THE NSW STATE VEGETATION MAP

A regional scale map of the NSW PLANT COMMUNITY TYPES

A Description of the Mapping Method

Version 3

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# Table of Contents

Revision Notes .................................................................................................................. 3  
INTRODUCTION .................................................................................................................. 4  
BACKGROUND .................................................................................................................... 5  
Intended Purpose of the *State Vegetation Map* .............................................................. 6  
ABOUT THE OEH METHOD AND ITS DEVELOPMENT PATHWAY ................................ 9  
Four Comparative Mapping Methods in NSW ................................................................. 10  
THE NSW GOVERNMENT OPERATING PRINCIPLES ....................................................... 16  
THE MAPPING PROCESS SCHEMATIC ............................................................................ 17  
METHOD DETAILS ........................................................................................................... 20  

## MODULE ONE: ACQUIRE FIELD AND TYPE DATA ...................................................... 20  
M1.1: Acquire existing plots and suitable Plant Community Types .................................. 20  
M1.2: New survey design and sampling .......................................................................... 22  

## MODULE TWO: ACQUIRE SPATIAL DATA ................................................................. 23  
M2.1: Acquire existing environmental layers .................................................................. 23  
M2.2 Acquire existing imagery ......................................................................................... 24  
M2.3: Acquire existing native vegetation mapping ........................................................ 26  

## MODULE THREE: CLASSIFICATION ANALYSIS ....................................................... 27  
M3.1: Vegetation community compilation ....................................................................... 27  
M3.2 Plot equivalences ..................................................................................................... 28  
M 5.1 Validation data set .................................................................................................... 29  

## MODULE FOUR: SPATIAL ANALYSIS ........................................................................ 30  
M4.1 Stratification ............................................................................................................ 30  
M4.2 Predictive layers ...................................................................................................... 31  
M4.3 Image Object segmentation ..................................................................................... 32  
M4.4 Assessment and Equivalence of legacy mapping ..................................................... 34  

## MODULE FIVE CLASSIFICATION PRODUCT DEVELOPMENT ................................... 35  
M5.2 Descriptions of vegetation map units ....................................................................... 35  

## MODULE SIX SPATIAL PRODUCT DEVELOPMENT .................................................. 36  
M6.1 Mapping Layers ...................................................................................................... 36  
M6.3 Expert Input ............................................................................................................ 42  
M6.4 User Acceptance testing and Evaluation .................................................................. 42  

## MODULE SEVEN REPORTING ...................................................................................... 43  
M7.1 Technical Reporting ................................................................................................. 43  

## MODULE EIGHT GEODATABASE AND UPLOADING TO VIS ..................................... 44  
M8.1 Geodatabase ............................................................................................................ 44  
M8.2 Uploading Mapping Outputs ................................................................................... 45
Revision Notes

Initial release and review by NSW Vegetation Information and Mapping External Scientific Advisory Committee (VIMESAC) - December 2013

First Revision February 2014

Second Revision February 2015

Updates to the method have been adopted where new data; tools; computing capacity or best practice techniques become available that enable mapping outputs to be enhanced, improved or provided in a more efficient or meaningful way.

Revision 2 Updates to this Method are shown in a highlighted text boxes.
INTRODUCTION

The purpose of this document is to describe the systematic approach to vegetation mapping that has been developed by the Office of Environment and Heritage.

The design of the *State Vegetation Map* is underpinned by principles outlined in the *Native Vegetation Interim Type Standard*¹.

The Standard defines the nature and quality of the scientific processes to be used for native vegetation type activities including remote sensing interpretation, field survey, data manipulation, data management and mapping.

Progressive delivery of the State Vegetation Map will coincide with improved descriptions of Plant Type Communities for NSW. The NSW approach to vegetation classification aggregates native plants into a foundational unit (called a Plant Community Type or PCT) which is a unit of sufficient detail to differentiate parts of the floristic landscape by describing the nature, relative differences and significance of the native vegetation within them. Adopting this standard classification unit allows all native vegetation in NSW to be described in a common language and become the key linkage between many different environmental management objectives.

The list of NSW PCTs is being continuously improved with ongoing projects of mapping, survey and expert review and data analysis. The prime objective is to improve the overall quality of the listed PCTs through integrated and transparent association to the data gathered at sites used to define them, to eliminate duplication, improve usability for environmental assessment and facilitate more effective mapping of their distributions. Initially this will involve resolving overlap issues around several large adjoining datasets and filling of remaining gaps. This necessarily may involve re-analysis of the indicative plant species patterns where required, to ensure there is an appropriate and consistent level of classification.

The *State Vegetation Map* is intended to show the distribution of as many as possible of the approved list of NSW Plant Community Types (PCTs) across NSW in a consistent manner and at a regional level of detail. Some PCTs currently lack adequate site data which can limit opportunities to map or model their distribution.

Complimentary fine scale mapping and survey will be required to address needs for higher levels of detail and certainty for targeted areas but this will also progressively incorporated to improve the whole state map.

The mapping approach developed by OEH has evolved by adaptive management, applied research and practical experience. These processes will continue to influence the Method so that there is constant improvement to the quality and consistency of map outputs.

¹ *Native Vegetation Interim Type Standards*
BACKGROUND

NSW Vegetation Classification Standard

In NSW, assemblages of plant species that often grow together, known as plant communities, are classified at different levels. The NSW standard for the state-wide vegetation classification allows the description of native vegetation at three levels of a hierarchy: Formations (16 in NSW), Classes (99 in NSW) and Communities (~1500 in NSW).

Simplifying and distilling the complex patterns of vegetation classifications into a hierarchy of vegetation communities is important to understand patterns of floristic diversity in the landscape and, in turn, to communicate fundamental information about the environment such as where natural resources and particular plants and animals are likely to be found within a landscape.

Vegetation community classification and the mapping sit alongside other government programs which use remote sensing technology to map overall change in vegetation extent, cover and condition.

The design of the State Vegetation Map is underpinned by:

• **Native Vegetation Interim Type Standard (Sivertsen 2009)** (the Standard) – a technical resource and guide for native vegetation mapping practitioners to ensure that vegetation data, information, classification and mapping undertaken across NSW meets identified benchmarks for quality and consistency. The Standard is available on the DECCW website: www.environment.nsw.gov.au

• **NSW Plant Community Type** (PCTs) – a master NSW plant community list for NSW. The plant community list is part of the NSWVIS (see below).

• **NSW Vegetation Information System** (NSWVIS) – a secure database for all NSW native vegetation information incorporating the single point of reference NSW plant community list and the central repository for all vegetation mapping products.
**Intended Purpose of the State Vegetation Map**

Historically, native vegetation mapping in NSW has been undertaken in discrete areas and for quite particular purposes. Localised mapping can provide useful information and can be adapted to meet the needs of many applications and users. However, use of bespoke or location specific vegetation classifications to describe vegetation can make wider integration and adaption to legislative purposes very difficult.

In order to form a comprehensive view about the significance of any given vegetation type, its context relative to the state, regional or local level is important.

The primary objective for completing a *State Vegetation Map* is to enable people and the government of NSW to have a more complete understanding about the nature, differences, likely location and relative significance of native vegetation using a single common list of plant communities.

An understanding of mapped attributes, their providence and mapping limitations are important for properly interpreting and using mapped products and gaining confidence in their accuracy.

The *State Vegetation Map* is therefore intended to show the distribution of NSW Plant Community Types (PCTs) across NSW at least at a regional level of detail.

Complimentary fine scale mapping will be needed in particular locations or to address emerging or strategically important issues. Primarily to achieve higher levels of accuracy and reliability or capture additional details such as disturbance, habitat features or condition metrics.

Achieving a complete *State Vegetation Map* will:

- Facilitate more integration across decision support tools;
- Identify where the NSW PCTs are most likely to be present in the landscape with a defined scale level of precision and confidence (regional as a minimum);
- Provide a new baseline vegetation layer for NSW that can be progressively and systematically updated.
- Provide a complete state-wide picture to prioritise investment in management and conservation of the native vegetation of NSW.

Progressive delivery of the State Vegetation Map will simultaneously integrate strategic improvements and changes to the approved list of Plant Community Types for NSW.
Vegetation mapping has a range applications:

**Assist with property or site level assessments**

This is generally the finest level of formal planning. It may involve, for example, development application assessments, property vegetation planning or site rehabilitation planning.

Information about plant communities, such as likely species composition, condition and legal status, particularly presence of Endangered Ecological Communities (EECs) requires relatively high accuracy and reliability at fine scale detail. Habitat suitability based on composition, presence and abundance of exotic species, canopy status and overall structural integrity etc is also required at this level. Fine-scale mapping, undertaken strategically in NSW is intended to primarily meet this need supported by detailed site surveys.

