Adopting national vegetation guidelines and the National Vegetation Information System (NVIS) framework in the Northern Territory

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Abstract: Guidelines and core attributes for site-based vegetation surveying and mapping developed for the Northern Territory, are relevant to botanical research, forestry typing, rangeland monitoring and reporting on the extent and condition of native and non-native vegetated landscapes. These initiatives are consistent with national vegetation guidelines and the National Vegetation Information System (NVIS) framework. This paper provides a synopsis of vegetation site data collection, classification and mapping in the Northern Territory, and discusses the benefits of consistency between the guidelines, core attributes and the NVIS framework; both of which has an emphasis on the NVIS hierarchical classification system for describing structural and floristic attributes of vegetation.

The long-term aim of the NVIS framework is that national attributes are adopted at regional levels to enable comparability of vegetation information within survey and jurisdictional boundaries in the Northern Territory and across Australia. The guidelines and core attributes are incorporated in current and future vegetation survey and mapping programs in the Northern Territory.

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Introduction

Information on vegetation in Australia is increasingly required at a range of spatial scales and levels of attribute detail, for regulatory, management and planning purposes. There have been a number of attempts to develop a consistent, comparable and Australia-wide approach to native vegetation mapping and compilation. The Australian Native Vegetation Assessment (NLWRA 2001) presents the first regional-level comprehensive guidelines for assessing and reporting Australia's native vegetation resources, including their extent and change since European settlement.

The National Vegetation Information System (NVIS) is an Australian vegetation information framework developed with States and Territories over the past decade to bring together vegetation datasets into one repository. The aim of NVIS is to improve the comparability and consistency of vegetation information across the continent. http://www.environment.gov.au/erin/nvis/index.html NVIS allows the compilation of spatial and non spatial vegetation datasets and provides a means of describing and representing vegetation information based on relationships between structural and floristic data. As a storage system its set of core attributes facilitate analysis and reporting of Australia's vegetation resources.

Since 1999 the Northern Territory has recognised inconsistencies in vegetation datasets, resulting from different data collection and classification methods, and developed guidelines and field methods for vegetation survey and mapping (Brocklehurst et al., 2007). The guidelines are a concise account of the national vegetation guidelines and provide reference to revised vegetation chapters of the colloquially known 'yellow book' (Hnatiuk et al., in press) and 'blue book' (Thackway et al., 2008).

Vegetation datasets generally incorporate qualitative and quantitative attributes to describe and map vegetation. Numerous terms are used to describe vegetation including alliance, society, association, type and community. The last term is defined as an assemblage of plant species which are structurally and floristically similar and form repeating units across a landscape (ESCAVI 2003). The generic term vegetation will be used throughout this paper in the context of the definition provided.

Mapped information on vegetation varies in terms of spatial scale, accuracy and level of attribute detail. Spatial changes in naturally occurring vegetation can be influenced by species composition, structural attributes including cover, height, growth form and seasonal responses (Mueller-Dombois &

Ellenberg 1974). Apart from environmental correlates (such as elevation, soils, aspect and latitude), local and regional spatial patterns observed in native vegetation can be strongly influenced by natural perturbations such as cyclones, wildfire, drought and insect damage. Vegetation mapping is an applied science that attempts to depict features from a remotely-sensed interpretive base at a point in time and provides a static descriptive view of the vegetation contained (Thackway et al., 2008; Wallace et al., 2006).

This paper provides a synopsis of vegetation site data collection, classification and mapping in the Northern Territory. Discussed are the linkages of the Northern Territory guidelines and soon to be published national vegetation guidelines for conducting, classifying, describing and mapping vegetation, including Hnatiuk et al. (in press), Thackway et al. (2008) and the Australian Vegetation Attribute Manual (ESCAVI 2003). The development of core attributes for vegetation site-based and map unit data for historic and future vegetation datasets is presented. We also highlight approaches promoting knowledge and adoption of Northern Territory and national vegetation guidelines through seminars and workshops.

National vegetation information

To describe, classify and map vegetation at the national level, several approaches have been developed. These have included new or primary mapping datasets and compiling existing mapped vegetation information. Vegetation datasets have included native, non-native and non-vegetated cover types.

Perhaps the most widely recognised national map of Australia's vegetation is that of John Carnahan (Carnahan 1976, AUSLIG 1990) which used new or primary mapping to characterise Australia's natural vegetation at 1:5 000 000 scale for both pre-European and present (1980) extent.

