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Manual of proposed national minimum standards for roadside erosion survey

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Government of South Australia
Department of Water, Land and Biodiversity Conservation

Manual of proposed national minimum standards for roadside erosion survey

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Science, Monitoring and Information Division
Department of Water, Land and Biodiversity Conservation

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Report DWLBC 2009/24

Government of South Australia
Department of Water, Land and Biodiversity Conservation

CARING FOR OUR COUNTRY

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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Scott Ashby
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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Dr John Leys, Department of Environment and Climate Change, NSW

Dr Sean Murphy, Department of Primary Industries, NSW

Richard MacEwan and Jodie Price, Department of Primary Industries, Vic

Dr Dan Carter, Jim Dixon, Ted Griffin and Justin Laycock, Department of Agriculture and Food, WA

Tony Meissner, Department of Water, Land and Biodiversity Conservation, SA.

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1. EXECUTIVE SUMMARY

Currently, "roadside" erosion survey programs (including ground reference site monitoring) are conducted by government agencies and regional catchment groups on farmed land in parts of WA, SA, Vic, NSW and Qld with fairly common aims but using varying survey methodologies and data formats

At a national workshop "Improving capacity to monitor wind and water erosion" in Canberra, May 2008, a number of recommendations were made for investment programs to improve monitoring of soil erosion in Australia. Funding was provided through the Caring For Our Country Monitoring Evaluation Reporting and Improvement (MERI) framework in 2008/09 for one of these recommendations, a short wind erosion project "Roadside survey manual and database scoping". This project's objectives were to develop a manual of proposed national standards for roadside erosion survey, identify a suitable system for national field data capture, and develop a prototype national database to accept survey data.

ROADSIDE SURVEY MANUAL

The project working group comprising agency representatives involved in these programs, reviewed the range of survey methodologies currently used, and considered nationally recognised frameworks for classification of soil erosion, land condition, land use and land management practices. A draft national roadside survey manual was produced, containing a proposed set of minimum roadside survey assessments with accompanying survey protocols which were appropriate for agricultural land use systems within southern Australian biophysical environments. This incorporated common elements of the existing survey programs as well as some modification of existing methods. Some aspects of the proposed survey methodology, however, were not resolved, and recommendations were made to further investigate:

- a system to characterise a survey sites' inherent susceptibility to wind and water erosion
- a system to estimate and classify wind and water erosion hazard
- consolidation of a system for classifying current land use/land management phase, and
- Establish more comprehensive set of photostandards for soil (water) erosion and groundcover.

FIELD DATABASE

State agencies use a range of database systems to capture roadside survey data. However, no existing field database possessed all the necessary key functionalities to accommodate the proposed survey methodology. Therefore, it was recommended that a relational database be designed and built to accommodate the national survey methods (Murphy 2009). This database system would enable data to be captured in a reliable and accurate manner, while accommodating key fields that align with those in the national field methods manual (Forward 2009) and facilitate reporting to a national data repository described by Griffin (2009).

Specifically, the database would:

- accommodate key data fields that align with those in the national field methods manual proposed by Forward (2009)
- have conformity of structure to permit common queries and standard export of data to national repository proposed by Griffin (2009)
- be distributed and be maintained via the internet.

NATIONAL DATA REPOSITORY

The specifications and structure of a suitable field database were documented (Griffin 2009). CSIRO's 'NatSoil' was determined to be the appropriate national repository for roadside erosion survey data. This is being modified to accommodate soil monitoring data, and will be part of the Australian Soil Resource Information System (ASRIS).

Each state would be responsible for converting its own data to the NatSoil format and uploading.

Estimated indicative costings to achieve the recommendations from this project over a 12 month timeframe are summarised in Table 1.

Table 1. Cost estimates to deliver recommendations from project

Sub-project	Deliverables	Cost 2009/10	Cost 2010/11
Roadside survey methods manual	• Report of scoping of project to fully consolidate national roadside erosion survey methods, including recommendations from initial national survey manual, consideration of water erosion monitoring, and synergies with remote sensing • Produce survey/parameter standards and outputs as per scoping report ($60K) • Publish and publicise consolidated national roadside survey manual ($10K)	$8,000	$70,000
Field database	• Develop a field database including real time tracking and automated reporting. Publish software manuals/instruction manuals and provide training in use of the database • Project/contract management costs	$30,000 $10,000	$30,000 $10,000
National data repository	• Complete updating of NatSoil to receive state data, and develop national reporting products which can be automatically generated from the data.	$15,000	$15,000
Total		$63,000	$125,000

2. INTRODUCTION

2.1 BACKGROUND

Wind and water erosion of soil, particularly accelerated erosion associated with land used for agriculture and pastoralism are major threats to the soil assets of Australia. Various national and state agencies currently conduct a range of programs using different approaches to monitor soil erosion, or predict likelihood of erosion.

In "Improving capacity to monitor wind and water erosion – A review" (Leys et al. 2009) national priorities and recommendations were made for investment programs to improve monitoring of soil erosion in Australia. One short term project recommended under the Monitoring Evaluation Reporting and Improvement (MERI) framework was "Roadside survey manual and database scoping". This project aims to standardise field methodologies used to assess soil erosion, propose a common field database to capture and manage erosion data, and develop links with a national repository for soils data, specifically:

1. Develop a manual of nationally consistent minimum standards for roadside survey and ground reference site monitoring of wind/water erosion (including hazard) appropriate for agricultural land use systems.
2. Review field databases currently used by State agencies to navigate, capture and manage data during roadside surveys (e.g. LandMAPT – New South Wales) and identify minimum specifications for a nationally compatible field database for monitoring of wind and water erosion.
3. Develop a prototype national database (e.g. based on CSIRO Land & Water Australian Soil Resource Information System - ASRIS) suitable to collate field data from roadside survey and ground reference sites.

This manual addresses objective (1) above, while separate reports Murphy (2009) and Griffin (2009) address objectives 2 and 3 respectively.

Currently, roadside type erosion and/or erosion hazard survey programs including programs with ground reference sites are conducted in several states (Western Australia, South Australia, New South Wales and Queensland). These are summarised in Leys et al (2009), and key details of these are provided in Appendices A – E. The proposed national roadside survey standards for this manual were developed based on these existing survey methods by a project working group that comprised:

Giles Forward and Tony Meissner, Department of Water, Land and Biodiversity Conservation, SA

Dr John Leys, Department of Environment and Climate Change, NSW

Dr Sean Murphy, Department of Primary Industries, NSW

Richard MacEwan and Jodie Price, Department of Primary Industries, Vic

Dr Dan Carter, Jim Dixon, Ted Griffin and Justin Laycock, Department of Agriculture and Food, WA.

It is not suggested that the methods contained in this manual are finalised nor need to be promptly adopted by any group doing or considering doing roadside erosion survey. It is hoped however that this might provide a basis for ongoing development, perhaps through the National Committee for Soil and Terrain (NCST) and the Australian Government Department of Agricultural Fisheries and Forestry, of nationally consistent methods for ground based soil erosion monitoring that could be integrated with other erosion monitoring methods. This manual identifies some key issues requiring further research.

2.2 ROADSIDE SURVEY AND GROUND REFERENCE SITE MONITORING

Roadside surveys, often referred to as "windscreen" or "drive-by" surveys are used to assess and monitor soil erosion and/or erosion hazard (risk) at a paddock scale. The observations are made from a vehicle, either while driving past the paddock site or from the vehicle stopped on the roadside. It enables relatively large areas to be assessed in relatively short time periods, especially compared to ground reference sites where measurements are taken, and enables multi-attribute observations to be made (e.g. link land management practices/phase to soil condition/erosion or provide test data for erosion modelling or remote sensing). As outlined in Leys et al (2009), current roadside survey programs are characterised by:

- Geo-located sites of a fixed size (e.g. 100m x 100m) on permanent transects
- Measurement of land management activity, ground cover and erosion at each site based on photo-standards
- Surveys repeated several times per year to track changes in land management and land condition through seasonal agricultural cycles
- Surveys are designed to be spatially representative of the survey area
- Provides for a large number of observations over a large geographic area.

