THE USE OF THE SOILOSS PROGRAM TO PREDICT SOIL EROSION HAZARD IN THE WHITSUNDAY REGION

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Abstract
The SOILOSS program was used to predict soil loss from 112 soils in the Whitsunday region. Soil and land attribute data collected from land resource surveys are used to predict soil erosion under five land uses, bare cultivated ground, ground with a 50 % cover of pasture, a crop of ¾ mature planted sugarcane, a crop of ¾ mature ratoon sugarcane with and without surface mulch. The program proved useful in determining relative amounts of soil loss from various soils under standardised conditions. Using SOILOSS, rates of erosion can be compared for various land management practices and topographic conditions. The program and model reinforce the role of vegetation on stabilising the soil surface and reducing water runoff velocity. Though the estimated soil loss rates have not been verified in field trials, the data compare favourably to trials conducted elsewhere in Queensland. The estimated soil loss data for the Whitsunday region (330000 ha) were incorporated into a GIS and mapped. The data can be used by natural resource management organisations to calculate sediment budgets, identify areas at risk to land degradation and assist with setting water quality targets.

Additional Keywords: soil, erosion modelling, soil mapping.

Introduction
Soil erosion is a natural process that can be accelerated by land clearing. The main factors which contribute to erosion are soil erodibility, slope length, slope steepness, rainfall intensity, land cover and land practices (Wischmeier and Smith, 1978). In 1976, the Queensland Department of Primary industries estimated that 1.9 million of the 2.8 million hectares of agricultural land in Queensland was affected by soil erosion (QDPI, 1978). Currently, it is estimated that 80% of the 3.3 million hectares of cultivated land in Queensland is affected by water erosion (QEPA, 1999).

The most common method of determining actual soil loss is by using field plots. The New South Wales Department of Land and Water Management have over 4500 plot - years of soil loss data which spans over 30 years (Edwards, 1987). Studies have shown that soil erosion can be dramatically increased under some land uses and land management practises. Prove (1984) conducted soil loss studies on cultivated soils on sloping caneland areas in north Queensland and demonstrated that during the 1980 – 1981 wet season, rates of soil erosion reached 380 t/ha/year. Freebairn and Wockner (1986) conducted field trials on black earths in the Toowoomba area in Queensland. This study found that in paddocks not protected by stubble, the rates of soil loss ranged between 29 – 62 t/ha for a rain event. Soil loss from pineapple fields in south east Queensland occurred at a rate of 7 to 36 t ha^{-1} yr^{-1} (Capelin and Troung, 1985). These losses are considerable when compared against estimated soil formation rates of approximately 1 t/ha/yr depending on climate, lithology and flooding (Edwards, 1991).

From plot trials, soil loss models have been developed. One of the most common soil erosion model is the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). The New South Wales Department of Land and Water Management have modified the USLE for Australian conditions. The SOILOSS program incorporates these modifications and is used by the NSW DLWM to predict soil loss under various climates and cropping systems (Rosewell, 1993).

The aim of this study is to use the SOILOSS program to predict the rates of soil erosion from soils mapped in the Whitsunday region, central Queensland (330000 ha). The program will be used to estimate the amount of soil erosion from five land uses in Central Queensland. The study will develop a soil loss rating scheme to reflect the soil erosion hazard of the soils. This information could then be used to make general comparisons of soil loss rates between soil types and land management practices.

Materials and Methods
Soil mapping has been conducted in the Whitsunday region at a scale of 1:50000 using a free survey technique and covering 330000 ha. The survey identified 112 soil profile classes (SPC) and variants. Surface and subsoil samples were routinely collected during the land resource surveys.

