Erosion Modeling of Biofuel Cropping Systems in California Using RUSLE2: Opportunities for Sustainable Crop Adoption

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Introduction

Although emissions reductions are often the focus of biofuel crop adoption, environmental sustainability must also be prioritized. Erosion is one of the most serious concerns stemming from agriculture; in addition to removing fertile topsoil and ultimately reducing yield, it transports harmful substances (pesticides, fertilizer, sediment itself) from fields to aquatic habitat.

The uplands of California's Central Coast receive enough rainfall to sustain dry-farmed crops such as wheat and barley, and are now being evaluated for bioenergy oilseeds such as canola and Camelina. If drought continues to be a concern in California, crops with low water demand such as these will become increasingly favorable.

This study assesses the severity of erosion from oilseed production in dry-farmed, upland systems through modeling with the Revised Universal Soil Loss Equation (RUSLE2) in California's Central Coast region.

Methods

16 fields deemed representative of dry-farmed systems in the Central Coast region (see Figures 1 & 2) were selected using Google Earth. The RUSLE2 program, available from the Agricultural Research Service (USDA-ARS), was used to estimate erosion from these fields.

Inputs:

- **slope** from a 10-m ASTER Global Digital Elevation Model (GDEM, Figure 1)
- **path length** (length of slope) from Google Earth and the GDEM
- Climate data from Daymet and files built by ARS specifically for RUSLE2
- **erodibility** from SSURGO data
- **management** information (field preparation, planting harvesting, yield, etc.) from grower's guides, RUSLE internal files, and data collected by the California Biomass Collaborative.

