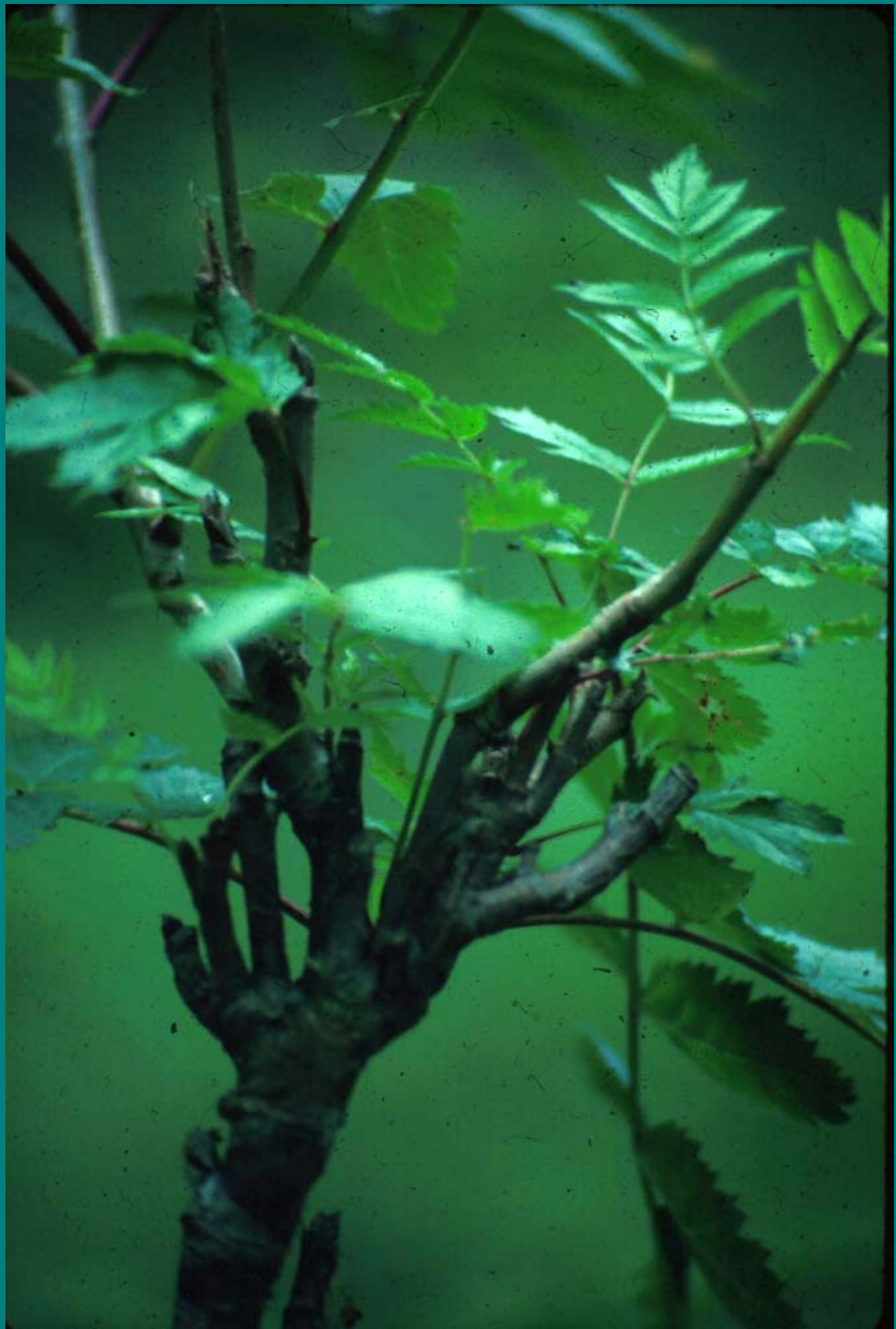
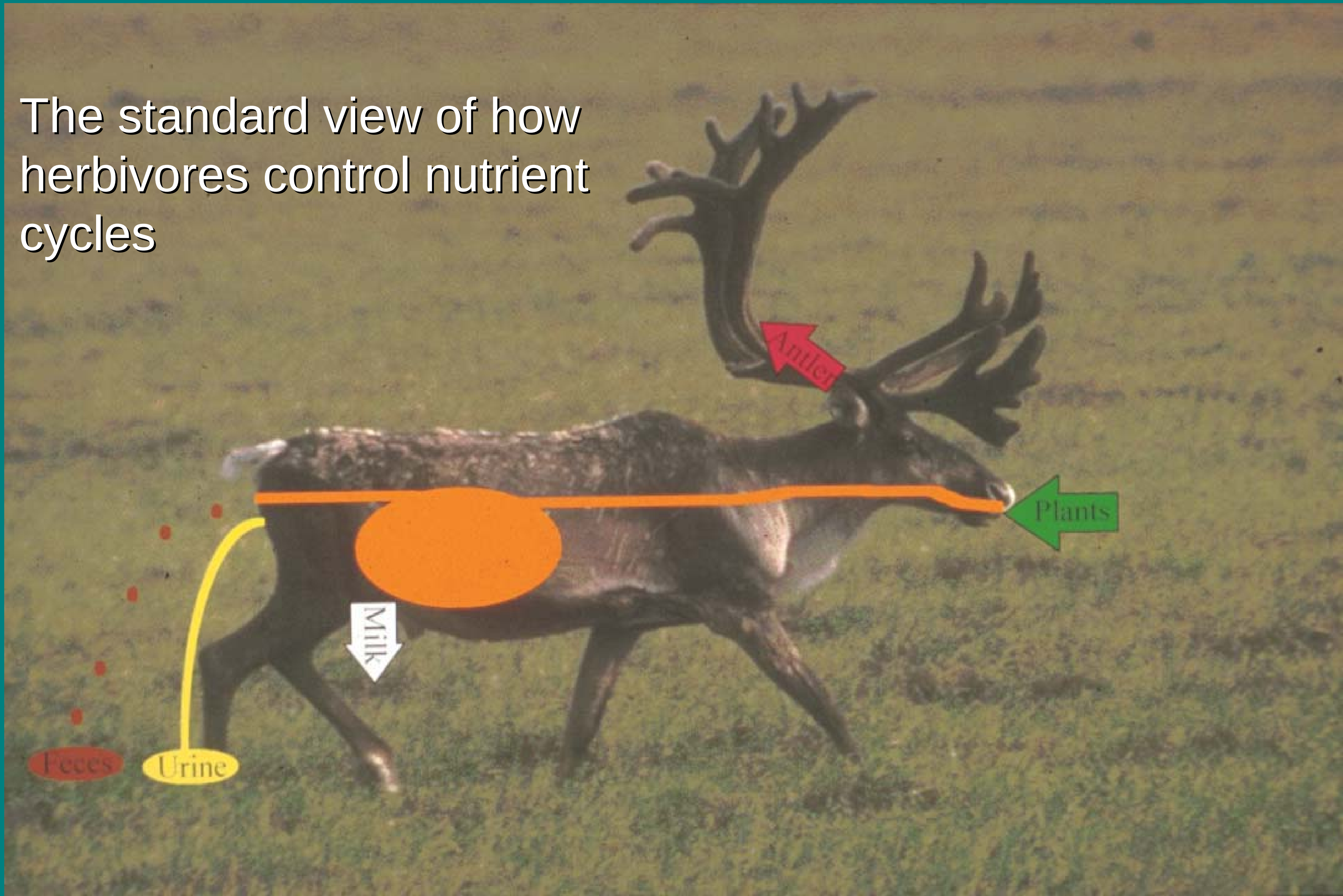
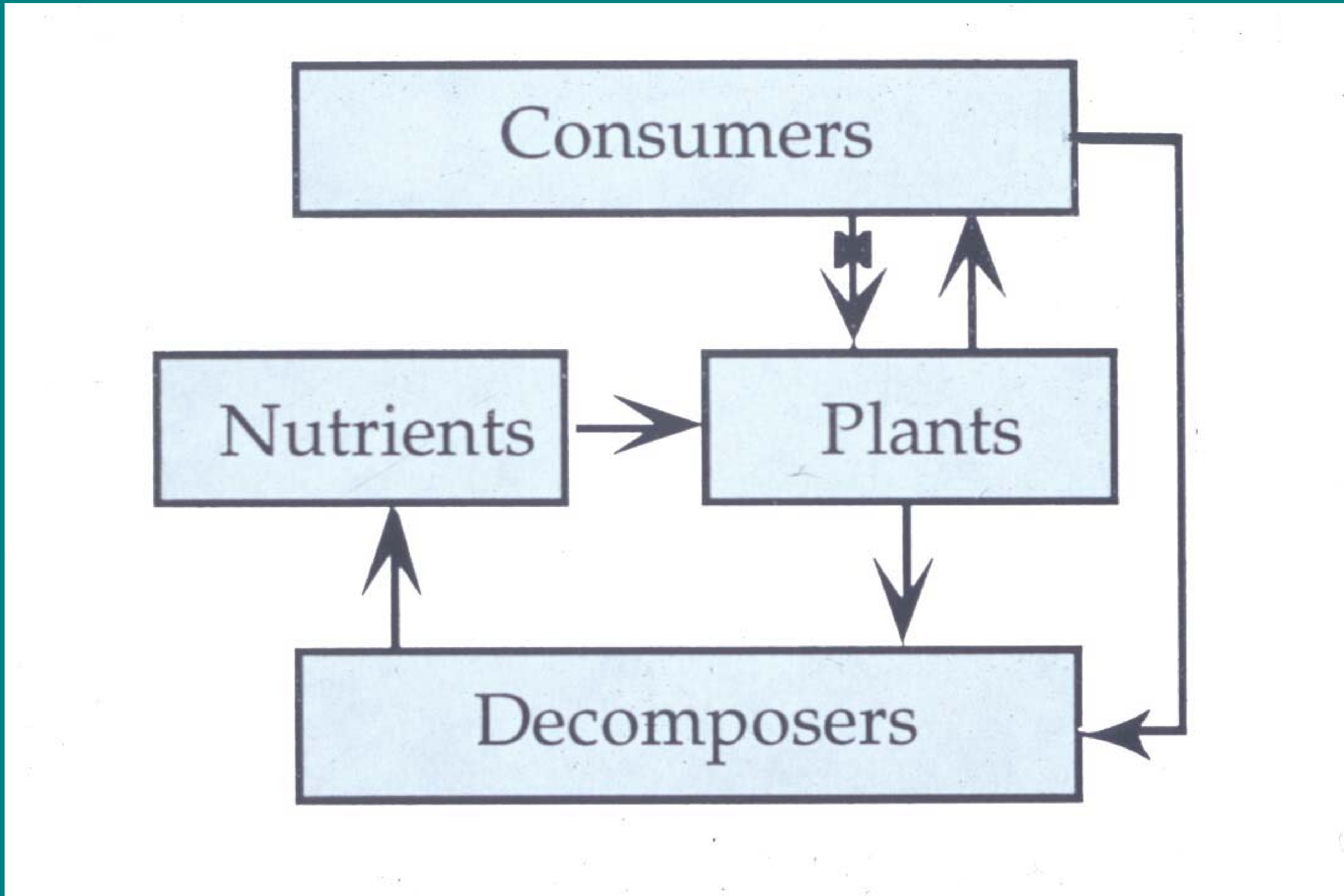


Grazing, Browsing, & Ecosystem Functions

John Pastor
Dept. of Biology
&
Natural Resources
Research Institute
Univ. of Minnesota
Duluth

