# Plantation Restoration in Tasmania
## Methodology and Prioritisation

**North East Bioregional Network**

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## Introduction

A tree plantations is an intensively managed stand of trees, even-aged and regularly spaced, grown for timber, fibre or other forest products. Extensive monocultures of trees occupy large areas in Australia, with 2 million hectares of plantations (ABARES 2013). Although plantations have similarities with native forests there are also important differences. Plantations can have environmental benefits by reducing pressure on native forests for wood products but plantations can also have serious environmental impacts. The scale, context and management of plantations determines the environmental impacts, such as fragmentation of native forest and hydrological changes. Globally, restoration of degraded forests, including plantations, will have biodiversity benefits and a large potential contribution to reducing atmospheric $CO_2$ (Mackey *et al.* 2014).

In Tasmania, large scale plantation forestry commenced in the 1960s and 1970s, initially growing *Pinus radiata* on State Forest land. Plantation forestry has since expanded to many parts of Tasmania, on public and private land. Tree plantations are established following harvesting of native forest or on cleared land, such as pasture. Softwood plantations of *Pinus radiata* (radiata or monterey pine) or hardwood plantations of *Eucalyptus globulus* (Tasmanian blue gum) are planted on mild lowland sites while *Eucalyptus nitens* (shining gum) is generally grown in colder frost-prone locations. These three tree species account for almost all of Tasmania's plantations.

Softwood plantations in Tasmania have remained relatively constant in area between 2001 and 2011 while hardwood plantations have doubled in area in the same period (Table 1; FPA 2012). Expansion of the hardwood plantation estate peaked around 2008 prior to the collapse of MIS schemes (FPA 2012). In a national context, Tasmania has Australia's second largest hardwood plantation estate, after Western Australia, but one of the smallest areas of softwood plantation (ABARES 2013).

During the period 2001-2011 the plantation hardwood harvest was 99% pulpwood and 1% sawlog and veneer while for softwood plantations it was 35% sawlog and veneer (FPA 2012). Projected woodflow for softwood plantations is expected to remain consistent through to 2030 while hardwood is predicted to increase substantially to a peak in the 2020s (at around four times the 2001-11 annual average) with a higher proportion (c. 22%) of sawlog and veneer (FPA 2012).

Table 1. Extent of plantations in Tasmania. Source: State of the Forests Tasmania (FPA 2012).

**Plantation Area Trends 2001–11**

| Reporting Year | Hardwood plantations (ha) | Softwood plantations (ha) |
|---|---|---|
| 2001 | 117 600 | 80 400 |
| 2006 | 158 900 | 71 500 |
| 2011 | 233 200 | 75 600 |

Table 2. Area of Tasmanian plantations by age classes, as at December 2010. Source: State of the Forests Tasmania (FPA 2012).

| Age Classes | Hardwood plantations (ha) | Softwood plantations (ha) |
|---|---|---|
| Unknown | 1 200 | 300 |
| Pre–1971 | 300 | 1 200 |
| 1971–75 | 100 | 900 |
| 1976–80 | 500 | 2 300 |
| 1981–85 | 1 100 | 6 000 |
| 1986–90 | 3 900 | 7 600 |
| 1991–95 | 14 300 | 10 600 |
| 1996–00 | 46 900 | 16 200 |
| 2001–05 | 64 900 | 14 400 |
| 2006–10 | 100 000 | 16 100 |
| **Total** | **233 200** | **75 600** |

*Photo 1: Skyline Tier restoration site, young eucalypt regrowth.*

# Environmental Impacts of Plantations

Plantations have a number of potential negative environmental impacts including changes to catchment hydrology, loss of native biodiversity, increased wildfire risk, soil disturbance and nutrient loss, pesticide contamination, weed invasion (including pine wildlings), hybridisation between plantation and native eucalypts and alienation of high quality agricultural land. Conversely, restoration of plantations to native forest can provide long-lasting environmental benefits such as improvements in biodiversity, connectivity, hydrology, soils and carbon stocks.

Few native understorey plants tolerate the shaded conditions of pine plantations, resulting in lower species richness (i.e. poorer diversity of native plants) than in native forest (Meers *et al.* 2010). Similarly, native forest invaded by wildlings or bordering pine plantation supports fewer native plants and more exotic plants (Baker *et al.* 2007). Diversity of native leaf litter invertebrates is much reduced in pine plantation litter compared with native forest (Robson *et al.* 2009).

Plantation species can be invasive in native vegetation, for example exotic pines can establish and grow in native eucalypt forest leading to a degraded ecosystem (Burdon & Chilvers 1994).

Higher water usage of radiata pine compared with eucalypts reduces water yields from catchments where pine plantation replaces eucalypt forest (Putuhena & Cordery 2000).

Globally, conversion of native forest to plantation results in an average loss of around 13% soil carbon (Guo & Gifford 2002). Research in SE Australia reports a reduction in soil carbon content by 30% with conversion of eucalypt forest to pine plantation, while the restoration of native forest resulted in either continuing decline or no change in soil C, at least in the first few years (Kasel & Bennett 2007). This suggests loss of soil carbon is long term, but may recover as restored forest matures.

Plantations have an important role in the supply of wood products and can provide environmental benefits, particularly compared with agricultural land. However they are inferior to native forest in all measures of environmental values, such as biodiversity. Many plantations are a legacy of poor land use planning, where extensive monocultures of plantation species dominate landscapes without adequate native habitat retention or stream-side protection. Some of the most negative impacts of plantations are in situations where they:

- are established on steep slopes,
- replace biodiverse native forest on nutrient-poor soils,
- replace carbon-dense mature native forest on productive sites,
- result in the loss of mature habitat such as old growth trees and fallen logs across the landscape.

These impacts of plantations can be reversed by restoration to native forest in particular target areas. While it is not desirable nor feasible to restore all plantations, there is great potential for strategic restoration projects to provide lasting environmental benefits alongside social and economic outcomes.

## Social and Economic Benefits of Plantation Restoration

Apart from the many environmental benefits of undertaking well funded, high standard ecological restoration, there are also positive social and economic outcomes.

Restoration work offers a feasible transition opportunity for retrenched forest workers and other people involved in practical outdoor work activities. Many forest workers are already skilled in the areas required to carry out restoration work while additional training can broaden this base. Locally based projects mean people can stay in rural communities undertaking meaningful work which will contribute to the long term health, sustainability and viability of their community. Employment and training opportunities in rural Tasmania are limited but an expanded ecological restoration industry could employ and train a large number of people with flow on benefits to local economies.

The range of skills acquired as a result of ecological restoration training open up a range of job opportunities including fire management, chainsawing, seed collection and plant propagation, conservation planning and management, first aid, assessment of carbon values, environmental education, use of forest harvesting machinery for restoration purposes, tour guiding, landscaping, team leader of work crews including Green Army, tree surgery, environmental science, parks ranger, ecological restoration teachers and ongoing work carrying out ecological restoration.

Schools are often the centrepiece/indicator of community viability and as such support for and provision of training in a growing ecological restoration sector would assist in increasing the numbers of local people participating in relevant training using local learning facilities such as Trade Training Centres and Schools.

The restoration of low value plantations back to healthy and diverse native forests will create in some cases the opportunity for harvesting of high value sustainable sawlogs with Forest Stewardship Certification. Areas with conservation value could generate economic benefits via carbon credits in recognition of their role as carbon sinks.

There is broad community support for restoration of plantations and as such there is an opportunity to find common environmental ground in often polarised communities. Growing awareness and understanding of the environment as a result of working and receiving training in ecological restoration can help to reduce land use conflict and create a stronger land stewardship culture in the community. A win-win situation with great environmental, social and economic results.

# Forest Restoration Projects

Restoration of plantations can be broadscale, such as around 2000 hectares of pine plantation at Delatite Arm in Victoria, or more strategic, such as at Seaview in north east Tasmania, where streamside zones, wildlife corridors and rainforest buffers are planned for restoration while the bulk of the eucalypt plantation is retained.

Several projects have been undertaken across southern Australia and in New Zealand. In Tasmania the largest plantation restoration is at Skyline Tier near Scamander where over 350 hectares of former pine plantation is undergoing restoration to native eucalypt forest using a combination of natural (passive) revegetation, replanting, pine wildling removal and controlled burning. This project could potentially cover the entire 2160 hectare plantation. Regeneration of native plants, including several threatened species, has proceeded following removal of pines (Bushways 2009).