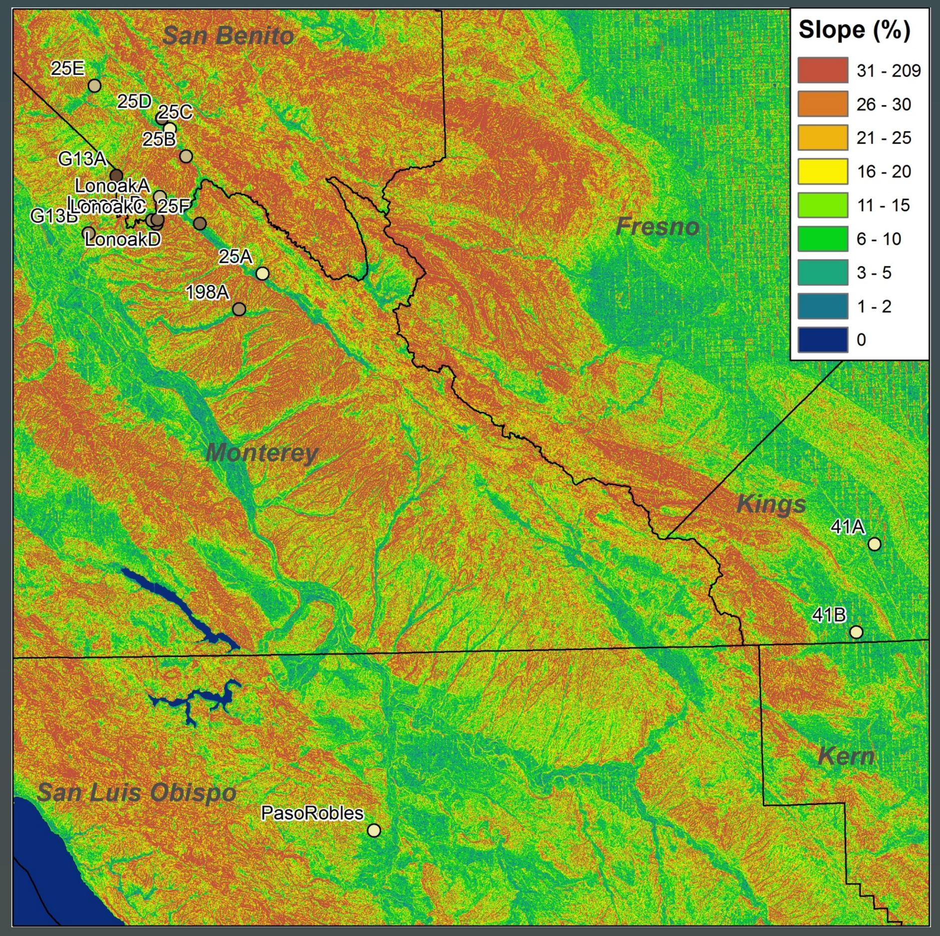

Figure 1. *Percent slope (derived from USGS LP DAAC) with modeled field points colored by erosion magnitude.*

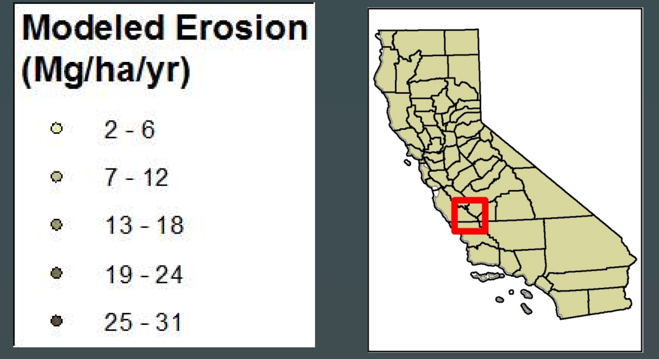

Figure 4. *Field Lonoak B, an example of a dry-farmed field in Monterey County.*

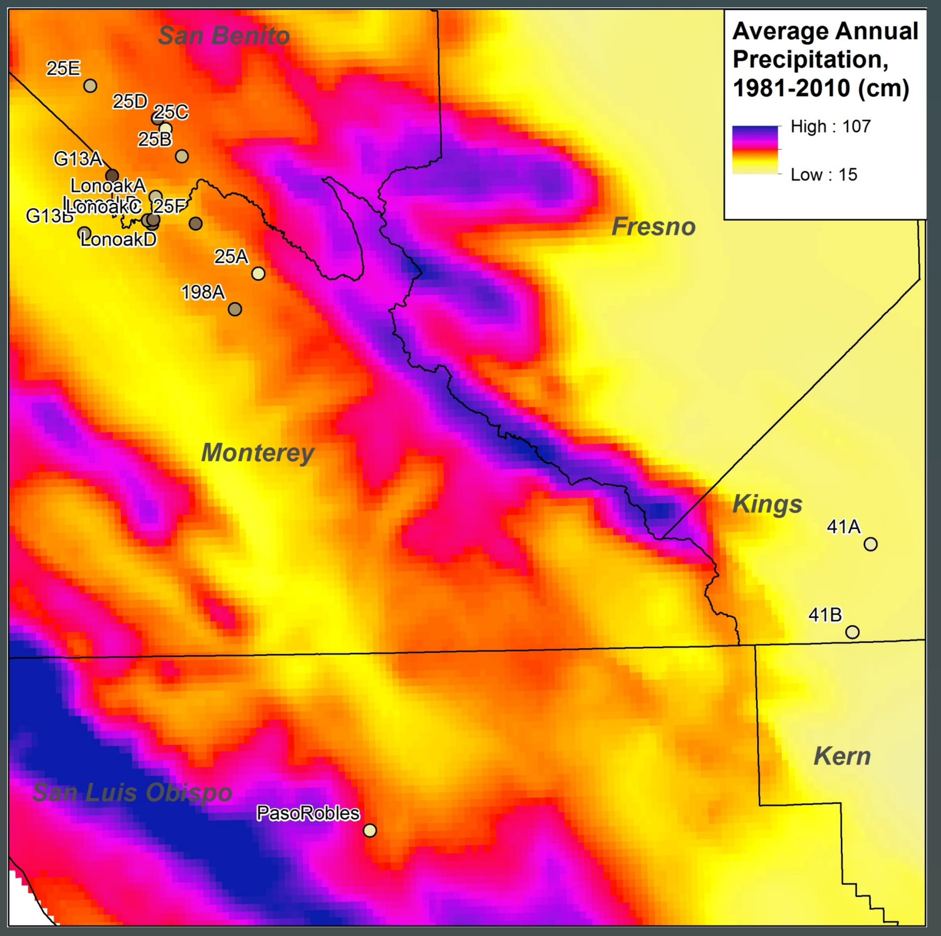

Figure 2. *Average annual precipitation in centimeters (NACSE)* with modeled field points colored by erosion magnitude.*

