5. Data

5.1 Introduction

Some of the issues pertinent to data collection in relation to land degradation management were discussed in Chapter 2. These include the type of information required and its usefulness to end users; variation in data collection, and the use of Geographic Information Systems (GIS) for the collection, organisation, management and visualisation of data. The general method developed in Chapter 4 can be applied at various scales, depending on the desired outcomes of the analysis and the availability of reliable information. In this chapter, the regional, farm and paddock data collected for the purposes of analysis is presented and discussed.

At the regional level, systematically-collected statewide land-degradation data with which to test the general approach are only available for New South Wales. The Local Government Area (LGA) is the basic unit for analysis at this level, as this is the most general data unit for population and human-related activities (Standing Committee on Agriculture and Resource Management [SCARM] 1993). The LGA data can be aggregated to provide both regional and statewide information on the effects of land degradation on agricultural output.

An area near Gunnedah was chosen for the farm and paddock-level analysis because of the availability of GIS data collected for 1:25 000 map sheets of the surrounding area by the NSW Department of Land and Water Conservation. The area is also relatively close to Armidale, thus reducing the costs of travel. Following consultation with staff from the Department of Land and Water Conservation (DLWC) Research Station at Gunnedah, a map sheet was chosen that had a wide range of land use, topography, vegetation, soil and land-management types.

5.2 Data at the regional level

5.2.1 Land degradation data

In 1987-88, the NSW Soil Conservation Service undertook a systematic survey of land degradation across the State (Soil Conservation Service of New South Wales 1989; Graham 1989, 1992). The Land Degradation Survey was restricted to degradation which affected the productive capacity of the agricultural, pastoral and forested lands, and only degradation due to European management was included. The survey did not incorporate measurements of productivity losses associated with land degradation.

The survey points, at which measurements were undertaken, were selected on a 5 km x 10 km grid of geographic coordinates in the Eastern and Central Divisions, and on a 10 km x 10 km grid in the Western Division, giving around 13,000 sample points in total. Data for these survey points were aggregated up to the LGA level for this project.

Information to assess each type of degradation was derived from aerial photographs and specialist knowledge, and was confirmed by field checking. Ten forms of degradation were assessed (Table 5.1). The quality and scope of the data provided by the Land Degradation Survey represent a significant advance on the only prior statewide data on land degradation — that available from the Federal/State Collaborative Soil Conservation Survey (Woods 1984). These data were used as the basis for an earlier attempt to estimate agricultural opportunity costs (Sinden and Yapp 1987), which was a precursor to the current study.

The degradation variables for the regional analysis are defined as follows.

TONS	=	sheet and rill erosion, as tonnes of soil lost per hectare per year.
GULLY	=	gully erosion, as the total length of gullies (metres) per 100 hectares.
MASSM	=	mass movement, coded as 1 for present and 2 for absent.
WIND	=	wind erosion, coded as 1 for a low hazard to 4 for the highest hazard.
DRYSAL	=	dryland salinity, coded as 1 for no obvious sign, 2 some sign and 3 for extensive areas.

Table 5.1

Forms of land degradation assessment

Form of degradation	Basis of assessment	Measurement	Comment
Sheet and rill erosion	Hazard 0.1 ha USLE estimate	Quantity of soil loss (t/ha) and 5 classes, negligible to very severe	Existing land use was the basis for USLE factors
Mass movement of soil	Status 100 ha	2 classes, evidence as yes/no	
Wind erosion	Hazard 0.1 ha	4 classes, low to high	Assessment depends on existing land use, soil group and ground cover
Gully erosion	Status 100 ha	Length of gullying (m/100 ha) and 7 classes none appreciable to extreme	
Dryland salinity	Status 100 ha	3 classes nil, minor and severe	Not converted to area affected
Irrigation salinity	Status 100 ha	3 classes none obvious, present and extensive	Not converted to area affected
Scalding	Status 100 ha	3 classes 5% and less, 5 to 50% and over 50%	
Soil acidity	Status 4 ha	3 classes none, potential and severe	Assessment depends on existing land use
Soil structure decline	Status 4 ha	3 classes undisturbed, intermediate and severe	Assessment depends on existing land use
Woody shrub infestation	Status 4 ha	4 classes absent to dense	

Source: Graham (1989).