Other pine plantation projects have been undertaken at Waterhouse Conservation Area and on private land on Bruny Island. In contrast, Seaview is a highland, high-rainfall eucalypt plantation.

A restoration project is currently underway in three recently logged coupes within the recent extension to Tasmania's Wilderness World Heritage Area. Methods being trialled include ecological burning, seeding of rainforest species, weed control, browsing control and track rehabilitation. While these are not plantations, the knowledge gained from this project will be valuable for any situations where plantations are restored to tall wet forest.

*Photo 2: Skyline Tier restoration site, eucalypt and understorey regrowth.*

# Project Planning

- Define scope of works, timelines and budgets.
- Define roles and responsibilities, if there are multiple stakeholders.
- Secure funding.
- Map the site – drawing n existing spatial data and on-ground surveys.
- Threatened species surveys and assessments.

# Key Principles of Plantation Restoration

Due to the wide range of site specific factors involved each project requires detailed planning drawing upon local knowledge as well as general principles of restoration ecology.

## Natural regeneration

- Natural or passive regeneration, where native plants establish themselves from the soil seed bank or local seed sources, requires minimal effort and allows natural processes to dictate the timing and success of regeneration.
- Site preparation and maintenance may be required for control of weeds and browsing animals.
- Passive regeneration may benefit from supplementary seeding or planting, if success rate is low or key flora species are missing (e.g. those that are poorly dispersed).
- Natural regeneration occurs as a successional process – over time it will transition from fast-growing pioneer species to a more structured community of trees, shrubs and ground covers as a forest develops.
- Controlled burning can be useful to promote regeneration.

## Replanting and seeding

- Direct seeding is an effective means of regeneration for many native species, but requires considerable quantities of seed.
- Seed should be local provenance.
- Tubestock planting is more labour intensive and costly but is useful for certain species or situations where natural regeneration or direct seeding are not feasible.
- Replanting and seeding require careful planning over several months or years to collect seed, grow plants, prepare the site and plant/sow at the optimum time of year.

## Weed control

- Weed control is generally a long term project and therefore it is best to develop and implement a weed control plan with mapping, methods and timelines.

## Fire management

- Controlled burning following harvesting can be an effective and efficient method of removing regrowth seedlings of plantation trees (Kasel *et al.* 2005) and also stimulating natural regeneration of native plants.
- Prescribed burning at a frequency which prevents seed production in pines can be effective for controlling establishment and spread of pine wildlings in native forest (Gill & Williams 1999).

### Monitoring

- A monitoring program should be devised and implemented before undertaking works.
- Monitoring methods and sites should be well documented to allow repeat monitoring over several years.
- Photo monitoring (repeat photography) is a cost effective and simple method of documenting change.
- Flora and fauna surveys provide an indication of biodiversity outcomes – these can take various forms such as permanent quadrats for flora, timed bird counts, hair-tube traps for small mammals, acoustic bat monitoring, etc.
- Monitoring of weeds or feral animals in and near the restoration site may be appropriate.

## Pine Control

The following points are taken from *Native Restoration Management Plan – Scamander Pine Plantation, Tasmania* (Bushways 2013):
Pine control is relatively simple where:

1. sites are not too steep or areas not too large for machinery or manual labour – factors of steepness and area affect the efficiency, effectiveness and even the possibility of mechanical or manual weeding being an option;
2. the low density (1-5 pines/10m$^2$) and height (<3m) of pines allows manual and/or mechanical weeding to be a viable option;
3. mechanical weeding can be used to remove taller individuals or clumps from native remnants or regeneration areas;
4. burning or weeding has been applied in a timely manner, i.e. when fire has been used to prevent pines re-establishing vigorously after harvest. On these sites manual follow up weeding is likely to be the only restoration task required; and
5. early treatment of pine wildlings – critical, to limit the extent of the future pine problem and reduce the resources ultimately necessary for pine wildling control (Kasel *et al.* 2005).

Pine control becomes more complex when pines are:

1. well established in sensitive areas like riparian zones;
2. are dense (>5/10m$^2$) and tall (>3m) on steep slopes difficult to access;
3. in areas which have a mixed collection of previous management regimes i.e. patches of cool burns, no burns, old pines, young dense pines; and
4. interspersed with different stages of native regeneration.

## Fire

A moderate to hot burn soon after harvesting pine plantation destroys much of the pine regeneration and pine seedbank, with a consequent considerable reduction in the time and labour involved in wildling control (Bushways 2013). Burning is also effective to remove pines and promote a second wave of native plant regrowth on sites where regrowth following plantation harvesting comprises a mix of pines and natives, where manual pine control is difficult. Burning trial patches is recommended to test methods before broadscale use of burning. Expert advice is essential for consideration of timing, patch sizes, fire breaks, fuel loads and weather. Experimentation is required to test this method for restoration of eucalypt plantations to native forest.

*Photo 3: Skyline Pine Plantation post harvest and burn.*

*Photo 4: Poor growth in* E.nitens *plantation established after clearing* E. amygdalina *forest near Goshen, northeast Tasmania.*

## Spatial Analysis of Potential Restoration Areas

In order to identify potential sites for restoring native forest, a spatial analysis of plantations was undertaken. This approach allows various factors related to the desirability and feasibility of plantation restoration to be assessed across the plantation estate. This provides a starting point for determining where efforts to restore native forest will be most effective and successful.

**Plantation Type**

The most up to date spatial data for plantations in Tasmania is the Forest Groups dataset 2011 (previously updated annually, this has not occurred since Forestry Tasmania ceased conversion of native forest to plantation). This is used as the basis for spatial analysis here. It comprises mapping of plantations on private land, updated annually by Private Forests Tasmania, with plantations on public land mapped by Forestry Tasmania. Unfortunately it does not indicate the age or establishment date for plantations.

Using a Geographic Information System, spatial data from other sources has been intersected with the plantation data to determine where possible the age range of the plantation and the preceding land use. The data layers are summarised in Table 3.

**Tenure**

Plantations have been classified as public or private depending on whether or not they occur on State Forest land. Also, plantations within land identified as Future Reserve Land under the Tasmanian Forest Agreement have been mapped since these may change in tenure and are areas of identified conservation values.

**Prior Native Forest**

Vegetation mapping from various time periods (RFA and Tasveg) intersected with areas of present plantation indicates what type of vegetation was present prior to plantation establishment (except in cases where plantations pre-date the earliest digital vegetation maps). Some older plantations have replaced native forest types which are now legally protected because they are rare or threatened in Tasmania, so identifying these presents an opportunity to restore these important forest communities. Similarly it may be desirable to restore high productivity native forest (tall wet forest) or rainforest in areas where plantations have replaced extensive areas of these forest types, or where they are locally rare. Tall wet eucalypt forests have exceptional carbon stocks, require less management and are more resilient to change than plantations (Fensham & Guymer 2009; Keith *et al.* 2009). Consequently, restoring these native forests presents significant carbon sequestration opportunities in addition to the biodiversity benefits (Fensham & Guymer 2009).

**Land Capability**

Plantations may have poor growth rates or high mortality due to frost, waterlogging, drought or poor soils. Often this is the result of inappropriate choice of site. Much of Tasmania has been mapped for 'Land Capability' which indicates suitability for different agricultural uses. Poor land capability indicates typically steep, rocky, infertile land generally not suitable for agriculture or grazing. These areas are also unlikely to be suitable or profitable for plantations and as such are good candidates for restoration.

**Plantation Age and Rotations**

Potential for restoration is influenced by plantation age and number of plantation rotations. Where native forest has been converted to plantation, first rotation plantations tend to maintain native plants in the understorey and soil seed bank, while successive plantation cycles deplete this natural regenerative capacity and also potentially suffer from soil disturbance and nutrient depletion.

The 'Forest Extent and Clearing' data provides an almost annual assessment of forest cover and recent clearing of tree cover (both native forest and plantation) from satellite images since the mid 1970s. This can indicate when a plantation was last cleared, which may be harvesting of a previous rotation or clearing of native forest prior to plantation establishment. Unfortunately more detailed data on plantation age and history is not readily available.