The standard view of how herbivores control nutrient cycles



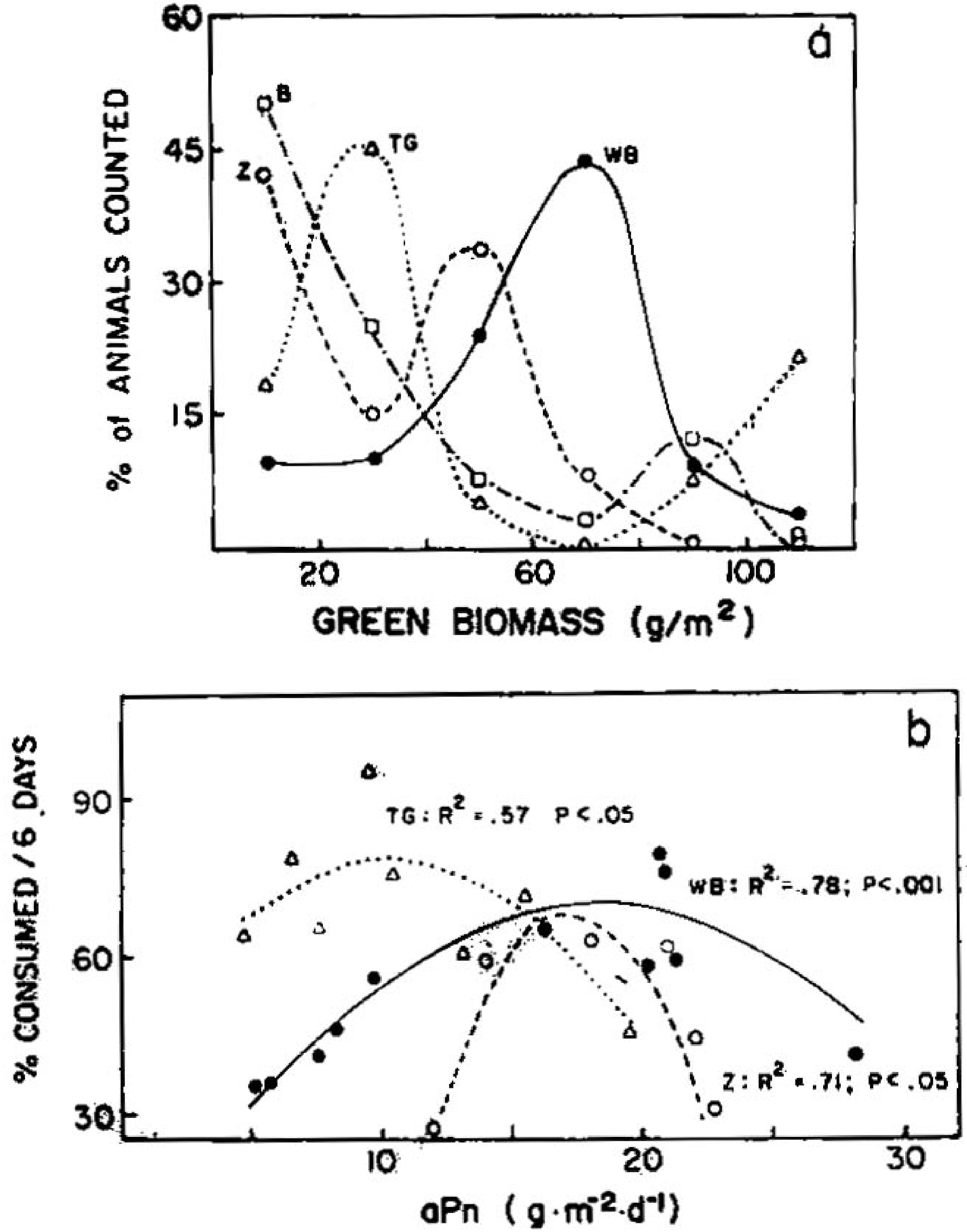


Herbivores also influence nutrient cycles by altering plant species composition

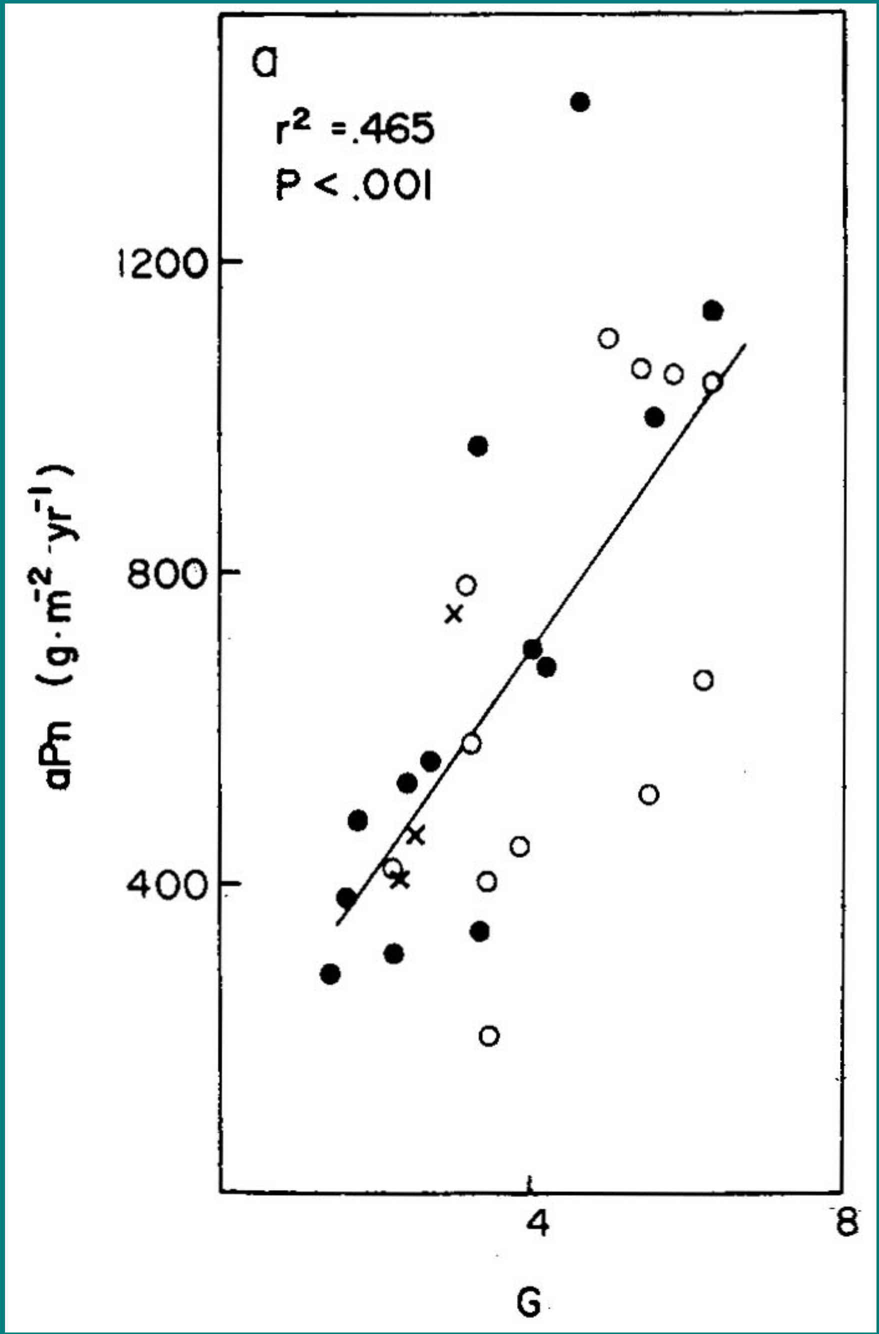

Waves of migrating wildebeest,
zebra, and other grazers on the
Serengeti Plains

Successive waves of herbivores in the Serengeti consume almost all aboveground production, converting it into carcasses, urine, and fecal waste

McNaughton 1985



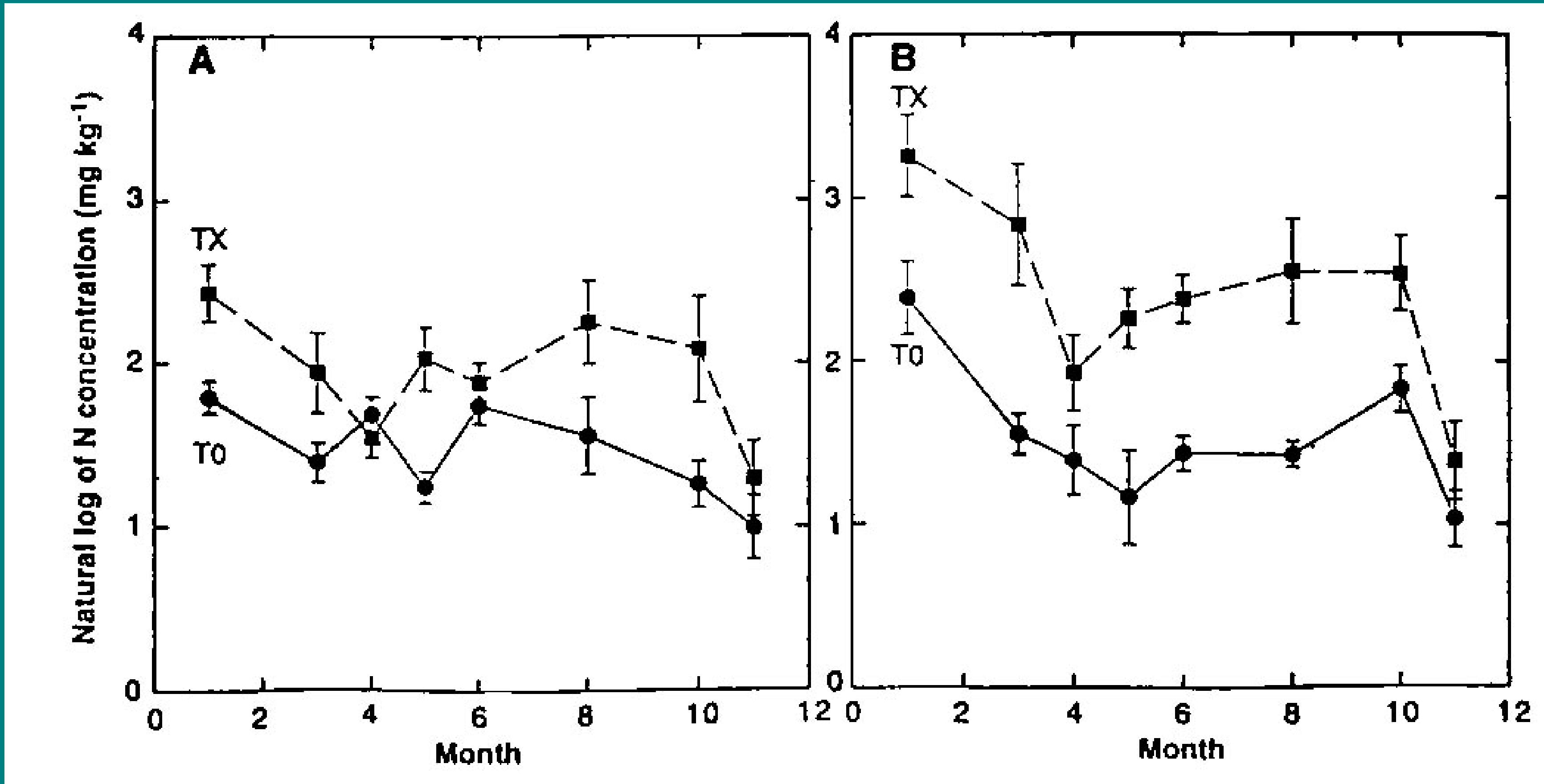
Grazing in the Serengeti increases aboveground production