In the early 1990s the National Forest Inventory (NFI) began to regularly compile available mapped information on forest types (Brack 2007). This dataset includes various spatial scales, levels of attribute detail and currency. In 1999 the National Land and Water Resources Audit commenced development of NVIS as a basis for regularly compiling the best available mapped information on vegetation types (NLWRA 2001). This approach translates and compiles maps of vegetation for pre-European and present extent and includes various spatial scales, levels of attribute detail and currency. Compilation of State and Territory vegetation datasets for NFI and NVIS datasets, showed numerous disparities, largely due to different methods used to classify and map vegetation. Since the early 2000s developers of NVIS have played a fundamental role in establishing comprehensive and systematic national guidelines for field-based vegetation survey (Hnatiuk et al., in press), standard vegetation classification and map attribution techniques (Thackway et al., 2008) and for compiling existing State and Territory datasets into one national dataset (ESCAVI 2003).

Vegetation classification systems and national vegetation guidelines

Classification systems are fundamental for vegetation description, to define patterns and simplify complex vegetation data. A classification system comprises classes that impose artificial boundaries on continuous variables. Various vegetation classification systems are used throughout Australia (Beadle 1981; Beadle & Costin 1952; Floyd 1990; Specht 1970; Specht et al., 1974; Walker & Hopkins 1990; Webb 1968), the majority are similar and use floristics, structure and physiognomy to distinguish vegetation (Sun et al., 1997).

Several Australian States have developed vegetation classifications for use in land use regulations or environmental assessment. Regional Ecosystems (Sattler & Williams 1999) are applied under clearing laws in Queensland. The Department of Environment and Sustainability in Victoria has developed and mapped Ecological Vegetation Classes that guide many decisions in that State. In NSW, a non-spatial plant community classification (NSW Vegetation Classification and Assessment database) described in Benson (2006) has so far covered the semi-arid and arid plains of that State (Benson et al., 2006) and the NSW South Western Slopes bioregion (Benson in review). The NSWVCA is used in the assessment of land development or conservation incentive proposals in the Property Vegetation Planning Biometric Tool (Gibbons et al., 2005) in NSW.

Vegetation classification in the Northern Territory has traditionally used a modified Carnahan (1976) and Specht (1981) system. The Northern Territory vegetation map (Wilson et al., 1990) altered the Specht (1981) system to characterise vegetation by the tallest stratum if vegetative cover was greater than 5%. If the tallest stratum was less than 5% cover, a lower stratum became the dominant or most characteristic. The Northern Territory's vegetation mapping program maintained this approach in successive vegetation survey and mapping projects. However, as independent surveys were instigated by other agencies, methods were modified and other classification systems introduced.

Specht (1970) devised a two-way structural classification scheme for vegetation formations based on life form, height and projective foliage cover (PFC) of the tallest stratum. This system has three height classes and four PFC classes and is possibly the most widely applied classification system in Australia (Sun et al., 1997), although lacking a floristic component. The classification system widely used for integrated surveys was Walker and Hopkins (1990) which characterises vegetation by the tallest stratum and aims to provide a single vegetation classification scheme. Walker and Hopkins (1990) is based on the Specht (1970) approach and uses physiognomy, height and crown cover complemented by dominant or diagnostic species. Crown cover in this instance treat canopies as opaque and is considered less time-consuming to collect in the field than PFC.

The two systems rely on slightly different criteria, for example height, cover and structural formation classes are not consistent. As a consequence once areas are mapped using the respective approaches, resultant maps are not directly comparable. Another factor to consider when classifying vegetation is the concept of 'real values' versus 'predefined classes'. The Braun-Blanquet (1932) cover abundance scale has also been used in the Northern Territory and is designed for estimating species abundances. This method is modified from Mueller-Dombois and Ellenberg (1974) and does not define actual cover values, making it difficult to relate vegetation data to other classification systems.

During the compilation of national, State and Territory vegetation datasets for the Australian Native Vegetation Assessment (NLWRA 2001), the NVIS framework had difficulty comparing and joining datasets, because of the different classification systems underpinning them, and the need for national vegetation guidelines was recognised. The opportunity also arose to revise vegetation chapters of the 'yellow book' vegetation – guidelines for site-based survey (Walker & Hopkins 1990) and 'blue book' vegetation – guidelines for conducting surveys (Pedley 1988) and replace them with Hnatiuk et al. (in press) and Thackway et al. (2008) respectively. This strategic opportunity was supported by NVIS developers.

The national vegetation guidelines can be applied to native (including rainforest) and non-native vegetation. Wetlands and rainforests are treated as a separate classification within the national guidelines. Wetlands are defined by the Ramsar Convention (Anonymous 1994) and rainforests include two special cases separately 1) tropical and subtropical rainforests, and 2) Tasmanian rainforests. Due to structural complexity these two varieties of rainforest may be sampled using either standard classification or methods supplemented with extra structural attributes. Dry rainforests in the Northern Territory, Western Australia and parts of Queensland, and temperate rainforests in south eastern mainland Australia are classified using standard methods. The guidelines also include procedures to add more detail by assessing growth stage and condition.