Limitations of the roadside survey approach, compared to other erosion monitoring techniques include:

- Limited temporal capture with only a few surveys per year
- Road transects tend to traverse convenient paths with good roadside visibility and may not be the best basis for representative sampling
- Statistical advice regarding stratification of the landscape sampling is required, and for robustness of output data sets to suit reporting and monitoring standards e.g. Natural Resources Management (NRM) bodies' targets
- Relatively high level of surveyor training and quality control is required due to the subjective nature of the assessments
- Large datasets are quickly amassed and require good data management

Such considerations need to be addressed and managed in any roadside survey program.

Ground reference site monitoring by in-paddock measurement has the advantage of objective, quantitative data collection but requires much more time per site. This approach has considerable scope for ground validation/calibration for remote sensing and erosion modelling methods, but was considered outside the scope of this project.

Ground reference site measurement methods were considered within the context of this project, but it was recognised that the requirements of this approach are usually closely dependent on the remote sensing or erosion modelling method involved, so there is no real basis for exploring common national standards. It was, however, recognised that there would be benefit for any roadside survey program to include a number of sites where in-paddock measurements are carried out to calibrate and quality check roadside observational assessments. Similarly, there may be benefits for any ground reference site monitoring programs to include roadside observational assessments at some sites.

2.3 SCOPE

The roadside survey approach has been primarily developed for use in agricultural land use systems, where

- Sites normally represent a "paddock" management unit or a dominant land facet within a paddock
- There are distinct annual cycles of land management phases and soil condition (groundcover, disturbance) and plant growth
- Vegetation is predominantly non-woody

Arid rangelands and dry tropics grazing systems have distinctly different seasonal dynamics in land condition, type of vegetative cover and spatial extent of management units. Different approaches are normally used to monitor groundcover and erosion in these contexts (e.g. Karfs et al 2009, Danaher et al 1998).

The scope of roadside survey methods outlined in this manual has therefore been designed for dryland agricultural cropping/grazing systems, primarily within southern (mediterranean climate system) areas of Australia. There is certainly potential, however, for elements of this approach to be modified or adapted to different land use and/or biophysical environments.

The range of data fields proposed in this manual are intended to be a minimum set of common data that could be reasonably captured in any roadside erosion survey program, including existing programs, within the scope described above. It is expected that individual monitoring programs would include additional data fields and/or data ranges to suit their respective needs.

3. DESIGN AND RATIONALE

3.1 DESIGN CONSIDERATIONS

The general principles for design of roadside erosion survey programs are:

- Data gathered is sufficiently representative of area/s surveyed and statistically robust for reporting/monitoring purposes
- Survey program is reasonably cost effective
- Field observations are as objective as possible, clearly defined and can be consistently recorded by field observers without needing extensive training or experience
- Ongoing quality assurance program is implemented
- Surveys of sufficient number and appropriate timing through seasonal/agricultural cycles to provide reasonable temporal monitoring of land condition
- Adequate electronic field navigation, data capture and database capabilities are available.

3.2 STATISTICAL DESIGN

It is recommended that professional statistical advice is sought when developing any new roadside survey program, and for any existing program if this has not been done.

Consideration should be given to the following for selection of field survey sites:

- adequate representation of the monitored areas – of sufficient number, and locations not biased
- stratification according to spatial variations in land types (erosion susceptibility), climatic zones, management regimes etc. that may occur within survey area.

The minimum number of sites required within sampling units is determined by the minimum target statistical error for output data calculations. Fixed sites provide greater statistical strength over time than the same number of random sites within a sampling unit.

A case study example of a statistical approach used to design sites for a drive-by erosion survey in the Victorian Mallee (Callinan and Clark pers. comm.) is provided in Appendix. G.

3.3 NUMBER AND TIMING OF SURVEYS

It is proposed that a minimum of two roadside surveys are done each year in Mediterranean zone agricultural areas. The timing and number of surveys may aim to capture:

- Times of the season when minimum/maximum groundcover or soil exposure usually occurs
- Time(s) of the season when soil erosion events are more common
- Time(s) when particular management practices are undertaken that have critical impacts on soil cover/exposure.

In the SA survey program for example, roadside surveys are done in June (usually maximum soil exposure at peak crop sowing time) and October (normally highest groundcover levels), The survey program is also conducted in March and May through the period when paddock cover levels are declining through grazing, natural breakdown, fallowing, burning etc. in order to track changes in soil exposure through this critical period. In the NSW roadside survey program, surveys are done in December (normally highest groundcover level) and March, the period when wind erosion is most commonly observed.

3.4 QUALITY ASSURANCE

Observational assessments with some degree of subjectivity inevitably result in some level of variability among observers, and this is an inherent source of error with roadside survey data. Ongoing quality assurance needs to be a part of any roadside survey program to maximise validity and consistency of field data. This could include:

- Evaluation and review of definitions/descriptions and photostandards for field observations to ensure they are as unambiguous and objective as possible
- Appropriate training and ongoing refresher training of field survey staff
- Independent checking of random field observations against regular survey team/s, with analysis of data to examine and address variability
- Doing quantitative on-ground measurements at a number of sites to verify roadside observations (e.g. percentage groundcover)
- Systematically checking survey datasets for errors and marking that this has been done.

The observations described in this manual have been largely adapted from existing survey programs that have aimed to design the observations to be as simple and unambiguous as possible, with clear category definitions and/or photostandards. This has involved significant ongoing refinement of definitions and expansion of photostandards in some cases. There is scope, however, for further improvement in categories and/or photostandards for some observations as identified in this manual.

3.5 RESOURCE CONSIDERATIONS

Based on experience with existing roadside survey programs, appropriate resourcing needs to include:

- People/time for
    - conducting field surveys (at least two people in survey vehicle); consideration should be given to time window within which surveys need to be completed – more than one concurrent survey team may be needed
    - data management – downloading/compilation, checking, analysis, error resolution, database development/maintenance
    - reporting
    - survey program management, including quality assurance (QA), staff training

- appropriate equipment and software for field navigation and data collection, data storage and analysis (see Section 2.7 data capture and management) (Murphy 2009).

3.6 RATIONALE AND PROTOCOL FOR FIELD OBSERVATIONS

The proposed set of roadside field observations and data fields (Table 2) are intended to provide best possible estimates of:

- Occurrence and relative severity of recent wind/water erosion
- Relative wind/water erosion hazard
- Current land use/management phase or practices with which current land condition is associated (causality)

The remaining data fields are proposed as minimum requirements for site/survey identification. Full proposed data field and category codes are detailed in Griffin (2009).

3.6.1 SITE SELECTION

It is proposed that "observed" field survey sites are of a size 100m x 100m.

Sites are located within the paddock adjacent the roadside, considering the following:

- Convenient/safe place to stop the vehicle, if necessary
- Good visibility of site, not obscured by roadside vegetation etc.
- Site is representative of the land/soil characteristics in the paddock or of a major land facet occurring in the paddock, and representative of overall management practices used in the paddock
- Site excludes features adjacent to fencelines such as firebreaks, headlands, areas around water troughs or stock camps that may have a surface condition that is not representative of the majority of the paddock.
- Site is located close to the roadside (given above requirements) to enable it to be observed as close-up as possible
- Topography of site allows at least 100m x 100m area to be clearly observed (i.e. not obscured by sharp hill or steep slope).

Practical considerations for selection of road transects include:

- Safety – less busy, lower speed limit roads are less hazardous for roadside survey
- Traversibility – all weather/season roads should be used where possible so surveys can be done at any time of the year.

