Developing a Land Use and Management Information System (LUMIS) for the Northern Territory

Report on the Northern Territory Pilot Project

Technical Report 30/2008D

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Acknowledgements

The development of a LUMIS Pilot Project in the NT has been the culmination of work by a number of people. Dave Howe, who retired in early 2008, was the driving force behind the creation of a Land Use dataset and the development of LUMIS for the Northern Territory. He continues to be an active supporter of both LUMIS and ACLUMP. The development of LIMUS NT had its foundations in the work done by Aidan Smith who laid the ground work for the original proposal.

Much of the credit for the LUMIS NT Pilot Project goes to Haylee Robinson who took on the job after Aidan Smith moved on. She worked closely with Greg Owens and Chelsea Hennessy of the Horticultural Branch of DPIFM and Tim West from the NT Horticulture Association to develop the structure of LUMIS. Concurrently with developing the LUMIS Pilot, Haylee also commenced a full update of the land use map of the NT taking it from a snapshot of the NT cadastre to a dataset that spatially located land use below the property boundary before

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Abbreviations

ABS	Australian Bureau of Statistics
ALUM v6	Australian Land Use and Management Classification, Version 6
BPSLUNT	Best Practice Guidelines for Sustainable Land Use in the Northern Territory
BRS	Bureau of Rural Science (Commonwealth)
DPIFM	Department of Primary Industry, Fisheries and Mines (NT)
LUMIS	Land Use Management Information System
LUMP	Land Use Mapping Project
NRETA	Department of Natural Resources, Environment and the Arts (NT)
NTAgA	Northern Territory Agricultural Association
NTHA	Northern Territory Horticulture Association
NTTGPA	Northern Territory Table Grape Producers Association

Definitions

Land cover

Land cover refers to the physical surface of the earth, including various combinations of vegetation types, soils, exposed rocks and water bodies as well as anthropogenic elements, such as agriculture and built environments. Land cover classes can usually be discriminated by characteristic patterns using remote sensing.

Land use

Land use means the purpose to which the land cover is committed. Some land uses, such as agriculture, have a characteristic land cover pattern. These usually appear in land cover classifications. Other land uses, such as nature conservation, are not readily discriminated by a characteristic land cover pattern. For example, where the land cover is woodland, land use may be timber production or nature conservation.

Land management practice

Land management practice means the approach taken to achieve a land use outcome - the 'how' of land use (eg cultivation practices, such as minimum tillage and direct drilling). Some land management practices, such as stubble disposal practices and tillage rotation systems, may be discriminated by characteristic land cover patterns and linked to particular issues.

Land capability and land suitability

Land capability assesses the limitations to land use imposed by land characteristics and specifies management options. Land suitability (assessed as part of the process of land evaluation) is the fitness of a given type of land for a specified use.

Source: May 2008
http://adl.brs.gov.au/mapserv/landuse/key_concepts.html

1. Introduction

1.1 Background

The Land Use Management Information System (LUMIS) is a national framework for collating land management practice information**.** It is intended to support the implementation of sustainable land management practices and has the support of Commonwealth, State and Territory Governments.

Information on land management practices can be used to observe and report on the state or condition of natural resources and identify changes, both positive and negative. The information supplied through management practices can also be entered into modelling programs to produce models of landscape processes (Zund, 2005). Information from a LUMIS that captures the range of land management practices associated with particular land uses can be integrated with other information, such as soil type, topography, climate and resource condition assessments, to guide managers in choosing the most appropriate practices for their intended land use that are in accordance with the physical and climatic attributes of their land and other resources.

The Northern Territory has a diverse range of environmental conditions, from the wet-dry tropics in the north to the arid lands of Central Australia. The majority of the Northern Territory's environment is still in a relatively natural state and most current development associated with broad scale land uses, such as pastoralism and agriculture, or intense land uses, such as rural residential development, involves change from predominantly natural vegetation. The land management practices used in the Northern Territory reflect the diversity of the environment.

To determine the information requirements for LUMIS a consultation process was undertaken involving representative groups from industry and government who make decisions or provide advice about land management practices. According to the responses, there is still a large amount to be learnt and understood as to what constitutes 'best' and sustainable practices in the Northern Territory (Smith, 2005 unpub.).

To develop an information system that would be appropriate for Northern Territory conditions, it was important to include stakeholders who were involved in actively managing natural resources and in the development phase of establishing new or expanding current primary industries. The main partnerships in the project were the Land and Vegetation Branch of the Department of Natural Resources, Environment and the Arts (NRETA), the Northern Territory Horticultural Association (NTHA), the Northern Territory Agricultural Association (NTAgA) and the Horticultural Branch of the Department of Primary Industry, Fisheries and Mines (DPIFM)

1.2 Objectives

The objective of this project was to design a pilot Land Use Management Information System (LUMIS) for the Northern Territory to record land management practice information that can be referenced to specific locations within the revised Land Use dataset for the Northern Territory. The revised Land Use dataset spatially locates land uses below the property boundary level (Owen, Berghout and Robinson, in press). The LUMIS pilot has focussed on irrigated agriculture and horticulture which reflects the input from the key partners. The outputs of the project are;

- A hierarchical land management practices classification for irrigated agriculture and horticulture;
- A design for an Oracle Spatial database (LUMIS) with a web based front end that will link with and interrogate other NTG databases; and
- A report on the development of LUMIS, problems encountered and the procedure for the future development, data collation and data entry.