**Landscape Context**

Landscape context was assessed subjectively using two criteria: connectivity and integrity. 'Connectivity' identifies areas where plantation restoration is likely to improve connectivity between areas of native forest by creating contiguous native habitat. Although plantations are not a barrier to many native fauna species they tend to provide lesser quality habitat for breeding, feeding and migration and therefore the restoration of plantations in these critical areas will improve overall landscape connectivity for flora and fauna. Plantations have been identified in areas where connectivity may be a key aim of restoration. Detailed local planning is needed to determine actual restoration design for connectivity in each area..

'Integrity' considers plantations within areas of extensive native vegetation where restoration to native forest would increase the naturalness of a landscape. These are typically small isolated plantations within a matrix of native vegetation.

**Threatened Species**

Plantation restoration may be beneficial for improving and restoring habitat for threatened species. Benefits will be modest for wide ranging species (unless the restoration is critical for connectivity) but could be very significant for forest-dependent fauna species with a limited range where plantation have replaced native habitat. Improved habitat quality and integrity would likely improve the population viability of fauna such as the five species of threatened stag beetles in eastern Tasmania (*Hoplogonus* and *Lissotes* species). The Regional Ecosystem Model (REM) used for Forestry Tasmania's High Conservation Value Assessment (Knight 2014) identifies such species as fauna with 'Critically Limited Locations'. The REM spatial data could be used to analyse plantation occurrences within the ranges of these species.

**Priority Areas**

Based on the available data, several potential priority restoration areas are evident. These areas require further investigation. This is not an exhaustive list and with more data there are likely to be other priority areas that have not been identified here.

1. Frankland River (Blackwater Rd)
2. Montagu area (Salmon River, Mill Creek)
3. lower Black River
4. Christmas Hills near Elizabeth Town
5. Que River
6. Warners Creek near Jackeys Marsh
7. northwest slopes of Mt Barrow
8. St Patricks River near Wombat Plain
9. Cuckoo Plantation near Legerwood
10. Musselroe Creek, Blue Tier
11. Hospital Creek at Wielangta
12. Tatnells Creek and Walkers Creek, Tasman Peninsula
13. Styx Valley
14. upper Arve Valley
15. King Island
16. Ocean Beach/Henty Dunes near Strahan

**Summary**

These spatial layers provide a landscape-level overview of plantations in Tasmania. They will help indicate potential areas for restoration. This is necessarily broadscale and preliminary due to inaccuracies and gaps in the spatial data. Further investigation, including on-ground assessment, will be needed to determine priorities and practicalities of restoration at particular sites.

## Conclusion

Tasmania has an extensive plantation estate but many plantations have been established on unfavourable or inappropriate sites and have significant environmental impacts due to poor planning or management. Our water catchments, rural communities and natural areas are all affected by excessive or inappropriately sited plantations. This land use legacy following 20 years of rapid plantation expansion provides an opportunity to restore native forest, with benefits for regional employment in addition to improvements to land, water and wildlife.

Furthermore, the economics of subsidised plantation establishment, low value product recovery and vulnerability to global markets has led to poor economic viability for many plantations. Consequently there is little desire to replant following harvesting in many situations. The relatively short rotation times for plantations means that they can be harvested as planned prior to restoration, allowing a strategic approach to landscape restoration. With limited capacity to restore plantations to native forest a prioritisation approach is needed.

Here we have attempted to identify criteria for an initial assessment of restoration viability and priority. This provides some guidance for further investigation of specific areas, including detailed information gathering and discussions with stakeholders. Aside from the environmental criteria, there may be opportunities for restoration where the land owner does not wish to replant plantation for economic reasons. This is likely to be the case in remote areas, such as King and Flinders islands and the West Coast.

The establishment of a Forest Restoration Fund along with other financial incentives is required to provide the impetus for landscape scale restoration of plantations. Many of the plantations established in the 1990's are scheduled for harvesting in the near future so now is a critical time to decide on restoration priorities. First rotation plantations are easier to restore as they still contain viable native seedbanks which result in more biodiverse natural regeneration.

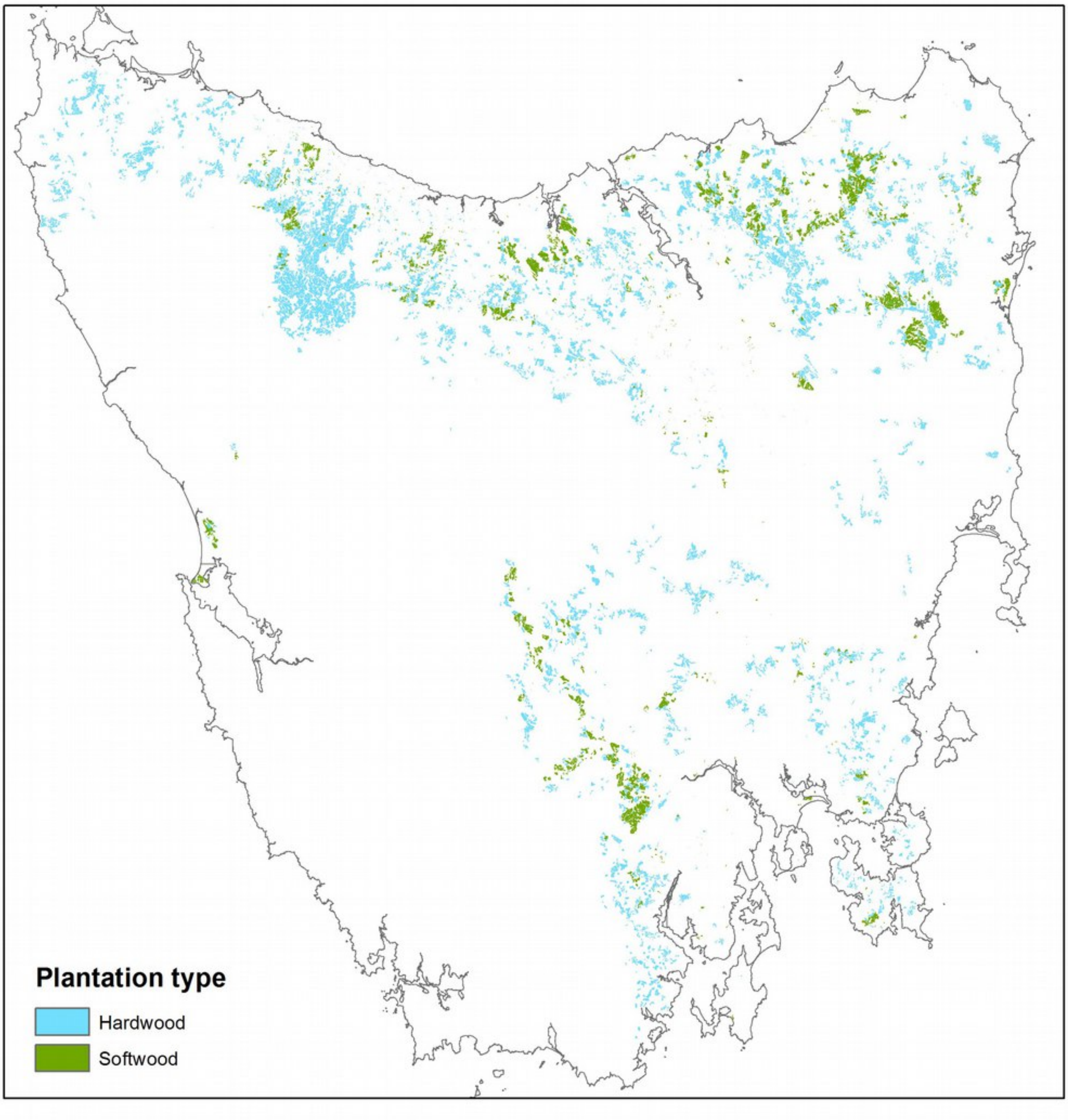
Landscape restoration will be an increasingly important activity in the future. Tasmania could invest in training in restoration, providing the capacity and skills to undertake this work. By making a start on this now we will be ready for future opportunities, such as carbon credits, to fund restoration projects.

Current restoration standards for plantations under the Forest Practices Code need to be reviewed and upgraded. For example at present native forest restoration is considered acceptable based on stocking rates of eucalypts even if most of a site is dominated by pine wildlings.

