Vegetation Assets, States, and Transitions: accounting for vegetation condition in the Australian landscape

Technical Report

November 2005

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Abstract

Since European settlement nearly 70 percent of Australia has been occupied by agricultural, forestry and livestock grazing enterprises, resulting in the extensive modification and conversion of forest, woodland, open woodland, shrubland and grassland systems. While vegetation is managed primarily for the production of food and fibre, effective management of vegetation is increasingly recognised as critical in responding to major issues for Australian landscapes such as salinity, water quality and yield, soil erosion and loss of biodiversity. The increasing demand for information on natural resource condition requires that strong linkages be established between vegetation type and extent, vegetation use, management and condition. To meet national monitoring and evaluation reporting requirements on native forests and vegetation there is need for improved spatial and temporal information on the anthropogenic impacts on vegetation.

The Vegetation Assets, States and Transitions (VAST) classification orders vegetation by degree of anthropogenic modification as a series of states, from a residual or base-line condition through to total removal. The VAST classification is offered as tool that can help describe, map and account for changes in the status and condition of vegetation.

VAST is being developed to make explicit the links between land management and vegetation condition, and provide a mechanism for describing the consequences of land management on vegetation condition, and contribute to the analysis of ecosystems services provided by vegetation.

Citation:
Thackway, R. and Lesslie, R (2005). *Vegetation Assets, States and Transitions (VAST): accounting for vegetation condition in the Australian landscape*. BRS Technical Report, Bureau of Rural Sciences, Canberra.

Introduction

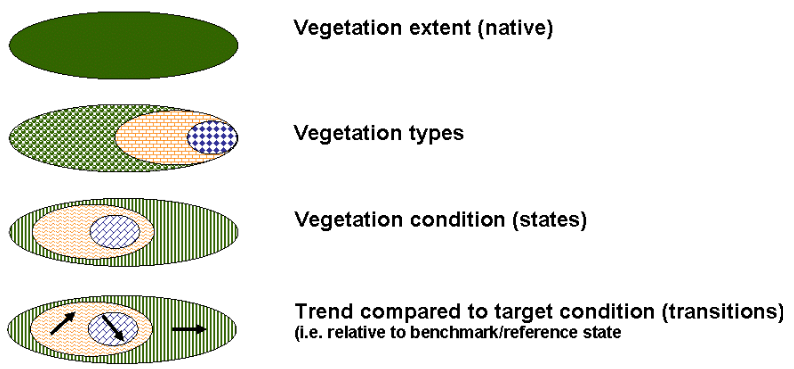
Vegetation, which refers collectively to all plant life in a given area, is a feature of the landscape that in technological societies is extensively managed for the production of a variety of goods and services. Since the European settlement of Australia approximately 200 years ago, about 62 percent of the continent has been occupied by agricultural and livestock grazing enterprises, resulting in the extensive conversion of forest, woodland, open woodland, shrubland and grassland systems. More intensive development, involving the complete removal of vegetation, covers less than 1 percent (Commonwealth of Australia 2004a).

While vegetation is managed primarily for the production of food and fibre, vegetation management is increasingly recognised as an important mechanism for sustaining and securing natural resources benefits including biodiversity, water and food and fibre (Abel *et al*. 2003, Millennium Assessment 2005), soil (McKenzie *et al*. 2004), and biodiversity (Hobbs and Saunders 1993). Effective management of vegetation is therefore critical in responding to major issues for Australian landscapes such as salinity, water quality, soil erosion and loss of biodiversity (NLWRA 2001, NSW Department of Infrastructure Planning and Natural Resources 2004, Victorian Catchment Management Council and Department of Sustainability and Environment, 2003, Williams *et al*. 1988). Increasing recognition of the strong linkage between vegetation management, vegetation condition, and natural resources outcomes has generated new demands for vegetation information – including information that adequately describes anthropogenic impact on vegetation (Thackway *et al*. 2005).

There are the numerous drivers of vegetation policy at the national level including water, salinity, carbon, biodiversity and sustainable agricultural production. Progress towards the implementation of vegetation-related policies and programs requires the development of approaches that enable assessments of multiple outcomes and market based instruments, trade-offs and developing scenarios, monitoring change and reporting performance, adaptive management and impacts of land management practices.

Conventionally, vegetation is described and classified in terms of its extent and type (distinctive structural arrangements, including height and spacing and taxonomic grouping) (AUSLIG 1990; ESCAVI 2003) (Figure 1).