Northern Territory approaches to vegetation survey and mapping

The Northern Territory occupies 18% of Australia and covers a range of environments and climatic regimes. In comparison to other States and Territories, it still retains large areas of uncleared native vegetation, and although not pristine, can be regarded as relatively intact and not fragmented. The environments range from wet/dry tropics in the north to semi-arid and arid regions in central Australia. The patterning of vegetation generally becomes broader as it progresses north to south, particularly from 18° south.

Many agencies within the Northern Territory and Commonwealth governments, universities and private industry are responsible for collecting vegetation data for an array of purposes including map unit interpretation, monitoring, flora and fauna surveys, carbon sequestration and environmental impact assessments. Applications for vegetation information include park management plans, habitat recognition, land cover change, mine site rehabilitation, vegetation retention for biodiversity conservation and to implement the Northern Territory land clearing regulations and controls (NRETA 2006).

Overall, vegetation information in the Northern Territory has been collected, described and classified using different methods and classification systems. Vegetation information can be categorised into site-based data and map unit data (vegetation mapping datasets). Map unit data across the Northern Territory comprises vegetation mapping and integrated surveys. There are two types of integrated surveys; land unit (finer spatial scale) and land system (broader spatial scale) surveys. A land unit is defined as a reasonably homogenous component of the land surface, distinct from surrounding terrain and is characterised by landform, soil and vegetation (Hooper 1970). Land systems are defined as an area, or group of areas throughout which there is a re-occurring pattern of topography, soils and vegetation, a term first described by Christian and Stewart (1953). Each land system is recognised as an assemblage of land units.

Site-based approaches

Ecological surveys prior to the 1950s were rare and botanical collections provide the only access to vegetation site-based data. Also limited published information on Northern Territory flora was available and the lack of taxonomic literature made site-based survey difficult.

Numerous sectoral groups collect site-based vegetation data for ecological, pastoral, biodiversity and botanical purposes. Attributes collected at sites generally incorporate floristic composition, structural characteristics and environmental information. However, the data collected by the different sectoral groups often varies in terms of attribute information, level of detail and classification system used.

The Department of Natural Resources, Environment and the Arts (NRETA) administers several divisions who are primary collectors of vegetation information. The Land and Vegetation Branch are the main collectors of site-based vegetation data to underpin vegetation mapping and integrated surveys. Current site-based data incorporates full floristics and structural characters including cover, height and growth form with a strong emphasis on strata. Other NRETA divisions collect and describe vegetation data with less emphasis on strata and species dominance. Data is generally collected in conjunction with fauna surveys for habitat recognition. Data collected by the Northern Territory Herbarium is primarily for floristic inventories, rare and threatened species records and taxonomic treatments. Associated data incorporates minimal structural characteristics and broad descriptive information (Brocklehurst 2003).

Map-based approaches

The first systematic vegetation survey and mapping in the Northern Territory was instituted by the Conservation Commission (now NRETA) following a feasibility study (Dickinson & Kirkpatrick 1985). Recommendations from this study resulted in formation of the Vegetation Mapping Unit, an autonomous group to develop a vegetation mapping program for the entire Northern Territory. The program resulted in a vegetation map at 1:1 000 000 spatial scale (Wilson et al., 1990) recognising 112 broad vegetation communities delineated from satellite imagery and numerical classification of 2 245 sites sampled for floristic and structural attributes. This information provided an ecological perspective of the Northern Territory and assisted with the bio-geographic regionalisation and other broad scale applications.

Another widely used vegetation map is the vegetation map of Northern Australia (Fox et al., 2001). Vegetation was mapped at 1:2 000 000 spatial scale across the tropical savanna region of Western Australia, the Northern Territory and Queensland. The map was compiled from existing and new information. This dataset has numerous applications one of which was to fill information gaps in the Australian vegetation database (NVIS).

Since the mid 1980s numerous local and regional scale vegetation maps with spatial scales ranging from 1:5 000 to 1:250 000 have been produced for small geographic areas. Figure 1 shows discrete area vegetation mapping datasets. Specific vegetation mapping datasets are not portrayed, although they do exist across particular regions and largely include vegetation mapped by genera or species and vegetation such as mangroves and monsoon rainforest. The mapping of structural characteristics such as PFC also exists across the Top End (Meakin et al., 2001). Less than 1% of the Northern Territory's vegetation is mapped at a spatial scale of 1:50 000 or less and approximately 7.5% either 1:100 000 or 1:250 000 (Table 1).