IRRSAL = irrigation salinity, coded as 1 for nil to minor, 2 for moderate and 3 for severe.

SCALD = scalding, coded as 1 for nil to minor, 2 for moderate and 3 for severe.

ACID = induced soil acidity, coded as 1 for none, 2 for potential to become acid and 3 for severe.

STRDEC = structural decline of the soil, coded as 1 for undisturbed land, 2 for intermediate decline and 3 for severe decline.

WSHRUB = level of woody shrub infestation, coded as 1 for not present, 2 as isolated individual shrubs, 3 as light to moderate infestation and 4 as dense, widespread infestation.

The variables are recorded as mean values per LGA. The variables TONS and GULLY are measurements of the intensity of land degradation. Two variables were developed from them to represent total levels of degradation per LGA.

SUMTON = sheet and rill erosion, as the total tonnes of soil lost per year.

SUMGUL = gully erosion, as the total length of gullies (metres).

It is important to note that although the rates of soil loss recorded are relatively low by world standards, indications are that soil formation rates in Australia are close to zero, meaning that any loss of soil material effectively results in a shortened productive life of the soil (Edwards 1987).

5.2.2 Bio-physical and land management data

As part of the Land Degradation Survey, a number of bio-physical and land management variables were collected. These variables are defined for the regional analysis as follows.

SLOPE = average slope gradient (%).

CROP = proportion of cropping land use (%).

PAST = proportion of pasture land use (%).

SOILG = soil group class (three classes, where class 1 = sandy soils, class 2 = length-textured brown soils, skeletal soils, red-brown earths, and class 3 = heavy-textured grey and brown soils, black earths, coastal peats.

5.2.3 Measurement in the Land Degradation Survey

Several aspects of the way degradation was measured in the Land Degradation Survey bear upon the interpretation of these values.

(a) The approach to measurement

The ten degradation variables in the SCS survey can be grouped according to whether they provide direct or inferred measures of land condition or measures of degradation hazard.

(a) *Gully length, mass movement, dryland salinity, irrigation salinity, scalding and woody shrub infestation*
— direct assessment of the condition of the land at the time of the survey.

(b) *Induced soil acidity and soil structure decline*
— indirect measurements of degradation inferred from land use, soil characteristics, farming practices and climate.

(c) *Sheet and rill erosion*
— estimated on the basis of hazard as the estimated level of soil loss, given particular land-use and soil-type parameters.

(d) *Wind erosion*
— estimated on the basis of hazard, given particular land-use and soil-type and cover parameters.

(b) The unit of measurement

Six of the degradation types in the Land Degradation Survey were recorded simply as ordinal classes: wind erosion, dryland salinity, irrigation salinity, acidity, soil structure decline and woody shrub infestation. The measurement of mass movement and scalding were dichotomous assessments. Two degradation types were recorded in terms of both a cardinal measurement and an ordinal class.

(a) The gully erosion variable is the most accurate degradation variable recorded. As well as being measured in terms of actual metres of length in each 100 ha plot, the gully lengths were also assigned into ordinal classes from 1-7.

(b) Estimates of the quantity of soil loss in tonnes were made by applying the Universal Soil Loss Equation (USLE), which combines a number of causal factors involved in the sheet and rill erosion process to predict the quantity of soil erosion. This equation was used by Graham (1989) in a modified form suitable for the Australian environment. Estimates were made in tonnes of soil loss per hectare and then converted into classes, numbered from 1-5.

A number of problems with the survey method should be highlighted. There is a lack of consistency between the number of severity classes assessed for each attribute, therefore individual percentages or areas of any one form of degradation cannot be added to others to derive a total picture of degradation across the state. Walpole *et al.* (1992) overcome this problem by developing an index of degradation that reduced each measurement to a consistent three-point scale, aggregated this information and calculated a weighted average. The data were collected at too broad a scale to be useful for precise monitoring of trends in the status of land degradation, with recognised field tests required to provide data for trend analysis. Graham (1992) outlines limitations in the survey method for particular forms of land degradation measured, and highlights the problem that the assessments for many forms of degradation were based on relationships with other factors rather than direct observations.