However, it should be noted that the apparent need for fine scale mapping for site assessment can be over-emphasised and lead to a perception that site assessment can be replaced by any form of remote assessments. Fine-scale mapping infills and the baseline State Vegetation Map intentionally depict information about Plant Communities at a fine-scale and regional scale respectively. While both depict native vegetation their main use however is to assist preliminary information gathering prior to site visits, not to provide absolute site level certainty for decision making.

Site - level certainty (accuracy and resolution) of any mapping may be relatively high where specific on-site information has been collected and used for site attribution. However, to put this into perspective, only a very small fraction of 1% of all possible vegetated sites across any sizable mapping extent are ever likely to have been visited and documented.

Without exception, both fine and regional scale mapping relies on sampling and extrapolation science. This science involves taking values from known sites (survey data, patterns or attributes), and using a combination of visual and/or computer-assistant methods to locate similar sites elsewhere. These methods involve different levels of certainty depending on the relative 'fit' between sites. The Standard seeks to ensure that minimum standards for certainty are met for all mapping methodologies.

**Localised or Sub-regional Investigations**

These involve broader native vegetation information needs such as assessment of the local significance of communities, local conservation planning, offsetting, assessing the local context of developments, bush hazard reduction planning and new reserve acquisition.

At this level, broader information about the local distribution and composition of communities is required with a reduction in emphasis on site detail. Information includes the likely distribution of significant communities and species, Endangered Ecological Communities (EECs) and threatened species, broader functional classes or groups of communities for bushfire planning and threat assessment. The ability to assess connectivity and patch characteristics is also important at this level.
It is important that communities used to describe vegetation at each level is the same as or an explicit local variant of those used at broader levels.

Some reduction in accuracy and resolution can be expected relative to regional-scale mapping at this level.

The State Vegetation Map can contribute valuable information at this level by providing local context for PCTs such as relative abundance, patch size, canopy densities and indications of likely EECs - through documented associations between PCTs and EECs.

**State and Regional Analysis and Prioritisation**

These may include strategic land use plans, green corridors and strategic biodiversity planning and Catchment Plans. These are the primary focus of the comprehensive *State Vegetation Map*.

At this level broader information about the distribution of communities is required to describe relative rarity/irreplaceability of communities, landscape connectivity and support broad scale conservation planning and prioritise investment in conservation and other natural resource management initiatives. Pre-clearing extent estimates are also often used at this level as a part of assessments of community significance.

These tasks still require a consistent set of vegetation communities that can be used as a surrogate for a region’s biodiversity values. Species composition is still important at this scale, particularly for development of secondary products such as habitat models. Lower levels of accuracy and resolution can be expected at this scale - delineation of communities need not be as fine and in some cases, communities delineated can be combinations of those used at finer scales.
ABOUT THE OEH METHOD AND ITS DEVELOPMENT PATHWAY

Contemporary vegetation mapping uses many approaches and technologies depending on the required outcomes, including:

• Detailed field measurements (plot surveys)
• Rapid site observations
• Local expertise and knowledge
• Expert panels
• Botanical compendia
• Derived maps based on abiotic features (soil, slope, rainfall etc)
• Feature recognition techniques
• GIS derived spatial information based on computer modelled data
• Remote sensing (including aerial photography and satellite imagery) spectral analysis and interpretation
• Use of dynamic geodatabases.

In most cases a combination of methods and technologies are used. For example, site familiarisation, survey plots, imagery interpretation, classification, interpolation, cartography and local expert knowledge are required by the Interim Native Vegetation Type and Mapping Standard. In recent years, four methods have been typically used for native vegetation mapping in NSW, summarised below.
Four Comparative Mapping Methods in NSW

1. Observational API Mapping

This method uses air photo interpretation (API) and *a priori* classification. Practitioners collect site information formally and intuitively by traversing accessible landscapes. They visually interpret patterns in 2D or 3D from film photography or digital high resolution imagery to manually draw boundaries around and attribute each individual patch of a vegetation classification unit.

- **Advantages:**
  - With skilled and experienced practitioners can deliver products of exceptional accuracy particularly with very high resolution digital aerial imagery
  - Mapping relates to a relatively common imagery base that is used for other mapping products.
  - Features are visually intuitive (smooth and organic looking shapes)
  - Botanically trained and experienced operators can remotely identify communities where they have personal field knowledge.
  - With recent advances in digital aerial imagery, can utilise image band stretch technology to assist operators in discerning vegetation patterns

- **Disadvantages:**
  - Relatively slow process, highly dependent on skill and experience of operators but has recently been improved with digital on-screen capture technology
  - Highly reliant on personal field knowledge.
  - Current digital 3D technology is expensive, has limited availability and the hardware and software environments can be unstable which can markedly slow-down production
  - Technically difficult and reasonably expensive to scale up for larger areas (more operators and equipment) especially with limited time frames
  - Operator inconsistency
    - Scarcity of skilled operators (not a common skill any longer)
    - variability between operators and operator fatigue leads to variable product quality and consistency
  - Currency and comprehensive availability of imagery
  - Lumps up visible patterns (to varying degrees depending on the operator) at the point of creation and therefore cannot be easily disaggregated.
- Tendency to over-map and find detail below that required, particularly in a less scale restricted digital environment.

2. Forest Ecosystem “CRA” Mapping:

This method uses the combination of rapid API (aka CRAFTI) and modelling to produce probability surface maps that can be used for indicative vegetation information of large regional areas.

Depending on the particular Comprehensive Regional Assessment (CRA) region, the approach entailed:

- the derivation of a forest ecosystem classification by splitting and amalgamation of existing SFNSW forest types and floristic data based on analysis of variation between field survey plots in relation to environmental variables; or
- mapping of derived ecosystems within the existing mapped extent, unmapped forest and cleared land by use of decision rules relating variation to abiotic environmental variables; or

The CRA mapping method included an early application of General Dissimilarity Modelling. CRAFTI is still used for identifying candidate old growth forest and rainforest but has proven to be dated and generally unreliable over private lands where less time and effort was afforded at the time of mapping.

Advantages:

- Provides products that support rapid and comprehensive regional decision making where site by site accuracy was not required.
- Efficient for covering large areas
- Facilitated the derivation of a likely pre-1750 extent

Disadvantages:

- Classification was forest type oriented and strongly biased towards public lands (being the objective of the CRA analysis).
- The Forest Type classification was intended more for identifying logging potential not environmental value
- Classification ignored or overly simplified non-commercial or non-forest communities.
- Site precision was low (very limited field validation particularly on private lands)
- Grid derived products were considered very artificial (square edged) and over-stated diversity of distribution (patchwork effect).

3. ‘Full Floristic” mapping:

This method is characterised by:

- A high density, systematic (stratified) and usually tenure-free full floristic site survey;
The NSW STATE VEGETATION MAP

- A quantitative analysis of plot data for derivation of a vegetation community classification for the mapping;
- Manual air photo interpretation for delineation of extent and attribution.

**Advantages:**
- Classification displayed on map relates directly to known field sites with detailed analytical data to define expected floristic patterns.
- Maps produced with this combination of techniques have proven to deliver very high quality mapped information that relates well to the real world.
- Generally consistent and repeatable across wide areas

**Disadvantages:**
- Difficult to relate all patterns visible in API to classifications
- Classification may vary from the state-wide *a priori* classification.
- Full floristic surveys are costly and slow and need high numbers of survey points across a mapping area.
- API inconsistency
  - lack of skilled operators (not a common skill any longer) and not all people can see in stereo
  - variability between operators and operator fatigue leads to variable product quality and consistency

This approach, with contemporary technological improvements, provides the basic method-template for fine-scale mapping in NSW.
4. OEH Regional Scale Mapping Method:

This new approach uses a combination of many of the methods and techniques identified above which have been tailored to fit available technologies, delivery expectations, available funds and contemporary information needs.

- Involves new site survey where required,
- Employs traditional API for components but automates where possible.
- Mapped features are defined via a controlled aggregation of finer detail units. This ‘segmentation’ of the source imagery is initially derived from intrinsic patterns in the imagery and then merged by dissolving boundaries between like entities.
- A customised spectral amplification of vegetative patterns is used to enhance the differentiation of vegetative features.
- Multi-temporal analysis of imagery is used where available to minimise impact of seasonal variations in vegetation growth.
- Attribution of the vegetation community classification is primarily determined from a comparison of results from applying an ensemble of different modelling methods (such as a Generalised Dissimilarity Model) to determine the most consistent result between models. Note: attribution can also be overridden by manual or other processes where required.

