CO-EXISTENCE OF ELEPHANTS AND TREES IN SYSTEMS WITH ABUNDANT AND RARE SPECIES

Kevin Duffy

Bruce Page

Rob Slotow

Recommendations from recent workshops on the elephant-tree problem that research on the influence of elephants on biodiversity should be model driven.

Two simultaneous approaches:

1. Complex models
2. Simple models

PURPOSE OF THE MODEL

To establish in a simple elephant tree system:

1. What the key variables are.
2. Evaluate data / parameter estimates.
3. Question assumptions.
4. Dynamics.
5. Determine conditions enabling rare species to persist.

APPROACH

- Elephants in mopane woodlands.
- Single staple diet species that influences demographics.
- Rare, highly selected for species with little / no influence on elephant demographics.
- Prediction of conceptual model that equilibrium will be reached, but that rare species will be eliminated unless
  - there are refugia available
  - elephant numbers reduced to a level where the capture rate is lower than recruitment rate.

ASSUMPTIONS

1. System consists of elephants, a staple diet species (mopane) and a rare species that is highly selected for (marula).
2. The abundance of trees and elephants are quantifiable as single variables.
3. All factors influencing tree growth are constant in time.
4. The rate of elimination of trees by elephants depends only on the quantities available.
5. Growth of the tree populations is a logistic function.
6. The rate of increase of elephants is a function of the availability of trees.
7. Mopane competes with rare tree at high mopane densities.

$$\frac{\partial x_i}{\partial t} = x_i [a_i - \sum_{j=1}^{3} b_{ij} x_j] \text{ , i = 1,2,3}$$

x_1, x_2, x_3 are the densities of mopane, the rare tree, and elephants

a_i , $i = 1,2$ are the natural rate of increase of mopane and the rare tree

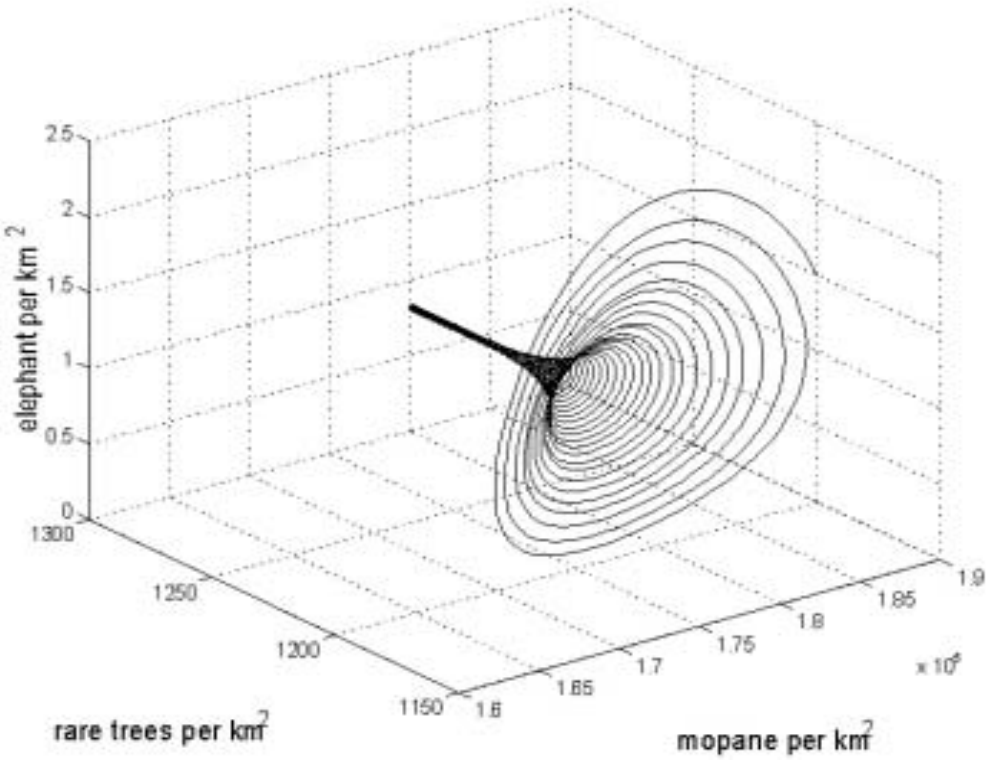
$b_{ij} = a_i / k_i$ for i=j and i, j = 1,2 and
ki are the max densities of mopane and the rare tree,

b_{ij} for $i \neq j$ and $i,j = 1,2$ are the competition coefficients between the two trees,

