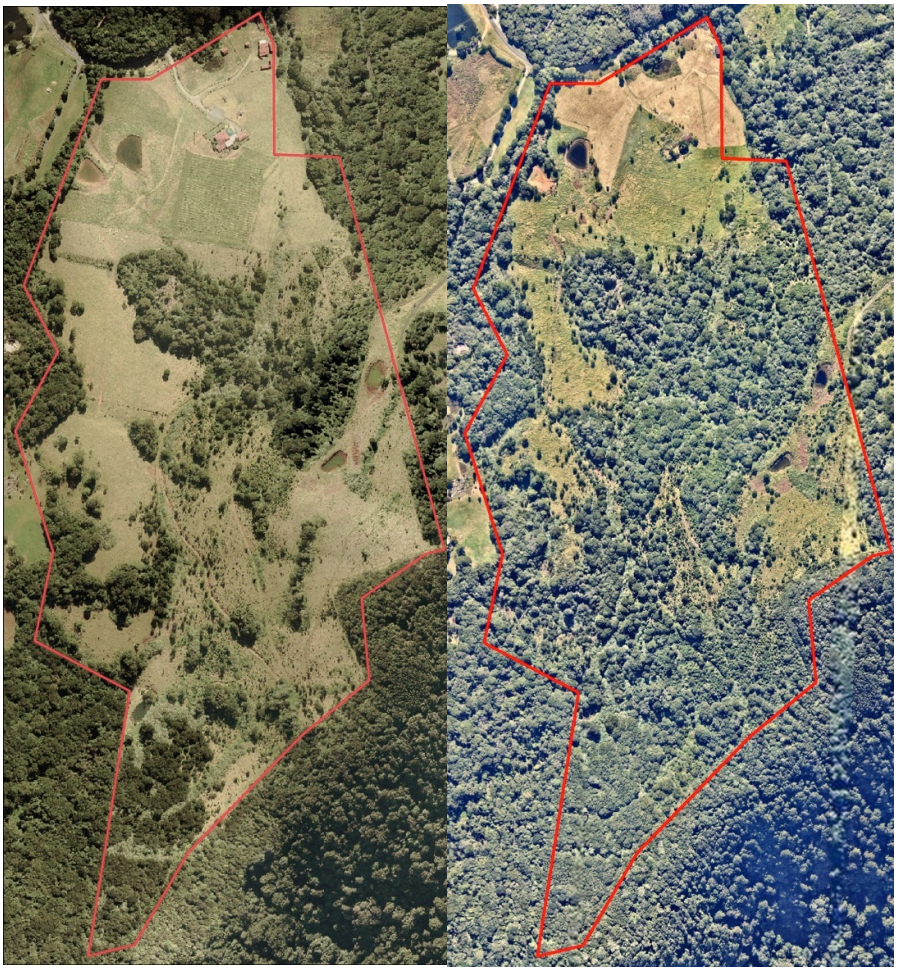
Springbrook Rescue Restoration Project

Progress Report

2014



Australian Rainforest Conservation Society Inc.

March 2015

This Report was prepared by Aila Keto and Keith Scott

Cover photo: Recovery of canopy cover on Pallida between 2005 (left) and 2014 (right)

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Introduction

In 2008, a Restoration Agreement was signed between the Queensland Government and Australian Rainforest Conservation Society Inc (ARCS). Under the Agreement, ARCS has undertaken to carry out a restoration project on a number of properties on Springbrook Plateau purchased by Queensland Government for addition to the Protected Area estate and eventually to the Gondwana Rainforests of Australia World Heritage Area. This work is carried out by ARCS for the State Government on an entirely *pro bono* basis.

In early 2010, ARCS provided the Department of Environment and Resource Management (DERM) with a progress report, *Springbrook Rescue Restoration Project — Performance Story Report 2008–2009*. The report was structured to be consistent with the Australian Government's Monitoring, Evaluation, Reporting and Improvement (MERI) framework, and with guidelines established by the International Society for Ecological Restoration (SER).

A third progress report was provided to the Department in March 2013. This present report covers the period to the end of 2014.

The Desired Outcomes defined in the *Performance Story Report 2008–2009* provide the framework for these annual reports.

The *Performance Story Report 2008–2009* defined four stages: Foundational activities, Initial activities and outcomes (0–3 years), Intermediate activities and outcomes (4–9 years) and Longer-term outcomes (≥10 years). This present report applies to the third year of the 'Intermediate activities'. The Program Logic setting out the stages of the project is reproduced on the following page.

As appendices to this report, we have included our 3-year Plan, Habitat Recovery Images based on Nearmap high-resolution Imagery and the Threat Management Plan.

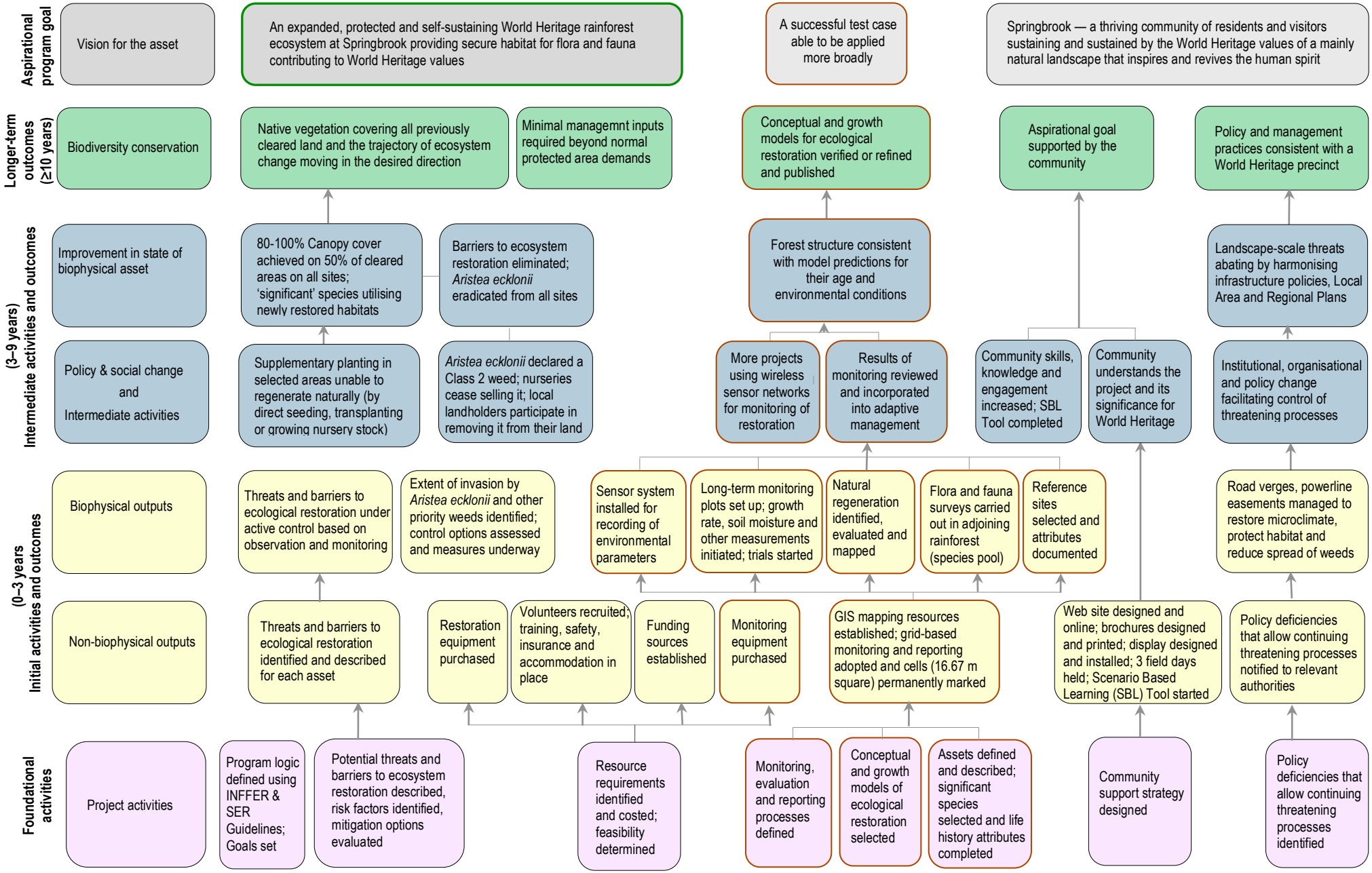
In June 2012, ARCS was awarded a grant of $270,000 over 3 years under the Biodiversity Fund Round One 2011–12 (http://www.environment.gov.au/cleanenergyfuture/biodiversity-fund/projects/pubs/qld-round1.pdf). The Federal Government cut short the program by a year but by negotiation we retained all funding but were required to complete the program by 31 December 2014, six months early.

The restoration project has been included as one of 12 Case Studies, The Springbrook Rainforest Project: Restoring World Heritage rainforests in Australia, in the IUCN World Commission on Protected Areas publication, *Ecological Restoration for Protected Areas - Principles, Guidelines and Best Practices. Best Practice Protected Area Guidelines Series No. 18.*

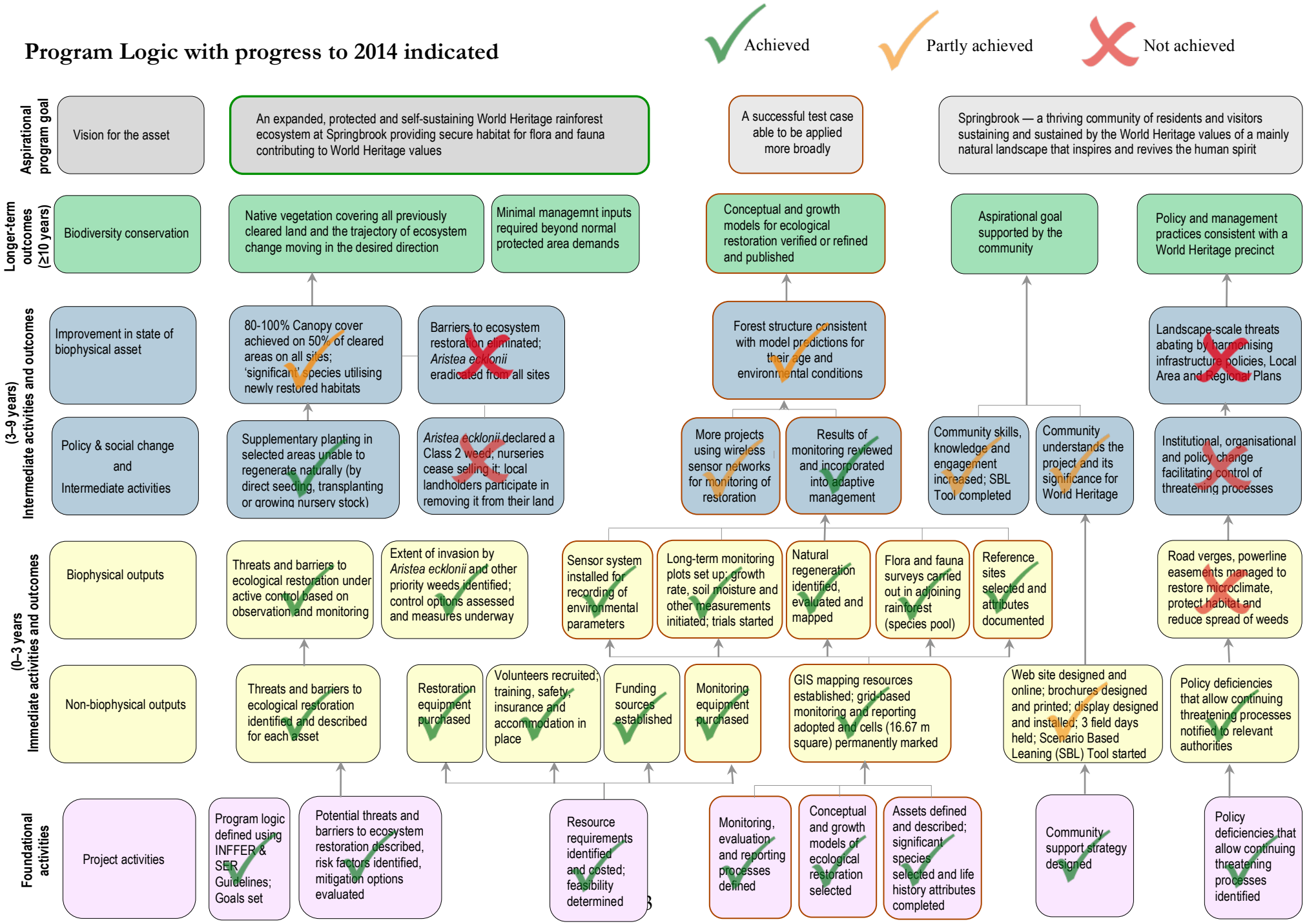
The paper "*Innovative Tools and Approaches in Long-term Ecological Restoration of World Heritage Natural Areas: Partnerships, Emerging Technologies and Sustainable, Novel Resourcing Strategies*" was presented at the IUCN World Parks Congress on 18 November, Sydney. A Powerpoint presentation of the talk available on the Springbrook Rescue website.

The project is comprehensively described on the web site launched in January 2013: http://www.springbrookrescue.org.au.

Program Logic



Program Logic with progress to 2014 indicated



Progress report 2014

Intermediate activities and outcomes

This reporting period represents the third year (2014) of the 6-year 'Intermediate activities and outcomes' phase which extends from Year 4 to Year 9 (2012–17) in our Program Logic.

A. Policy and social change, and intermediate actions

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
Supplementary planting in selected areas unable to regenerate naturally (by direct seeding, transplanting or growing nursery stock)	SUMMARY No broad-scale supplementary planting has yet been deemed necessary on any of the restoration sites. All indications are that, after accounting for 'year effects', there will be no sound, evidence-based reasons to direct seed, plant nursery stock, or transplant seedlings during the course of this project. Inadequacies in the Species Pool, dispersal processes, and abiotic conditions —major drivers affecting regeneration as described in our Ecological Conceptual Model — do not represent barriers to natural generation on any of the properties in the long term. The challenge is to ensure necessary time-critical resources are available to manage the opposing ecological processes of competition and facilitation so as to favour natural regeneration. As incorporated in the Restoration Agreement, restoration will be based on facilitating natural regeneration. Planting will only be undertaken when there is credible peer-reviewed evidence that the particular area is showing no signs of natural regeneration in the medium-to-long term or that Critical Habitat recovery becomes paramount for a species likely to become extinct unless remedial action is urgently required. This approach is fully consistent with the IUCN WCPAs Best Practice Protected Area Guidelines Series No. 18: Ecological Restoration for Protected Areas: Principles,	Evaluation questions for the third "Intermediate" level of the program were described in our Foundation report in 2008-09, and were based on the MERI Framework of the Australian Government. The same questions apply to each phase of the program: immediate, intermediate and long-term. The five evaluation categories adopted include: *1. Impact* • In what ways and to what extend has the program contributed to changing asset condition and management practices and institutions? • What, if any, unanticipated positive or negative changes or other outcomes have resulted? • To what extent were the changes directly or indirectly produced by the program interventions? *2. Appropriateness* • To what extent is the program aligned with the needs of the intended beneficiaries? • To what extent is the program compliant with recognised best practice processers in the field, e.g. the type, level and context of

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	Guidelines and Best Practices (2012). These guidelines formally underpin advice to signatory countries of the International Convention on Biological Diversity for meeting their restoration targets. The Springbrook project is Case Study 11 in these guidelines. **In conclusion** there are no barriers to natural regeneration that would require supplementary planting in any of the Recovery Areas. It is important to remember that "year" and "facilitation" effects are critically important, consistent with results reported in the literature, and that "patience" is paramount. To intervene when unnecessary can have seriously counterproductive results on ecosystem resilience in the long term. The only justifiable basis for supplementary plantings under these circumstances is for urgent restoration of critical habitat of species at grave risk of serious decline or extinction in the absence of active interventions of this nature. The only species that may fit into this category is the endangered *Ochrosia moorei*, with a Queensland population of not more than 20 individuals in the wild. [In north-east NSW it is represented by singletons or small populations at most known localities with the total populations thought to be less than 50 individuals in the wild.]. The only site at which supplementary plantings would be suitable would be on Kanimbla nearby the only known populations in Queensland (the O'Shea property was purchased by the Beattie Labor government and is now National Park).	investment and associated activities? • How time critical is the program? *3. Effectiveness* • To what extent have the planned activities and outputs been achieved? • Are current activities the best way to maximise impact or are there other strategies that might be more effective? • To what extent is the program attaining, or expected to attain, its objectives efficiently and in a way that is sustainable? *4. Efficiency* • To what extent has the program attained the highest value out of available resources? • How could resources be used more productively and efficiently? • What could be done differently to improve implementation, and thereby maximise impact, at an acceptable and sustainable cost? *5. Legacy* • Will the program's impacts continue over time and after the program ceases? • How and by whom should the legacy be managed?