1.3 Land Management Information in the Northern Territory

There is a vast amount of information on land management as well as advice on land management practices available through an amazing array of industry associations, government departments, universities and non-government organisations. The information is available in the form of best practise guidelines, newsletters, fact sheets, workshops, and the list goes on.

Industry associations and government have responded by working together with producers, consultants, government agencies and research bodies to develop industry specific “Best Practice” guides. Two examples are the NTHA/NTAgA “Best Practice Guidelines for Sustainable Land Use in the Northern Territory” released in 2008 (NTHA & NTAgA, 2008) and the “Cattle and Land Management Best Practices in the Katherine Region” (DPIFM, 2008) which brought together producers, DPIFM, Meat and Livestock Australia and the Katherine Pastoral Industry Advisory Committee.

What makes LUMIS unique will be the ability spatially locate or tag land management practices to particular land uses on particular areas of land at or below the property level. LUMIS will group related land management practices into classes and identify linkages between land management classes but at this stage will not seek to capture the detail of the land management practices as this can be quite complex and is often well handled in “Best Practice” guidelines. LUMIS can provide a repository for land management practice information, or provide a link to up-to-date land use and land management information held in other databases or websites. LUMIS will also be able to query both spatially and textually other NTG databases such as the Soil and Land Information System (SALIS) and the Resource Assessment Vegetation System (RAVS) administered by NRETA. Being spatially enabled LUMIS data can be integrated with other spatial datasets for modelling and interpretation.

2. Drivers and Needs

2.1 Consultation with stakeholders

The consultation process (Smith, 2004, unpub.) consisted of interviews and a written survey, a copy of which is included as Appendix 1. The consultation involved a range of different industry bodies and government stakeholders including; NTHA, NTAgA, the Northern Territory Table Grape Producers Association (NTTGPA), the Aquatic Health Division of NRETA, and the Horticultural Branch of DPIFM.

The survey consisted of three sections in a top-down approach. It started with general questions regarding business objectives and requirements for land management practice information and then developed into questions about specific roles and objectives. In the third section stakeholders where asked to discuss the relevance of the land management practice classes and themes of the ABS Agricultural Census. This determined specific information requirements and provided the starting point for developing a classification system for land management practice information.

The survey indicated that there is a critical requirement for land management practices information so that development can proceed whilst ensuring economic and environmental sustainability.

2.2 Summary of Drivers for Land Management Practice Information

2.2.1 Government stakeholders

The Northern Territory agencies primarily involved in natural resource management are NRETA and DPIFM. A significant challenge in the Northern Territory is the limited availability of resources to monitor and manage a vast and environmentally diverse landscape where industries have tended to be more reactive than proactive. Consideration of land management practices is regarded as significantly absent from current environmental impact decision making. This situation is changing with the development of “Best Practice” guides for a number of primary industries and regions.

Within NRETA there are a number of branches that would benefit from readily available and spatially enabled land management practice information. For example, the Aquatic Health Unit is involved in monitoring stream quality, which in effect reflects what is happening within the catchment Land management practice information provides insight into the anthropogenic and natural processes that effect water quality and stream health.

For the Rangeland Management Branch (NRETA), a database containing land management practices would improve their ability to provide timely advice to both its internal and external clients. Historically, overgrazing has been identified as one of the main causes of land degradation in pastoral areas. Information on the number of grazing animals, the types of grazing

rotations used, pasture type, and the locations of watering points (high impact areas) would assist decisions regarding resource allocation and improve the management of pastoral areas. Some of this data / information is already available but is not easily accessible and difficult to integrate.

The Primary Industry Group of DPIFM works with producers, industry bodies, and community groups to develop primary industry across the NT. This group is dedicated to delivering research and extension programs through various research farms and other projects across the Northern Territory. DPIFM already publish a large amount of agronomic advice relating to land management practices but there is no formal process for monitoring the application of this advice or for locating the applied practices spatially. Spatially located land management practices would enable DPIFM to benchmark industry development, monitor the uptake of information, assess the adoption and impacts of different practices, and control and locate biosecurity threats.

2.2.2 Industry Stakeholders

Key partnerships have been established with NTHA and NTAgA. In May 2008, the NTHA/NTAgA released the 'Best Practice Guidelines for Sustainable Land Use in the N.T.' These guidelines were developed to assist the Industry in working towards the national trend of environmental stewardship and enhance economic sustainability. The aim of the NTHA/NTAgA project is to increase the uptake of sustainable horticulture/agriculture practices through the adoption of environmental management planning specific to both region and industry.

