Land Management Practices Mapping - A Tasmanian Pilot Study to Develop the Methodology and Test the Feasibility of Statewide Land Management Practice Mapping

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For the Bureau of Rural Sciences

Tasmania

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Introduction

As part of Tasmania's commitment to developing a system for mapping Land Management Practices at a suitable scale for the state's Natural Resource Management activities and research, a pilot project was undertaken in a selected project area to the south of Launceston.

The area included a variety of different landuses in order to fully test the methodology, including irrigated and dryland cropping, grazing, perennial horticulture, forestry, conservation, rural-residential, urban and industrial. The area comprised 762 privately and publicly owned land parcels, however, this number was reduced to 260 after ignoring property sizes of less than 1 hectare to remove the urban landuse of the Evandale township.

Using the results of a 2005 scoping study in Tasmania to determine the drivers for land management practices information, 21 of the 326 key land management practices identified were chosen to test the recording and mapping information to address NRM regions, local and state government priorities for ensuring sustainable land use and natural resource management.

Objectives

1. Test the reporting and appropriate mapping of the top twenty-one land management practices as identified by stakeholders in a recent consultative project.
2. Test both desktop and field methodologies
3. Determine the utility of the reporting and mapping product to stakeholders.
4. Perform a cost-benefit analysis of the different mapping methods and final products.

Outcomes

1. Recommended list of land management practices that should be mapped in Tasmania.
2. Recommended mapping and reporting methodology.
3. Recommended data resolution (scale) for state-wide mapping.
4. Time and budget estimate for state-wide mapping of land management practices.

Outputs

Four maps were produced grouping the 21 land management practice categories,

- Practices related to native vegetation
- Practiced related to property planning
- Practices related to riparian zones and irrigation
- Practices related to cropping

A spatial dataset was also developed to enable analysis of practices, with each polygon or parcel boundary containing sub-practice information linked to a unique property identifier. The methodology used was documented and reviewed to assess its applicability and ability to map land management practices, and where any improvements might have been possible. Using the developed methodology, a project proposal was developed to estimate the costs and benefits of delivering the project statewide.

Study Area

The pilot area is approximately 10,000ha, 15km to the south of Launceston, in the municipalities of Launceston and Northern Midlands, and within the South Esk, North Esk and Nile catchments. It was chosen as an area of recent landuse change, (including expansion of irrigated agriculture), with a variety of different landuses (see Table 1) to fully test and challenge a methodology for mapping land management practice information.

Land Use Class	Area (ha)
Agriculture	5,849
Built Environment	297
Conservation	181
Irrigated Agriculture	2,053
Minimal Use	1,333
Plantation	19
Production Forestry	934
Water	67
Total	10,735

Table 1. Area and Proportion of Land Use Class

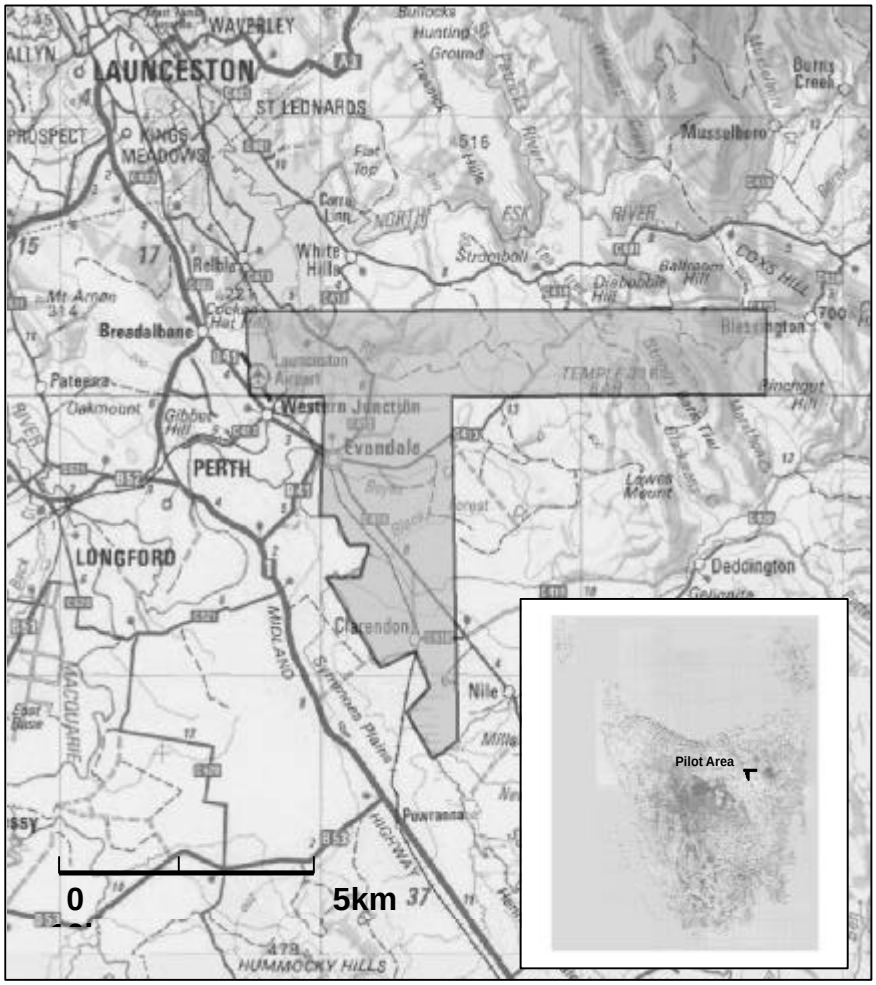


Figure 1. Location of Pilot Area

Targeted Land Management Practices

The twenty-one top-ranked land management practices determined by the 2006 scoping study are grouped into eight categories, as per Table 2.

A. Practices about native vegetation A1. Formal protection of native vegetation A2. Informal protection of native vegetation A3. Fenced remanent vegetation A4. Vegetation management plan
B. Practices about property planning B1. Property management plan B2. Environmental management systems B3. Quality assurance systems
C. Practices about riparian areas C1. Fenced riparian management zones C2. Off-stream watering points C3. Riparian management zone revegetation
D. Practices about irrigation management D1. Irrigation scheduling method D2. Irrigation water application method D3. Water storage facility type D4. Water source D5. Monitoring irrigation water quality
E. Practices about soil conservation E1. Soil conservation methods
F. Practices about weed and game management F1. Controlling specific weed species F2. Game management plan
G. Practices about cropping G1. Crop rotation system G2. Nutrient Input
H. Practices in general H1. Accessing technical support, training and skill development

Table 2. Land Management Practices targeted for the pilot project

The most common sub-practices were also targeted, recorded and mapped using various techniques, either as discrete polygons, or linked to unique parcel identifiers where deemed applicable (the majority of practices). Detailed practices are listed in Appendix 1, which lists land management practice category, sub-practices, spatial description and attribution, and the associated data source(s).

Method

Landuse Updates

Initially, it was decided that the existing 2003 Land Use dataset would require updating due to known landuse change in the area, to enable more accurate targeting of appropriate land parcels for land management practice mapping.

This procedure was performed using desktop analysis, primarily using interpretation of 1:42000 rectified aerial orthophotos with 1m pixel resolution, (year 2005), (which enables approximately x12 zoom-in/enlargement before actual pixels become visually apparent), and latest Google-Earth Imagery. QuickBird® imagery is not yet available for the entire state, and was not available for the pilot area. Most landuse changes were clearly visible by photo interpretation using parcel by parcel on-screen examination, for example, centre-pivot irrigation, cropping, viticulture and quarrying, however, some areas where rotational cropping or irrigation was present required alternative detection methods. Paper maps were updated using various departmental experts and industry representatives with extensive local knowledge, and relevant departmental data sources. The land use updates were field-checked and corrected by project-staff, and finalised during field collection of land management practice data.

