

2. METHODS

2.1 DATA AUDIT

2.1.1 Summary

Data audit was the first phase undertaken and two types of data were collated; site information and digital GIS layers. Data that could be rapidly applied to answer API field validation questions was considered beneficial. A review of digital capture techniques was also completed and a method selected.

2.1.2 Site information

Site information was taken from data collated for the Eden Forest Ecosystem Classification and Mapping Project. This data had already been extensively audited. A total of 1,500 full floristic sites were databased and the point locations imported into a GIS. A print out of canopy species at sites was provided to interpreters to assist in rapid typing. Unfortunately these sites rarely occurred in controversial areas and the benefit of this system was minimal.

2.1.3 Map information

Mapped GIS layers were evaluated for their accuracy and resolution. When the layers did not meet the Eden CRA specifications they were ignored or updated. After a rapid evaluation of these layers, only information providing the maximum practical benefit for the project was collated. Rapid valuation for existing data layer was undertaken to assess the practicality of incorporating these layers to assess final project outputs.

A digital drainage network layer provided by the Land Information Centre (LIC), Department of Land and Water Conservation was used for linear ground control. RN17 forest typing was collated by SFNSW then provided to NPWS. This was reviewed and where information was missing manual digitising of 1:25,000 dye-line printouts using Environmental Resource Mapping System (ERMS) captured the mapped information.

Digital growth stage and disturbance mapping captured during the IFA was used as a primary reference point. The information was captured from 1994 and 1990/1991 1:25,000 colour aerial photography. Specifications for CRA rainforest and non-forest were defined in the "Integrated Comprehensive Regional Assessment Aerial Photograph Interpretation"

(CRAFTI) Assessments. Where field validation by API found coding errors these were corrected.

The logging layer provided by SFNSW was used to update logging histories to the beginning of 1997. This corrected for logging that had occurred after the date of photography.

2.1.4 Selection of digital capture techniques

Recommendations of preferred technique for capture of information were taken from the CRAFTI report. Scanning capture was selected as it provided the most accurate result within budget and time constraints. Other methods trialed in the CRAFTI report were stereo-plotting and manual digitising of individual overlays. Rules regarding colour, ink type and pen size were the result of CRAFTI trials.

2.2 API PATHWAY

2.2.1 Summary chronology of API Tasks

The tasks undertaken by the API in mapping are detailed below. The phase identified in brackets refers to the project specification phases.

Task 1 (Phase 2)

Initial step was the preparation of photography for API interpretation. Strict rules were then established regarding process photography preparation, nomenclature and overlay markings.

Task 2 (Phase 2)

Pathways for the floristic and growth stage capture were defined.

Task 3 (Phase 2)

While broad forest class table and growth stage attribute tables were derived all interpreters mapped rainforest non-forest native communities.

Task 4 (Phase 3)

Broad forest communities, rare forest communities and cleared land were then mapped by interpreters who could demonstrate greater than three years local experience.

Task 5 (Phase 4)

On completion of the floristic mapping overlays the photography was handed over to growth stage interpreters. These interpreters undertook the inserting of rainforest and non-forest communities into the BOGMP, inserting new polygons down to 10 hectares if they were not delineated, and correcting attribute inaccuracies after field verification.

Task 6 (Phase 4)

Two senior interpreters at the end of the project did a systematic field validation of final digital growth stage attributing. This information was then critically assessed for bias and accuracy.

Task 7 (Phase 5)

Disturbance assessment tagged to growth stage mapping was done by interpreters doing growth stage validation and correcting attribute inaccuracies after field verification.

Task 8 (Phase 5)

Two senior interpreters at the end of the project did a systematic field validation of final disturbance attributing. This information was then critically assessed for bias and accuracy.

Task 9 (Phase 5)

A rapid API assessment of broad forest disturbances from 1962 and 1968 black and white 1:40,000 aerial photography was completed at the end of the project by two senior interpreters.

Task 10 (Phase 7)

Quality audit of nomenclature and compatibility was then conducted before photography was combined into 1:25,000 map sheet tiles and forwarded to digital capture contractors.

Task 11 (Phase 7)

Positional accuracy of the final digital layer was conducted using 1:25,000 topographic map sheets and print outs of the final GIS layers.