The systematic way in which the survey was undertaken, and the checks that were employed, ensured that there was a high degree of consistency in the way each degradation type was evaluated across the State (Graham 1989). The use of direct quantitative degradation data rather than qualitative or standardised values may have a number of advantages. In particular, such data accurately describe the occurrence of individual degradation types, and the interpretation of results from functions that use these variables is straightforward. Alternatively, the measurement of degradation by classes, with ordinal numbers for each class, may provide more scope for comparison between degradation types, once the numbers are converted into a standardised value — as indicated later in this chapter.

5.2.4 *Agricultural Data*

The dependent variable in the models includes all agricultural outputs from an LGA to provide information on opportunity costs of agriculture as a whole. The dependent variable per LGA is therefore defined as follows.

GVAP = gross value of all agricultural production, in $000 dollars, as a three year average 1987/88 to 1989/90.

To capture other inputs in the production process, the independent or regressor variables are defined for a given LGA as follows.

AREA = the total area in agricultural production, in hectares, as a three-year average 1987-88 to 1989-90.

LABOUR = the total number of farmers, managers, farm labourers and farm workers in 1986.

TFERT = total quantity of fertiliser used, in tonnes, as a three-year average 1987-88 to 1989-90.

CHEM = total quantity of chemicals used, in litres, as a three-year average 1987-88 to 1989-90.

The data for GVAP are taken from the Australian Bureau of Statistics publication, *Value of Agricultural Commodities Produced* (ABS 1989, 1990, 1991). The data for AREA and TFERT are taken from Australian Bureau of Statistics Annual Agricultural Census (ABS Agriculture Statistics Service, AgStats microcomputer package). Information for labour, by LGA, is available only from census results and so the data for LABOUR were taken from the 1986 Census. No satisfactory data could be found for capital. The logarithmic transformations of these variables are specified by the prefix L as LGVAP, LAREA, LLABOUR, and LTFERT. The per hectare transformations are specified by the prefix HA as GVAPHA, LABHA, FERTHA, and CHEMHA.

5.2.5 *Cost data*

Cost data for each LGA for the necessary conservation measures include those due to installation of works, operation and maintenance, change in management practices and technical assistance to the landholder. Ideally, the cost estimates should relate to land that

matches these degradation types and land, soil and slope categories. A possible set of such land categories from the Gunnedah area is outlined in Table 5.2.

While 800 costs would be required (5 degradation types x 2 soil types x 5 slope classes x 4 land uses x 4 management alternatives) to cover all the land categories, far fewer are needed in practice because far fewer combinations of alternatives actually exist. For example, not all degradation types, and not all the kinds of land use, may occur together or in a particular LGA.

The required cost data information was provided by district Soil Conservation officers in the NSW Department of Land and Water Conservation. The costs were provided for different erosion, soil, slope and land-use categories.

5.3 Data at the farm level

An area near Gunnedah was used to apply the general method to the farm and paddock scale. Farm surveys were undertaken to gain information on the production characteristics of the farm for the 1992-93 output period (Appendix 5). Information on the landholders' perception of degradation and other bio-data were also collected through the survey. Geographic Information System data available at the 1:25 000 scale for the same area enabled a detailed bio-physical description of each farm to be developed, as well as enhancing the information provided by the landholders on the extent and severity of land degradation. Due to the confidential nature of the data provided by individual farmers and potential sensitivity of subsequent results, the name and specific location of the map sheet is not given.

5.3.1 Survey data

Using a map of property names and boundaries from the Gunnedah Shire Council, it was possible to identify which farms occurred within the boundaries of the chosen map sheet. Landholders were then contacted by telephone to arrange an interview. At the time of the survey (early 1995) drought was having a significant effect on the area, and some landholders were reluctant to co-operate due to the major difficulties associated with the prevailing conditions. Due to these constraints, selection of properties was based on the first 31 landholders with whom appointments could be made. The data collected from

Table 5.2

A possible set of land categories for cost estimates in the Gunnedah area

Land attribute/management	Alternative categories
Degradation type	Sheet and rill erosion
	Gully erosion
	Dryland salinity
	Scalding
	Acidity
Soil type	Red brown earth
	Black earth
Slope	< 2 %
	2 — < 5 %
	5 — < 10 %
	10 — < 20 %
	> 20 %
Current land use	Continuous grazing
	Pasture/crop rotation
	Lay/fallow/weed crop phase
	Continuous cropping
Potential management alternatives for land degradation prevention and control	Do nothing
	Maintain current land management
	Restore the land
	Change to stabilised flow of net income

these landholders are considered to be representative of properties in the area, and provide a good coverage of the map sheet.