Table 2. Proposed roadside survey observations and data fields

Field	Description	Categories/range	State
AgencyID	State or territory where site is surveyed	1xx – 8xx	Static
TransectID	Transect number assigned by survey agency	1xxxx – 9xxx	Static
SiteNumber	Site number assigned by survey agency	1xxx – 9xxx	Static
SiteLocation	GPS location of site centroid and survey navigation details	-27.xxxxx, 148.xxxxx, etc.	Static
SurveyorID	Alpha code of name of principal surveyor	ABCD	Dynamic
SampleDate	Site survey date	dd/mm/yyyy	Dynamic
Land Use	ALUM version 6/7 land use categories with extended field for crop types	3.x.x.x	Dynamic
Plant growth stage/cycle	Main crop/pasture growth phase	growing, mature, residue etc.	Dynamic
Land Management action	Key land management action categories	tilled, sprayed, grazed, standing, baled, burnt, abandoned, none, etc	Dynamic
GroundcoverLevel	Mean percentage (flattened) groundcover, 6 categories	0-12, 13-25, 26-50, 51-75, 76-88, 89-100%	Dynamic
GroundcoverHeight	Predominant height distribution (cm) of groundcover, 4 categories	0, 0-10, 10-40, >40	Dynamic
WindErosionSeverity	Presence and severity of recent wind erosion of site, 5 categories	X, 0-4	Dynamic
WaterErosionSheetSeverity	Presence and severity of recent water erosion (sheet) of site, 4 categories	X, 0-3	Dynamic
WaterErosionRillSeverity	Presence and severity of recent water erosion (rill) of site, 4 categories	0-3	Dynamic
Disturbance	Degree of physical disturbance of soil surface, 3 categories	Insignificant, partial, complete disturbance	Dynamic
Stability	Stability against wind erosion	Stable, unstable	Dynamic
ErosionOnTheDay	*Proposed optional observation – wind erosion occurring on site at time of survey*	*None, minor, severe*	Dynamic

3.6.2 WIND AND WATER EROSION SEVERITY

The wind erosion severity categories and descriptions used currently in roadside survey programs in NSW, SA and WA were broadly compatible with the wind erosion severity categories in the Australian Soil and Land Survey Field Handbook 3rd Edition (NCST 2009), and were adapted to match these categories. The wind erosion photostandards used in existing state survey programs were retained.

Currently a five category scale for water erosion (combining sheet/rill erosion) severity is used in SA and WA. There is reasonable compatibility between these categories and the separate sheet erosion and rill erosion description fields in the Australian Soil Survey Field

Handbook 3rd Edition. It was decided to adopt the sheet and rill erosion fields and categories in this handbook for the proposed national survey protocols. There is need however to expand the photostandards for these water erosion categories.

The proposed protocol for assessing wind/water erosion severity is that the observation is based wherever possible on the surveyor's knowledge that erosion occurred since the date the site was previously surveyed. There may not necessarily be certainty in this, particularly where there is a change in survey personnel between successive surveys. It is an advantage if previous survey site data can be viewed on the field data capture system when entering site data (Murphy 2009).

Analysis and reporting of such erosion data should take into consideration that the erosion observations are somewhat opportunistic. Erosion events may occur between surveys but are subsequently masked by cultivation etc, or it may be unclear how long it was since active erosion occurred on a site with erosion evident. If survey programs have available resources, it may be advantageous to conduct opportunistic surveys as soon as possible after major erosion events occur. In this situation the complete survey should be done to maintain data integrity.

3.6.3 EROSION ON THE DAY OF SURVEY

Geo-located and dated ground observations of actual occurrence of wind erosion are of value to the Computational Environmental Management System (CEMSYS) wind erosion model (Butler et al 2008). As it is simple to include such an observation with roadside surveys, it is suggested this could be included as an optional observation field, i.e. when wind erosion is observed to be occurring on the observation site at the time of survey. A further possible observation is erosion occurring on land other than the observation site.

Three categories of erosion are proposed, based on relative dust concentration above the site (visibility):

- No erosion
- Minor erosion, visibility across site >100m
- Major erosion, visibility across site <100m.

3.6.4 EROSION HAZARD

Wind erosion hazard is a function of:

- Inherent susceptibility of land to wind/water erosion (soil erodibility, topography/slope, climate)
- Soil surface condition resulting from management
    - amount and type of groundcover (percentage cover and lateral distribution, height, anchorage to soil, volume)
    - physical disturbance or disaggregation of soil.

Inherent erosion susceptibility

Various systems are used across states and biophysical areas to classify agricultural land according to inherent susceptibility to soil erosion. An example is given of the approach used in SA (App. F) where each site has been characterised for wind/water erosion susceptibility using a rating scale called "topography rating" which is based on the eight class land capability class system described in Maschmedt (2002) and Houghton and Charman (1986). This has been modified slightly in WA to suit local conditions. No comparable site characterisation is carried out in NSW or Victoria. It was recognised that there were variations in the range of soil erodibility, slope and climate regimes on land surveyed in different states, so neither of the existing characterisation scales used in SA or WA would necessarily be appropriate for other areas.

The development of a universal system to categorise the relative inherent erosion susceptibility of land for roadside surveys is recommended for further research.

Groundcover

It is proposed that groundcover (i.e. vegetative matter, stones) is assessed by primary observations of (1) flattened percentage groundcover, and (2) groundcover height. Percentage groundcover is widely accepted as a primary indicator of soil erosion hazard. The categories proposed are those currently used in NSW. The percentage cover ranges (0-12, 13-25%, 26-50%, 51-75%, 76-88, 89-100%) have been chosen to be within the capability of field observers to reliably discern different levels of groundcover. Photostandards have been developed from field sites where actual percentage flattened cover has been measured. There is scope, however, for a more comprehensive range of photostandards to be compiled that would include the full range of cover types that may be observed (e.g. crops, stubbles, pastures, fallows).

Percentage groundcover is the primary characteristic of groundcover that controls erosion hazard for sheet/rill water erosion, but for wind erosion, groundcover height (and anchorage) is also significant. It is therefore proposed that groundcover height is also assessed. This is currently done in WA, and is one of the factors described in the categories for "cover rating" used in SA. The proposed height categories (0, 0-10cm, 10-40cm, >40cm) are those used in the current WA survey program, derived from the SA "cover rating" descriptions. The SA 8 categories of "cover rating" (App. F) do not have percentage cover descriptors, so are not directly equivalent to the proposed percentage groundcover categories.

Disturbance

Observations of relative soil physical disturbance are done in SA and WA to estimate soil looseness (disaggregation) as a factor controlling erosion hazard. Three categories for soil disturbance (insignificant, partial, complete) being proposed are those currently used in SA. Experience in SA has indicated that there are difficulties associated with defining and effectively observing a higher number of categories than these three.

A limitation of such disturbance classification is that it implies erosion hazard is proportional to the degree of soil disturbance. While this generally is the case, in a small number of situations it is not necessarily so, and can even be inversely proportional. This is related to the physical condition of the soil resulting from the disturbance. For example, on some soil types, particularly those with moderate or higher clay content (e.g. clay loam or finer), particular types of tillage operations create large stable clods that may reduce wind erosion

hazard in some situations, as has been observed in NSW surveys. For this reason, a separate “wind erosion stability” assessment is proposed.

Erosion hazard

A range of approaches are currently used to estimate soil erosion hazard in roadside survey programs.

In NSW, wind erosion hazard is visually estimated using the five categories equivalent to the wind erosion severity rating and pre-empts conditions that may occur if the site experiences and erosive wind event. However this is subjective and requires significant observer expertise/experience.

In SA, overall erosion hazard (without regard for inherent susceptibility to wind/water erosion) is estimated using a threshold category of “cover rating”, while wind and water erosion hazard is estimated from matrix tables that combine “topography rating”, “cover rating” and “disturbance rating” fields (App. F). Hazard ratings for the combinations of these primary observations were based on field experience in the agricultural areas of SA. This approach has been adopted in WA with minor modification.

A similar conceptual approach could be used to estimate relative erosion hazard for the proposed national standards, but as yet a satisfactory universal system to classify inherent erosion susceptibility of land has not been identified, as discussed previously.

It was considered that further research was required to develop an appropriate uniform national approach to estimating erosion hazard in roadside type surveys.

3.6.5 STABILITY (WIND EROSION)

A basic assessment of soil stability to wind erosion is proposed, in view of the inconsistency between soil disturbance rating and wind erosion hazard.

The surveyor assesses the overall condition of the site to predict whether it is likely or not to erode in a potentially erosive wind event (>30km/h). This would include consideration of soil erodibility, topography/location, effective groundcover level and soil looseness. This assessment would require a significant level of surveyor experience/knowledge.

3.6.6 LAND USE

It was recognised that there would be wider benefits in roadside erosion observational data that included a land use field that aligned with the latest version of the Australian Land Use and Management (ALUM) classification. Current roadside survey programs include a broad “land management phase” field that incorporates some basic land use components (e.g. crop and pasture types) but with the exception of NSW are not necessarily compatible with ALUM.

An ALUM land use field was proposed to be a component of a new structure for “land management phase” (see Section 2.6.7) that would be compatible with national database specifications. Either the existing ALUM version 6 (Bureau of Rural Sciences 2006) or the proposed version 7 would be used. Further value could be added to ALUM by adding quaternary level categories for crop types (e.g. 3.3.1 Cereals – wheat, barley, oats, triticale etc.), and additional tertiary level categories for pasture types to match the detail of existing land management phase categories used in some states.

