REGIONAL EROSION RISK ASSESSMENT IN AREAS OF SHRUB ENCROACHMENT IN CENTRAL WEST AND WESTERN NSW

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ABSTRACT
Soil erosion in the rangelands in Central West and Western New South Wales has been associated with shrub encroachment due to shrubs out-competing herbage and reducing live understorey plant cover. While efforts are currently being made to map soil erosion rates in Australia, little research has been undertaken into the link between shrub encroachment and soil erosion at a regional level. This work reports on preliminary results regarding the integration of the RUSLE (Revised Universal Soil Loss Equation) into a GIS to represent the erosion controlling factors and to develop an erosion risk map in Central West and Western NSW.

INTRODUCTION
Across large areas of central and western NSW, the encroachment of dense stands of woody native species onto previously more open landscapes has become a significant management issue. This encroachment involves a wide range of native tree and shrub species and has been referred to as Invasive Native Scrub (INS) (Environmental Outcomes assessment Methodology, Native Vegetation Regulation 2005). The causal factors contributing to this encroachment have been much debated and include changes in the area of land under active management, variations in grazing pressure from domestic, feral and native animals, change in fire regimes, changes in grass competitive ability, specific climatic events (flood, drought etc.), climate change and combinations of these factors (Milton *et al.* 1994). Encroachment has frequently been associated with land degradation, particularly reduced groundcover, and increased runoff and soil erosion. For example, studies in the USA (Davenport *et al.* 1998), South America (Parizek *et al.* 2002) and Australia (Johns 1983) report associations between shrub encroachment and an increase in runoff and soil erosion. The shrub encroachment issue is recognised as important by government and by the community. Research is underway across the region to understand the relationships between INS and soil erosion in order to inform best management principles.
Field methods for quantifying soil loss have limitations in terms of cost and representativeness. An alternative approach in large areas is the integration of the factors influencing soil erosion in a Geographic Information System (GIS) to produce a spatially explicit model of erosion risk. Identification of areas prone to water erosion will help prioritise areas for scrub management. The Revised Universal Soil Loss Equation (RUSLE) has been used widely to assess soil erosion. The RUSLE was derived from plot data in the USA and integrate soil properties, topography, rainfall and vegetation cover. The RUSLE has also been used in combination with GIS to assess soil erosion risk across large areas (Fistikoglu and Harmancioglu 2002; Onyando *et al.* 2005; Svorin 2003).
Efforts have been made to map soil erosion rates across Australia (Rosewell 1997; Lu *et al.* 2003), however little research has been undertaken into the link between scrub encroachment and soil erosion at a regional level. This work reports preliminary results regarding the integration of the RUSLE into a GIS to represent the erosion controlling factors and to develop an erosion risk map for Central West and Western NSW.

METHODS

Study area

The Cobar Pediplain occupies an area of 73,500 km^2 within the semi-arid area of New South Wales with rainfall ranging from 260 to 500 mm (Figure 1). The main land systems within the study area are the Cobar, Ironstone, and Kopyje land systems (Walker 1991), which comprise generally gently undulating plateau elements sometimes sharply incised by narrow valleys and slightly convex plains of red earths (Kandosols) (Bureau of Rural Sciences 1991). INS is dominated by *Acacia aneura*, *Eucalyptus populnea*, *Eucalyptus intertexta* and *Callitris glaucophylla* (New South Wales Department of Environment and Climate Change 2008).