Figure 1 National vegetation information for NRM



Indicators for Native Vegetation were developed for the National Monitoring and Evaluation Framework by the Executive Steering Committee for Australian Vegetation Information (ESCAVI) (NLWRA 2005). The indicators are intended to guide regions in compilation of native vegetation information for use in regional target setting and monitoring. While the indicators do not provide guidance on how information gathered against targets should be compiled, they were developed to ensure national consistency across regions in their approaches to vegetation target setting (NLWRA 2005). Once data collection against targets is more widely taken up by regions, this approach will stimulate the collection of additional data at the regional level. In order to promote the compilation of consentient national data, there is a need for national guidelines for the collection of site-based vegetation data and information (Hnatiuk et al. In Press).

The NVIS framework (attributes and database) is a nationally consistent approach for describing and compiling data and information for all vegetation types (ESCAVI 2003). NVIS contains information that is relevant to the Matters for Target described as part of the National Monitoring and Evaluation Framework indicators (NLWRA 2005), to other associated indicators and to broad scale national vegetation assessment.

These attributes are essential in tracking human impacts on vegetation, and relating vegetation change to effects on ecosystem services. However, in addition to extent, and type (eg structure and taxonomic composition) information is also required about vegetation condition, or the degree of vegetation change in terms of its state and level transformation against a putative baseline or reference condition (Hobbs 1994, Hobbs and Norton 1996, McIntyre and Hobbs 1999, Hobbs and Hopkins 1990, Hnatiuk *et al*. In Press, Thackway *et al*. 2005). Without this, it is not possible to adequately address links between levels of management intervention, vegetation structure and floristics and impacts on natural resources, including biodiversity (McIntyre and Hobbs 1999, Hobbs and Hopkins 1990, Parkes *et al*. 2003, Thackway *et al*. 2005).

Approaches to evaluating vegetation modification

The evaluation and assessment of vegetation modification can be approached from a range of different perspectives, these include:

- Analysis of vegetation resilience and regenerative capacity in applications such as habitat restoration – (e.g. Hobbs and Hopkins 1990),
- Analysis of vegetation landscape processes e.g. succession and fragmentation, (e.g. Forman and Godran 1986, McIntyre and Hobbs 1999 and 2000, Lesslie 1997),
- Scoring and ranking key vegetation structural and functional attributes associated with condition state such as Habitat Hectares – (Keighery 1994, Parkes *et al*. 2003); and
- Vegetation state and transition models (e.g. Westoby *et al*. 1989, Phelps and Bosch 2002)

While these approaches contribute important insights into the modification of native vegetation, there is a need for a conceptual framework that can integrate the ecological principles from these approaches into an ordinal classification.

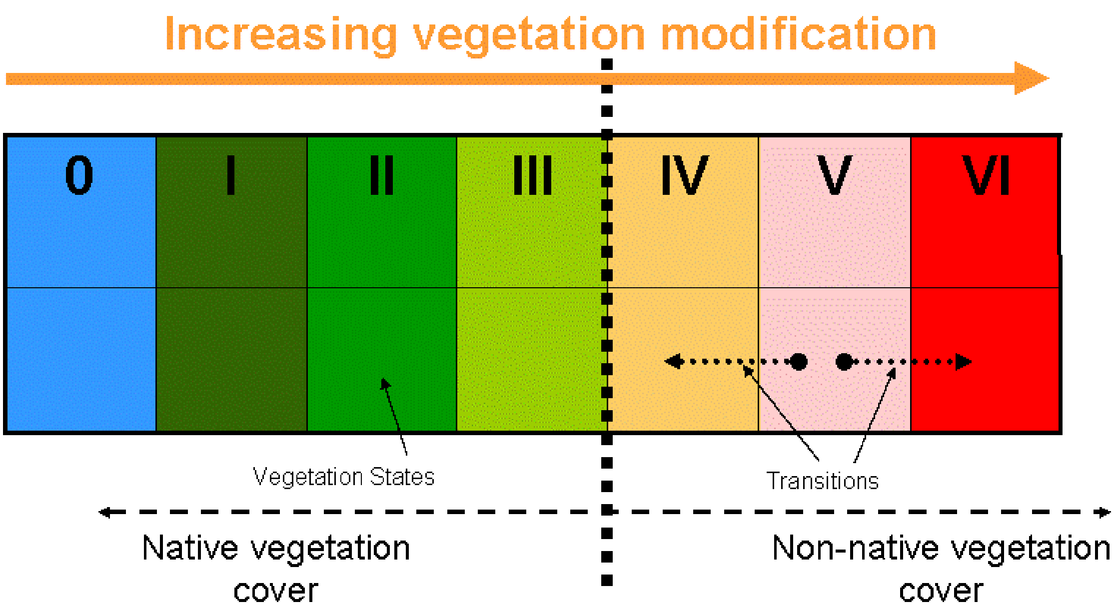
The Vegetation Assets, States and Transitions (VAST) classification framework is offered as a means of ordering native vegetation by degree of anthropogenic modification as a series of states, from a residual or base-line condition through to total removal. The classification is not linked to any particular method of vegetation survey, and is designed to accommodate a range of survey data from which inferences (information) about vegetation composition, structure and regenerative capacity can be derived (Figure 2). Thus, the assignment of VAST classes can be made on the basis of data and information sourced from a wide range of assessments (as above) as demonstrated in case study examples presented in this report.