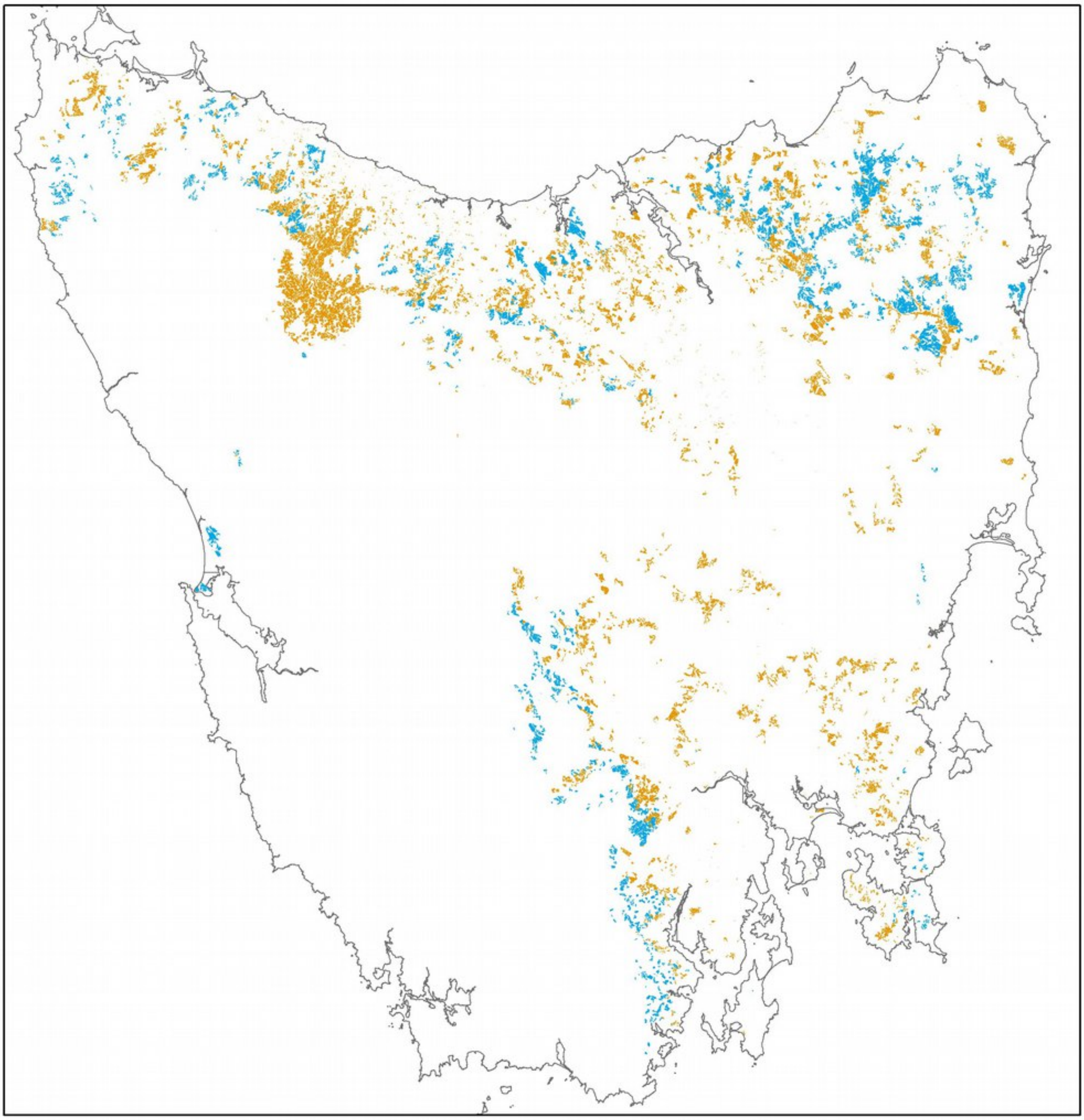
The future for plantations in Tasmania should involve better landscape planning, higher value products and diversification such as agro-forestry and mixed species plantings.

Table 3. Spatial datasets used to create the plantation dataset. Field1 and Field2 are fields in the final plantation dataset.

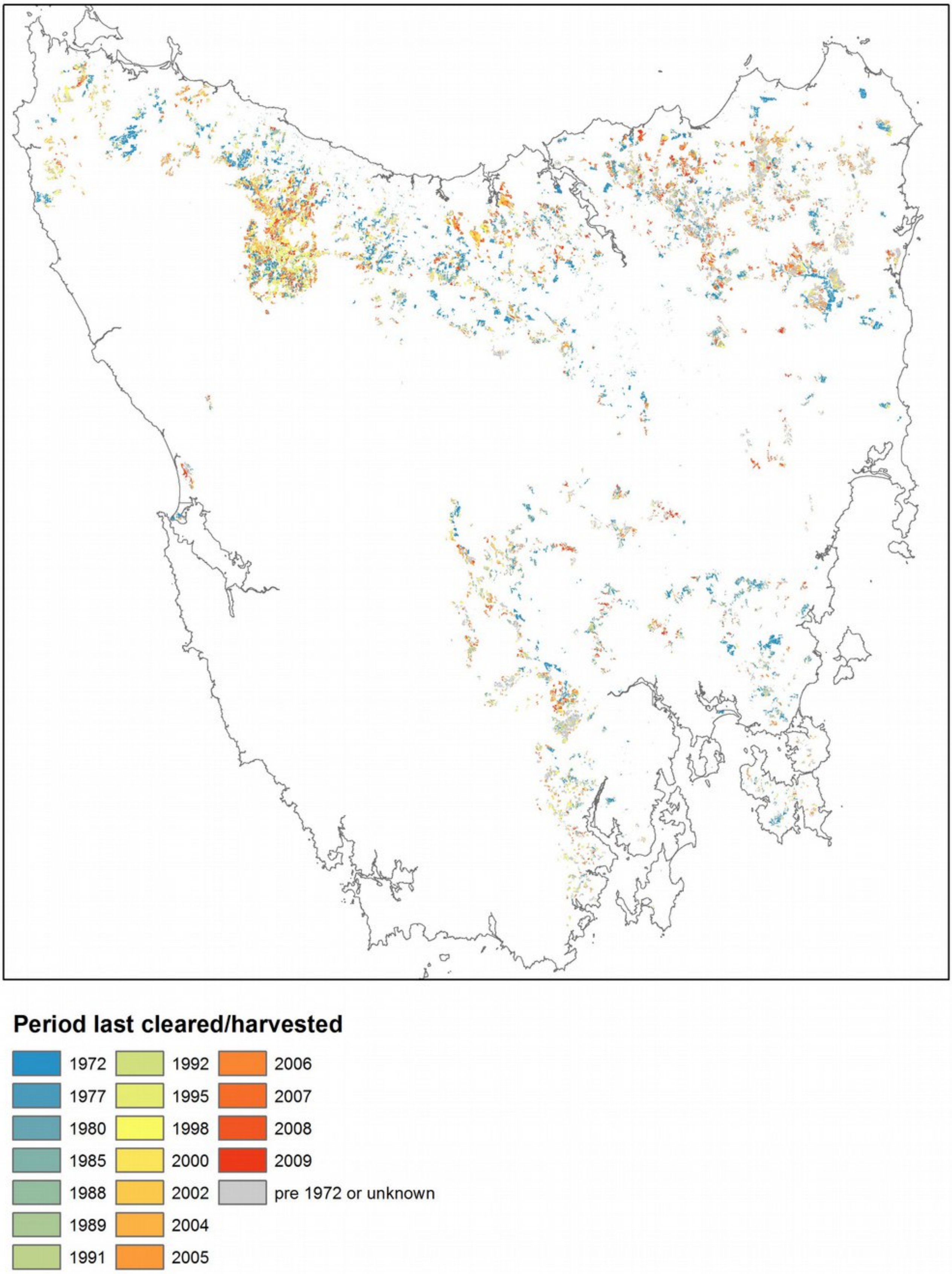
| Dataset | Attribute | Field | Values |
|---|---|---|---|
| Forest Groups 2011 | | FG2011 | 1 hardwood<br>2 softwood |
| Tasveg 3.0 | VEGCODE | TV3 | 1 Non-forest<br>2 Forest<br>3 Cleared<br>4 Plantation |
| Tasveg 2.0 | VEGCODE | TV2 | 1 Non-forest<br>2 Forest<br>3 Cleared<br>4 Plantation |
| Tasveg 1.2 | VEGCODE | TV1 | 1 Non-forest<br>2 Forest<br>3 Cleared<br>4 Plantation |
| Forest extent and change | Time since clearing: year_sc | time_clr | time_clr |
| Forest extent and change | Number of years forest present | forest_years2 | forest_years2 |
| RFA forest | RFA_VEG | HPwet2 | 1 BA<br>2 BF<br>3 BR<br>4 DSC<br>5 DT<br>6 M+<br>7 OT<br>8 OV<br>9 R<br>10 SI<br>11 VW |
| RFA forest | RFA_VEG | OG_HPwet2 | 1 BA<br>2 DSC<br>3 DT<br>4 M+<br>5 OT<br>6 OV<br>7 R<br>8 VW |
| Land Capability (modelled and field checked) | COMPLEX | LandCap | 1 unmapped<br>2 good to moderate (classes 1-5)<br>3 poor (classes 6-7) |
| Public Land Use Classification (PLUC) | CATEGORY | StateFor2 | 0 Private land<br>1 Public land |
| TFA future reserves | | | 1,2 TFA future proposed reserves |
| Landscape Context | | INTEGRITY | 1 Integrity |
| Landscape Context | | CONNECT | 1 Connectivity |