2.3 API SPECIFICATIONS**2.3.1 Summary**

All land tenures in the Eden CRA were mapped with the same API specifications. Specifications were split between broad forest class mapping, growth stage and disturbance mapping and historical disturbance mapping. Specifications for historical disturbance mapping are separately treated (refer Chapter 5). Specifications were adapted from IFA specifications and amendments suggested by API-EWG. Later, minor amendments were made to meet CRAFTI API Trial results that eventually became accepted as statewide API specifications.

The API pathway worked through six phases of the original project proposal using flowcharts and attribute tables detailed in Appendices 9.4 and 9.5.

2.3.2 Equipment and annotation rules**Photography used**

The most recent high resolution photography available for the entire Eden CRA area was used for the project. The photographs were colour 1:25,000 aerial photography owned by NPWS and flown by LIC. These were the same photographs used for the BOGMP. Growth stage overlays were attached to photographs. The photographs were taken in 1994 for the coast, hinterland and part of the escarpment and in 1990/1 for the remainder of the escarpment and tablelands.

Preparation of photographs and overlays

Four overlays were provided for each photograph. The first was for broad forest class mapping. The second was for growth stage and disturbance mapping. The third was the original BOGMP overlay. The fourth was for field notes. These were attached using special adhesive tape (Appendix 9.8). This enabled the overlays to be flipped along “hinges”. Interpreters transcribed fiducials onto new overlays as required.

Reason for annotation rules for recording information on overlays

Strict annotation rules were introduced to maximise the longevity of the overlays and to minimise GIS editing work after data capture (Appendix 9.8). These rules related to pen type, colour and ink standards used. Scanning overlays into computer files enabled digital colour separation to be used to separate polygon codes from line-work and fiducials. This minimised machine time for rectification, vectorisation and GIS editing.

Annotation rules for broad forest vegetation class overlays

All polygons and fiducials recorded on broad forest vegetation class overlays were in red except for small or narrow riparian occurrences of rainforests that could not be encircled in a polygon or information recorded that was not for digital capture.

Small non-linear rainforest polygons that could not be encircled (usually less than two hectares) were coded with a green triangle. Linear rainforests too narrow for encircling were recorded with a green line. All other rainforest polygons on the floristic overlay were recorded in red.

All labelling was in black. Any field notes were not to be in green, red or black and preferably done using a chinograph pencil.

Annotation rules for growth stage overlays

Since the existing BOGMP was to be kept as the basis for this project, the purpose of API growth stage overlay was to provide the lines and label edits required to

update the layer. As such no existing BOGMP line was to be traced for digital capture. This would avoid sliver errors occurring in the updating of the GIS layer.

On the growth stage overlay all line work to be digitally recorded was in red. These lines principally were for stitching in new rainforest polygons and new growth stage polygons.

All line work that was not to be digitally captured was in green. These lines were mostly transcriptions of rainforest polygons from broad forest class mapping overlays. This enabled growth stage API mapped to incorporate new rainforest boundaries into the existing BOGMP map layer. Small or narrow rainforest occurrences recorded with green crosses or lines on the broad forest vegetation overlays were not transferred onto the growth stage overlays.

The growth stage interpreters also recorded other green lines to assist data capture contractors to fit red line edits recorded in the existing BOGMP layer. These lines were not to be digitally captured.

All labelling was in black. A separate overlay was used for any field notes. Any field annotation on broad forest class or growth stage overlays were not to be in green, red or black and preferably done using a chinograph pencil.

2.4 BROAD FOREST CLASS MAPPING METHOD

2.4.1 Derivation of broad forest classifications

Broad forest vegetation classes were mapped using a two stage pathway. Stage one mapped the rainforest, non-forest communities, rare eucalypt communities, structurally complex (riparian and littoral) communities. Stage two involved the mapping of broad eucalypt communities. Statewide CRA API project specifications were adopted. A three tier hierarchical classification system was used.

In the project proposal it was agreed that time limitations would not allow RN17 typing to be completed throughout the Eden CRA area. An indicative list of forest and non-forest classes in Eden was provided. This would form the basis of the forest classifications used in this project. (Appendix 9.2, 9.3) A senior interpreter, after wide consultation with other interpreters and project staff, updated the indicative list provided in the project proposal (Appendix 9.3). A three tier hierarchical system was derived; level one being broadest and level three being most defined. These classes were cross correlated with RN17 forest typing (SFNSW 1994) and IFA Vegetation Mapping for Eden and Southern Interim Assessment Areas (KBS 1995, CSIRO 1996). The correlation was based on expert experience.