Figure 2 VAST and the assessment of vegetation condition

The VAST conceptual framework

The VAST classification orders native vegetation as a series of states or conditions from 'residual' (baseline) through 'replaced native' (cultivated or non-indigenous) to 'removed' (non-vegetated) as represented in Figure 3.

Figure 3 The VAST conceptual framework



A major break in the condition spectrum occurs between states III and IV where the vegetation transition switches from a vegetation cover with native dominant structuring species to a vegetation cover that is dominated by species alien to the locality. States and transitions in the VAST classification are defined by breakpoints in vegetation composition, structure and regenerative capacity relative to an identified base-line condition. Terms used in Figure 3 are defined in Appendix 1.

Table 1 shows the VAST classification. The table elaborates the seven states, the diagnostic criteria used to distinguish them, and provides examples. These states can be mapped onto the landscape as vegetation condition classes where appropriate input data and information satisfy the required diagnostic criteria.

Table 1 Vegetation Assets, States and Transitions

Increasing vegetation modification from left to right →

		Native Vegetation Cover Dominant structuring plant species indigenous to the locality and spontaneous in occurrence – i.e. a vegetation community described using definitive vegetation types relative to estimated pre1750 types[#]				***Non-native Vegetation Cover*** Dominant structuring plant species indigenous to the locality but cultivated; alien to the locality and cultivated; or alien to the locality and spontaneous*		
Vegetation Cover Classes		Type 0: RESIDUAL BARE Areas where native vegetation does not naturally persist	Type I: RESIDUAL native vegetation community structure, composition, and regenerative capacity intact – no significant perturbation from land use/land management practice	Type II: MODIFIED native vegetation community structure, composition and regenerative capacity intact - perturbed by land use/land management practice	Type III: TRANSFORMED native vegetation community structure, composition and regenerative capacity significantly altered by land use/land management practice	Type IV: REPLACED - *ADVENTIVE* native vegetation replacement – species alien to the locality and spontaneous in occurrence	Type V: REPLACED - *MANAGED* native vegetation replacement with cultivated vegetation	Type VI: REMOVED vegetation removal
Diagnostic criteria	Current regenerative capacity	Natural regenerative capacity unmodified - ephemerals and lower plants	Natural regenerative capacity unmodified	Natural regeneration tolerates / endures under past &/or current land management practices	Natural regenerative capacity limited / at risk under past &/or current land use or land management practices. Rehabilitation and restoration possible through modified land management practice	Regeneration of native vegetation community has been suppressed by ongoing disturbances of the natural regenerative capacity. Limited potential for restoration.	Regeneration of native vegetation community lost or suppressed by intensive land management. Limited potential for restoration	Nil or minimal
	Vegetation structure	Nil or minimal	Structural integrity of native vegetation community is very high	Structure is predominantly altered but intact e.g. a layer / strata and/or growth forms and/or age classes removed	Dominant structuring species of native vegetation community significantly altered e.g. a layer / strata frequently & repeatedly removed	Dominant structuring species of native vegetation community removed or predominantly cleared or extremely degraded	Dominant structuring species of native vegetation community removed	Vegetation absent or ornamental
	Vegetation composition	Nil or minimal	Compositional integrity of native vegetation community is very high	Composition of native vegetation community is altered but intact	Dominant structuring species present - species dominance significantly altered	Dominant structuring species of native vegetation community removed	Dominant structuring species of native vegetation community removed	Vegetation absent or ornamental
Examples		Bare mud; rock; river and beach sand, salt and freshwater lakes	Old growth forests; Native grasslands that have not been grazed; Wildfire in native forests and woodlands of a natural frequency and/or intensity;	Native vegetation types managed using sustainable grazing systems; Selective timber harvesting practices; Severely burnt (wildfire) native forests and woodlands not of a natural frequency and/or intensity	Intensive native forestry practices; Heavily grazed native grasslands and grassy woodlands; Obvious thinning of trees for pasture production; Weedy native remnant patches; Degraded roadside reserves; Degraded coastal dune systems; Heavily grazed riparian vegetation	Severe invasions of introduced weeds; Invasive native woody species found outside their normal range; Isolated native trees/shrubs/grass species in the above examples	Forest plantations; Horticulture; Tree cropping; Orchards; Reclaimed mine sites; Environmental and amenity plantings; Improved pastures. (includes heavy thinning of trees for pasture); Cropping; Isolated native trees/ shrubs/ grass species in the above examples	Water impoundments; Urban and industrial landscapes; quarries and mines; Transport infrastructure; salt scalded areas