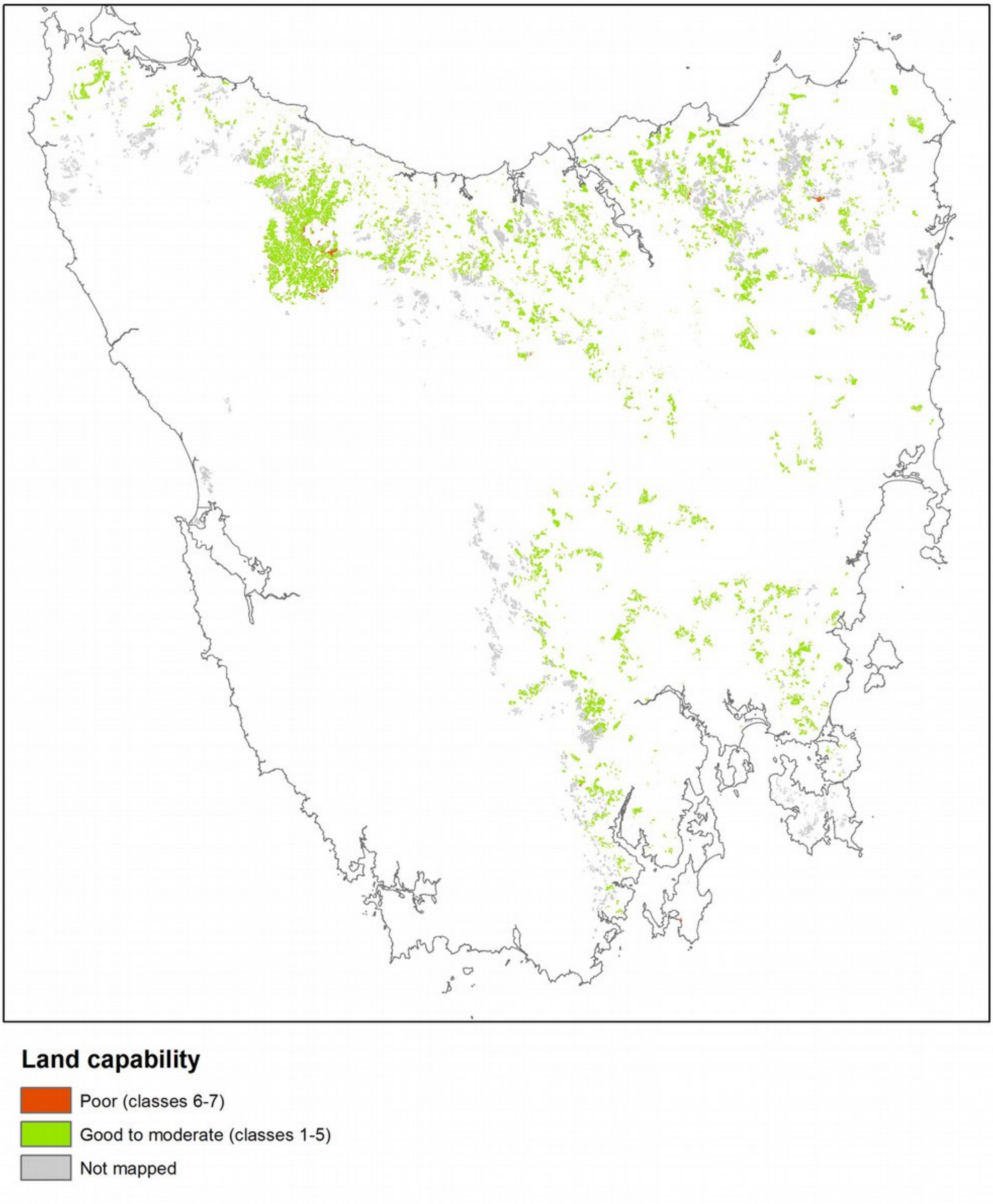


Plantation type
Hardwood
Softwood

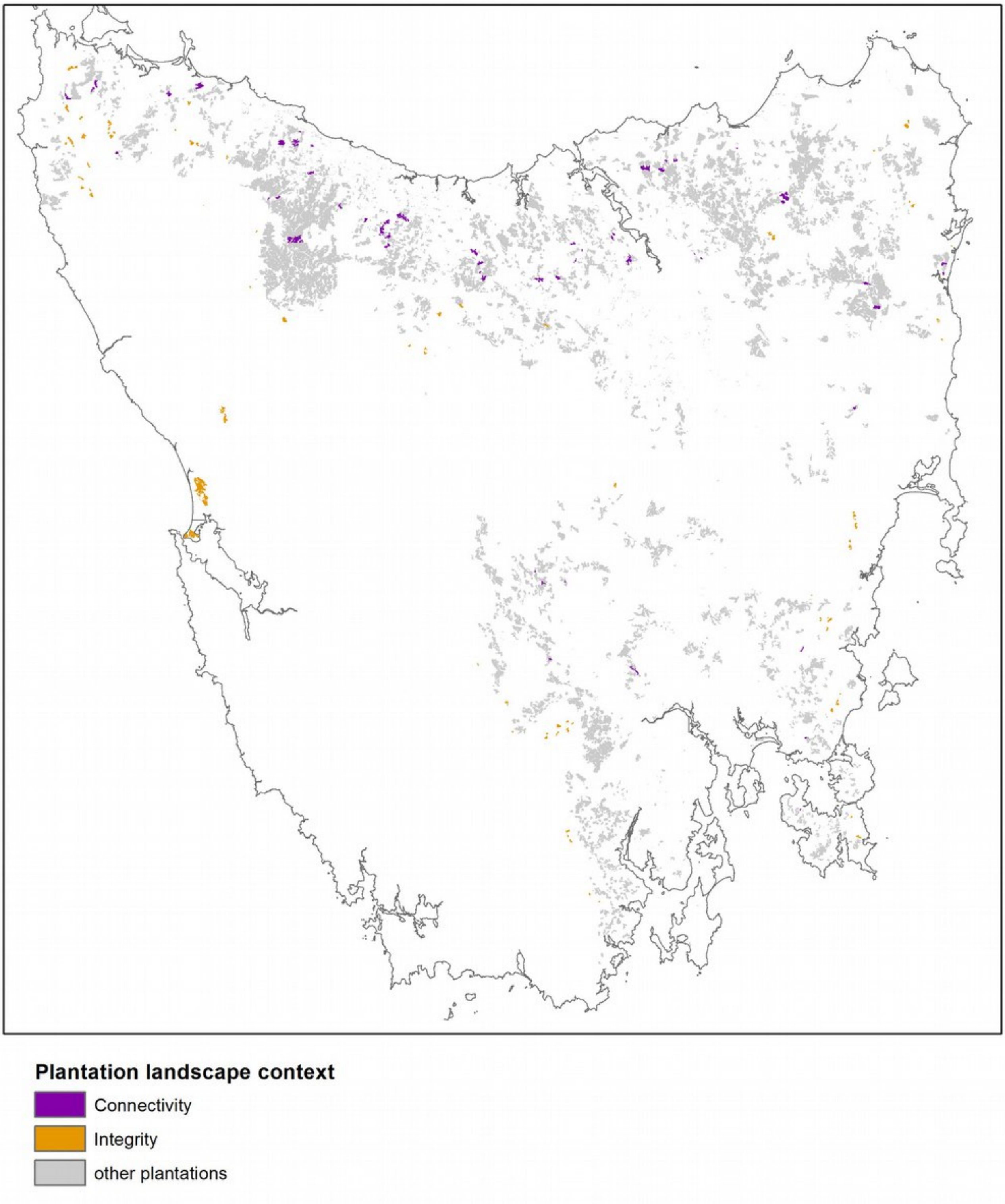


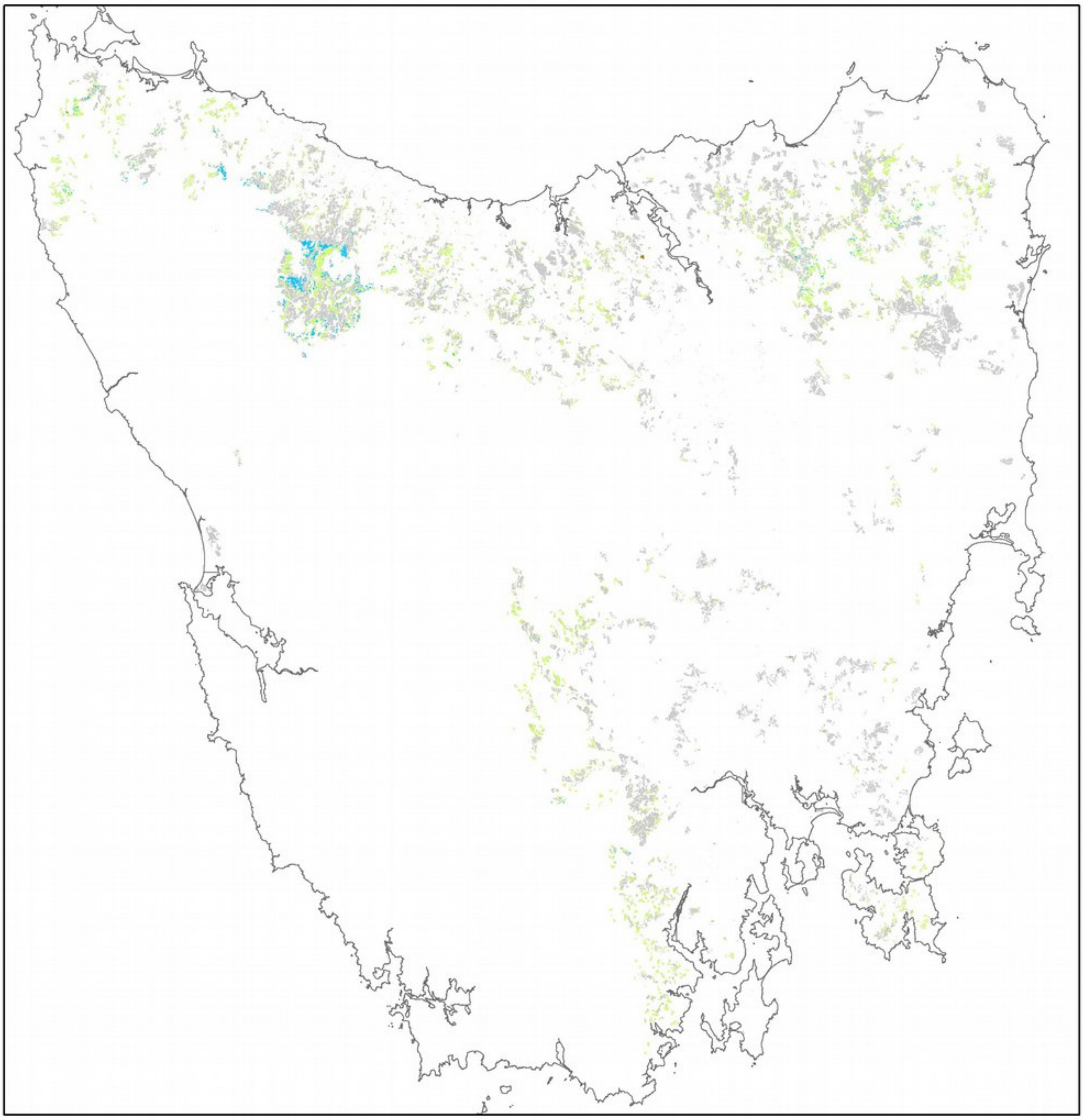
**Land tenure of plantations**


Period last cleared/harvested
1972