3.6.7 CURRENT LAND MANAGEMENT PHASE

Land management phase is recorded in existing roadside survey programs to provide overall agricultural context for observations of land condition, and to detect causal relationships between erosion, erosion hazard and agricultural rotation phase and/or management practices. A minimum set of land management phase categories (Table 3) was originally proposed which was intended to represent the main categories of interest in Mediterranean climate dryland agricultural areas of southern Australia, and which incorporated common categories recorded in existing survey programs in SA, WA, NSW and Vic. Definitions for categories and codes are those currently used in NSW.

Table 3. Original land management phase categories

Category	NSW Code	Definition
Fallow - chemical	FC	Land kept free of live vegetation with the use of herbicides. No mechanical disturbance of site.
Fallow - tilled	FT	Land kept free of live vegetation with the use of mechanical cultivation.
Crop - cereal	CC	Wheat, barley, oats, triticale etc.
Crop – grain legume	CL	Field peas, field beans, lupins, lentils, vetch etc.
Crop - oilseed	CO	Canola, mustard etc.
Crop - hay	CH	Crop that has been cut for hay. May not necessarily be observed depending on timing of survey.
Stubble	S	Greater than 50% of vegetative cover present is crop stubbles.
Stubble - burnt	SB	Stubbles at least partly burnt.
Pasture	P	Greater than 50% of vegetative cover present is pasture species.
Pasture - burnt	PB	Pasture residues at least partly burnt.

In the process of examining compatibility of such data specifications with a national roadside erosion survey database (Griffin 2009), the existing hierarchical structure of these categories was revealed to be unsuitable. An alternative structure for land management phase categories was proposed, comprising three base fields:

1. ALUM land use category
2. Plant growth phase (cycle)
3. Land management action.

Provisional categories proposed include:

Plant growth phase:

- growing
- mature (eg crop flowering - in head, not harvested),
- residue (eg stubble, senesced pasture)

Land management action:

- tilled
- sprayed

- grazed
- standing/none
- baled
- burnt
- abandoned (e.g. failed crop)

Combinations of categories using this new structure were found to be generally compatible with the original land management phase categories, and this structure enables flexibility in the hierarchical level of land use recorded. Further work, however, is needed to clarify the range and definitions of categories in these new fields.

Existing survey programs would need to establish whether there are identifiable links between categories in their current land management phase categories and those of the proposed national standards, if they are going to continue surveying using existing categories.

3.7 DATA CAPTURE AND MANAGEMENT

Recommended minimum requirements for a field database system to capture and manage roadside erosion survey data as proposed in this manual are presented in a complimentary report to this manual (Murphy 2009). Summary points are as follows.

For survey teams to conduct surveys efficiently and accurately, a field database should have key functionalities that enable teams to establish a survey, accurately navigate a route, record data at each site and report findings in a common and accurate manner.

No existing database possesses all the key functionalities and so it is recommended here that a relational database be designed and built to accommodate the national methods and to provide the appropriate functionality for teams to conduct surveys efficiently and accurately.

A suitable field database would:

- be built using Microsoft Access and run on field laptop PC
- have built in tools to establish a survey route, including the accurate capture of site locations and potential to modify them as necessary
- assist observers to accurately navigate to fixed site locations so that data values are collected from the same location each sample time
- accommodate key data fields that align with those in the national field methods manual proposed by Forward (2009)
- check for data entry errors at the time of data entry to ensure integrity of the data
- have the functionality to graphically report survey results and summarise them according to transect or region of survey
- have conformity of structure to permit common queries and standard export of data to national repository proposed by Griffin (2009)
- be distributed and be maintained via the internet.

4. FIELD ASSESSMENT STANDARDS

4.1 GENERAL FIELD SURVEY PROTOCOL

It is envisaged that the roadside survey is carried out at a vehicle speed that allows the observations and data entry to be carried out accurately. It may be necessary to stop the vehicle briefly at some or all sites to achieve this. If unusual or unclear land conditions are encountered, then it may be worth spending longer at such a site to clarify the observation categories, so that further similar sites can be accurately assessed more quickly. It may be helpful to carry binoculars.

Taller (e.g. four wheel or all wheel drive) vehicles allow a slightly higher angle of view, and should probably be the standard for roadside surveys.

For safety reasons, surveys should be carried out with at least two people in a vehicle, with the driver responsible foremost for road safety.

It is beneficial if the driver as well as observer(s)/recorder(s) are trained in the survey method, so they can concur on site observation categories for better quality control.

The following sub-sections list the proposed data required to be recorded for each field survey site, with definitions and photostandards for each data field.

4.2 STATE/TERRITORY AGENCY

A data field is entered according to the state or territory agency conducting the survey, as in Table 4 (e.g. DAF WA = 501).

Table 4. Survey agency identification codes

Agency	Code
New South Wales	1xx
Victoria	2xx
Queensland	3xx
South Australia	4xx
Western Australia	5xx
Tasmania	6xx
Northern Territory	7xx
Australian Capital Territory	8xx

4.3 TRANSECT NUMBER

Transect number determined by the agency conducting the survey is entered into this field.

4.4 SITE NUMBER

Site numbers determined by the agency conducting the survey are entered into this field.

4.5 SITE LOCATION

Fixed GPS coordinates of site centroid are entered into this field, with datum and zone. This will also include details of roadside position and bearing to site centroid for field navigation purposes.

It is recommended that a one-off digital photograph is taken at each site from the roadside, to provide visual confirmation of the site location.

4.6 SURVEYOR ID

Identification of principal field observer is entered into this field, using first three letters of surname followed by first letter of personal name.

4.7 SAMPLE DATE

Date of site observation.

4.8 LAND USE

Record current land use according to ALUM version 6, to the highest categorical level that can be readily distinguished (i.e. tertiary if possible). Table 5 shows the main higher order categories likely to be observed.

Table 5. Sample of ALUM v6 categories to secondary level

Primary level	Secondary level
2 Production from relatively natural environments	2.1.0 Grazing natural vegetation
3 Production from dryland agriculture and plantations	3.2.0 Grazing modified pastures 3.3.0 Cropping
4 Production from irrigated agriculture and plantations	4.2.0 Grazing modified pastures 4.3.0 Irrigated cropping 4.5.0 Irrigated seasonal horticulture

4.9 CURRENT LAND MANAGEMENT PHASE

Record current rotational land management phase according to the following provisional categories of plant growth stage and management action in Table 6 and Table 7.

Table 6. Provisional growth stage (cycle) categories

Category	Provisional definition
Growing	Seedling emergence to mature, or growing pasture
Mature	Crop or pasture from flowering to in-head, and not harvested
Residue	Crop stubble (after harvest or hay cut), or senesced pasture

Table 7. Provisional land management action categories

Category	Provisional definition
Tilled	Soil surface disturbed by mechanical means
Sprayed	Herbicide applied
Grazed	Livestock currently grazing paddock or evidence of having been grazed
Standing/none	No evidence of any other action/s
Baled	Crop or pasture cut and baled
Burnt	At least some of site burnt
Abandoned	Failed crop or fallow not sown

4.10 GROUNDCOVER LEVEL

Estimate of percentage flattened groundcover on the site according to the following categories and photostandards in Table 8. The photostandards in Figure 1 are sites where actual flattened percentage groundcover was measured.

Table 8. Groundcover level categories

Category	Code
0 – 12%	0
13 – 25%	1
26 – 50%	2
51 – 75%	3
76 – 88%	4
89 – 100%	5

0 – 12% (3%)

0 – 12% (7%)

13 – 25% (20%)

13 – 25% (19%)

26 – 50% (29%)

26 – 50% (42%)

Figure 1 Provisional flattened percentage groundcover photostandards. Photo credits: M. Case DECC NSW.