**Update February 2015**

Pre-classifying of the mapping area is used as a way to constrain modelling outcomes to appropriate ecological boundaries. This is done using semi-automated API (assisted by spectral amplification in some cases), expert decision-rules and existing mapping that are collectively used to assist experts to delineate Landscape Classes and PCT ecological ‘envelopes’.

Some specific PCTs are hand-mapped - where the number of sites is insufficient for modelling, but where they can be reasonably discerned through traditional API.

Where PCTs can be neither modelled nor delineated through API, for regional mapping purposes, they are reported as unmapped.

Source imagery now includes Airborne Digital Scanner (ADS 40/80) where available.
Advantages

- Replaces much of the manual API effort with pattern recognition and automated feature extraction.
- Tends to be more repeatable and consistent across large areas (no operator fatigue)
- Maximises use of existing (often limited) site and survey data
- Integrates underlying source information more directly with end product
- Maps can be more systematically edited with updated site information or guided by having predefined range of candidate types to choose from.

Disadvantages

- Attribution accuracy is highly reliant on site allocation and survey information
- Feature delineation is limited to resolution of main source imagery (for the State Vegetation Map this is ADS40/80 but SPOT5 is still used for some parts of NSW)

The following policy and operational context outlines the adoption of the OEH Regional Mapping Methodology as the preferred approach for the State Vegetation Map.

POLICY CONTEXT

- Delivers outcomes that support the State Plan including natural resource targets for vegetation monitoring, evaluation and reporting,
- Consistent with the NSW Vegetation Type Standard,
- Meets the outcomes sought by the NSW Native Vegetation Mapping Strategy 2009-2013,
- Capable of mapping the distribution of the PCT (where sufficient data is available) for NSW and,
- Mapping methods are consistent, repeatable, transparent and scientifically credible.

Update February 2015

*This Method is consistent with the NSW Office of Environment and Heritage - NSW Native Vegetation Information Strategy 2013-2018.*
OPERATIONAL CONTEXT

- Can be applied anywhere in NSW (depending on government priorities).

SPOT5 imagery currently provides a complete high resolution, multi-temporal coverage of NSW. This has been an ongoing investment made by NSW government to support better natural resource monitoring, evaluation and reporting (including mapping and compliance) in NSW.

**Update February 2015**

*Very high resolution digital aerial imagery (ADS40/80) is the primary image source for map features.*

*Incomplete coverage for NSW and has limited repeat captures.*

- **Is timely and responsive to government and community needs for information.**

The configuration of computer-aided technologies, multi-disciplinary expertise and mapping scale have been specifically configured to map (define landscape patterns, survey and deliver products) for any selected NSW CMA within 12 months using a team of specialists. This configuration makes the selected priority mapped information relevant and timely in relation to government and community information needs. This Method strongly contrasts with traditional approaches that can take up to four times longer to cover the same extent without any assurance of greater certainty.

- **Is affordable and cost effective**

The size of budget required to produce a NSW State Vegetation Map precludes the use of recurrent departmental funding. Accordingly, the mapping approach is tailored to fit a medium size budget allocation from a NSW government external grant program. Each component can be undertaken individually or collectively as a series of overlapping or end-to-end projects.

- **Provides in-depth vegetation information**

The Method has been specifically designed to provide access to the core site and community data that underlies the State Vegetation Map through the VIS online or customised stand-alone versions. This includes exhibiting and making readily accessible attributes such as site floristic, structural values, biometrics, legacy mapping, core landscape patterns, mapped community profiles, environmental and spatial attributes for each mapped unit. The State Vegetation Map includes a hierarchy of mapped information including native, woody, non-native, vegetation community and site values. Some high quality API mapping are also integrated into the State Vegetation Map by adoption of core attribution data.
• **Designed to be updated**

Generations of NSW government investment have been made in native vegetation mapping in NSW. To date only small progress has been made towards complete coverage of vegetation community extent, distribution or description in NSW. Repetitive, competitive and duplicative mapping have been common occurrences in NSW due to poor governance arrangements. New governance arrangement are now in place that address many of the past poor practices and is focussed on delivering comprehensive vegetation information for NSW. The State Vegetation Map is part of a program embedded in the NSW Strategy and Standard to provide the foundation vegetation information set for NSW that can be updated more cheaply, simply and rapidly as new information becomes available.

**THE NSW GOVERNMENT OPERATING PRINCIPLES**

OEH has adopted some key approaches to work within a government context and deliver products that are timely, accessible and credible:

- a standard Geodatabase Schema to form a seamless, thematically consistent state wide coverage;
- an explicit spatial accuracy and attribution confidence;
- align map features accurately with a common image base that is available from NSW government;
- use methods that are consistent, repeatable, transparent, scientifically credible;
- enable flexible mechanisms to promote continuous quality improvement and updates from within OEH and external users
- provide open access to all government held data except where privacy or commercial obligations preclude this.
The OEH *Regional Scale Vegetation Mapping Method* is designed to be as systematic and repeatable as possible to facilitate understanding and repeated application across NSW.

Four recurrent activities characterise the mapping workflow:

1. Acquire
2. Analyse
3. Develop
4. Report

These occur along two interrelated pathways of classification and spatial processing. Refer to Diagram 1: *Vegetation Classification and Spatial Products*.

Each step in the Regional Mapping Method is further explained as a discrete *Module*.

Diagram 2, *State Vegetation Map Process Flow and Inter-relationships* illustrates the interrelationships between the spatial and classification work flows.
Diagram 1: State Vegetation Map Production Schematic
Diagram 2: State Vegetation Map Process Flow and Inter-relationships
METHOD DETAILS

MODULE ONE: ACQUIRE FIELD AND TYPE DATA

The purpose of this Module is to acquire field survey data for evaluation and potential use and to identify existing PCT and other vegetation community types that have resulted from analysis of field data.

M1.1: Acquire existing plots and suitable Plant Community Types

An audit of all relevant classifications of native vegetation PCTs, survey, plots and other candidate vegetation types is undertaken within the project area. Sources include private and public data, Local, State and Australian government.

Survey and type information includes:

- full floristic survey data in a spatial database, including all living vascular flora in area-defined plots,
- rapid survey data, in written or mapped form, describing the composition and/or patterns in vegetation community distribution,
- PCTs from the NSWVIS
- Other classified native vegetation communities based on analysis and interpretation of field data and,
- Other non-empirically based classifications

A number of native vegetation survey datasets are held in the VIS Flora Survey Module (formerly known as YETI). These data comprise geo-located empirical information about the structure and composition of native vegetation at individual survey plots.

The VIS Classification Database holds the master list of native vegetation types for NSW (NSW PCT List). PCT data includes their geophysical, structural and floristic characteristics. The PCT is currently not comprehensive nor definitive as it has been established from a variety of sources and supported by different levels of observed, qualitative and quantitative analysis. They range from detailed floristic survey analysis, through extensive survey and literature review down to simple expert opinion. Broadly PCTs include some 1600 types. There are recognised gaps and duplications within the PCT list that are being progressively resolved.

Accordingly further sources of vegetation survey and classification where available, are assessed for their site data values and/ or for contribution to vegetation community classification. Site information is sought for candidate vegetation communities that have no existing site information (refer M1.2)

Some important plot and plant type information is held by individuals or may be found in published and ‘grey’ literature. Acquisition of these data can be time-consuming and may be strategically limited to those of most importance for mapping purposes.
Plots surveyed before the availability of GPS or during the First Gulf War may be inaccurately geo-located. In extreme cases, where no precisely located plots are otherwise available, site coordinates of pre-GPS plots may be interpreted if sufficiently detailed site descriptions are available with reference to topographic maps and satellite imagery.

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<th>Dependencies and Standards:</th>
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<tr>
<td>- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 2</td>
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<tr>
<td>- Access to OEH Spatial catalogue</td>
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<tr>
<td>- Access to the NSW VIS Flora Survey and Classification database</td>
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<tr>
<td>- OEH only holds (external) field plot data that is legally unconstrained and meets the technical requirements of the OEH Vegetation Information System</td>
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M1.2: New survey design and sampling

The nature and extent of new survey is a function of existing (legacy) survey intensity and quality as well as available funds and survey resources. Survey information can be important in areas for example, that contain little or no previous survey information, complex landscapes or candidate communities lacking documented survey sites.