1977
1980
1985
1988
1989
1991
1992
1995
1998
2000
2002
2004
2005
2006
2007
2008
2009
pre 1972 or unknown



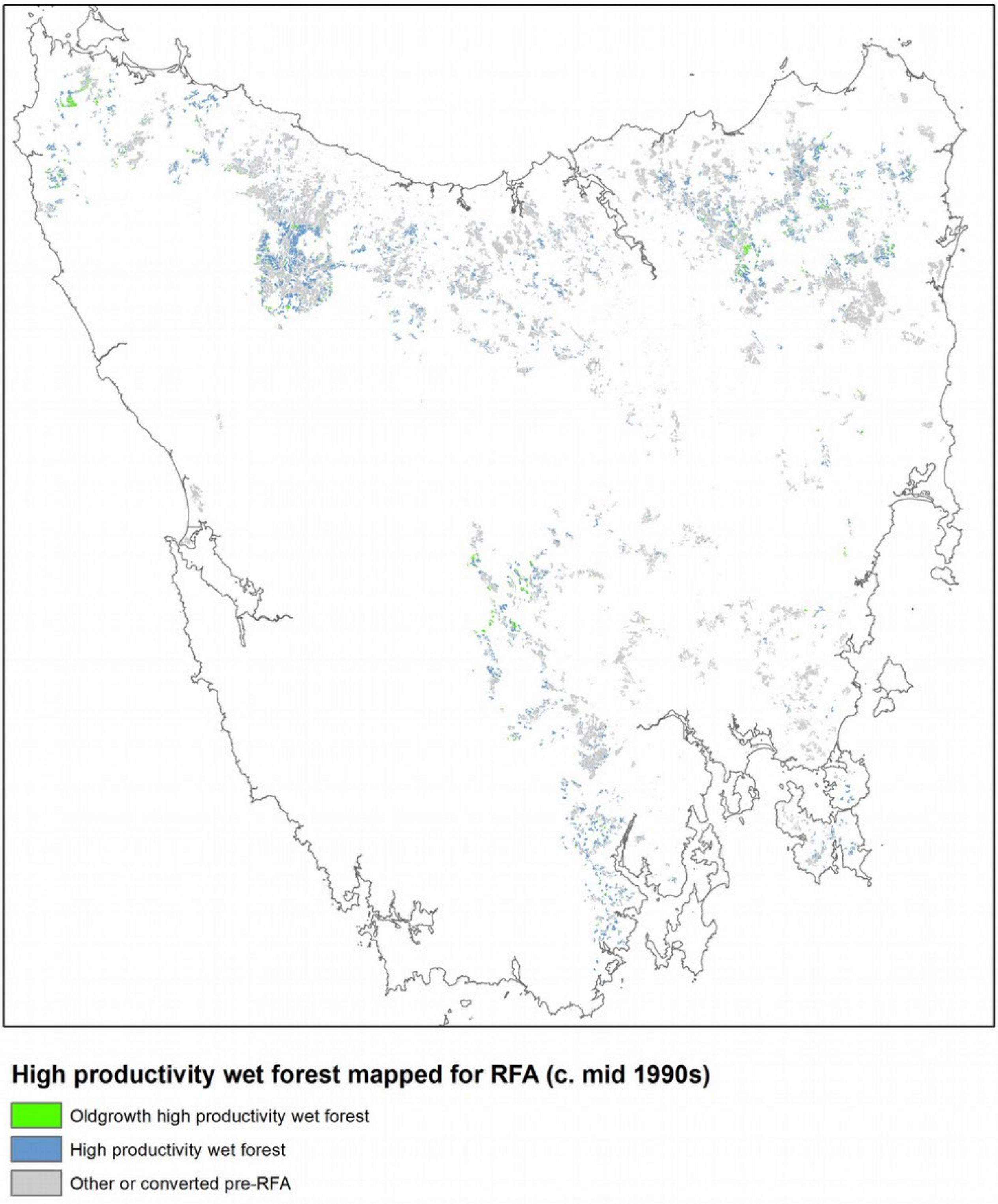
Land capability
Poor (classes 6-7)
Good to moderate (classes 1-5)
Not mapped

