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A method for using WEPS to map wind erosion risk of Alberta soils

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Abstract

Alberta has 27 million hectares of agricultural land, a significant portion of which is at risk to wind erosion. Combining recently completed provincial digital soils maps (Agricultural Region of Alberta Soil Inventory Database—AGRASID) with geographically referenced spatial weather data and land management descriptions (crop rotations plus cultivation practice) provided an opportunity to evaluate, using the Wind Erosion Prediction System (WEPS) model, wind erosion risk on soils/land in the dominantly agricultural portion of Alberta. Since WEPS is a point model, it requires comparatively specific environmental and management information. We used a quarter section (65 ha) as a typical situation for a WEPS estimation. Using these data, the erosion risk for each of the 28,000 AGRASID polygons in Alberta was obtained by the sum of the separate contributions of each soil–management–climate combination. The WEPS model with appropriate databases provides a means to make more spatially explicit, and hopefully more accurate, assessments of wind erosion risks as affected by changing agricultural management.

Keywords: Extrapolation procedure; Wind erosion risk; Risk modeling; Risk mapping

Software availability

Name of software: WEPS (Wind Erosion Prediction System), version WEPS 1.0
Developer: USDA-ARS, Wind Erosion Research Unit, Manhattan, KS 66506, USA. E-mail: office@weru.ksu.edu (verified 16 September 2002)
Minimum hardware required: 128 MHz Pentium, 100 MB free disk space on hard drive, with Windows 95/98 (48 MB RAM); Windows NT (64 MB RAM); Windows 2000 (192 MB RAM)
Hardware used: various computers
Program language: various (Wind Erosion Research Unit, 2001)
Program size: 24 MB
Availability and cost: contact office@weru.ksu.edu and http://www.weru.ksu.edu/ (verified by G.M. Coen, 16 September 2002)

1. Introduction

Alberta has 27 million hectares of dominantly agricultural land (Fig. 1), a significant portion of which is at risk to wind erosion. The recent availability of Agricultural Region of Alberta Soil Inventory Database (AGRASID), a seamless, standardized digital soil map at a scale of 1:100,000 (CAESA Soil Inventory Working Group, 1999) and daily, geographically referenced spatial weather data (Shen et al., 2001) provides data for detailed environmental assessments. The Wind Erosion Prediction System (WEPS) is a process-based, continuous daily time step model (Skidmore and Tatarko, 1999), which has the ability to predict erosion events in

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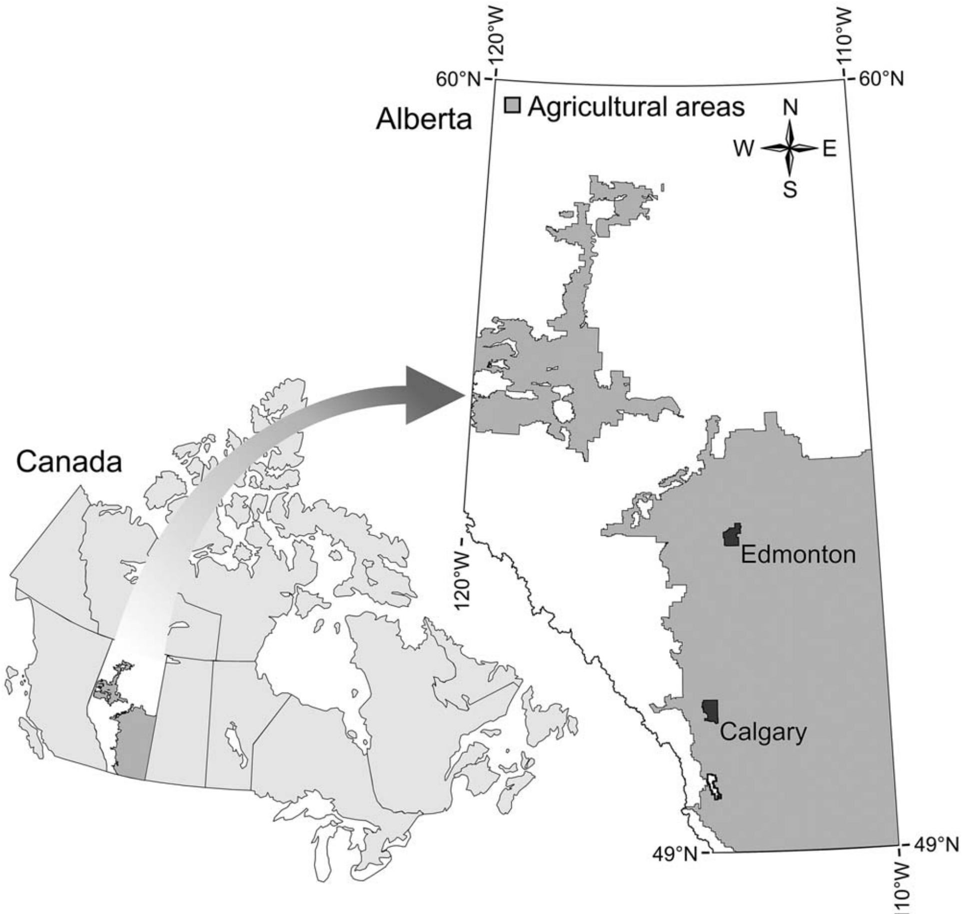