Estimates collected through the survey were based on the 1992-93 season, as this was when the GIS data were collected. The total area of the farm (AREA), and area of lucerne (ALUC) were measured in hectares. Productivity was measured in terms of gross value of agricultural output (GVAP), with the number of stock (STOCK) and tonnes of grain (TGRAIN) also recorded. Data on number of farm workers (LABOUR) were also collected, as was the tonnes of fertiliser (TFERT), and litres of chemicals applied (CHEM). Membership of a landcare group (LCARE), whether the owner intended to sell the property in the future (SELL) and the intention to undertake soil conservation (CONS) were also recorded (1=yes/0=no).

5.3.2 GIS data

(a) Land degradation data

Erosion was one of eight attributes collected through the GIS survey of the map sheet. The erosion classifications range from no appreciable erosion to very severe for sheet, wind, rill, gully and streambank erosion. Mass movement was also recorded; however, for this particular study area, only sheet and rill erosion and salinity were recorded as present. Figure 5.1 shows the land degradation types occurring in the survey area, with the corresponding data being summarised in Table 5.3.

For the purposes of analysis, the erosion classifications were converted to measurements in t/ha. According to the NSW Land Degradation Survey, no appreciable erosion = <1t/ha/year; minor sheet and rill erosion = 1-<5 t/ha/year; moderate sheet and rill erosion = 5-<10 t/ha/year; severe sheet and rill erosion = 10-<25 t/ha/year; and very severe sheet and rill erosion = >25 t/ha/year.

The degradation variables from the GIS are defined for the farm analysis as follows.

SUMTON	=	the total amount of sheet and rill erosion per farm in tonnes.
ARE ROS	=	the area of sheet and rill erosion in hectares.

