RUSLE2-GRAZE: Predicting Management Effects on Residue Production and Soil Erosion

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ABSTRACT

Calculating residue production only during periods of canopy decline or in response to operations underestimates residue cover amounts resulting in overestimates of soil erosion from pasture and hay lands. To solve this problem, new vegetation routines were developed for RUSLE2 that better reflect the amount of residue added by perennial vegetation during its growth, and that make it is easier to model haying/grazing scenarios. The new routines improve prediction of the impact of management on plant growth, forage harvest, residue returns, and soil erosion. Work conducted jointly between the USDA-ARS, the University of Tennessee, and the USDA-NRCS has resulted in the creation of version of RUSLE2 that includes a “vegetation wizard” that allows advanced users to create vegetation descriptions that respond to management in realistic ways. Users describe the potential growth of vegetation in terms of: total annual production potential under good management, monthly production percentages, the average lifespan of vegetation, maximum canopy and biomass at peak live biomass, the cutting height that allows potential growth, and the tendency of the vegetation to thicken (form a sod) in response to repeated defoliations. Potential yield levels are changed to reflect different fertility or irrigation levels and the program automatically calculates the effect of alternative management on forage harvested and the amount of above and below ground residues that are returned to the soil. The resulting vegetation descriptions are brought into erosion calculations using normal the RUSLE2 operation/management approach. USDA-NRCS grazing specialists are in the process of developing regional databases of vegetation descriptions that will allow the new capabilities of RUSLE2 to be used in field offices nationwide. The new version of RUSLE2 will allow erosion estimates to be a factor considered as part of grazing planning.

RUSLE2 Conventions

When biomass declines (senescences):
- Above ground biomass added to surface residue
- Root biomass added to dead root biomass pool

Killing vegetation: converts live to standing residue

Flattening residue: converts standing to surface residue

Standing residue: is converted to surface residue as a function of decomposition controlled by climate and residue properties. By default, standing residue decomposes at a rate 0.3 times that of surface residue and the base of standing residue decomposes at the same rate as surface residue.

Surface residue decomposition: up to 25% of amount lost is added to the buried residue pool in the upper 50 mm of the soil

Perennial Vegetation Descriptions

Annual primary production target
Monthly growth percentages
Average lifespan of vegetation
Shoot:root ratio target
Height at maximum biomass
Height for potential growth harvest
Sod-formation tendency
(other parameters hidden in Grazing Planner template)

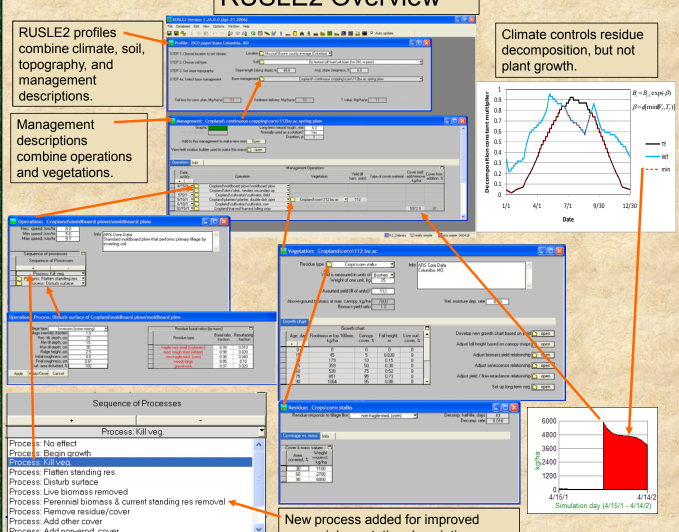
Assumption: all biomass produced dies and is added to standing residue after its life span, if not harvested; standing residue is converted to surface residues using normal RUSLE2 procedures (like wheat straw or corn stalks falling over)

RUSLE2 Overview

RUSLE2 profiles combine climate, soil, topography, and management descriptions.

