Hydrological impacts of forest conversion to grassland in small catchments in Brazilian Amazon

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In general, it is accepted that changes on hydrological response are associated with equivalent changes in evapotranspiration. Therefore, and since deforestation reduces the evaporation, it should produce an increase of water yield.
Guiana, 1 South Africa and 1 Austrália

(ANDREASSIAN, 2004)
Pasture lands in Amazonia

- They cover about 80% of deforested lands

(MORAN, et al., 1994; FEARNSIDE, 1996, 1999; MARGULLIS et al., 2003; ASNER et al., 2004)
Study Area: two experimental catchments with forest and pasture (Drained area ~1.2 Km$^2$ for both catchments)
Catchments Instrumentation
Results

Topography

% da área de contribuição da bacia acima de uma dada elevação

$A / A_{max}$

$A / A_{max}$

Pastagem

Floresta

Latossolos

Argissolos

Espodossolos

Gleyssolos

PLATÔ

VERTENTE

BAIXIO

Pastagem

Floresta de Terra Firme

Campinarana Floresta ripária
Precipitation

Cumulative precipitation (mm)

Precipitation on pasture (mm.day\(^{-1}\))

Precipitation on forest (mm.day\(^{-1}\))

Pasture
Forest

Foto: A. Nobre
Evapotranspiration

- - - Pastagem (Evaporação + Transpiração)
- - Floresta (Interceptação+Transpiração)
- - - Floresta (Interceptação do dossel)
Discharge Curves

Mathematical models to convert water level (cm) to discharge (m$^3$.s$^{-1}$)

- **Catchment with forest**
  
  \[ Q = 8 \times 10^{-7} h^{3.2594} \]
  
  \[ R^2 = 0.984 \]

- **Catchment with pasture**
  
  \[ Q = 4 \times 10^{-5} h^3 - 0.0008 h^2 + 0.0115 h - 0.0447 \]
  
  \[ R^2 = 0.985 \]
Discharge
Water yield in catchments with forest and pasture

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Discharge (mm.day(^{-1}))</th>
<th>Base flow (mm.day(^{-1}))</th>
<th>Storm Flow (mm.day(^{-1}))</th>
<th>Base flow (%)</th>
<th>Storm Flow (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>1.888</td>
<td>1.388</td>
<td>0.500</td>
<td>73.53</td>
<td>26.47</td>
</tr>
<tr>
<td>Forest</td>
<td>0.902</td>
<td>0.764</td>
<td>0.138</td>
<td>84.72</td>
<td>15.28</td>
</tr>
</tbody>
</table>
Evidences of runoff generation and erosion
Comparison of the hydrological response to equivalent rainfall
## Discharge

### Speed response to precipitation

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Concentration Time</th>
<th>Recession Time</th>
<th>Base Time</th>
<th>Peak Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>6.66 ± 1.46</td>
<td>5.90 ± 1.92</td>
<td>7.80 ± 1.83</td>
<td>2.53 ± 0.81</td>
</tr>
<tr>
<td>Forest</td>
<td>19.43 ± 5.31</td>
<td>18.60 ± 5.53</td>
<td>21.36 ± 5.54</td>
<td>3.24 ± 0.93</td>
</tr>
</tbody>
</table>

*Statistical significance:
- **Forest** vs. **Pasture**:
  - Concentration Time: $F = 214.9; P < 0.001; N = 40$
  - Recession Time: $F = 188.4; P < 0.001; N = 40$
  - Base Time: $F = 215.9; P < 0.001; N = 40$
  - Peak Time: $F = 13.4; P < 0.001; N = 40$
Relationship between Precipitation and storm flow generation

- Pastagem: $Q_{esc \ direto} = 0.1124P - 0.2747 \quad R^2 = 0.498$
- Floresta: $Q_{esc \ direto} = 0.0359F - 0.0961 \quad R^2 = 0.648$
Flow duration curves

Streamflow

- - - Pastagem
--- Floresta

Percentual do tempo que a vazão é excedida

Vazão (mm/dia)
Water Balance

Comparison of cumulative changes of storage

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Precipitation (mm.day(^{-1}))</th>
<th>Discharge (mm.day(^{-1}))</th>
<th>Evapotranspiration (mm.day(^{-1}))</th>
<th>Changes of storage (mm.day(^{-1}))</th>
<th>Runoff coefficient (Q/P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>5.96</td>
<td>1.88</td>
<td>2.40</td>
<td>1.68</td>
<td>0.32</td>
</tr>
<tr>
<td>Forest</td>
<td>5.83</td>
<td>0.90</td>
<td>3.50</td>
<td>1.43</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Conclusions

- Although the similarity on precipitation, significant differences were found on the other water balance components. Streamflow and water storage were respectively 0.98 mm.day\(^{-1}\) e 0.25 mm.day\(^{-1}\) higher in the pasture catchment than in the forest. The sum of these values is quite similar to evapotranspiration differences.

- Evapotranspiration average was 1.1 mm.day\(^{-1}\) lesser in the pasture catchment than in the forest. 50% of this difference (0.54 mm.day\(^{-1}\)) is because of the canopy interception.

- Water yield was much higher on the pasture catchment due to changes on evapotranspiration. Discharge was 108% higher, Baseflow was 81% higher and stormflow was 262% higher on the pasture catchment

- Analysis of individual events have shown significant differences between forest and pasture in terms of the rainfall/runoff response. The speed response to precipitation in the pasture site is higher than in the forest site.

- Forest lose a great part of available water by evapotranspiration, and exerts an important ecological role in the water balance cycles. Observations suggest that conversion of forest to pasture might have significant impacts on the ability to regularize floods during the wet season and droughts in dry seasons on larger scales.
Acknowledgments

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