The landuse change summary is included in Table 3, however, this does not reflect actual land use change for the area, as some changes could be due to different detection methods and personnel interpretation. Map 1 in the Appendices shows updated landuse for the area.

ALUM Code	original area (ha)	update area (ha)	% change
1.1.7	181.80	230.34	26.7
1.3.3	1333.99	1284.03	-3.7
2.1.0	90.73	90.48	-0.3
2.2.0	934.13	933.41	-0.1
3.1.0	0.60	0.61	1.3
3.1.2	18.43	18.91	2.6
3.2.0	5758.42	5745.02	-0.2
4.3.0	2053.36	3028.32	47.5
4.4.4	0.00	5.63	new landuse
5.4.0	131.81	131.78	0.0
5.5.0	4.24	4.30	1.5
5.5.2	3.39	3.37	-0.7
5.5.3	10.82	10.86	0.4
5.7.1	111.01	111.40	0.3
5.8.0	22.21	22.21	0.0
5.9.2	2.00	2.00	0.0
5.9.5	4.82	4.85	0.6
6.2.0	23.43	24.14	3.0

Table 3. Landuse Updates

The most significant changes include;

- A 26.7% increase in conservation area (ALUM Code 1.1.7)
- A 47.5% increase in Irrigated Cropping (ALUM Code 4.3.0

Land Management Practice Mapping

It was determined that due to the varying physical and social types of data represented across the targeted land management practices, different data sources and assessment methodologies would be required for each practice and sub-practice. Initially, desktop

analysis was used where possible, in conjunction with accessing existing datasets held by the agency, local council and NRM groups. However, some practices were deemed virtually impossible to determine using desktop procedures due to their nature, for example, crop rotation phases and irrigation scheduling methods cannot be detected without more frequent aerial photography or satellite imagery to allow temporal-based remote-sensing assessments. For such sub-practices, it was decided that land-owner or industry representative contact was essential, to enable recording of meaningful data using personal, web-based, mail out or telephone survey techniques.

For most practices, mapping to the land parcel level was deemed suitable, with sub-parcel mapping considered impractical due to the time and resources involved in doing so, and the difficulties encountered in the temporal variances evident in many practices. In addition, the 2003 Landuse Dataset for the state was not mapped at the sub-parcel level, which would be required to target appropriate areas to map management practices. Land parcel identifier was used to attribute the entire land parcel if that land management practice was considered a substantial proportion of that parcel. In many cases, practices such as irrigation involve the rotation of irrigators and crops around various parts of the property; therefore that was considered a major land management practice for that parcel. However, some practices were considered as non-representative of entire parcels, and thus mapped as the sub-parcel or polygon level using ortho-photo interpretation, or as indicated during land owner/ manager surveys.

The various techniques developed and implemented for collecting land management practice information are detailed as follows;

Database and Spatial Attribution

Base spatial information was used as cadastral land parcels, with parcel identifiers (PID) as the primary identifier. Property owner surname was also used as a primary identifier, which was obtained using LIST (Land Information System Tasmania) subscriber services. The Department of Primary Industry and Water's Land Services Branch is custodian of this data, and provides all property owner and valuation details.

GIS Interpretation

ESRI® ArcMap® was used to manipulate, interrogate and display spatial data. In conjunction with the base layer datasets, rectified ortho-imagery was obtained for the study area for visual detection of land use and management practices relevant to this study. Images were full colour, 1:42000 rectified aerial orthophotos with 1m pixel resolution, (year 2005), (which enables approximately x12 zoom-in/enlargement before actual pixels become visually apparent). Google Earth imagery was also used to improve interpretation confidence, especially temporally-dependent practices which could only be detected visually for limited times of limited years.

Local Expert Departmental/ Industry/ Local Knowledge Base

It was determined that time and resource efficiency would be improved by consulting experts with local knowledge of the pilot area. It was found that this method was essential for updating land use information, and targeting areas to apply the different land management specific mapping methodologies. This method was also invaluable for identifying property owners who could not be determined using LIST data, as many properties are listed in Tasmania as being owned by Businesses or Holdings. A combination of departmental staff, local representatives of agricultural service providers, and key local farmers where used to update land use, identify areas where the required land management practices would be found, and also as a check of the initial land use updates for the area. This process was achieved by individually meeting each expert, and scanning each parcel within the area with respect to relevant uses and management being targeted.

Database

A simple Microsoft® Access® database was developed, using PID and land owner surname as primary keys. Each land management category was attributed with individual fields in separate tables, all linked by PID. Land Management sub-practices were also represented by

individual fields, each in the format of 'true/ false' or 'yes/no' fields to record whether a land management practice is undertaken, or not. Where applicable, numeric fields were associated to each practice where an estimate of extent or volume was possible and relevant to determine more representative figures than allowed by recording parcel area only.

The database was linked by PID to the GIS, providing spatial extent of each land management practice, and the output mapping products. For the majority of practices, the map outputs display land parcels which land management practices occur, but not the spatial extent of where practices are occurring in each parcel, (ie. not generally mapped to polygon level). This was mainly due to the temporal or rotational variations in the practices targeted, which would be difficult to boundary map without detailed and highly frequent (eg. biannual) imagery.

Land Owner Survey
Where land management practices could not be determined using desktop methods, or needed more accurate attribution or verification, a face to face land owner survey was developed and conducted. This method was chosen over telephone or mail-out survey, as past projects such as SCEAM (Soil Condition Evaluation and Monitoring Project Tasmania) collecting land management information have shown these methods unreliable. The majority of land owners targeted are farmers, who have tended to voice their dislike to departmental staff of phone survey, while written mail-out/ fax or electronic email forms have tended to have very slow return rates, or lack of completion. Delays are also experienced if farmers are unsure of exactly what or why a question is being asked.

A series of questionnaire forms was developed using the Land Management Practices database, to directly input land owner responses using a lap top computer (See Appendix 2). Forms were sequential, working through all targeted land management practices, using simple tick-boxes, with some numeric fields, and note fields to enhance assessment of the developed methodology. New records were imported to the main database on return from the field.

The preliminary requirement was for landowners to estimate percentage area of the five main landuses that were deemed directly relevant to the target management practices;

1. Estimate % Area Exclusion (eg. riparian zones, native vegetation)
2. Estimate % Area Irrigated Land
3. Estimated % Area Non-Irrigated Land
4. Estimate % Area Grazed Land
5. Estimated % Area Cropped Land

From the above estimates, it becomes possible to estimate the actual area covered within the pilot area, where the percentage of the relevant use can be applied to the land management recorded, and multiplied out by the entire property cadastral area. This provides more meaningful results in terms of estimating area for each land management practice, and disregarding smaller insignificant areas that fall below a minimum mappable area, without the need for time consuming and expensive polygon mapping. This is especially the case for a methodology that could be used on a statewide scale, with detailed polygon mapping deemed impracticable due to resource constraints.

Land Management Practice Categories

Land Management Practice Category
A. Practices Related to Native Vegetation

Land Management Practice
A1. Formal Protection of Native Vegetation

Land Management Sub-practices
Conservation Covenant, Conservation Covenant (Part 5 agreement), Vegetation management agreement, private sanctuaries, public reserves

Method
Desktop Analysis - These sub-practices are formally recorded and held by the DPIW Integrated Private Conservation Registry and the DPIW's LIST (Land Information System of Tasmania) cadastral land tenure datasets, as Land Parcel Identifiers that are linked to spatial property parcels.

Attribution
Polygon or Parcel Identifier - Within the pilot area, the entire land parcel is classified as a reserve, or covered by conservation covenants/ agreements. The polygon boundary information held by the Department would be used if applied to the remainder of the state, where parts of land parcels might be mapped as this management type.