Two types of surveys are used with the **Regional Scale Vegetation Mapping Method**:

- **Full floristic quadrants** are a prerequisite for quantitative classification of vegetation communities. However they cost from 15 to 20 times that of rapid survey points.
- Rapid survey points are generally used for gap filling and spatial interpolation (mapping coverage).

Full floristic plots are based on systematic stratified random sampling of environmental units, generally on a tenure free basis. In contrast, rapid survey is generally allocated by stratification constrained to the public road network. Methods that maximise the utility of rapid survey are still in development. Their role in characterising whole vegetation communities rather than points is being explored as a means to enhance their role in spatial interpolation.

The **Regional Scale Vegetation Mapping Methodology** is highly reliant upon the availability of legacy full floristic quadrant information held by in the VIS Flora Survey. This often patchy coverage is used both as a source for classification and spatial interpolation purposes. While a preferred source of survey data, new quadrat information is generally cost-prohibitive. Consequently, rapid survey affords an opportunity to collect further basic information where there are gaps in the database.

**Update February 2015**

*The comparative market cost of Full Floristic to Rapid data is currently about 2:1.*

**Dependencies and Standards:**

- Completion of M1.1, M2.1, M2.2, M2.3, M4.1, M4.3 (optional)
- OEH Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 4 and Section 5
- Access to private property is a prerequisite to systematic tenure-free survey.
- Electronic data capture technologies are a prerequisite for new plot data capture.
- Full floristic plots are mandatory for systematic quantitative classification
MODULE TWO: ACQUIRE SPATIAL DATA

The purpose of this Module is to acquire and prepare and in some cases augment existing spatial data in preparation for data analyse.

M2.1: Acquire existing environmental layers

Existing explanatory environmental data may comprise continuous or categorical data. Preferably they cover the regional mapping extent. Shortfalls in coverage or quality may require gap filling by extrapolation, sourcing new data or commissioning revised assessments.

Key layers include soil maps, existing vegetation mapping, geology, the Shuttle Radar Topographic Mission (SRTM) digital elevation model, interpolated climate layers, and magnetic and radiometric layers. The environmental layers that may be used are contingent upon the region of mapping and their availability.

Dependencies and Standards:

- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Appendix 3, Part A
- Access to OEH Spatial Catalogue
**M2.2 Acquire existing imagery**

OEH has an extensive catalogue of imagery. The key resources for regional vegetation mapping include ADS40/80 digital aerial photography, SPOT 5 satellite imagery, time series Landsat imagery (1989–2008) and LIDAR (2006).

SPOT 5 is the currently the preferred sensor for the delineation of vegetation patterns because of its relatively high spatial resolution, multispectral values and synoptic coverage. Each SPOT scene is approximately 60 km by 60 km. Unfortunately each scene is acquired opportunistically and seasonal effects such as high rainfall can dominate the global spectral response. The time series qualities of the NSW SPOT5 catalogue help to minimise scene to scene differences and enhance the accuracy and currency of native vegetation products.

Additional imagery may be acquired, if available. This often requires a Data License and licensing conditions. The key imagery products used for the State Vegetation Map are:

1. SPOT 5 - 2.5 panchromatic, 5m and 10m multi-temporal/multispectral, near natural orthorectified scene and mosaic products
2. Multispectral and near natural Landsat TM and multi-temporal Landsat TM
3. LPI Digital Aerial Imagery ADS40/80

Imagery products are often further processed to enable their management, transfer and use within GIS software.

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**Update February 2015**

*NSW has substantially accelerated the delivery of ADS40 imagery for NSW, covering most of eastern and central NSW. A forward program has been implemented to complete coverage for all of NSW by 2018.*

*ADS40/80 is a 50cm on-ground resolution product comprising RBG and Infrared bands. The Infrared band is not always available to OEH.*

*ADS40/80 imagery is now used by regional mapping as the primary source of imagery underpinning all imagery analysis and interpretation routines. SPOT5 imagery continues to be used where ADS40 may not be available.*

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**Dependencies and Standards:**

- SPOT 5 - 2.5m near-natural colour less than 3 years
- SPOT 5 - 5m multi-spectral most recent, 3 - epoch time series
- OEH Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 3
• Access to OEH Spatial Catalogue

• High resolution imagery files are extremely large and off-line secure storage is necessary for its use and management during large-scale mapping projects
M2.3: Acquire existing native vegetation mapping

Existing native vegetation mapping provides one of the tools used to gain an appreciation of the known extent of vegetation types. An audit of existing native vegetation (spatial) mapping is undertaken. The primary source is the VIS Map Catalogue but research may be required to obtain other mapping that may contribute to the current ecological understanding of that region (e.g. Local Government may hold mapping not available via the VIS).

The availability of contemporary and high quality mapping generally decreases across NSW from east to west. Suitable high quality mapping coverage is infrequent even along the eastern seaboard.

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MODULE THREE: CLASSIFICATION ANALYSIS

The purpose of this Module is to analyse sources of field data and classified community type to compile a candidate vegetation community list for mapping purposes.

M3.1: Vegetation community compilation

The VIS Classification Database provides an a priori vegetation community classification for NSW. These types are taken as the foundation set on which to develop a candidate vegetation community list for mapping purposes. The work done in Module One (collating plots and extant PCTs) is brought together here to help develop a candidate native vegetation community classification for the mapping area.

Three possible approaches may be taken to classification:

- The NSWVIS Classification Database provides complete coverage for the target with PCT’s of high classification confidence and therefore provides the best starting classification. The aim is to give spatial expression to this classification. Any changes are based on experience gained in the course of mapping.

- The NSWVIS Classification Database provides coverage of PCTs with low or very low Classification Confidence (largely expert opinion based interim BioMetric Vegetation Types. In this case full floristic data, both new and existing, are used to develop a new classification that confirm or replace the PCTs. This is tested by local experts. Classification gaps encountered during the interpolation process are identified for future field survey and classification. The new classification is matched to existing classifications both internal and external to the mapping area.

- The NSWVIS PCT provides partial coverage of suitable Classification Confidence (most common scenario). All legacy classification and mapping, particularly in areas not covered by good PCTs are evaluated and equated to PCT types where possible. Any types not able to be equated to the PCT constitute a new and additional type.

Dependencies and Standards:

- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 2 and section 7.
- Completion of Module One and Module Two.
- Availability and use of statistical analysis and classification software
- Consultation with local ecological/botanical expertise
- Redundant plots (unusable for classification) may be retained for later visual quality assurance (refer M6.3)
M3.2 Plot equivalences

Allocation of plots to vegetation types is integral to quantitative classification. However, if an *a priori* classification is used (such as the PCT), the assignment of individual plots to candidate vegetation classes is undertaken manually by matching floristic and structural information; relative species importance (cover and abundance), location, photo-pattern and landscape as well as any reference to the original classification in the PCT. This expert-intuitive approach includes taking into account outliers or mixed plots that can be assigned an appropriate class based on the surrounding photo pattern, soil type or a range of environmental layers.

Manual classification of plots may become impractical when thousands of plots need to be assessed. Automated classification routines such as PATN may be used to complement manual attribution.

At this stage, “icon” plots may be identified, where possible using API and satellite imagery for each candidate vegetation type to be mapped. Icon sites are used as representative sites from which modelling can be confidently extrapolated (refer Module M6.2). The key attributes for an icon site include: pattern uniformity and size, consistent spectral signature, absence of disturbance or infrastructure.

**Update February 2015**

*Semi-automated classification of plots includes the use of the “SAAP” software program. (Oliver et al 2013). Expert opinion is required to evaluate the outputs of this software.*

*The use of icon sites has been discontinued and replaced by the derivation of Landscape Classes and Ecological Envelopes as a means of informing and constraining modelling outputs.*

**Dependencies and Standards:**

- Completion of Module One, Module Two and M3.1
- Availability and use of statistical analysis and classification software
- Consultation with local ecological/botanical expertise
M 5.1 Validation data set

A validation data set - usually about 20% of the total available survey plot data is randomly selected from the total cache of available plots and set aside from further spatial or thematic analysis. This reserve data set is used during the mapping validation process outlined in Module 6.

Dependencies and Standards:

- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 9 and Appendix 8
- It is important for the integrity and confidence in mapping that the validation plot set is not accessible to the mapping team in any form during the analytical and product development processes.
- Once the results of mapping validation are reported, the validation plot set may be added back into future mapping iterations.

Update February 2015

The Vegetation Information and Mapping External Scientific Committee (VIMESAC) has endorsed the minimum reservation of 10% of the available survey data for validation purposes. This is especially important in a data poor environment (most of NSW), so that training data set available for modelling is least disadvantaged.