McNaughton 1985

Without Grazing

With Grazing

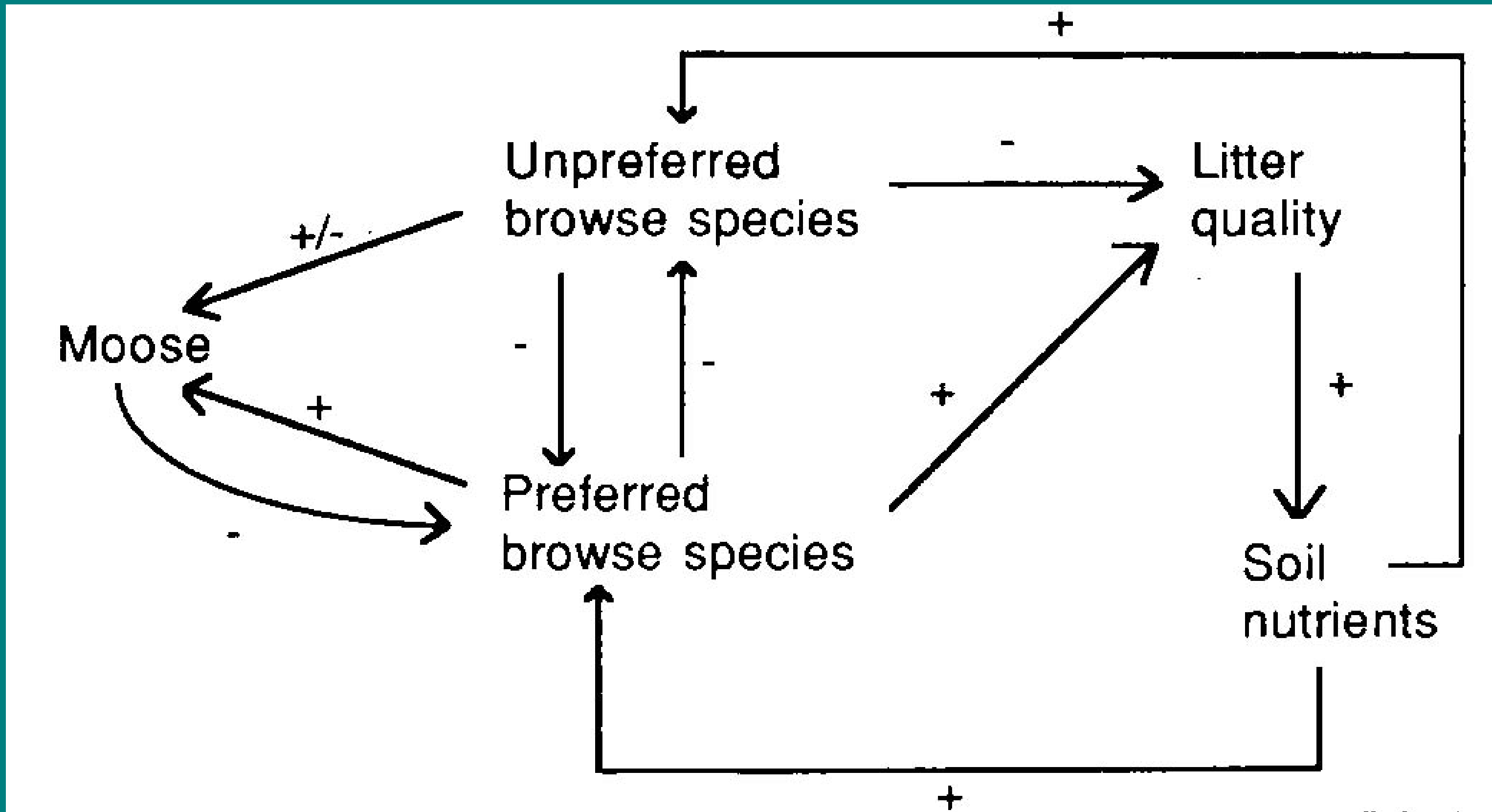


McNaughton et al. 1997

Grazing in the Serengeti increases soil nitrogen availability


Moose – a solitary browser
in the boreal forest

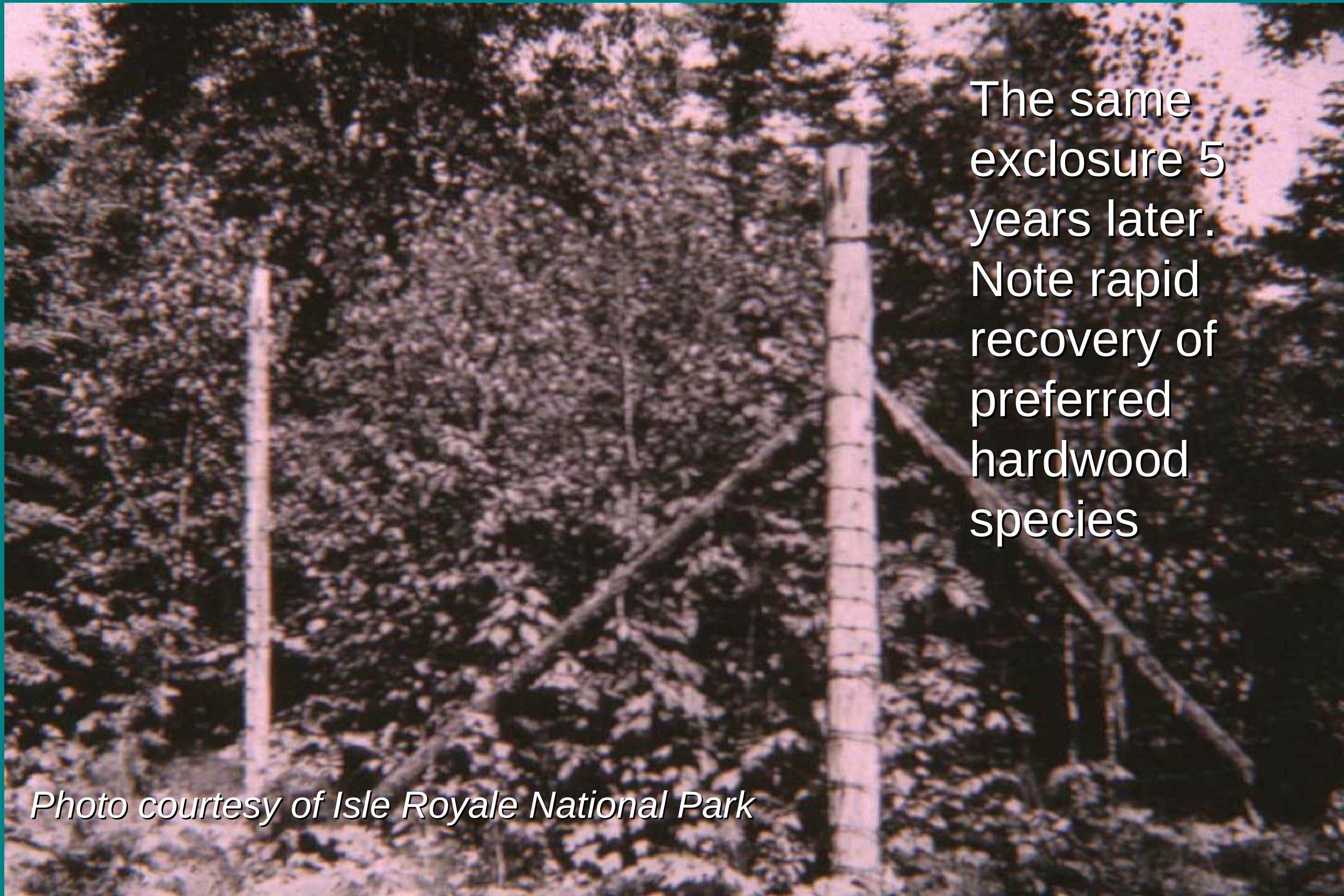
Moose control nutrient cycles by selective foraging



McInnes et al. 1992

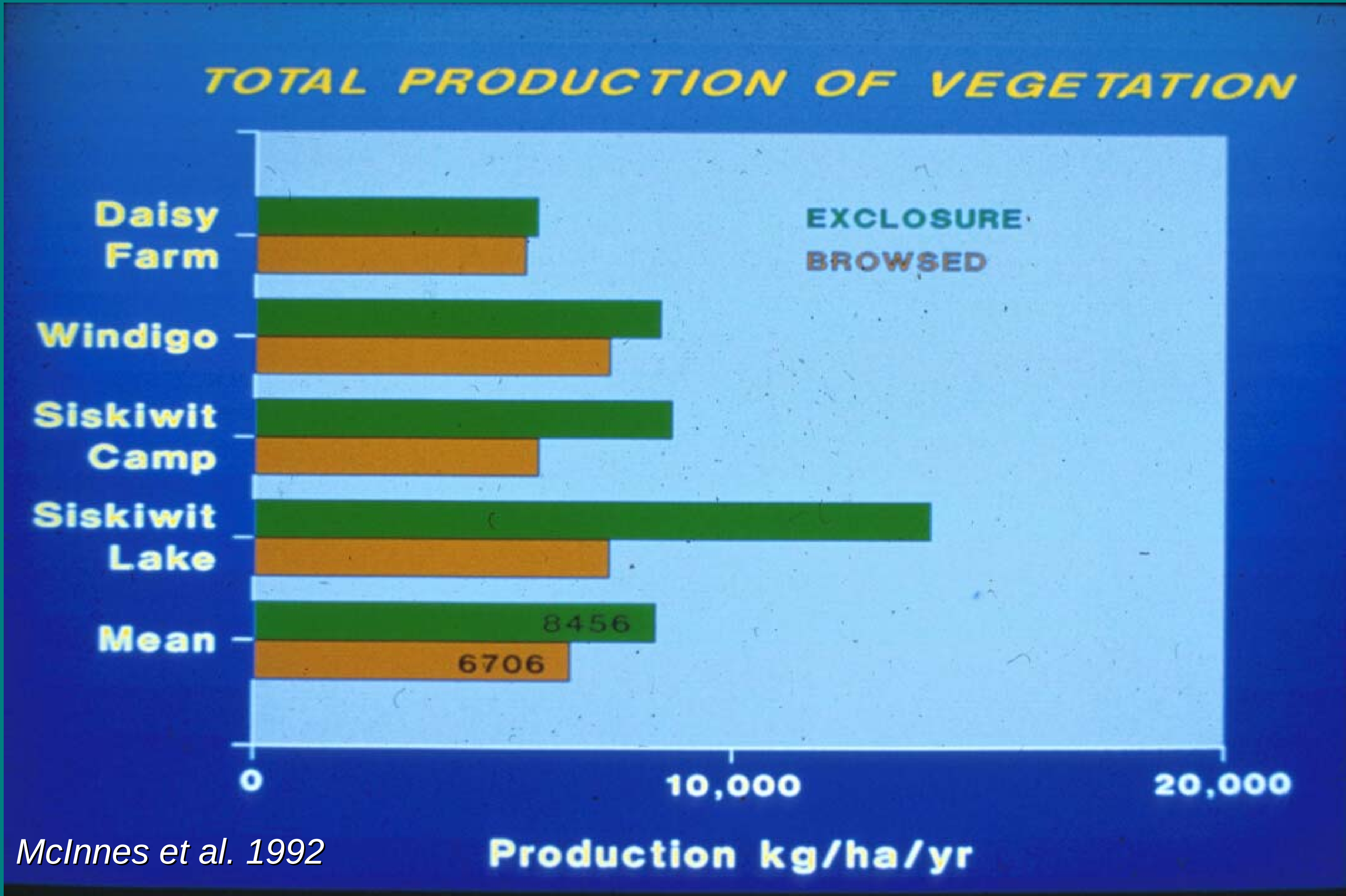
Browsing on preferred hardwoods causes then to become overtopped by unbrowsed adjacent conifers. This increases mortality of browsed hardwoods