Land Management Practice
A2, A3, A4 - Informal Protection of Native vegetation, Fenced Remnant Vegetation, Vegetation Management Plan

Land Management Sub-Practices
Conservation of Native Vegetation, Easements Being Managed for Conservation

Method
Desktop Analysis - Although some areas of fenced vegetation are identifiable by aerial photo interpretation, the rationale behind fencing of native vegetation is unclear. Easements are identified through council records.
Land-Owner Interview - this method will identify whether native vegetation is informally being protected or fenced, included in management planning, with rationale and methods of conservation. This provides the most accurate mapping, and was recorded through a set questionnaire that also records other Land Management Practices of interest. (See Appendix 2 F. Practices Related to Native Vegetation)

Attribution
Native vegetation management areas were recorded as linked to PID (parcel identifier) if a substantial proportion of an entire land parcel (ie. Greater than 80%), or not of minimum mappable area (less than 10ha). Other management areas greater than 10ha were recorded as polygons by ortho-photo manual interpretation, or as indicated during land owner survey.

Land Management Practice Category
B. Practices Related to Property Planning

Land Management Practice
B1. Property Management Plan (PMP), B2. Environmental Management System (EMS), B3. Quality Assurance Systems (QA)

Method
These categories of land management practice do not visually present using satellite or ortho-photogrammetry - this can only be determined from regional environmental organisation/ industry or land owner records.
NRM, NLP, Industry Records - Land Owners who have undertaken formal PMP's through the National Landcare Program or NRM regional bodies were recorded via formal record-keeping processes through NRM and ENVIROFUND
Land Owner Interview - Any Property management Plans undertaken externally to the above systems were recorded through the land owner survey process. However, land owners were targeted who were assessed as having cropping-associated landuse, therefore the extent of this management practice could have been underestimated. . Practices of land owners who are accredited with EMS or QA practices were determined using the survey technique, as

these records were protected by privacy legislation. (See Appendix 2 B. Practices Related to Weed and Game Management)

Attribution
Practices related to property planning were attributed to parcel identifier, as PMP's, QA and EMS are related to each property as an entire entity.

Land Management Practice Category
C. Practices Related to Riparian Areas

Land Management Practice
C1. Fenced Riparian Management Zones, C2 Off-Stream Watering Points, C3. Riparian Management Zone revegetation

Method
Riparian practices were determined using a mixture of desktop, departmental records and land owner interview.
Desktop/ orthophoto analysis - Riparian management zones could be determined from orthophoto manual interpretation, although some instances proved difficult to detect fences, off-stream water points or revegetation extent and species. It was concluded that these practices might be underestimated using this technique, and was better detected using departmental records or survey techniques.

Land Owner Survey - survey methods were used to capture data where riparian management wasn't documented as a formal process, or funded through NRM programs. (See Appendix 2
Attribution
Parcel identifier was used as an indication of the number of properties managing riparian zones, with polygons or arcs recorded where practical, or substantial zones greater than minimum mappable area.

Land Management Practice Category
D. Practices Related to Irrigation Management

Land Management Practice
D1. Irrigation Scheduling Method, D2. Irrigation Water Application Method, D3. Water Storage Facility Type, D4. Water Source

Method
Irrigation Scheduling practices could not be determined from desktop GIS analysis, and this information is not recorded by the DPIW Water Management Branch and the Water Information Management System (WIMS). Irrigation Application method, storage type and water source was initially determined using desktop methods, using WIMS and orthophoto interpretation, however, rotational irrigation, some application methods which aren't clearly visible (ie. non centre-pivot applications), and definite water source could only be determined or verified using land owner survey.

Water Management Information System (WIMS) - WIMS is held by the DPIW Water Management Branch, and contains data relevant for storage facility, ie. Dam ID, purpose (stock, domestic or irrigation), storage capacity, and usage rates. WIMS data is adequate for addressing the listed sub-practices, but remaining sub-practices required additional mapping.
Desktop/ GIS - Areas of irrigation landuse were identified using manual orthophoto interpretation, which was especially evident for centre-pivot styled irrigation. However, rotational irrigation, other application types, and water source was not able to be determined.
Land Owner Survey - Remaining irrigation management practices recorded by land owner interview, where water source, application scheduling and irrigation monitoring was able to be determined and verified. (See Appendix 2 D. Practices Related to Irrigation)

Attribution
WIMS data has point source data (Easting and Northing, GDA94 Zone 55) relating to each dam. Other irrigation practice information was recorded by parcel identifier, as it was considered impracticable to map polygon irrigation areas, especially at a state-wide scale.

Land Management Practice Category
E. Practices Related to Soil Conservation

Land Management Practice
E1. Soil Conservation Methods (see Appendix 1 for detailed sub-practices)

Method

Desktop/ GIS - Practices such as windbreaks, permanent waterways, contour drains and contour farming were possible to be identified using desktop orthophoto manual analysis, however, most practices are on a rotational basis, and difficult to determine using this method. Automated detection methods were not developed for this technique, as they were considered too time consuming to calibrate for the numerous land management practices and sub-practices targeted for such a small area. This approach would be warranted for a state-wide approach.

Wind breaks were hand digitised using orthophoto interpretation, and extensively field checked. Amendments were re-digitised in the field using ArcGIS, however these errors were minimal with approximately 80% accuracy. Difficulties were encountered differentiating between wind-breaks and shelter belts, therefore these practices were amalgamated where not obvious, as they essentially perform the similar functions, ie. soil conservation and stock shelter. Another source of desk-top error was remnant hedge-rows, which have overgrown over several decades, but still maintain the linear features of windbreaks. These were omitted, as the current and initial purpose wasn't regarded as being for soil conservation, or even stock protection.

Land Owner Survey - Many soil conservation management practices could only be determined via direct land owner contact (survey). Some practices were determined via industry representative contact, however, it was decided that the survey approach was the only method which could guarantee the required 80% accuracy. (See Appendix 2 E. Practices Related to Soil Conservation)

Attribution
Where definite and substantial areas of soil conservation were evident (> 10ha), these practices were mapped as polygons using direct digitising over rectified ortho-photos. However, many practices were related to rotational cropping, (ie. varied in spatial and temporal extent). These were therefore recorded against parcel identifier (PID) only, (ie. as occurring within the relevant parcel).

Land Management Practice Category
F. Practices Related to Weed and Game Management

Land Management Practice
F1. Controlling Target Weeds, F2. Game Management Plan

Method
Land Owner Survey - No weed or game management plans were registered with DPIW. This information could only be recorded and mapped using direct Land Owner Survey, as these type of practices would not be evident from satellite or orthophoto imagery. (See Appendix 2 F. Practices Related to Weed and Game Management)

Land Management Practice Category
G. Practices Related to Cropping

Land Management Practice
G1. Crop Rotation System, G2. Nutrient Inputs

Method
Desktop/ GIS - Cropping landuse was updated using orthophoto manual interpretation, with various phases of crop rotational cycles clearly identifiable. However, where pasture phases of crop rotations were evident at the time of aerial fly-over, this landuse could be potentially underestimated if no other visual signs of cropping were evident. It was also impossible to identify the type of rotational management system in operation, without detailed time series photogrammetry.
Land Owner Survey - Detailed crop rotational systems were only identifiable using direct land owner contact due to the temporal variability of these practices. This was also the case for nutrient (fertiliser) inputs, with type, rate and area spread impossible to identify from spatial images. (See Appendix 2 - G. Practices Related to Cropping)

Land Management Practice Category
H. Practices Related to Technical Training and Development

Land Management Practice
H1. Accessing Technical Support, Training and Skills Development

Method
Land Owner Survey - Although information regarding these practices are kept as departmental, NRM, Private Industry, TFGA (Tasmanian Farmers and Graziers Association) and TAFE records, due to privacy legislation it was deemed not practicable to use these sources for land management practice mapping. This information was only obtained through land owners who were surveyed by direct contact, (See Appendix 2. H. Practices related to Technical Training).