The most up-to-date vegetation dataset is NTNVIS (Version 3), a derivative of the national NVIS (Version 3) dataset. It includes both a pre-European (pre development) and present vegetation data and recognises 174 distinct vegetation types. Essentially NTNVIS is an amalgamation of the 1:1 000 000 vegetation mapping (Wilson et al., 1990) and finer spatial scale datasets and therefore contains a range of spatial scales. The attribute information is consistent for all surveys and is contained in the NVIS oracle database. Publicly accessible versions of NTNVIS (Version 3) are attributed with a subset of NVIS attributes, namely the NVIS Information Hierarchy. The Information Hierarchy is based on six levels of structural and floristic information. The threshold for input of vegetation description data into the NVIS database is NVIS Level V (Association) (Appendix 1).

The NTNVIS dataset is the Northern Territory component of NVIS. Since 1999, a number of data supplies from each State and Territory have occurred leading to a number of NVIS versions. Version 3 is based on data collated in 2005, Version 2 contains detailed Level V (Association) data following a restructure of the NVIS database and Version 1 is the original NVIS supply released in 2001.

The benefits of using NVIS are various. Standardisation of vegetation descriptions provide a basis to compare datasets with different mapping methods and/or spatial scales and assist in identifying equivalent vegetation. Users of Northern Territory vegetation mapping datasets are encouraged to use the NTNVIS (Version 3) dataset.

Several applications of the original 1:1 000 000 vegetation map and NTNVIS dataset has highlighted the importance for finer spatial scale vegetation mapping across the Northern Territory. In particular, the reservation status assessment of vegetation recognised 1:1 000 000 as coarser than desirable for reserve planning (Woinarski et al., 1996), and recommended spatial scales of 1:100 000 or 1:250 000. Limitations are most profound for vegetation which occur in small isolated patches such as monsoon rainforests (Price et al., 1995). There has been no comprehensive and systematic re-mapping of vegetation in the Northern Territory since the production of 1:1 000 000 vegetation map in 1990.

Table 1. Vegetation spatial mapping scales in the Northern Territory (Brocklehurst pers. com.).

Spatial scale	Area km^2	% NT Coverage	Significance	Datasets
≤ 1:50 000	7 662	0.6	Local*	Various
1:100 000 -1:250 000	100 898	7.5	Regional*	Various
1:1 000 000	1 346 200	100	National	1:1 000 000 pre-European NT vegetation map
1:100 000 – 1: 1 000 000 mixed scale	1 346 200		National/Regional	NVIS Version 3.1 pre-European NT vegetation map & NVIS Version 3.1 present vegetation map

* approximately 8% of Northern Territory mapped at regional or local spatial scales

Integrated surveys

Aside from vegetation mapping, integrated surveys, describing landform, soil and vegetation within one map unit, have dominated land resource mapping. Land units are typically generated at spatial scales between 1:25 000 and 1:100 000 and land systems between 1:100 000 and 1:250 000 (Fig 2). Traditionally the primary focus of integrated surveys was to identify agricultural soil landscapes whilst taking into account other landscape features such as vegetation (Aldrick & Robinson 1972). Vegetation attributes for integrated surveys were not generally described at the same level of detail as soil landscape properties. vegetation attributes in earlier surveys comprised structure and dominant species in all characteristic strata.

The first integrated surveys were conducted by CSIRO in 1946 in the Katherine and Darwin region and the approach continued to target important pastoral regions across the Northern Territory. In the late 1960s, the Northern Territory Government adopted the land system approach developed by CSIRO and progressed a unique land unit method to describe and map landscapes (Hooper 1970; Laity 1971).

Integrated surveys in the Northern Territory are still undertaken where pedologists and ecologists concurrently record information at identical field sites. The level and quality of vegetation data varies according to project aims and staff availability. In the past, at least a qualitative assessment of structural characteristics and dominant species were recorded. Over the past decade surveys have incorporated full floristics, structural characteristics and physiognomy (Hill 2004; Napier & Steen 2002). These and future integrated surveys, if not already, will be compliant with Northern Territory and national vegetation guidelines for collecting, classifying and mapping vegetation.

Core attributes and vegetation information infrastructure

The development of national vegetation guidelines has been a key driver towards addressing current vegetation information infrastructure in the Northern Territory. Vegetation site-based databases are the basis of vegetation mapping programs largely to classify vegetation and assist in providing map attribution. Upon completion of a vegetation