Moose exclosure on
Isle Royale established
1948 by L. Krefting
Photo courtesy of Isle Royale National Park

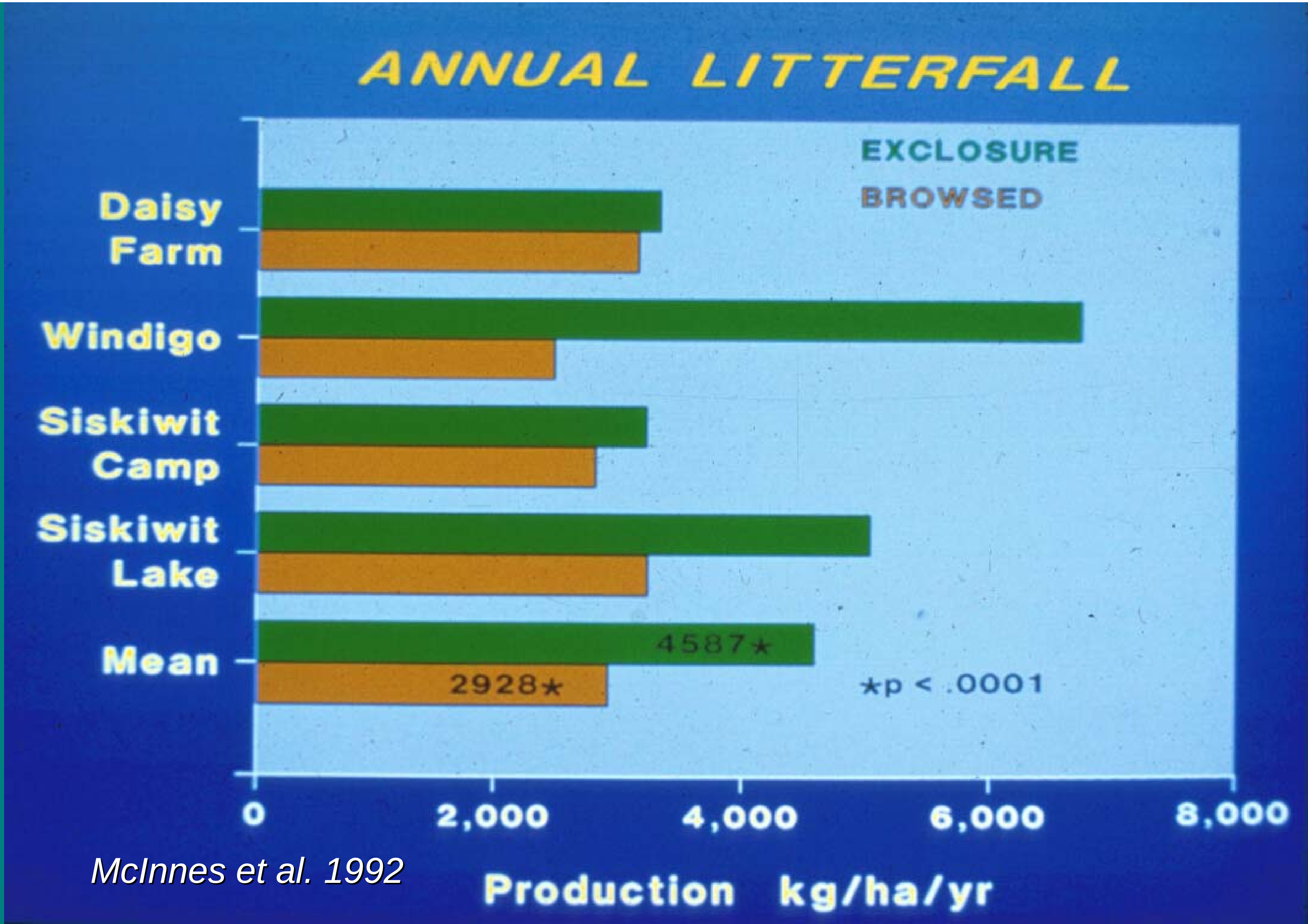

The same exclosure 5 years later. Note rapid recovery of preferred hardwood species
Photo courtesy of Isle Royale National Park


The same exclosure 40
years later

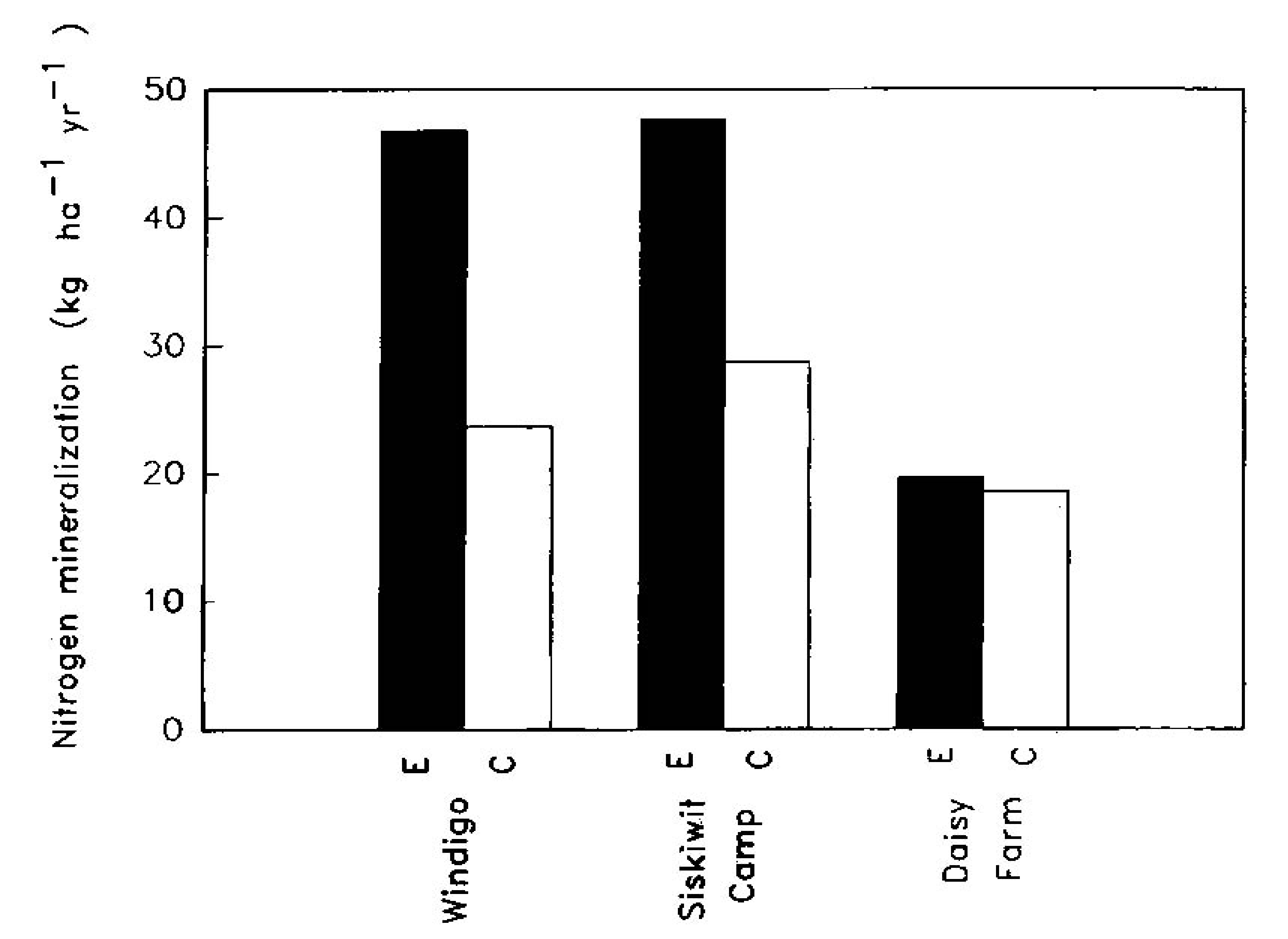

The control (browsed) plot.
Note virtual absence of
preferred hardwood
species



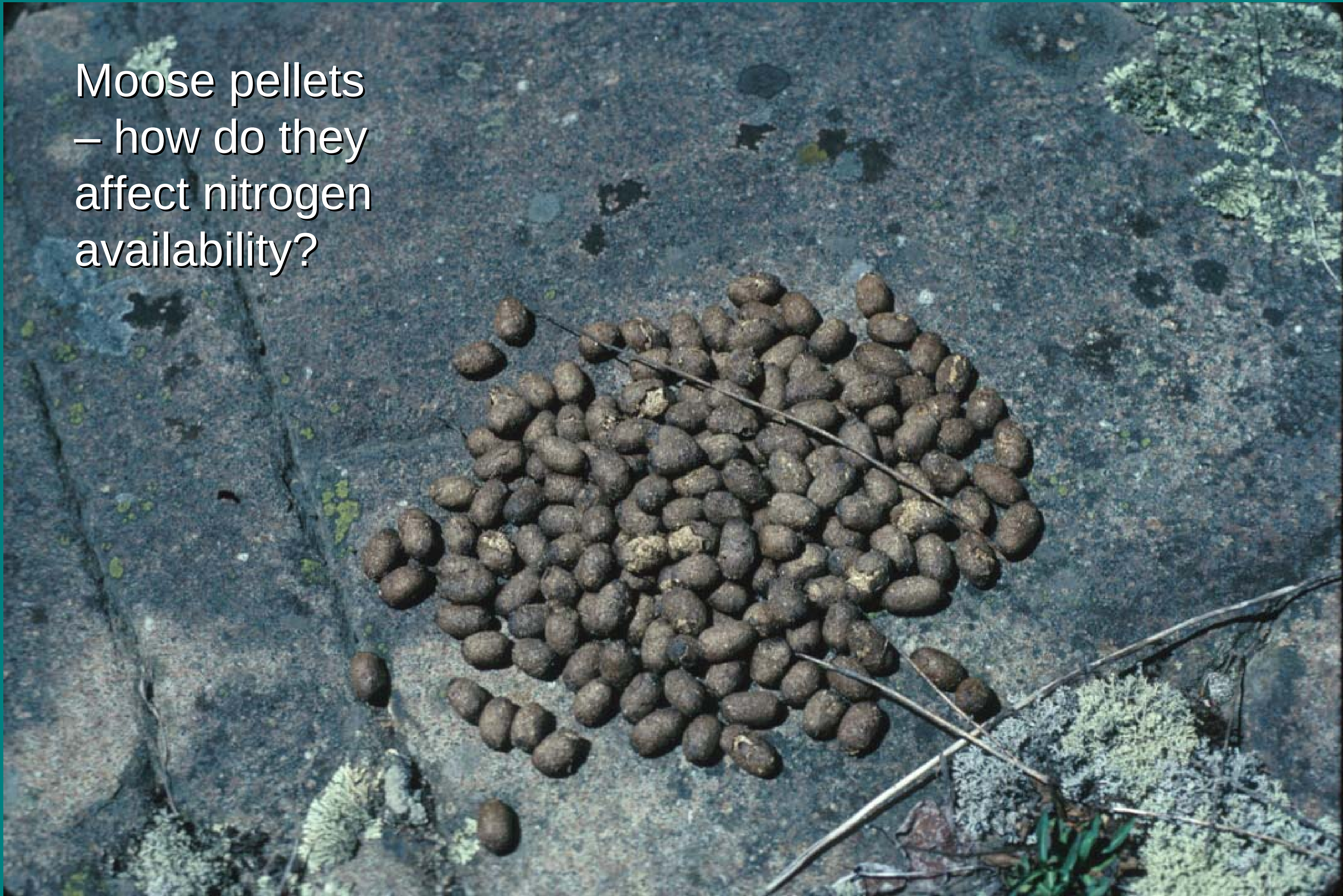
Moose browsing decreases aboveground productivity