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	MUNDORA RECOVERY AREA In the case of the **Warblers** property, regeneration is occurring naturally across the entire 3-ha area as predicted and no planting is likely to be required. Each of the 91 monitoring quadrats covering the entire property now contains some or extensive natural regeneration.	*Impact*: • the program of allowing assisted natural regeneration is totally responsible for the positive, ongoing **improvement in the asset condition** • There are no **unanticipated outcomes** regarding this objective • Avoidance of the need for supplementary plantings is **directly due** to our evidence-based manipulation of the key opposing ecological processes of competition and facilitation *Appropriateness* • We believe the program continues to be **aligned with needs** of the public with respect to the protection and restoration of World Heritage values; however, in the period 2012 to the end of January 2015 our partner, the Queensland Government, did not accept that conservation was necessarily the best use of the land with their priority being a "financial return on a valuable asset". • Our management practices are compliant with recognised **best practices**, e.g. Keenleyside *et al.* (2012). *Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices.* Gland, Switzerland: IUCN. X + 120pp. In fact, Springbrook Rescue is one of 12 international case studies cited. • Whereas recovering integrity of habitat and landscape connectivity is **time critical** for long-term survival of threatened 'significant' species and ecosystem resilience or stability against impacts of climate change, evidence suggests natural regeneration is the most effective method of meeting those goals in the long term. *Effectiveness* • **Achievement of the planned activities and outputs** has been achieved in terms of the success of natural regeneration and avoidance of supplementary plantings

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
		• Our business plan for financial resourcing; our volunteer program supplemented only when necessary by grants to employ contractors appear to be the best way to maximise impacts. No other strategies seem likely to be more effective than that adopted. • The program, as assessed in 2014, is expected to attain its objectives in an efficient and sustainable way. *Efficiency* • Whether we have attained the highest value from available resources for this particular objective will be assessed over the entire program period rather than annually, although natural regeneration is recognised universally as the most cost-effective strategy known. • We do not believe resources could have been used more productively and efficiently through plantings, especially when taking account of the long-term risks with that strategy. • Natural regeneration in some areas of the property could have been accelerated by more timely control of the grass *Setaria sphacelata* which can affect the productivity and health of native pioneer species. However the demands on resources to control the more dangerous *Aristea ecklonii* precluded the above option. Eventual culling of *Setaria* resulted in remarkable recovery of suppressed or spittle-bug affected individual plants. *Legacy* • Natural regeneration will continue to accelerate particularly as reproductively mature individuals on-site seed their surroundings; the program is on track to deliver these lands to the National Parks and Wildlife Service with minimal ongoing management requirements or costs.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	EE-JUNG RECOVERY AREA On **Ashmiha**, regeneration is occurring naturally across much of the property and no planting is being considered at this stage. Isolated nurse plants are developing in key areas, consistent with the 'nucleation' model of ecological restoration. The 'facilitation' function of even exotic grasses is significant particularly with respect to protection from frost damage. In the east-west band across the middle of the property we identified in the last Annual Report as requiring careful monitoring because of the absence of regeneration, isolated wind-dispersed plants were recorded and marked in 2014. These are mostly *Leptospermum polygalifolium* var. *montanum* and *Lomatia arborescens*. This band was dominated by the mat-forming grasses, kikuyu and setaria which have the potential to block regeneration if not controlled strategically. Strategies involve reaching a fine balance between the competition and facilitation processes served by these invasive species. Both function to rehabilitate compacted soils and to create microclimates that facilitate germination and survival of native species during periods of prolonged high evaporative demand. They also facilitate survival of young seedlings from winter frosts. Thus we cull the grass during the peak growing seasons of Spring and Summer, if heavy rains do not prevent slashing in the latter, but allow sufficient grass cover to grow during late Autumn and Winter to provide frost-protection of young regeneration. **Pumilo**: No supplementary plantings will be necessary on this property. Good regeneration of pioneer species is occurring. Management will be restricted to facilitating/accelerating this regeneration through control of competing pasture grasses and exotic weed species. On **Barimbah**, forest edges are expanding and nuclei of isolated or	*Impact*: • the program of allowing assisted natural regeneration is totally responsible for the positive, ongoing **improvement in the asset condition** on Ashmiha, Pumilo and Barambah • There are no **unanticipated outcomes** on any of the properties in this Recovery Area regarding this objective • Avoidance of the need for supplementary plantings is **directly due** to our evidence-based manipulation of the key opposing ecological processes of competition and facilitation at least on Ashmiha. Natural regeneration on Pumilo has occurred without any management interventions until late 2014. Strategic brushcutting or slashing of exotic grasses on Barambah appears to have accelerated natural regeneration in these areas. *Appropriateness* • We believe the program continues to be **aligned with needs** of the public with respect to the protection and restoration of World Heritage values; however, in the period 2012 to the end of January 2015 our partner, the Queensland Government, did not accept that conservation was necessarily the best use of the land with their priority being a "financial return on a valuable asset". • Our management practices are compliant with recognised **best practices**, e.g. Keenleyside *et al.* (2012). *Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices.* Gland, Switzerland: IUCN. X + 120pp. In fact, Springbrook Rescue is one of 12 international case studies cited. • Whereas recovering integrity of habitat and landscape connectivity is **time critical** for long-term survival of threatened 'significant' species and ecosystem resilience or stability against impacts of climate change, evidence suggests natural regeneration is the most effective method of meeting those goals in the long term.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	clusters of nurse plants are emerging and maturing amongst the weed species. The latter, whilst slowing down the pace of regeneration, do not appear to be inhibiting it such as to require costly interventions of active planting. Again, management is directed at biomass removal (e.g. of weeds, as a management-based driving force) to facilitate regeneration and native plant productivity.	*Effectiveness* • **Achievement of the planned activities and outputs** has been achieved in terms of the success of natural regeneration and avoidance of supplementary plantings • Our business plan for financial resourcing; our volunteer program supplemented only when necessary by grants to employ contractors appear to be the best way to maximise impacts. No other strategies seem likely to be more effective than that adopted. • The program, as assessed in 2014, is expected to attain its objectives in an efficient and sustainable way. *Efficiency* • Whether we have attained the highest value from available resources for this particular objective will be assessed over the entire program period rather than annually, although natural regeneration is recognised universally as the most cost-effective strategy known for larger landscapes. • We do not believe resources could have been used more productively and efficiently through plantings, especially when taking account of the long-term risks with that strategy. • Natural regeneration in some areas of the property could have been accelerated by more timely control of the grass *Setaria sphacelata* which can affect the productivity and health of native pioneer species. However the demands on resources to control the more dangerous *Aristea ecklonii* precluded the above option. Eventual culling of *Setaria* resulted in remarkable recovery of suppressed or spittle-bug affected individual plants. *Legacy* • Natural regeneration will continue to accelerate particularly as reproductively mature individuals on-site seed their surroundings;

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		the program is on track to deliver these lands to the National Parks and Wildlife Service with minimal ongoing management requirements or costs.
	BOY-ULL RECOVERY AREA On **Pallida**, natural regeneration is progressing extremely well on the upper and middle slopes and along the western boundary. On the lower flatter section historically impacted to the greatest extent by cattle grazing, natural regeneration is impeded by the presence of mat-forming grasses such as kikuyu, setaria and dactylis. As the case for Ashmiha, this area will require careful monitoring to determine if and/or when active intervention might be necessary. To date, intervention has been limited to slashing/brushing at appropriate intervals to reduce competition from mat-forming pasture grasses. The image (Appendix 2) shows the regeneration that has occurred naturally over the past eight to nine years. Canopy cover has been estimated using nearmap.com imagery. A 2-metre grid is overlaid on the imagery and canopy cover estimated on each 2 x 2 m cell. The results for 2013 show an increase in canopy cover from 31 to 60 per cent. Whereas the quantitative estimates of canopy cover increase have not yet been completed for 2014, Nearmap imagery shows virtually complete canopy cover in a north-east to south-west	*Impact* In all Recovery Areas, natural regeneration would not have occurred to the extent achieved in this project because the land-use practices by previous owners largely prevented it. The positive changes have resulted in significant increases in critical habitat and landscape connectivity that will make a marked difference to the World Heritage values and their transmission to future generations. *Appropriateness* The project is entirely directed at meeting obligations under the World Heritage Convention which requires us to do our utmost to ensure that places of Outstanding Universal Value are not lost. *Effectiveness* The project is essentially going according schedule outlined in the plan and consistent with international guidelines.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	corridor traversing the whole property. **Koonjewarre**: In areas allocated to natural regeneration upslope of buildings and on the southern and eastern boundaries supplementary planting has not been required. As part of Lease conditions those areas (including sporting fields) required for operation of the business as an activity centre catering for schools and community groups, no regeneration work on those areas has occurred to the end of 2014. As the number of school bookings is declining due to their funding restrictions, and therefore the need for the ropes courses and sporting fields, we will be able to expand the areas devoted to natural regeneration in 2015. **The Lodge**: There is no requirement for supplementary plantings as, except for the volunteer accommodation buildings, the remainder of the property has full canopy cover. **Logrunners**: There is no requirement for supplementary plantings as, except for the volunteer accommodation buildings, the remainder of the property has full canopy cover.	*Efficiency* The program attains the highest value from available resources because of the very strong reliance on *pro bono* contributions by the project managers and the volunteers recruited to assist. Everyone involved can attest to the tangible and very significant progress being made that inspires continued efforts. *Legacy* ARCS is committed to achieving the program's objectives so that only minimal inputs will be necessary by the long-term managers of the restoration areas: the National Parks and Wildlife Service of Queensland.

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	CAVE RECOVERY AREA **Quolls**: No supplementary plantings are required. All previously cleared areas are within the dispersal distance of mature forests. Continuing work involves removal of competing weed species and exotic garden plants established by the previous owners of the property. As most of the exotic species planted around the building were removed in previous years follow-up work is scheduled for 2015 to deal with re-sprouts. **Lyrebird Retreat**: No supplementary planting will be required. All cleared areas are within dispersal distance of a diverse pool of natural seed sources so this driver will not be limiting. The only impediment would result from changes to the abiotic environment through compaction; even this impediment will abate with time as natural ecological processes in the soil slowly recover naturally.	
	PURLING BROOK RECOVERY AREA **Kanimbla** continues to be monitored and it is clear that there are no obstacles to natural regeneration. Canopy closure goals are close to being achieved. When the aristea scourge on Warblers (and Ashmiha) is eliminated resources will be available to accelerate natural regeneration on this property, although there is no pressing need currently. We have had advice from local arborist Mark Donaldson that active clearing of a small plantation of exotic conifers will cause more damage than natural attrition and removal of small seedlings.	*Impact* Natural regeneration has resulted in almost total canopy closure on the property. *Appropriateness* Restoration of critical habitat and landscape connectivity is consistent with obligations under the World Heritage Convention *Effectiveness* Planned outcomes have been achieved *Efficiency* Restoration in this Recovery Area has been the most cost effective of all the properties in the Springbrook Rescue program because of the minimal inputs required for natural regeneration *Legacy*

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
		Very little effort will be required to maintain this property, except for the minor plantation of exotic conifers. Allowing natural attrition will be the most effective way of removing the conifers over the long term with minimal effort involved in regularly removing seedlings.
	LITTLE NERANG RECOVERY AREA The **Ankuna** property is being monitored but it is considered unlikely that any planting will be necessary. It will, however, be necessary to control and eventually eradicate the aristea occurrence on the southern part of the property. There was an infestation of montbretia in a swampy area south of Little Nerang Creek which flows through the property which appears to have been eradicated by our removals. Japanese honeysuckle is an emerging ground-smothering threat which needs to be dealt with urgently.	*Impact* The major challenge on this land remains eradication of *Aristea ecklonii*. Regeneration from soil seed stores continues to present a challenge, given the even greater challenge in controlling this weed on Warblers and Ashmiha. Whilst the results without our interventions would have been uncontrolled growth and spread of this forest-destroying weed, the current status is still not satisfactory. *Appropriateness* Controlling *Aristea ecklonii* is absolutely critical to the survival of the National Park and World Heritage Area *Effectiveness* Effectiveness on this property has not been high because of the development of a large soil seed bank. *Efficiency* The answer for Warblers applies here.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
		Legacy The long-term legacy for the National Park estate and those responsible for its long-term management will be a critical
Aristea ecklonii declared a Class 2 weed; nurseries cease selling	There has been no change to the situation in 2014 regarding *Aristea ecklonii* being declared a Class 2 weed; nurseries (particularly Bunnings) continue to sell the plant. Colleagues have directly	*Impact* • Our efforts have had no impact on Biosecurity Queensland or political will to help address this problem.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
it; local landholders participate in removing it from their land	approached Bunnings to warn them of the serious environmental impacts of this weed and to seek their cooperation in not continuing to sell it. We have no positive results to report as yet. The history: ARCS made repeated approaches to Biosecurity Queensland in an attempt to have *Aristea ecklonii* declared a Class 2 weed. Biosecurity Queensland carried out and published a risk assessment of the plant. The report is available at http://www.daff.qld.gov.au/documents/Biosecurity_EnvironmentalPests/IPA-Blue-Stars-Risk-Assessment.pdf. The following a is a quote from the risk assessment: *A. ecklonii* has a history as a weed in New Zealand and interstate (New South Wales and Victoria). As such, it is predicted to become a weed within comparable habitat types and climate zones in Queensland. Based on climatic and habitat information from its native range, habitats at risk of invasion appear to be limited to open or otherwise disturbed sites in mesic, upland rainforests in sub-tropical Queensland (open grassy areas/pastures, roadsides, tracks and riparian habitats). Remaining areas of the state are predicted to be either too hot or dry. Even though *A. ecklonii* is listed as a weed interstate and overseas, there is very limited information available on its impact. It is reported to be replacing native vegetation in New Zealand, but the scale of such impacts is poorly described. *A. ecklonii* is in an early stage of invasion in Queensland and could become a significant pest within suitable habitats after its population has had sufficient time to develop. In short, Biosecurity Queensland has declined to list the plant as a pest. It would appear that it is the intention to allow the species to develop to the point where it becomes a significant pest, threatening the viability of a World Heritage area, before taking any action.	• Failure to achieve this objective means that *Aristea ecklonii* continues to be sold in the marketplace *Appropriateness* • *Aristea* is a forest-replacing weed and if uncontrolled would have potentially immense impacts on forests that are difficult to access. *Effectiveness* [a] We have been singularly ineffective in convincing governments and Biosecurity Queensland to take the necessary actions *Efficiency* • A disproportionate (hence inefficient) amount of resources for lobbying will have to be expended to achieve the objective. *Legacy* • Success will make a huge difference to future generations not to have to deal with this unprecedented scourge that threatens the Gondwana World Heritage Area.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	Many private landholders are now aware of the threat posed by this new class of shade-tolerant weed that is capable of invading undisturbed forests, and are actively removing it from their properties. This awareness and action is critical as the seeds are now recognised as being bird-dispersed. As previously reported, we have established that application of glyphosate to aristea can be effective even at the early fruiting stage. Plants bearing well-developed green fruits were treated with glyphosate and monitored. The fruits dried out and opened up exposing the seeds as the plant died. However, seeds were collected and 200 seeds tested for germination. No germination occurred. We have previously been concerned that glyphosate was not effective on aristea plants with well-developed rhizomes. Over the past year, we have observed that plants with rhizomes are being killed by glyphosate application in some instances. We suspect that the effect of glyphosate is dependent on timing — the time of year, growing stage of the plant (not necessarily actively growing). Glyphosate is applied with a rope wick at a concentration of 120 g/L. Hence, in 2014, as well as maintaining our volunteer program for physical removal of plants, a greater proportion of resources (e.g. the balance of funds from the Federal Government Biodiversity Fund Stage 1 grant) has been directed to herbicide treatment of aristea. The effectiveness of this treatment will be evaluated in 2015. There is some evidence that, without continuing follow-up, even herbicide treatment will not be effective.	
More projects using wireless sensor networks for monitoring of	The Springbrook wireless sensor network project is arguably the largest of its kind in the world and won the 2012 Queensland iAwards for Research and Development. This award is acknowledgment of the transformational potential of this	*Impact* The Springbrook network provided a valuable 'prototype' enabling the CSIRO to improve this revolutionary environmental monitoring technology allowing study of ecological processes at real temporal

