance with 10 years maintenance	 $5250 $7500	 $7K $9K

Ecological tree-planting

- Seedlings - 3600 stems/ha at $3.40/tree (mixed species as per TRC & QPWS) – includes nursery materials eg potting mix, seed collection, labour
- Tree planting based on practitioner and contractor-derived costs for establishing tree islands at this site extrapolated to a cost/ha
- Maintenance (weed control, seedling replacements) based on practitioner and contractor-derived costs/ha until maintenance can end (3 yrs post-planting)

Pasture conversion

- Maintenance for seven and 10 year scenarios – the approximate time range at which experts infer maintenance can be ceased
- Costs estimated from non-tree island components of first two years of Cloudland natural regeneration trial
- Site preparation initial and follow-up sprays @ $1792/ha; Maintenance spraying over 7 or 10 years @ $750/ha
- The cost of methods which may complement and/or catalyse regeneration such as perches and tree islands are not included here

Both methods

- The site has moderately easy terrain and access and is adjacent to forest; site preparation = backpack spray of disused pasture
- Direct costs are included – ie equipment and materials – vehicles, spray packs, tools, herbicide; mileage & labour (rates not specified)
- Indirect costs and overheads are not included – eg. administration, depreciation, infrastructure, monitoring

Literature Cited

Catterall, C. P. (2016) Roles of non-native species in large-scale regeneration of moist tropical forests on anthropogenic grassland. *Biotropica* 48:809–824

Catterall, C. P. (2019) Values of weedy regrowth for rainforest restoration. *Ecological Management and Restoration* 21:9-13

Catterall, C., Freebody, K., Freeman, A. and Shoo, L. (2018) Catalysing rainforest regrowth after pasture: five years of Kickstart explorations. *TREAT News* Wet Season Jan-March 2018 http://www.treat.net.au/publications/WnsJan2018.html#catalysing_rainforest

Catterall, C. P. and Harrison, D. A. (2006) *Rainforest Restoration Activities in Australia's Tropics and Subtropics.* Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns, Australia (94 pp) http://rainforest-crc.jcu.edu.au/publications/restoration_activities.pdf

Elgar, A. T., Freebody K, Pohlman, C. P., Shoo, L.P., Catterall, C. P. (2014) Overcoming barriers to seedling regeneration during forest restoration on tropical pasture land and the potential value of woody weeds. *Frontiers in Plant Science* 5:200 doi: 103389/fpls201400200

Freeman, A.N.D. and Von Der Linden, L. (2014) Bird communities in early-stage assisted regeneration comparable to those in directly planted sites. Poster paper. Association for Tropical Biology and Conservation Conference, Cairns https://www.academia.edu/14553568/ATBC_CONFERENCE_POSTER_2014_Bird_communities_in_early-stage_assisted_regeneration_comparable_to_those_in_directly_planted_sites).

Hunt, C. (2008) Economy and ecology of emerging markets and credits for bio-sequestered carbon on private land in tropical Australia. *Ecological Economics* 66: 309-318

Kanowski, J. and Catterall, C. P. (2007) *Converting stands of camphor laurel to rainforest: What are the costs and outcomes of different control methods?* Griffith University, Nathan 4111 Australia (16 pp.)

Moran, C., McCaffrey, M., McCaffrey, A., Freebody, K., Snodgrass, P., Conway, S., Onus, G., King, A., Crook, L., Retter, C., Tucker, N., Burchill, S., Catterall, C. and Clarke, C. (2017) *Rainforest replanting practice in the upland wet tropics of Australia 2017* http://www.treat.net.au/resources/Replanting_methods_Moran_web.pdf

Moran, C., Hudson, D. and Skelton, D. (2019) *A guide to carbon farming for ecological planting on the Atherton Tablelands. Final report from the Freeman's Forest pilot project*. Report to Trees for the Evelyn and Atherton Tablelands (TREAT), Yungaburra, Australia.

For summary see: Moran, C., Hudson, D. and Skelton, D. (2019) Can Biodiversity Plantings Earn Income as Carbon Farms? *TREAT News* Dry Season July-September 2019 http://treat.net.au/publications/WnsJuly2019.html#carbon_farms

van Oosterzee, P., Liu, H. and Preece, N. D. (2020) Cost benefits of forest restoration in a tropical grazing landscape: Thiaki rainforest restoration project. *Global Environmental Change* 63: 102105