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Key assumptions

Five assumptions are implicit in the VAST framework depicted in Table 1:

1. Recognising that vegetation species and communities are distributed in response to environmental gradients (Whittaker 1967), the current structure, composition and function of the vegetation types present in an area is to a large extent a result of historic and prevailing land use and land management practices.
2. The natural regenerative capacity of native vegetation is to a large extent a result of historic and prevailing land use and land management practices.
3. The seven states should be capable of being recognised and mapped at a range of scales and therefore can be surveyed, classified and mapped using a range of methods. These seven states can be detected at the patch level (e.g. 50m x 50m) through to the regional level (e.g. 250m x 250m). Appropriate existing input datasets can be used to 'remap' VAST states onto these datasets.
4. The seven broad states encompass all vegetation types found across the landscape.
5. Additional sub-states can be developed with each of the seven main states.

Concepts and Principles

1. Depending on the requirements of clients and stakeholders a number of vegetation 'states' can be defined that describe native or non-native vegetation across the whole landscape (states 0-VI in Table 1). At different points in time, clients/stakeholders can use these definitions and descriptions to assess changes in type and extent of these states in different parts of the landscape. These criteria can be measured, mapped and monitored using structural, compositional and functional attributes.
2. Natural non-vegetated classes (i.e. states and sub-states) are bare areas. In the context of the NVIS framework naturally non-vegetated 'Definitive Vegetation Types' could be included in state 0 (e.g. salt lakes, sand, mud flats and rock).
3. Native vegetation refers to those states and sub-states that can be defined and mapped where the regeneration of species / communities and ecosystems is not predominately prevented or excluded by land management practices. Native vegetation can be identified by characteristics of its dominant structure and composition (Taylor 1990). Because of these characteristics, it provides a distinctive, but not exclusive, set of attributes that can be surveyed and mapped or monitored. In the context of the NVIS framework Native 'Definitive Vegetation Types' (Thackway *et al*. In Press) could be included in states I-III.
4. Non-native vegetation includes those vegetation classes (i.e. states and sub-states) where the vegetative cover is predominately non-native and regeneration of the native vegetation is predominately repeatedly suppressed or prevented or excluded by land management practices. In the context of the NVIS framework non-native 'Definitive Vegetation Types' (Thackway *et al*. In Press) could be included in state V.

5. In the context of point 2 above, i.e. where vegetation ‘states’ can be defined and mapped across the whole landscape, management actions can be used to ‘transition’ the vegetation state:
   - management actions can ‘transition’ a vegetation state from state I to a state III or even a state VI.
   - depending on the value system and management intent, with sufficient investment, management actions can ‘transition’ a vegetation state from state III to a state I. Such investments would aim to remove impediments to a vegetation type’s regenerative capacity. Vegetation types under state III need to differentiate those sites where the regenerative capacity has been lost.
   - it is not possible in the short-medium term (e.g. 10-20 years) to ‘transition’ a non-native vegetation state (states IV-VI) back to a native vegetation state once the natural regenerative capacity of a native vegetation community has been irreversibly depleted or changed. Where stakeholders revegetate areas that were formally non-native vegetation types with native species the structure, composition and function and the regenerative capacity of the ‘reconstructed native vegetation’ will in the short to medium term be discernable as a revegetated type (state V).

Case studies

Three case studies showing implementation of the VAST classification using national and regional input datasets are presented below. Details of the methods used to inform the VAST classification using input data in each case are available from BRS.