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
restoration	technology in environmental monitoring. The project allowed the CSIRO to further develop the technology to improve its performance and affordability. The CSIRO reported on the progressive uptake of this technology on their dedicated web site. During 2014, the network problems were not resolved due to a lack of commitment from the government. CSIRO was only committed to setting up the network and has no responsibility for maintaining it. ARCS is still prepared to contribute significantly to ongoing maintenance of this unique and extremely import monitoring system provided the government is committed to the project and contributes the required personnel and resources.	and spatial scales. The most positive outcome for restoration was the ability to identify the most climatically stable areas that are the highest priority to restore and protect. The data also provided insights into why plants grow and thrive where they do, and more importantly, where intervention is NOT needed — saving time and resources. These insights would not have been possible without the WSN project the establishment of which is directly attributable to the Springbrook Rescue project. *Appropriateness* Monitoring technologies such as that of wireless sensor networks can be invaluable in improving broad-scale restoration strategies. It was important to obtain results from the network at the early stages of the project as actions taken during this phase have long-term consequences. *Effectiveness* WSN technologies are probably the most effective way of monitoring the critical drivers of ecosystem dynamics and especially so in restoration ecology. The data acquisition cannot be replicated cost-effectively by traditional survey techniques. However, the sustainability of such a program is critically dependent on ongoing resources for maintenance. *Efficiency* A network of 175 nodes and 700 sensors, although extremely valuable, is not necessarily the most cost-effective investment if only applied to a single project such as Springbrook. The significance of the network lay in the long-term and broader applications to environmental monitoring around the world. *Legacy*

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
		Whether the network is maintained into the long-term future will depend on resources from government, the CSIRO and community groups such as ARCS that provide valuable pro-bono contributions to day-to-day maintenance.
Results of monitoring reviewed and incorporated into adaptive management	The process of Monitoring, evaluation, review and improvement in the adaptive management Decision Framework is described in detail in the Springbrook Rescue website: http://www.springbrookrescue.org.au/DecisionFramework.html 1. CONTEXT. The socio-economic context has seen some changes in the past 12 months which is normal during a long-term project that ecological restoration necessarily has to be. However, despite fluctuations in economic uncertainty which affects both business revenue and volunteer availability, risk assessment in our decision framework remains essentially unchanged. The ecological context from the point of view of climate change worsens, but merely highlights the importance of the project towards helping protect the outstanding universal value of this World Heritage Area. The 'problem' as originally assessed remains valid — loss and impairment of critical habitat and landscape connectivity. Our biodiversity surveys, assessments of fauna and flora most vulnerable to these impacts, and identification of the most pressing bottlenecks to functional connectivity has assisted prioritisation of objectives for the 2012-2015 Restoration Plan. 2. GOAL: The original Goal of the project remains valid and unchanged by results of monitoring and review over the foundation period. The Goal is fundamentally tied to implementing obligations under the World Heritage Convention and its associated Operational Guidelines. 3. OBJECTIVES: The ecological restoration objectives remain unchanged, based as they are on those	

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	recommended by the International Society for Ecological Restoration and in the IUCN WCPAs "*Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices*" (2012). These objectives, and thereby the Goal, are achieved and reported on through time-bound, measurable actions detailed in each 3-year Restoration Plan (Attached). This plan details the baseline, the expected results and how they will be measured. 4. RESOURCES: Our access to material, financial, in-kind, informational and legal resources remains adequate for the viability or sustainability of the project. Our Management Plan and detailed costings allow us to apply for grants in a strategic and targeted way to supplement core funding. These resources are a major in-kind community contribution that helps the Queensland Parks and Wildlife Service, achieve its objective of protecting, managing and restoring Queensland's outstanding biodiversity. 5. RISK ASSESSMENT: Our risk assessment framework provides an integrated systems approach to considering social, economic or ecological barriers to achieving the project's Goals and Outcomes allowing continual improvement as part of adaptive management. 6. MANAGEMENT ACTIVITIES: All management activities are guided by evidence and our ecological and social conceptual models, as well as principles of best practice. These are detailed in our earlier reports and website (http://www.springbrookrescue.org.au/DecisionFramework.html). Key lessons learned to date include: (a) our conceptual models have stood the test of evidence for the past 5 years and give vital guidance (b) "facilitation", as an ecosystem process, is as important to the success of ecological restoration in refugia as is "competition"; our conceptual model facilitate research	

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	to help determine which ecosystem of these two ecosystem processes are most relevant on a site-by-site basis. (c) understanding "year" effects for mass seeding events avoids costly financial and ecological mistakes; many rainforest species do not fruit annually; some only every 5 to 7 years. (d) a long-term view & patience are needed for ecological restoration of viable & resilient communities; short-sighted rush to plant in the absence of apparent progress in regeneration can lead to costly and unnecessary interventions as natural regeneration can suddenly explode in subsequent years if aggressively competing mat-forming weeds are kept in control. (e) a business model that can provide sustainable long-term funding is vital for ecological restoration but is now recognised as less sustainable that earlier thought due to changes in political support (f) a robust legal framework underpinning the project is vital for the success of long-term ecological restoration (g) management without monitoring is likely to fail as required solutions are often counter-intuitive (h) understanding "social learning" is important for an effective communication & engagement strategy (i) convincing people about the important role of weeds as nurse plants is essential but challenging (j) In summary, the most significant learning from monitoring is that even weeds can serve an ecological function for a time without which restoration can fail under particular circumstances. Plants from old lineages and with conservative traits can fail to germinate or survive in microclimates radically different from their evolutionary past. Any plant, whether native or alien, can serve to ameliorate	

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	conditions inimical to regeneration. A scientific approach coupled with monitoring is essential to guide the timing of interventions when the role of weeds shifts from facilitation to competition. Given the historically and generally valid view of weed invasions as one of the most threatening processes known, accepting a constructive role for weeds can require a difficult paradigm shift.	
Community skills, knowledge and engagement increased; SBL Tool completed	During 2014, 270 **volunteers** were involved in the project and have gained relevant skills. We continue to attract additional volunteers and from new groups. The Springbrook Rescue **web site** (http://www.springbrookrescue.org.au) should considerably increase community understanding and support for the project. A brochure explaining the project and providing the URL for the web site continues to be distributed both to volunteers at Springbrook and to partner group members. The reprint made in October 2013 is also available at the Wunburra information centre run by the local community at Springbrook.	
	Our **Facebook** page which was launched in February 2013 though very successful in terms of viewing lapsed in 2014 due to the intensity of other time-critical work during that year. The **SBL Tool** will be finalised towards the end of the project when the learnings from the full Restoration Agreement period are analysed. A draft framework has been created and will be iteratively improved year-by-year. ARCS presented a paper at the IUCN World Parks Congress in Sydney in November 2014: "*Innovative Tools and Approaches in Long-term Ecological Restoration of World Heritage Natural Areas*: *Partnerships, emerging Technologies and Sustainable, Novel Resourcing Strategies*". It was	

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
	reported by session participants as the stand-out presentation. The broader community through our Partnerships program is involved in learning on-ground restoration skills and about biodiversity through participation in scientific surveys (both traditional and audio and video recording of avifauna). The results are communicated through volunteer information nights. Through these means new life history attributes of significant fauna are discovered and shared. The results of our scientific projects will start to published in 2015–2017.	
Community understands the project and its significance for World Heritage	There continues to be significant progress in this regard. There are clear indications that a large proportion of the local community supports the program for greater protection of biodiversity generally and World Heritage values specifically. A well-supported local group "Springbrook Wildlife Appreciation Group" (SWAG) has formed, produced web and associated Facebook social networking sites enabling local community members to share experiences and voice support. More articles relating to nature occur in the local newspaper "Springbrook Voices". Almost all accommodation businesses at Springbrook now use World Heritage in their advertising when in 2005 only one did so. The Springbrook Chamber of Commerce increasingly deals positively with World Heritage and has produced a brochure highlighting World Heritage as the basis of a sustainable local tourism industry. It is distributed to visitors through tourism venues. Feedback from the information centre confirms the majority of the visiting community are attracted by the beauty and remarkable biodiversity on this part of the Gondwana Rainforests of Australia World Heritage Area.	*Impact* Springbrook Rescue has increased the local community's awareness of and importance of World Heritage and by the end of 2017 there should be further improvements. *Appropriateness* Long-term viability of a World Heritage area depends on community support and the extent to which World Heritage plays a meaningful role in the life of the community. *Effectiveness* Maximum effectiveness has not been achieved because eradication of the near-intractable weed *Aristea ecklonii* absorbs most of our energies and time.

Desired outcome	Activity and outcome reporting for year 4	Evaluation: re. *impact, appropriateness, effectiveness, efficiency and legacy*
Institutional, organisational and policy change facilitating control of threatening processes	The draft GCCC City Plan 2015 will provide greater protection to native vegetation when enacted. That appears to cover all existing vegetation (remnant and regrowth). Provisions exempt dwellings. Changes to the State's Nature Conservation Act have potentially negative impacts on the National Parks and thus the World Heritage area by allowing commercial tourism developments. Loss of the tenure "National Park (Recovery)" in the Act has as yet unknown impacts on governance of the Springbrook Rescue program.	*Impact* The Gold Coast City Plan can potentially help control threatening processes of habitat fragmentation through clearing controls. Springbrook Rescue may have indirectly had an influence by increasing general awareness in the community of the critical importance of protecting World Heritage values. Weakening the State's Nature conservation Act is likely to lessen controls on threatening processes. These changes were unrelated to the Springbrook Rescue program

B. Improvement in state of biophysical asset

Desired outcome	Activity reporting	
80-100% Canopy cover achieved on 50% of cleared areas on all sites;	**Recovery of Canopy Cover** MUNDORA RECOVERY AREA **Warblers**: At least 80% canopy cover should be achieved on 50% of the cleared area at time of purchase is on track to be achieved by 2018. Canopy closure exists in many areas. Corridors are establishing. Much of the regrowth is already becoming reproductively mature and seeding adjoining cleared areas. Isolated plants in some cells act as nurse plants either catching wind-blown seeds that germinate or ameliorating abiotic conditions facilitating recruitment and survival of native species that have germinated. Forest edges are extending 5 to 10 metres or more in places. Our on-ground photo-monitoring and analysis of high-resolution aerial photography (NearMap) shows dramatic differences between	*Impact* The key to resilience and/or stability of a refugial area in the face of climate change is the recovery of extensive forest canopy cover. The project's interventions to assist natural regenerations have had a very significant positive effect with project targets being met ahead of projections. *Appropriateness* Recovery of forest canopy cover is fundamentally necessary for long-term viability of the World Heritage values of this key refugium. *Effectiveness* The program has been effective in reaching projected targets ahead of time.

Desired outcome	Activity reporting	
	2005 and June 2014. EE-JUNG RECOVERY AREA **Ashmiha**: More intensive removal of competing mat-forming grasses such as Setaria sphacelata and Paspalum will be needed to reach the minimum target by 2018. Significantly expanded canopy cover has been achieved at the property boundaries, along riparian areas, where connectivity has already been achieved, and especially in the south-east sector of the property. **Pumilo**: The goal of at least 80% canopy cover on 50% of the cleared area was exceeded in 2014. It can be expected that major further progress will be made over the next four years. **Barimbah**: Compared to the baseline clearing in 2005, the goal of at least 80% canopy cover on 50% of the cleared areas has been met. BOY-ULL RECOVERY AREA **Pallida**: compared to the baseline in either 2000 or 2005 when the property was purchased by the Beattie Labor government, the canopy cover goal has already been met in 2014 — four years ahead of schedule. **Koonjewarre**: The baseline area of clearing on Koonjewarre was 79.5% of the property. By the end of 2014 **The Lodge**: The cleared area resulting from the volunteer buildings represented about 2.5% of the total area of the property at the time of purchase by the government. As a result of natural regeneration and maturing of canopy trees the area devoid of canopy is less than 2%. This is unlikely to change for as long as the accommodation buildings are required. **Logrunners**: The original cleared area of 150 m^2 has reduced due to progressive expansion of tree canopies adjacent to the building.	*Efficiency* Cost-effectiveness of the program is allied to our very significant reliance on volunteers. Achieving cost-effective large-scale ecological restoration is one of the key goals of the project so as to provide useful learnings for others. *Legacy* Achieving complete canopy recovery as well as integrity of critical habitat and landscape connectivity will help ensure the protected area estate requires minimal management costs for its long-term viability.

Desired outcome	Activity reporting	
	CAVE RECOVERY AREA **Quolls**: The original cleared area of 1841 m² in 2005 has effectively diminished due to expansion of maturing canopies of trees adjacent to the clearing. **Lyrebird Retreat**: The original cleared area of 14.4 ha in 2005 has significantly reduced due to natural regeneration but more work needs to be done. PURLING BROOK RECOVERY AREA **Kanimbla**: The canopy cover goal has already been exceeded on Kanimbla at least four years ahead of schedule, i.e. before 2018. LITTLE NERANG RECOVERY AREA **Ankuna**: The original cleared area of close to 1.2 ha has been reduced by a small extent through natural regeneration. Removal of wild tobacco and other smothering weeds during the remainder of the Intermediate phase will accelerate recovery.	
'Significant' species utilising newly restored habitats [**"Critical Habitat and Landscape Connectivity" Recovery]**	**Mundora Recovery Area:** This area contains one of the three identified most vulnerable bottlenecks to critical habitat connectivity in the highest rainfall (cloud forest) zone of the McPherson Range. As a result of natural regeneration, increasing canopy closure and connectivity many rare, threatened and significant species are recorded as utilising the new habitats: — Albert's Lyrebird, both Satin and Regent Bowerbirds, both White Throated and Red Browed Treecreepers; — Giant Land Mullet, Red-bellied Black Snake — *Litoria revelata*, *L. pearsoniana*, *Assa darlingtoni*, *Mixophyes fleayi*	

Desired outcome	Activity reporting	
	Ee-jung Recovery Area: This contains the second most vulnerable bottleneck to connectivity of critical habitats in the cloud forest zone. As a result of recovery of riparian, montane heath and rainforest habitats in particular several rare, threatened and significant species utilise these habitats: — Albert's Lyrebird, both Satin and Regent Bowerbirds, both White Throated and Red Browed Treecreepers, Lewin's Rail, Latham's Snipe — Giant Land Mullet, Red-bellied Black Snake	
	Boy-ull Recovery Area: This catchment contained the most significant bottleneck to connectivity in the cloud forest zone as clearly visible in Figure 1.9 (2006) of our Foundation Restoration Report 2008-09 (p. 7) held by the government and available on the Springbrook Rescue website (https://springbrookrescue.org.au/ProgressReports.html). A major north-east to south-west trending corridor has established at the end of 2014 (See Appendix 2). Albert's Lyrebird and Logrunners are now able to utilise the additional habitat that this corridor provides. We do not as yet have a more comprehensive assessment of species occupying this corridor.	
Barriers to ecosystem restoration eliminated;	Altered **biogeochemical processes** **Summary:** Biogeochemical barriers have been significantly diminished but not entirely eliminated Ongoing recovery of canopy integrity and successional processes on the restoration properties including those reliant on functional diversity will continue to diminish residual barriers to regeneration — **hydrological** (including erosion, soil compaction), altered **nutrient cycling** or **climate processes** (including those affecting evapotranspiration and micrometeorological parameters	*Impact* Barriers due to altered biogeochemical processes are reducing satisfactorily due to natural regeneration possible through this project. This project may be negatively impacted through lack of controls on fragmentation through increasing urbanisation. x

Desired outcome	Activity reporting	
	inimical to required refugial conditions). On the other hand, progress on restoration properties is likely to be undermined by fragmentation effects of increasing urbanisation and associated countervailing infrastructure strategies at broader landscape scales.	
	Detrimental regimes of **physical disturbance** events **Summary**: whilst barriers have diminished, long-term resilience and stability against extreme disturbance regimes will only be achieved after full canopy closure and restoration of functional diversity Ongoing recovery of canopy integrity as well as species and functional diversity will diminish risks from abnormal fire regimes and vulnerability to extremes of weather (including wind, drought, frost).	
	Altered **ecological resources and/or processes** **Summary**: barriers due to weed, pest and pathogen invasions have not been eliminated yet. Most progress has been with weed invasions which are under active control; control of feral dogs, cats and foxes, as also with non-indigenous ants, cane toads and pathogens, will depend critically on actions by other land owners on a broad land-scape scale; The main threats and barriers to restoration result from: **weed invasions:** The most invasive weed species being dealt with include Aristea ecklonii, Kahili Ginger, *Plectranthus ciliatus*, Montbretia etc, and exotic mat-forming pasture grasses such as Kikuyu, Setaria, Paspalum and Dactylis spp. and smothering vines such	

Desired outcome	Activity reporting	
	as Japanese Honeysuckle). Aristea, being capable of replacing forests, remains a major threat to the Gondwana World Heritage Area. Despite an intensive effort in 2014 with extra resources from the Biodiversity Fund grant applied to employing contractors to supplement efforts of volunteers, we expect an additional two years before it is finally controlled. Residual rhizome remnants and soils seed stores still remain and unless follow-up treatments are maintained could quickly lead to returning back to "square one". Kahili Ginger infestations from Warblers, Ashmiha, Barambah, Pallida and Koonjewarre have been removed in 2014 to very small areas of resprouts which should finally be removed in follow-up treatments in 2015. Montbretia, despite a major eradication effort by contractors and volunteers in 2014, is still resprouting from culms in some areas and will need attention in 2015. Its final removal from the sites can be achieved well before the end of the Intermediate period in 2017. Removal of other weed species, because of the seriousness of the threat from Aristea ecklonii have a lower priority but are expected to be under control or eliminated by the end of 2017. **pest invasions** (domestic and introduced animals: dogs, cats, foxes, cane toads, exotic ants etc); Camera trap monitoring does not indicate an increase in **pest mammals** but elimination requires an over-arching, coordinated response across all tenures and land managers. ARCS unsuccessfully applied for a grant under the former Biodiversity Fund Round 2 that had the potential to eliminate **cane toads** from the restoration properties in the fist instance; the approach provided a model for tackling other areas on	