Fig. 1. Location of the agricultural portion of Alberta.

response to environmental and management variations. The beta version we used has been based on research on soil and residue decomposition relationships (Retta et al., 2001; Zobeck, 1991) studied over the past 60 years. A recent validation study (Hagen, 2001) found the WEPS model simulated data recorded from an instrumented test plot with reasonable agreement (R^2 = 0.65). There is no published research testing WEPS under Alberta conditions. However, the model is based on fundamental relationships and we feel that it will fairly represent wind erosion susceptibility ranking of AGRASID. The objective of this study is to develop a method to use available databases and the WEPS model to assess the inherent susceptibility of Alberta agricultural soils to wind erosion risk and the degree of exposure of Alberta soils under current management.

2. Materials and methods

Weather data were obtained by interpolating daily weather data, from nearly 300 stations, to Alberta Soil Landscapes of Canada Polygons (Shen et al., 2001; Soil Inventory Staff, 1988). Land management data were obtained from a survey of field management practices (Dey, 2000), supplemented by interviews with specialists. Crop rotations and percentages were assigned to Ecodistrict polygons ("Ecodistricts are subdivisions of ecoregions and are characterized by distinctive assemblages of landform, relief, surficial geologic material, soil, water bodies, vegetation and land use."—Ecological Stratification Working Group, 1995) after being reviewed by regional specialists. Soils data were developed from AGRASID soil layer files supplemented by relationships derived from the Alberta pedon database.

All files were formatted to meet the requirements of WEPS. Each AGRASID polygon was assigned the same weather as was assigned to the Soil Landscapes of Canada and the same management as was assigned to the Ecodistrict polygon where the AGRASID polygon centroid was located. We used a quarter section (65 ha) as a typical situation for a WEPS estimation. Since shelterbelts are usually found only on field margins in most of Alberta, and the area of influence is a minor portion of a quarter section field, we chose not to include them in the specifications driving the model. Also, we chose not to assess the influence of strip cropping in this gen-

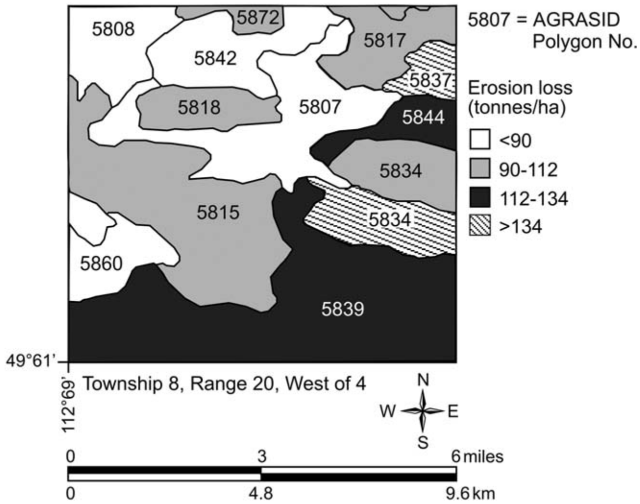

Fig. 2. Example of an erosion susceptibility map of a Township (9.6 km × 9.6 km) in Southern Alberta, Canada.

eralized consideration. Erosion predictions for each unique soil–management–weather combination were made using a batch procedure from the WEPS command line. The total erosion attributed to each soil–management–weather combination was apportioned to the AGRASID polygon to estimate a mean loss per unit area in the polygon. These values were then used to rank the erosion susceptibility of each polygon (Figs. 2 and 3).