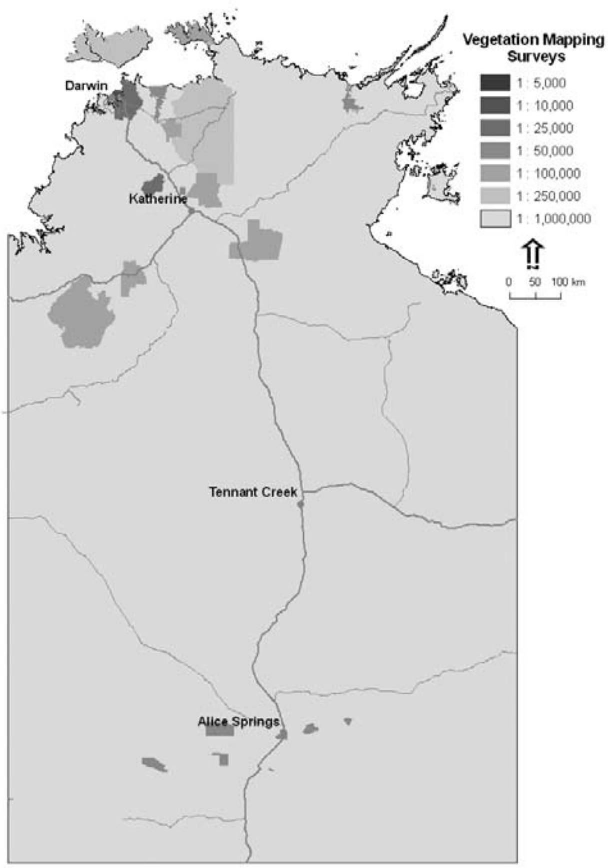

Fig. 1. Extent of discrete area spatial scale vegetation mapping surveys in the Northern Territory.

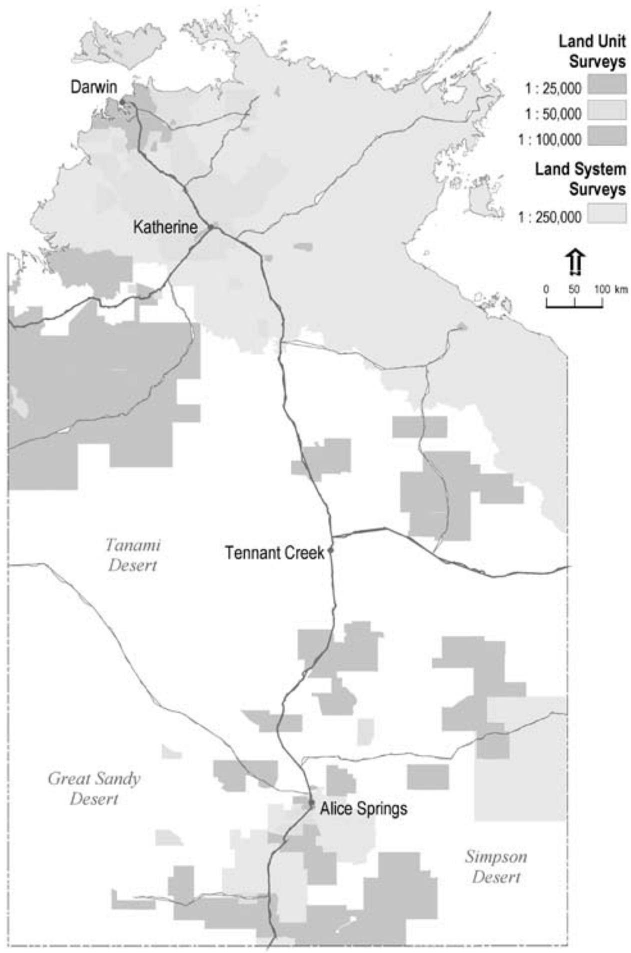

Fig. 2. Extent and spatial scales of integrated surveys in the Northern Territory.

map, these datasets become part of a corporate spatial data archive. Datasets are made available to users including the public via servers and web-based applications.

Core attributes have been developed for collecting and compiling site-based and map unit vegetation datasets. The aim of these is to promote consistency between agencies collecting data and increase data sharing capacity. Core attributes attempt to reduce data entry, simplify querying vegetation information across adjoining surveys and assist the Northern Territory with national reporting requirements.

Site data

Numerous site-based databases are maintained by various government agencies. An inventory was undertaken in 2003 primarily to asses the feasibility of historic site data to generate a listing of vegetation types in the Northern Territory (Brocklehurst 2003). The inventory assessed and compiled information on site data location, number of sites and an estimate of site detail and quality for approximately 250 surveys and over 30 000 sites. The inventory suggests approximately 66% of site data are stored electronically. The majority of sites are digital with about 56% collected in conjunction with mapping programs (Brocklehurst 2003). The digital site data is stored in a number of different software packages and applications maintained by several custodians. The inventory also showed there is no centralised vegetation site database in the Northern Territory, nor is there an agreed set of attributes. There are number of major impediments including no standard definition of attributes, some data is non digital (paper copy), detail of existing data varies and data continues to be collected, described and stored inconsistently.