Desired outcome	Activity reporting	
	Springbrook Plateau The elimination of **exotic ants** which could be expected to impact heavily on native species will be impossible without a concerted cross-tenure strategy to reduce introductions associated with urban and infrastructure developments. Introduced **pathogens** (fungal: *Phytophthora* spp., *Favolachia calocera*, *Armillaria luteobubalina*, *Puccina psidii*, Chytrid fungus; viral: Inclusion Body Disease (IBD) affecting reptiles, Beak and Feather Disease affecting birds) Favolachia, Myrtle Rust and Chytrid fungus are now widespread throughout Springbrook's forests. Isolated hygiene protocols, such as introduced by ARCS, will be insufficient to control or minimise the threats from these sources across all tenures. Nevertheless, we will be purchasing boot stations from the National Parks and Wildlife Service to try to minimise ongoing infestations from boots of volunteers.	
	Impacts of pollution **Chemical**: to our knowledge only xxx is used for the control of the most invasive, otherwise intractable weed species so as to minimise collateral impacts on native species and ecosystems; glyphosate formulations we use () are considered the most 'benign' re environmental and human health. The reported half-life in soils is xxxx ARCS continues to monitor the scientific literature for any indications to the contrary.	
	Impacts of detrimental land-use or land-use change Whereas barriers from past detrimental land-use and land-use change were eliminated by the buyback of private land for addition to the National Park estate, the fragmentation effects of intervening blocks of private land and	

Desired outcome	Activity reporting	
	infrastructure (roads, powerlines, communication towers) remain. Conservation covenants over private land and better codes of practice for road and infrastructure management need to be encouraged.	
	Impacts of socio-political processes: Political: Lack of political support over the past three years, particularly from the key project partner (the Queensland Government) potentially threatened to cut short the program after completion of only 15% of the project period of 20 years, or 30% of the 10-year segment. A key learning, not recognised at the initial planning phase, has been that the political risk can re-emerge at any time over the long-term. This is potentially a terminal risk to the viability of the project. It can potentially be minimised by building a stronger community constituency and ensuring all parties are aware of the critical significance and fragility of this refugium (one of the two most important rainforest refugia in Australia).	
Aristea ecklonii eradicated from all sites	Clearly, this objective was not achieved by the end of 2014, but we expect to reach this goal by the end of 2016. This is achievable only if (a) we are aware of all sites of infestation on Springbrook; and (b) Biosecurity Queensland declares the species as a Class 2 weed. Achieving (b) will be a challenge for 2015.	
Forest structure consistent with model predictions for their age and environmental conditions	Results of studying community assembly processes via our 15 growth plots on Warblers, Ashmiha and Pallida are broadly consistent with predictions based on our conceptual models and comparison with reference sites. Species recruitment initially reflects the local species pool; productivity and mortality rates are affected by local abiotic environments (even at the micro-habitat scale since seedling recruitment is affected by micro-habitat	

Desired outcome	Activity reporting	
	conditions). Canopy closure was achieved relatively suddenly during the period 2013-2014 on many plots on Warblers and Pallida such that continuation of early measurements are no longer possible (i.e. plant height and other dimensions are obscured by thick coalescing canopies).	
Landscape-scale threats abating by harmonising infrastructure policies, Local Area and Regional Plans	Road verge and powerline easement management to restore microclimates and habitat, and to reduce the spread of weeds that should have been achieved duing the first 3-year phase of Immediate Activities, remain elusive. In fact impacts from these management practices have increased because of detrimental changes to policy.	

Appendix 1

Springbrook Restoration Plan for first 3 years of the Intermediate phase (2012–2015)

Mundora, Ee-jung, Boy-ull Restoration Areas

Project description	Springbrook Rescue is a long-term project that aims to restore and enhance critical habitat and functional connectivity, lost over the last century, around the wet heartland of the Gondwana Rainforests World Heritage Area (GRWHA). Assisting natural regeneration of canopy cover and key ecosystem functions catchment-wide will increase carbon storage and resistance and resilience to climate change and other threatening processes. Using alternative stable state theory and wireless sensor networks to evaluate regeneration strategies, the project breaks new ground on more cost-effective methods for restoration of degraded lands. Eradicating new, forest replacing, shade-tolerant weeds that threaten the World Heritage Area is an urgent priority for the 2012–2015 planning phase.
Project outcomes	Between 2005 and 2009, the Queensland Government spent $40 million purchasing land adjoining the Springbrook National Park section of the Gondwana Rainforests of Australia World Heritage Area (GRAWHA). The majority of this land is now gazetted as National Park or National Park (Recovery). Some of this land is cleared and ARCS Inc has entered into a legal agreement with the State of Queensland to restore, pro bono, native vegetation on the land over a period of 10–20 years. The regeneration plan for the National Park (Recovery) areas is accessible electronically at http://www.derm.qld.gov.au/parks/springbrook/pdf/regeneration-plan-web.pdf Springbrook Rescue aims to restore the viability and resilience of one of the planet's most significant World Heritage areas but which has been severely put at risk by clearing and fragmentation over the past 100 years. Through restoration of connectivity and critical habitat integrity, Springbrook National Park will be extended giving this national hotspot of biodiversity and universal significance greater security. To be effective connectivity must consider processes related to ecosystem resistance and resilience at habitat, landscape, ecological and evolutionary scales. The success of interventions in the short- and long-term will be measured against goals (desired ecosystem parameters) published by the International Society for Ecological Restoration. Critical habitat restoration will give priority consideration to a wide range of functional groups amongst ancient plant and animal lineages (to their resource, shelter, and reproductive needs as well as their sensitivity to habitat loss, modification and fragmentation). The approach adopted is to build first on those areas that will establish initial connectivity with the least effort and most effect. Then later build connections between these primary corridors (interlinked landscape matrices) with continuing infilling until all gaps are closed. Thus during the current Project term a specific aim is to improve canopy cover in three primary corridors within the Mundora, Ee-jung and

	Boy-ull Creek catchments that bridge a significant gap between the Queensland and New South Wales sections of the Gondwana Rainforests of Australia World Heritage Area (GRAWHA). This section represents the superwet, core refugium of the GRAWHA where ancient, conservative Gondwanan lineages have the greatest potential to recover and survive climate change. Centred in the highest rainfall zone of the McPherson Range (≥3,500 mm av. annual rainfall), the high country cloud forests of Springbrook Plateau represent the wettest core of the GRAWHA. The area is the closest present-day analogue, outside the Wet Tropics of Queensland, of wetter and more equable palaeo-climates under which the ancestry of the world's songbirds and many other ancient lineages evolved. The most vulnerable bottlenecks in this linkage zone have been identified (Warblers, Ashmiha, Barimbah and Pallida) and are targeted for substantial improvement during the current 3-year period: The Mundora linkage bridges a 1.25 km N–S gap over a 170-m elevational band that is 670 m at its widest and 140 m at its narrowest points. The "**Warblers**" site represents the critical bottle neck in this corridor being an essentially cleared gap 140 m wide and 250 m long on flat land at the base of the elevational gradient. The Ee-jung linkage adjoins the Mundora corridor at the watershed boundary between the Mundora and Ee-Jung Creek catchments. The N–S corridor is 775 m long and, on average, 545 m wide, spanning an elevational gradient of 160 m (790 m to 950 m). The last major clearing was in 1975. The "**Ashmiha"** site is the critical bottleneck at the base of the corridor creating an almost complete break ~530 m long and 250 m wide and extending for more than half the length of the planned primary corridor. A diversity of aspects ranging between east and west, from valley floor to mid-slopes contributes to topographic diversity fundamental to refugia where species have only short distances to move to track climate change. The "**Barimbah"** site forms the upper elevational connection (870 m–940 m) in the corridor spanning a range of aspects from predominantly northwest to to northeast between the watershed boundaries. This is the most intact part of the corridor with a remnant core that escaped all past clearing. The Boy-ull linkage adjoins the Ee-jung Linkage at the watershed boundary of the two catchments. This region is the most heavily impacted of the three priority corridors, experiencing repeated near-complete clearing, the last on the "Pallida" site being in 1992. The "**Pallida"** site spans the full elevational gradient between the two blocks being connected (from 780 m to 935 m) and occurs in the

	eastern half of the Boy-ull Creek catchment with largely a westerly to northerly aspect. Invasive weed eradication is a significant element of Springbrook Rescue and aims to not only prevent invasion of the GRAWHA by the weeds but also remove their inhibiting effects on natural regeneration. In this term the project aims to assist natural regeneration through a concentrated focus on the two most aggressively invasive and ecologically damaging weeds — blue stars and kahili ginger, whilst controlling the impact of other weeds, especially mat-forming exotic pasture grasses, so as to reduce barriers to natural regeneration. Blue stars (*Aristea ecklonii*) and kahili ginger (*Hedychium gardnerianum*) not only inhibit natural regeneration on cleared areas but, being shade-tolerant and bird-dispersed, also have the potential to invade native vegetation including in inaccessible areas and form dense ground cover preventing seedling establishment and threatening long-term survival of the ecosystem. They represent a significant threat to the adjoining World Heritage areas. The most critical intended outcome over the next three years is eradication of blue stars and kahili ginger on the restoration land. Project outputs related to this specific objective are highlighted in green in the table below.

Projected Intermediate Outcomes and Methods of Assessment (2012–2014)

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
Mundora Catchment **Warblers site (3 ha)** **Acquired August 2007**	**A. Exotic grassland** (sown pasture) dominated primarily by the bunch grass *Setaria sphacelata* and the rhizomatous herb *Aristea ecklonii* (blue stars); On the adjoining northern, eastern and southern boundaries of this property is unclassified "High value regrowth vegetation" (mapped by Qld Dept of Environment) that acts as a potential species pool of colonisers for the Warblers site. Canopy species on the eastern and northern boundaries include *Callicoma serratifolia*, *Pittosporum undulatum*, *Leptospermum trinervium*, *Leptospermum polygallifolium*, *Lomatia arborescens*, *Persoonia media*, *Orites excelsa*, and *Acacia* spp. Along the northern boundary is well advanced regrowth of	***1. Recruitment***		
		Assisted natural regeneration since the beginning of the project has resulted in an increase in native plant density to ≥1,000/ha (a spacing of ≥ 3.25m or ≥30 plants/sub-cell) over 89% of the area	Assisted Natural regeneration will have resulted in a native plant density of ≥ 1,800 plants/ha (an av. plant spacing of 2.5 m or 50 plants/sub-cell) on 100% of the area	Plant species assembly (**density**, **richness**) is monitored directly in the field by marking & labelling all new plants in each 16.66m x 16.66m sub-cell, that is part of a continuous grid, annually for most (**Project SS2**), but seasonally in 8 subcells (**Project SP1**). Values are corrected for mortality at each measure. Data are collated and analysed using FileMaker databases.
		2. Plant community composition and structure		
		Plant community composition and structure is maximally divergent from that of reference ecosystems. Species accumulation is mainly restricted to wind-dispersed pioneer and some animal-dispersed early- to mid-successional species In the northern section, "High value regrowth vegetation of Regional Ecosystem 12.8.2 is expanding into the cleared areas with individuals of *Eucalyptus oreades* reaching above 6 m.	A plant community composition and structure that in the southern half includes more animal-dispersed rainforest species from Araliaceae, Elaeocarpaceae, Icacinaceae, Lauraceae, Meliaceae, Myrtaceae, Rutaceae, Sapindaceae, families (which in turn will facilitate recovery of keystone avian frugivores); and in the northern half more animal-dispersed species typical of RE 12.8.2. Along the northern boundary on rhyolite (the northern half of Grid	Trends in plant community ***composition*** *and relative* ***abundance*** are based on annual monitoring of stratified quadrats compared with the previous year's results and with characteristic composition and abundance of indicator species in corresponding Reference Sites **(Project SSP4)** Changes in plant community ***structure*** is monitored in 8 stratified quadrats by comparing changes in height and leaf area index summarised into height-classes differing by 20 cm up to 1 m,

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
	Regional Ecosystem 12.8.2, *Eucalyptus oreades* tall open forest on Cainozoic igneous rocks (Conservation status 'Of Concern'). Indicator species include: a **canopy** layer of *Eucalyptus oreades* and *E. campanulata*; a **subcanopy** of *Elaeocarpus reticulatus*, *Acacia obtusifolia*, *Litsea reticulata*, *Leptospermum petersonii*; **shrubs** including *Elaeocarpus reticulatus*, *Logania albiflora*, *Cyathea australis*, *Cassinia subtropica*, *Synoum glandulosum*, *Melicope micrococca*, *Prostanthera phylicifolia*, *Pittosporum undulatum*, *Neolitsea dealbata*, *Polyscias sambucifolia*; a **ground layer** of *Dicranopteris linearis*, *Calochlaena dubia*, *Gonocarpus teucrioides*, *Hibbertia dentata*, *Gahnia melanocarpa*, *Dianella caerulea*		Cell A in attached file "BiodiversityPlanGrids&Photopoints.pdf") plant stocking levels expected to exceed 3000–5000 plants/ha within 50 metres of the forest edge. Plant species accumulation will grade inversely with distance from forest edge (50 to 5 species)	and by 50 cm increments thereafter to 6 m **(Project SP1).** Data can be extrapolated to adjoining areas to project expected rates of change. In older communities basal area estimates are made by random or systematic point sampling
		3. Animal community composition and structure		
		Animal community composition and structure reflect disturbance. Bird species common to disturbed areas dominate (ravens, crows, currawongs, magpies);	An increased use of regenerating vegetation is expected for foraging by scrubwrens and bowerbirds (and possibly Albert's Lyrebird), and for nesting by thornbills and gerygones.	Targeted surveys and incidental observations. Acoustic monitoring **(Project SS1)** using an omnidirectional, high-powered microphone (Song Meter, Wildlife Acoustics Inc.). Identification to species and abundance assessment is by analysis of sonograms using specialist software (Songscope, Wildlife Acoustics Inc.). Alternative software (SoundID) will be explored in 2015
		4. Habitat for rare, threatened or significant species		

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		The regenerating ecosystems can only ever provide extensions of viable habitat for rare, threatened or significant species that occur in contiguous parts of the primary corridor being restored: currently recorded are *Acacia orites* (NT), *Austrobuxus swainii* (NT), *Lenwebbia prominens* (NT), *Rhodamnia maideniana* (NT), *Assa darlingtoni* (NT), *Litoria pearsoniana* (V), *L. revelata* (NT), *Mixophyes fleayi* (E); the highly cryptic Lewin's Rail (NT) is recorded on the site where grass cover is tall; grey goshawk (NT) sighted but has a large range	The population of *Litoria revelata* (NT) is expected to increase Threatened (E, V, NT) or significant plant species increased in both density and extent of occurrence	Acoustic monitoring **(Project SS1)** as above for bird and frog species supplemented by incidental records Plant species monitoring associated with routine marking and monitoring in Growth Plots (**Project SP1**) and in other Grid cells on the site (**Project SS2**)
		5. Non-indigenous species		
		Non-indigenous species levels high; *Aristea* and *Setaria* blanket most of the site potentially producing tonnes of seed heads with billions of highly dispersible seeds in 1.5–3 months if uncontrolled	Aristea, kahili ginger, montbretia absent; fireweed reduced to low levels; setaria kept from forming thick necrotosing mats	Quantitative assessment of plant/plant part removals (by weight and number/subcell) provides confirmation of trends on repeated removals **(Project SD7)** Semi-quantitative assessment of effectiveness of repeated removal effort via inspection (scale of 1–4) and photopoint monitoring of each subcell on the site **(Project SP4)**
		6. Functional Diversity		

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		Functional diversity of regenerating native plant species characteristic of 5-year old regrowth All trophic levels of fauna are represented but restricted to occasional use for non-breeding activities	Each functional group characteristic of the stage of succession is represented with increased 'redundancy'	The biodiversity surveys (**Projects SBD1-7**) provide the basic information for assessing functional groups integrity. Functional groups are defined by taxonomic, morphological, & trophic classes; with subsets relating to niche specialization (resource, habitat, reproduction); as well as to fragmentation sensitivity (area- and barrier-sensitive; habitat specialist; dispersal-limited; metapopulation-dependent, otherwise ecologically important or phylogenetically significant) **(Project SBD9).** Surveys of birds and frogs at this site are restricted to incidental records and acoustic monitoring using omnidirectional, high-powered microphones (Song Meter, Wildlife Acoustics Inc.). Identification to species is by analysis of sonograms using specialist software (Songscope, Wildlife Acoustics Inc.) **(Project SS1)**
		7. Canopy Cover		
		Canopy cover exists on 18% of the site; regeneration nodes with canopy closure act as stepping stones for some frugivorous birds (e.g. bowerbirds) and ground-dwelling invertebrativores (e.g. logrunners);	An east–west corridor linking the central regeneration node on outcropping rhyolite to that at the eastern boundary is advanced to either canopy closure or high plant	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file warblers_14Jun2012.jpg)