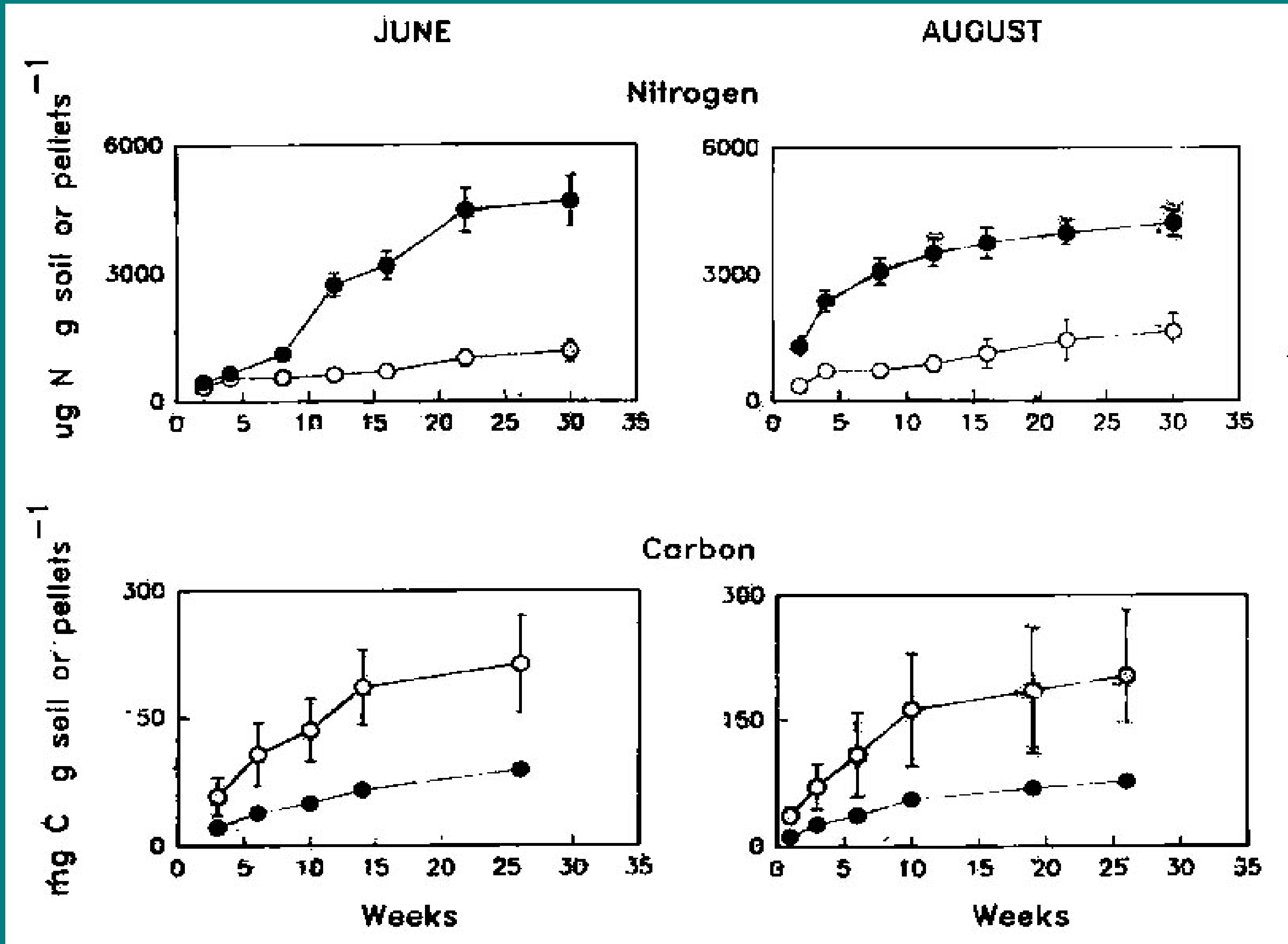


Moose browsing decreases litter return to soil



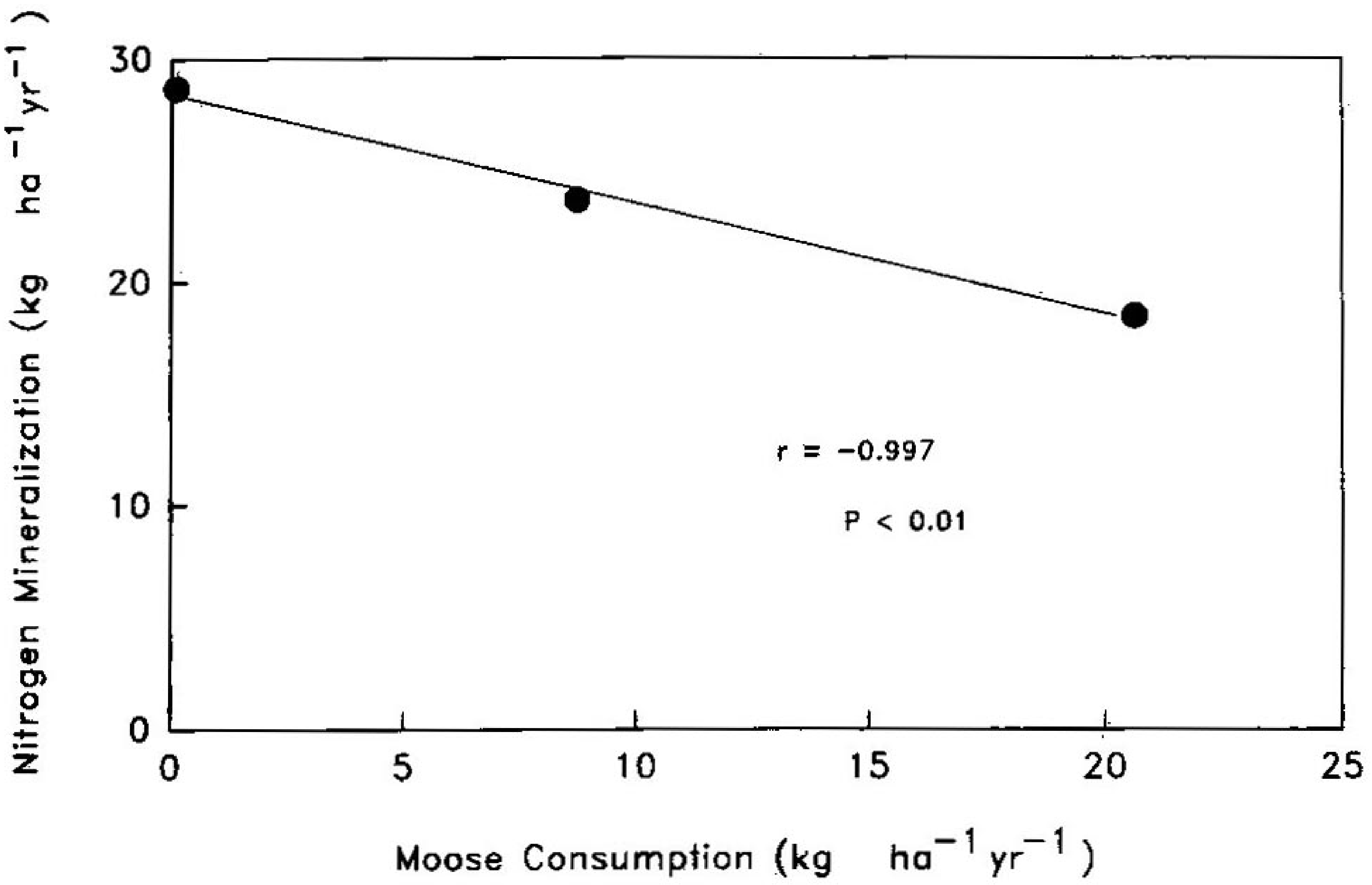
Moose browsing decreases soil N availability *Pastor et al. 1993*


Moose pellets
– how do they
affect nitrogen
availability?



Pastor et al. 1993

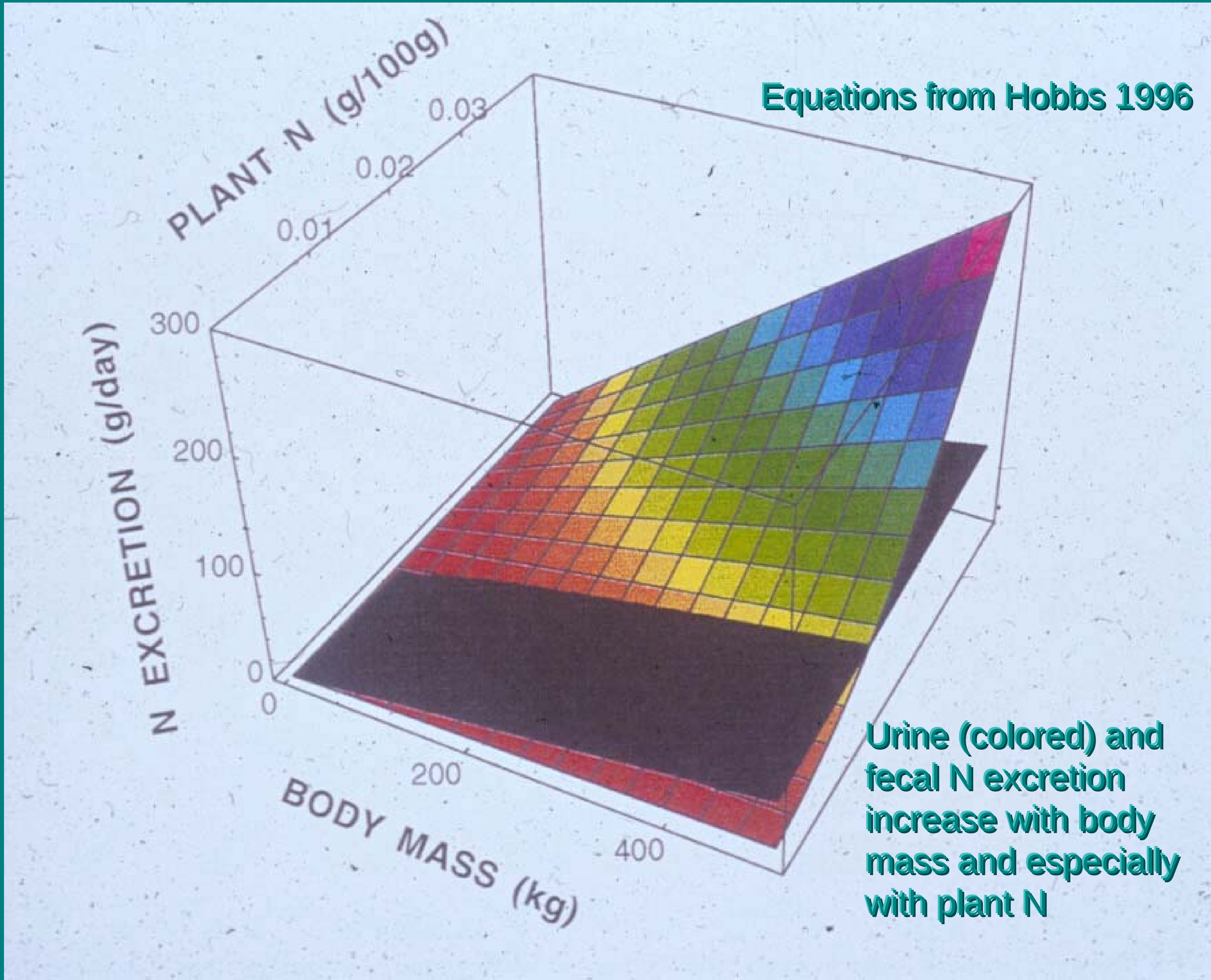
Pellets (open) mineralize N slower and C faster than humus (black)