A further two levels of classification were inserted during the GIS collation. The initial level divided eucalypt forest, rainforests, and all other native cover and cleared land. The final level divided eucalypt forests based on their structural characteristics (e.g., dry

grassy, dry shrubby, wet grassy, wet shrubby). These levels were inserted to assist the Eden Forest Ecosystem Classification and Mapping Project.

2.4.2 Use of Research Note 17 mapping

Eucalypt forests previously mapped and digitally captured by SFNSW using RN17 were not re-mapped using the broad forest classifications. However the rainforest mapping was undertaken in areas mapped by RN17 to ensure that the updated specification for rainforest mapping was used throughout the Eden CRA area.

A collated digital copy of RN17 areas was not available when API mapping commenced. Location of these areas already mapped was provided by expert knowledge of SFNSW API employees working on this project. SFNSW provided a merged GIS layer of digitised RN17 mapping. An audit of the RN17 layer found three areas were missing. A digital copy of Mount Pericote RN17 was later located and provided. Digital copies of two remaining areas; Rockton Section and an area in the junction of the Coolangubra, Tantawangalo, Wyndham, Cathcart 1:25 000 map sheets, could not be found. As a result NPWS manually digitised these areas from 1:25,000 hardcopy dye-line maps provided by SFNSW Eden Region.

2.4.3 Use of other digital API vegetation layers

Given time and resource constraints, only digitally available API vegetation maps were considered. Only the Wadbilliga National Park Vegetation map by NPWS was located. This map was not used as it did not meet API specifications for vegetation classifications, accuracy statements, metadata and supporting report documentation. Expert opinion also considered the layer inaccurate.

2.4.4 Code specifications

All spatial and crown cover percentage specifications were derived from the project proposal. They were changed as required to meet the draft CRAFTI specifications that had been submitted to the API-EWG as the statewide standard API at the time. Minimum polygon area, crown cover percentages and other specifications are detailed in Appendix 9.2.

The operational rule for the interpretation of rainforest was to include all areas of forest with <10% pyrophytic emergents and all areas >10% pyrophytic emergents where there was a visible sub canopy of rainforest. These were mapped as two classes and tagged as R and RE respectively.

All rainforest areas were remapped throughout the Eden CRA area. Areas delineated as rainforest by the BOGMP and IFA Vegetation Map (KBS 1995) were used as a guide to assist location.

Initially interpreters responsible for broad forest class mapping were instructed to map down to level three where practical. However due to the compressed timeframe this was reduced to level two at the

suggestion of the statewide API manager. This ensured that enough time would be available to properly validate growth stage mapping. In some cases level one was recorded where the quality of photographs was poor and access difficult. For the meaning of label annotations refer to Appendix 9.3.

2.4.5 Field validation

Field validation was undertaken to improve the accuracy of the API work. Field evaluation was used to overcome difficulties when API interpretation alone was unable to distinguish canopy species composition.

These problems principally occurred when:

- the crown form of a species or forest stand were cryptic or similar;
- the crown form of species changed relative to its growth stage;
- the site productivity, (environmental site quality) was low;
- broad forest types occurred outside of their normal environmental range;
- non-eucalypt species displayed similar crown forms to eucalypts;
- quality of the photography was low; and
- confidence of the API to accurately identify the canopy species was low.

API field checking initially occurred on two days per week. Due to compressed timeframes and increasing local experience for interpreters this gradually reduced to two days per fortnight. Initially two interpreters undertook field validation with one field survey coordinator circulating between teams. In the later third of the project this was reduced to one API person undertaking field validation alone with the field survey coordinator still circulating between interpreters to maintain consistency. Route maps were recorded along with site inspection locations (Chapter 8, Map 3). A rapid assessment proforma was prepared to assist in ocular assessments. Initially interpreters were to complete this proforma though this requirement was removed as interpreters increased their local experience and the value of the completed proformas did not compensate for the time taken to complete them. Interpreters undertook basal area sweeps of trees to ensure they were only considering species contributing to the canopy. It is noted that the API specifications for the remaining CRA area has changed and point to plan sampling techniques are now the CRA standard specification (CRAFTI, 1997). This was not the case at the start of this project.