Figures 4 and 5 show the application of the VAST classification at regional scale to the Bogan Gate area in central New South Wales (NSW Department of Infrastructure Planning and Natural Resources, 2002). The analysis illustrates the extent and spatial configuration of condition classes in the region and the relative areas of selected vegetation types. Both figures show that the majority of the native vegetation in the study area has been changed to non-native vegetation (i.e. VAST V - cropping and improved pastures). The largest extent of native vegetation (VAST II and III) is associated with Grasslands and herbaceous communities, Plains woodlands, Hills and footslope woodlands, Floodplain woodland and Alluvial woodlands. The ‘best of the last’ of the native vegetation (i.e. VAST I) is associated with Hills and footslope woodlands (i.e. upper slopes and ridges).

Figure 6 shows application of the VAST classification at regional scale to the north west of Victoria. This example uses a model of site-condition based on vegetation attributes collected using the ‘Habitat Hectares’ approach (Parkes *et al*. 2003, Newell in prep).

Both the New South Wales and Victorian case studies are based on detailed site-based assessments by state agencies as part of the respective vegetation survey and management programs coupled with expert ecological knowledge.

Figure 7 shows application of the VAST classification at the national scale. This representation provides a continental overview of VAST conditions capable of supporting strategic-level analysis, identifying regional patterns and pointing to data gaps and priorities for information collation. The dataset is of limited value for monitoring because of spatial and temporal variability in the accuracy and precision of input data.

In this case the representation of vegetation states and transitions is based on a range of national scale data from a variety of sources. This includes the Biophysical Naturalness layer within the Australian Land Disturbance Database (ALDD) held by the Australian Government Department of Environment and Heritage, the 1996/97 (National) Land Use of Australia, Version 2, catchment scale land use mapping produced through the Australian Collaborative Land Use Mapping Program, and MODIS satellite imagery (bare ground). The allocation of VAST classes is presented in Table 2.

Table 2 National-scale allocation of VAST classes from source data

Source* (field)	Input	VAST conversion
BN (value)	0 1 2,3 4,5	4/5. Replaced 3. Transformed 2. Modified 1. Residual
NLUM (v5_secondary)	5.4 5.7 6.2	6. Removed 6. Removed 6. Removed
CLUM (lu_code) *(Tasmania and WA only)*	1.1.1 - 1.2.5 1.3.0 - 2.2.2 3.1.0 - 5.3.0 5.4.0 - 5.9.5 6.1.0 - 6.1.3 6.2.0 - 6.2.4 6.3.0 - 6.3.3 6.4.0 - 6.4.2 6.5.0 - 6.6.3	1. Residual 2. Modified 4/5. Replaced 6. Removed 0. Bare 6. Removed 0. Bare 6. Removed 0. Bare
MOD (value)	16	16 = 0. Bare

* Sources of data used in deriving the national level representation of VAST

BN Biophysical Naturalness grid derived from Australian Government Department of Environment and Heritage, Australian Land Disturbance Database (ALDD), Biophysical Naturalness layer (cf Lesslie and Maslen 1995).
NLUM 1996/97 (Stewart et al. 2001) Land Use of Australia, Version 2, NLWRA, 2001.
CLUM Catchment scale land use mapping for Tasmania (2000) and Western Australia (1997) (Bureau of Rural Sciences 2002).
MODIS MODIS Land Cover Type 2001 (MOD12C1), International Geosphere-Biosphere Programme Classification, (cf Loveland and Belward 1997).