Management descriptions combine operations and vegetations.

Climate controls residue decomposition, but not plant growth.



New process added for improved perennial vegetation descriptions .

Underlying new RUSLE2 is adapted from Schwinning and Parsons.1996. J. of Ecol.84:799-813

$$B = B_x + B_C$$

B is total biomass (kg ha^{-1}), B_x is structure, and B_C is carbohydrate substrate

$$\frac{dB}{dt} = a\frac{B_x}{B_x + K_B}$$

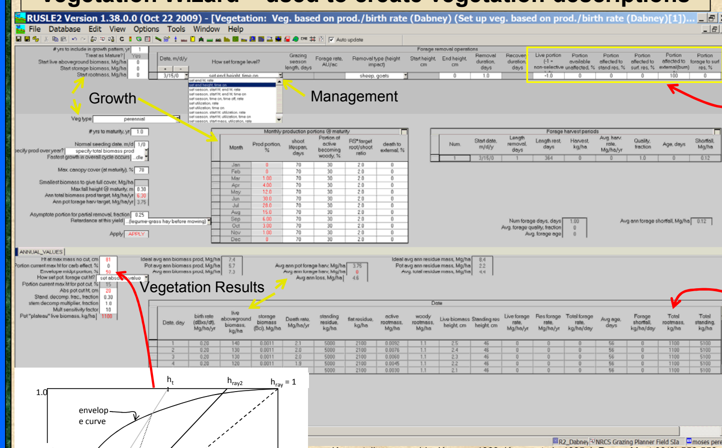
“a” is the maximum assimilation rate at very large biomass, K_B is equal to the structural biomass that give half of the maximal net primary productivity (NPP)

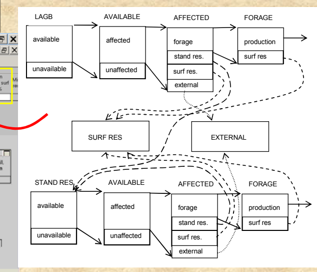
$$\frac{dB_x}{dt} = gB_x\frac{\frac{B_c}{B_x}}{\frac{B_c}{B_x} + K_C}$$

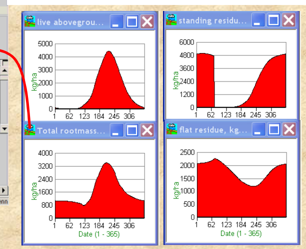
“g” (d^{-1}) is an intrinsic growth rate parameter for a species, K_C is the carbohydrate to structure ratio where growth rate per unit structure is half maximum

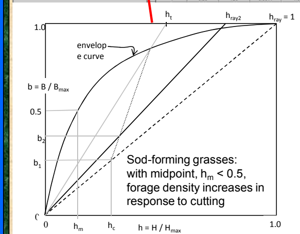
In practice, g, K_B, and K_C are fixed and RUSLE2 iterates daily estimates of “a” to achieve the specified monthly growth percentages and the specified total NPP. Net primary productivity is split between shoots and roots, and equations use shoot mass for B_x.

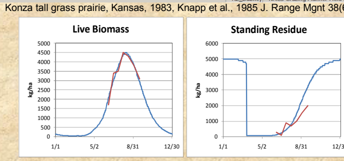
Vegetation Wizard – used to create vegetation descriptions







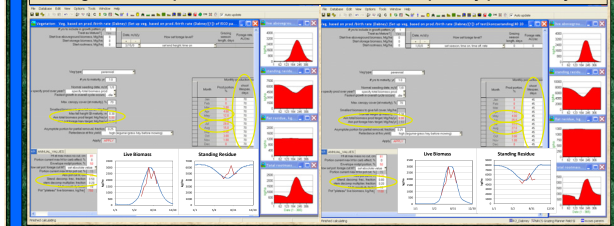




Konza tall grass prairie, Kansas, 1983, Knapp et al., 1985 J. Range Mgnt 38(6):556-558

The vegetation wizard allows advanced users to create vegetation descriptions that respond to management in expected ways. These vegetation descriptions can then be used in management descriptions and profiles to predict management effects on forage production and soil erosion.