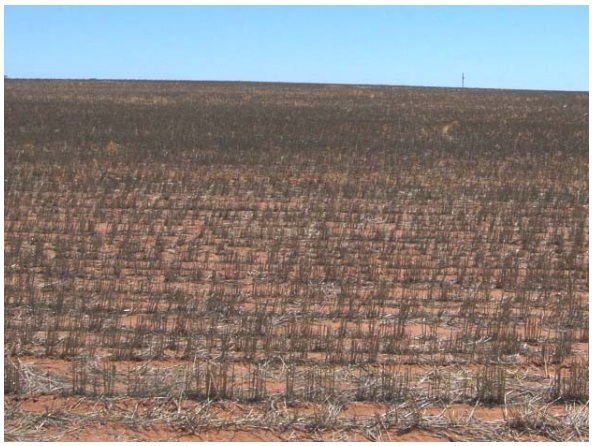
51 – 75% (59%) 	**51 – 75%** (71%)
76 – 88% (76%) 	**76 – 88%** (80%)
89 – 100% (89%) 	**89 – 100%**

Figure 1 (continued).

4.11 GROUNDCOVER HEIGHT

Estimate the dominant height category of vegetative matter on site, as shown in Table 9.

Table 9. Groundcover height categories

Category	Code
0cm (bare)	0
0 – 10cm	1
10 – 40cm	2
>40cm	3

4.12 DISTURBANCE

Assess the presence and degree of physical disturbance of the soil evident on site.

Table 10. Disturbance categories

Category	Code	Description
No significant disturbance	1	No significant disturbance apparent*
Partial disturbance	2	Disturbance of some of the soil surface by: • No-Till/Zero Till sowing (narrow point/disc) • First working with blade plough, prickle chain or harrow • Grazing livestock Land cultivated at least once: • Which has consolidated due to rain and/or new growth (not sandy soils) • Which is very cloddy and has some residue present • Which has moderate to high residue levels on surface, some likely to be anchored Land with new crop sown with full cut, up until late tillering, that has partially consolidated due to rain and/or plant growth Crops beyond tillering stage where cover too poor for complete stability or consolidation is only partial or patchy (e.g. drought or erosion affected soils)
Complete disturbance	3	Complete soil disturbance by cultivation, heavy grazing or both

* the presence of livestock or evidence of grazing at the site does not necessarily signify “partial disturbance” unless obvious soil disturbance is observed.

4.13 STABILITY (WIND EROSION)

Assess the overall stability of the site to wind erosion, according to the descriptions in Table 11. Take into account all apparent and relevant aspects of surface condition and site characteristics e.g. groundcover, disturbance, macro-aggregation, inherent erodibility, topographic exposure.

Table 11. Wind erosion stability categories

Category	Code	Description
Stable	0	Unlikely to erode with >30 km/h wind
Unstable	1	Likely to erode with >30 km/h wind

4.14 WIND EROSION SEVERITY

Assess the occurrence and relative severity of recent wind erosion at the site according to Table 12, based on visual evidence of soil erosion since the site was last surveyed.

Table 12. Wind erosion severity categories and photostandards

Category	Code	Description	Photostandard
Not apparent	X		
No wind erosion	0	No erosion evident • Soil clods (1a, b) and cultivation furrows present. • No evidence of sorting (i.e. no larger particles on the surface). • No change of soil colour (e.g. from dark to light red) • No localised accumulation of sediment.	1a 1b
Minor	1	Some loss of surface. There is evidence of erosion but eroded sediment remains within the paddock. • Larger sand particles on the surface. • Some sediment accumulation 'hummocking' around obstacles, such as plants, vegetative residues, clods, sticks or rocks (2a). • A change in the soils colour (e.g. lighter shade than of parent soil). • Smoothing of cultivation ridges, i.e. tops of ridges are rounded off, soil particles, and organic matter accumulate in the furrows and/or micro-depressions (2b).	2a 2b

Table 12. continued

Moderate	2	Most or all or surface removed. There is evidence that sediment is being exported off site, e.g. out of the paddock or from one part of the paddock to another part, such as off a sandhill on to the adjacent flat. • Cultivation ridges are no longer evident. (3a) • Windsheeting and/or ripple drift of surface. (3b) • Accumulation (hummocking) of sediment and organic matter along fence-lines or around plant residues. (3b) • Sand drift outside paddock boundary (3a and 3b).	 3a 3b
Severe	3	Most or all or surface removed. There is evidence of surface lowering (up to 10 cm) often exposing a hard surface. • Surface lowered by > 5-30cm • Deflation of surface to form a blow out.(4) • Large sandy deposit downwind of blow out.(4)	 4
Very severe	4	Deeper layers exposed. There is evidence of major surface lowering (> 10 cm) often exposing a hard surface. • Surface lowered by > 30cm • Major surface lowering with remnant soil pedestals	

4.15 WATER EROSION (SHEET) SEVERITY

Assess the occurrence and relative severity of recent sheet water erosion at the site as per Table 13, based on visual evidence of soil erosion since the site was last surveyed.

Table 13. Sheet water erosion severity categories

Category	Code	Description
Not apparent	x	
No sheet erosion	0	
Minor	1	Indicators may include shallow soil deposits in downslope sediment traps (fencelines, farm dams). Often very difficult to assess as evidence may be lost with cultivation, pedoturbation or revegetation.
Moderate	2	Indicators may include partial exposure of roots, moderate soil deposits in downslope sediment traps.
Severe	3	Indicators may include loss of surface horizons, pedestalling, root exposure, substantial soil deposits in downslope sediment traps.

The following picture shows an example of downslope deposition of sheet erosion.

4.16 WATER EROSION (RILL) SEVERITY

Assess the occurrence and relative severity of recent rill water erosion at the site as per Table 14, based on visual evidence of soil erosion since the site was last surveyed.

Table 14. Rill water erosion severity categories and photostandards

Category	Code	Description	Provisional photostandard
No rill erosion	0		
Minor	1	Occasional rills	
Moderate	2	Common rills	
Severe	3	Numerous rills forming corrugated ground surface	

4.17 WIND EROSION OCCURRING ON THE DAY OF SURVEY

Erosion occurring on the day of survey is proposed as an optional observation.

Assess what level of wind erosion, if any, is occurring at the site when it is surveyed, according to Table 15.

Table 15. Wind erosion on day of survey categories and photostandards

Category	Code	Description	Provisional photostandard
None	0	None observed	
Minor	1	Some minor sweeping or dust entrainment at site, visibility >100m	
Major	2	Major erosion at site, visibility <100m	

5. RECOMMENDATIONS FOR FURTHER RESEARCH

In the process of preparing this provisional set of national roadside survey standards, some key issues were identified that require further research and development.

Characterisation of site's inherent susceptibility to wind and water erosion

Currently, differing systems are used in SA and WA to characterise sites for their inherent susceptibility to wind and water erosion. Due to variation in soil erodibility, slope range and climate factors (rainfall, wind regimes) that occurs across the different states' agricultural regions, neither of these systems are appropriate to be applied to other areas. There is a need to identify a suitable method for characterising inherent erosion susceptibility of survey sites that can accommodate the range of biophysical environments of agricultural land in southern Australia, and possibly elsewhere.

Wind and water erosion hazard

None of the existing methods for estimating relative erosion hazard in roadside erosion survey programs are directly compatible with, or suitable for this provisional set of national roadside survey standards. The general conceptual approach used in SA and WA may be suitable, that is, an empirical estimation of erosion hazard using parameters of inherent erosion susceptibility, effective groundcover level and soil looseness. However at the present time, a suitable method for categorising inherent erosion susceptibility across all agricultural areas has not been identified.

Current land management phase

A new structure has been proposed for categories of current land management phase, consisting of ALUM land use categories, plant growth stage and land management action. Provisional categories (and definitions) for plant growth stage and land management action have been presented in this manual, but further work is required to consolidate the range of categories and their definitions.

Photostandards

It was also recognised there is a need to establish a more comprehensive set of photostandards for the following observations that represent the full range of field conditions likely to be observed (i.e. different types of crops, pastures, fallows, stubbles, soil/land types):

- Sheet and rill water erosion
- Percentage flattened groundcover.

APPENDICIES

A. DWLBC SA FIELD "WINDSCREEN" SURVEY PROGRAM

Specifications current as at June 2009.