The existing Resource Assessment Vegetation System (RAVS) Oracle database maintained by NRETA's Land and Vegetation Branch is currently being redeveloped. The intention of the web-enabled database is to become the centralised repository for Northern Territory vegetation site-based data. The database will be developed to allow government and non government custodians to view, enter, edit and retrieve data for particular surveys across the Northern Territory. Surveys existing in the database are consistent with national vegetation guidelines and the NVIS framework.

Contained in the database are mandatory fields that incorporate core attributes divided into five categories (Lewis et al., 2007b) (Table 2). Core attributes ensure data across surveys are comparable. The number of fields within each category at a given site is constant with the exception of the 'stratum' field. The number of fields for 'stratum' are dependent on the number of strata identified at a given site location. Up to eight sub-strata may be identified based on the NVIS framework; traditionally up to three are recognised in the Northern Territory.

Map unit data

Completed vegetation surveys and mapping datasets including reports are stored and managed in an oracle dissemination database on behalf of the Northern Territory's data custodians including government and non government agencies and the general public.

Table 2. Northern Territory vegetation site data core attributes.

Core Attribute Category	Field Code	Field Name
1) Survey	SURVEY_NAME	Survey Name
	SURVEY_ID	Survey Identifier
	SITE	Site Number
	DATE	Site Sample Date
2) Location and Geo-referencing	LONG	Latitude
	LAT	Longitude
3) Landform	LAND_PAT	Landform Pattern
	LAND_ELE	Landform Element
4) Broad Vegetation	NVIS_CODE	NVIS Structural Formation Code
	STRU_FORM	Structural Formation
	COM_ DESC	Vegetation Community Common Language Description
5) Stratum	GRTH_FORM	Dominant Growth Form
(Information is recorded for each identified Strata U, M, G	COV_TYPE	Cover Type
	COV_%	Cover Percentage
OR Sub-strata U1, U2, U3, M1, M2, M3, G1, G2)	HGT_TYPE	Height Type
	HGT_AVE	Height Average
	HGT_RANGE	Height Range
	SPECIES	Dominant Species List

Source: Lewis et al. (2007b)

Mapped vegetation datasets are one of many natural resource datasets that are archived. The archive includes digital vegetation datasets of surveys in various formats and at specific spatial scales. Accompanying reports, maps and in some situations interpretive maps are available. A digital data summary and a link to metadata describing each dataset are provided. External users to Northern Territory Government agencies can access data via digital data agreements.

Portions of spatial data maintained on the spatial archive are made available on a web enabled mapping application called NRETA Maps www.nt.gov.au/nretamaps.

The primary purpose of this application is data discovery and interrogation of natural and cultural resource data and information available to Northern Territory Government agencies and the general public. Themes currently available include vegetation, land, water, parks and wildlife, biodiversity, maps, reports and projects. Also included are base layers such as topography, land administration, infrastructure, satellite imagery and aerial photography and offers several functions including basic downloads and map creation.

Core map unit attributes are derived partly from the NVIS Information Hierarchy, a subset of the NVIS attribute entirety with thirteen attributes defined (Lewis et al., 2007a) (Table 3). The NVIS Information Hierarchy is the chief system for describing structural and floristic information. Collectively, the different levels in the hierarchy provide a description of vegetation linked directly to precise spatial areas on a vegetation map.

Historic mapping datasets that are not incorporated in NTNVIS (Version 3) require core attributes to allow comparability across survey boundaries. To assist in this process a program has been developed to build the NVIS Information Hierarchy from structural and floristic components. The first vegetation survey attributed with the NVIS framework core attributes is the Stray Creek Catchment Vegetation Survey (Lewis 2005). Datasets attributed with map unit core attributes are available on NRETA Maps www.nt.gov.au/nretamaps.

The way forward is for existing surveys and in some instances integrated surveys to be assigned core attributes and be available on the NRETA spatial data server and NRETA Maps. Future vegetation surveys should first be entered into the NVIS oracle database currently being developed.

Discussion

Spatial scales, currency and limitations in Northern Territory mapping

Under the national vegetation guidelines and NVIS framework, the Northern Territory is divided into two mapping zones. The intensive land-use zone (ILZ) occupies most of north-west portion of the Northern Territory and includes major urban areas, peri urban areas as well as agricultural and pastoral zones covering Darwin, Pine Creek and Victoria River District (VRD) bioregions. The extensive land-use zones (ELZ) cover the western portion of the Top End and southern arid regions of the Northern Territory and include aboriginal lands and pastoral areas.