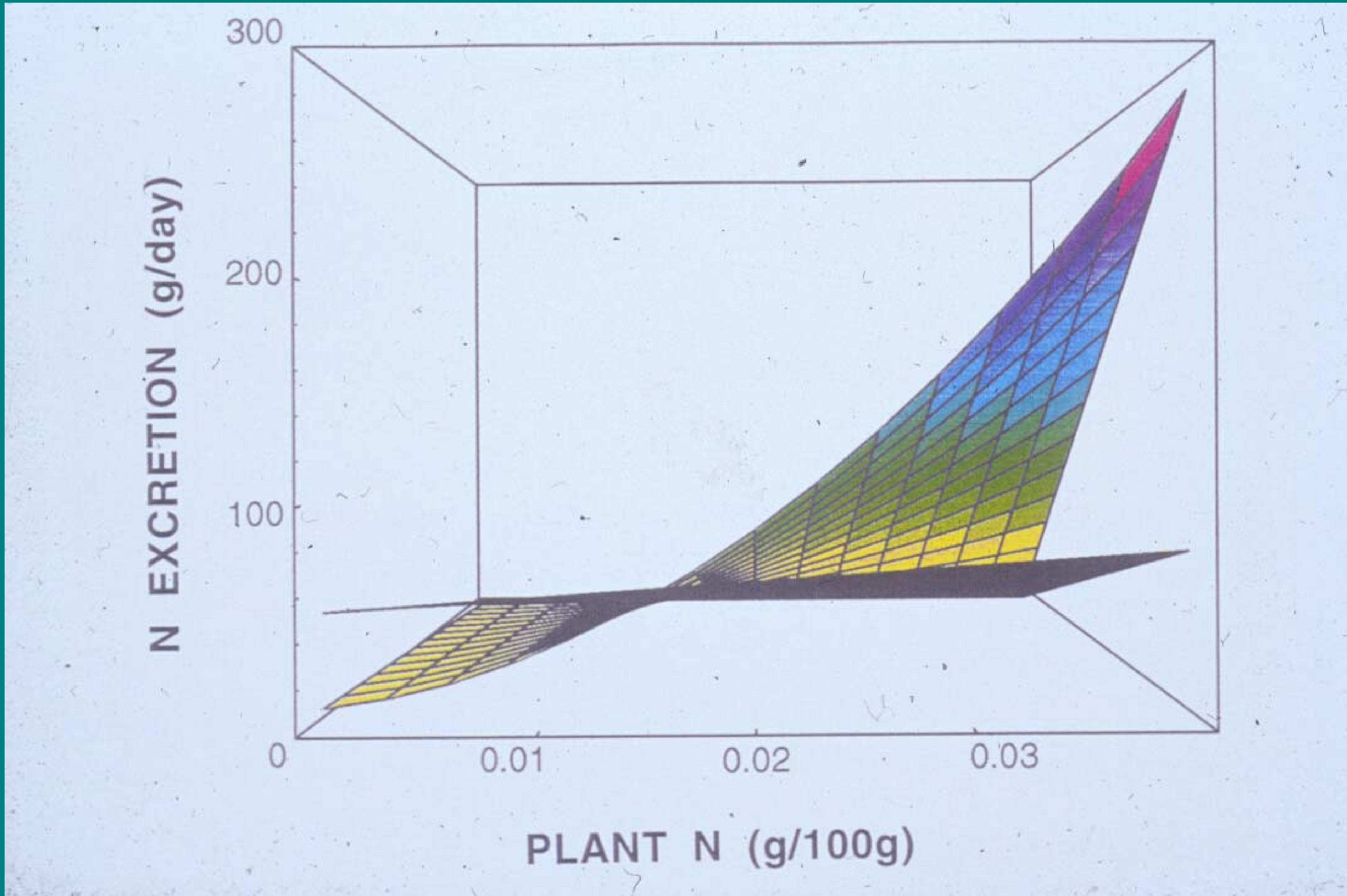


Pastor et al. 1993

Soil N availability declines in proportion to consumption of browse by moose

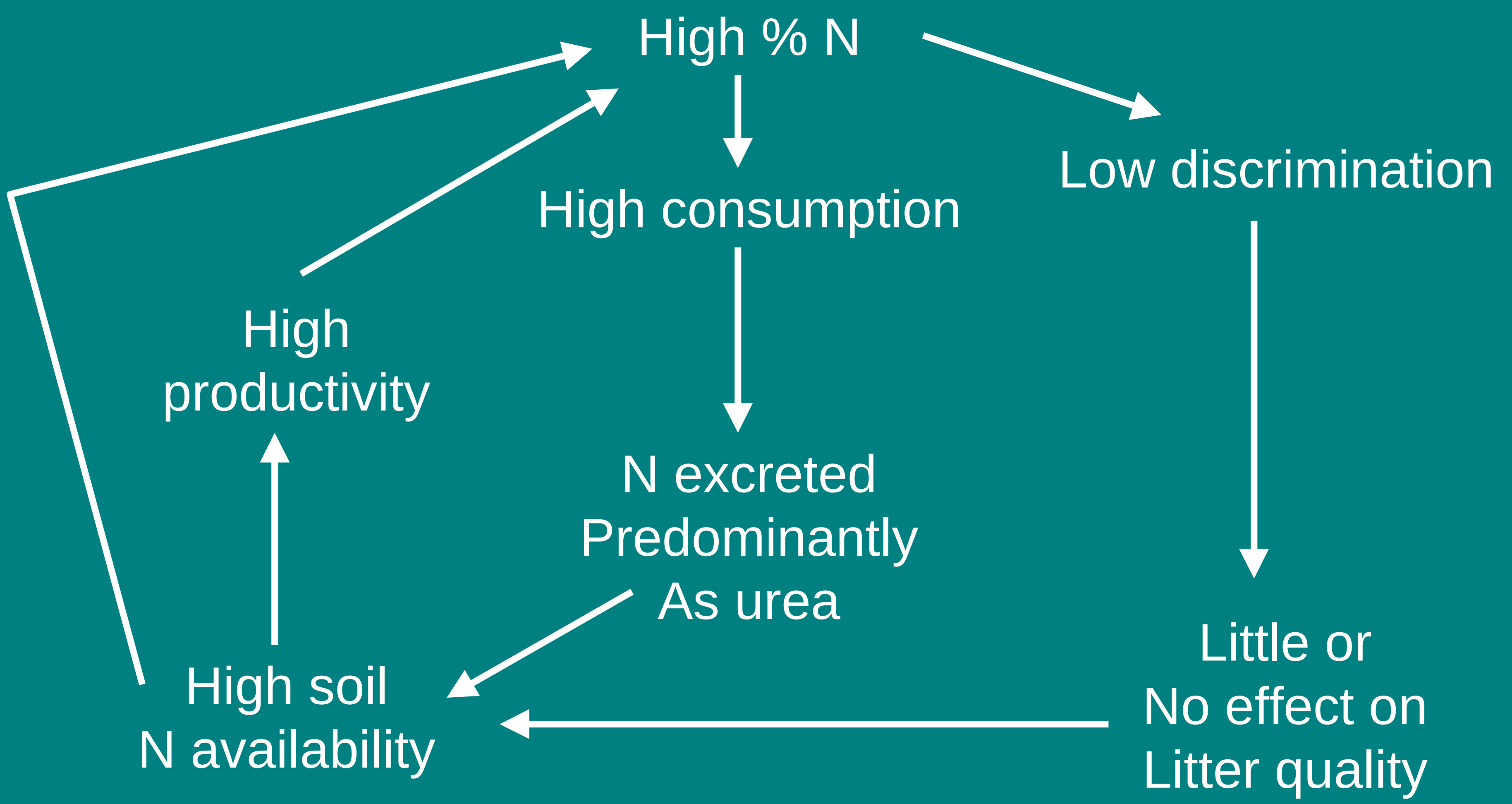
How can we reconcile the divergent responses of the Serengeti and boreal forest to herbivores?


PLANT N (g/100g)
0.01
0.02
0.03
300
200
100
0
N EXCRETION (g/day)
0
200
400
BODY MASS (kg)
Equations from Hobbs 1996
Urine (colored) and fecal N excretion increase with body mass and especially with plant N



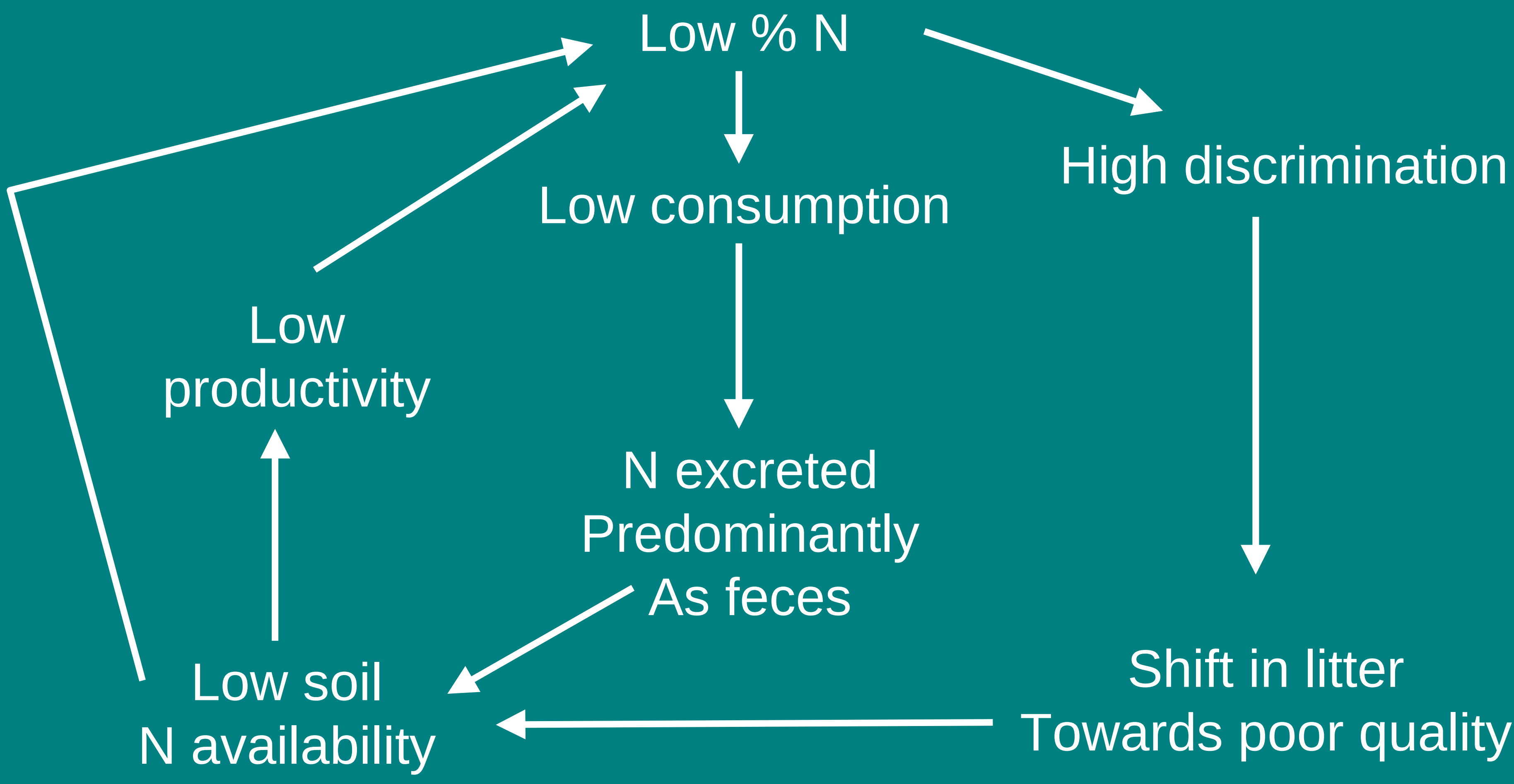
There is a critical plant %N, at about 1.5%, above which excretion is mainly in urine and below which excretion is mainly in feces

