A simulation model for nitrogen and phosphorus retention in seasonally flooded and permanently flooded wetlands in East Africa

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Provisioning services

Harvest for use of the papyrus

Clearing for agriculture and or bush meat
Regulating service
Nutrient cycling
This leads to the following questions?

- Does harvesting influence nutrient retention?
  - Is the effect on nitrogen the same as on phosphorus?
  - Does it matter where the papyrus is harvested (permanently or seasonally flooded)?
  - Does it matter how much you harvest and how often?
- Do you need to make a trade-off?
Lake Naivasha
Conceptual model

- Seasonally flooded wetland
- Permanently flooded wetland
- River discharge
- Groundwater recharge
- Precipitation
- Evapotranspiration
- Lake Naivasha
particulate

NH₄ NO₃ AP

dissolved

N

CNP

NP

C

N

inflow
• 7 sub-models
  • 2 carbon
  • 2 nitrogen
  • 2 phosphorus
  • 1 hydrology

Stella 9.1.4
54 state variables and 158 flows
Characteristics of the model

- Literature data on Lake Naivasha was used for parameterization
  - Precipitation and evaporation (Gaudet, 1979)
  - Irradiance (Muthuri et al., 1989)
  - Biomass (Muthuri et al., 1989; Jones and Muthuri, 1997; Boar et al., 2006 and Saunders et al., 2007)

- Model based on three existing models
  - Van der Peijl and Verhoeven, 1999
  - Jorgensen et al., 2002
  - van Dam et al., 2007
Nitrogen in biomass (g*m$^{-2}$)

Literature values

ABG 44 g*m$^{-2}$
BGB 31 g*m$^{-2}$

Phosphorus in biomass (g*m$^{-2}$)

ABG 2.6 g*m$^{-2}$
BGB 2.8 g*m$^{-2}$

Boar et al., 1999
Boar, 2006
Harvesting scenarios of above ground papyrus

Daily harvesting (e.g. 50%)

\[
\text{Biomass} \times 0.5 / 365
\]
(every day)

Batch harvesting (e.g. 50%)

\[
\text{Biomass} \times 0.5
\]
(once per year)
Ammonium and available phosphorus in outflow (g*m\(^{-3}\))
Harvesting 0%, 10%, 20% and 100%
Results for effects of harvesting on N and P retention

Retention is defined as \((\text{IN} - \text{OUT})/\text{IN} \times 100\%\)

- **Daily N**
- **Batch N**
- **Daily P**
- **Batch P**

Graphs showing the retention of N (solid line) and P (dashed line) in S and P wetlands.
Discussion and conclusion nitrogen and phosphorus

- Papyrus wetlands play a role in buffering and removal of nitrogen and harvesting has a positive effect.
- Papyrus wetlands play a marginal role in buffering phosphorus.
- Converting papyrus to agricultural land in the dry season may have a positive effect of N retention
- Peat formation
Discussion and conclusion on differences between hydrology

- More N retention in seasonally flooded wetlands due to N limitation of uptake by papyrus in permanently flooded wetland with harvesting.
- Without harvesting higher in permanently flooded wetland due to denitrification.
- For other cases this may be different (nutrient loading).
Finally

Papyrus harvesting has a positive impact on nutrient retention as long as the papyrus is allowed to grow back and no fertilizer is applied.

Papyrus wetlands do retain nitrogen, but phosphorus much less.
Thank you!