The VIMESAC has endorsed the use of 100% of available site data for the derivation of Landscape Classes and Ecological Envelopes, neither of which are used as modelling inputs but only used to constrain modelling outputs.

Validation statistics are considered as only one way to communicated mapping confidence. A range of mapping confidence information including survey intensity and modelling probabilities are used with model validation.
The NSW STATE VEGETATION MAP

MODULE FOUR: SPATIAL ANALYSIS

The purpose of this Module is to select, analyse and prepare primary spatial information for mapping purposes. Object-recognition of high resolution imagery is at the core of the Regional Scale Vegetation Mapping Methodology. One of the assumptions of an object-based approach is that spectral similarity and thematic similarity are synonymous (Roff et al. 2010). Object-recognition is complemented by API-style interpretation, previous mapping, field survey data and local expertise.

M4.1 Stratification

Stratification of environmental layers is used to identify unique environmental units that inform the basis for systematic field survey and as a unique input layer to ensemble modelling of vegetation communities. In both cases stratification provides a systematic and evidence-based methodology.

As examples, stratification may include:

- a soil layer, on the assumption that clay and sandy soils, for example, have an impact on species distribution
- SLATS foliage projective cover (FPC), which was used to create a threshold for woody and non-woody communities
- tenure, with a focus on getting access to traditionally under sampled communities on private property
- distance from roads, in accordance with survey contracting requirements.

Non-systematic methods may also be used as a basis for survey design. The circumstances that may require consideration of this approach include:

- survey is required for interpolation purposes only
- gaps in survey coverage a disparate and localised
- insufficient time and resources for formal survey design

Dependencies and Standards:

- A systematic approach to stratification is preferred where new survey information is required.
- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 4
- Completion of M1.2 and Module Two.
M4.2 Predictive layers

The contribution of various environmental layers and satellite imagery to the classification are visualised in a series of maps representing the value of these layers at each floristic survey site. This is informative, as it provides point-specific environmental data on which can help the process of spatial interpolation relies. A range of example predictor layers are shown in Appendix A

<table>
<thead>
<tr>
<th>Dependencies and Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer</td>
</tr>
</tbody>
</table>
M4.3 Image Object segmentation

Segmentation of imagery is a means of identifying and delineating objects, including native vegetation patterns. This method uses the multi-resolution segmentation algorithm of the software package Definiens eCognition to define patterns with low internal variation (low heterogeneity). The process is analogous to merging nearby objects that contribute the least to heterogeneity. The algorithm is novel because it includes the shape of the object in its measurement of heterogeneity. It allows the user to skew the segmentation in favour of regions with smooth edges and a more or less compact form. The software also allows for the classification of image objects at multiple scales.

Segmentation is currently based on SPOT5 data that has been pre-processed to accentuate vegetation pattern characteristics. The ‘sizing’ of polygons is deliberate and iterative, designed to reach a balance between under and over segmentation across landscapes of variable complexity. Ideally, feature recognition should be applied at the same scale in which thematic classes occur.

Assessing the quality of feature boundaries in segmentation is simple for sharply defined features. Where the transition zone between classes is smooth, it is much more difficult to represent, particularly when the transition may not have a linear function of change. This is a commonly observed phenomenon within the natural world and such locations are formally described as ecotones or environmental gradients (Reinke and Jones, 2009).

Object boundaries may infrequently be distorted to include adjoining dissimilar features due to their similar spectral responses. These dissimilarities are generally minimised or eliminated when choosing the stand segmentation scale or may be further manually edited, where practical. They are generally an insignificant feature at the presentation scale.

A range of object-validation techniques are available for assessing uncertainties in segmentation based on object extraction (Möller et al., 2007; Shi et al., 2005; Hay et al., 2003). They currently do not form part of this Method.
ADS40/80 high resolution imagery is currently the preferred data for image analysis where it is available, otherwise SPOT5 continues to be used.

The multi-resolution segmentation algorithm (Baatz and Schäpe, 2000 & Benz et al., 2004) is used in Definiens eCognition to create image objects with low internal variation (low heterogeneity). Image objects represent patches of vegetation that can later be classified based on attributes such as crown cover, spectral response, or soil type.

The segmentation parameters and scale is derived iteratively based on visual inspection. Vegetation patterns from existing stereoscopic aerial photo interpretation and those recognized in high spatial resolution imagery (ADS40) are used as a reference point. Segmentation is performed using ADS40, SPOT 5, SRTM derived topographic indices and the NSW Woody Vegetation Extent (2011).

An existing NSW water storage and road network layer is used in segmentation and classification.

**Dependencies and Standards:**

- Definiens eCognition scale-level for object segmentation is generally between 40 and 60 for regional scale purposes
- Access to Definiens eCognition software
- Polygon boundaries are smoothed to reflect feature boundaries.
- The spatial resolution is 2.5m, the minimum mappable unit is 0.5ha.
M4.4 Assessment and Equivalence of legacy mapping

Legacy native vegetation mapping is an important historical and technical resource upon which to build a contemporary regional scale map. Each legacy map is systematically evaluated to assess its potential to contribute to the contemporary coverage. Those criteria may include:

- Thematic Accuracy
- Spatial Precision
- Currency

It is also important to provide an explicit relationship between the candidate mapping classification and that of legacy mapping. This ensures that there is a clear and articulated relationship between legacy mapping and the mapping project. An equivalence table performs this function. An example is illustrated in Appendix B. Ultimately; legacy maps stored in VIS Map will receive an additional feature attribute to hold the relevant equivalence linkages to the State Vegetation Map and the underlying PCT Classification.

This expert-driven process examines relationships between characteristic (high fidelity) species, dominant species, floristic composition, geographic range, substrates, spatial distribution and landforms. Legacy map units that approximate a vegetation type from the candidate vegetation classification in all of these themes are considered to be equivalent. However, it is important that ‘equivalence’ should not be interpreted as ‘identical’.

As a result of this analysis, selected high quality maps may be chosen as the primary spatial and thematic source for the mapping project. (Refer Module 6)

<table>
<thead>
<tr>
<th>Dependencies and Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Completion of M1.2, Module Two, M3.1.</td>
</tr>
<tr>
<td>- Selected high quality legacy maps may need to be georeferenced and mosaiced for further use - licensing permitting.</td>
</tr>
</tbody>
</table>
MODULE FIVE CLASSIFICATION PRODUCT DEVELOPMENT

The purpose of this Module is to describe biophysical, structural and floristic descriptors for each of the new or varied candidate vegetation mapping types.

M5.2 Descriptions of vegetation map units

The requirements for Mapping Unit description are detailed in the Standard, Appendix 9(B)

 Dependencies and Standards:

- Only new or varied candidate mapping types which have a spatial expression (Module 6) are described
- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 10 and Appendix 9 (B)
- Completion of Module 6.
The purpose of this Module is to create the *State Vegetation Map* products based on native vegetation attributes including native-ness, woodiness, canopy and type; and their validation.

**M6.1 Mapping Layers**

**Crown Scale Segmentation Layer**

The location of scattered paddock trees and narrow roadside remnants is important for biodiversity conservation and wildlife corridor assessment. The State Vegetation Map includes a Crown Cover product including all forest and woodland trees, isolated trees and roadside remnants. The Crown Cover is type and tenure-free.

Woody vegetation patterns at the crown-scale are delineated using a grid-cell classification approach. The Crown Cover layer is derived from multi-temporal SPOT5 data and provides a seamless, binary layer of both stand-scale and scattered tree crowns. The spatial resolution is 2.5m by virtue of ‘pan-sharpened’ imagery. The minimum mapped unit is a single tree crown. Time slices of SPOT5 data are used to help identify stable woody signatures. Grid-cells defining tree crowns or clusters of tree crowns have are converted to vectors (polygons) for use in this product (Roff et al. 2010).

Segmentation at the crown scale is undertaken in ENVI’s Feature Extraction Module (http://www.ittvis.com/). The algorithm applies a simple edge-based segmentation algorithm followed by a region merging step. The region merging routine employs the Full Lambda-Schedule algorithm created by Robinson et al. (2002). The Feature Extraction Module was designed as an anomaly detector to reduce the need for the labour-intensive process of picking out objects of interest over broad areas. This makes it ideal for delineating individual tree crowns in paddocks. It was not designed to distinguish individual crowns in closed forest, so the layer was dissolved to merge adjacent crowns, (Roff et al 2010)

Segmentation is conducted on pre-processed imagery in an Interactive Data Language (IDL). This allows for the segmentation algorithm to be run automatically in a batch mode for multiple tiles. A threshold is manually applied for each individual SPOT 5 scene to differentiate woody vegetation from the matrix of grasses, shrubs and soil. The results are subjected to a manual process that removes false positives in green grasslands and crops. The layer is then dissolved to remove boundaries between adjacent crowns. The area and the number of crown-scale woody objects is then available as an input and/or standalone product. No validation routine is applied to this product.
The NSW STATE VEGETATION MAP

Update February 2015

The Crown Scale Segmentation Layer is now known as the NSW Woody Vegetation Extent (2011). It has been completed for all NSW. It has been validated to between 88%-94% accurate for all NSW.