2.5 GROWTH STAGE AND DISTURBANCE MAPPING METHOD

2.5.1 Use of BOGMP layer

In the project proposal it was agreed that the existing BOGMP growth stage layers would be used. During the IFA, rapid desktop audit found a 70% agreement. This audit was not validated with field assessment. However, the API-EWG agreed to use this layer to minimise GIS digitising time.

2.5.2 Code specifications

This project extended mapping over areas previously unmapped and updated existing mapping to meet Eden CRA API specifications for rainforest and minimum polygon size. The project re-evaluated all codes tagged with a doubtful (D) or unknown (U) attribute codes and validated all logging (Y) and fire (F) disturbance tagging. Code changes to existing polygons were to be avoided and only undertaken with SFNSW' agreement. The API pathway and spatial specifications are in Appendix 9.4.

Rainforest locations delineated by the interpreters in the broad forest vegetation overlays were inserted directly into the broad old growth layer. Areas coded as rainforest in BOGMP that no longer met CRA API specifications were absorbed into surrounding polygons. This was also the case for non-eucalypt forest communities and cleared land delineated and coded by floristic interpreters.

Growth staging of Eucalypt forest communities was undertaken in BOGMP. Forest stands with relatively homogenous proportions of regrowth and senescent trees were delineated. Regrowth and senescent contributions to percentage canopy cover was classified into three classes: less than 10%, from 10-30% and greater than 30%. Coding systems and codes used are in Appendix 9.5.

All spatial specifications were derived from the project proposal. They were changed as required to meet the draft CRAFTI specifications that had been submitted to API-EWG as the statewide standard API at the time. Minimum polygon area and other specifications are detailed in Appendix 9.4.

Every polygon was re-evaluated by API. No assessment was made of trees not contributing to the canopy coverage (i.e. regrowth beneath the canopy of older trees). Likewise, fire and logging evidence not visible in the canopy was accessed. This rule was established to ensure that field validated results could be accurately extrapolated to surrounding areas by an API desktop assessment alone. This was imperative since not every stand was accessible for field validation within the resources available to the project. This rule improved the precision of mapping by reducing variation between interpreters, and accessible and inaccessible locations.

2.5.3 Field validation

Field validation was also undertaken particularly to assist with interpreting the characteristic growth stages. Field evaluation was used to overcome difficulties when API interpretation alone was unable to distinguish growth stage proportions or when obvious inaccuracies in the BOGMP typing had occurred. The problems principally occurred where:

- the crown form of a species or forest stand were similar between growth stages;
- the site productivity, (environmental site quality) was low;
- broad forest types occurred outside of their normal environmental range;
- regrowth stands were reaching maturity
- non-eucalyptus species displayed similar crown forms to eucalypts; and
- quality of the photography was low

Growth stages of trees were defined as in the BOGMP. Diagrams of different species at different growth stages were used to calibrate interpreters. Basal area sweeps were used to identify the relative proportion of trees occurring in each growth stage class. All techniques for growth stage recognition and field checking were as undertaken in the BOGMP. This report should be referred to for further details. API field checking was the same as undertaken for broad forest class mapping except that no formal assessment of canopy species was recorded.

2.6 INTERPRETER CALIBRATION

Calibration exercises were established for growth stage interpreters to ensure they understood the specifications. Occasional tests were also established to validate and calibrate growth stage. Interpreters were overseen by a senior interpreter and the API Project Manager.

2.7 SPATIAL ACCURACY

The maximum allowable error for broad vegetation mapping and growth stage and disturbance mapping was 37.5 metres from linear topographical features on photography (i.e. drainage lines, ridgelines, roads, and power easements) and topographic maps. This is a distance of 1.5 millimetres on a 1:25 000 map sheet. Generally the error was less than 25 metres on the ground (1.0 mm on a 1:25,000 map sheet)

This level of accuracy is within the described accuracy of 1:25,000 topographic map sheets provided by LIC. GIS interrogation of LIC digital drainage layer provided control points and grid references that could be allocated to confluences and other features marked on overlays and captured by scanning contractor. This procedure provided an excellent fit to 1:25,000 topographic maps. It provided good value for money and time. It is also the preferred method used by the Victorian Department of Natural Resources and

Environment for the conservation and forest resource planning, including CRAs.