3. Results and discussion

The WEPS 1.0 beta 8.0 release can only estimate erosion losses on a relatively homogeneous area, rectangular in shape and for a single soil type and land use. For this study, a quarter section (65 ha) was chosen as the type situation for a WEPS run. In order to derive an estimation of erosion for an entire AGRASID polygon, it was necessary to run WEPS for each common cultivated soil–management–weather combination and sum their respective contributions. For the batch runs, a 30(±)-year simulation was used. Two sites, one near Lethbridge where wind erosion risk is high and another near Edmonton where wind erosion risk is low, are presented as examples (Tables 1 and 2). Total wind erosion rates were estimated for each combination of soil, management and weather. These rates were then multiplied by the area of the portion of the AGRASID polygon represented by that combination resulting in an estimation of the annual erosion loss associated with a given soil–management–weather combination. The annual wind erosion loss for the polygon was determined by summing the contribution from each soil–management–weather combination. Then by dividing this total by the cultivated area of the polygon, a combined annual rate of wind erosion per unit area was estimated for each of the 28,000 AGRASID polygons. As an example of a possible mapping procedure, the average soil loss in each polygon was then grouped into internally relative erosion risk classes (Figs. 2 and 3).

WEPS is an example of a point model that provides fairly specific information given uniform environmental and management scenarios. The methodology described here provides a procedure to extrapolate point results to more complex soil landscapes. The version of WEPS we used does not consider landform shape (slope and curvature) but the soil data carry an implied landform position, so that soils from different portions of the landscape are included. The resulting spatial representation is appropriate to be displayed at a map scale of 1:100,000. The format of the AGRASID database (Soil Landscapes of Canada database is comparable) is fairly easy to modify to match the input requirements of WEPS. Some data required by WEPS are not part of these databases and must be derived from various other databases and relationships. The daily weather database was prepared specifically to meet the requirements of WEPS. Now that the databases are in place, the methodology will allow relatively easy temporal comparison of management practices used in the future with those used at present or with past management procedures, thereby providing an opportunity to evaluate environmental sustainability. It will also allow a more spatially precise evaluation of the inherent wind erosion susceptibility of Alberta soils than previously published (Coote and Pettapiece, 1989; Padbury and Stushnoff, 2000).

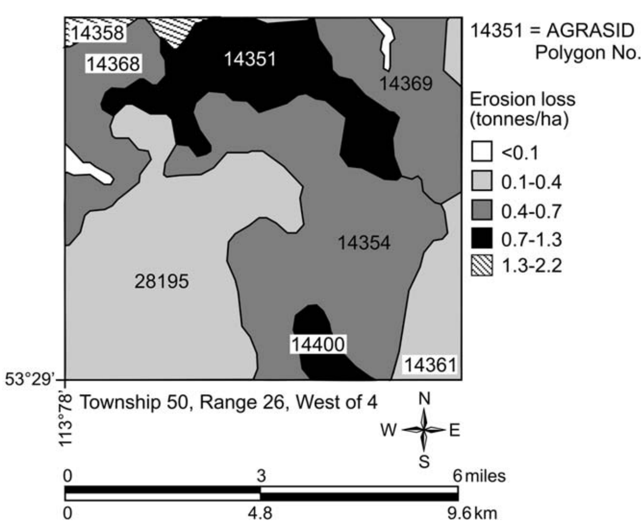

Fig. 3. Example of an erosion susceptibility map of a Township (9.6 km × 9.6 km) in Central Alberta, Canada.