The NSW Woody Vegetation Extent (2011) is making an important contribution to vegetation mapping and other NSW biodiversity information. It is used in segmentation and for thresholding Landscape Classes.

Woody/Non Woody Layer

The purpose of this layer is to create a binary categorisation of the combined Crown and Stand scale segmentation as a prerequisite to the Native/Non Native Layer. Each stand-scale polygon containing Crown features with a Crown Cover value of more than 5% are categorized through automated analyse as woody, the remainder non woody. The purpose of this operation is to help accelerate the next process of native and non-native vegetation interpretation.

Update February 2015

The production of a Woody/Non Woody Layer has been discontinued as a specific prerequisite to Type mapping in favour of Landscape Classes and Ecological Envelopes.

A woody- non woody layer can be retrospectively derived in ARCGIS from the mapping outputs by selecting woody and non woody PCTs.

A Crown Cover value of 10% is generally used as the automatic default value for spatially classifying a polygon as vegetation.

Native/Non Native Layer

The purpose of the Native/Non Native Layer (NNV) is to provide a template of areas of native vegetation for further classification. This layer is derived by manually interpreting the products from Stand-scale Segmentation and the Woody/Non woody Layer against a backdrop of satellite imagery and aerial photography. Near natural colour, multi-temporal and enhanced SPOT5 are interchanged manually on-screen as an aide to interpretation. Each polygon is attributed as either native-woody, native-non woody or non-native:

**Native woody** polygons are that which are interpreted as containing at least 5% native vegetation canopy cover. The Woody/Non woody Layer is used as a guide for this purpose and may be modified following manual interpretation of errors of omission and commission. Depending in relative scale, native vegetation polygons may include other coincident features such as rock outcrops small farm dams,
watercourses and wetlands and isolated buildings. Recent fire scaring is interpreted relative to the adjoining land cover or by referencing earlier imagery.

**Native non woody** polygons are generally determined with reference to the Woody/Non Woody Layer and by extrapolation from the nearest likely native grassland reference sites. Very open native woodlands for example provide excellent candidate grassland signatures between tree features. The determination of grazing paddocks as either native or non-native can be especially difficult due to the great variety of management practices. These include grazing intensity, infrequent/periodic cultivation, regeneration, and fertilisation applied individually or in combination; which in turn influences spectral response. To complicate this issue, each Spot 5 scene exhibits a relative unique colour spectrum. ‘Stretched’ multi-temporal SPOT 5 imagery is proving a useful means for interpretation of relative disturbance and therefore the likely status of native-non woody polygons. The focus of ongoing adaptive research is to improve certainty in categorisation of native non woody features. Both automated techniques and 3D interpretation of high resolution imagery strategically applied to problematic areas may offer further certainty in classification.

**Non Native polygons** are those interpreted as; intensively or recently modified grazing paddocks, recent land clearing, closely settled urban and industrial land; cropping, silviculture, roads, infrastructure, home paddocks and associated buildings.

The Native Non Native Layer is iteratively validated and amended where necessary during further use in native vegetation mapping (M6.2).

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**Update February 2015**

*The delineation of a Native-Non Native Layer has been discontinued in favour of Landscape Classes and Ecological Envelopes.*

**Landscape Classes**

*The purpose of attributing Landscape classes to polygons by remote sensing is to predetermine broad vegetation structural classes and in some cases, specific PCTs, for modelling purposes. These classes reduce the PCT options for any one polygon making the modelling more effective in its attribution with commensurate less computing effort/time. A landscape class is attributed to every polygon in the study area. Landscape classes are aided by reference to existing mapping. Corrections are made based on ADS40 with on-screen attribution.*

Some of the Landscape classes used (but limited to) are: not-native, water bodies, grasslands, riparian, shrublands, open woodlands, dry sclerophyll forests, rainforests, wet sclerophyll forests, belah, weeping myall, riparian forest, non-woody wetland, floodplain forests, mallee and, lignum shrublands.. The use of ADS40 and the SRTM Digital Elevation Model as the basis for segmentation has helped differentiate narrow features within closed vegetation, such as narrow gully rainforest, and identify shrublands.
Ecological Envelopes

As a further constraint to modelling outcomes, spatial envelopes are used to constrain PCTs to a certain geographic range, reducing the number of types competing within the model at any particular location. The constraints used are applied at different stages in the mapping process. The Keith Class (Keith 2004) models are constrained to particular IBRA subregions (Interim Bioregionalisation of Australia v7; Commonwealth of Australia 2012) and/or Mitchell Landscapes (REF), based on review of the literature and expert opinion.

<table>
<thead>
<tr>
<th>Dependencies and Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• SPOT 5 near natural, multi-spectral and multi-temporal coverage</td>
</tr>
<tr>
<td>• Completion of Modules Two and Four.</td>
</tr>
</tbody>
</table>
M 6.2 Native Vegetation Type Mapping

The goal of mapping is to establish a relationship between remote sensing, survey information and the Classification to show with confidence, where vegetation types occur across the landscape.

The first stage is the definition and spatial delineation of biolandscapes. Biolandscapes are akin to broad ecosystems comprising areas of functionally similar vegetation types, soils, surficial geology and landscape position. Biolandscapes help to break down apparent regional complexity into smaller units that can observed and understood more readily. The key spatial layers currently used to define biolandscapes include IBRA sub-regions, the NNV layer, legacy API layers, soils and geology layers.

The second stage is to interpret SPOT 5 imagery that has been ‘stretched’ and ‘enhanced’ and Definiens software for a supervised classification within each biolandscape. The purpose of the supervised classification, similar to API, is to assign explicit image patterns to vegetation types where a relationship can be confidently observed. The basic unit is the segmentation polygon.

Where relationships are less reliable or unknown, the approach shifts to explicit decision rules whether computer or human-based within each biolandscape, to assess the likelihood of a given candidate community type (Module 5) occurring in a given polygon (M4.3) - known as ‘modelling’.

**Update February 2015**

Both Biolandscapes and supervised classification have been discontinued in favour of the Landscape Classes and Ecological Envelopes for modelling purposes.

This Method uses an ensemble approach to modelling native vegetation. Spatial interpolation, i.e. estimating and inserting values falling between known values, is an integral part of the modelling process.

Modelling includes Generalised Dissimilarity Modelling (GDM) and a supervised classification that uses an Object-based Nearest Neighbour (NN) algorithm. Linear Discriminant Analysis (LDA) is used as a feature reduction tool for two data mining algorithms, Random Forests (RF) and Artificial Neural Networks (ANN). Each approach has performed well in international comparative studies. This makes hybrid systems of classification relatively repeatable when compared with intuition-based mapping. (Roff et al, 2010). An analysis of international trends, standards and outcomes regarding ensemble mapping is provided in Appendix E (J. Thonell, unpublished) 2010.

The results of these approaches are used to obtain the best-possible modelled output (best ensemble). The best ensemble method involves picking the best model result based on validation statistics for each class. Percent correct results are reported on the basis of the number of GHM types mapped in four classes of precision, consistent with the Standard.
Update February 2015

Attribution currently includes the top three predicted Types for each polygon. This approach helps users to interpret some of the uncertainty around the specific identification of PCTs in the field when using the map products.

At this point the Validation Plot Set (M5.1) is used to test the validity of the modelling using methods outlined in Appendix 8 of the Standard. The results of Type Mapping should at this point meet or exceed an Overall Accuracy of 70%.

These outputs are visually checked using a range of primary (see M2 and M4) and secondary spatial products (M6.1). Visual quality assurance includes checking modelled outputs against the best available remotely sensed imagery (SPOT5 and ADS40) and mapping. Where errors are detected the model output is manually adjusted.

Some candidate vegetation community types may not be modelled as they lack sufficient survey information or cannot be differentiated by remote sensing or environmental spatial layers. Visual interpretation is focused on communities that are difficult to model and relatively limited in extent. They may be mapped intuitively based on the visual interpretation of SPOT 5 pan-sharpened satellite imagery (2.5 m) and ADS40 imagery (50cm) or they may be grouped with very closely related communities.