General characteristics

BIOPHYSICAL ZONE/S	Agricultural
TYPE OF OBSERVATION	Roadside survey visual assessment
NUMBER OF SITES	5611
STRATIFICATION	39 Land Zones / 4 Agro-ecological Regions
EXTENT	Principal agricultural cropping NRM regions in SA (4)
SITE SIZE	200m x 200m
Comments	Some sites include dune/flat facets - each assessed
FREQUENCY OF OBSERVATIONS	4 times per year (March, May, June-crop sowing, October)
OTHER	Commenced in 1999/2000

Site observations and data type

Field	Description	Categories/range	Type
Location	*gps location*		*Site characterisation*
Date	Survey date	dd-mm-yy	Dynamic
TransectID	Transect number	1 - 14	Site characterisation
ZoneID	Land Zone number. Equivalent to Level 3 (Zone) in ASRIS	1 - 45	Site characterisation
SiteID	Site number. Values identify transect number and site number	1xxx - 14xxx	Site characterisation
LandTypeID	Identifies land facets dune (d), flat (n), or both, in dune/swale land systems	d, n	Site characterisation
PhaseID	Identifies key land use/rotational phase relevant to time of survey	crop/cereal, canola, grain legume, pasture, stubble, fallow, chemical fallow	Dynamic
TopoRWind	Characterisation of inherent wind erosion susceptibility by soil texture x landscape rating	1 - 5	Site characterisation
TopoRWater	Characterisation of inherent sheet/rill erosion susceptibility by slope rating	1 - 5	Site characterisation
WindSev	Severity of any wind erosion (drift banks, soil scouring) evident at site	1 - 5	Dynamic
SheetRillSev	Severity of any sheet or rill water erosion evident at site	1 - 5	Dynamic
DetachRating	Disturbance of surface soil (eg by cultivation, grazing) intensity rating	1 - 3	Dynamic. Now called disturbance rating.
CoverRating	Relative cover of vegetative matter (incl stones) by class rating. Incorporates height, approx % cover, horizontal distribution and volume (bulk).	1 - 8	Dynamic. Ratings descriptions updated in May 2009 to improve definition and better accommodate water erosion susceptible land.
Burn	Evidence of residue burning by completeness of burn e.g. nil, minor (<25% area), partial (25-50%), complete (>50%)	n, mb, pb, cb	Dynamic
Comments	Optional observations including contour banks, tillage type, irrigation, lucerne, clay spreading		Dynamic

B. DAF WA ROADSIDE SURVEY PROGRAM

Information provided by J. Laycock and D. Carter, DAF WA, June 2009.

General characteristics

BIOPHYSICAL ZONE/S	Agricultural
TYPE OF OBSERVATION	Roadside Survey Visual assessment
NUMBER OF SITES	2011
STRATIFICATION	20 Zones/ 76 Soil Systems/ 178 Soil SubSystems
EXTENT	18 Crop Variety Testing Zones
SITE SIZE	100 x 100
Comments	
FREQUENCY OF OBSERVATIONS	2 x Year. Nov-Dec and March-May (max-min cover)
OTHER	Commenced in 2007

Permanent data

Transect	Transect 1 - 6 (Plan to make 1 more transect running North/ South)
Site ID	Combination of transect name and number i.e. GY1 = Geraldton to Yalgoo site 1
GPS position	GPS coordinates of the site. GDA 94, UTM zone 50 and 51
Side of Road	Left or Right
Photo	Photograph of the site
Wind Topographic Rating	5 textural categories, modified from SA categories
Water Topographic Rating	5 slope categories, Same as SA
Items such as soil zone/ landscape unit can be obtained through the soils database	

Survey results (dynamic data)

Date	Date of transect
Phase	Cropping Phase; Stubble, Crop, Lupin, Canola, Peas, Pasture, Fallow (chemical or cultivated)
Cover rating	6 categories, percentage soil exposed (inverse of NSW categories)
Detachment Rating	Same as SA
Stability	3 categories
Wind Erosion	Same as SA
Water Erosion	Same as SA
Burning	Same as SA
Stock	Sheep, Cattle, Horses etc.
Tillage	
Comments	Additional site information observed

C. NSW DECC ROADSIDE SURVEY AND GROUND REFERENCE SITE PROGRAM

Information provided by J. Leys, DECC NSW and S. Murphy DPI NSW.

General characteristics

	Roadside survey	Ground reference sites
BIOPHYSICAL ZONE/S	Agricultural - Rangelands	Agricultural - Rangelands
TYPE OF OBSERVATION	Roadside survey visual assessment	In paddock
NUMBER OF SITES	877	71
STRATIFICATION	Vegetation units	none
EXTENT	3 CMAs	1 CMA
SITE SIZE	25x25m	25m transect
Comments	sites only encompass one land unit	sites only encompass one land unit
FREQUENCY OF OBSERVATIONS	2 times a year (Dec, March)	2 times a year (Dec, March)

Roadside survey data fields

Field	Description	Categories
Sampling date, time	Date and time of observation	GMT from GPS
Operator	4 letter code for name of observer – first 3 letters of surname, initial	e.g. MURS
Site location	Coordinates of centroid of site in GDA94 geographic projection, decimal degrees. Range of fixed site parameters.	Latitude, longitude
Site number	4 digit code, different series for each CMA	1xxx-9xxx
Land use	5 categories	Arable, irrigation, rangelands, conservation, forestry
Land management phase	36 categories in hierarchical system covering agricultural and horticultural crops, pastures, fallows, stubbles and woody vegetation	
Wind erosion rating	4 classes	
Water erosion rating	3 classes	
Erosion hazard (wind)	4 classes corresponding to wind erosion ratings	
Groundcover	6 classes of % flattened groundcover	0-12, 13-25, 26-50, 51-75, 76-88, 89-100

Ground reference site assessments

Operator	
Site Number	4 digit number unique to Lower Murray Darling CMA area, 3xxx's
Property name	Text
DateSampled	Date of sample
OriginalVegetation	Stratification layer - same as roadside survey
cover hits	number of hits out of 200 from tape measured every 10cm
bare hits	number of bare ground out of 200 from tape measured every 10cm
%veg cover	Calculation of hits/ hits+bare * 1//100
R1 Wt of clod >0.85mm	Rep 1 of approx 1 kg sieved soil > 0.85mm
R1 Wt of clod <0.85mm	Rep 1 of approx 1 kg sieved soil < 0.85mm
R1 %DryAgg	Rep 1 mass >0.85/(total mass)*1/100
R2 Wt of clod >0.85mm	Rep 2 of approx 2 kg sieved soil > 0.85mm
R2 Wt of clod <0.85mm	Rep 2 of approx 2 kg sieved soil < 0.85mm
R2 %DryAgg	Rep 2 mass >0.85/(total mass)*1/100
R3 Wt of clod >0.85mm	Rep 3 of approx 3 kg sieved soil > 0.85mm
R3 Wt of clod <0.85mm	Rep 3 of approx 3 kg sieved soil < 0.85mm
R3 %DryAgg	Rep 3 mass >0.85/(total mass)*1/100
Mean %Dry Agg	Mean of Rep 1 2 and 3
Soil Transport Rate g/m/s	8.11375017*EXP(-0.05172598*(%veg*100))*EXP(-0.038989759*(%DA*100))
Land Use	Same as Roadside Survey
Rotational Phase	Same as Roadside Survey
Ero Class	Same as Roadside Survey
Ero Hazard	Same as Roadside Survey

D. VICTORIAN MALLEE CMA – DPI VIC GROUND REFERENCE SITE PROGRAM

Information provided by L. Wakefield and R. MacEwan, DPI Vic.

General characteristics

BIOPHYSICAL ZONE/S	Agricultural
TYPE OF OBSERVATION	in paddock assessment
NUMBER OF SITES	150-160
STRATIFICATION	6 Landsystems/3 landforms
EXTENT	Vic Mallee CMA
SITE SIZE	100m x 100m
Comments	
FREQUENCY OF OBSERVATIONS	3 times/year Feb/Mar, Jun/July, October
OTHER	Methods were employed from 2007 but are still under development

Ground reference site assessments (from Gordon 2008)

	Assessment method	**Categories**
All sites (160)		
gps location	site characterisation	
approximate slope %	site characterisation	
surface roughness	site characterisation	
Erosion (wind)	visual - photostandards/descriptions	minor / moderate / severe
soil dry aggregation % >0.85mm	visual - photostandards/descriptions	<10, 10-30, 30-50, >50
vegetation cover %	visual - photostandards/descriptions	<10, 10-30, 30-50, 50-70, >70
current management phase	visual	conventional fallow, chemical fallow, stubble, crop, pasture
livestock presence	visual	present / absent
Subsample test sites (40)		
vegetation cover %	measurement	<10, 10-30, 30-50, 50-70, >70
soil dry aggregation % >0.85mm	measurement	<10, 10-30, 30-50, >50

E. RAPID CONDITION ASSESSMENT PROGRAM - QLD

General characteristics (from Karfs et al 2009)

BIOPHYSICAL ZONE/S	Dry tropics - rangelands
TYPE OF OBSERVATION	Roadside survey visual assessment
NUMBER OF SITES	
STRATIFICATION	Landscape types within grazing lands
EXTENT	Fitzroy and Burdekin catchments
SITE SIZE	1 - 2 ha
Comments	
FREQUENCY OF OBSERVATIONS	Dry season
OTHER	Observations done to determine ABCD land condition rating

F. EROSION HAZARD ESTIMATION – SA DWLBC FIELD "WINDSCREEN" SURVEY PROGRAM

Information largely extracted from McCord (2007).

