Scaling changes in biogeochemistry of small streams to the regional landscape

Linda A Deegan, Chris Neill, M. Victoria Ballester, Alex Krusche, Reynaldo Victoria
How does deforestation for pasture alter small stream:

✓ Chemistry, Habitat, Physical & conditions
✓ Nutrient cycling - altered nitrogen
• Nitrogen cycle on a regional scale
NH₄⁺ Uptake

NH₄ and NO₃ in stream flow

NH₄ and NO₃ in seepage from catchment

NH₄ and NO₃ in export

NH₄ regeneration

NH₄ uptake

Assimilatory NH₄ uptake

Direct nitrification

Assimilatory NO₃ uptake

NO₃ regeneration

Biota

NH₄ → NH₄ + Uptake

NO₃ → NO₃ + Uptake

Indirect nitrification

Reuptake

Mineralization

Denitrification

N₂
Where did the N go?

NH₄ and NO₃ in stream flow

Stream bottom

NH₄ and NO₃ in seepage from catchment

NH₄ and NO₃ in export

NH₄ and NO₃ regeneration

Assimilatory NH₄ uptake

Direct nitrification

Assimilatory NO₃ uptake

NH₄ regeneration

Biota

reuptake

mineralization

reuptake

indirect nitrification

denitrification

N₂
Where did the N go?

NH₄ and NO₃ in stream flow

NH₄ regeneration

Assimilatory NH₄ uptake

Direct nitrification

Assimilatory NO₃ uptake

NO₃ regeneration

NH₄ and NO₃ in export

Stream bottom

Biota

NH₄ and NO₃ in seepage from catchment

Reuptake

Mineralization

Reuptake

Indirect nitrification

Denitrification

N₂
### Change From Export to Storage

<table>
<thead>
<tr>
<th></th>
<th>% of N Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export</td>
<td>67</td>
</tr>
<tr>
<td>Storage</td>
<td>1</td>
</tr>
<tr>
<td>Forest</td>
<td>21</td>
</tr>
<tr>
<td>Pasture</td>
<td>58</td>
</tr>
</tbody>
</table>

Forest streams have very long N travel distances and are P limited. Most N flows unchanged on to larger rivers.

Pasture streams disappear under grasses that fill in the channel and slow water movement, resulting in greater N uptake and retention.
LBA III: Scaling up to larger region

Take process based measurements to the regional scale

Rondônia State

Amazon Basin
LBA III: Scaling up to larger region

Ji Paraná River Basin, Rondônia

1) Determine land use for the watershed

2) Overlay river network, including new determination of 1st and 2nd order streams based on IKONOS images and a refined DEM
LBA III: Scaling up to larger region

Ji Paraná River Basin, Rondônia

% of area deforested: 30
Km 1st and 2nd order streams altered: 7,102
Small Stream Alteration has a Disproportionate Impact

700% increase N retention
30% land altered

Total N Uptake by small streams in watershed

Kg N m$^{-2}$ d$^{-1}$

Forest
30% Pasture

Class
- Forest
- Water
- Urban
- Savanna
- Annual Crops
- Riparian/regrowth

Pasture Pasture
LBA III: Next step - Link land use mosaic to stream function at the regional scale

1992

Distance of stream (km)

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest

Pasture

Forest
LBA III: Next step - Link land use mosaic to stream function at the regional scale

PROCESS MODELS

Terrestrial (TEM) (Model developing using $^{15}$N addition)

Forest

Pasture

Stream

REGIONAL LANDSCAPE

Spatially explicit land use and river network

1st

2nd

3rd

Forest

Pasture

Predict N & C delivery to Larger Rivers
Disappearing Streams

Small streams fill with pasture grass
Cascading effects - high plant debris, low oxygen, slow water movement

Disappearing ecosystem function

- Loss of animal diversity and productivity
  - Complete switch in nutrient cycling
    - Change limiting nutrient P to N
    - Change from export to retention of N

Change to a more N retentive landscape?
Thank you

- MBL Ecosystems Center:
  - Chris Neill, Suzanne Thomas, Christie Haupert, Jerry Mellilo, Paul Steudler
- CENA-USP, Piracicaba, Brazil:
  - Alex Krusche, Victoria Ballester, Reynaldo Victoria, Alaide Gessner, Jean Ometto, Cristiane Tumang Frare, Adriana Bonilla, Sergio Neto
- Nova Vida Ranch
- NSF and NASA LBA-ECO program