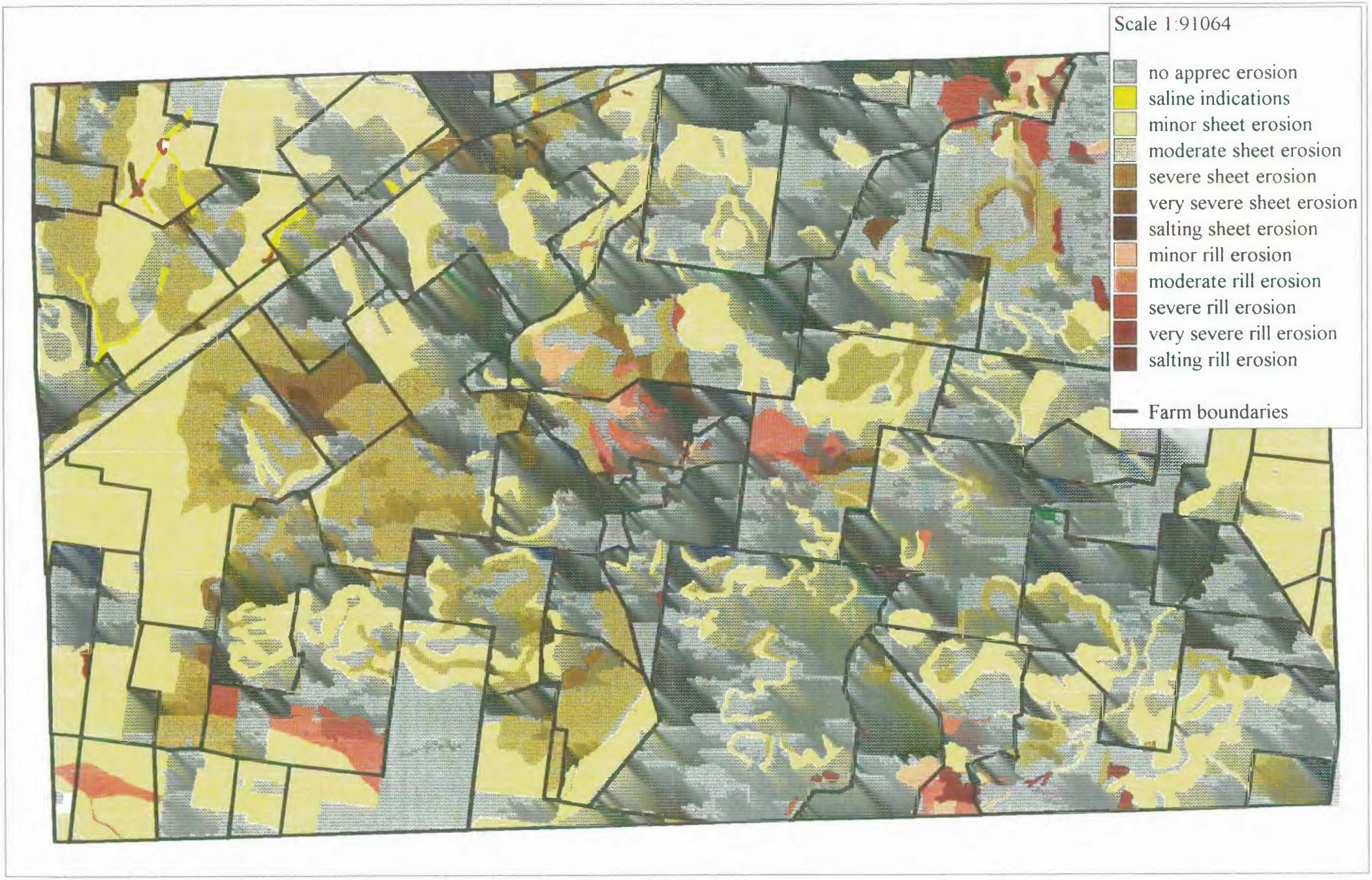

Figure 5.1

Degradation types in the farm survey area

Table 5.3

Degradation types in the farm survey area

Degradation classification	Area (ha)	% of total
No appreciable erosion	19 784.2	59.8
No erosion classification	2.1	0.0
Saline indications	96.4	0.3
Minor sheet erosion	7910.0	23.9
Moderate sheet erosion	3990.0	12.1
Severe sheet erosion	321.2	1.0
Very severe sheet erosion	56.2	0.2
Salting sheet erosion	6.5	0.0
Minor rill erosion	193.3	0.6
Moderate rill erosion	395.6	1.2
Severe rill erosion	209.3	0.6
Very severe rill erosion	115.3	0.3
Salting rill erosion	16.7	0.1
TOTAL	33 096.8	100.0

Source: NSW Department of Land and Water Conservation GIS data.

(b) Bio-physical and land-management data

Using an overlay of property boundaries on the GIS data, detailed bio-physical information could be extracted for each farm. Measured attributes include slope, terrain, land use, timber, erosion, rock, soil and soil-erosion control earthworks. Figure 5.2 shows the land-use types occurring in the survey area, with the corresponding data being summarised in Table 5.4. Appendix 6 contains figures displaying slope, timber, soil type and soil conservation for the map sheet. The following data were extracted from the GIS, in terms of average values per farm: slope (SLOPE) in degrees, area under cropping (CROP), pasture (PAST), improved pasture (IMP), and trees (TREES) in hectares, and the presence or absence (1=present/0=absent) of red brown earth (RBE), skeletal soil (SKEL) and euchrozem (EUCH). For all defined variables, the logarithmic transformations will be specified by the prefix L and the per hectare transformations will be specified by the prefix HA

5.3.3 Cost estimates

Costs can be estimated according to areas requiring some form of soil-conservation treatment. At the farm level, the area treated with soil conservation works, but requiring additional works to complete erosion control (AREA SC), was extracted from the GIS database. Using an overlay in the GIS, it is also possible to determine for which soil type, degree of slope and land use additional soil conservation is required. This was undertaken by linking this information with cost data obtained from DLWC staff at Gunnedah. The costs were provided for different soil, slope and land-use categories. Therefore, cost estimates can be made to reflect more closely the true condition of the land.

5.4 Data at the paddock level

Two landholders were surveyed at both the farm and paddock level. For both farms, information was collected on the production characteristics of each paddock for the 1992-93 output period. Geographic Information System data enabled a detailed bio-physical description of each paddock to be developed, as well as enhancing the information provided by the landholders on the extent and severity of land degradation.