Erosion hazard

Two categories of erosion hazard are estimated from "cover rating" as follows:

Classification	Cover rating
Not at risk of erosion	1 – 5
At risk of erosion	6 – 8

Wind/water erosion hazard

Categories for wind erosion and water erosion hazard are estimated from matrix tables, as below, that incorporate all relevant combinations of "wind/water topography rating", "cover rating" and "disturbance rating". For current reporting purposes these are simplified into two classifications - all sites with hazard categories from "safe" to "slight/moderate" are deemed as not at risk, while those with hazard categories from "moderate" to "very high" are deemed as at risk.

Topographic Rating - Wind (soil x land type)

Relative site characterisation for inherent susceptibility to wind erosion. In March 2006 newly georeferenced sites were characterised by roadside observation by staff with expertise in soil science and land capability, together with independent on-site assessment of a random selection of sites. Categories are relevant for wind erosion prone land e.g.

- dune swale country in Eyre Peninsula/Murraylands/Upper South east
- other known areas, e.g. Calcareous loams at Booleroo (Northern and Yorke Agricultural region).

Land type	Wind Erosion Topography Rating
Loam/Clay Flat/slope/rise	1 (Essentially no risk)
Sandy or Calcareous Loam Flat/slope/rise	2 (Low/moderate risk)
Sandy Flat/Slope	3 (Moderate high risk)
Low Sandhills (<5m)	4 (High risk)
Mod/Large Sandhills (>5m)	5 (Very high risk)

Topographic Rating - Water (Slope)

Relative site characterisation for inherent susceptibility to water (sheet/rill) erosion. Sites were characterised as per wind erosion topography rating.

Water erosion topography rating	Slope
1	0-3%
2	3-6%
3	6-12%
4	12-24%
5	> 24%

Disturbance rating (previously called detachment rating)

Category	Code	Description
No significant disturbance	1	No significant disturbance apparent*
Partial disturbance	2	Disturbance of some of the soil surface by: • No-Till/Zero Till sowing (narrow point/disc) • First working with blade plough, prickle chain or harrow • Grazing livestock Land cultivated at least once: • Which has consolidated due to rain and/or new growth (not sandy soils) • Which is very cloddy and has some residue present • Which has moderate to high residue levels on surface, some likely to be anchored Land with new crop sown with full cut, up until late tillering, that has partially consolidated due to rain and/or plant growth Crops beyond tillering stage where cover too poor for complete stability or consolidation is only partial or patchy (e.g. drought or erosion affected soils)
Complete disturbance	3	Complete soil disturbance by cultivation, heavy grazing or both

* the presence of livestock or evidence of grazing at the site does not necessarily signify “partial disturbance” unless obvious soil disturbance is observed.

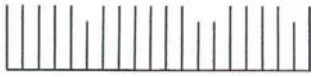
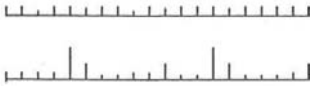
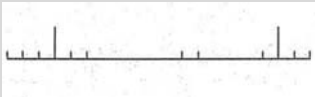
Cover Rating

Surface cover rating - combined dry and green material (and stones) protecting the soil surface. Descriptions updated May 2009.

Definitions

Height	Height of the surface cover. Used as the main factor to assess areas with inherent susceptibility to wind erosion
Cover%	Percentage of the soil surface covered with plant material or stones etc. as viewed from the roadside, (oblique view). Used as the main factor to assess areas with inherent susceptibility to waster erosion.
Bulk	This is the overall amount of the surface cover material. For example, canola stubble vs. cereal stubble, both with similar height of cover will have different bulks.
Anchorage	Is the **surface cover** attached to the soil (e.g. Undisturbed plant crowns) or is it detached (unanchored) by cultivation, grazing etc, and likely to blow or wash away?

Surface cover rating table

Rating	Height (wind erosion)	Cover % (water erosion)	
1	Residues 40cm or higher.	75 to 100%	
	Bulk: Very high level of plant matter Anchorage: Majority of cover is anchored and stable, not easily washed or blown away.		
2	Residues between 10cm and 40cm.	Even coverage of approx. 75 to 100%	
	Bulk: high amount of plant matter, most of which is standing Anchorage: Majority of cover is anchored.		
3	Residue height variable from less than 10cm to 40cm.	More variable cover of approx. 75 to 100%	
	Bulk: moderate to high but more variable across the paddock Anchorage: Cover often slightly flattened and damaged		
4	Residues 2cm-10cm, but of moderate bulk. Residues a mixture of upright and flattened.	50 to 75% cover, residue colour dominates	
	Bulk: Moderate Anchorage: Majority of residues are anchored, although often flattened or damaged.		
5	2cms of relatively even but thin residue cover remain. or, cover variable from sparse 40cm to less than 2cm cover	50 to 75% cover, Residue colour still dominates	
	Bulk: Low, damaged through moderately heavy grazing or traffic by animals and/or machinery. Anchorage: majority of residues are anchored, most residues are damaged.		
6	Height is variable and less than 10cm high to bare.	Soil colour dominates, 25 to 50% cover	
	Bulk: Low amounts of plant material. Anchorage: some residues are anchored; most are damaged through grazing or cultivation.		
7	Mostly bare although some residues can be seen. Grazed or cultivated virtually bare.	Soil colour dominates, 1 to 25% Scattered residues (and/or rocks) remain.	
	Bulk: minimal amount of plant material. Anchorage: Any residues probably unanchored		
8	Nil cover (bare)	0% cover	
	Bulk: Nil Anchorage: Nil		

Matrix table for wind erosion hazard

Topographic rating - wind	Cover rating	Disturbance rating	Hazard
1-5	1-3	1-3	Safe
1-2	4-5	1	Safe
1	6-8	1	Safe
2	6-8	1	Safe/Slight
3-5	4	1	Safe
3-5	5	1	Slight
3-5	6-8	1	Moderate/High
1	4-5	2	Safe
1	6-8	2	Safe
2	4-5	2	Slight
3-5	4	2	Slight
3-5	5	2	Moderate
2-5	6-8	2	Moderate/High
1-2	4	3	Safe
1	5	3	Safe
1	6-8	3	Safe
3-5	4	3	Slight/Moderate
2-5	5	3	Moderate/High
2-5	6-8	3	High/Very High

Matrix table for water (sheet/rill) erosion hazard

Topographic rating (water)	Cover rating	Disturbance rating	Hazard
1-5	1-3	1-3	Safe
1-2	4-5	1	Safe
1	6-8	1	Safe
2	6-8	1	Safe/Slight
3-5	4	1	Safe
3-5	5	1	Slight
3-5	6-8	1	Moderate/High
1	4-5	2	Safe
1	6-8	2	Safe
2	4-5	2	Slight
3-5	4-5	2	Moderate
2-5	6-8	2	Moderate/High
1-2	4	3	Safe
1	5	3	Safe
1	6-8	3	Safe
3-5	4	3	Moderate
2-5	5	3	Moderate/High
2-5	6-8	3	High/Very High

G. STATISTICAL APPROACH TO ROADSIDE SURVEY – VICTORIAN MALLEE DRIVE-BY EROSION SURVEY

This is the approach used to determine the number of paddock sites for a drive-by survey of wind erosion in the Victorian Mallee. Information provided by Leigh Callinan, PhD, AStat, Biometrician and Rob Clark, Remote Sensing, Technical Officer DPI-Vic, Bendigo, 1 June 2009.