The NTHA and NTAgA have envisioned a number of opportunities for a LUMIS, the most basic is providing information to industry representative associations, such as themselves, to horticulturalists and other groups and organisations that work in and with the horticultural industry. For example, LUMIS information would enable the NTHA and NTAgA to determine which 'best practices' are being adopted and in what area as well as practices that need focusing on for improvement. It has the potential to provide the industry with a 'one stop shop' for land use information enabling informed sustainable enterprise planning.

The NTTGPA represents local growers whose industry, located primarily at Ti Tree, 190kms north of Alice Springs, is the second largest horticultural industry in the Northern Territory. For the NTTGPA, the main need is to determine which practices are being used and where. A system that also provides information on alternative / best practices considered important.

Both industry and government have a number of drivers for land management practice information (table 1). The information will allow industries to have access to relevant user friendly information in a one-stop shop environment.

Drivers for Land Use Management Practice Information	Stakeholders			
	NTHA / NTAgA	NTTGPA	NRETA	DPIFM
Benchmarking				x
Bio security				x
Business growth	x			
Chemical management	x	x	x	
Clearing guidelines	x		x	
Crop management		x		x
Develop regulations	x	x	x	
Fire management	x	x	x	
Ground water management		x		
Land use planning	x	x	x	
Legal requirements	x			
Industry development	x	x		
Irrigation management		x		x
Market management		x		x
Native vegetation management	x		x	
Nutrient flow information	x		x	
Pest management	x			
Property management plan	x		x	
Quarantine regulations		x		
Soil management	x			
Soil nutrients		x		
Staff training			x	
Stocking rates			x	
Strategies and actions plans	x			
Sustainable enterprise plans	x			
Waste management	x			
Water management	x		x	
Water quality			x	
Water supply			x	
Weather information	x	x	x	
Weed management	x	x	x	

Table 1 Drivers for Land Management Practices identified through consultation

3.0 Land Management Practice Classification

3.1 Classification design

The first draft LUMIS classification followed a farming systems approach and the initial structure was guided by the approach taken in the technical handbook “Guidelines for land use mapping Australia; principles, procedures and definitions, Edition 3” (Bureau of Rural Science, 2006). This design broadly groups the management practices into their primary aims relating to which part of the landscape (or enterprise) is the primary target for a management action. Under this structure there are five main groups; soil, water, plants/vegetation, animals, and ‘business’ with ‘air’ also being a possibility. The “Best Practice for Sustainable Land Use in the Northern Territory” Guidelines developed by NTHA and NTAgA is structured using similar categories, therefore was easily incorporated into this management practice classification.

However, after reviewing the desired function of LUMIS it was decided to modify the classification structure to one that was based more on management actions rather than farming systems. Land use in the NT has been remapped using the “Australian Land Use and Management Classification, Version 6” (ALUM v6) and, unlike the original land use map which assigned land use to a cadastral land parcel, the new dataset spatially locates land use to the paddock level. The scale of data captured and hence the minimum size of mapping units in the new Land Use dataset is in accordance with the scales recommended by the BRS (BRS, 2006).

In the development of the pilot project the focus has been on irrigated horticulture as this reflects the project partnerships with the Horticulture Branch (DPIFM), NTHA and NTAgA. The land management practice classification is designed only to include practice information that directly effects the environment and is not intended to reflect social or economic values or conditions.

3.2 Sources of land use management practice information for LUMIS NT

Once the design concept for the classification system was finalised the tables were populated with relevant land management practice information. The list of relevant land management practices was determined by reviewing current land management practice information and expert advice (see Appendix 2). The level of detail / specificity increases down the hierarchy. For this Pilot project the majority of the horticultural management practices were provided through the “Best Practice for Sustainable Land Use in the Northern Territory: Sustainable Land Use Guidelines” (NTHA,2008) and a range of DPIFM publications. The draft land management practices tables were sent the Horticultural Branch (DPIFM) for review and feedback was used to modify the both the categorisation and structure of LUMIS (NT).

General land management practice information was sourced from other State Land Use reports (Henry, 2005 and Zund, 2005) and a Bureau of Rural Science publication (Yapp & Stewart, 2006).

The project partners are all aware that there is much more data and information on or affecting land management practice available. Both NRETA and DPIFM are actively collecting and collating related data and information which will be incorporated as LUMIS is developed and expanded into other areas of production.

3.3 Other sources of land management practice information

There are number of web-based tools that enable land mangers to access a broad range of land management information. Much of the information is provided at a regional level; is general information describing the impact or opportunity associated with particular land management practices; or discusses principles of land management practise. Certainly the future development of LUMIS for the Northern Territory will incorporate, wherever possible, such information but the role of LUMIS is to spatially locate land management practice to the area of land to which it is being applied. Much of the current web-based information does not lend itself to accurate spatial location nor is much specifically relevant to the Northern Territory.