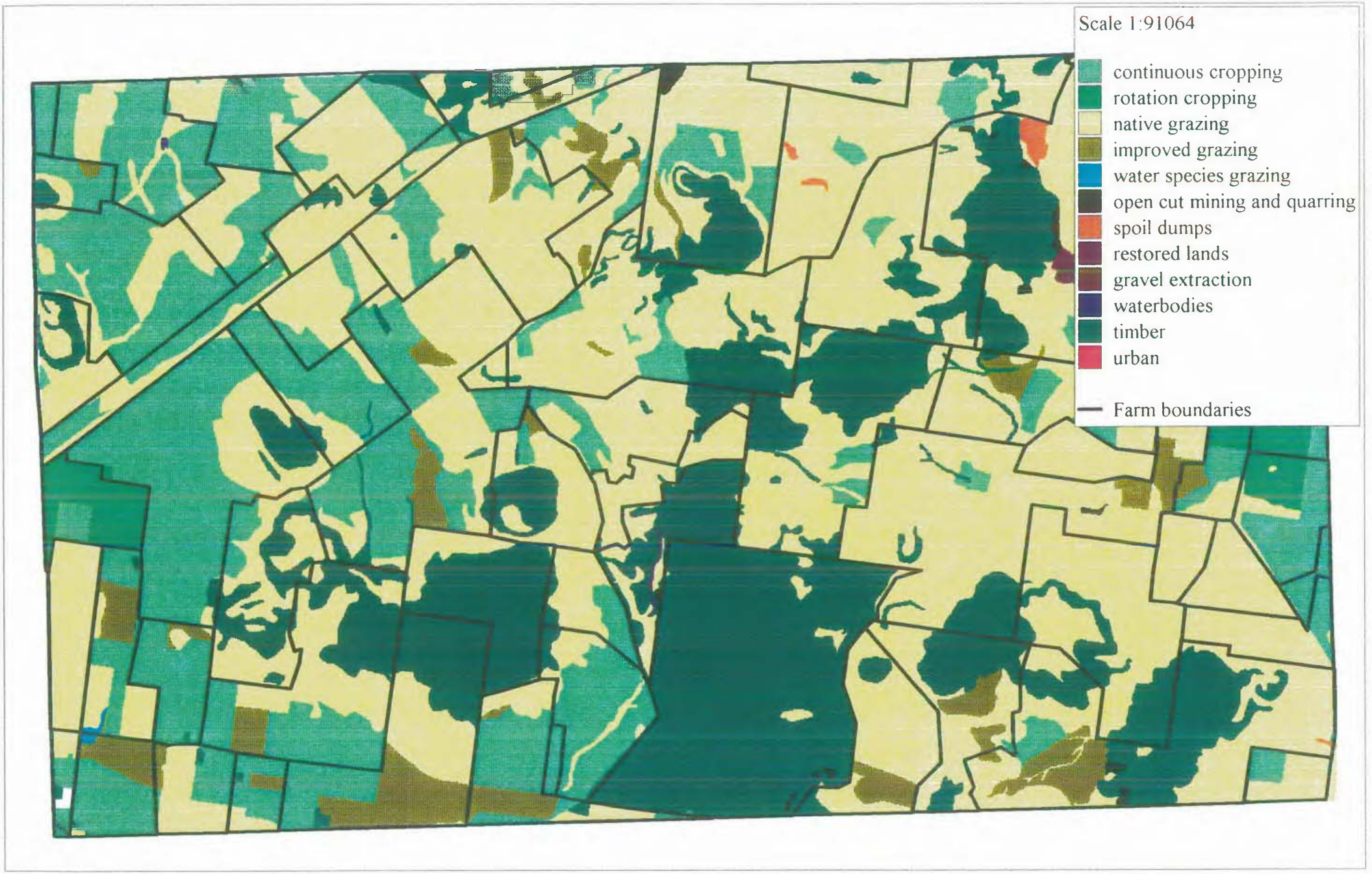

Figure 5.2

Land-use types in the farm survey area

Table 5.4

Land-use types in the farm survey area

Land-use classification	Area (ha)	% of total
Continuous cropping	7430.1	22.4
Rotation cropping	599.7	1.8
Native grazing	16 387.1	49.5
Improved grazing	1436.6	4.3
Water species grazing	11.4	0.0
Open cut mining	81.2	0.2
Spoil dumps	49.2	0.1
Restored lands	34.9	0.1
Gravel extraction	37.0	0.1
Waterbodies	9.7	0.0
Timber	7009.9	21.2
Urban	9.9	0.0
TOTAL	33 096.8	100.0

Source: NSW Department of Land and Water Conservation GIS data.