Summary of Land Management Practice Methods

Land Management Practices	***Method of Mapping/ Attribution***
A. Practices about native vegetation	
A1. Formal protection of native vegetation	DPIW Records
A2. Informal protection of native vegetation	DPIW Records, Survey
A3. Fenced remanent vegetation	Spatial Image interpretation, Survey
A4. Vegetation management plan	DPIW Records, Survey
B. Practices about property planning	
B1. Property management plan	Survey (available from NRM North in future)
B2. Environmental management systems	Survey
B3. Quality assurance systems	Survey
C. Practices about riparian areas	
C1. Fenced riparian management zones	Survey
C2. Off-stream watering points	Survey
C3. Riparian management zone revegetation	Survey, Spatial Imagery Interpretation
D. Practices about irrigation management	
D1. Irrigation scheduling method	Survey
D2. Irrigation water application method	Spatial Imagery Interpretation, Survey
D3. Water storage facility type	Spatial Imagery Interpretation, DPIW Records, Survey
D4. Water source	Survey
D5. Monitoring irrigation water quality	Survey
E. Practices about soil conservation	
E1. Soil conservation methods	Survey
F. Practices about weed and game management	
F1. Controlling specific weed species	Survey
F2. Game management plan	Survey
G. Practices about cropping	
G1. Crop rotation system	Expert, Industry, Survey
G2. Nutrient Input	Survey
H. Practices in general	
H1. Accessing technical support, training and skill development	Survey

Table 4. Summary of Practice Mapping Method

Linkages to LUMIS

An attempt was made to link LUMIS (Land Use Management Information System) codes with the land management practices targeted for the pilot study. These linkages are included in Appendix 3 - Linkages to LUMIS v1d. The most appropriate LUMIS v1d codes were applied to the practices and sub-practices used in the study, with 'none applicable' coded to those practices where no LUMIS code could be attributed. LUMIS codes that were assessed as not quite fitting the pilot study categories are included in red font.

The land management practices categories targeted were developed in 2006, independently to LUMIS, and as a result did not fit well for some categories, whereas some categories such as irrigation management fitted well.

A. Practices about Native Vegetation

Land management practices including formal and informal protection of native vegetation was not easily coded to LUMIS, however, this maybe due to LUMIS 1.4 Plant Protection appearing to be incomplete for the version used (September 2007). As a result, sub-practices such as conservation covenants and vegetation management agreements could not be assigned LUMIS codes.

B. Practices about Property Planning

Property planning practices were assigned LUMIS codes to the practice level, with no detailed categories available for the sub-practice levels. Property Management Planning in Tasmania is managed and funded on private properties by NRM regional bodies, and is a process similar to whole farm planning. The most appropriate LUMIS category applied to this practice was 6.1.2.1Resource Management Plan under Business Planning.

Accreditation / Certification (6.3.3.1) was coded to Environmental Management Systems and Quality Assurance Systems, however it may be necessary to split this code to allow differentiation between the two. Detailed LUMIS lists would also be required to record the sub-practices targeted in the pilot, (eg EurepGAP, Freshcare).

C. Practices about Riparian Areas

Practices regarding riparian vegetation management were generally linked to 'plant' LUMIS categories. There was no split in the LUMIS system to differentiate between riparian and non-riparian vegetation, which would be required if the accepted Tasmanian Land Management practices were to be mapped using LUMIS codes. It was also difficult to identify a LUMIS link for off-stream watering points for livestock.

D. Practices about Irrigation Management

Irrigation management practices were generally well matched to the LUMIS v1d codes. LUMIS codes were provided at greater detail than used in the pilot project for irrigation scheduling and monitoring, therefore the Tasmanian practices were coded to a higher level.

Water storage facility type did not link well to LUMIS, with no splits apparent for in-stream or off-stream dams. Water source is also considered a management practice, with no LUMIS codes apparent for this category, or the sub-practices mapped, for example, recycled effluent water, groundwater, or directly from river.

E. Practices Relating to Soil Conservation

The majority of soil conservation land management practices targeted for the pilot study did not link well to LUMIS v1d codes. Drainage practices across contours; to reduce surface run-off velocity; and maintaining cover in waterways were coded from water categories rather than soil. Several categories were also related to plant categories rather than soil conservation. The soil categories were recorded under rehabilitation, which generally fitted well, however, there was no specific LUMIS code or detail for several of the Tasmanian practices.

It is not known whether management systems considered as soil conservation practices in Tasmania being categorised as other than soil and soil rehabilitation or protection will be an

issue. This should cause no problems when mapping soil conservation practices, as searches would be performed on known code groups within the entire suite of categories. Extra LUMIS codes will need to be created to cater for several Tasmanian specific practices in the soil conservation category.

F. Practices about Weed and Game Management

Weed management practices fitted well within the LUMIS coding system, although detail of Tasmanian targeted species will require coding. Game management was difficult to link to LUMIS, with regards to limited options for controlling animal pests within the animal categories available.

G. Practices about cropping

Linking crop rotation systems as a LUMIS code was possible, however, detailed LUMIS codes will be required to cater for the most common systems used in Tasmania. The systems chosen were commonly accepted generalised orders of crop type used throughout Tasmania's cropping areas. It became apparent while linking the LUMIS codes to the Tasmanian practices that the rotational cropping system option of "opportunistic" was overlooked in this study.

Nutrient inputs linked quite well to LUMIS, with detailed LUMIS code generation required where sub-practice information including fertiliser constituent and application rates were recorded.

Discussion

It was obvious from the study that while several sources of desktop mapping adequately recorded land management practice information within desired accuracy limits, there were several categories that could only be mapped using direct farmer contact (survey). Practices such as property planning, some water management data, and native vegetation protection are already recorded adequately by the Department of Primary Industries and Water, and regional NRM bodies, and would not require any further modifications. These practices were not tested thoroughly during the pilot study, as they already undergo rigorous data collection procedures, error checking and analysis from the sections involved.

Practices and sub-practices such as crop rotations, nutrient inputs, soil moisture monitoring for irrigation, and farmer technical training is impossible to detect from remote sensing or aerial image interpretation. These practices don't present as adequately evident visual physical changes, and are not generally recorded by the agency. Some of this information would be available from private industry organisations and agricultural service providers, but is difficult to obtain due to privacy legislation and confidentiality of customer records. Private property planning information held by regional NRM bodies, (which contract this work out to agricultural consultants), is also bound by privacy legislation. The privacy issue would need to be addressed before any statewide mapping program was undertaken, and would require mass agreements signed by landholders to allow release of this information to the agency. This would be a large undertaking, and would be met by some resistance from both the agricultural companies and landowners, especially in competitive, commercially sensitive situations where commercial confidence is effectively practiced, as confirmed from discussions with several landholders and industry representatives.

Additional difficulties with the desktop analysis included;

- The "intent" of the mapped management practice, that is, whether the practice recorded is intended to serve the purpose of the mapping category. For example, determining whether a row of trees was planted to provide wind shelter for the purpose of soil conservation, (windbreaks were listed in the scoping study as a sub-practice of soil conservation). The trees main intent may have been for privacy or stock protection purposes, without any consideration for protecting soils. The trees would physically protect the soil from wind, so could be mapped for this reason. However, if the purpose of collecting this information is for assessing the uptake or adoption of soil conservation techniques in a defined area for NRM investment strategies, it could be argued that these instances do not fit this category. It is therefore important to understand the purpose for which a land management practice is being mapped, with such ambiguities unavoidable without direct landowner contact in many instances.