Examples of web sites for Land Managers:

- The Tropical Savannas CRC with support from the National Heritage Trust developed the "Northern Australia Land Manager" website (www.landmanager.org.au) to "*meet the information needs of north Australian land managers including pastoralists, Landcare groups Indigenous groups and government agencies*."
- National Agricultural Monitoring System (www.nams.gov.au) "*contains a range of climatic and production information, for dryland / broadacre and irrigated industries*"

4.0 Developing a Land Use & Management Information System

4.1 NT Pilot

During the initial stages of the LUMIS project, there was a major change in the way the information system was going to be developed. The original idea was to have the information stored in a personal geodatabase in ArcGIS®. Both spatial and tabular data could have been stored together. With tabular data also accessible via Microsoft Access® this would have provided an information system that was simple and one that could have been designed and built within NRETA. However, such a system would not have allowed for dynamic interaction with other NTG databases.

The final design for LUMIS is for an Oracle Spatial® database with a web based front end. This will enable data entry and querying from other NTG

departments as well as allowing integration with other NT Government databases such as the Soil and Land Information system (SALI) and the Resource Assessment Vegetation System (RAVS). Being Oracle Spatial® based selected LUMIS data can be displayed via NRETA maps for public viewing whilst sensitive information will only be available to "registered users". NRETA Maps is a web-based application for displaying natural and cultural resource data and information via the internal and external NRETA website.

Currently corporate vector and imagery datasets are stored in server data libraries but the NTG is investigating linking GIS directly to Oracle Spatial to remove the need of the data libraries. This will enable spatial queries utilising LUMIS in conjunction with a large number of other vector and raster datasets.

By linking the management practice to the land use the LMP classification hierarchy begins at the secondary or tertiary land use code. In LUMIS (NT) only those land management practices relevant to the selected "land use" will be available. The list of relevant land management practices is determined by reviewing current land management practice information and expert advice (see Appendix 2). The level of detail / specificity increases down the hierarchy. An example would be if the selected land use was 4.4.1 'Irrigated tree fruits' then management practice information appropriate for 'Grazing modified pastures' would not be listed. A sub-set of the classification has been included as Appendix 3 and a worked example of the classification is Appendix 4. For the user, the benefit of this classification style is that only the possible management practices are listed, simplifying the classification process. It also allows for there to be a direct link made between land use and the associated land management practices.

For DPIFM's Horticultural Branch, it was important that the LUMIS incorporate information they collect in their annual Tree Count Surveys. With access via the web, the Horticultural Branch wanted to be able to edit, view and analyse Tree Count Survey data, as well as add additional information or records.

It is recognised that there are issues of "commercial in confidence" related to some land management practice information. The level of detail that can be accessed is likely to be restricted to registered users. Users will also have view, query and edit ability depending upon their level of access. This allows a range of stakeholders to use the information system in numerous ways, but only certain users to edit and update the information. Within the Northern Territory Government a similar system already in use regarding access to ILIS, the Integrated Land Information System that stores information such as details related to cadastral land parcels. The same principles will be applied to LUMIS.

Future development should eventually include the capacity to collate, store and query the vast amount of information and research that has been collected in the Northern Territory that relates to whole properties or regions and hence do not link directly to the polygons within the Land Use polygon dataset.

4.2 Building LUMIS NT

Whilst the pilot for LUMIS has focussed on Horticulture the implementation version will incorporate the range of major land uses within the NT. This task will be facilitated by significant progress in identifying and defining land management practices for key primary industries across the NT.

Involving some 45% of land, pastoralism is the dominant broad scale land use in the Northern Territory. Incorporation of pastoral land management practices will depend on involvement of a number of groups including the Rangelands Management Branch of NRETA, Pastoral Division of DPIFM and other industry and community organisations. There has already been significant progress in developing land management practices information by DPIFM who have worked closely with organisations such as Meat and Livestock Australia (MLA), other producer groups and producers to develop land management practice guides and best practice guides for regions within the NT. For example, DPIFM and MLA use forums such as Grazing Land Management workshops to introduce many pastoralists to land management practice information, such as the "*Cattle and Land Management Best Practices in the Katherine Region*", and other decision support tools. DPIFM has been involved in the soon to be defunct Tropical Savannas CRC to develop "grazing management tools" to assist land managers in developing sustainable practices such as appropriate short term and long term stocking rates, and understanding and assessing the condition of their land.

Water management is an important issue in the NT and knowledge of water management practices is needed to assist decision makers. Water control Districts are being gazetted in areas where there are competing use pressures on the water resources. Irrigation practices are coming under the spotlight as DPIFM is preparing to embark on a comprehensive review of irrigation knowledge and practice in the Northern Territory. Some of this information will be incorporated into LUMIS. Being Oracle Spatial based will enable LUMIS to interact with Hydsis, the NT Government's hydrology database.

Forestry is an emerging land use in the Northern Territory and knowledge of land management practices is evolving. Government and other organisations, such as Greening Australia, have undertaken or are undertaking research in relation to forestry development and on farm forestry.