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		otherwise the site remains a bottleneck in the corridor	density capable of closure in the near term	Estimates of Leaf Area Index (LAI) and effective plant biomass outside the WSN nodes using a portable ceptometer (AccuPAR, LP-80, Decagon Devices, Inc.) provides a measure of canopy density. Alternatively, finer-scale assessments are carried out using point sampling with a Spherical Crown Densitometer or line-point transect sampling with a GRS Densitometer. The latter method allows greater characterisation of forest structure in addition to canopy closure levels
		8. Abiotic conditions — Microclimate		
		Microclimate over most of the area deviates maximally from the optimal buffered condition characteristic of climate refugia.	Microclimate is significantly moderated through shading by advancing regeneration	Three micrometeorological nodes **(Project SRC1)** sample at 15 min intervals: rainfall, PAR, air RH & T, leaf wetness, soil moisture and soil water potential; a further two only sample PAR as a function of distance from forest edge to assess the impact of shading. Monitoring elsewhere as required using a Kestrel 4500 Pocket Weather Meter with comparisons

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
				to adjacent cleared areas and the formal weather stations on the site.
		9. Abiotic conditions — Soil health		
		Soil health is still generally poor (high compaction levels and low water holding capacity); thin skeletal soils devoid of leaf litter render new regeneration highly frost prone	Soil compaction continues to be significantly reduced, on average, across the site. Earthworm activity and density in soils increasing Leaf litter levels improving in areas of advanced regeneration	Soil health assessments are conducted as part of **Project SRC3**. Soil compaction and moisture levels are considered a minimal set of surrogate indicators of soil health at a broad scale (other physical parameters measured on more limited stratified quadrats include depth, texture, pH, dispersion and colour). Transect-based measure of soil compaction is done using a drop-cone penetrometer; soil moisture other than at micrometeorological stations is measured using an MPKit (ICT International) Earthworm activity (a key bioindicator including of soil organic matter) is semi-quantitative (counts per unit area dug) but non-lethal, non-invasive soil imaging methods are being investigated Leaf litter levels measured by steel prong capture method
		10. Successional processes		

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		Successional processes likely to flip to undesired Alternative Stable State (ASS) in the absence of active intervention to control the key drivers of phase shifts (Aristea, setaria & Kahili Ginger)	Successional processes less prone to ASS; the need for active intervention re. 2 of the 3 critical biotic drivers of phase shifts removed	Our broad- and fine-scale ecological conceptual models provide the basis for assessing emergent system dynamics that consider the drivers of environmental change (species pool characteristics, climate, resource fluxes, disturbance regimes), state response variables (ecosystem structure and processes, including feedbacks that stabilise/destabilise alternative stable states) **(Project SS3)**.
	B. Unclassified regrowth vegetation on outcropping rhyolite with emergent *Leptospermum polygalifolium* var. *montanum*, *Lomatia arborescens*, *Orites excelsa*, *Persoonia media*, *Acacia* spp., *Pittosporum undulatum*, *Tasmannia insipida* etc.	**1. Recruitment**		
		Edges have expanded (through control of competition from setaria) at least 16–20 m into adjoining cleared area on rhyolite around the southern half with a density ≥5000 plants/ha; (the core regrowth area has significant infestations of kahili ginger)	Further increasing density and extent of the leading edge to south, east and west	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of increase in vegetation extent Plant density estimated from number of individuals per marked grid cell
		2. Plant community composition and structure		
		Plant community composition is dominated by Leptospermum polygalifolium var. montanum with minor presence of Lomatia	Plant community composition is likely to increase and include more bird-dispersed species as canopy	Plant species assembly (**richness**) is monitored directly in the field by marking/labelling new plants

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		arborescens	cover increases	annually in 16.66m x 16.66m sub-cells, that are part of a continuous grid (**Project SS2**). Values are corrected for mortality at each recording. Data are collated and analysed using FileMaker databases.
		3. Animal community composition and structure		
		Animal community composition reflects the currently small size and quality of the fragment but logrunners, bowerbirds, pheasant coucals use the area occasionally; unidentified birds nests have been found in the regeneration area	Improvements in animal community composition are expected as the canopy and plant species composition develops further; and linkages to more mature vegetation consolidates	Ad hoc sightings are useful due to the frequent presence of regenerators on the site including volunteers from Birds Queensland; Project SS2 and Project SBD6
		4. Habitat for threatened or significant species		
		Viable habitat extensions for rare and threatened animal species is unlikely until greater connectivity is achieved	No change in representation of threatened species is expected	Acoustic monitoring of bird and frog species (Project SS1) allows detection of rare, threatened or significant species and their abundances
		5. Non-indigenous species		
		The vegetation on this outcropping rhyolite is extensively infested with kahili ginger (rising up into the trees) and aristea	Kahili ginger and aristea absent; Setaria prevented from seeding and necrotising mat-formation	Quantitative and semi-quantitative methods (subjective rating scale and photographic records) for assessing effectiveness and efficiency of removals as above (Project SD7) Setaria controlled by mowing where interference with natural

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
				regeneration is not compromised, and hand-shearing otherwise
		6. Functional diversity		
		Functional diversity is at a low level	Functional diversity slightly improved	Functional group analysis (Projects SBD1-9) as above based on data from targeted surveys and incidental recordings
		7. Canopy cover		
		Canopy cover is broken by windthrow of two structure-forming canopy trees	Canopy cover improved by lateral expansion of existing tree canopies; canopy closure increasing in expanding margins and along newly emerging/facilitated linkages to the eastern and southern boundaries	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file warblers_14Jun2012.jpg) Estimates of Leaf Area Index (LAI) and effective plant biomass outside the WSN nodes using a portable ceptometer (AccuPAR, LP-80, Decagon Devices, Inc.) provides a measure of canopy density. Point- or line-point transect sampling with spherical crown or GRS densitometers.
		8. Abiotic condition — microclimate		
		Microclimate is suboptimal in the remnant core because of its small size and edge effects; vegetation is exposed to drying and strong winds causing loosening or uprooting of trees growing on almost bare rock	Microclimate improved due to expanding edge with canopy closure	Monitoring as required using a Kestrel 4500 Pocket Weather Meter with comparisons to adjacent cleared areas and formal weather stations on the site.
		9. Abiotic condition — soil health		

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		Soil health difficult to assess on outcropping rhyolite where soil development is minimal; trees form thick root mats covering rock for anchorage and nutrient & water extraction Soil health in adjoining areas with expanding regeneration recovering from past heavy vehicle impacts. Litter development low	Soil health continuing to improve	Soil health assessments are conducted as part of Project SRC3. Soil compaction and moisture levels are considered a minimal set of surrogate indicators of soil health at a broad scale (other physical parameters measured at more limited sites include depth, texture, pH, dispersion and colour). Transect-based measure of soil compaction is done using a drop-cone penetrometer; soil moisture other than at micrometeorological stations is measured using an MPKit (ICT International) Earthworm activity (a key bioindicator including of soil organic matter) is semi-quantitative (counts per unit area dug) but non-lethal, non-invasive soil imaging methods are being investigated Leaf litter levels measured by steel prong capture method The method chosen depends on the nature of the substrate
		10. Successional processes		
		Successional processes maintained through active intervention balancing competitive/facilitative	Succession progress maintained through active intervention to remove competing setaria	Resilience model based on assessing drivers and response variables affecting ecosystem

Mundora: Warblers	Vegetation description	Current condition (2012)	Intended condition (2014)	Method of assessment
		interactions between weeds and native species		dynamics and potential for sudden, essentially irreversible change in ecosystem states (Project SS3)

Ee-jung ASH–PUM	Vegetation description	Current condition	Intended condition in 2015	Method of assessment
Ee-jung catchment: **Ashmiha site (12 ha)** **Pumilo site pt (6 ha)**	A. Exotic grassland (sown pasture) dominated primarily by the bunch grass *Setaria sphacelata*, kikuyu and paspalum. Grazing ceased in 2008. Just prior to being acquired by the Queensland Government, regeneration along the south-western boundary was killed with the persistent herbicide Grazon. The property consists of two lots. Southern lot: Immediately adjoining the southern and western boundaries is advanced regrowth of Regional Ecosystem 12.8.5 (Complex notophyll vine forest on Cainozoic igneous rocks >600 m altitude), mapped by Qld Dept of Environment as "High value regrowth vegetation". Near the south-eastern boundary is a small remnant patch of Regional Ecosystem 12.8.5 which survived more than 100 years clearing on the plateau. These areas provide the	**1. Recruitment**		
		Natural regeneration in the Southern lot and part of the Northern lot (trial areas testing both capacity for unassisted regeneration and recovery of soil health under the respective covers of kikuyu, paspalum and setaria) has largely failed in the absence of active intervention to control necrotosing mat-forming exotic grasses (setaria, kikuyu and paspalum). Isolated *Leptospermum polygalifolium* present from the end of cattle grazing when grass canopies were low. Assisted natural regeneration near forest edges of the Northern lot since the beginning of the project has resulted in an increase in native species recruitment with an average current density of 5,560 plants/ha	Density of assisted natural regeneration greatly increased, via control of mat-forming grasses, with pant densities within 35 m of forest edges approaching 5000 plants/ha, decreasing with distance from forest edge	Plant species assembly (density) is monitored directly in the field by marking/labelling all new plants in each 16.66m x 16.66m sub-cell, that is part of a continuous grid, annually for most (Project SS2), but seasonally in 4 subcells associated with productivity assessment (Project SP1). Values are corrected for mortality at each measure. Data are collated and analysed using FileMaker databases.
		2. Plant composition and structure		
		Plant community richness, composition and structure over most of the area is dominated by pasture grasses and isolated shrubs of mainly orites, lomatia and acacia species especially at the highest altitudes. The Northern boundary in the Northern lot contains a greater	Plant community richness, composition and structure are likely to increase with increased representation of plant families and genera, as well as of animal dispersed species as regenerating species provide perching opportunities for birds from the forest blocks being connected.	Grid-based marking/labeling as above for monitoring trends Four stratified quadrats for monitoring and predicting changes in productivity and structure as above (Project SP1).

	potential species pool of colonisers for the southern lot of Ashmiha. Indicator species include: **emergent** *Ficus watkinsiana*; a canopy *Argyrodendron actinophyllum*, *A. trifoliolatum*, *Sloanea australis*, *Acmena ingens*, *Syzygium crebrinerve*, *Caldcluvia paniculosa*, *Geissois benthamii*, *Aronychia octandra*, *Acronychia suberosa*, *Doryphora sassafras*, *Orites excelsa*, *Cryptocarya erythroxylon*; **Subcanopy** *Daphnandra tenuipes*, capparis arborea, Sloanea australis, Quintinia verdonii, Baloghia inophylla, Scolopia braunii, Geliotropium glabellum, Alangium villosum; **Shrubs** *Cyathea leichhardtiana*, *Linospadix monostachya*, *Ardisia bakeri*, *Capparis arborea*, *Rhodamnia maideniana*, *Harpullia alata*, *Wilkiea austraoqueenslandica*, *Wilkiea huegeliana*, *Psychotria simmondsiana*, *Cryptocarya meisneriana*, *Citrus australasica*; **Ground layer** *Lastreopsis marginans*, *L. decomposita*, *Lomandra spicata*, *Pellaea falcata*	diversity of species as measured in the formal growth plots. Twenty-five plant species in 15 families and 22 genera comprise the recruited pool (c.f. 63 species in 31 families & 51 genera in the source pool) representing significant phylogenetic diversity. Plant functional types (plant form) include trees, shrubs, herbs, vines, ground ferns and orchids. Large tree species, e.g. *Eucalyptus oreades* and *E. campanulata* now reach ≥6 m in height. Wind-dispersed propagules dominate over animal dispersed ones ~ 2:1 (c.f. 1:3 in the total species pool)		
		3. Animal composition and structure		
		Animal community richness, composition reflects the high level of disturbance and fragmentation; birds include ravens, crows, butcherbirds, currawongs and generally a pair of masked lapwings. Raptors are frequently recorded. Forest edges frequently utilised by bowerbirds (satin bowerbird), pardalotes (both spotted and striated), white-browed treecreepers and occasionally Victoria's Riflebird.	Changes in animal community composition are likely to remain relatively unchanged.	Targeted surveys and incidental records associated with routine management activities as above
		4. Habitat for threatened or significant species		
		The site does not necessarily provide viable habitat for rare, threatened or significant species, but two of the four rare species known to occur on	No major progress is expected in three years, and until canopy closure is reached; however an increase expected in population numbers of	Plant monitoring/marking associated other restoration activities (prior to slashing or other means of weed control)

	Northern lot: Along the northern boundary of the lot is well advanced regrowth of Regional Ecosystem 12.8.2, *Eucalyptus oreades* tall open forest on Cainozoic igneous rocks (Conservation status 'Of Concern'). Mapped by Qld Dept of Environment as "High value regrowth vegetation" Detailed description above for this species pool.	Ashmiha (*Acacia orites* (NT) and *Lenwebbia prominens* (NT)) are dispersing onto the site.	*Correa lawrenciana* var. *glandulifera* (significant species)	Incidental records of fauna by experienced observers
		5. Non-indigenous species		
		Non-indigenous species levels high; setaria, kikuyu, paspalum blanket most of the site; fireweed is common; Aristea has invaded the eastern and northern boundaries the likely source being from Warblers and the road reserve) Kahili ginger infestation minimal. Yorkshire Fog in wetter areas with poor drainage	Aristea, kahili ginger absent. Fireweed reduced but not eradicated due to continuing re-infestation from neighbouring private land; Setaria, kikuyu, paspalum prevented from forming thick necrotosing mats that inhibit natural regeneration	Quantitative estimates of aristea removals as above Photopoint monitoring where relevant
		6. Functional diversity		
		Functional diversity of plants very low over much of the site but relative high close to forest edges (all morphological groups present). Bird functional diversity associated with exotic pastures comprises mainly omnivore/carnivore classes.	Functional diversity is not expected to change dramatically overall in 3 years	Analysis of selected functional groups recorded by targeted surveys (Projects SBD1–8) as described above
		7. Canopy cover		
		Canopy cover minimally contributes to improved connectivity	Improvements in connectivity are not expected within 3 years but edge expansion continues consistent with growth plot data	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file ashmiha_14Jun2012.jpg) Estimates of Leaf Area Index (LAI) and effective plant biomass outside the WSN nodes using a portable ceptometer (AccuPAR, LP-80,

				Decagon Devices, Inc.) provides a measure of canopy density. Photomonitoring where relevant
		8. Abiotic condition — microclimate		
		Microclimate deviates maximally from the optimal buffered condition in reference sites	Microclimate changes at expanding forest edges mainly related to effects of shading	Extrapolation of micrometeorological monitoring on analogous environments on the Warblers site in the Mundora Creek catchment
		9. Abiotic condition — soil health		
		Soil health generally improved by utilising principle of "ley" pasture management (high compaction levels and low water holding capacity originally due to impact of cattle grazing and heavy machinery ameliorated by certain pasture grasses during a sufficiently long fallow period); Soil nutrient levels still elevated patchily from past cattle grazing; Erosion significant along Ee-jung Creek due to removal of vegetation and cattle trampling up to 2007; Erosion along a deep artificial trench (40 m long, 1.5 m deep and 5 m wide on average in the worst parts); established in past to divert overland flow from the former house site	Soil health, 7 years after grazing ceased & ley pasture type management, has returned to ~ normal (re compaction, aggregate stability, hydraulic conductivity) — essential for overcoming major abiotic barrier to effective regeneration Residual levels of Grazon (persistent herbicide) likely to be negligible 5-7 years after original application by previous private owners Hydrological improvements as a result of in-filling of artificial trenches previously diverting overland flow, and increased native plant cover along riparian areas	Soil health assessments are conducted as part of Project SRC3. Soil compaction and moisture levels are considered a minimal set of surrogate indicators of soil health at a broad scale (other physical parameters measured on more limited stratified quadrats include depth, texture, pH, dispersion and colour). Transect-based measure of soil compaction is done using a drop-cone penetrometer; soil moisture other than at micrometeorological stations is measured using an MPKit (ICT International) Earthworm activity (a key bioindicator including of soil organic matter) is semi-quantitative (counts per unit area dug) but non-lethal, non-invasive soil imaging methods are being investigated