*separate from data input into RUSLE2

Revised Universal Soil Loss Equation:

$$a = r*k*l*S*c*p$$

where: a = net detachment (mass/unit area), r = erosivity factor (climate), k = soil erodibility factor, l = slope length factor, S = slope steepness factor, c = cover-management factor, and p = supporting practices factor (USDA-ARS). Note that in this study, no supporting practices (erosion control measures) were considered.

Results and Discussion

Biofuel crops (canola and Camelina), incumbent crops (wheat and barley), and bare soil scenarios were modeled for each field. Only scenarios for Camelina, wheat, and bare soil results are discussed here.

Model inputs are provided in Table 1. Slope ranged from 3.4 to 16.9 %. Path length ranged from 35 m to the maximum allowable input, 305 m. Average annual rainfall ranged from 25 to 51 cm.

Table 1. *RUSLE2 inputs and erosion estimates for each field.*

Field Name	Soil Type	Slope (%)	Annual Rainfall (cm)	Path Length (m)	*Modeled Erosion (Mg/ha/yr)*		
					Camelina	*Wheat*	*Bare*
198A	Silty clay loam	7	40	305	*17*	*15.7*	*80.7*
25A	Silty clay	3.4	38	305	*2.2*	*2.2*	*10.3*
25B	Loam	7.7	43	305	*7.8*	*7.2*	*35.9*
25C	Sandy loam	4.8	42	305	*2.7*	*2.5*	*12.1*
25D	Clay loam	16.9	44	305	*20.4*	*18.6*	*94.2*
25E	Silt loam	6.4	41	305	*8.5*	*7.8*	*40.4*
25F	Silty clay loam	9.4	39	274	*21.7*	*20.2*	*105.4*
41A	Loam	7.3	25	305	*4.5*	*4*	*24.7*
41B	Loam	5.7	29	305	*4.7*	*4.3*	*22.4*
G13A	Silt loam	9.7	43	305	*31.4*	*26.9*	*148*
G13B	Silt loam	8.5	36	244	*16.6*	*15*	*76.2*
Lonoak A	Sandy loam	8.8	37	274	*8.3*	*7.4*	*38.1*
Lonoak B	Silty clay loam	8.6	36	198	*14.6*	*13.2*	*67.3*
Lonoak C	Silty clay loam	9.2	38	305	*22*	*20.4*	*107.6*
Lonoak D	Silty clay loam	10	36	305	*22.4*	*21.3*	*112.1*
Paso Robles	Channery clay loam	7.8	51	35	*5.6*	*5.6*	*20.8*

RUSLE-generated erosion estimates are provided in Table 1 and visualized in Figure 3. Values under the Camelina scenario range from 2.2 to 31.4 mt per hectare per year (Mg/ha/yr), under wheat from 2.2 to 26.9 Mg/ha/yr, and under bare soil from 10.3 to 147.8 Mg/ha/yr.

In most cases, field ranks of erosion values matched across scenarios. Though Camelina showed slightly higher erosion than wheat, the difference was negligible. Camelina is a short, small-leaved plant, reaches maturity sooner , and requires less water and nutrients than canola; a less dense canopy is the cause of its slightly greater erosivity. RUSLE assumes aboveground biomass (as cover) reduces rainfall-induced erosion. Erosion increases by almost an order of magnitude under bare ground, underscoring the importance of cover. Since Camelina thrives as a winter crop throughout California, it has the potential to reduce erosion if incorporated as a cover crop. Low water requirements may allow for an increase in crop cover.