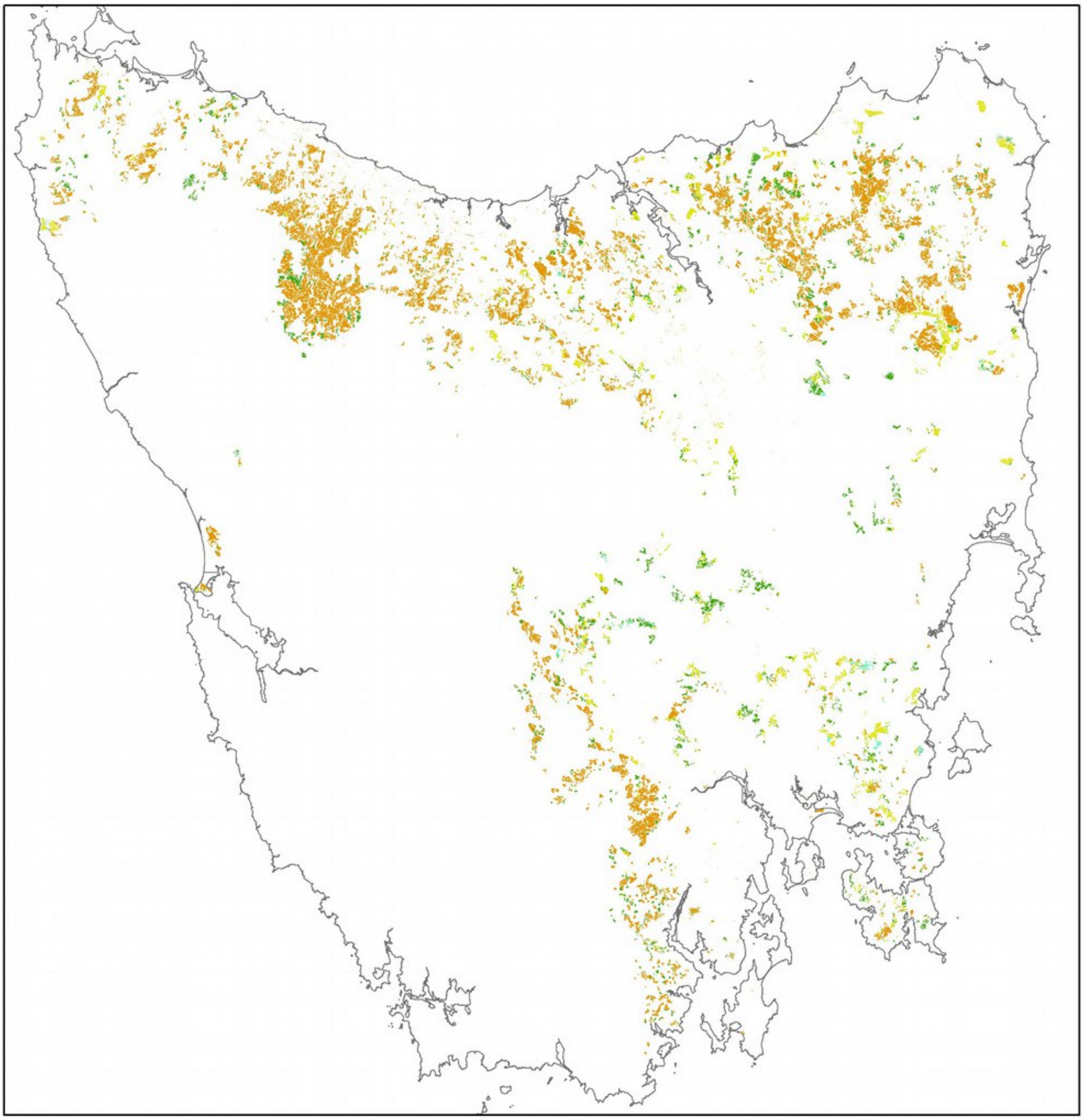

Plantation landscape context
Connectivity
Integrity
other plantations



**Threatened forest types and rainforest converted to plantation post-RFA**

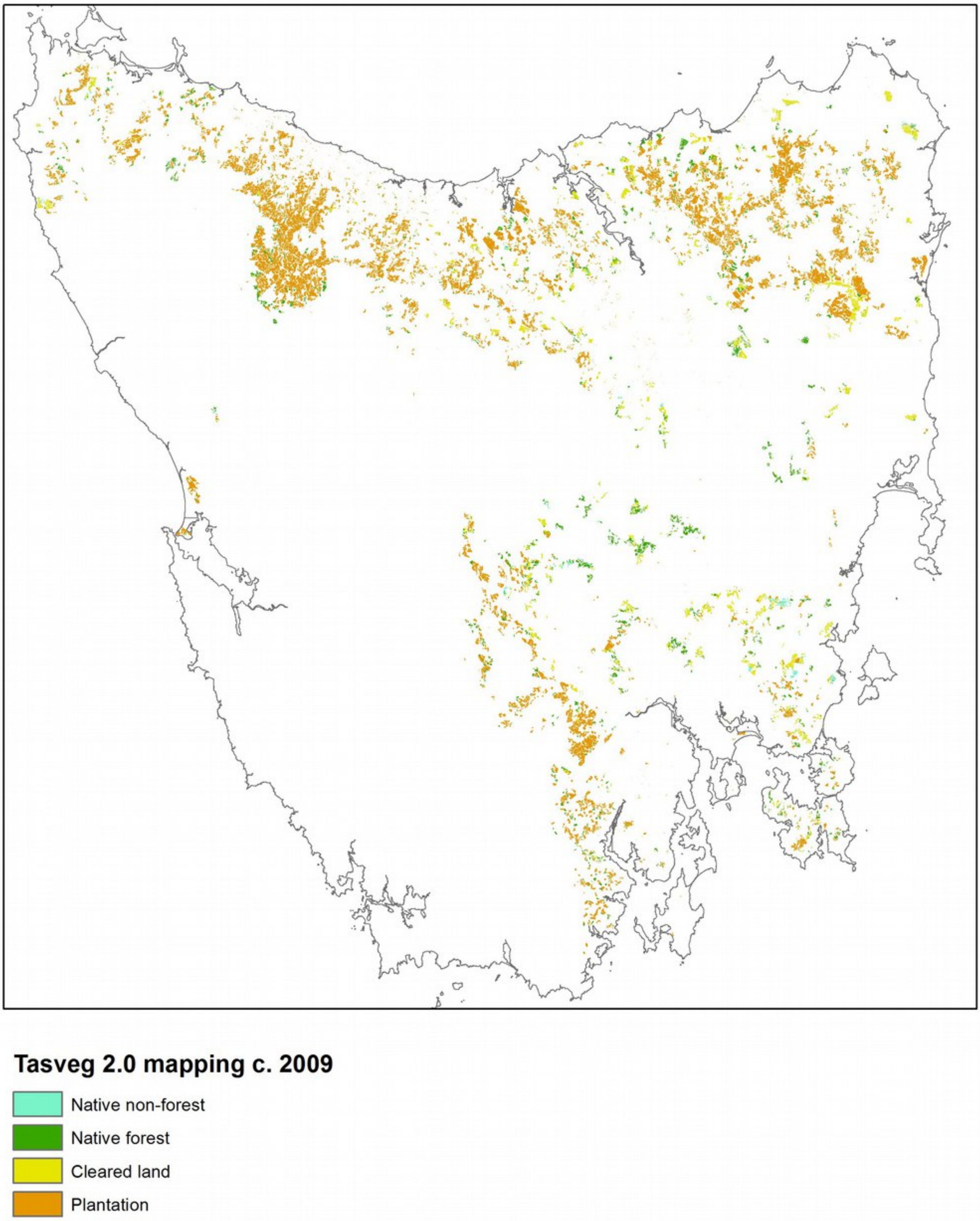
- E. viminalis tall forest
- E. ovata - E. viminalis forest
- Rainforest
- Other high productivity wet forest
- E. brookeriana wet forest
- Other or converted pre-RFA