- Detecting fencing of riparian zones, and the purpose of riparian vegetation. Riparian vegetation can easily be determined from aerial image interpretation, however, fence-lines were not evident at the resolution of image used. The one-metre pixel resolution available in the orthophotos was not adequate for this purpose, with more detailed images required for successfully mapping these practices. This would require an improved flying program in many areas of the state. In addition, the intent of the vegetation is not evident without landholder contact (as above).

  Riparian management plans, formerly held by DPIW Rivercare Section, are now held with regional NRM bodies. The information available would require re-formatting and interpretation for use with effective land management practice mapping.

- Cropping phases. As discussed, crop rotations could not be detected from aerial imagery without numerous images being available over a sequence of years, to visually site changing phases. Also, detecting cropping landuse proves difficult if the crop rotation is in a pasture phase at the time of photography.

- Irrigation. While orthophoto interpretation is a good technique for identifying centre-pivot irrigation due to the unmistakable ground patterns present fro this practice, it is difficult to detect other types of irrigation, especially travelling systems which might be moved around paddocks in an opportunistic manner. Also, aerial imagery of irrigation areas where centre-pivots have been moved in a rotational manner can become faint over time, especially under thick groundcover.

- Formal property management planning shapefile boundaries had not been finalised for the pilot area at the completion date of the pilot project, and were subsequently neither unavailable nor released by the NRM contracted consultancies.

Outputs and Outcomes

Maps 2, 3, 4, 5, 6 and *7* show selected mapped land management practices for the Evandale pilot area. Only selected practices are displayed as a sample, as aesthetically legible maps would be too complex to produce due to the over-lap in practices across each property. Using the estimated land use percentages for each of the cropping/ irrigation properties targeted, it will be possible to make area estimates from cadastre parcel area information. For example, to find the total area where irrigated cropping management is occurring, each parcel where irrigation management is not null, the total percentage of irrigated cropping is multiplied by the total area. This particular land management combination is shown in Table 5.

Property Identifier	Area Estimate Irrigated Cropping
2768750	1958
2800693	2779
6398929	3245
7350345	1704
7607657	1278
7797382	1844
TOTAL AREA	**12808**

Table 5. Example of Irrigated Cropping Area

This approach would be useful for estimating area where each practice is being undertaken, and an effective tool for relevant agencies and NRM Regional bodies to assess the uptake and adoption of sustainable land use practices. For example, this data could be used to target areas where intensive cropping is a major landuse (or other soil-impacting uses such as forestry), and determine where a lack of mapped practices related so soil conservation is apparent, in conjunction with poor river quality data, and possibly erosion-prone soil hazard maps. This combination of data would most likely imply a soil erosion problem, with impacts on water quality. These areas could then be targeted for increased investment in terms of soil conservation education programs.

Recommended list of land management practices, mapping and reporting methodology for Tasmania

Due to the fact that DPIW and NRM regional bodies adequately map several of the targeted twenty-one land management practices, there is little need to develop methodology to record these practices further. However, there would be some need to refine existing data-sharing agreements to adequately address privacy legislation in some instances. The following practices and sub-practices can adequately be recorded using desktop analysis, specifically use of existing datasets.

Desktop Compilation - Existing Data

- Formal Protection of Native Vegetation (DPIW ILS)
- Property Management Planning (NRM Bodies)
- Irrigation - Water Storage Facility Type (WIMS)
- Irrigation - Water Source (WIMS)

The following practices can also be compiled using desktop data audit, however, this information comes from private data sources, and would require privacy and data release agreements to be developed (as discussed).

Desktop Compilation - Private Data Sources

- Environmental Management Systems
- Quality Assurance Systems
- Some Crop Rotation Data
- Nutrient Input (fertiliser companies)

The following practices can be compiled from desktop analysis, using automated (eg ERDAS Imagine), and manual on-screen digitising. Automated methods weren't developed for the small pilot area, but would be employed for statewide mapping. Image resolution didn't allow for effective digitising of some practices, which would need rectifying for future mapping using these methods.

Desktop Compilation - Aerial Image Analysis

- Fenced Remnant Vegetation
- Water Storage Facility Type
- Irrigation Application Method
- Riparian Management Zones
- Soil Conservation - Windbreaks
- Soil Conservation - Contour Farming
- Soil Conservation - Stormwater Retention Ponds
- Soil Conservation - Across Slope Cultivation

The following practices could not be accurately mapped using any other method than direct landholder contact using survey techniques. However, several practices would have the opportunity for detection with improved aerial imagery.

Field Survey of Landholders

- Informal Property management Plans
- Irrigation Scheduling Practices
- Irrigation Application Method
- Irrigation Water Quality Monitoring
- Soil Conservation - Cover Crop
- Soil Conservation - Deep Ripping
- Soil Conservation - Incorporation of Crop Residue
- Soil Conservation - Stubble Retention/ Cover
- Soil Conservation - Perennial Pastures as Part of Crop Rotations
- Soil Conservation - Controlled Traffic
- Soil Conservation - Precision - farming
- Soil Conservation - Minimum Tillage
- Soil Conservation - Direct Drill
- Soil Conservation - Raised Beds (if not apparent from aerial imagery)
- Weed and Game Management Plans (formal and informal)
- Crop Rotation Systems
- Nutrient Inputs
- Technical Training

Recommended Scale

For the methods used in the pilot study, ie. Collecting the majority of information at the land parcel level, the most appropriate scale is 1:25,000 (the scale of the departmental cadastre coverages). This is also a reasonably obtainable level of mapping at the statewide scale. Larger scales could however be applicable to some land management practices, especially those collected using manual or automated image analysis.

Presentation to Stakeholders

Samples of various land management practices mapping combinations were presented to two representatives from NRM North (the Region containing the pilot area and perceived main stakeholders for this type of data), to determine the usefulness and format requirements, and obtain general feedback. Feedback was generally positive, and indicated that the techniques used to capture the practices data would be very useful to the Regions, especially when used in conjunction with other biophysical data such as soils and land capability mapping.

It was indicated that many of the practices are already recorded using alternative techniques, for example, fencing of riparian zones using NRM funding as the indicator, however, this method was considered imperfect in that several instances; fencing had since been removed

or not erected within acceptable timeframes. A small number of suggestions were made to potentially improve the data and usefulness to the Regions, the main one being a need to determine whether nutrient inputs were determined with, or in consideration of any nutrient budgeting. It was decided that this would be easily added to any future landholder survey.

It was also stressed by the Regional representatives that an improved and updated landuse coverage would be highly desirable for the state, and is one of the most requested data sources that continually arises through many of their regional activities.

Statewide Costs, Time and Feasibility

Several of the Land Management Practices targeted for mapping in this pilot were able to be determined with reasonable confidence via a desktop audit, using departmental, NRM Regional and consultant records, basic orthophoto interpretation, and expert departmental, industry and landowner knowledge. However, many practices could only be determined using direct landowner survey, especially practices related to cropping and soil conservation methods, ie. No departmental records exist, and are not visually apparent unless detailed time-sequenced spatial imagery was available. This outcome would significantly increase the time and resource requirements to undertake the survey approach to the entire state due to the cost involved in obtaining imagery, or time and resources taken for large-scale survey.

An alternate approach would be to use a desktop audit approach for many of the suitable practices listed in the methodology, with landowner/ farmer survey in key targeted areas only, for example, areas of intensive landuse of interest, or where management practices might be exacerbating known environmental degradation issues.

Automated image analysis (eg. ERDAS IMAGINE) would be developed to map more permanent physically evident practices on a statewide basis; for example, winds breaks; contour banks and fenced riparian zones. These were either mapped during the pilot process using manual ortho-image interpretation with on-screen hand-digitising or recorded using farmer survey responses and linked to a parcel identifier. The development of an automated process was considered too time consuming for a single practice over the 10000 ha pilot area when compared to the manual process, but would be warranted over the entire state.