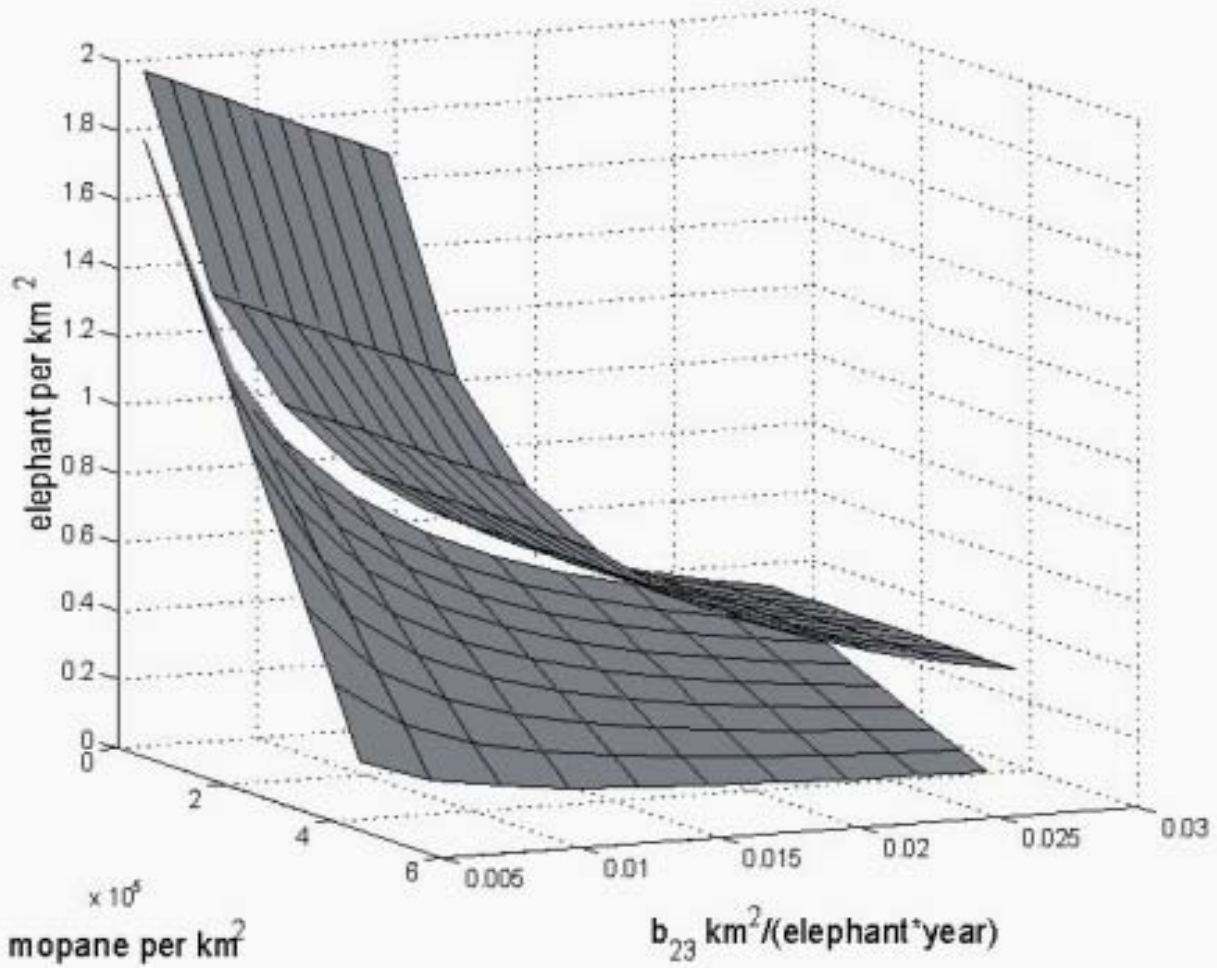
b_{i3}, $i = 1,2$ are the instantaneous rates of elimination of the two trees by elephant

$a_3 = -\delta$ the rate of decrease of elephants in the absence of trees

$b_{3j} = -g_j$ for $j = 1,2$, the rate at which the decrease is ameliorated per tree



1. Damped oscillation.
2. Equilibrium (1.03 elephants.km^{-2}, 1.77 x 10^5 mopane.km^{-2} and 1290 rare trees.km^{-2}.


elephant per km 2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
x 10^5
mopane per km^2
0.005
0.01
0.015
0.02
0.025
0.03
b23 km^2/(elephant*year)

CONCLUSIONS

1. Coexistence possible if capture rates are reduced.
2. “Too low” densities of elephants may result in loss of rare trees.
3. Shape and values of interaction functions require elaboration.
4. System too simple?
5. “Triangulation” with similar models of different form required.