5.0 Conclusion

There is increasing recognition of the value of land management practice information to inform and assist decision makers. The development of a Land Use and Management Information System (LUMIS) that links land management practices spatially to the area on the ground to which these practices are applied will have significant benefits. When combined with information regarding land or resource condition the data from LUMIS NT will allow land managers to monitor the impact of land management practice. Land managers would also be able to assess the impact of any changes to land management practice they initiate. For government, LUMIS will enable

There is availability of web-based information on land use and management practice is steadily increasing. Certainly the further development of LUMIS for the Northern Territory will incorporate, wherever possible, such information but as the role of LUMIS is to spatially locate actual land management practice as opposed to particular principles of land management practise.

6.0 References

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Appendix 1 Drivers and Needs Survey

Introduction

NRETA is currently engaged with the BRS in a pilot design study of a Land Use Management Information System (LUMIS). This system is to address the need for a national approach or framework to collect and collate land use management practices information. Users and clients to the system will range from national institutions to land holders and managers, including regional bodies, local governments and industries.

The first phase of this project is to determine the needs and drivers for information regarding land use practices in the NT. Clients currently identified include land holders and managers, local industries, such as NTHA and NTAgA, NT NRM institutions and local government.

The Questionnaire

In order to understand the drivers and needs of clients and stakeholders, they must be put into the context of roles and objectives. The following questionnaire is aimed gathering drivers and needs in this way.

Institution or industry type/name?

What are your roles and objectives?

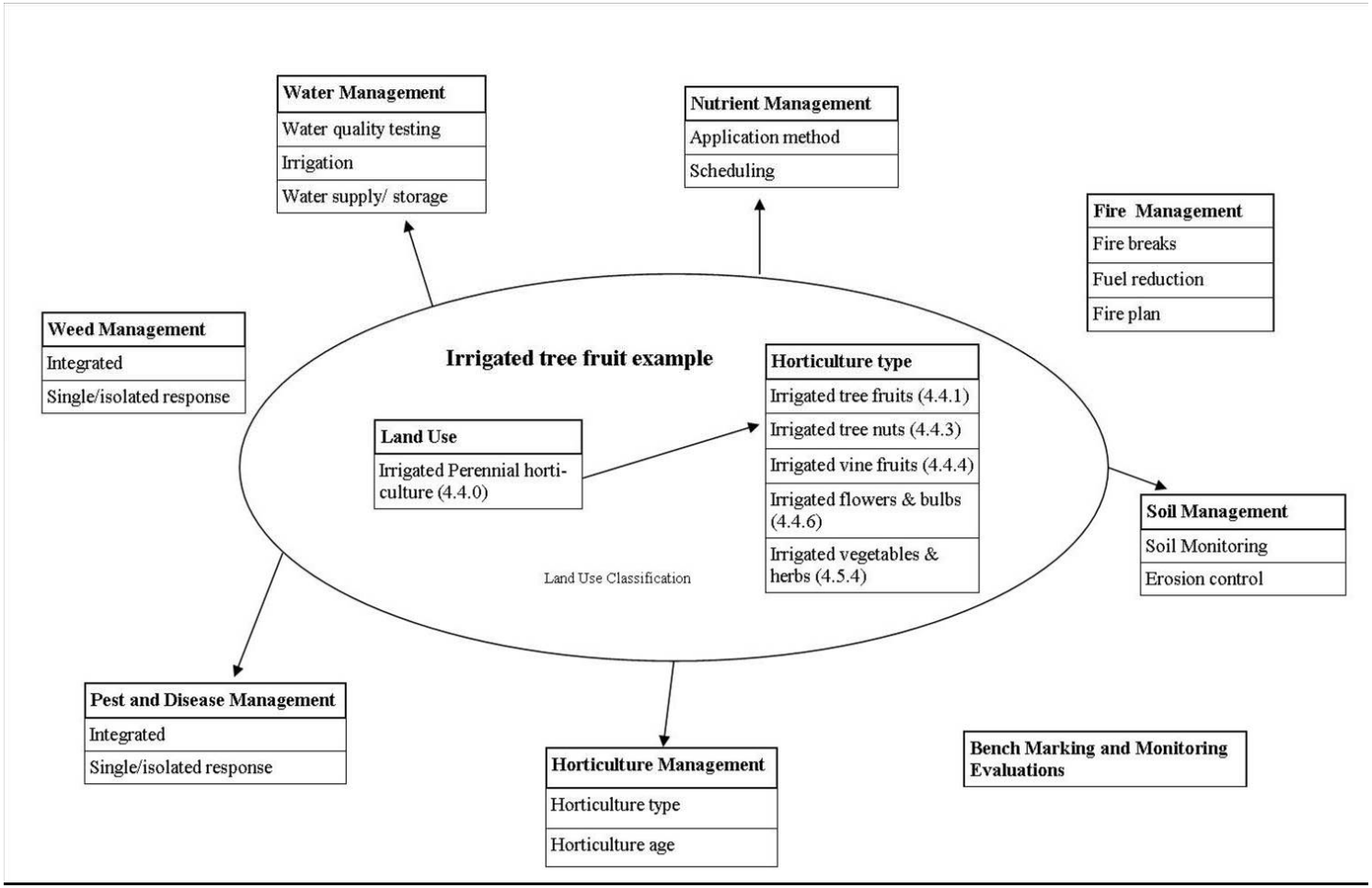
What are your general requirements for land use management practice information?