In addition, preceding any attempt to undertake Land Management Practice Mapping at an applicable scale would require updating the statewide Landuse coverage. As demonstrated with the pilot study, landuse has changed throughout Tasmania since the last version was released, and is set to transform dramatically in coming years with:

- Irrigation expansion throughout the Midlands with a recent pipeline proposal,
- Irrigation expansion into areas serviced by the new Meander Dam,
- Increased vegetable production to offset national productivity decrease,
- Expansion of the Tasmanian dairy Industry
- Increase in plantation forestry on private land

If all twenty-one land management practice categories were to be mapped statewide, updated landuse would be essential to aid in targeting land where mapping would proceed, and which method would be employed. For example, landuse agriculture - cropping and irrigation would be targeted for landholder survey to collect soil conservation, irrigation and crop rotation data, while agriculture in general targeted for image analysis where practices such as windbreaks are visually evident.

It is also unlikely that all contacted landholders would be willing to provide potentially commercially sensitive information, with some concern and reluctance to participate experienced with the handful of farmers interviewed for the pilot study.

Statewide Approach

A full time project officer would be employed to undertake the majority of the statewide mapping. It is envisaged that the officer would be proficient in GIS and spatial data analysis, and also have the ability to liase and interview a variety of different landholders for face to face survey.

Task	**Time**	**Resources**
1. Update Tasmanian Landuse Coverage + Ground Truthing	6 Months	1 x FTE Level 1 Professional Officer
2. Desktop Mapping (Automated & Manual Image Analysis of Practices Suited to this Method, Collation of existing departmental datasets)	6 Months	1 X FTE Level 1 Professional Officer
3. Identify & Survey Cropping Areas - non spatially evident practices (Targeted Farmer & Key Representative Interviews)	6 Months	1 X FTE Level 1 Professional Officer
Total	**18 months**	**1 X FTE Level 1 Professional Officer**

Funds Required	**Per annum**	**Total (18 months)**
Labour (1 x FTE Project Officer, Level 1 Professional) @ $55,000 pa + 20% on costs	$66,000	$99,000
Vehicle	$25,000	$37,500
Recruitment	$1,000	$1,000
Field Travel & Accommodation	$14,400	$21,600
Operating	$25,000	$37,500
TOTAL Cost (18 months)		**$196,600**

State Contribution (In Kind)	**Per Annum**	**Total (18 months)**
Labour (Supervision by Principal Land Management Officer, 0.2 FTE)	$18,000	$27,000
Operating (Office, PC)	$10,000	$15,000
TOTAL (18 months)		**$42,000**

Cost Benefit

The above cost estimates are calculated for mapping the entire state using similar methodology employed in the pilot study, however, it is unlikely that all agricultural areas will need to be mapped this way. Focusing on the state's major cropping areas, where recording cropping, irrigation and soil conservation strategies would require the largest proportional work component, could reduce the above cost estimates. In addition, practices that are already collected by various sections of the agency (for example, WIMS and water data, conservation covenant areas, and property management planning areas) would not require additional funding to capture.

It would therefore be the most cost-effective and beneficial approach for the state to target cropping areas only, the landuse where the majority of the listed practices are evident, which would provided useful information to regional bodies, research bodies such as TIAR (The Tasmanian Institute of Agricultural Research), and various state agencies. Non-cropping areas would be mapped using desktop procedures only. Again, updated landuse coverage would be required before any statewide approach could be possible. Costs could also be reduced by using NRM bodies to develop key target areas, as opposed to a blanket state approach, for example, the Meander Valley Irrigation Scheme.

It is difficult to determine whether expenses of around $250,000 would be warranted to produce the type of data capable of being mapped across the state at a scale of 1:25,000, although a proportion of this cost would be to update landuse. When broken down into components of required funding, the cost would equate to around $67,000 per NRM region to update landuse and capture key land management practices, which could provided enough benefits to warrant the expense.

Conclusions

Before a mapping program of land managemnt practices could be undertaken across the state, the existing landuse coverage would require updating. This has been emphasised by various NRM groups, who have immediate needs for these updates. They have also been positive of the benefits of collecting the land management practices targeted in the pilot study, mapped across broader target areas.

While some practices were easy to capture using a simple desk-top approach, other practices could only be captured using direct farmer contact and field mapping. This method is slow, and would consequently increase time and costs to apply across the state's cropping areas. There are also several issues of the temporally changing nature of practices that would require refining before further mapping was to commence.

In summary, the actual time and costs involved in collecting the practices for the pilot study were considered reasonably low with respect to the type of data achievable and its potential usefulness, when used in conjunction with existing datasets, and for targeting areas of research or NRM-based investment strategies.

References

Leslie, R (2004). Land use and land management practices: Concepts, terms and classification principals. Bureau of Rural Sciences, Canberra. Unpublished

Zund PR (2006) Tasmanian requirements for land management practices information. Department of Primary Industries and Water, Tasmania, Australia.