At the end of both modelling and further hand editing (including M6.3 Expert Input, detailed below) the Overall Accuracy of native vegetation type mapping must approach 70%.

Dependencies and Standards:

- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 8 and Section 9, Appendix 8
- Validation Plot Set (M5.1)
- Access to specified spatial analysis programs
- Completion of Modules One, Two, Three, Four, Five and M6.1.
- The Overall Accuracy of the State Vegetation Map should exceed 70%
M6.3 Expert Input

A range of practitioners with expertise in native vegetation are invited to provide insight and direct input to the regional native vegetation mapping product. They often have particular expertise in discrete locations as well as broader landscapes. Amendments are effected at the individual polygon scale within ArcGIS.

<table>
<thead>
<tr>
<th>Dependencies and Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The Interim Type Standard (Sivertsen, 2009), refer Section 8</td>
</tr>
<tr>
<td>• Completion of Module 6.2.</td>
</tr>
</tbody>
</table>

M6.4 User Acceptance testing and Evaluation

Government and community users with a variety of interests and expertise may comprise a group of active and interested clients across a mapping region. Mapping products are distributed to each identified group or individual where they have a direct professional interest in ultimately consuming the native vegetation information. Unconstrained comment and any new information are invited from those clients as part of a user testing program. New information (such as new sites, community attributions) is updated within the geodatabase to produce a new Version.

Key Clients are individually interviewed to ensure that the mapping meets a level of acceptance whereby they are happy to retain a version for use and subsequent maintenance. Several successive versions may be required to incorporate new information and meet user expectations.

Update February 2015

*Draft mapping products are currently made available to internal and external stakeholders for a 3-month review period after which correction and incorporated into a production version.*
The NSW STATE VEGETATION MAP

MODULE SEVEN REPORTING

The purpose of this Module is to provide a guide to the various information and data sources, either analysis and use in creating mapping products

M7.1 Technical Reporting

**Dependencies and Standards:**

- Reporting requirements are comprehensively outlined in the Standard, Section 10 and Appendix 9A.

**Update February 2015**

*Technical reporting now takes the form of Technical Notes for each mapping region. The purpose of Technical Notes are to communicate specific mapping tools, decision rules and mapping outcomes used for a mapping region.*
Module Eight  Geodatabase and Uploading to VIS

State Vegetation Map projects are created for upload to VIS Map in a discrete project geodatabase (Gdb). The Gdb has multiple layers which include a number of ‘standard’ information presentations but which provide the opportunity to analyse and re-visualise data to individual requirements.

M8.1 Geodatabase

The mapping outputs are stored in the proprietary ESRI Gdb format – File Gdb in stand-alone format and ArcSDE in VIS Map. All standalone spatial data can be viewed by using ESRI ArcMap software and VIS Maps can be viewed as generic web map services.

The mapping and source data are made available in the File Gdb to facilitate interactive exploration of the mapping, plot data and field photos. See Appendix C.

Existing vegetation maps may (dependent on licensing provisions) be available inside the Ddb. However those map units are independently preserved and can be displayed simultaneously with the final mapping units. There are two advantages to this approach: the first is that additional layers do not need to be displayed in the GIS; secondly, it gives the interpreter more confidence when the mapping units of existing mapping align with the current project’s results.

The Gdb default view is of an index of 1:100 000 maps. The map contents sidebar features selectable layers that include site survey data, vegetation mapping, the crown segmentation layer, and a mosaic of SPOT 5 imagery.

<table>
<thead>
<tr>
<th>Dependencies and Standards:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion of Modules One to Six.</td>
</tr>
<tr>
<td>The Gdb must conform to the OEH VIS Native Vegetation Mapping Geodatabase Data Model.</td>
</tr>
<tr>
<td>A Metadata statement in accordance with the Standard (Appendix 1) is prepared and posted to the ANZLIC and OEH metadata record sites.</td>
</tr>
</tbody>
</table>
M8.2 Uploading Mapping Outputs

State Vegetation Map products comprise four outputs:

**Survey Plot data (extracted from NSW VIS Flora Survey)**

The procedure for uploading Site data into the VIS Flora Survey Database are detailed in Appendix D

**Vegetation Communities**

Vegetation communities not already in the PCT are presented to the PCT Change Control Panel for assessment, approval and uplift to VIS Classification Database and ultimately available for regulatory site assessment tools.

**Geodatabase**

The master copy of the File Geodatabase delivered to project partners is held by OEH Information Sciences Branch as a stand-alone entity with spatial incorporated into the seamless NSW State Vegetation Map available in VIS Map.

**Report**

This is a Word document that is accessible through the VIS website.

---

**Update February 2015**

*Regional Mapping Geodatabase outputs include:*

*NSW Woody Vegetation Extent (2011)*

*PCT (three highest probabilities)*

*PCT (single highest probability)*

*Source of mapping*

*Survey Plot data*

*Survey images*

*Survey intensity*

*Vegetation geodatabases are stored and managed by the Biodiversity Information Systems Team*

*Regional mapping documentation include:*

*Technical Notes*

---

**Dependencies and Standards:**

- Completion of Modules One to Seven and M8.1
- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 10
- Access to OEH Yeti
- The Gdb complies with the VIS geodatabase Data Model
M8.3 Updating the Geodatabase

A system for user-generated updates to the mapping Gdb is planned so that the product can evolve as more field data are collected.

ArcGIS Server provides access to multiuser geodatabase editing for distributed data management. ArcGIS Server ([http://www.esri.com/](http://www.esri.com/)) provides the framework to ensure that remote editors can make their updates directly to the multiuser Gdb while maintaining data integrity.

The Gdb can be replicated to a number of locations on independent stand-alone systems. Periodically, each instance needs to send and receive the most recent changes to synchronise and replicate contents.

**Dependencies and Standards:**

- DECCW Native Vegetation Interim Type Standard (Sivertsen, 2009), refer Section 8
- Completion of Module 6.2.
## Appendix A Example Predictor Layers (Refer M4.2)

<table>
<thead>
<tr>
<th>Predictor Layer</th>
<th>Description</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terrain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Direction a slope faces, measured counter clockwise in degrees from 0 (due north) to 360 (again due north). Flat slopes given a value of -1.</td>
<td>ASP</td>
</tr>
<tr>
<td>Aspect smoothed</td>
<td>As above, but with smoothed elevation data (mean neighbourhood of 3 x 3 grid cell).</td>
<td>ASPSM</td>
</tr>
<tr>
<td>Beers aspect</td>
<td>Transformation of aspect to a continuous scaled variable set to maximum for NE slopes (warmest slope).</td>
<td>BEERS</td>
</tr>
<tr>
<td>Compound Topographic Index (CTI)</td>
<td>Steady state wetness index, representing the volume of water draining to a given location, based on slope and downslope flow accumulation (Moore <em>et al.</em>, 1993, Wilson and Gallant, 2000).</td>
<td>CTI</td>
</tr>
<tr>
<td>Curvature</td>
<td>Curvature of the surface. It is a second derivative of the surface or slope of the slope.</td>
<td>CURV</td>
</tr>
<tr>
<td>Curvature profile</td>
<td>Curvature in the direction of maximum slope</td>
<td>CURVPRO</td>
</tr>
<tr>
<td>Curvature plan</td>
<td>Curvature perpendicular to the direction of the maximum slope</td>
<td>CURVPLAN</td>
</tr>
<tr>
<td>Distance to Coast to Stream</td>
<td>Absolute distance (shortest path Euclidean distance) to coastline derived from coastline layer.</td>
<td>DISTCOAST</td>
</tr>
<tr>
<td>Easting</td>
<td>Easting values in Map Grid of Australia (MGA) Zone 56.</td>
<td>EAST</td>
</tr>
<tr>
<td>Elevation</td>
<td>Elevation above sea level (m) from SRTM.</td>
<td>DEM</td>
</tr>
<tr>
<td>Northing</td>
<td>Northing values in MGA Zone 56.</td>
<td>NORTH</td>
</tr>
<tr>
<td>Slope</td>
<td>Inclination from horizontal (percent).</td>
<td>SLOPE</td>
</tr>
<tr>
<td>Distance to stream</td>
<td>Distance to stream</td>
<td>STRDIST</td>
</tr>
</tbody>
</table>
## Appendix B