Figure 4 VAST classification Bogan Gate, New South Wales

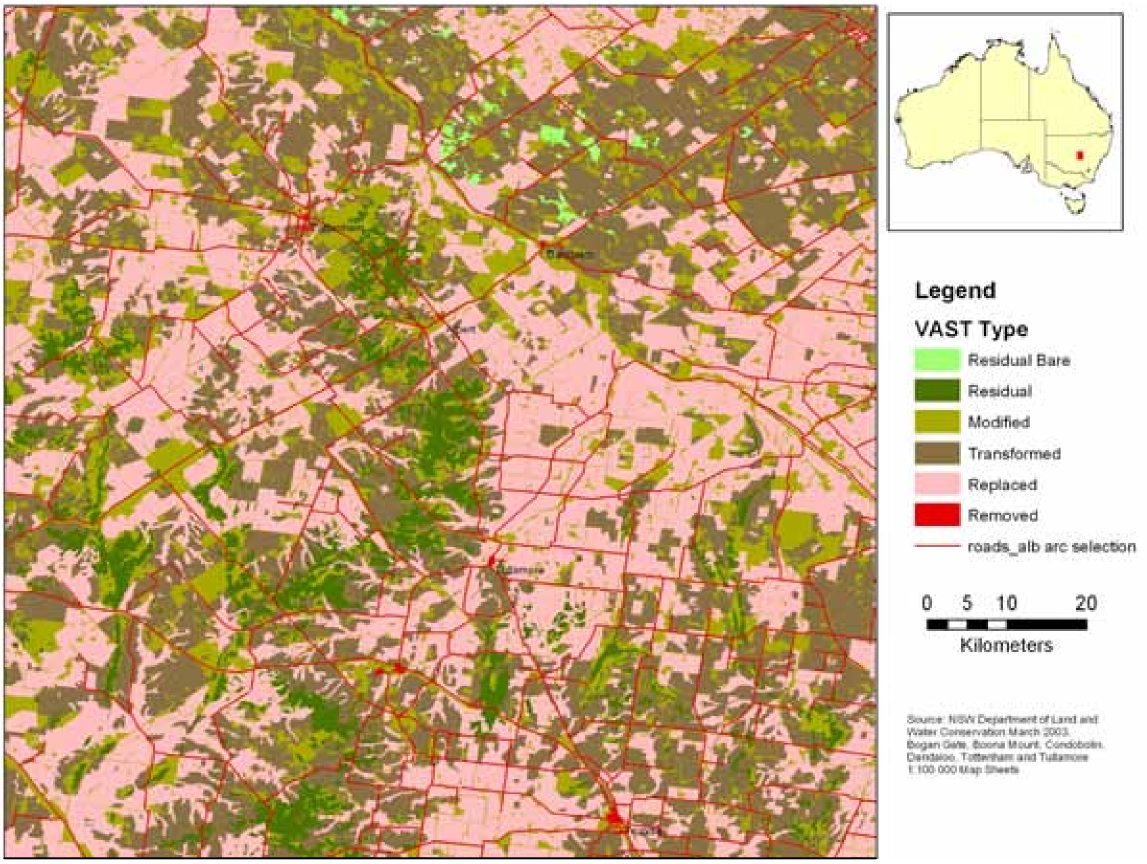


Figure 5 VAST classes for selected vegetation types in Bogan Gate study area, New South Wales

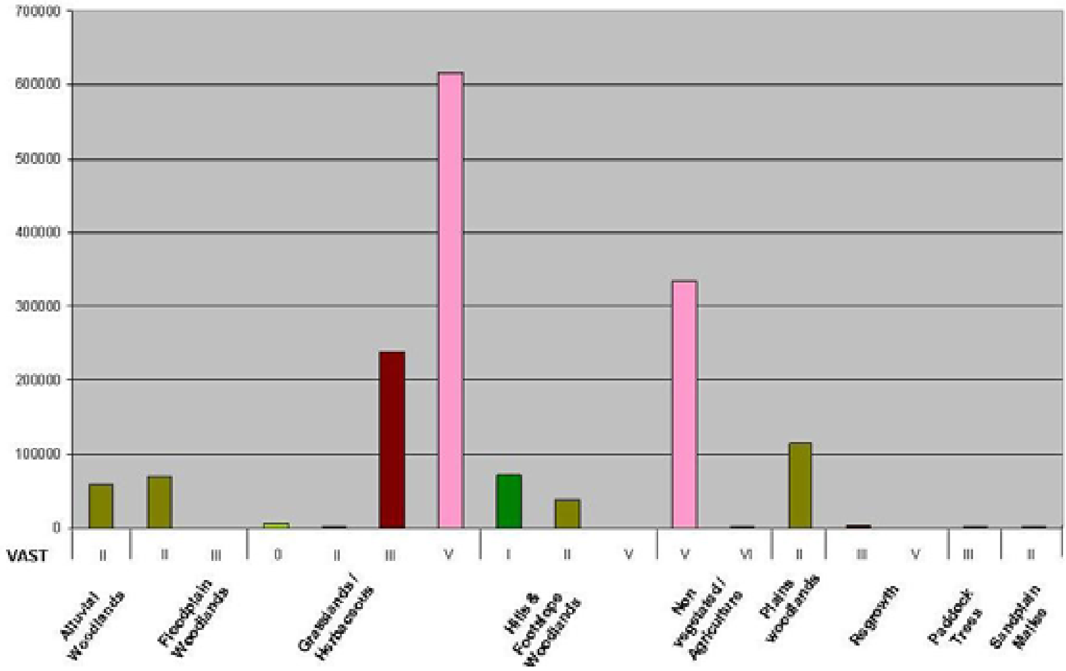


Figure 6 VAST classification for northern Victoria (draft)