Benchmarks for vegetation mapping spatial scales include 1:100 000 or better in the ILZ and 1:250 000 in the ELZ. Likewise benchmarks for currency are 12 months for priority vegetation including wetlands, riparian and remnant vegetation and 18 months for agricultural lands (ILZ) and pastoral/rangelands (ELZ). Table 4 shows that the current status of Northern Territory vegetation datasets do not meet national benchmarks.

The most recent Northern Territory wide vegetation mapping dataset is NTNVIS (Version 3) discussed previously. The finer spatial scale mapping datasets incorporated are generally of discrete or lineal closed forest vegetation. Large areas of the Northern Territory still remain mapped at 1:1 000 000 and currency of circa 1986. In comparison to other States and Territories, the Northern Territory vegetation mapping remains at the broadest of spatial scales. The smaller more developed and populated States have finer spatial scale datasets (Table 5).

The Integrated Natural Resource Management Plan (INRM) identifies the importance of vegetation information in the Northern Territory to satisfy both regional objectives and national outcomes (DIPE 2005). The INRM and the Northern Territory Parks and Conservation Master Plan (NRETA 2005) recognise the limitations of the 1:1 000 000 spatial scale vegetation map and NTNVIS (Version 3) dataset for regional applications. The need for finer spatial scale mapping of vegetation across the Territory has been identified. Thus a Natural Heritage Trust (NHT) funded NRM project and working group are currently addressing this issue (Brocklehurst pers. com.).

Northern Territory guidelines, knowledge and adoption

The need for consistent vegetation data collection, storage, description, classification and mapping was recognised by the Northern Territory Government following the Australian Native Vegetation Assessment 2001 (NLWRA 2001). To address these limitations guidelines and core attributes have been developed (Brocklehurst et al., 2007) consistent with national vegetation guidelines and NVIS. These guidelines promote the use of standardised methods, procedures and terminologies on vegetation survey and mapping and will be revised in parallel with national standards as they become available. The guidelines are obtainable via the NRETA website www.nt.gov.au/natveg.

A series of regional seminars and workshops were delivered in tropical and arid climatic zones of the Northern Territory to promote knowledge and adoption of national standards. Linkages of Northern Territory and national vegetation

Table 3. Northern Territory vegetation map unit core attributes.

Field Code	Field Name
DATASET_ID	Dataset Identification
NVIS_DATA	NVIS Dataset
NVISVEG_ID	NVIS Vegetation Identification
SOUR_CODE	Source Code
NTMU_ID	Northern Territory Map Unit Identifier
SPA_MIX	Spatial Mix
COM_DESC	Community Description
L1_CLASS	Level 1 Class
L2_STR_FOR	Level 2 Structural Formation
L3_BR_FLR	Level 3 Broad Floristic Formation
L4_SUB_FOR	Level 4 Sub-Formation
L5_ASSOC	Level 5 Association
(if fields are too long the following split applies)	
L5_ASSOC_U	*Level 5 Association Upper*
L5_ASSOC_M	*Level 5 Association Mid*
L5_ASSOC_G	*Level 5 Association Ground*
EN_DESC	Environmental Description

Source: Lewis et al. (2007a)

guidelines and NVIS were discussed. Participants included ecologists from Northern Territory, South Australia and Commonwealth government agencies, and non government agencies including environmental consultants, universities and landholders. Proceedings are available on the NRETA website www.nt.gov.au/natveg Seminars and Workshops.

Conclusions

Considerable progress has been made in the Northern Territory towards adopting and implementing national vegetation guidelines and the NVIS framework. Through strategic investment by the Northern Territory Government, vegetation information will continue to become available through the provision of accessible and NVIS compliant vegetation spatial data, information databases and web-enabled applications.

Regularly updated Northern Territory guidelines, in line with national guidelines, will encourage consistency in the future collection, classification, description and storage of vegetation information. This information will assist future finer spatial scale vegetation mapping across the Northern Territory and consequently improve on the NTNVIS (Version 3) dataset. The integration of Territory programs dealing with spatial aspects of vegetation will deliver information on proposed national initiatives such as vegetation extent and condition.

Table 4. Spatial scales and time frames for Northern Territory vegetation mapping datasets (Brocklehurst pers. com.).

Type	Nationally recommended spatial scales	NT datasets	NT spatial scales	Time frames	% NT
Wetlands, Riparian, Remnant, Priority Vegetation Types	1:25 000	Paper bark forests (*Melaleuca spp*)	1:100 000	1991	7.4%
		Monsoon rainforests	1:100 000 -1:250 000	1986	
		Mangroves	1:100 000	2001	
		Lancewood (*Acacia shirleyi*)	1:100 000 -1:250 000	1992	
		Wetlands*	1:250 000		
		Clearing dataset	1:100 000	2005	
Agricultural Lands: Intensive Landuse Zone	1:100 000	As above or	1:100 000 - 1:1 000 000	1986-1991[#]	40%
	1:50 000 (preferred)	NTNVIS Version 3			
Pastoral/Rangelands: Extensive Landuse Zone	1: 250 000 1:100 000 (preferred)	NTNVIS Version 3	1:1 000 000	1986	52%
Other fine spatial scale vegetation datasets		Stray Creek, Popham Creek, Bynoe Harbour etc	≤1:50 000	1990-2005	0.6%

* defined boundaries only

[#] vegetation component - clearing circa 2005

Table 5. Vegetation spatial mapping scales and proportional areas and populations for Australian States and Territories (Brocklehurst pers. com.).