These questions are to be taken in consideration of land use management practices.

What: Decisions do you make OR questions do you answer OR services do you provide	**Why:** Do you make these decisions OR do you answer these questions	**What:** Information you need to fulfil your roles/objectives	**How:** will you use this information

Appendix 2 Diagram of the Land Use involvement in the classification

The diagram displays the land use classification in the middle and the possible management practices use on irrigated tree fruits in the Northern Territory. The arrows indicate the management practices that are actually used on this plantation of irrigated tree fruits.



Appendix 3 LUMIS Classification version 1 – Irrigated Agriculture/Horticulture

Irrigated Plantation Forestry (4.1.0)		
Water Management		
Irrigation	Type	Trickle/drip
		Fixed sprinkler micro jet
		Travelling irrigators
	Scheduling	Establishment
Water supply/storage	Dam	
	Tanks	
	Wells	
	Bores	
	Natural surface water	
Nutrient Management		
Application method	Fertigation	
	Aerial broadcast granular fertilisers	
	Ground broadcast granular fertilisers	
Scheduling	Establishment	
	Crop factor	
Soil Management		
Soil monitoring	Chemical	Soil nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Erosion control	Shelter belts	
	Ground cover	
	Contour farming	
	Agri drains, grassed waterways	
Horticulture Management		
Horticulture type	High value hardwood	
	Native forest	
	Woodchip	
	Other products	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Weed Management		
Integrated	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	
	Fuel reduction	

	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	

Irrigated modified pastures (4.2.0)		
Water Management		
Irrigation	Type	Sub-surface drip
		Fixed sprinkler overhead
		Centre pivot
		Travelling irrigators
		Lateral irrigators
		Other
	Irrigation scheduling	Soil moisture monitoring
		Crop factors
Water supply/storage	Dam	
	Bores	
	Natural surface water	
Nutrient Management		
Application method	Fertigation	
	Aerial broadcast granular fertilisers	
	Ground broadcast granular fertilisers	Inorganic
		organic
Scheduling	Nutrient monitoring	
	Crop replacement	
	Annual fertiliser programs	
Soil Management		
Soil monitoring	Chemical	Soil nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Erosion control	Shelter belts	
	Ground cover	
	Contour farming	
	Agri drains, grassed waterways	
Grazing Management		
Grazing rotation systems	Set stocking	
	Occasional grazing	
	Cell grazing	
	Continuous	
	Rotational	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Weed Management		

Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	
	Fuel reduction	
	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	
	Organic Federation of Australia (OFA)	
	Australian Certified Organic (ACO)	

Irrigated Cropping (4.3.0)		
Water Management		
Irrigation	Type	Surface drip
		Sub-surface drip
		Fixed sprinkler overhead
		Centre pivot
		Travelling irrigators
		Lateral irrigators
		Other
	Irrigation scheduling	Soil moisture monitoring
		Crop factors
Water supply/storage	Dam	
	Bores	
	Natural surface water	
Nutrient Management		
Application method	Fertigation	
	Aerial broadcast granular fertilisers	
	Ground broadcast granular fertilisers	Inorganic
		organic
Scheduling	Nutrient monitoring	
	Crop replacement	
	Annual fertiliser programs	
Soil Management		
Soil monitoring	Chemical	Soil nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Erosion control	Shelter belts	
	Ground cover	
	Contours	
	Agri drains, grassed waterways	
Crop Management		

Sowing period	Wet season	
	Dry season	
Rotation system	Rotational	
	Continuous	
Crop type	Broadleaf	
	Cereals (grasses)	
	Legumes	
	Hay and silage	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Weed Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	
	Fuel reduction	
	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	
	Safe Quality Foods (SQF)	
	Freshcare	
	Organic Federation of Australia (OFA)	
	Australian Certified Organic (ACO)	

Irrigated Perennial horticulture (4.4.0)		
Water Management		
Water quality testing	Chemical	
	Biological	
Irrigation	Type	Surface drip
		Sub-surface drip
		Moveable sprinklers
		Fixed sprinkler micro jet
		Fixed sprinkler overhead
		Fixed sprinkler low throw
		Pivot
		Travelling irrigators
	Irrigation scheduling	Soil moisture monitoring
		Crop factors
Water supply/storage	Dam	