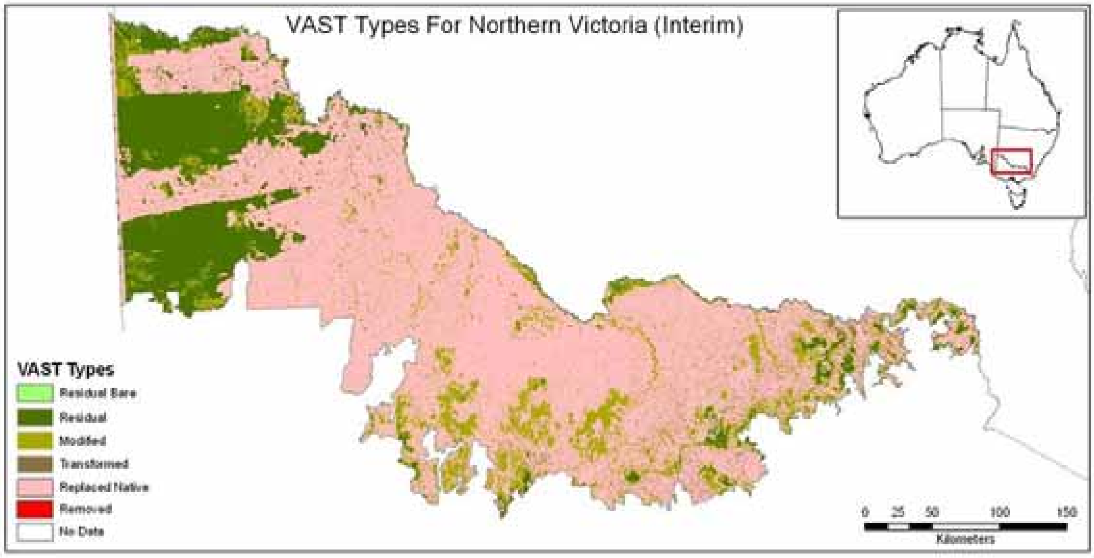
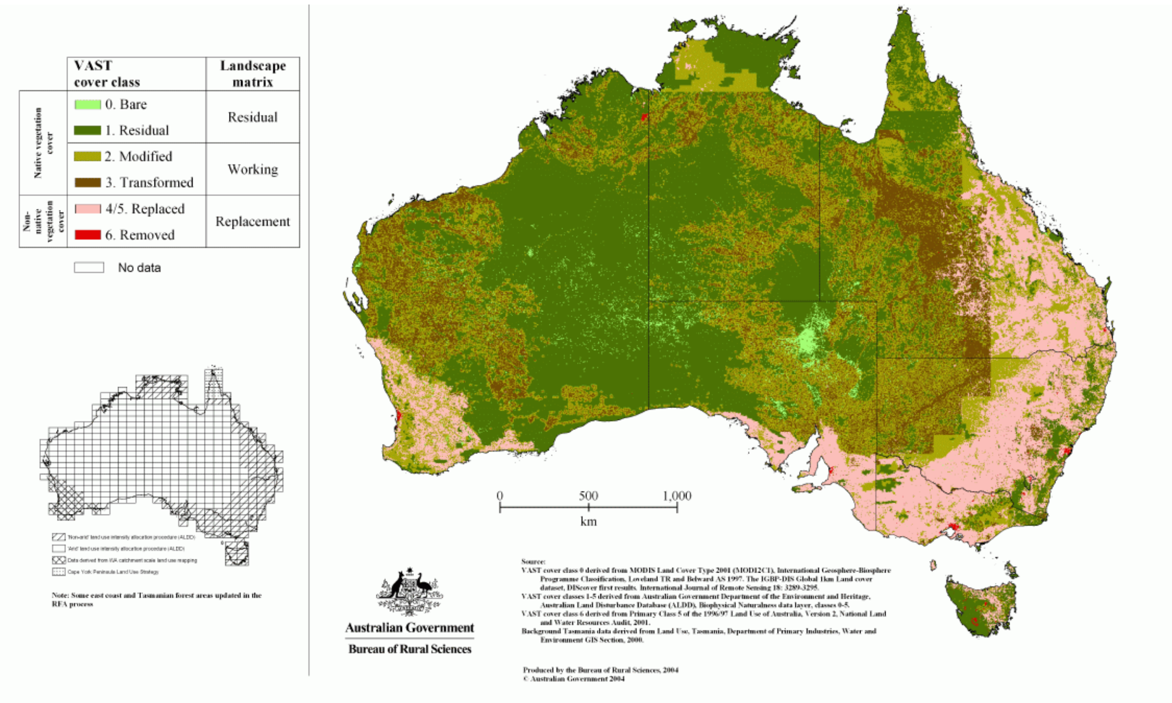


Figure 7 VAST classification for Australia (draft)



Applications

Considerable progress has been made on an approach for collecting and reporting the condition of native vegetation from a biodiversity perspective (Parkes *et al*. 2003, Commonwealth of Australia 2004b, Thackway *et al*. In Press).