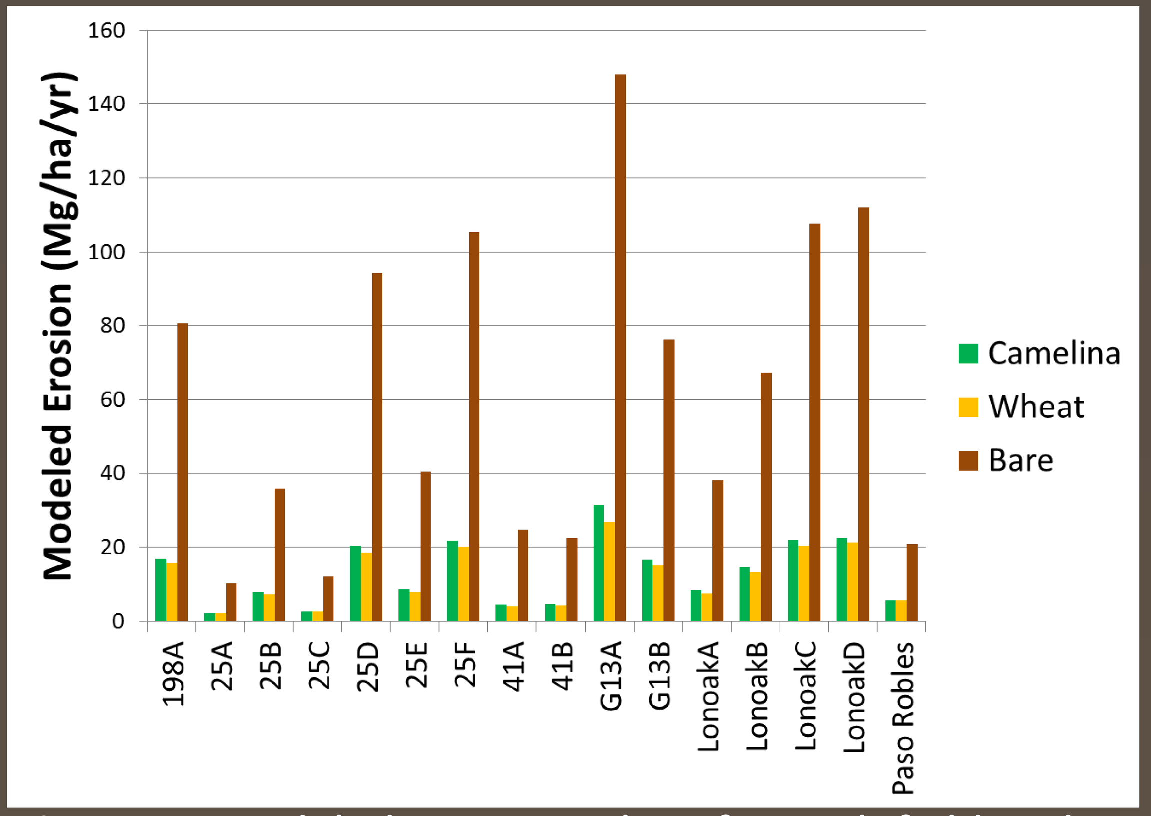

Figure 3. *Modeled erosion values for each field under three scenarios: biofuel crop Camelina, incumbent crop winter wheat, and bare soil.*

Conclusions

- ***Erosion does not differ substantially between biofuel crops and standard crops*** and agree with literature that ***slope*** and ***cover*** are extremely important.
- When used as ***cover crops***, biofuel crops ***reduce erosion compared to fallow*** and require no new land. They may be grown in ***orchard and vineyard middles*** or as an alternative to fallowing fields during the winter season in dry-farmed systems, when a majority of rainfall occurs and cover is needed most.
- Camelina shows particular potential as a cover crop thanks to its low water and nutrient demands. Its use may also increase the frequency of crops in dry-farmed systems compared tom ore water intensive alternatives.

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