	Tanks	
	Wells	
	Bores	
	Natural surface water	
Nutrient Management		
Application method	Fertigation	
	Manure	
	Aerial broadcast granular fertilisers	
	Ground broadcast granular fertilisers	
Scheduling	Nutrient monitoring	
	Crop replacement	
	Annual fertiliser programs	
Soil Management		
Soil monitoring	Chemical	Soil nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Erosion control	Shelter belts	
	Ground cover	
	Contours	
	Agri drains, grassed waterways	
Horticulture Management		
Horticulture type	Mango	
	Citrus	
	Tropical fruits	
	Bananas	
	Table Grapes	
	Flowers	
	Other	
Horticulture age	Juvenile	
	Mature	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Weed Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	
	Fuel reduction	
	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	

	Safe Quality Foods (SQF)	
	Freshcare	
	Organic Federation of Australia (OFA)	
	Australian Certified Organic (ACO)	

Irrigated Seasonal Horticulture (4.5.0)		
Water Management		
Water quality testing	Chemical	
	Biological	
Irrigation	Type	Surface drip
		Sub-surface drip
		Moveable sprinklers
		Fixed sprinkler micro jet
		Fixed sprinkler overhead
		Fixed sprinkler low throw
		Pivot
		Travelling irrigators
	Irrigation scheduling	Soil moisture monitoring
		Crop factors
Water supply/storage	Dam	
	Tanks	
	Wells	
	Bores	
	Natural surface water	
Nutrient Management		
Application method	Fertigation	
	Manure	
	Aerial broadcast granular fertilisers	
	Ground broadcast granular fertilisers	
Scheduling	Nutrient monitoring	
	Crop replacement	
	Annual fertiliser programs	
Soil Management		
Soil monitoring	Chemical	Soil nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Erosion control	Shelter belts	
	Ground cover	
	Contours	
	Agri drains, grassed waterways	
Soil health	Green manure cropping	
	Organic mulches	
Horticulture Management		
Horticulture type	Asian veg	
	Traditional veg	
	Melons	
	Flowers	

	Herbs	
	Ornamental	
	Other	
Rotational system	Rotational	
	Continuous	
Horticulture age	Juvenile	
	Mature	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Weed Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	
	Fuel reduction	
	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	
	Safe Quality Foods (SQF)	
	Freshcare	
	Organic Federation of Australia (OFA)	
	Australian Certified Organic (ACO)	

Intensive Horticulture (5.1.0)		
Water Management		
Water quality testing	Chemical	
	Biological	
Irrigation	Type	Moveable sprinkler
		Surface drip
		Sub-surface drip
		Fixed sprinkler micro jet
		Fixed sprinkler overhead
		Fixed sprinkler low throw
		Travelling irrigators
	Irrigation scheduling	Soil moisture monitoring
		Crop factors
		Evapo-transpiration demand
		Potting media water demand
Water supply/storage	Dam	

	Tanks	
	Wells	
	Bores	
	Natural surface water	
	On-site recycled water	
Nutrient Management		
Application method	Fertigation	
	Manure	
	Growing media base nutrient	
	Controlled release	
	Ground broadcast granular fertilisers	
Scheduling	Nutrient monitoring	
	Crop replacement	
	Crop fertiliser programs	
Soil & Potting Media Management		
Soil & media monitoring	Chemical	Soil & media nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Soil health	Green manure cropping	
	Organic mulches	
Horticulture Management		
Horticulture type	Nursery products	
	Herbs	
	High value vegetables	
	Flowers	
	Other	
Production cycles	Programmed cycles	
	Continuous	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Weed Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	Adequate distance from cables etc.
	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	
	Safe Quality Foods (SQF)	
	Freshcare	
	Organic Federation of Australia	

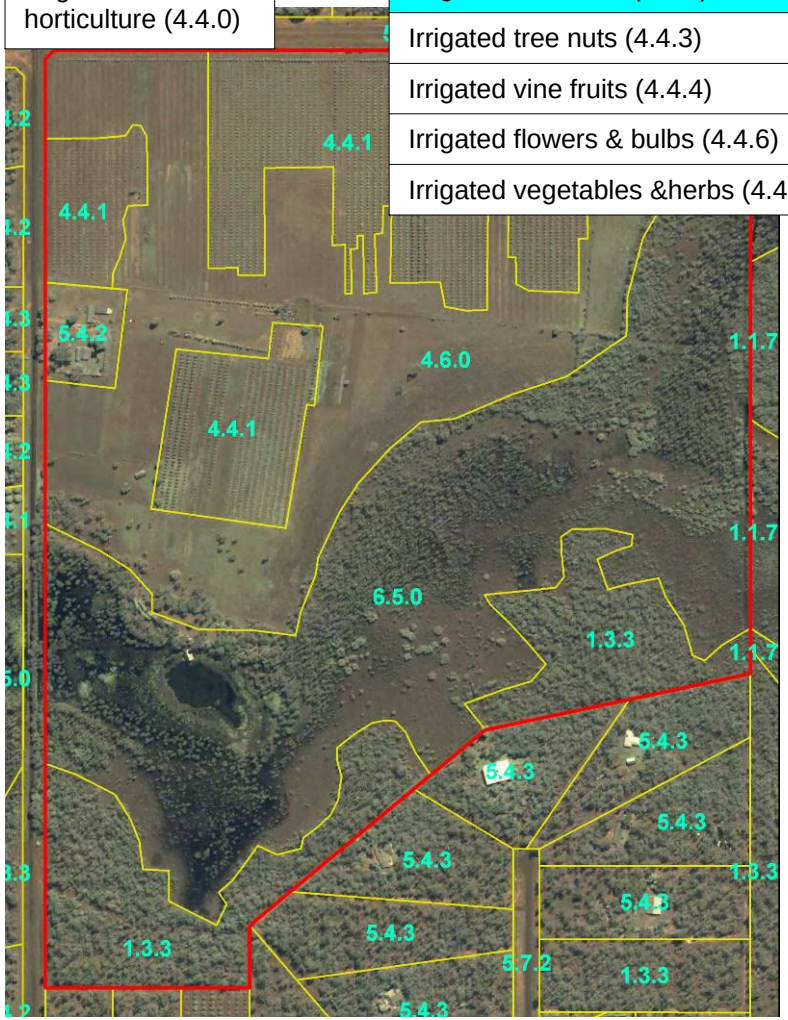
	(OFA)	
	Australian Certified Organic (ACO)	