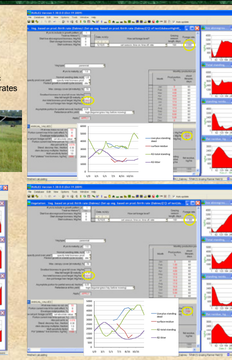
To match measured live and standing dead biomass in unburned Konza prairie, vegetation lifespan had to be decreased more than primary productivity

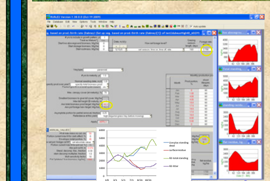


Bahiagrass in FL

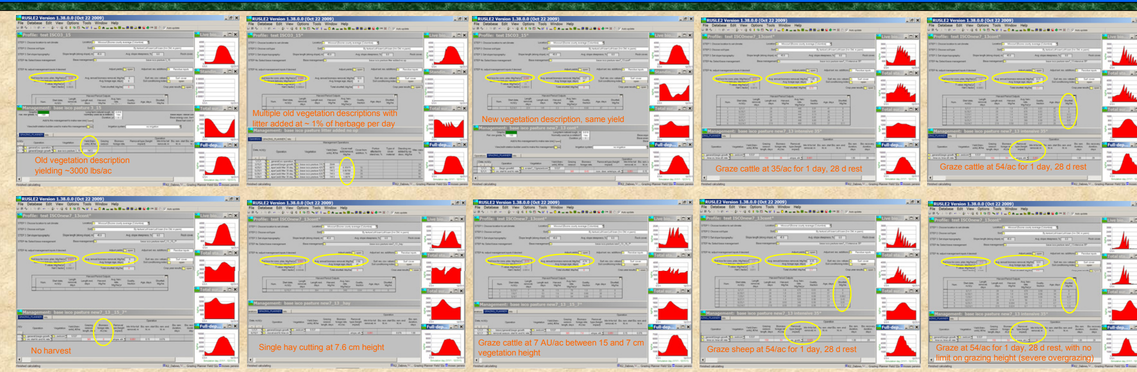
Dubeux et al. (2006) Crop Sci. 46:1299–1304.

- Three management levels
  - Low - 40 kg N ha^{-1} Apr; 1.3 AU/ac
  - Mod – 40 kg N ha^{-1} Apr, Jul, Aug; 2.7 AU/ac
  - High – 90 kg N ha^{-1} Apr, Jun, Jul, Aug; 4.0 AU/ac
- Measured total herbage, existing litter, and litter creation rates at multiple dates





A single vegetation description allowed matching litter, herbage, and forage harvest for the high and moderate management levels. However, the low production level, where all fertilizer N was applied in the spring, would need a different set of monthly growth percentages to match observed growth and litter production patterns.



Summary: Adding appropriate amounts of surface residues to old perennial vegetation descriptions reduced predicted erosion by a factor of three. However, this required development of matched part-year vegetation descriptions and creation of complex management descriptions. In comparison, using new RUSLE2 vegetation technology to match above and below ground biomass and forage yield, reduced predicted soil erosion by a factor of six compared to the base case and required only a simple management description. The new procedures are flexible enough match nearly any situation, as illustrated with published data from burned and unburned areas of prairie in Kansas, and with three bahiagrass management levels in Florida.

If monthly growth percentages are constant, a single vegetation description can be used to compare many alternative management scenarios in terms of forage harvest, supplemental feeding requirements, and soil erosion consequences.   Not burning vegetation or fertilizing only in the spring are examples of managements that changed monthly growth percentages.

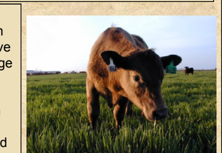


photo: Harry Schomberg