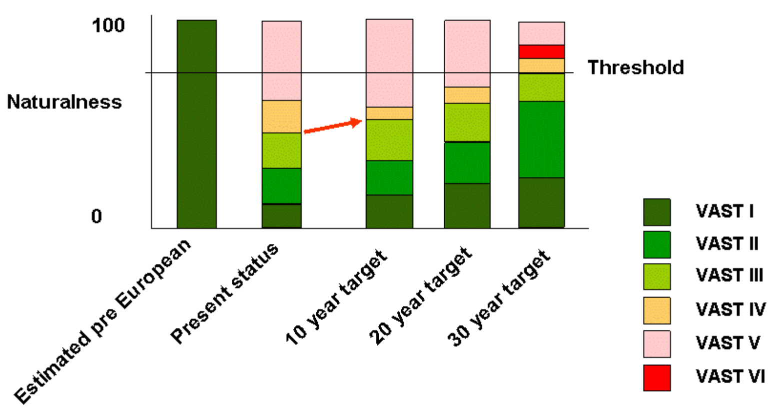
These case studies demonstrate how vegetation survey and mapping information, and land use and land resources data may be interpreted using the VAST classification to provide information on the condition states of native vegetation. A recent application of the VAST framework across the Northern Territory used modifiers of vegetation structure, composition and function to assess and report on the condition states of native vegetation (Brocklehurst *et al*. 2005). These modifiers included fire frequency, land uses, clearing, domestic stock watering points and infrastructure e.g. urban areas and roads.

The VAST classification is offered as tool that can assist in valuing, evaluating and accounting for the states and transitions of vegetation. Applications of VAST could be used to report natural resource condition monitoring and evaluation requirements for reporting the condition of native vegetation (Commonwealth of Australia 2004b), at regional and national scales. In addition, the VAST classification can help describe and account for changes in the status and condition of vegetation, make explicit the links between land management and vegetation condition, provide a mechanism for describing the consequences of land management on vegetation condition, and contribute to the analysis of ecosystems services provided by vegetation.

For example VAST is useful for prioritising investments in on-ground actions in the context of NRM targets and measuring and monitoring performance against these targets (Figure 8). VAST is also useful for :

- Describing ecosystem services provided by vegetation
- Assessing impacts of land management actions on ecosystem services
- Accounting multiple ecosystem services provided by a vegetation type/s
- Discussing trade-offs and costs/benefits of on-ground management actions
- Prioritising investments in on-ground actions
- Monitoring performance toward thresholds for ecosystem services

Figure 8 Linking VAST to targets and thresholds



Acknowledgements

The development of the VAST framework was funded by the Natural Heritage Trust and the Bureau of Rural Sciences.

Many people across Australia have contributed to the ideas in this report. Officers from agencies that have contributed to the conceptual framework include the Australian Government Department of Agriculture, Fisheries and Forestry, Australian Government Department of Environment and Heritage, CSIRO Sustainable Ecosystems, Victorian Government Department of Sustainability and Environment, Northern Territory Department of Infrastructure, Planning and Environment, and the New South Wales Department of Infrastructure and Natural Resources.

Appendix 1 - Definitions

States – are defined in terms of vegetation attributes	• States are separated by thresholds • For vegetation types to change from one state to another a state must cross a measurable threshold defined in terms of observed changes in e.g. strata, growth form and dominant structuring species • A state encompasses multiple expressions of vegetation types • A state represents the results of management actions undertaken to vegetation types either within a state or another state • The drivers of changes between states (management actions) that have resulted in a change of a vegetation type from one state to another should be understood and described in terms of their impacts on vegetation structure (e.g. cover, basal area, strata, growth forms) composition (e.g. dominant structuring species) and function (e.g. regenerative capacity, soil health, water quality)
Transitions and thresholds are defined relative to states i.e. how the various components and drivers may interact	• A threshold must be crossed in order for a change in state to occur

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