Background: Following a teleconference on monitoring wind erosion (on Tues 28 April 2009), we were asked to detail advice for determining the size of the monitoring sample and a method for locating the sample sites. The aim of this work is to determine the prevalence of and changes in wind erosion in paddocks in several Australian Landscapes.

Advice: In the Victorian Mallee, wind erosion has been monitored for some years and the Mallee can be used as an example for determining sample sizes. The Mallee is characterised by 13 Land Systems with one to four Land Forms in each (Rowan and Downs, 1963). Not all these will be of sufficient interest to include in the survey.

Paddocks will be classified by two Likert Scales, i.e.:

- 'State of Erosion' viz: Active, Stabilised or Partly Stabilised.
- 'Level of Erosion' viz: None, Minor, Moderate, Severe, Very Severe

These classifications are taken from McDonald R. C. et. al. (1990). Australian Soil and Land Survey. Field Handbook. Second Edition.

Selection of paddocks should be stratified by Land System and Land Form.

The statistical model suitable for this ordinal data will have multinomial errors. This model is best suited for minimum cell sizes of five. So if we wanted to study the main effects and interactions of all cofactors in the model we would need to monitor about 750 paddocks stratified by these cofactors, i.e. 10 Land Systems * 3 Land Forms * 5 levels of wind erosion * 5 samples per cell. This number might not be achievable; but a reduced number e.g. 375 sites, will at least allow an analysis of the main effects and interactions of the cofactors. This number should also allow us to determine the prevalence of wind erosion presence to < ± 4%, with 90% confidence and will be appropriate regardless of the size of our Landscape.

A limitation of this approach is that while the Land systems are spatially defined, the land forms are only described and are not spatially defined within each land system. It is possible that a random selection of sample points within each land system may not adequately represent the component land forms. Care should be taken to ensure that the significant land forms within each land system are represented by the random sampling process.

Other landscapes will have different features of interest; so the sample size will also be different, in any case they can be calculated using the procedure shown above.

Let's assume you decided on monitoring 375 paddocks. Select say 500 sample co-ordinates by random sampling from the spatial co-ordinates of the whole landscape. Then from this sample select a sub-sample of 375 co-ordinates with equal representation for each Land System * Land Form * Climate Zone combination. Then locate the nearest road-facing paddock to each of the 375 co-ordinates. Get GPS co-ordinates of each of these sampling

positions, if you want return to the same positions over time. It would be preferable to draw up a new random sample at each sampling time, if possible.

The data can be analysed in a generalised linear model with multinomial errors. If too many cell sizes are too small (<5) then there is a non parametric Exact method of analysis for two ordered multinomials with or without strata, is available in StatXact (Version 8.0.0. Cytel Studio. MA, USA). These models can also be used to determine whether there has been a change in wind erosion severity over time.

Reference:

Rowan J. N. and Downs R. G. (1963) A study of the land in north-western Victoria. Soil Conservation Authority, Victoria.

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	μg	10^{-6} g	mass
microlitre	μL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

GLOSSARY

ACLUMP. Australian Collaborative Land Use Mapping Program

Aggregation. Clumping together of fundamental soil particles due to interparticle bonding.

ALUM. Australian Land Use and Management classification.

Arid. Climate or region which lack sufficient rainfall for crop production or extensive sown pastures, usually defined as annual average rainfall less than 250mm.

ASRIS. Australian Soil Resource Information System

Blowout. A closed depression formed in the land surface as a result of wind erosion removing material and depositing it in an accumulation adjacent to the resulting trough.

BRS. Bureau of Rural Sciences. Government of Australia.

CEMSYS. Computational Environmental Management System.

Clod. A large, compact and coherent soil aggregate produced artificially, usually by ploughing or digging soils that are either too wet or too dry for normal tillage operations.

CSIRO. Commonwealth Scientific and Industrial Research Organisation

DAF WA. Department of Agriculture and Food, Western Australia.

DECC NSW. Department of Environment and Climate Change, New South Wales.

DPI NSW. Department of Primary Industries, New South Wales.

DPI Vic. Department of Primary Industries, Victoria.

Dry tropics. Areas of northern Australia within tropical zone that receive relatively low annual rainfall.

Direct Drill. Method of sowing a crop in a one-pass operation (without prior cultivation).

DWLBC. Department of Water, Land and Biodiversity Conservation. Government of South Australia.

EP. Eyre Peninsula Region.

Erosion. Natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities.

Erosion hazard. The susceptibility of a parcel of land to the prevailing agents of erosion. It is dependent on a combination of climate, landform, soil, land use and land management factors.

Fallowing. The management practice of leaving land in an uncropped state for a period of time prior to sowing another crop. Its purpose is to allow for the accumulation and retention of water and mineralized nutrients in the soil, and generally to also allow for weed control. Where this is done by mechanical means e.g. tillage it is termed mechanical or tilled fallowing, and where it is done by application of herbicides it is termed chemical fallowing.

GIS (geographic information system). Computer software allows for the linking of geographic data (for example land parcels) to textual data (soil type, land value, ownership). It allows for a range of features, from simple map production to complex data analysis.

GPS. (global positioning system

Ground cover. Any material on the soil surface, including plants, their residues, rocks, manure etc.

Gully. An open incised erosion channel in the landscape generally greater than 30cm deep.

Herbicide. A chemical substance used for killing plants, usually weeds.

Inherent erosion susceptibility. The intrinsic susceptibility of a parcel of land to the prevailing avents of erosion. It is dependent on a combination of climate, landform and soil factors. (equivalent to *erosion risk* defined in Glossary of terms used in soil conservation, Houghton and Charman 1986, Soil Conservation Service of NSW)

KI. Kangaroo Island Region.

Land. Whether under water or not and includes an interest in land and any building or structure fixed to the land.

Land system. An area or group of areas commonly delineated on a map, through which there is a recurring pattern of topography, soils and vegetation.

Land zone. Level of land classification above land system.

LandMAPT. Field survey database developed by NSW DPI & DECC.

LCMP. Land Condition Monitoring Program.

LUMIS. Land Use and Management Information System.

Mediterranean climate. Climate regime characterized by hot dry summers and cool wet cool winters.

MERI. Monitoring Evaluation Reporting and Improvement component of Australian Government "Caring for Our Country" funding program

ML. Murraylands Region.

MLR. Mount Lofty Ranges.

Model. A conceptual or mathematical means of understanding elements of the real world which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

NCST. National Committee for Soil and Terrain

NLWRA. National Land and Water Resources Audit.

Natural Resources. Soil; water resources; geological features and landscapes; native vegetation, native animals and other native organisms; ecosystems.

Natural Resources Management (NRM). All activities that involve the use or development of natural resources and/or that impact on the state and condition of natural resources, whether positively or negatively.

No-Till. Method of sowing crop in a one-pass operation using narrow seeder points or disc openers.

NRM Plan. State Natural Resources Management Plan.

N&Y. Northern and Yorke Region.

Pasture. Grassland used for the production of grazing animals such as sheep and cattle.

PC. Personal computer.

PDA. Personal Data Assistant.

Pedoturbation. Mixing within a soil or sediment profile by various processes, such as animal burrowing, tree throw, wetting-drying or freeze-thaw cycles etc.

QA. Quality assurance

Remote sensing. The collecting of information about an object or phenomenon by the use of sensing devices not in physical or intimate contact with the subject under investigation, such as aerial photography, satellite imagery, electro-magnetic survey, radar imagery.

Rill. A small channel, cut by concentrated runoff, through which water flows during and immediately after rain. Defined as up to 30cm deep, and can be easily obliterated by tillage operations.

SA. South Australia.

SE. South East Region.

Semi arid. Climate or region which lack sufficient rainfall for crop production or extensive sown pastures, usually defined as annual average rainfall of greater than 250mm but less than 375mm in southern areas of Australia.

Soil erodibility. The susceptibility of soil to the detachment and transportation of soil particles by erosive agents, due to the intrinsic characteristics of the soil, independent of factors such as climate, topography land use and plant cover that can affect erosion.

Stubble. The straw residue that remains after a grain crop has been harvested.

Tillage. The use of various types of implements for the mechanical preparation of the soil to facilitate the growth of a crop or pasture, ie to prepare the seedbed, manage weeds or vegetative residues etc.

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