2.8 ANNOTATION AUDIT

Before sending photographs with their broad forest and growth stage overlays to digital capture contractors, an audit was undertaken to ensure that all nomenclature, polygon codes and line work was correctly completed. Types of errors removed were:

- unclosed polygons that overlapped photographs;
- un-coded polygons;
- polygons with multiple codes;
- incorrect use of line colours;
- incorrect labelling of overlays; and
- smudged or dirty overlays.

It was essential that all these errors were removed prior to scanning and digital capture.

2.9 ACCURACY ASSESSMENT OF FINAL GROWTH STAGE MAP

A combination of desktop audit and field checking was considered to best meet CRA API agreement assessment standards. Accuracy assessments of API is difficult to achieve for a variety of reasons including:

- The inherent subjectivity of the process of API (polygon boundary definition combined with polygon labelling) does not lend itself to statistically rigorous analysis
- For the most part, eucalypt forest polygons are not homogenous and it is difficult to select practically achievable field sampling methods
- Field based decisions relating to key API attributes can be just as difficult to make as photo based decisions e.g. is a tree or stand mature or senescent.

The project specifications and the API-EWG required an agreement assessment of the final growth stage map. The statewide API Manager selected a survey design and sampling technique after consultation with the API-EWG and project staff.

The API-EWG's principal areas of interest were in comparing the accuracy of the BOGMP with the new growth stage layer. Two areas were assessed; growth stage coding and disturbance coding. Four principle changes occurred in growth stage coding:

- Polygons that had old BOGMP codes changed without any significant alteration to their boundaries;
- Polygons that had boundary changes and no code change;
- New polygons with new codes; and

■ Old polygons with unchanged codes.

Another area of interest was the validation of line accuracy and disturbance coding.

Every tenth photograph along a run was initially targeted for agreement assessment. When the photograph did not have accessible forested land the nearest photograph along that run was selected. The BOGMP polygons with changed codes and no significant boundary alterations were targeted and re-evaluated. All polygons in the immediate proximity to changed polygons were then re-evaluated.

Initially the desktop audit was undertaken first followed by field checking. This was later reversed to give the validator the benefit of field checking experience before completing the desktop audit of the remainder of the photograph.

A proforma for desktop audit was provided by the statewide CRA API Manager. Two senior interpreters undertook the survey work. Results were collated and analysed using spreadsheets (Appendix 9.6).

2.10 DIGITAL CAPTURE SPECIFICATIONS

2.10.1 Summary

This phase of the project used digital mapping technology to transfer the data from the aerial photography overlays into a GIS coverage. The data could then be provided in a spatially corrected and rectified GIS coverage for use in other assessment projects.

Selection of equipment used in this project aimed to minimise problems and time required for digitising (scanning) and in the GIS editing. Specific methodology regarding inks and pens were required. (See Appendix 9.8)

2.10.2 Control and spatial accuracy

The digital capture contractors had complete responsibility for spatial accuracy. A maximum acceptable error for final GIS map was to within 37.5 metres (1.5 millimetres on 1:25,000 map sheet) of linear drainage features.

Apart from the 1:25,000 colour aerial photographs and all overlays the contractors were also provided with a set of flat 1:25,000 topographic maps and a digital version of the drainage layer created by Land Information Centre for those maps. The scanning contractors used the photography to transcribe drainage lines onto broad forest vegetation overlays. They then used the digital drainage layer to get accurate grid references for key points (e.g. confluences). The linear drainage layer was also used as a backdrop after rectification of scanned overlay lines for visual spatial accuracy checks.

Spatial accuracy against 1:25,000 topographic drainage features was chosen as an absolute reference point for spatial accuracy because it was cost and time effective

and concurrence with 1:25,000 map would maximise field reliability and utility of the GIS layers.

Two independent checks of the spatial accuracy were also undertaken. The first was by the API officer stationed with the digital capture contractor and the second was by NPWS staff on receipt of the final GIS layers. Where accuracy was not up to standard, tiles were returned to the transfer contractor for rectification.

2.10.3 Digital capture methodology and equipment

The principal steps of the two approved digital capture techniques are detailed below (refer Appendix 9.7 for details).