5.4.1 Survey data

The initial intention was to gather paddock-level information from as many farms as possible in the study area. In the event, it became evident that most landholders were unable to provide this information due to a lack of detailed records at this level. Neff, Garcia and Nelson (1993) observe in their research that while landholders keep yield and crop area records, input quantity use is less often recorded or reported. Two landholders from adjoining farms were approached to provide information regarding agricultural production activities from individual paddocks on their farms. These farmers were progressive in terms of their management skills; however, they still had difficulty in providing some of the required information, because they lacked detailed paddock records. Estimates collected through the survey were based on the 1992-93 season. Due to the confidential nature of the information, the specific data collected is not presented. The total area of the paddock (AREA) was measured in hectares, and the predominant land use undertaken in each paddock was also recorded (LAND USE). Productivity was measured in terms of gross value of agricultural output (GVAP), with the number of stock (STOCK) and tonnes of grain (TGRAIN) also recorded per paddock. Data on number of hours of labour per paddock (LABOUR) were also collected, as was the tonnes of fertiliser (TFERT) litres of chemicals applied (CHEM) and presence or absence of soil conservation (CONS) was also recorded (1=yes/0=no). The information that proved to be most difficult for the landholders to provide was pasture output and labour.

5.4.2 GIS data

(a) Land degradation data

Degradation data for paddock-level analysis came from the same source as at the farm level. Information was extracted for each paddock, as it was for farms, by using an overlay of the paddock boundaries on top of the existing GIS data. As with the farm data, the GIS area measurements for each erosion classification were converted to t/ha/year estimates.

The degradation variables from the GIS are defined for the paddock analysis as follows.

SUMTON = the total amount of sheet and rill erosion per paddock in tonnes.

(b) Bio-physical and land-management data

As with the farm data, the following data were extracted from the GIS as average values per paddock slope (SLOPE) in degrees area under cropping (CROP), pasture (PAST), improved pasture (IMP) and trees (TREES) in hectares, and the presence or absence (1=present/0=absent) of red brown earth (RBE), skeletal soil (SKEL) and euchrozem (EUCH). The TREES variable was also converted to a proportional measurement by dividing the area of trees by the total area of the paddock (PROP TREES). For all defined variables, the logarithmic transformations will be specified by the prefix L and the per hectare transformations will be specified by the prefix HA.

5.4.3 Cost data

Cost data obtained from DLWC staff a Gunnedah for the farm-level analysis was also valid information for application at the paddock level.

5.5 Summary

New South Wales is the only State in Australia with systematically collected land-degradation data. The Soil Conservation Service of New South Wales Land Degradation Survey collected statewide information on the extent and severity of ten different degradation types for 1987-88. These data can be aggregated to the scale of Local Government Area, thus allowing analysis with LGAs as the unit of measurement. Agricultural data at the regional scale is available for each LGA in the form of the ABS Annual Agricultural Census, which collects information on the value and volume of farm inputs and outputs. An average was taken of three years of data to coincide with the timing of the Land Degradation Survey. Cost data necessary for the conservation measures of each LGA was provided by district Soil Conservation officers from various parts of the State.

Data collection through landholder surveys proved to be more fruitful at the farm than the paddock level. An area near Gunnedah was chosen to apply the general method at the farm and paddock scale. Personal interviews were conducted with 31 landholders, from which information on inputs and outputs to production for individual properties in a given financial year was gained. Data on a number of management factors were also recorded.

Using an overlay of property boundaries on GIS data, bio-physical information was determined for each farm. These bio-physical attributes included slope, terrain, land use, timber, erosion, soil type, and soil-erosion-control earthworks.

The initial intention was to gather paddock-level information from as many farms as possible on the map sheet. It became evident that most landholders would be unable to provide this information due to a lack of detailed records at this level. Two landholders from adjoining farms were able to provide information regarding agricultural production activities from individual paddocks on their farms. Information was extracted for each paddock, as it was for farms, by using an overlay of the paddock boundaries on top of the existing GIS data.

The general method of analysis will now be applied at the regional level in Chapter 6.