				Leaf litter levels measured by steel prong capture method Soil nutrient levels qualitatively inferred by quality of grass patches affected by cow dung and urine (still visible 4 years after grazing stopped) Macrofungi surveys in stratified quadrats (Project SBD2) indicative of soil health and successional development.
		10. Successional processes		
		Successional processes unstable with formation of undesired Alternative Stable State (ASS) likely in the absence of active interventions to control the key drivers of phase shift by setaria, kikuyu, paspalum and potentially aristea.	Succession favouring native trajectory only if controlled disturbance to mat-forming grasses maintained until natural shading by emerging canopies effective	Our resilience-based conceptual model incorporating drivers and response variables associated with ecosystem dynamics assists determination if and when interventions are required to avert negative phase shifts or accelerate regeneration
	B. Advanced regrowth of montane heath on outcropping rhyolite along the south-western boundary of the northern lot, mapped as Regional Ecosystem 12.8.19. The canopy is dominated by *Leptospermun polygalifolium*	**1. Recruitment**		
		Native plant recruitment is limited but existing canopies are coalescing	Recruitment density continuing unassisted; extent increasing to within 20 m	Plant species assembly (density) is monitored annually by marking new plants in stratified 16.66 m x 16.66 m sub-cells, that are part of a continuous grid system (Project SS2)

	var. *montanum*. The vegetation was largely cleared by 1930, recovered canopy integrity by 1961, half was re-cleared in 1975, clearing completed by 1989, remaining so until 1993. At most regrowth is ~20 years old. At Springbrook, these heaths and rock pavements may provide habitat for rare and threatened plant species including: *Callitris monticola* (NT), *Gahnia insignis* (NT), *Plectranthus torrenticola* (E), *Westringia blakeana* (NT), *W. rupicola* (V), *Eucalyptus codonocarpa* (NT), *Leptospermum oreophilum* (V), *Arundinella montana* (NT), *Comesperma esulifolium*, *Leionema elatius* subsp. *beckleri* (E)	**2. Plant community composition and structure**		
		Plant community richness, composition and structure are consistent with 20-year regrowth. *Callistemon pallida*, *Leptospermum polygalifolium* var. *montanum*, *Acacia obtusifolia* and *Callicoma serratifolia* the main emergent canopy trees. Opportunities for expansion of the community are limited by the size of the rhyolite outcropping.	Slight improvement in plant community richness, composition and species relative abundance	Trends in plant community richness, composition and relative abundance are based on annual monitoring of stratified quadrats compared with the previous year's results (Project SS2) and with characteristic composition and abundance of indicator species in corresponding Reference Sites (Project SSP4)
		3. Animal community composition and structure		
		Animal community richness and composition: comprehensive surveys have not yet been conducted; grey goshawks (NT) use emergent trees as perches; *Crinia signifera* and *Limnodynastes peronii* main amphibians	Animal community richness, composition and relative species abundance consistent with 22-year old regrowth	Targeted surveys and incidental observations (Projects 4-6). Acoustic monitoring of fauna (Project SS1) using an omnidirectional, high-powered microphone (Song Meter, Wildlife Acoustics Inc.). Identification to species and abundance assessment is by analysis of sonograms using specialist software (Songscope, Wildlife Acoustics Inc.).
		4. Habitat for threatened and/or significant species		
		Viable habitat extensions for threatened (E, V, NT) or significant species is likely to be restricted to frog species in the marshy conditions surrounding the outcropping rhyolite. The grey goshawk (NT) is	Situation unchanged	Acoustic monitoring (Project SS1) as above for bird and frog species supplemented by incidental records

		regularly observed		
		5. Non-indigenous species		
		Non-indigenous species levels mainly kahili ginger and mistflower	Kahili Ginger removed; mistflower absent	Quantitative assessment of plant/plant part removals (by weight and number/subcell) provides confirmation of trends on repeated removals (Project SD7) Semi-quantitative assessment of effectiveness of repeated removal effort via inspection (scale of 1–4) and photopoint monitoring of each subcell on the site (Project SP4)
		6. Functional diversity		
		Functional diversity not yet assessed comprehensively	Functional diversity assessed c.f. reference sites	Biodiversity surveys (Projects SBD1-7) underpin functional group integrity assessments defined as above (**Project SBD9**)
		7. Canopy cover		
		Canopy cover over at least 50% of the rock surfaces	Canopy extent continually improving but natural wind-throws create periodic gaps	Aerial photography (NearMap) and GIS-based quantitative, grid-based coarse assessment of canopy cover to determine extent (See attached file ashmiha_14Jun2012.jpg) Finer-level point and line-point transect sampling of Leaf Area Index (LAI) and effective plant biomass outside the WSN nodes using a portable ceptometer (AccuPAR, LP-80, Decagon Devices, Inc.) provides an indirect measure of canopy density. Spherical Crown Densitometer and GRS

				Densitometer assessments allow greater definition of canopy and forest structure. Where relevant, additional photomonitoring.
		8. Abiotic condition — microclimate		
		Microclimate not measured	Microclimate not measured but inferred to be consistent with 20-year regrowth	Inference supplemented with a Kestrel 4500 Pocket Weather Meter readings
		9. Abiotic condition — soil health		
		Soil health not assessed quantitatively; soils are skeletal on rock surfaces with thick fibrous root-mat and litter development; polluted by cattle dung from previous grazing history	Soil/substrate health improving; largely because litter levels increasing and cow pads absent	The following methods apply only where soil depth is sufficiently developed: Soil health assessments are conducted as part of Project SRC3. Soil compaction and moisture levels are considered a minimal set of surrogate indicators of soil health at a broad scale (other physical parameters measured on more limited stratified quadrats include depth, texture, pH, dispersion and colour). Transect-based measure of soil compaction is done using a drop-cone penetrometer; soil moisture other than at micrometeorological stations is measured using an MPKit (ICT International) Earthworm activity where relevant and possible (a key bioindicator

				including of soil organic matter) is semi-quantitative (counts per unit area dug) but non-lethal, non-invasive soil imaging methods are being investigated Leaf litter levels measured by steel prong capture method Cow pad residuals: semi-quantitative scale of 1–4 based on visual inspections) Macrofungi surveys in stratified quadrats (Project SBD2) indicative of soil health and successional development
		10. Successional processes		
		Successional processes normal and unaided for 20-year regrowth	Successional processes remain normal and unaided	Resilience model guides assessment of drivers and response variables affecting ecosystem dynamics and potential for sudden, essentially irreversible changes in ecosystem states (Project SS3)

Ee-jung - Barimbah	Vegetation description	Current condition	Intended Condition in 2015	Method of Assessment
Ee-jung catchment — Barimbah (28 ha)	**A. Regional Ecosystem 12.8.5**, complex notophyll vine forest on Cainozoic igneous rocks >600 m altitude (mainly advanced regrowth surrounding a remnant patch of not greater than ~80 m^2 representing one of the few remaining relicts of the original forest on the Springbrook plateau) The surrounding regrowth is mapped by Qld Dept of Environment as "High value regrowth vegetation". Detailed description of Indicator species above in **Ee-jung — Ashmiha** The remnant and regrowth patches in the Barimbah corridor provides confidence that recovery of all historically occurring species can be recovered. Four "stepping stones" have persisted since (and likely before 1930) in P', Q' and N' grids but were separated by clearing in ~1975. The link between P' and Q'	**1. Recruitment**		
		Native plant recruitment is unassisted with high densities (≥5000 plants/ha) at forest edges attenuating rapidly with distance from edge	Native plant density increasing with distance from forest edges and around existing regeneration nodes acting as "nurseries"	Plant species assembly (density distribution) is monitored annually by marking new plants in stratified 16.66 m x 16.66 m sub-cells, that are part of a continuous grid system (**Project SS2**)
		2. Plant community composition and structure		
		Plant community richness, composition & structure: flora surveys are incomplete but to date comprise 101 native species in 87 genera within 57 families; basal lineages well represented	Flora surveys indicate greater species richness and composition than indicated by ARCS surveys in late 2005	Trends in plant community **richness**, ***composition*** *and relative* ***abundance*** are based on monitoring of stratified quadrats and transects compared with the previous year's results and with characteristic richness, composition and abundance of indicator species in corresponding Reference Sites **(Project SSP4)**
		3. Animal community composition and structure		
		Animal community richness, composition & structure is incompletely documented but ARCS bird surveys under adverse weather conditions in 2006 recorded 25 species in 17 families and 23 genera.	Richness, composition and structure more comprehensively inventoried	Targeted surveys and incidental observations. Acoustic monitoring in reference site Q' **(Project SS1)** using an omnidirectional, high-powered microphone (Song Meter, Wildlife Acoustics Inc.). Identification to species and abundance assessment is by analysis of sonograms using specialist software (Songscope,

	cores is ~37 years old, that between Q' and N' 25-27 years. The uppermost elevations are directly in contact with the NSW Nature Reserve (maximum naturalness) via a low saddle bridging the otherwise cliff-lined caldera edge with a sufficient low gradient to facilitate movement of fauna and flora from "source" populations. Forest in Grid K' (Barimbah) providing seed sources to the adjoining Ashmiha site is 35–40 years old. Forest in Grid C" has a minimum age of 40 years.			Wildlife Acoustics Inc.). SWAG annual Lyrebird surveys (triangulation methods allows some assessment of abundance)
		4. Habitat for threatened and/or significant species		
		Viable habitat extension for threatened (E, V, NT) or significant species recorded for 8 plant species, the Australian Logrunner and the Albert's Lyrebird. Six calling males were recorded in July 2012. ARCS records also include sightings for 5 frog species including *Litoria revelata* (NT) and *Assa darlingtoni* (NT); 3 significant reptile species including eastern tiger snake, red-bellied black snake and rough-scaled snake	Comprehensive surveys more accurately reflect the numbers of threatened and significant species	Targeted surveys, incidental records and Song Meter records from the Q' reference site (Project SS1) SWAG annual Lyrebird surveys as above
		5. Non-indigenous species		
		Non-indigenous species levels are comparatively low in regrowth forest and comprise mainly mistflower and kahili ginger in gullies	Kahili ginger removed from Rolfe Creek (small tributary) and from most of the remaining area	Quantitative assessment of plant/plant part removals (by weight and/or number/subcell or other fixed unit area) provides confirmation of trends on repeated removals **(Project SD7)** Semi-qualitative assessment of effectiveness of repeated removal effort via inspection and photopoint monitoring of infested sites **(Project SP4)**

		6. Functional diversity		
		Functional diversity amongst bird guilds is comparable to that on the plateau as a whole	Functional diversity encompassing a broader range of taxa assessed. The Barimbah Reference site more fully documented	Functional group analysis (**Projects SBD1-9)** as above based on data from targeted surveys and incidental recordings
		7. Canopy cover		
		Canopy cover is complete over 75% of the site	Canopy cover greater than 75% for the site	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file barimbah_14Jun2012.jpg) Estimates of Leaf Area Index (LAI) and effective plant biomass outside the WSN nodes using a portable ceptometer (AccuPAR, LP-80, Decagon Devices, Inc.) provides a measure of canopy density. Point- or line-point transect sampling with spherical crown or GRS densitometers provides fine-scale descriptors of canopy structure and vertical complexity. Basal area assessment by random or systematic point sampling using a wedge prism relascope (or Haglöf Factor Gauge) to complement site data obtained for canopy structure. Where relevant, additional photomonitoring.

		8. Abiotic condition — microclimate		
		Microclimates are highly buffered by the intact and mostly contiguous forest canopies	Microclimate parameters measured quantitatively for the reference site in remnant forest	Monitoring using a Kestrel 4500 Pocket Weather Meter with comparisons to adjacent cleared areas and the formal weather stations on the adjoining Boy-ull Creek - Pallida site.
		9. Abiotic condition — soil health		
		Soil health, although unmeasured is likely to be high in areas undisturbed since 1961 or longer; In other areas the long legacy of repeated clearing is likely to have long-term impacts due to the known vulnerability of kraznozems (red ferrosols) to degradation from clearing	Soil moisture, leaf litter development, and other parameters measured in Reference site Q' Soil moisture and pH outside the reference site in different parts of the chronosequence recorded	Soil health assessments are conducted as part of **Project SRC3**. Soil compaction and moisture levels are considered a minimal set of surrogate indicators of soil health at a broad scale(other physical parameters measured on more limited stratified quadrats include depth, texture, pH, dispersion and colour). Transect-based measure of soil compaction is done using a drop-cone penetrometer; soil moisture other than at micrometeorological stations is measured using an MPKit (ICT International) Earthworm activity (a key bioindicator including of soil organic matter) is semi-quantitative (counts per unit area dug) but non-lethal, non-invasive soil imaging methods are being investigated

				Macrofungi surveys in stratified quadrat associated with Reference site Q' (**Project SBD2**) indicative of soil health and successional development Leaf litter levels measured by steel prong capture method
		10. Successional processes		
		Successional processes appear to be trending normally towards the reference condition unaided	Successional processes continue trending normally towards the reference condition unaided	Resilience model based on assessing drivers and response variables affecting ecosystem dynamics and potential for sudden, essentially irreversible change in ecosystem states (**Project SS3**)
Ee-jung catchment — Barimbah (28 ha) **(Continued)**	**B. Cleared land** dominated by kikuyu and in parts by setaria remain, as a result of past slashing and other management practices, as relatively small residues of old historical clearings: (1) **a 2.6 ha patch** associated with a recently demolished house and bitumen access road, and equally split along the watershed boundary between Ee-jung and Boy-ull Creek catchments — dominated by kikuyu and	**1. Recruitment**		
		Recruitment of pioneer species into clearings proceeding naturally but hindered by mat-forming exotic grasses	Recruitment density accelerated by controlling mat-forming exotic grasses	Plant species assembly (density distribution) is monitored annually by marking new plants in stratified 16.66 m x 16.66 m sub-cells (part of a continuous grid-based monitoring system), located in high priority areas that are critical linkage bottlenecks (J'part, P', M'part) (**Project SS2**)
		2. Plant community composition and structure		
		Richness and composition of plant communities limited in expanding	Richness and composition improving as a result of active control of	Results of targeted transect/quadrat based plant

	setaria; (2) **a 0.2 ha clearing** at the summit of Mt Springbrook dominated by setaria; (3) **a 0.92 ha clearing** dominated by setaria at lowest altitudes (<800 m), surrounded by 50–55 year-old regrowth (4) **An 0.35 ha clearing** at the caldera edge, surrounded by 30–35 year-old regrowth (5) **An 0.8 ha clearing**, surrounded by 30–35 year old regrowth, along the watershed dominated by kikuyu and setaria as well as patches of lantana (6) **part of a 2.5 ha clearing** maintained since 1930, surrounded by 35-year old regrowth, dominated mainly by kikuyu and lantana in parts, 75% of the clearing being in the Mundora catchment. The whole clearing will be managed as a unit.	edges mainly to wind-dispersed species in the east; isolated trees and advanced shrubs of *Lomatia*, *Callicoma* with occasional relict trees such as *Acronychia suberosa*, *Syzygium crebrinerve* occur	competing mat-forming exotic grasses	surveys and incidental records analysed in terms of changes in species richness, composition and relative abundance **(Project SS2)**
		3. Animal community composition and structure		
		Richness and composition of animal communities characteristic of disturbed areas; red-bellied black snakes abound	Little change is expected in 3 years	Transect-based monitoring (**Projects SBD4-7)** supplemented by incidental records associated with routine management activities analysed re richness, taxonomic composition and relative abundance (**Project SS2**)
		4. Habitat for threatened and/or significant species		
		Viable habitat extension for threatened and significant species unlikely until native species canopy closure	No change expected in 3 years	Records from plant and animal monitoring as above
		5. Non-indigenous species		
		Non-indigenous species include mainly kikuyu, setaria, lantana, montbretia, and expanding populations of Formosan lily	Kikuyu and setaria prevented from seeding by preventing necrotosing, light-blocking mats Montbretia, kahili ginger (if it is found), Formosa lily absent Lantana occurrence reduced by half	Quantitative assessment of plant/plant part removals (by weight and/or number/subcell or other fixed unit area) provides confirmation of trends on repeated removals **(Project SD7)** Semi-qualitative assessment of effectiveness of repeated removal effort via inspection and photopoint monitoring of infested sites **(Project SP4)**