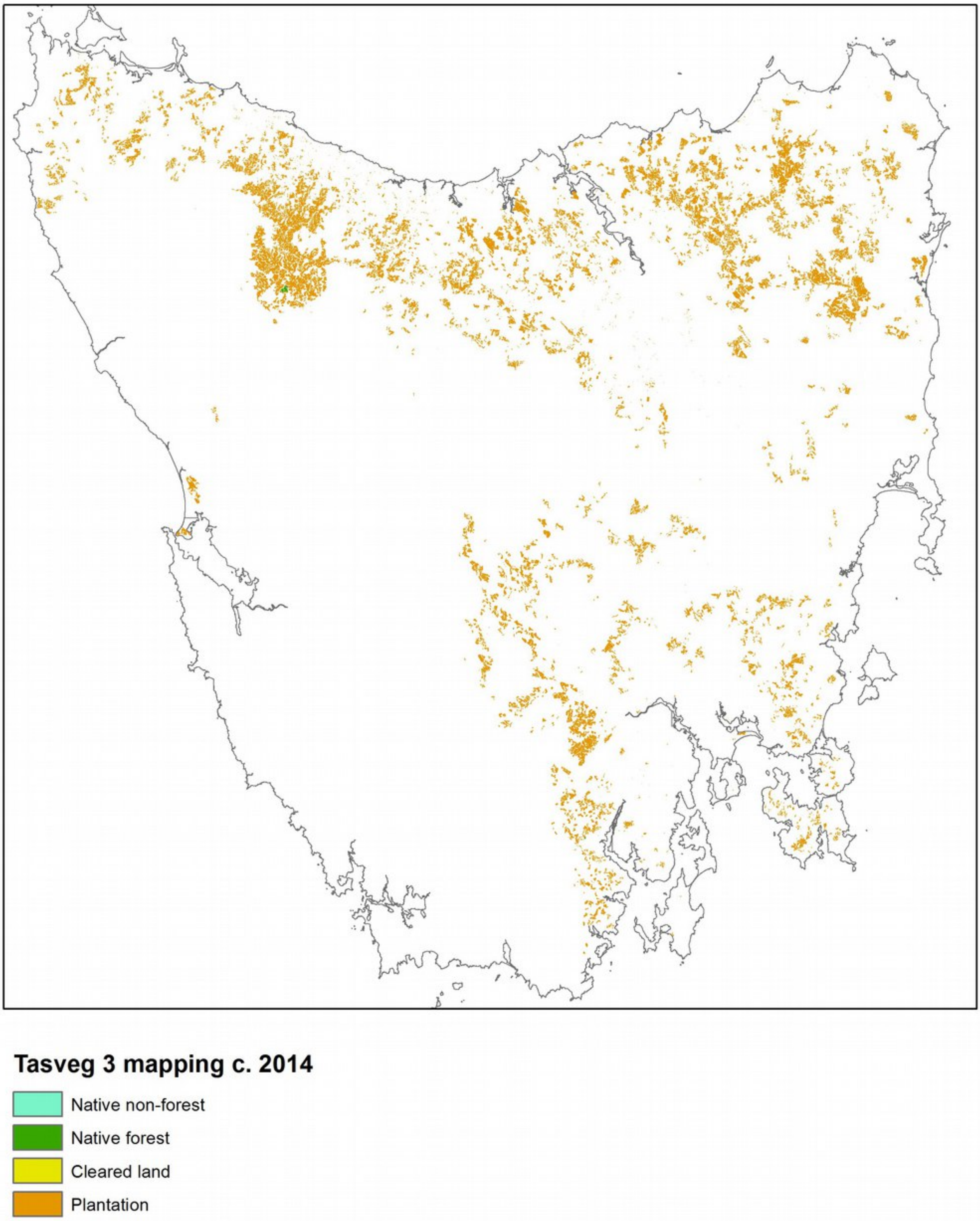

High productivity wet forest mapped for RFA (c. mid 1990s)
Oldgrowth high productivity wet forest
High productivity wet forest
Other or converted pre-RFA



**Tasveg 1.0 mapping c. 2004**

- Native non-forest
- Native forest
- Cleared land
- Plantation


Tasveg 2.0 mapping c. 2009
Native non-forest
Native forest
Cleared land
Plantation


Tasveg 3 mapping c. 2014
Native non-forest
Native forest
Cleared land
Plantation

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# Appendix 1 – Carbon Stocks of Skyline Tier

The following carbon assessment of the Skyline Tier restoration project is from the report *Benefits of Restoring Skyline Tier Scamander Plantation, Tasmania* (Bushways 2011).

The estimated current carbon storage in native forest at Skyline Tier ranges from:

1) 1 t/ha Carbon OR 4 t/ha of $CO_2$ Equivalent in five year old regenerating forest
2) 81 t/ha OR 296 t/ha $CO_2$ Equivalent in thirty year old regenerating forest
3) 176 t/ha OR 644 t/ha $CO_2$ Equivalent in mature forests.

Mature forests are assumed to be at an equilibrium stage where sequestration gains are offset by loss through death and decay.

Total carbon storage over the 382 ha is currently 2083 tonnes Carbon. Assuming that the whole restoration area will achieve similar growth and sequestration rates as the mature forest currently has then the 382ha estate has the potential to:

4) Store an estimated 67,323 tonnes of Carbon (possibly over 100-150 years).
5) Sequester 246,741 $CO_2^{-e}$ in achieving this storage.

The majority of this (235,760 $CO_2^{-e}$) will be from forests now 2-5 year old and under restoration following pine harvest.

In thirty years (June 2041) the 365ha restoration area currently supporting the 2 and 5 year age class is estimated to store 29,538 tonnes Carbon and to have sequestered 108,405 $CO_2^{-e}$.
In thirty years the current 14ha 30 year old forest is estimated to be storing 1,692 tonnes Carbon (120t/ha Carbon) and sequestering 6,210 $CO_2^{-e}$.

We assume the mature forest will be storing the same amount of carbon in thirty years as it is now. The estimated total Carbon storage at Skyline Tier in thirty years is 32,279 tonnes.

### 3.1.2 Areas and estimated carbon storage

| Plot No | Stratum | Entire Stem Volume (m3/Ha) | Entire Stem weight t/ha | Total above ground biomass (t/ha) | Total Biomass including roots (t/ha) | Total Carbon (t/ha) | $CO2^{-e}$ t/ha |
|---|---|---|---|---|---|---|---|
| 1 | 5 year old ironbark regeneration | 1.3 | 0.7 | 1.0 | 1.2 | 0.6 | 2.2 |
| 3 | 5 year old stringybark and white gum regeneration | 3.9 | 1.9 | 2.8 | 3.5 | 1.8 | 6.5 |
| 2 | 30 y ironbark regrowth | 177 | 88 | 129 | 161 | 81 | 296 |
| 4 | Stringybark and white gum mature forest | 359 | 180 | 262 | 328 | 164 | 602 |
| 5 | Ironbark mature forest | 411 | 205 | 300 | 375 | 187 | 687 |

*Table 2a Biomass and carbon per age class showing plot variation*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1&3 | average 5 year old regeneration | 3 | 1 | 2 | 2 | 1 | 4 |
| 2 | 30 year old regrowth | 177 | 88 | 129 | 161 | 81 | 297 |
| 4&5 | average mature forest | 385 | 192 | 281 | 351 | 176 | 646 |

*Table 2b Biomass and carbon per averaged age class*

| Stratum | A<br>Area (ha) | B<br>$CO_2^{-e}$ t/ha | A x B = Total $CO_2^{-e}$ | $CO_2^{-e}$ / 3.67 =<br>Total Carbon (t) |
|---|---|---|---|---|
| 2 year old regeneration | 94.2 | - | - | - |
| 5 year old regeneration | 270.3 | 4 | 1,081 | 294 |
| 30 year old regrowth | 14.1 | 297 | 4,187 | 1140 |
| mature forest | 3.7 | 646 | 2,383 | 649 |
| | | | | |
| **TOTALS** | **382.3** | | **7651** | **2083** |

*Table 3: Estimated total current carbon sequestration and storage capacity for Skyline Tier restoration area*

North East Bioregional Network