4. Conclusion

1. We have developed a procedure to use the available databases for soils, weather and land management with the WEPS model to spatially evaluate inherent wind erosion risk of Alberta soils.

Table 1
Example of a calculation of predicted annual soil loss for one AGRASID polygon in southern Alberta based on the sum of losses from each soil–management–weather combination

AGRASID polygon number	Polygon area (ha)	Cult[a] (%)	Soil[b]		Crop rotation		Soil surface texture class	Erosion loss[c] (tonnes/ha)	Total soil loss for cult area[d] (tonnes)	Mean loss for cult. area[e] (tonnes/ha)
			Symbol	(%)	Symbol[f]	(%)				
5807	1263	72	KSR	30	pwcb	50	SL	11	1825	
5807	1263	72	KSR	30	wfcb	50	SL	132	22470	
5807	1263	72	LET	30	pwcb	50	L	7	1103	
5807	1263	72	LET	30	wfcb	50	L	149	25208	
5807	1263	72	OAS	10	pwcb	50	L	6	317	
5807	1263	72	OAS	10	wfcb	50	L	122	6894	
5807	1263	72	RDM	10	pwcb	50	SiL	28	1610	
5807	1263	72	RDM	10	wfcb	50	SiL	286	16184	
5807	1263	72	ZERzdb	10	pwcb	50	CL	na[g]	na	
5807	1263	72	ZERzdb	10	wfcb	50	CL	na	na	
5807	1263	72	ZGW	10	pwcb	50	L	na	na	
5807	1263	72	ZGW	10	pwcb	50	L	na	na	
Mean annual erosion of a polygon										84

[a] Cult % is the portion of an AGRASID polygon that was cultivated in 1996.
[b] Soil symbols beginning with a "Z" were considered to belong to the uncultivated portion of the polygon.
[c] Rate of erosion on the portion of the polygon where the given soil/crop rotation occurs.
[d] Total estimated soil loss associated with the soil/crop rotation combination in the selected AGRASID polygon.
[e] The mean erosion rate for the cultivated potion of the AGRASID polygon.
[f] Crop rotation symbol: pwcb = peas/wheat/canola/barley, wfcb = wheat/fallow/canola/ barley.
[g] na—not applicable—erosion considered negligible where perennial vegetation is in place.

Table 2
Example of a calculation of predicted annual soil loss for one AGRASID polygon in Central Alberta based on the sum of losses from each soil–management–weather combination.

AGRASID polygon number	Polygon area (ha)	Cult[a] (%)	Soil[b]		Crop rotation		Soil surface texture class	Erosion loss[c] (tonnes/ha)	Total soil loss for cult area[d] (tonnes)	Mean loss for cult. area[e] (tonnes/ha)
			Symbol	(%)	Symbol[f]	(%)				
14351	1261	84	AGS	10	bcp	20	L	0	0	
14351	1261	84	AGS	10	cbw	80	L	2	2330	
14351	1261	84	HBM	60	bcp	20	L	0	0	
14351	1261	84	HBM	60	cbw	80	L	1	381	
14351	1261	84	POK	20	bcp	20	L	0	0	
14351	1261	84	POK	20	cbw	80	L	1	127	
14351	1261	84	ZGW	10	bcp	20	L	na[g]	na	
14351	1261	84	ZGW	10	cbw	80	L	na	na	
Mean annual erosion of a polygon										0.7

[a] Cult % is the portion of an AGRASID polygon that was cultivated in 1996.
[b] Soil symbols beginning with a "Z" were considered to belong to the uncultivated portion of the polygon.
[c] Rate of erosion on the portion of the polygon where the given soil/crop rotation occurs.
[d] Total estimated soil loss associated with the soil/crop rotation combination in the selected AGRASID polygon.
[e] The mean erosion rate for the cultivated potion of the AGRASID polygon.
[f] Crop rotation symbol: bcp = barley/canola/peas, cbw = canola/ barley/wheat.
[g] na—not applicable—erosion considered negligible where perennial vegetation is in place.

2. By using the current management information, the degree of exposure of the soils to wind erosion risk and associated environmental sustainability can be estimated.

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