		6. Functional diversity		
		Functional diversity of native species limited	Functional diversity of native species present increasing	Functional group analysis (**Project SBD09**) based on results of plant and animal surveys above (**Projects SBD1-7**)
		7. Canopy cover		
		Canopy cover limited to that of isolated regenerating plants (mainly *Lomatia arborescens*)	Canopy cover expanding at edges at the expense of grass cover in cleared areas	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file photomonitoring.barimbah_14Jun2012.jpg) Finer-scale estimates of Leaf Area Index (LAI) and effective plant biomass outside the WSN nodes using a portable ceptometer (AccuPAR, LP-80, Decagon Devices, Inc.) provides one measure of canopy density. Point and line-point transect sampling using a Spherical Crown Densitometer and GRS Densitometer allow greater definition of canopy and forest structure. Basal area point sampling using a wedge prism relascope (or Haglöf Factor Gauge) to complement site data associated with the above

				measures. Where relevant, photomonitoring additional
		8. Abiotic condition — microclimate		
		Microclimate characteristic of cleared areas	Changes in microclimate only expected at expanding edges and isolated regenerating clumps	Monitoring using a Kestrel 4500 Pocket Weather Meter with comparisons to data from the formal weather stations at Nodes 210, 211, 213, 214, 216 on the Barimbah site (Grids J', M' on Attached file "BiodiversityPlanGrids&Photopoints .pdf) and corresponding nodes on the adjoining Boy-ull Creek - Pallida site (Project SRC2). Weather station data as part of Project SRC2 are publicly available on http://www.sensornets.csiro.au/deployments/63
		9. Abiotic condition — soil health		
		Soil health impacted by long history of clearing and compaction from cattle and machinery	Soil health improving steadily based on 2012-13 baseline (earlier for the broad long-term project)	Soil health assessments are conducted as part of **Projects SRC2** and **SRC3**. Soil compaction and moisture levels are considered a minimal set of surrogate indicators of soil health at a broad scale(other physical parameters measured on more limited stratified quadrats include depth, texture, pH,

				dispersion and colour). Transect-based measure of soil compaction is done using a drop-cone penetrometer; soil moisture other than at micrometeorological stations is measured using an MPKit (ICT International) Soil moisture and soil water potential data obtained from the Wireless Sensor Network nodes 210, 211, 213, 214, 216 as above. Earthworm activity (a key bioindicator including of soil organic matter) is semi-quantitative (counts per unit area dug) but non-lethal, non-invasive soil imaging methods are being investigated Presence of indicator species of macrofungi in regenerating areas (**Project SBD2**) indicative of soil health and normal successional development Leaf litter levels measured by steel prong capture method
		10. Successional processes		
		Successional processes still capable of transitioning to Alternative Stable	Control of necrotising, light-blocking exotic grasses allowing assisted	Resilience model of drivers and response variables affecting

		State of kikuyu/setaria dominated exotic grassland in absence of active interventions	natural regeneration to continue more effectively	ecosystem dynamics and potential for sudden, essentially irreversible change in ecosystem states drive decisions on appropriate type and timing of interventions (**Project SS3**)
Boy-ull catchment **Pallida (33 ha)** **Acquired 2004**	**A. Regrowth Regional Ecosystem 12.8.5** Approximately half of the property is advanced regrowth (of varying ages) of Regional Ecosystem 12.8.5, complex notophyll vine forest on Cainozoic igneous rocks >600 m altitude Mapped by Qld Dept of Environment as "High value regrowth vegetation" Some kahili ginger present Detailed description of Indicator species above in **Ee-jung — Ashmiha** Almost complete clearing occurred by 1930, again between 1961–1975, and yet again in 1992, the latter being accompanied by major landscape-wide erosion. Only small patches survived the repeated clearing since	**1. Recruitment**		
		Ongoing high *densities* of native plant recruitment within older regrowth and newer regrowth into adjoining cleared areas involves both wind- and animal dispersed species within a large proportion of plant families represented in old-growth reference sites	High levels of natural recruitment continue (≥5000 plants/ha) over the upper half the 33 ha Pallida site with the exception of setaria-dominated parts of Grid cell L". further increased around established growth nodes	Recruitment *densities* in advanced regeneration within the primary corridor are determined quadrats located at point intersects every 50 m along 4 x 350-m transects (a) following the 820- and 850-m contours (Lower Forest Track and Middle Forest Track respectively) as well as (b) along a 350-m transect traversing a 70-m gradient between 800-870 m (the Rolfe Track). Forest patch age is inferred from 1930, 1961, 1975, 1989, 1993 and 2005 mostly high-resolution air photos.
		2. Plant community composition and structure		
		Plant community richness, composition and structure is relatively simple in younger regrowth as expected, for the majority of the area; wind-dispersed species >> animal dispersed species.	Plant richness and diversity in plant composition continues to increase in regenerating areas with increasing proportions of drupe- or berry-bearing species	Plant community richness, composition, and structure (**Project SS2)** is recorded along 6 x 350-metre transects through regenerating forest in the primary corridor (See above.), stratified by

	1930 — in H", J", M", N" Grid cells. Additional regenerated patches occur in Q" (intact since 1975) and K" (intact since 1990). These form the oldest nodes in the developing corridor. The main bottlenecks in corridor connectivity requiring priority attention occur in Grid cells X" (link associated with Rolfe Creek to the World Heritage area in Queensland and D" (linking the eastern half of the catchment to the main trunk of Boy-ull Creek)	Monocultures of either wind-dispersed *Lomatia arborescens* or *Callicoma serratifolia* are frequent Richness and composition in older regrowth or small relict patches of original vegetation not comprehensively surveyed but 56 of the plant 126 species encountered to date are bird or other animal dispersed, including the phylogenetically significant species *Berberidopsis beckleri*		age and compared with previous years' results and characteristic indicator species lists from corresponding Reference Sites (**Project SSP4**) Each transect is measured every 2 years. Recruitment projections for wind-dispersed species are inferred from typical dispersal kernels of individual species and distribution of reproductively mature individuals (**Project SSP2 & SSP3**) Literature values are used to infer likely age/size at reproductive maturity for fleshy-fruited species (**Project SSP1**)
		3. Animal community composition and structure		
		Animal community richness, composition and structure: 40 species of birds in 28 families and 38 genera have been recorded across all environments and include basal lineages (representing considerable phylogenetic diversity) Frog species recorded in association with Boy-ull Creek and marsh habitats: 10 species in 3 families and 4 genera including 2 threatened	A higher proportion of forest inhabiting birds including Scrubwrens are expected to be recorded in advancing and established regeneration. Increased diversity of frogs and reptiles recorded (including geckoes, agamids and skinks)	Baseline monitoring of avifauna was conducted for the lower half of Pallida in March 2007 by Dr Gayle Johnson. Incidental records of birds, reptiles, frogs, mammals, during routine project management activities at any time of the year contribute significantly (doubling of bird species recorded over targeted surveys).

		species) Reptiles: records restricted to diurnal snakes: 3 species Mammal species restricted to pademelons and		Targeted monitoring of frog species in different habitat types, during and after dusk, using both omnidirectional (Edirol R09, Zoom H2n pocket recorders) and directional (Sennheiser ME67/K6 or MKH70) microphones with a high-capacity portable field recorder (Sound Devices 722). Ongoing traditional field monitoring of avifauna and reptiles along a 1000-m transect in the primary corridor (combined Lower- and Middle-Forest Tracks) conducted twice-annually (Spring, Autumn). Autonomous acoustic monitoring (1 Song Meter node, 7 hrs/day) is located adjacent to WSN Node #46 which is close to a creek line and relict remnant (in Grid H") within the primary corridor being restored. Diversity and abundance of both bird and frog species is assessed using analytical software (Songscope, Wildlife Acoustics Inc.).
		4. Habitat for threatened and/or significant species		
		Viable habitat extensions for threatened or significant species (basal lineages, palaeo-endemic and keystone species) of uncertain	Albert's Lyrebird is extending its range further into regrowth; logrunners able to migrate along the full length of the corridor but only 1–	Results of transect surveys, incidental records contribute to monitoring progress in restoration of habitat viability

		quality due to the young age of most of the regrowth (7 to 20 yrs). However, populations of logrunners may survive for at least one generation within the primary corridor until habitat quality improved sufficiently for reproductive viability. Lyrebirds are not known to extend into the current primary corridor but utilise more mature forest adjoining the site. *Litoria revelata* (NT), *L. pearsoniana* (V), and *L. brevipalmata* (NT) are recorded but status of their habitat for reproductive viability is unknown	2 breeding pairs likely to be supported. *Assa darlingtoni* (NT) is expected to be recorded.	Autonomous acoustic monitoring (1 Song Meter, as above) as described for Mundora – Warblers and above Suitability of habitat analysed through knowledge of life history traits and niche specificity and requirements of indicator species Corridor integrity re required habitat parameters is deduced from other assessments (canopy, microclimate, soil parameters, functional/trophic diversity)
		5. Non-indigenous species		
		Non-indigenous species levels are mainly restricted to kahili ginger, mistflower, lantana , wild tobacco, & setaria along old tracks	Kahili ginger absent; lantana & wild tobacco removed; setaria controlled on tracks	Where feasible, quantitative assessment of plant/plant part removals (by weight and/or number/subcell or other fixed unit area) provides confirmation of trends on repeated removals **(Project SD7)** Semi-quantitative assessment of effectiveness of repeated removal effort via inspection and photopoint monitoring of infested sites **(Project SP4)**
		6. Functional diversity		

		Functional diversity in bird species overall is high covering all trophic groups but with low redundancy. Functional diversity of plants is low to moderate, varying according to age of nodal areas that escaped clearing: probably nil for most habitat- and area-specialists, dispersal-limited species	Functional diversity incrementally increasing associated with improvements in plant community richness, composition and structure	Biodiversity surveys (**Projects SBD1–7**) as previously described provide the primary data for functional diversity assessment. Functional groups defined in earlier sections (**Project SBD9**)
		7. Canopy cover		
		Canopy cover now almost continuous for the entire length of the corridor but only 44 m wide at its narrowest and of relatively poor quality at the northern end comprising low monoculture of *Lomatia arborescens*; a significant advance has occurred since November 2011 associated with La Nina conditions	Canopy cover continuous with at least a 150-m width over the core corridor length Forest edges expanded by 20–30 m in priority bottleneck areas	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent at a coarse scale (See attached file pallida_14Jun2012.jpg) Indirect measures of canopy development from the WSN data for Total Radiation Flux, PAR, Relative Humidity and leaf wetness located at 175 nodes distributed 50 m apart along 10-m contours over the entire Pallida site. Data have been logged at 15-sec intervals since 2008 (10 nodes), 2010 (49) and finally 175 by 2011. The majority of nodes fall within the primary corridor or immediately on its edges. Ten nodes occur directly on the Lower Forest Track and Middle Forest Track 350-m transects.

				Estimates of Leaf Area Index (LAI), thus effective leaf biomass, outside the WSN nodes are carried out along 350-m transects using a portable ceptometer (AccuPAR, LP-80, Decagon Devices, Inc.) provides a measure of canopy density. Finer-scale assessments are carried out along the 350-m transects as above using point sampling with a Spherical Crown Densitometer or line-point transect sampling with a GRS Densitometer. The latter method allows greater characterisation of vertical and horizontal forest structure in addition to canopy closure levels (**Project SS2**) Photomonitoring supplements the above assessments where significant differences need to be highlighted (**Project SP4**). Trend predictions can be made based on (a) quantitation of past changes over fixed periods visible in aerial photography and (b) from productivity measurements on growth Plots (**Project SP1**)

		8. Abiotic condition — microclimate		
		Microclimate is variable depending on the vertical and horizontal density of forest cover in the primary corridor as a function of the age of regrowth. The trends in buffering by canopies against extremes of temperature, humidity and sunlight exposure, are positive and significant.	Microclimate buffering over larger areas of the corridor continues to increase significantly	Micrometeorological monitoring (**Project SRC2**) based on a network of 175 nodes at 50-m intervals along the 10-m contours, sampling at 15-second intervals a broad range of parameters encompassing rainfall, both PAR and total radiation, air RH & T, leaf wetness, and associated impacts on soil (soil moisture, soil water potential). One third of all nodes are located in regrowth of RE 12.8.5 (65 of 175) along the full altitudinal gradient. Daily differences in environmental parameters are compared with analogous sites in cleared areas as a measure of progress to re-establishing refugial conditions.
		9. Abiotic condition — soil health		
		Soil health estimates in regrowth areas is based on recovery of normal values for soil water potential. It is likely that pre-clearing soil nutrient levels will never be recovered given the combined impacts of repeated and extensive clearing, erosion and compaction from cattle grazing. The history of fertilizer use is unknown	Erosion along old cattle tracks is stabilised by native vegetation cover. Soil water potential in regrowth areas continually improves.	Soil Water Potential sensors (MPS-1), as part of the wireless sensor network (Project SRC2) measure water availability for plant growth, water flow, and soil stability. Twenty-six are distributed in cleared (18), canopied (2) and edge (6) environments across part of the altitudinal environment. Soil Health aspects are part of **Project SRC3** as

				in previous sections.
		10. Successional processes		
		Successional processes in regrowth areas appear to functional normally for their age of development except in limited areas where dense lantana blocks succession	Successional processes normal with no signs of dysfunction Where lantana removed, improvements in native species recruitment occur rapidly	Our resilience-based conceptual model incorporating drivers and response variables associated with ecosystem dynamics assists determination if and when interventions are required to avert negative phase shifts or accelerate regeneration
	B. Advanced regrowth of montane heath on outcropping rhyolite — Regional Ecosystem 12.8.19 The vegetation (except for riparian corridors) was cleared by 1930. Regrowth is visible around the margins of the outcrop by 1961. Capacity for expansion is limited by the size and extent of the outcropping rhyolite.	**1. Recruitment**		
		Recruitment is limited to the small in-situ species pool because of the small size and relative isolation of these areas	The local species pool is reproductively mature, producing most of the new recruits in the area	Density of new regeneration is determined by plot-based survey of plant species, with the presence of young seedlings produced *in situ* indicative of a self-organising community
		2. Plant community composition and structure		
		Community richness and composition is limited by the size, age and isolation of this forest type	Surveys provide an improved record of species richness, composition and structure	Results of plant surveys analysed for changes in species richness, composition and phylogenetic structure
		3. Animal community composition and structure		
		Animal richness, and composition have not been systematically assessed.	No significant change in the situation expected over the 3-year period	Incidental records associated with routine management activities is the main source of data analysed

		Incidental records indicate frequent present of a grey goshawk (white morph) (NT) Soil disturbance is indicative of the present of either bandicoots or potoroos	A more accurate faunal richness, composition and phylogenetic structure obtained	Camera trapping, equipped with motion detection sensors, of sites with soil disturbance to identify animals responsible Temporary acoustic monitoring with a Song Meter (Project SS1) to augment fauna records
		4. Habitat for threatened and/or significant species		
		Viable habitat for habitat specialists associated with this ecosystem alone is unlikely, unless for basal lineages of invertebrates with limited dispersal ability (e.g. dung beetles) The montane heath is likely to contribute additional habitat diversity to species that utilise riparian corridors that pass through this patch	Habitat quality is likely to be improved but without adequate baselines conclusions will only deal with trends	Surveys of flora and fauna provide the base data for analysis
		5. Non-indigenous species		
		Non-indigenous plant species occurring in this vegetation type include kahili ginger, lantana, mistflower and some crofton weed.	Kahili ginger and lantana eliminated. Mistflower appears to be successfully controlled progressively by the bio-control agent white smut fungus (*Entoloma ageratinae*), accidently introduced from New Zealand by bushwalkers	Quantitative assessment of plant/plant part removals (by weight and/or number/subcell or other fixed unit area) provides confirmation of trends on repeated removals **(Project SD7)** Semi-qualitative assessment of effectiveness of repeated removal effort via inspection and photopoint monitoring of infested sites **(Project**

				SP4)
		6. Functional diversity		
		Plant functional diversity is likely to be moderate	Functional diversity baselines for ongoing monitoring determined	Biodiversity surveys as indicated above provide the primary data for functional groups analysis, functional groups being defined above (**Project SP4**).
		7. Canopy cover		
		Canopy cover has increased to ~ 70% of the potential habitat area since last clearing	Canopy closure further increased	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file pallida_14Jun2012.jpg)
		8. Abiotic condition — microclimate		
		Microclimate is moderated compared with adjoining cleared areas	Microclimate, as measured by the WSN sensors continues to improve with increasing canopy closure	WSN Nodes 18, 19, 20, 30, 31, 32 occur within this forest type and provide data on microclimate parameters as described above (Project SRC2) WSN Nodes 19, 20 and 32 contain sensors measuring wind speed and direction (MetOne) to evaluate the extent of edge effects.
		9. Abiotic condition — soil health		
		Soil health status based on soil moisture levels recorded but not yet analysed	Soil health status assessed in comparison with 2012-13 levels, together with data on litter	Soil Water Potential sensors (MPS-1), as part of the wireless sensor network (Project SRC2) measure

			development	water availability for plant growth, water flow, and soil stability. Twenty-six are distributed in cleared (18), canopied (2) and edge (6) environments across part of the altitudinal environment. Soil Health aspects are part of Project SRC3 as in previous sections.
		10. Successional processes		
		Unaided successional processes appear to be normal except in those areas with heavy infestations of lantana occur	Successional processes accelerated by removal of competition from lantana and other weed invasions	Rectified images from Aerial Photographs in 1930, 1961, 1975, 1989, 1993, 1998, 2005 (and thereafter using NearMap) (Project SSP4) provide coarse-level information on trends. The absence of non-indigenous species capable of outcompeting native species provides another indicator of ecosystem health. However, few areas if any escaped clearing (repeated in many cases) thus analogous undisturbed reference sites in close proximity are not available. Permission to access private land for surveys will be sought to provide data relating to mid-successional ecosystems.
	C. Cleared land with dense	**1. Recruitment**		
		Recruitment density of native	Recruitment substantially increased	Recruitment densities at lower

	cover of introduced pasture grass (kikuyu, setaria, cocksfoot), and, in west-facing upper elevations, whiskey grass and large-leaved paspalum Grazing ceased in 2005, which prior to that, significantly impeded natural regeneration.	species is especially poor in frost-prone areas with a dense cover of introduced mat-forming stoloniferous and rhizomatous pasture grasses. These areas occur in Grid cells A", B", C" (part), D", E", G"(part), J"(part) (See in Attached File"BiodiversityPlanGrids&Photopoints.pdf" Forest edges (western edge in Grids G", J" and those further south) are expanding effectively with recruitment levels ≥ 5000 plants/ha	by better management of the balance between competition and facilitation amongst weed and native species (the former can act as nurse plants for palaeoendemic species at the vulnerable seedling stage) Direct seeding in areas greater than 50 from forest edges providing more regeneration nodes	altitudes (790 m – 825 m) monitored quantitatively in Growth Plots G361, G367 and A689 (**Project SP1**), and by marking of new plants in remaining 16.66 m x 16.66 m sub-cells within this altitudinal zone (as previously described) Priority assessments are given to areas identified as critical bottlenecks within the defined primary corridor (cleared areas in Grids C", W" and X") associated with Rolfe Creek; riparian corridors in Grids D", G" and J") At higher altitudes, where regeneration >> 5000 plants/ha it is impractical to mark all grid cells. Plant species within 5 metres of the 300-m Top Track transect along the 900-m contour are identified to allow analysis of developing richness, composition and structure. In addition, one 16.66 m x 16.66 m sub-cell will be established late in 2012 near WSN Node 176 and the north-facing ARCS meteorological station (PALTOPN) on the 910-m contour.
		2. Plant community composition and structure		