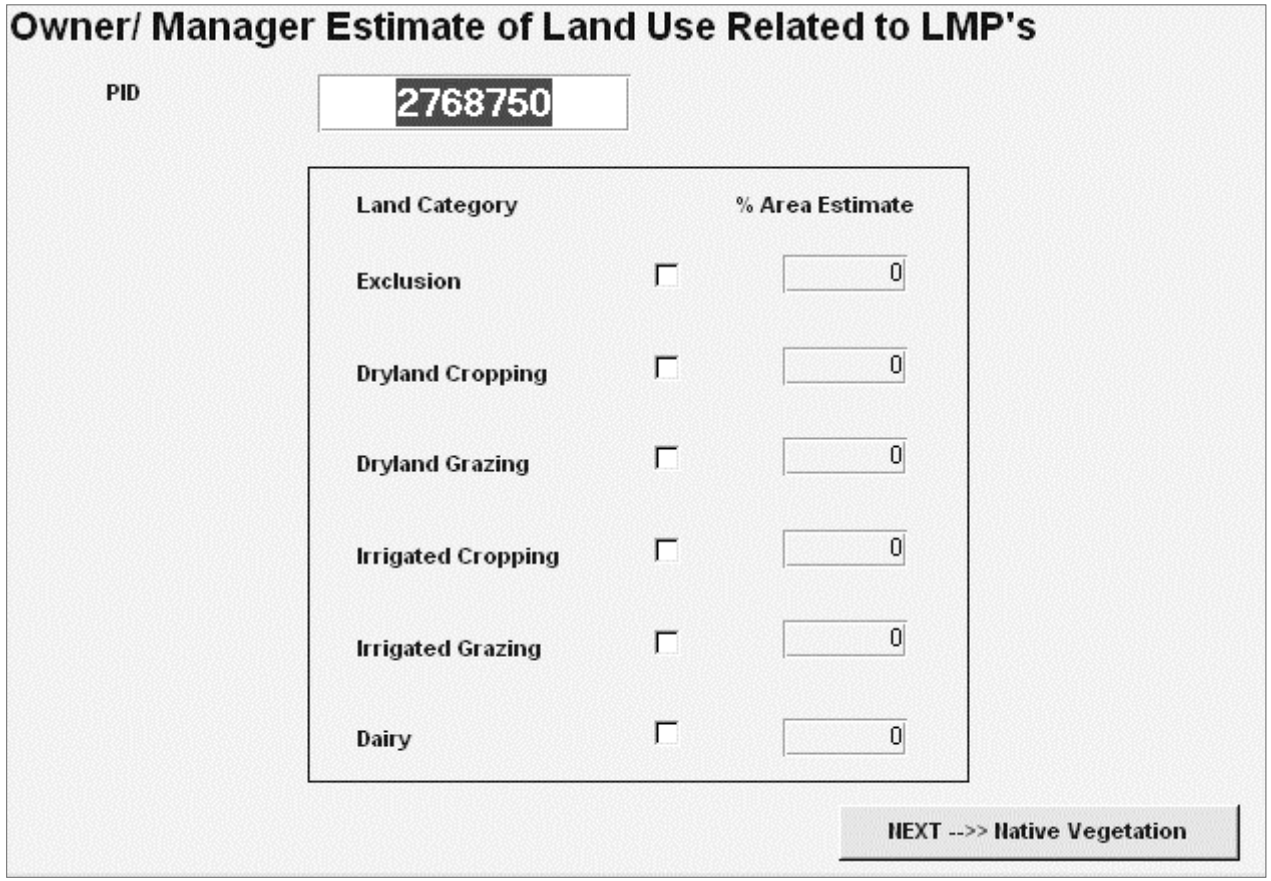
Appendices

Appendix 1 - Detailed Land Management Practices

Land Management Practices	Land Management sub-practices	Spatial information	Attribute information	Desktop data source
A. Practices about native vegetation				
A1. Formal protection of native vegetation	Conservation covenant	Polygon		DPIWE Office of the Recorder of Titles
	Conservation covenant under Part 5 Agreement	Polygon		DPIWE Office of the Recorder of Titles
	Vegetation management agreement	Polygon		DPIWE Integrated Private Conservation Registry
	Private reserve	Polygon	Reserve name	DPIWE Integrated Private Conservation Registry
	Private sanctuaries	Polygon	Reserve name	DPIWE Integrated Private Conservation Registry
	Public reserve	Polygon	Reserve name	DPIWE
A2. Informal protection of native vegetation	Conservation of native vegetation	Polygon		
	Easements being managed for vegetation conservation	Easement centreline and width		
A3. Fenced remanent vegetation		Polygon	Stock access?	DPIWE Integrated Private Conservation Registry; Tamar NRM; Rural Development Services Pty. Ltd.
A4. Vegetation management plan		Land parcel number	Stand-alone or part of a PMP.	DPIWE Integrated Private Conservation Registry
B. Practices about property planning				
B1. Property management plan		Land parcel number	Themes	Rural Development Services Pty. Ltd. Agricultural Resource Management Pty. Ltd.
B2. Environmental management systems	EurepGAP; Natures Choice	Land parcel number		
B3. Quality assurance systems	Cattlecare; Freshcare; Woolworths quality assurance standard; SQF2000	Land parcel number		
C. Practices about riparian areas				
C1. Fenced riparian management zones		Stream name; GPS start and finish of fence	Native veg; exotic veg; cleared;	DPIWE Rivercare section; Tamar NRM
C2. Off-stream watering points		GPS centre point		DPIWE Rivercare section; Tamar NRM
C3. Riparian management zone revegetation		Stream name; GPS start and finish of fence	Species planted	
D. Practices about irrigation management				
D1. Irrigation scheduling method	Water balance; Soil moisture monitoring; Calender; other	Land parcel number		McCains; Simplot; Tasmanian Alkiolds; Glaxo Smith Kine; DPIWE Water Management Audit of licensed irrigators; DPIWE Annual wine industry survey

D2. Irrigation water application method	Flood/furrow; Solid set drip/micro-spray; Overhead sprinkler; Centre pivot; Traveller	Land parcel number		McCains; Simplot; Tasmanian Alkiolds; Glaxo Smith Kine; DPIWE Water Management Audit of licensed irrigators; DPIWE Annual wine industry survey
D3. Water storage facility type	Off-stream gully dam; On-stream dam; Turkey's nest; Springfed dam; Catchment dam	GPS centre point	Storage volume (ML)	DPIWE Water Management Audit of licensed irrigators; DPIWE Annual wine industry survey; DPIWE ILS Topographic mapping
D4. Water source	Recycled effluent water; Groundwater; Flood flow harvested water; Irrigation scheme; Overland flow; Town/country reticulated supply; Recycled grey water; Direct from river	Land parcel number	Volume (ML)	DPIWE Water Management Audit of licensed irrigators; DPIWE Annual wine industry survey
D5. Monitoring irrigation water quality		Land parcel number	What for?	
E. Practices about soil conservation				
E1. Soil conservation methods	Cover crop; Windbreak; Deep rip; Grassed headlands; Permanent waterways; Fencing to exclude grazing; Incorporate crop residue; Cut-off drain; Contour farming; Stubble retention/cover; Cultivation across slope; Maintain surface roughness; Perennial pasture phase; Mulched-rip lines; Contour drain; Grassed lane and water ways; Stormwater retention ponds	Polygon		
F. Practices about weed and game management				
F1. Controlling target weed species	Gorse; Blackberry; Willows; Boneseed; Serrated Tussock; Bridal Creeper	Land parcel number		DPIWE Integrated Private Conservation Registry
F2. Game management plan		Land parcel number	Stand-alone or part of a PMP.	
G. Practices about cropping				
G1. Crop rotation system	Cereal phase; Cropping (cereals,peas,poppies) + no pasture; Cropping (cereals,peas,poppies) + pasture + stock; Legume phase; Pasture phase; Pasture + occasional cereals + crop; Vegetables (brassicas,peas) / poppies + pasture + stock / no stock; Vegetables (potatos,carrots,brassicas,peas,beans) + green manure + no stock; Vegetables (potatos,carrots,brassicas,peas,beans) + green manure+stock; Vegetables (potatos,carrots,brassicas,peas,beans) / poppies + no pasture	Land parcel number		Simplot
G2. Nutrient input	Bio-solid; bio-dynamic preparations; compost; inorganic fertiliser; manure; organic fertiliser	Land parcel number	Rate of application	Simplot; McCains; Tasmanian Alkaloids; Glaxo-Smith-Kine
H. Practices in general				
H1. Accessing technical support, training and skill development		Land parcel number	What type of info?	Rural Development Services Pty. Ltd.

Appendix 2. Land Owner Survey Questions Sample (from LMP Access Database)



A - Practices Related to Native Vegetation

PID 2768750

Fenced Remnant Vegtation?

Fenced Remnant Veg Purpose

Remnant Veg Notes

Method of Attribution

Vegetation Management Plan?

Vegetation Management Plan Type

Veg Management Plan Notes

Method of Attribution

NEXT -->> Property Planning

B - Practices Related to Property Planning

PID 2768750

Property Management Plan?

B1_PropManTheme

PMP Notes

Method of Attribution

Environmental Management Systems

EurepGAP

Nature's Choice

Other EMS

EMS Notes

Method of Attribution

Environmental Management Systems

Cattlecare

Freshcare

Woolworths Quality Assurance Standard (SQF2000)

QA Other

QA Notes

Method of Attribution

NEXT -->> Riparian Zones

C - Practices Related to Riparian Vegetataion

PID 2768750

Riparian Areas?