State/Territory	Predominant spatial scale	Extent	Management scale	Predominant Mapping Type	% of Australia	% of Aus Population
Australian Capital Territory	≤ 1:50 000	100%	local	vegetation	0.04	1.7
New South Wales	1:25 000 - 1:250 000	60%	regional/local	vegetation	10.5	33
Northern Territory	≤ 1:1 000 000	100%	national/regional	vegetation	17.5	0.9
Queensland	1:100 000 -1:250 000	90%	local/regional	ecosystems	22.5	18
South Australia	1:50 000 -1:250 000	90%	regional/local	vegetation	13	8
Tasmania	1:25 000 - 1:100 000	100%	local	vegetation	0.8	2.6
Victoria	1:25 000 - 1:250 000	100%	local	ecological vegetation classes (EVC)	3	24.6
Western Australia	1:250 000	100%	regional	vegetation	33	9.6

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Appendix 1. The NVIS Information Hierarchy.

Level	Description	Species	Growth form	Cover	Height
I	**Class***	-	1 dominant growth form for the dominant stratum	-	-
	Example	*Tree*			
II	**Structural Formation***	-	1 dominant growth form for the dominant stratum	1 cover class for the dominant stratum	1 height class for the dominant stratum
	Example	*Open woodland*			
III	**Broad Floristic Formation****	1 dominant genus name for the dominant stratum	1 dominant growth form for dominant stratum	1 cover class for dominant stratum	1 height class for dominant stratum
	Example	*Eucalyptus open woodland*			
IV	**Sub-Formation****	1 dominant genus name for each stratum (max 3 strata; i.e. for U, M, G where substantially present)	1 dominant growth form for each stratum (max 3 strata)	1 cover class for each stratum (max 3 strata)	1 height class for each stratum (max 3 strata)
	Example	*+Eucalyptus open woodland\Petalostigma tall sparse shrubland\Sorghum tussock grassland*			
V	**Association****	Up to 3 dominant species for each stratum (max 3 strata; i.e. for U, M, G where present)	Up to 3 dominant growth forms for each stratum (max 3 strata; i.e. for U, M, G where present)	1 cover class code for each stratum (max 3 strata; i.e. for U, M, G where present)	1 height class code for each stratum (max 3 strata; i.e. for U, M, G where present)
	Example	*U+ ^Eucalyptus miniata, Eucalyptus tetrodonta, Erythrophleum chlorostachys \^tree\7\r;M ^Petalostigma pubescens, Buchanania obovata, Planchonia careya\^shrub\4\r;G ^Sorghum plumosum, Heteropogon triticeus, Chrysopogon latifolius\^tussock grass\2\c*			
VI	**Sub-Association****	Up to 5 dominant species for each sub-stratum (i.e. for U1, U2, U3, M1, M2, M3, G1, G2 where present) *Indicate characteristic genus in each sub-stratum with an up arrow or hat "^". Must match characteristic growth form.*	Up to 5 dominant growth forms for each sub-stratum. *Indicate characteristic growth form with an up arrow or hat "^". Must match characteristic genus.*	1 cover class code for each sub-stratum	1 height class code for each sub-stratum
	Example	*U+ ^Eucalyptus miniata, Eucalyptus tetrodonta, Erythrophleum chlorostachys, Corymbia foelscheana, Corymbia polysciada \^tree\7\r;M ^Petalostigma pubescens, Buchanania obovata, Planchonia careya, Livistona humilis, Terminalia grandiflora\^shrub,palm,tree\4\r;G ^Sorghum plumosum, Heteropogon triticeus, Chrysopogon latifolius, Distichostemon hispidulus, Erythrophleum chlorostachys\^tussock grass,forb,tree\2\c*			

* Walker & Hopkins 1990
** NVIS (defined for the NVIS Information Hierarchy)
U – Upper stratum, M – Mid stratum, G – Ground stratum (1, 2 & 3 indicates sub-stratum)
+ denotes dominant stratum
^ denotes dominant species and dominant growth form in each identified stratum
+/- indicates a species may or may not be present

Source: ESCAVI (2003)