Plants with > 1.5% N



Grazing systems like the Serengeti?

Plants with < 1.5% N



Browsing systems like the boreal forest?

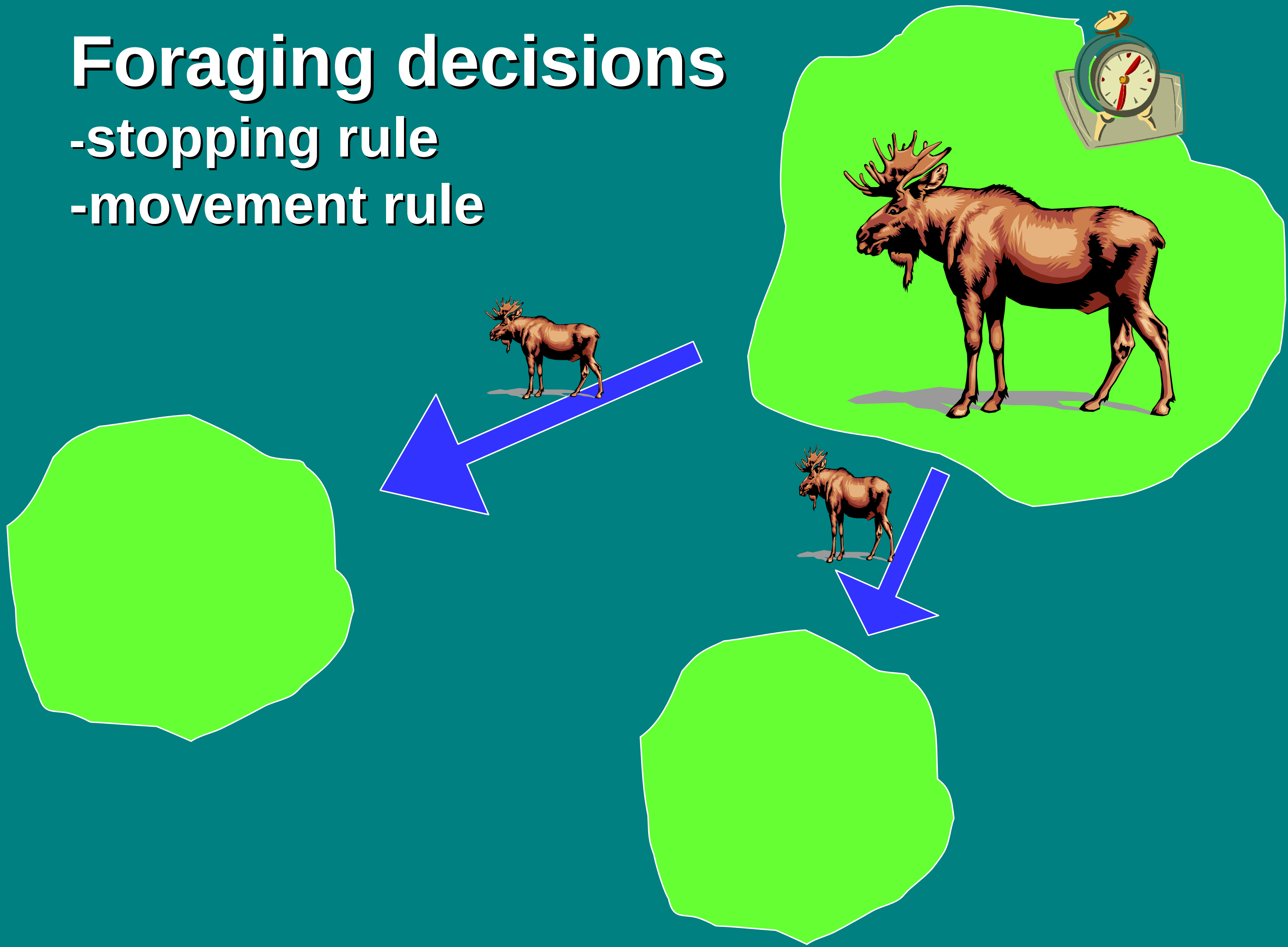
What's next?

How do ecosystem effects of herbivores relate to their behavioral decisions?

Foraging decisions

-stopping rule

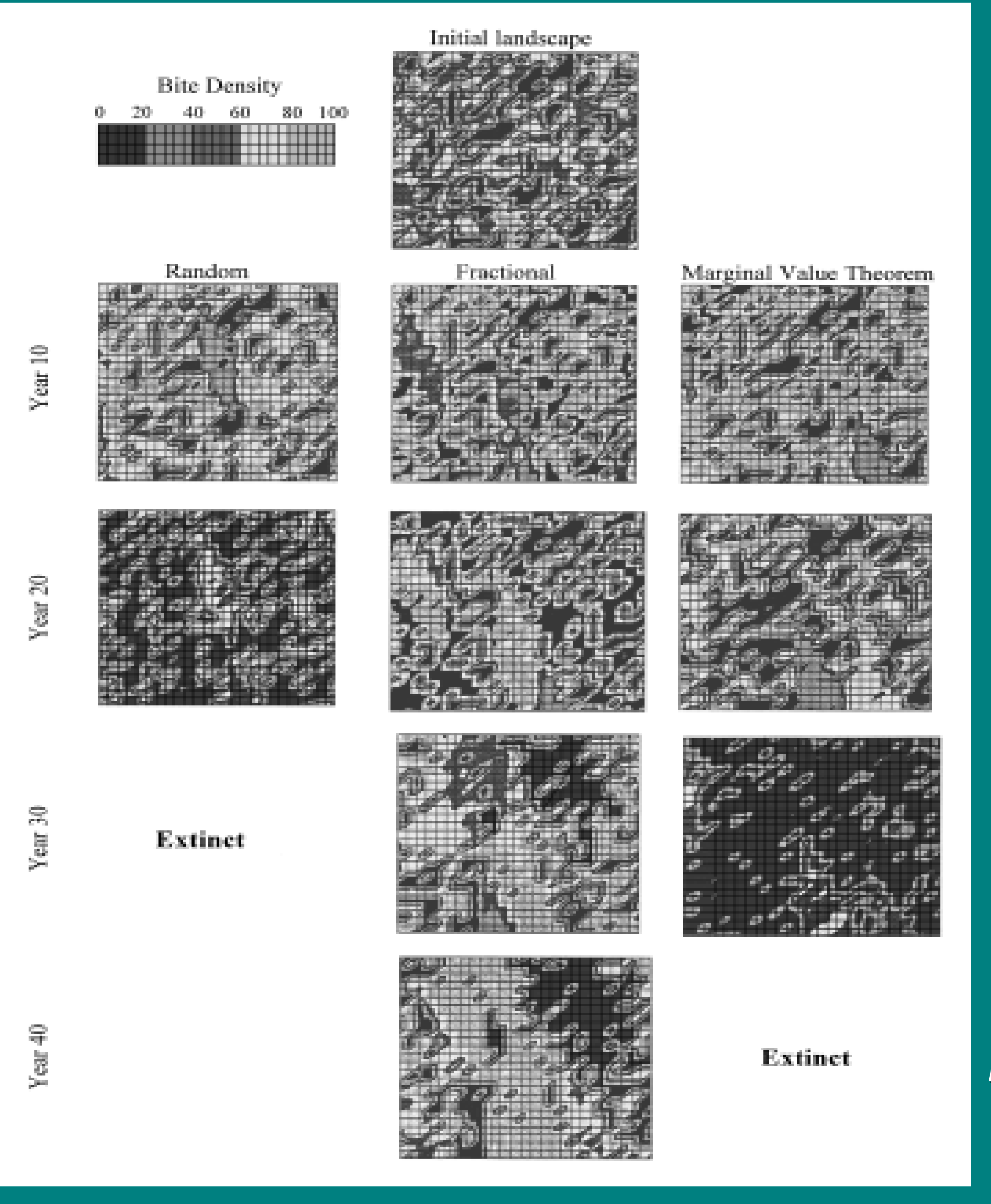
-movement rule



EASE Simulation Model

(Moen 1995)

- 8 ha landscape, 284 X 284 m, 1 m^2 cells
- Simulated moose feeds each day until energy needs are met
- Foraging strategies can be altered
- Browse distribution can be modified
- Plant growth and browse availability is updated after each step



