Soil Erosion Modeling & Control in Brazil: Past, Present, and Future

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Outline

1. Erosion & Sedimentation in Brazil: Lessons from the Past
2. Assessment of the present: Erosion & sedimentation modeling & control
3. Vision of the future: Can we achieve sustainability?
4. Conclusions
1. **Lessons from the Past**

- Brazil’s economy relied strongly on agriculture & mining
- The lush native forest was considered an “enemy” to be conquered
- Little concern existed about soil protection & conservation
- As a result, severe erosion & sedimentation occurred
Spix & von Martius (1820)
2. **Assessment of the Present**

- 28% of Brazil’s territory is under crop & pastureland (2.4 M km²)
- Under conventional systems, erosion rates exceed 20 tons per hectare per year
- Soil loss tolerance is 10 t /ha yr
- As a result, over 2 billion tons of sediment silt up rivers & lakes
- Off-site costs: US$ 1 billion/yr
- Impacts threaten sustainability
Assessment of Erosion Susceptibility
Assessment of Erosion Susceptibility

Campagnoli (2005)
Soil Mgt. vs. Erosion: Conventional x No-Till

- Runoff (cm/yr)
- Soil Loss (t/ha.yr)

Merten et al (1993)
Soil Mgt. vs. Erosion: Growth of No-Till in Brazil
Erosion Modeling & Land-use Planning

A = R K L S C P

A < T

Land Use (C)

Topography (LS)

Erodibility (K)
Erosion Modeling Challenges: USLE’s K for Brazil

\[ K = -0.000430 \times (AF+SIL)/CO + 0.000437 \times AR + 0.000862 \times SIL \]

Chaves (1994)
Challenges:

USLE’s C for Brazil

(Variant authors)
Erosion Modeling Challenges: Designing Buffer Strips with WEPP

What is the width $W$ of buffer strip capable of reducing 90% of sed. yield?
Erosion Modeling Challenges: Designing Buffer Strips with WEPP

![Bar graph showing buffer width (m) for different land uses: Conv. Agr. (120m), Pasture (60m), Bush (30m). Chaves (1996).]
Erosion Modeling Challenges: Uncertainty in Erosion & Sedimentation Modeling

Chaves & Nearing (1991)
Erosion Modeling Challenges: Uncertainty in Erosion & Sedimentation Modeling

WEPP Rill Erosion Component:

\[
\frac{\partial Q_s(x)}{\partial x} = K_r (\tau - \tau_c) \left(1 - \frac{Q_s(x)}{T_c(x)}\right)
\]

Boolean structure
Erosion Modeling Challenges: Improving Sediment Database & Analysis

UNESCO-ISI HidroPlata-Sed

- 5 Countries
- Over 100 stations
- User-friendly
- Data integration is difficult
3. **Vision of the Future**

- Agriculture & hydropower will be increasingly more important in Brazil
- Farmers face market & financial burdens
- Reservoirs are being silted up
- How do we tie both ends?
- How do we tackle model complexity?
Payments for Environmental Services

- BMPs such as no-till farming, reforestation, terracing, & gully control reduce erosion & sedimentation
- Their effectiveness can be estimated by modeling
- Farmers could be financially compensated based on practice performance
Payments for Environmental Services - PES

Benefits to water users & environment

Water Quality Improvement (US$ Billion)

PES to Farmers (US$ Billion)

USDA-ERS (2001)
Water Provider Program

Estimating Environmental Additionality:

\[
\frac{A_1}{A_0} = \frac{R K L S C_1 P_1}{R K L S C_0 P_0} \quad \Rightarrow \quad \frac{A_1}{A_0} = \frac{C_1 P_1}{C_0 P_0}
\]

Erosion Reduction:

\[
E_r (\%) = 100 \left[ 1 - \left( \frac{C_1 P_1}{C_0 P_0} \right) \right]
\]
Recent models are complex, with many input variables & parameters

Data are frequently not available in developing countries

Is it possible to emulate models and to bridge this gap?
Emulating WEPP with Neural Networks (SONN)

- **Inputs**: 28 variables & parameters
- **Simulations**: 1.500
- **SONN nodes**: Kolmogorov-Gabor polynomials

\[ y = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_1 x_2 + a_4 x_1^2 + a_5 x_1^2 x_2 + \ldots \]
Emulating WEPP w/ Neural Networks (SONN)

![Bar chart showing the number of inputs used for Total Inputs, Runoff, Soil Loss, Deposition, and Sed. Yield. The Total Inputs are the highest, followed by Sed. Yield, Soil Loss, Deposition, and Runoff.](image-url)
Emulating WEPP w/ Neural Networks (SONN)
4. **Conclusions**

- Erosion & sedimentation are important issues in Brazil
- Situation is improving with BMPs
- To be more effective, PES shall be considered in integrated basin planning
- Complexity & insufficient data hinder model application in the tropics
- Models can be simplified by suitable algorithms
Soils are nothing but rocks in their way to the Ocean.

M.L. Jackson