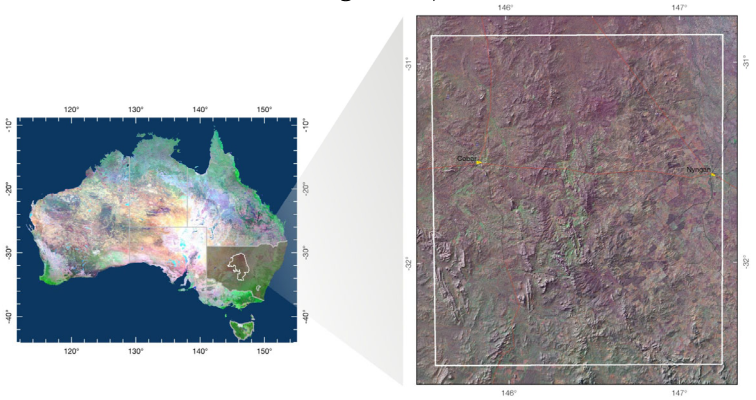

Figure 1. Location of the study area within the Cobar Pediplain Bioregion

Integration of RUSLE into a GIS

The RUSLE integrates the main factors controlling soil erosion to produce an estimate of rainstorm based sheet and rill erosion. A separate approach is being developed to account for gully erosion risk since RUSLE does not predict gully erosion rates. Each factor was mapped and integrated into a raster-based GIS in order to produce the annual soil loss estimation as a function of (Renard, *et al.* 1996):

$$A = R * K * LS * C * P$$

Where A is the average annual soil loss (t/ha/yr); R is a measure of the erosive forces of rainfall and runoff; K is the soil erodibility factor; L is the length factor; S is the slope steepness factor; C is a vegetation cover factor, and P is the conservation practice factor.

The R factor consists of the sum of individual storm kinetic energy values of maximum 30 min intensities for a year and was computed by using the model developed by Yu and Rosewell (1996). This model predicts R based on an empirical relationship between R-factor calculated using pluviograph rainfall data and daily rainfall amount (Figure 2a).

Soil erodibility is defined as the resistance of the soil to both detachment and transport and varies with soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical content (Morgan 2005). The K factor was estimated by combining published K values from the Australian Soil Resource Information System (Figure 2b) and the surface geology layer from Geoscience Australia.

Erosion increases with slope steepness and length as a result of respective increases in velocity and volume of surface runoff (Morgan 2005). The LS factor was computed by applying the Unit Stream Power Theory (Moore and Burch 1986) to a Digital Elevation Model acquired by the Shuttle Radar Topographic Mission (Figure 2c).

Vegetation acts as a protective layer between the atmosphere and the soil. Groundcover elements such as leaves, stems, forbs, grasses and litter absorb some of the raindrop energy and running water so that less is directed at the soil. The C factor in RUSLE comprises canopy cover and height, and groundcover proportion. These data, however, are not available for the study area. In order to provide an estimate of these factors, the Normalised Difference Vegetation Index (NDVI) from SPOT imagery and vegetation maps were used to classify vegetation and C values (Figure 2 d) were assigned from published data (Rosewell 1997).

RESULTS AND DISCUSSION

The preliminary spatial distribution of erosion risk is shown in Figure 2e, and the sensitivity of each raster cell with respect to parameters affecting soil erosion can be observed. The integration of erosion factors through RUSLE shows that topography plays an important role in determining soil erosion risk. In this semi-arid pediplain environment, which is generally gentle slopes, sediment transport capacity is relatively low, and individual soil redistribution and deposition events are probably restricted to the landscape scale. Estimated annual soil erosion rates are from 0 to 5 t/ha/yr. These erosion rates agree with those estimated by Lu *et al.* (2003) who applied the RUSLE nationally. While these values are not great in comparison to annual erosion estimates in cropping and tropical areas (Edwards and Zierholz 2000), the cumulative impact of erosion towards the upper limit of the estimated range would have serious consequences over just a few years. Soil nutrients are concentrated in these infertile soils mainly in the top first 35 mm (Greene and Tongway 1989). Given a bulk density of 1.5 g/cm^3 (Greene and Tongway 1989), an annual loss of 5 t/ha corresponds with superficial soil loss of about 0.33 mm/yr. The natural rates of soil formation in semi-arid areas are likely to be only of the order less than 0.5 t/ha/yr (Edwards and Zierholz 2000).

Validation of the erosion risk map is being underway by means of a regional survey of erosion features throughout the study area. In addition, a more detailed estimation of the *C* factor in shrub encroachment areas is being developed in order to account for the effect of shrub encroachment on groundcover.