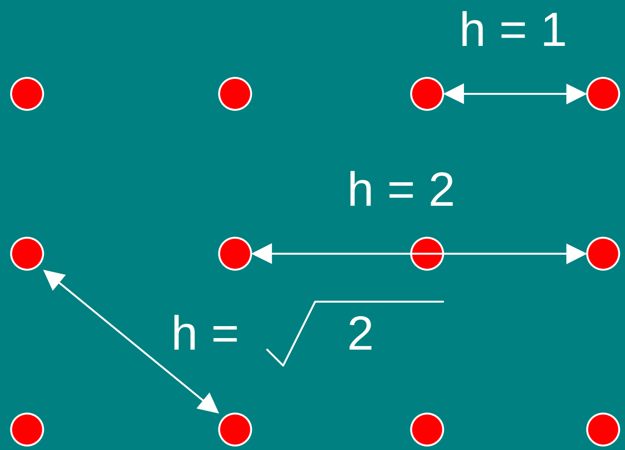
Moen et al. 1998

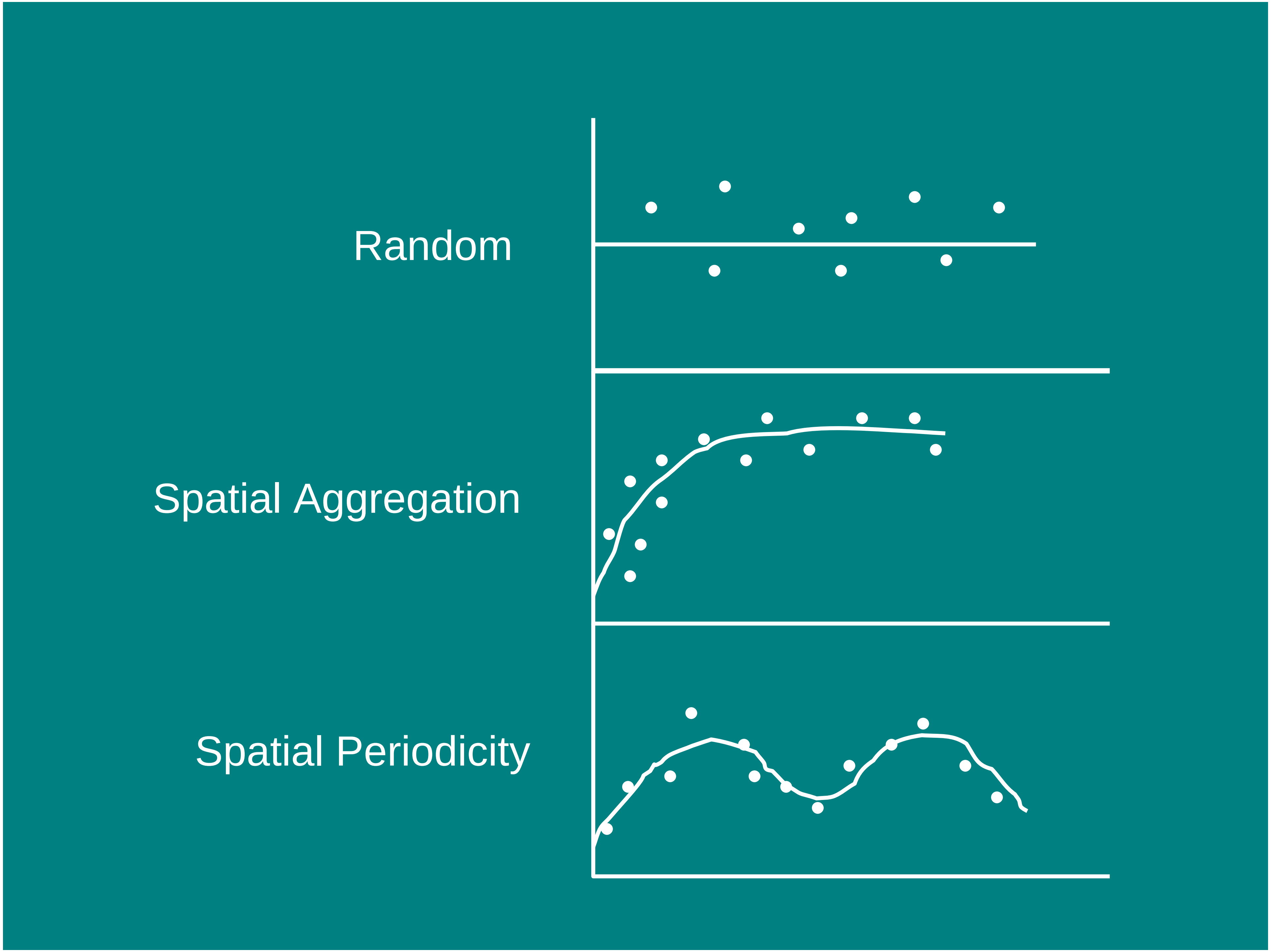
Do herbivores impose spatial patterns on the distribution of ecosystem properties?

Semivariance –

measure of spatial dependence

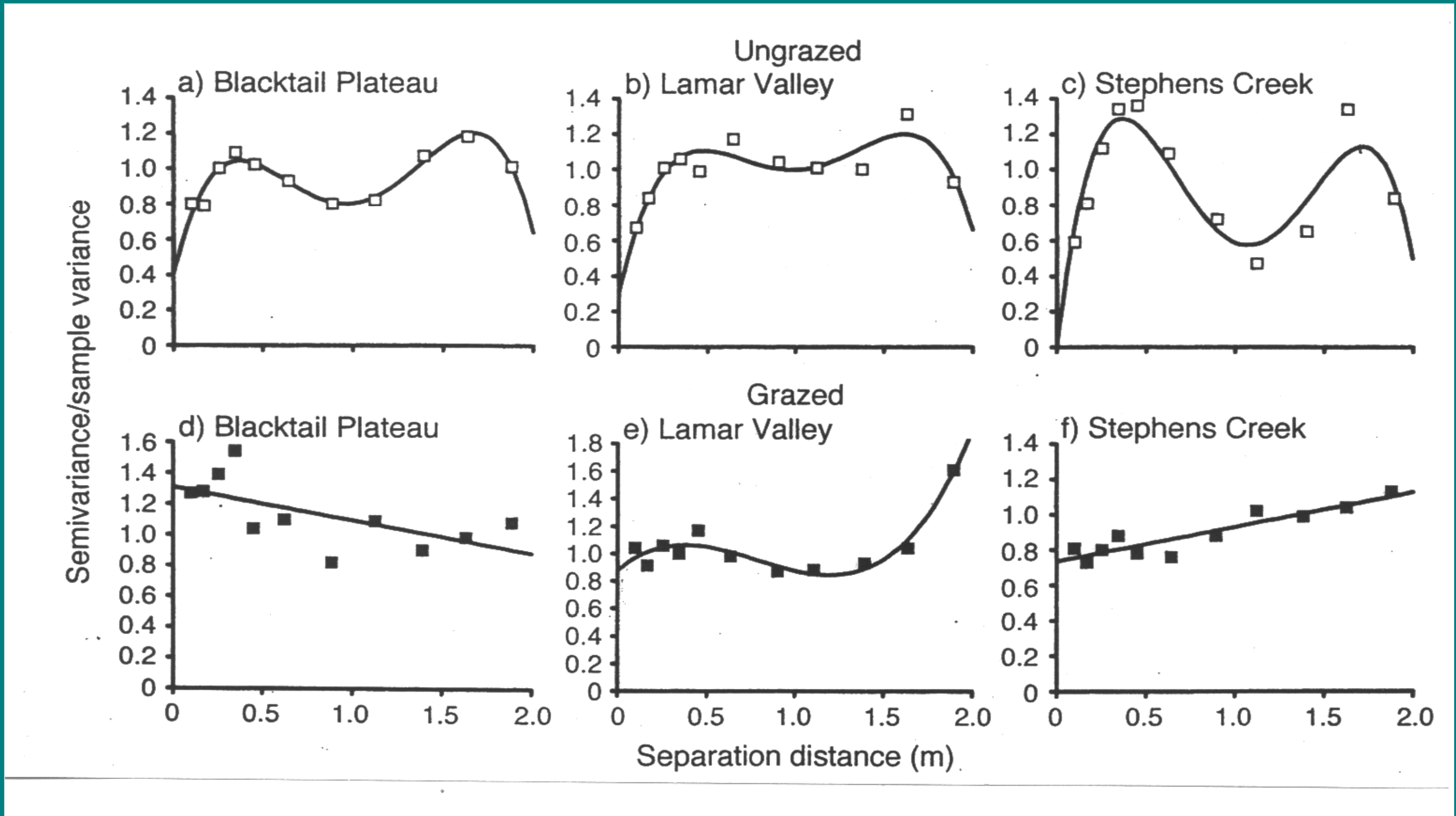
$$? (\mathbf{h}) = \frac{1}{2\,N(\mathbf{h})} \; ? \; [\,(z(x_i) - z(x_i + \mathbf{h})]^2$$





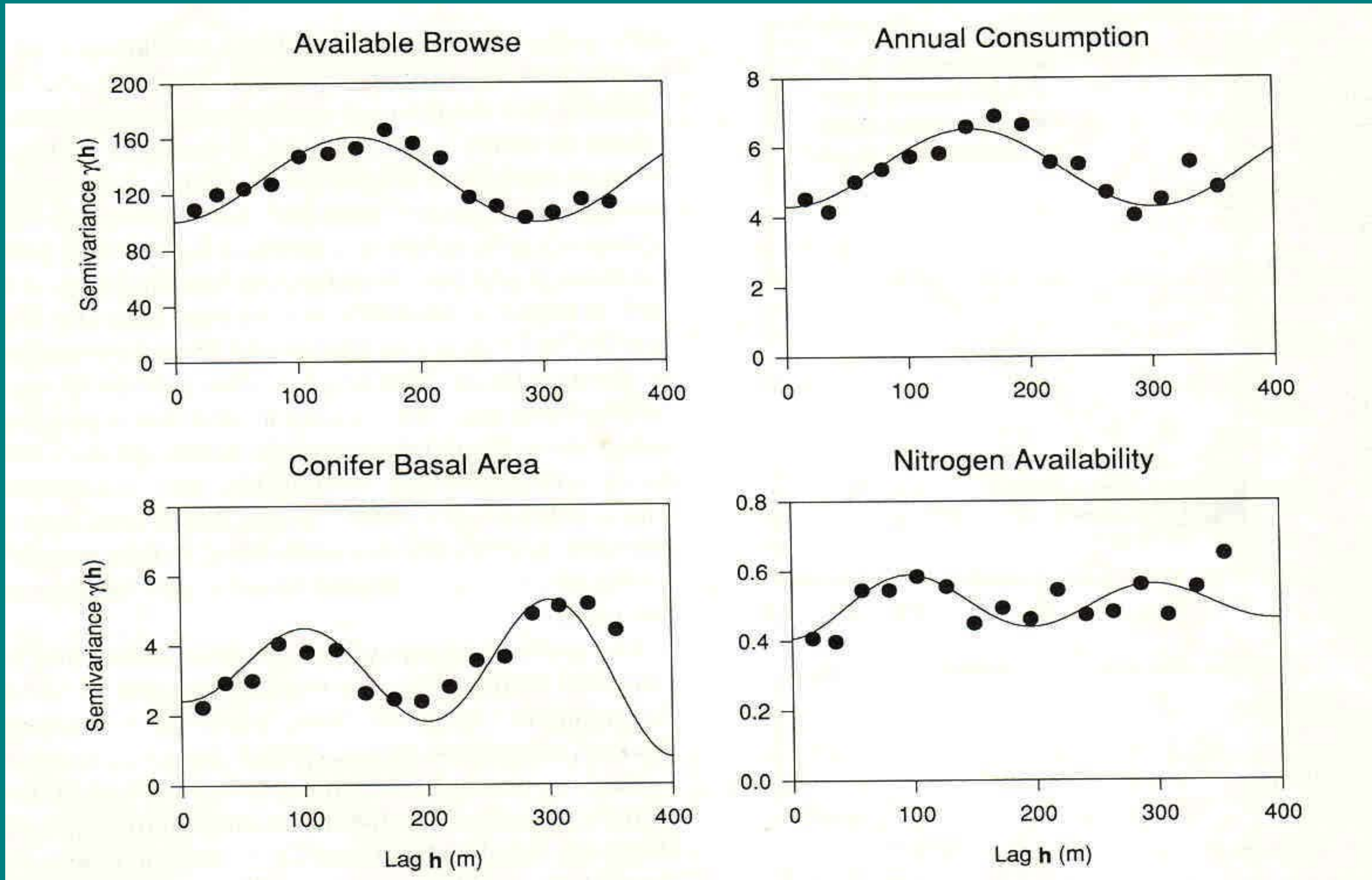
Random
Spatial Aggregation
Spatial Periodicity

Spatial patterns of soil nitrogen mineralization in Yellowstone



Augustine and Frank 2001

Spatial patterns of browse, conifers, and soil nitrogen availability on Isle Royale



Pastor et al. 1998

What are the implications of ecosystem effects of herbivores for their evolution

??