### Table 0.1 Translation of Gwydir Wetlands Floodplain Vegetation Map 2008 to BRGN PCT's.

<table>
<thead>
<tr>
<th>Communities of the Gwydir Wetlands and Floodplain Vegetation Map 2008</th>
<th>PCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myall - Rosewood Association</td>
<td>27</td>
</tr>
<tr>
<td>Native grasslands</td>
<td>1 (Grasslands)</td>
</tr>
<tr>
<td>Coolibah woodlands</td>
<td>40</td>
</tr>
<tr>
<td>Belah</td>
<td>55</td>
</tr>
<tr>
<td>Myall - Rosewood - cultivated</td>
<td>27</td>
</tr>
<tr>
<td>River Cooba - Lignum Association</td>
<td>241 (or shrubland as 247)</td>
</tr>
<tr>
<td>Derived grasslands</td>
<td>49</td>
</tr>
<tr>
<td>Coolibah - River Red Gum Association</td>
<td>36</td>
</tr>
<tr>
<td>Baradine Red Gum Association</td>
<td>206</td>
</tr>
<tr>
<td>River Red Gum</td>
<td>36</td>
</tr>
<tr>
<td>Marsh Club-rush</td>
<td>205</td>
</tr>
<tr>
<td>Common Reed - Tussock Sedge</td>
<td>181</td>
</tr>
<tr>
<td>Water Couch - Spike-rush - Tussock Rush</td>
<td>204</td>
</tr>
<tr>
<td>Coolibah - Black Box Association</td>
<td>37</td>
</tr>
<tr>
<td>Recovering River Cooba - Lignum Association - previously cleared land</td>
<td>241 (or shrubland as 247)</td>
</tr>
<tr>
<td>Cumbungi - Marsh Club-rush</td>
<td>182</td>
</tr>
<tr>
<td>Coolibah - River Cooba - Lignum Association</td>
<td>39</td>
</tr>
<tr>
<td>Common Reed - Marsh Club-rush</td>
<td>181</td>
</tr>
<tr>
<td>Cumbungi</td>
<td>182</td>
</tr>
<tr>
<td>Bimble Box Association</td>
<td>98</td>
</tr>
</tbody>
</table>
**APPENDIX C Example Geodatabase Information**

**C.1 Example of primary geodatabase information layers - Sample Purposes only**

<table>
<thead>
<tr>
<th>Folder</th>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey</td>
<td>RapidSurvey</td>
<td>Rapid Survey Data (z56 GDA94)</td>
</tr>
<tr>
<td></td>
<td>FullSurvey</td>
<td>Full Floristic Survey Data (z56 GDA94)</td>
</tr>
<tr>
<td></td>
<td>OEH_yeti_xxx_DD</td>
<td>YETI survey data in Decimal Degrees (GDA94)</td>
</tr>
<tr>
<td></td>
<td>Rapid_Survey_Site_Photos</td>
<td>Hyperlinks to site photo images</td>
</tr>
<tr>
<td></td>
<td>Vegetation_Type</td>
<td>Segmentation merged based on vegetation type</td>
</tr>
<tr>
<td></td>
<td>Vegetation_Data</td>
<td>Raw segmentation with attributes</td>
</tr>
<tr>
<td></td>
<td>Crown_Layer</td>
<td>Crown scale woody vegetation polygons</td>
</tr>
<tr>
<td></td>
<td>Place_NAMES.shp</td>
<td>Town names</td>
</tr>
<tr>
<td></td>
<td>Roads.shp</td>
<td>Road network</td>
</tr>
<tr>
<td></td>
<td>Boundary.shp</td>
<td>Boundary of Mapping area</td>
</tr>
<tr>
<td></td>
<td>100k_Atlas.shp</td>
<td>Atlas of 100k sheets that intersect with GHM area</td>
</tr>
<tr>
<td></td>
<td>100k_1500m.shp</td>
<td>Boundary of GHM area with 100k sheets</td>
</tr>
<tr>
<td>Imagery</td>
<td>2p5m_SPOT_2008_RGB_250k</td>
<td>SPOT 5 2.5m ECW images</td>
</tr>
</tbody>
</table>
### C.2 Example of attributes of the vegetation data layers -

**Sample Purposes Only**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Geometry</td>
</tr>
<tr>
<td>Project code</td>
<td>GHM (Greater Hunter Mapping)</td>
</tr>
<tr>
<td>100k</td>
<td>100k Map sheet name</td>
</tr>
<tr>
<td>100kUNQ</td>
<td>Unique number per 100k Sheet</td>
</tr>
<tr>
<td>NNV</td>
<td>Candidate Native</td>
</tr>
<tr>
<td>Woody</td>
<td>Above 10.% woody cover</td>
</tr>
<tr>
<td>FPC</td>
<td>Foliage projected cover</td>
</tr>
<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
</tr>
<tr>
<td>Life Form</td>
<td>Eg. Grassy, dry scrub, wet heath, mesic, intermediate</td>
</tr>
<tr>
<td>Cover</td>
<td>Percent crown Cover</td>
</tr>
<tr>
<td>Formation</td>
<td>Keith</td>
</tr>
<tr>
<td>Class</td>
<td>Keith</td>
</tr>
<tr>
<td>Area</td>
<td>Hectares</td>
</tr>
<tr>
<td>GDM</td>
<td>Generalised Dissimilarity Result</td>
</tr>
<tr>
<td>ANN</td>
<td>Artificial Neural Network Result</td>
</tr>
<tr>
<td>RF</td>
<td>Random Forests Result</td>
</tr>
<tr>
<td>LDA</td>
<td>Linear Discriminant Analysis</td>
</tr>
<tr>
<td>WA</td>
<td>Weighted average of Models</td>
</tr>
<tr>
<td>Reliability</td>
<td>Per class accuracy estimates in 4 classes</td>
</tr>
<tr>
<td>Shape Length</td>
<td>Length of feature in internal (ESRI) units</td>
</tr>
<tr>
<td>Area</td>
<td>Area of feature in internal (ESRI) units</td>
</tr>
<tr>
<td>Hectares</td>
<td>Area in Hectares</td>
</tr>
<tr>
<td>PCT ID</td>
<td>Unique NSW Plant Community Type code</td>
</tr>
<tr>
<td>PCT Scientific</td>
<td>Species names in scientific nomenclature form</td>
</tr>
</tbody>
</table>
APPENDIX D Managing and Uploading Rapid Site Data

A) Preparation of photographs using ArcGIS

1. Rapid site data, including grid coordinates of each site, are collated and a point shape file created.

2. A field (column) is added to the shape file attribute table that contained filenames for photos associated with a particular site. Note that, because the photo files are in the same folder as the shape files, only the file name is required. If the photos are in another folder, the path name describing where the photos are located must be included.

3. Because some sites may have more than one photo associated with them, the attribute table of the shape file was modified to create a new record for each photo.

4. In order to view the photos from within ArcGIS, a hyperlink is set up. To do this, the operator needs to ensure that hyperlinks are supported using the field containing photo file names (and paths if applicable). To do this, open Layer Properties, click Display tab, click on the Support Hyperlinks using field checkbox and select the field in which the photo file names are located (in this case the Photo_ID field). Close Layer Properties. The hyperlink icon (lightning bolt shape) should now be visible on the toolbars.

B) Uploading Rapid Site Data to VIS Flora Survey Database

1. Rapid site data are transferred from the ArcGIS shape file attribute table (mentioned above) into an Excel table.

2. A new survey is created in a stand-alone version of YETI to receive the data.

3. The data is copied into the relevant back-end tables of Yeti. This involves cutting and pasting subsets of the data into a number of different linked back-end tables.

4. Information about site photos are similarly copied into the backend table called Graphics. This table include, among other things, site, photographer, date, photo direction and photo file names.

5. The survey is exported from the stand-alone version of Yeti as a transfer file (tfv), and imported into the network version of Yeti.

6. All photo files are placed in a computer folder.

7. After opening the network version of Yeti, navigate to Database settings, and set the directory for graphics files using the browse tool. Close database settings.

8. Open the survey in Yeti. Images can be viewed by selecting the desired site and clicking on the Add/View button under Site Graphics. The number of photos for each site will be listed under the Add/View button. For sites with more than photo, the operator can scroll to select the desired photo.
REFERENCES

DECCW (2009), NSW Native Vegetation Mapping Strategy 2009-2013, NSW Department of Environment, Climate Change and Water, Sydney, Australia


Jones, S., And Reinke, K., 2009, Innovations in remote sensing and photogrammetry: Springer Verlag).


Roff, A., Sivertsen, D., And Denholm, B. 2010. The Native Vegetation of the Murray Catchment Management Authority Area, NSW Department of Environment, Climate Change and Water, Sydney, Australia


Sivertsen.D, (2009) Native Vegetation Interim Type Standard NSW Department of Environment, Climate Change, Sydney, Australia