The predicted soil erosion of each soil under five different land uses is estimated using SOILOSS. The five land uses are ploughed bare ground, pasture with 50 % cover, a crop of ¾ mature planted sugarcane, a crop of ¾ mature ratoon sugarcane, with and without surface mulch. The SOILOSS program requires inputs for the USLE in order to estimate soil loss. Using the USLE, soil loss can be expressed by:

$$A = R \times K \times (L \times S) \times C \times P$$

The SOILOSS program allows the user to define the slope steepness (S), slope length (L), rainfall erosivity factor (R), crop cover (C), soil erodibility (K) and land management practices (P). The study will use a standardised plot size of 50m in length. This length was chosen so that comparisons of soil loss can be made between hill slope soils and floodplain soils. The average slope values for each soil will be based on field observations. The slope for the floodplain Vertosols (Hapusterts, Soil Survey Staff, 1991) will be fixed at 0.5 %, other alluvial soils will be 1 % and soils of the uplands will range from 2 to 15 %.

SOILOSS allows the use of laboratory derived data for soils to calculate soil erodibility. The particle size analysis of soil samples collected from the land resource surveys will be used to estimate the K value for the program.

The rainfall erosivity value for Mackay is approximately 1141 t m $(ha.cm)^{-1}$ (Rosenthal and White, 1980). This value is based on 16 years of rainfall data with a mean annual rainfall for this period of 1678 mm. To convert this value to SI units which is used by SOILOSS, the 1141 value is multiplied by 9.8 (Rosewell, 1993). The rainfall erosivity value for the Mackay area is therefore 11181. However, the rainfall erosivity value depicted in Rosewell (1993) for the Proserpine - Mackay area is a more conservative 9000. This study will only assess the soil loss during the summer months of December, January and February, which account for 61 % of the annual rainfall (Rosenthal and White, 1980). For the purpose of this study the R value for the study will be: 9000 x 0.61 = 5490. The rainfall erosivity value described by Rosewell (1993) will be used because it is a more recent value. The ten classes used to map predicted soil loss will be based on the scheme used by East *et al*. (1998) but expanded. The soil loss scheme classes are shown in table 2. Each soil will have a soil loss hazard rating for each land condition for the three month period.

Table 1. Summary of USLE inputs

Landuse	R	K	L	S	C	P
Bare ground	5490	Soil specific data	50 m	Soil specific data	0.45	> 75 mm
Pasture 50% cover	5490	Soil specific data	50 m	Soil specific data	0.07	> 75 mm
¾ planted sugarcane	5490	Soil specific data	50 m	Soil specific data	0.26	> 75 mm
¾ ratoon sugarcane – no mulch	5490	Soil specific data	50 m	Soil specific data	0.21	> 75 mm
¾ ratoon sugarcane – with mulch	5490	Soil specific data	50 m	Soil specific data	0.08	> 75 mm

Table 2. The soil loss classes

Class	Rates of erosion t ha^{-1} per 3 months	Rating
1	0-10	Very low
2	11-15	Low
3	16-20	
4	21-25	Moderate
5	26-30	
6	31-50	High
7	51-70	
8	71-100	
9	101-200	Very high
10	201-400	Extreme

Results and Discussion

The application of the SOILOSS program using five land use conditions reinforces the impact of land clearing in the wet tropics during the summer months, and the role of ground cover in reducing erosion. The SOILOSS program has been used to predict soil loss from 112 soils in the Whitsunday area. The results from the study show that soil loss rates vary depending upon the soil properties and site conditions such as slope, and ground cover. When Black and Grey Vertosol soils (Hapulusterts, Soil survey Staff, 1992) formed on alluvial floodplains with slopes of 0.5 % and devoid of vegetation during summer, soil loss rates of 4 and 10 t ha^{-1} can be expected. With a 50 % ground cover of grass on the clay soils, the soil loss rates drop to 1 to 3 t ha^{-1}. If the clay soils have a ¾ mature crop of sugarcane then the soil loss rates drop to 0.8 to 1.8 t/ha over the summer months. These soil loss results however do not take into account any deposition from flood events during the summer months. It is likely that the addition of material from minor low velocity flood waters would off-set the soil loss rates from the Vertosol soils.