The results are likely to reflect closely the real erosion risk and can be used for identifying areas at risk of water erosion, help determine the spatial link between erosion and scrub encroachment and prioritise areas for invasive shrub management.

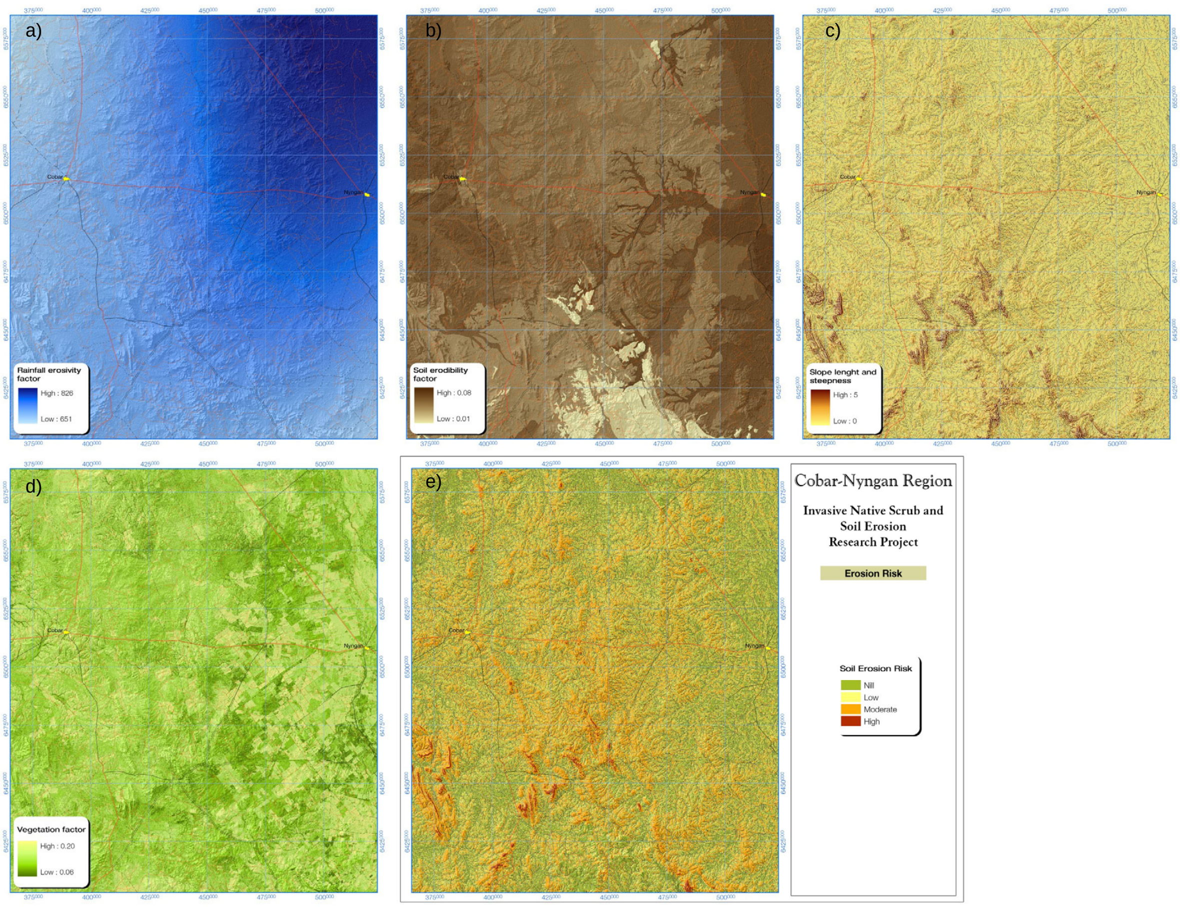

Figure 2. Spatial distribution of the RUSLE factors and the erosion risk map; a) Rainfall erosivity; b) Soil erodibility; c) Slope length and steepness; d) Vegetation factor; e) Erosion risk

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