		Richness, composition and abundance of native plant species varies considerably away from forest edges	Increasing diversity (richness, composition and relative abundances) of native species in all areas being monitored	Data from stratified plots and transects (above) are analysed for changes in species richness, composition, relative abundance, and phylogenetic structure
		3. Animal community composition and structure		
		Richness, composition and abundance of fauna has not been measured systematically, but incidental records show sharp transitions away from forest edges to disturbance-tolerating bird species (currawongs, magpies, ravens, crows, butcherbirds, kookaburras Reptiles recorded to date include 3 venomous Elapid snake species: red-bellied black snake, eastern tiger snake and rough-scaled snake Mammals include pademelons and feral foxes and wild dogs	Changes are not likely to be significant over the next 3 year period	Incidental records associated with routine management activities the main source of information
		4. Habitat for threatened and/or significant species		
		Viable habitat extensions for threatened and significant species are unlikely at these early stages of regeneration post-2005.	Changes unlikely in 3 years.	
		5. Non-indigenous species		
		At lowest altitudes some lantana, cobbler's pegs, mistflower, rubus and wild tobacco present around forest edges potentially impeding	Lantana, cobbler's pegs, wild tobacco removed. Mistflower removed where	Where feasible quantitative assessment of plant/plant part removals (by weight and/or number/subcell or other fixed unit

		natural regeneration Aristea removed from the property but infestations on the adjoining road reserve not completely controlled Other species in Grids A", B", C", D" and E" include limited but spreading occurrences of Agapanthus, American Elder, Camphor Laurel, common fireweed, crofton weed, Formosan lily, groundsel, inkweed, passionfruit, spear thistle, thickhead, tibouchina, tradescantia, white arum lily, Yorkshire Fog. At all altitudes, setaria and kikuyu occur where soil moisture and nutrients are not limiting. Yorkshire fog occurs in wetter areas with impeded drainage, and broad-leaved paspalum is a problem at mid- and higher altitudes. Whiskey grass is not considered a threat at this stage and in fact acts as a vital nurse plant in many areas;	inhibiting regeneration and not naturally killed by introduced biocontrol agent (white smut fungus) Presence of aristea monitored and all new emergence from rhizomes or soils seed stores on the road reserve removed Agapanthus, American elder, camphor laurel, crofton weed, Formosan lily, groundsel, tibouchina, white arum lily removed Other weed species under active control towards elimination where possible. Exotic grasses unlikely to be eliminated until full canopy cover established beyond the current 3-year project Whiskey grass is naturally controlled by shading from developing canopies of pioneer native species A priority focus of controlling biotic barriers includes key corridor bottleneck areas in Grids D" and X".	area) provides confirmation of trends on repeated removals **(Project SD7)** Semi-qualitative assessment of effectiveness of repeated removal effort via visual inspection and photopoint monitoring of infested sites **(Project SP4)** Otherwise, repeated visual inspection of areas allows classification of sub-cells within the Grid-based monitoring system as free of weeds
		6. Functional diversity		
		Functional diversity is dominated by exotic C3 and C4 grasses (monocotyledonous herbs)	Functional diversity expected to improve by control of smothering	Functional group diversity is derived from analysis of data from

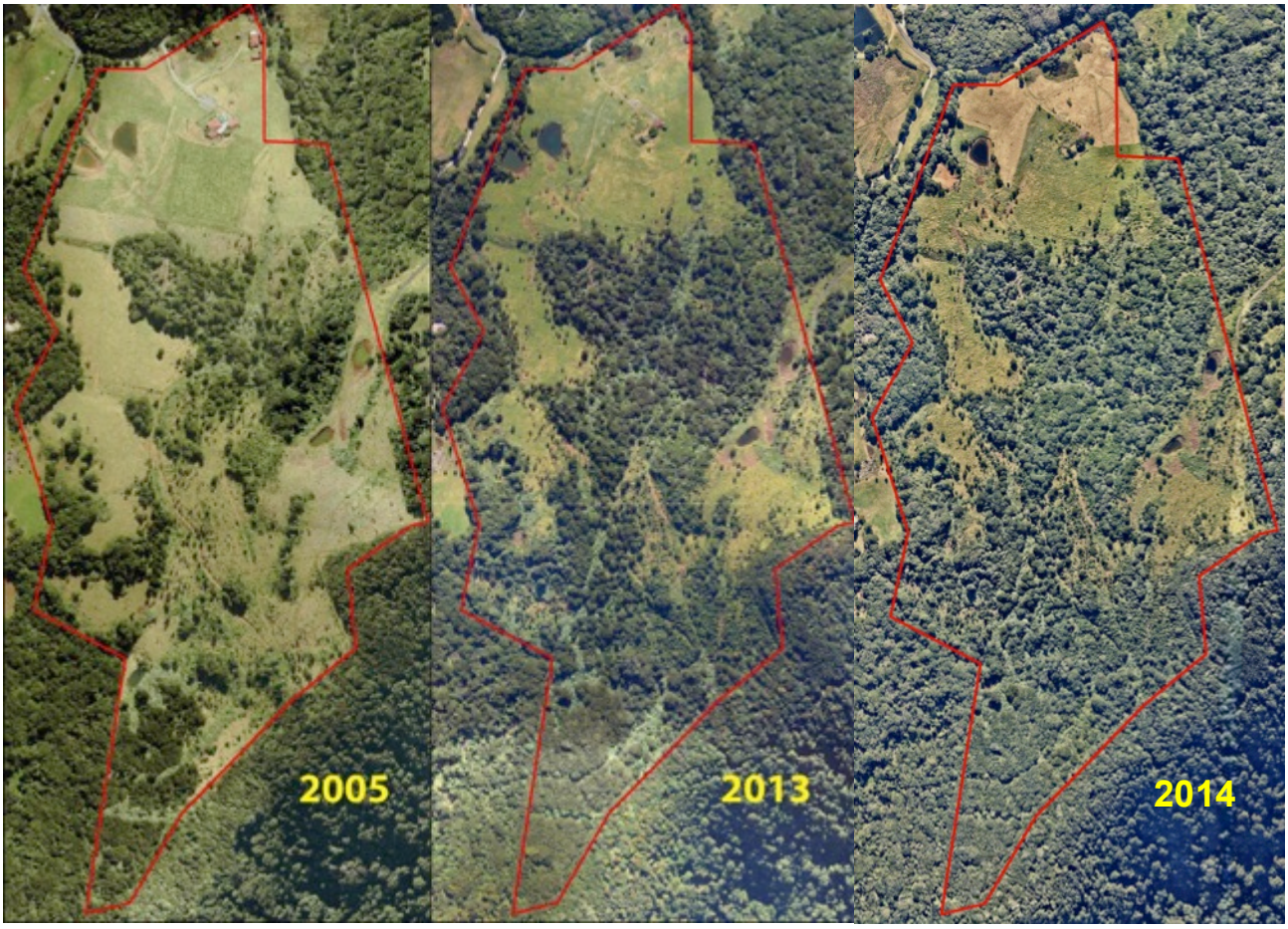
			exotic grasses	biodiversity monitoring projects as outlined above
		7. Canopy cover		
		Canopy development is least in Grid cells A", B", C"(part), D", E", G", J" and X" at lower altitudes At higher altitudes north-facing aspects of Grids L" and O" have minimal canopy development	Canopy extending out from existing forest edges and regeneration nodes	Aerial photography (NearMap) and GIS-based quantitative, grid-based assessment of canopy cover to determine extent (See attached file pallida_14Jun2012.jpg) Photopoint monitoring at locations in Grids E" and G". Additional photopoints to be established in Grid X" associated with Rolfe Creek
		8. Abiotic condition — microclimate		
		Microclimates typical of open pastures	No major changes until native species canopy closure achieved; significant improvements expected closer to 5 years from 2012	57 of the 175-node WSN network nodes occur in cleared areas within this project site in the Boy-ull Creek catchment. They are distributes at all altitudes from 790 m to 910 m and are equipped with sensors directly related to measurement of microclimate parameters. An additional 3 non-networked meteorological stations established by ARCS (PALEAST, PALTOPN and PALTOPW) measure PAR, rainfall, air relative humidity and temperature, leaf wetness and soil moisture levels at 15 min intervals

				since the beginning of 2010.
		9. Abiotic condition — soil health		
		Soil health improved following grazing and frequent use of heavy machinery ceased in late 2005	Continuing improvement in soil health indicators	Soil Health aspects are part of Project SRC3 as in previous sections. Soil Water Potential sensors (MPS-1), as part of the wireless sensor network (Project SRC2) measure water availability for plant growth, water flow, and soil stability. Twenty-six such sensors in the network are distributed in cleared (18), canopied (2) and edge (6) environments across the altitudinal gradient (790–900 m). All nodes also have soil moisture sensors as do the three ARCS nodes referred to above. Microtopographic variation in soil moisture levels across Grid A" measured using an MPKit portable soils moisture probe (ICT International) Transect-based measure of soil compaction is done using a drop-cone penetrometer Earthworm activity (a key bioindicator including of soil organic matter) is semi-quantitative (counts per unit area dug) at limited sites

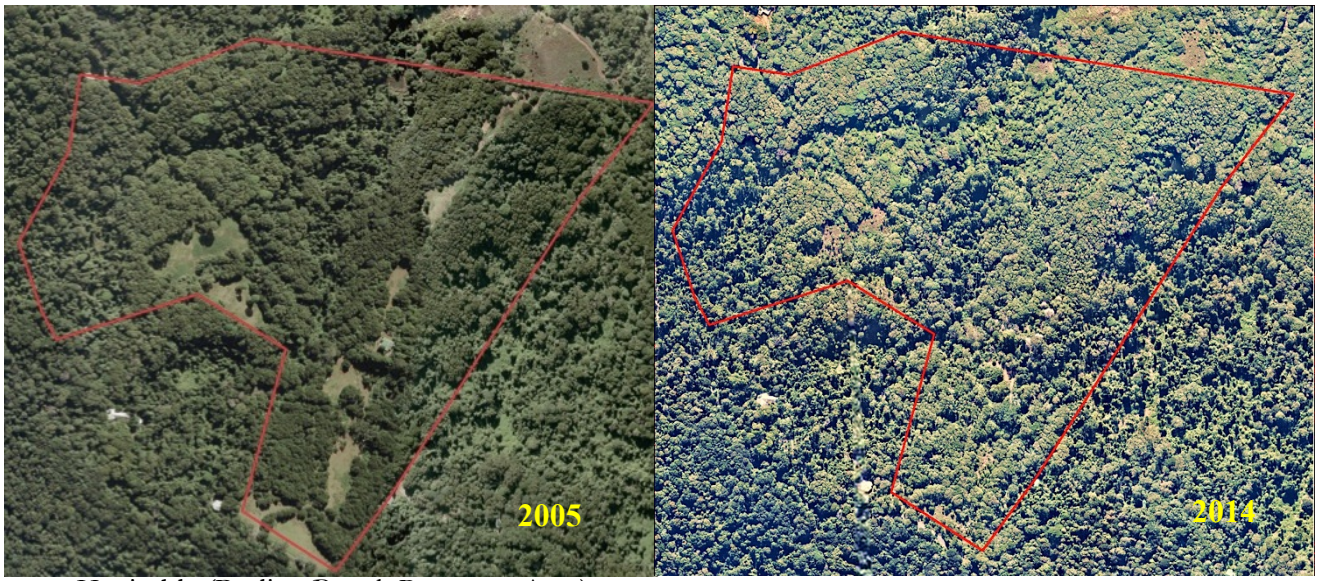
				but non-lethal, non-invasive soil imaging methods are being investigated Leaf litter levels measured by steel prong capture method Macrofungi surveys in stratified quadrats (**Project SBD2**) indicative of soil health and successional development
		10. Successional processes		
		Succession likely to revert to Alternative Stable States (ASS) dominated by exotic pasture grasses without their active control	Successional dynamics will still be vulnerable to ASS transitions without continuing control of mass-seeding, microclimate controlling, mat-forming exotic pasture grasses	A resilience-based conceptual model incorporating drivers and response variables associated with ecosystem dynamics assists determination if and when interventions are required to avert negative phase shifts or accelerate regeneration Macrofungi provide key bioindicators successional development

Appendix 2

Habitat recovery images based on Nearmap high-resolution imagery



Pallida (Ee-jung Recovery Area)[brown areas in top right-hand side of image represent slashing]



Kanimbla (Purling Brook Recovery Area)

Warblers (Mundora Recovery Area)

Appendix 3

THREAT MANAGEMENT PLAN

Threat[1] *Description of each threat and its sources and impacts*	**Controls/contingency** *Actions to reduce or manage the threat*
1. **frost** causing differential mortality of frost-sensitive plants in exposed areas (especially in corridor bottleneck areas) [DISTURBANCE Driver]	Utilise natural ecosystem processes of 'facilitation' by maintaining protective ("nurse") plant cover (including weeds and grass) around seedlings until frost period has passed; time grass and weed control carefully to maximise facilitation processes when needed and minimise competition processes that threaten native plant viability At a limited scale, such as regeneration nodes, if no nurse plants are available, either (a) maximise water availability to the plants through mulching, or (b) try reducing water loss via transpiration using foliar anti-transpirants
2. **fire** caused by accident, arson, or natural causes [DISTURBANCE Driver]	Implement a Fire Plan that (a) monitors fire risk; (b) identifies high risk ignition points; (b) utilises natural fire-breaks (riparian areas, remnant or advanced regrowth of rainforest and wet sclerophyll forest); (c) reduces risk of trespass through signage; (d) reduces risk of ignition from carelessness though education of volunteers; (e) maintains high-risk grass cover (kikuyu, setaria) at low heights optimal for both facilitating regeneration and reducing fire risk
3. natural regeneration (**recruitment) failure** due to abiotic and biotic barriers (a) [SPECIES POOL Driver] (b) [BIODIVERSITY Driver – species interactions: "herbivory"] (c) [RESOURCES & CLIMATE Driver]	Assess likely cause(s) and mitigation measures: (a) **species pool** deficiency or dispersal failures — supplement by direct seeding, transplanting or biodiverse plantings; (b) Establishment failure due to unnaturally high population levels of mammalian herbivores (pademelons) (**species interactions)** — try establishing exclusion fences in critical areas (corridor bottlenecks and potential critical habitat) (c) weed control of the most ecologically damaging, near-intractable weeds failing with current resources (**project resources)** — seek additional resources and support to combat the most serious threats (e.g. *Aristea ecklonii*) (c) environmental barriers (soil damage; adverse microclimates)(**resources & climate)** — address by monitoring and improving soil health (retain grass cover of species with high soil remediation potential, e.g. kikuyu, for periods required by monitoring data; improve microclimate for vulnerable seedling life stage through careful timing of facilitation by nurse plants (these may even be weed species)
4. Increased mortality from **pests and disease**	(1) Monitor leaf and stem herbivore populations and control by the most effective, efficient and safe means available if necessary (2) Monitor disease incidence (e.g. Myrtle Rust in susceptible plants; chytrid fungus in frogs; other known or emerging fungal/viral pathologies — monitor/ report/ institute appropriate hygiene protocols to mitigate spread and impacts
5. failure to recruit volunteer **resources**	Assess effectiveness of recruitment strategies, review and improve the Volunteer Recruitment Plan
6. failure to generate sufficient **financial resources** to support the project	(a) Find additional sources (grants, donations, bequest); (b) rationalise program activities to the most time-critical

[1] Threats are categorized in terms of 'drivers' identified in our ecological conceptual model