Turf farms do not fit very well into any current category, a new one should be created.

Turf farms (4.4.0)		
Water Management		
Water quality testing	Chemical	
	Biological	
Irrigation	Type	Sub-surface drip
		Fixed sprinkler overhead
		Fixed sprinkler low throw
		Pivot
		Travelling irrigators
	Irrigation scheduling	Soil moisture monitoring
		Crop factors
Water supply/storage	Dam	
	Tanks	
	Wells	
	Bores	
	Natural surface water	
Nutrient Management		
Application method	Fertigtion	
	Manure	
	Ground broadcast granular fertilisers	
Scheduling	Nutrient monitoring	
	Crop replacement	
	Crop fertiliser programs	
Soil Management		
Soil monitoring	Chemical	Soil nutrient testing
	Physical	Texture & structure monitoring
	Biological	Organic C & Bioassays
	Environmental	Residue & seasonal
Erosion control	Shelter belts	
	Ground cover	
	Contours	
	Agri drains, grassed waterways	
Soil health	Green manure cropping	
	Organic mulches	
Horticulture Management		
Horticulture type	Seed production	
	Rolled turf	
	Plugs & pieces	
Rotation system	Rotational	
	Continuous	
Pest and Disease Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	

	Physical	
Weed Management		
Integrated plan	Biological	
	Chemical	
	Physical	
Single/isolated response	Biological	
	Chemical	
	Physical	
Fire Management		
	Firebreaks	
	Fire plan	
Bench marking and monitoring evaluations		
Membership of accreditation / QA systems	ISO 9000's	
	Euro GAP	
	Safe Quality Foods (SQF)	
	Freshcare	
	Organic Federation of Australia (OFA)	
	Australian Certified Organic (ACO)	

Appendix 4 Worked example of LUMIS



Land use
Irrigated Perennial horticulture (4.4.0)

Type
Irrigated tree fruits (4.4.1)
Irrigated tree nuts (4.4.3)
Irrigated vine fruits (4.4.4)
Irrigated flowers & bulbs (4.4.6)
Irrigated vegetables &herbs (4.4.7)

Horticulture Management
Horticulture type
Horticulture age

Horticulture age
Juvenile
Mature

Horticulture type
Mango
Tropical fruits
Bananas
Table grapes
Flowers
Citrus
Other

Nutrient Management
Application method
Scheduling

Application method
Fertigation
Manure
Ground broadcast granular fertilisers
Aerial broadcast granular fertilisers

Scheduling
Nutrient monitoring
Crop replacement
Annual fertiliser program

Water Management
Water quality testing
Water supply/storage
Irrigation

Irrigation
Type
Irrigation scheduling

Irrigation type
Surface drip
Sub-surface drip
Moveable sprinklers
Fixed sprinkler micro jet
Fixed sprinkler overhead
Fixed sprinkler low throw
Pivot
Travelling irrigators

Irrigation scheduling
Soil moisture monitoring
Crop factors

Appendix 5 A small selection of Websites providing information to Land Managers the Northern Territory

Department of Natural Resources, Environment and The Arts
www.nt.gov.au/nreta/natres/

Department of Primary Industry, Fisheries and Mines
www.nt.gov.au/dpifm/Primary_Industry

Northern Territory Agricultural Association (NTAgA),
www.ntaga.org.au

Northern Territory Horticultural Association (NTHA),
www.ntha.com.au

Australian Fodder Industry Association
www.afia.org.au

Meat and Livestock Australia
www.mla.com.au

National Agricultural Monitoring System
www.nams.gov.au

North Australian Land Manager Website
www.landmanager.org.au/