The Effectiveness of Riparian Buffers for Reducing Sediment Loading to Streams Under Alternative Climate Change Scenarios

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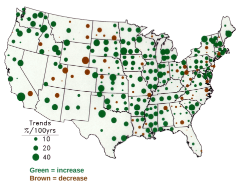
Introduction

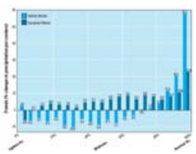
Sediment loading from agricultural areas is a major cause of stream impairment in the U.S. The combined influence of watershed physiographic, landuse, and climatic factors determine rates of sediment loading.

During the last century, much of the US experienced warmer temperatures and increased precipitation. These trends are projected to continue into the next century.

Trends in U.S. Precipitation Totals (1901-1998)



Projected Trends in U.S. Precipitation



Regulatory agencies and other watershed stakeholders require a better understanding of the potential effects of climate variability and change on stream sediment loading. Strategies for managing any adverse effects of climate change, i.e. adaptive responses, are also required.

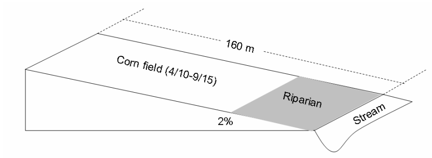
Riparian buffers are a well established BMP for sediment loading to streams, and buffer strategies could be an effective adaptive response to climate change.

Study Goals:

- Model and assess how different type/width riparian buffers influence stream sediment loading from agricultural fields under a range of climate change (precipitation) scenarios
- Develop a modeling framework for decision support to guide watershed management (e.g. TMDL)

Modeling Approach

Hillslope:



Models:

CLIGEN →	WEPP →	REMM
• Stochastic weather generator, developed by USDA ARS • Randomly generates daily precipitation, temperature, dewpoint, wind, and solar radiation based on monthly statistics	• Water Erosion Prediction Project; developed by USDA ARS • Process-based, continuous simulation • Simulates… – plant growth/cropping practices – hydrologic processes – sheet, rill, gully erosion – hillslope deposition	• Riparian Ecosystem Management Model, devlpd. by USDA ARS • Process-based, continuous simulation • Simulates… – riparian plant growth – hydrologic processes – sediment and nutrient dynamics

Climate Scenarios:

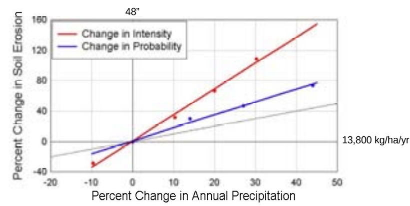
- 100-year daily weather representative of potential future climate at Athens, GA
  - Changed CLIGEN parameters for historical monthly precipitation probability and intensity
    - probability -10, 0, 10, 20, 30%
    - intensity -10, 0, 10, 20, 30%
    - combined -5, 0, 5, 10, 15%

Buffer Scenarios:

- Forested and grass vegetation
- Widths of 0, 5, 10, 15, 20, 30, 50 meters

Results

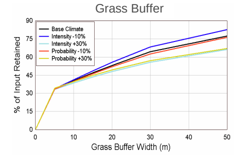
Sensitivity of Soil Erosion in the Field to Changes in Precipitation Probability and Intensity



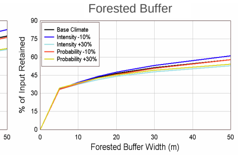
Rates of soil erosion are about 2X as sensitive to changes in precipitation intensity than probability. For this GA location and hillslope, the percent change in erosion was 1.8X and 3.5X the percent change in precipitation, respectively, depending on whether the change was due to precipitation probability or intensity.

Percent Reduction in Sediment Loading With Buffer – Relative to Input (Trapping Efficiency)

Grass Buffer



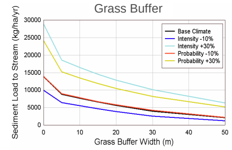
Forested Buffer



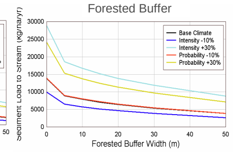
Grass buffers have a higher trapping efficiency than forest, but are more sensitive to changes in precipitation. With a 30% increase in intensity, the trapping efficiency decreases from 63 to 55% for a 30m grass buffer, and from 52 to 48% for a 30m forest buffer.

Sediment Loading to Stream With Changes in Buffer Width and Precipitation

Grass Buffer



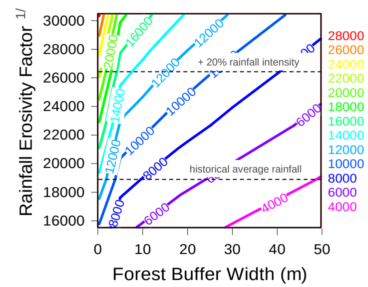
Forested Buffer



Buffers are capable of significant load reductions, but large increases in loading to stream could still occur due to increased soil erosion and reduced trapping efficiency with increased precipitation. With a 30% increase in precipitation probability or intensity, loading could increase 105% to 150% with 30m grass buffer, and 80% to 120% with a 30m forest buffer.

Decision Support

Stream Sediment Load (kg/ha/yr)



1/ The USLE erosivity factor, R, can be used as an index of the combined changes in precipitation probability and intensity

$R \sim \mathrm{Sum}(E * I_{30})$

R in $MJ*mm*ha^{-1}*hr^{-1}*yr^{-1}$

E = total kinetic energy of the storm

I_{30} = max 30 minute intensity

Example Application: The modeled field with a 10 meter buffer currently produces ~8000 kg/ha/yr. If precipitation intensity increases by 20%, the yield would be ~13000 kg/ha/yr. Increasing the buffer width to ~40m would maintain current loading rates if precipitation intensity increased 20%.

Conclusions/Future Work

Agricultural soil erosion and sediment loading to streams are highly sensitive to changes in precipitation.

Riparian buffers could be effective as an adaptation strategy, but the effectiveness related to antecedent width; buffers most effective where currently less than ~ 10m in width.

Decision support tool based on the coupled WEPP-REMM hillslope modeling system could provide useful information to watershed managers about the potential influence of climate change on stream sediment loading, and the effectiveness of buffer strategies as an adaptive response to climate.