Fenced Riparian Areas

Off-Stream Watering Points

Riparian Revegetation Management

Species Planted

Riparian Zone Notes

Method of Attribution

NEXT -->> Irrigation Management

D - Practices Related to Irrigation

PID 2768750

Do You Irrigate? ☑

Percentage Area Estimate: 10

Rate (ML/ Ha): 0

Method of Attribution:

Irrigation Scheduling? ☐

Water Balance ☐

Soil Moisture Monitoring ☐

Calendar ☐

Other ☐

Irrigation Scheduling Notes

Method of Attribution:

Irrigation Management Notes

Irrigation Water Application Method

Flood/ Furrow	☐
Solid Set/ Micro-Spray	☐
Centre Pivot	☐
Traveller	☑
Drippers	☐
Other	☐

Irrigation Application Method Notes

Method of Attribution:

Irrigation Water Storage Method

		Volume/yr (ML)
Off Stream Dam	☐	0
In-Stream Dam	☐	0
Turkey's Nest	☐	0
Other	☐	0
Total Storage Volume (ML)		0

Application Notes

Method of Attribution:

Water Resource

		Volume/yr (ML)
Recycled Effluent Water	☐	0
Groundwater	☐	0
Flood Flow Harvested Water	☐	0
Managed Irrigation Scheme	☐	0
Town/ Country Reticulated Supply	☐	0
Recevied Grey Water	☐	0
Direct from River	☑	0
Other	☐	0
Total Water Used per Year (ML)		0

Resource Notes

Method of Attribution:

Monitoring Irrigation Water Quality ☐

method 1

method 2

method 3

method 4

Method of Attribution:

NEXT -->> Soil Conservation

G - Practices Related to Cropping

PID 2768750

Do You Undertake Cropping? ☐

Method of Attribution

Crop Rotational System		Rate Yrs Cropped /10Yrs
Cropping (Cereals, Peas, Poppies) + No Pasture	☐	0
Cropping (Cereals, Peas, Poppies) + Pasture + Stock + Break Crop Phase	☐	0
Pasture Phase	☐	0
Pasture + Occasional Cereal + Crop	☐	0
Vegetable (Brassicas, Peas)/ Poppies + Pasture + Stock/ No Stock	☑	0
Vegetables (Potatoes, Carrots, Brassicas, Peas, Beans) + Green Manure + Stock	☐	0
Vegetables (Potatos, Carrots, Brassicas, Peas, Beans) + Green Manure + Stock	☐	0
Vegetables (Potatos, Carrots, Brassicas, Peas, Beans)/ Poppies + No Pasture	☐	0
Other	☑	4

Method of Attribution

Nutrient Input		Tonnes / Ha/ Yr	Ha Spread /Yr
Biodynamic Preparations	☐	0	0
Compost	☐	0	0
Inorganic Fertilizer	☐	0	0
Manure	☐	0	0
Organic Fertilizer	☐	0	0
Other	☐	0	0

Method of Attribution

Cropping, Nutrient Input Notes

wheat, barley, canola

NEXT -->> Technical Development

Appendix 3 - Linkeages to LUMIS v1d

Category	Land Management Practice	LUMIS Code	Project Code	Land Management Sub-Practice	LUMIS Code	Alternate Code
A. Practices about Native Vegetation						
A0	Native Vegetation Management	1.4				
A1	Formal protection of native vegetation		A1.1	Conservation covenant	none applicable	
			A1.2	Conservation covenant under Part 5 Agreement	none applicable	
			A1.3	Vegetation management agreement	none applicable	
			A1.4	Private reserve	none applicable	
			A1.5	Private sanctuaries	none applicable	
			A1.6	Public reserve	none applicable	
A2	Informal protection of native vegetation	1.4	A2.1	Conservation of native vegetation	none applicable	
			A2.2	Easements being managed for vegetation conservation	none applicable	
A3	Fenced Remnant Vegetation	1.4				
A4	Vegetation management plan	1.4				
B. Practices about Property Planning						
B1	Property management plan	6.1.2.1?				
B2	Environmental management systems	6.3.3.1	B2.1	EurepGAP	none applicable	
B3	Quality assurance systems	6.3.3.1	B3.1	Cattlecare	none applicable	
			B3.2	Freshcare	none applicable	
			B3.3	Woolworths quality assurance standard SQF2000	none applicable	

C. Practices about Riparian Areas					
C0	Riparian Management	1.4			
C1	Fenced riparian management zones	1.4			7.2.2.7.3
C2	Off-stream watering points				
C3	Riparian management zone revegetation	1.1.5.1 1.1.5.2			
D. Practices about Irrigation Management					
D0	Irrigation	4.3.1			
D1	Irrigation scheduling	4.5.5	D1.2	Water balance	4.5.5.4
			D1.3	Soil moisture monitoring	4.5.5.4
			D1.4	Calender	4.5.5.3
D2	Irrigation water application method	4.3	D2.1	Flood/furrow	4.3.1.1
			D2.2	Solid set/micro-spray	4.3.2.2
			D2.3	Centre pivot	4.3.2.3.1
			D2.4	Traveller	4.3.2.3.3
			D2.5	Drippers	4.3.3.1.2
D3	Water storage facility type	4.1	D3.1	Off-stream dam	4.1.2.1.2
			D3.2	In-stream dam	4.1.2.1.2
			D3.3	Turkey's nest	none applicable
D4	Water Source		D4.1	Recycled effluent water	none applicable
			D4.2	Groundwater	none applicable
			D4.3	Flood flow harvested water	none applicable
			D4.4	Managed Irrigation scheme	none applicable
			D4.5	Town/country reticulated supply	none applicable
			D4.6	Recycled grey water	none applicable
			D4.7	Direct from river	none applicable

D5	Monitoring irrigation water quality	4.5.1 4.5.2 4.5.3 4.5.4	D5.3 D5.4 D5.5 D5.6		
E. Practices Relating to Soil Conservation					
E0	Soil Conservation Methods	3.1?	E1.1	Cover crop	none applicable
E1			E1.2	Windbreak	none applicable
			E1.3	Deep rip	4.1.3.4
			E1.4	Grassed headlands	none applicable
			E1.5	Permanent waterways	none applicable
			E1.6	Fencing to exclude grazing	7.2.2.7.3
			E1.7	Incorporate crop residue	1.3.4.3
			E1.8	Cut-off drain	4.1.1.1.2
			E1.9	Contour farming	none applicable
			E1.10	Stubble retention/cover	none applicable
			E1.11	Cultivation across slope	none applicable
			E1.12	Maintain surface roughness	none applicable
			E1.13	Perennial pasture phase	none applicable
			E1.14	Mulched-rip lines	none applicable
			E1.15	Contour drain	4.1.1.1.2
			E1.16	Grassed lane and water way	4.1.1.2
			E1.17	Stormwater retention ponds	none applicable
			E1.18	Controlled Traffic	3.1.1.3
			E1.19	Precision Farming	3.1.1.4
			E1.20	Minimum Tillage	3.1.1.2.1
			E1.22	Raised Beds	none applicable

F. Practices about Weed and Game Management						
F0	Do you undertake a program of weed management					
F1	Controlling target weed species	1.3.3.1.1 1.3.3.1.2	F1.1	Blackberry	13311a	13312a
			F1.2	Willows	13311a	13312a
			F1.3	Boneseed	13311a	13312a
			F1.4	Serrated Tussock	13311a	13312a
			F1.5	Bridal Creeper	13311a	13312a
F2	Game management plan	2.5.2?				
G. Practices about Cropping						
G0	Cropping					
G1	Crop rotation system	1.2.1.5	G1.1	Cropping (cereals, peas, poppies) + no pasture	none applicable	
			G1.2	Cropping (cereals, peas, poppies) + pasture + stock; Legume phase	none applicable	
			G1.3	Pasture phase	none applicable	
			G1.4	Pasture + occasional cereals + crop;	none applicable	
			G1.5	Vegetables (brassicas, peas) / poppies + pasture + stock / no stock;	none applicable	
			G1.6	Vegetables (potatoes, carrots, brassicas, peas, beans) + green manure + no stock;	none applicable	
			G1.7	Vegetables (potatoes, carrots, brassicas, peas, beans) + green manure + stock;	none applicable	
			G1.8	Vegetables (potatoes, carrots, brassicas, peas, beans) / poppies + no pasture	none applicable	
G2	Nutrient input	1.2.1.2	G2.1	bio-dynamic preparations	3.2.1.2.6	
			G2.2	compost	3.2.1.2.3	
			G2.3	inorganic fertiliser	3.2.1.1	
			G2.4	manure	3.2.1.2.2	
			G2.5	organic fertiliser	3.2.1.2	