Technique 1: Scanning digital capture

- The digital capture first traced drainage lines onto broad vegetation classification overlays. These were done in blue.
- The overlays were then scanned OR manually digitised using SINGLE PHOTO digitising software;
- Colour separation of scanned images into two files, polygon labels (black) and lines and fiducials (red, blue and green);
- Lines and fiducial layer vectorised using raster to vector software;
- Line layer rectified using control points taken from drainage junctions and grid references from 1:25,000 map sheets;
- Line layers separated into blue, red and green;
- Polygons labelled on red file using MICROSTATION with scanned label layers as backdrop;
- Individual red overlays merged into 1:25,000 map sheets, lines stitched together between photographs;
- Edited and built in GIS red line layer;
- Independent API assessments of:
 - spatial accuracy using printout at 1:25,000 overlaid onto 1:25 000 flat and laminated topographic map;
 - code attribution by cross referencing photographic overlays with printout; and
 - GIS editing errors.
- Correction of errors identified by independent API assessment by digital capture contractor;
- Merging of 1:25,000 broad vegetation and growth stage map sheets together to check boundary consistency;

- Digital layer returned to NPWS in 1:25,000 map sheets tiles;
- Further assessment of spatial accuracy by CRA Unit, NPWS.

Technique 2: Manual digital capture

- The digital capture first traced drainage lines onto broad vegetation classification overlays. These were done in blue;
- Manual digitisation of red, green and blue lines using SINGLE PHOTO digitising software onto different data files;
- Blue line layer rectified using control points taken from drainage junctions and grid references from 1:25,000 map sheets;
- Rectification from blue line layer transferred to red and green line layers;
- Polygons labelled on red file using SINGLE PHOTO;
- Individual red overlays merged into 1:25,000 map sheets, lines stitched together between photographs;
- Edited and built in ARCINFO red line layer;
- Independent API assessments of:
 - spatial accuracy using printout at 1:25,000 overlaid onto 1:25,000 flat and laminated topographic map;
 - code attribution by cross referencing photographic overlays with printout; and
 - GIS editing errors.
- Correction of errors identified by independent API assessment by digital capture contractor;
- Merging of 1:25,000 broad vegetation and growth stage map sheets together to check boundary consistency;
- Digital layer returned to NPWS in 1:25,000 map sheets tiles;
- Further assessment of spatial accuracy by CRA Unit, NPWS.

provided with “creative” reworking of lines and codes then the boundary inconsistency was kept. The broad forest vegetation layer was combined with the digital RN17 layers. Digital RN17 layers were provided by SFNSW or digitised by the NPWS. RN17 was given precedence over broad forest mapping except when it was not mapped to the forest types. No attempt was made to merge forest type codes with broad forest vegetation codes. No attempt was made to rectify sliver and intersect errors in the SFNSW collated digital RN17 provided.

The merged growth stage mapping was updated with a digital layer of logging, that had occurred since photography, non-eucalypt plantations (provided by SFNSW), and the non forest polygons (from the broad forest vegetation layer: rainforest, heathlands, wetlands, cleared land, riparian and littoral communities) (refer Appendix 9.11 for detailed procedure). Final error correction was also undertaken. Final layers were then released to the Eden Forest Ecosystem Classification and Mapping (NPWS), Old Growth Mapping (NPWS) and Wood Resources Projects (Bureau of Resource Sciences and SFNSW). The Bureau of Resource Sciences have subsequently created an attribute table collating all broad forest vegetation classes with RN17 forest types.

2.11 FINAL GIS COLLATION

Final GIS collation involved the merging of 1:25,000 map sheet tiles of broad forest vegetation classifications and growth stage mapping into two single GIS layers with editing and sorting of polygon code attributes. Any stitching of polygon boundaries was only undertaken when obvious joins or errors could be identified. Where errors were not obvious or a solution could not be

All final GIS collation was undertaken at NPWS GIS Division using ARCVIEW 7.0 for NT. API project manager and GIS Division project officer completed these tasks. A GIS editing procedure was adopted to remove sliver and intersect polygons created during the merging procedures. Minimum size tolerance for polygons was set at 1.5 hectares for rainforest and rare forest classes and 7.5 hectares for all other broad forest and growth stage classes. These polygons were assimilated into the adjoining non rainforest polygon (Appendix 9.11).