The soil loss rates from Sodosol soils (Natraqualfs, Soil survey Staff, 1992) formed on floodplains were found to vary depending on subsoil permeability and surface texture. In general, the more silty the topsoil the higher the rate of estimated soil loss. The Sodosols with a silty topsoil and a slope of 1.5 % were found to have predicted soil loss rates of 17 to 25 t ha^{-1} when cleared during the summer months. When a ¾ crop of sugarcane is pre-existing during the summer months on Sodosols, the rate of soil loss range from 1.8 to 2.9 t ha^{-1}.

The soils with the lowest rate of soil loss are the rapidly drained, deep, levee soils. These stratic Rudosols (Aquiustifluvents, Soil survey Staff, 1992) have a predicted soil loss rate of 2.2 t ha^{-1} on bare ground, 0.5 t ha^{-1} with a 50 % cover of grass and 0.4 t ha^{-1} with a ¾ mature crop of sugarcane where the slope is 1 %.

The soil loss rates of Brown Dermosols (kandihumults or kandiustults, Soil survey Staff, 1992) formed on Andesite with 15 % slopes were 248 t ha^{-1} to over 450 t ha^{-1} when cleared during the summer months. These rates are very similar to those calculated by Glanville *et al.* (1997) using the WEPP model. When a crop of sugarcane is grown on the Brown Dermosols during the summer months the rates of soil loss are still unsustainable at 23 to 50 t ha^{-1}. The predicted soil loss from a Dermosol in the Whitsunday's with a 5 % slope and no ground cover was 36 t ha^{-1} over the three summer months. The shallow sandy Rudosols developed on 15 % slopes on rhyolite or sandstone have soil loss rates between 330 and 390 t/ha for bare ground during the summer months.

The SOILOSS program has allowed an analysis of the value of sugarcane mulch in reducing soil erosion. On a brown Dermosol with a 5% slope, ratoon sugarcane can expect soil loss in the vicinity of 15 t ha^{-1} per 3 months, but with 50% surface mulch the rate of erosion is reduced to 5.7 t ha^{-1} per 3 months. Table 3 shows an extract of the data generated from the study and a comparison of the land uses and soil loss rates.

Table 3. An extract of the soil loss data for soil profile classes against land use

Soil code	Soil profile class	Slope %	Soil-loss-bare t ha^{-1}	soil-loss-pasture t ha^{-1}	Plant cane t ha^{-1}	Ratoon No mulch t ha^{-1}	Ratoon mulch t ha^{-1}
Ab	Albert	1.5	24	3.6	12	8.9	3.4
Ad	Andromache	1	15	1.8	8	7.2	2.5
Am	Ameliavale	1	9.4	1.4	4.5	3.3	1.3
An2	Andergrove (var)	2	18	1.4	5	4	1.2
Bb	Balbera	3	28	4.5	18	13	4.8
Bc	Billy creek	1.5	15	2.3	6.9	5.1	1.9

The data determined in this study have been incorporated into a GIS and mapped for the Whitsunday region (330000 ha). The soil loss data can be used to identify areas susceptible to high rates of soil loss and can also be used to estimate the amounts of soil loss in catchments by linking it to land use and ground cover. The estimation of catchment and sub-catchment soil loss could be useful for water quality studies. One possible application is the estimation of soil loss in the catchment divided by the catchment area to determine the average soil loss per hectare. These calculations could prove useful in identifying the catchments which contribute the majority of sediment to waterways. This soil loss data will also be valuable for inclusion into more recent multivariate models such as SEDNET.

Conclusions

The SOILOSS program has enabled a comparison of erosion rates for 112 soil types which cover 330000 ha under five land uses. The program has reinforced the role of ground cover on reducing soil erosion and can be used to support agricultural best practises such as the retention of surface mulch on sugarcane fields for soil protection purposes. The results from the study are comparable to results derived from plot experiments in other parts of Queensland. SOILOSS can provide soil erosion information that is useful for agricultural and urban land use planning.

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