Simulations of woodland grassland transitions caused by elephant

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Introduction In South Africa, reintroduction of wildlife on small to medium sized farms is common. A primary concern for the landowners who introduce elephant is the effects they will have on tree and grass densities. It is possible that elephant impact can exacerbate a shift from woodland to grassland. In this paper it is shown how simulations can possibly assist in understanding the possible dynamics involved.

Simulation methods Global characteristics of the dynamics between elephant and trees are simulated using ordinary differential equations (given in Stretch & Duffy, 2003). A range of parameters from literature data applicable for African Savannah's were used (Stretch & Duffy, 2003). These differential equations ignore spatial heterogeneity that can be simulated using a grid-based simulation. A grid is placed on a vegetation map of a region and elephant and tree dynamics are simulated as elephant move from square to square.

Results Data from the Pongola Game Reserve (PGR) in South Africa, a relatively small game ranch (75 km^2), where elephant were reintroduced gave initial tree reduction by elephant as 0.035 /year at a density of 0.3 elephant/ km^2 (Duffy *et al*., 2002). Using equations alone no combinations of parameters could mimic this trend. In the model, one parameter *teq* represents the overall trees needed per elephant in their range Varying *teq* revealed that it is possible to recreate the first few years of elephant growth together with tree removal in the PGR using a value of *teq* = 8000 trees/elephant. Simulations using this value for the next 60 years result in a constant decrease in trees (Figure 1). Although grass is not directly part of the model it is evident that this would represent a switch from wooded Savannah to grassland.

Different areas of the region have similar elevation, species composition and distance from water, but have different elephant impact (Duffy *et al*., 2002). This difference is found to be as large as a factor of four and is quite surprising because it is assumed that food preference is based on environmental conditions and food species composition. Using the grid-based model it is possible to recreate these differences for individual runs. This result is dependent on the stochastic nature of elephant movement over a short time frame. This indicates that while the data in Duffy *et al*. (2002) is useful for understanding initial elephant impacts it cannot be used conclusively for global model parameters. It is interesting to reconsider the density of trees required for elephant equilibrium *teq* (the only one based on PGR data). By varying this parameter it is possible to show at what value the density of trees can persist.

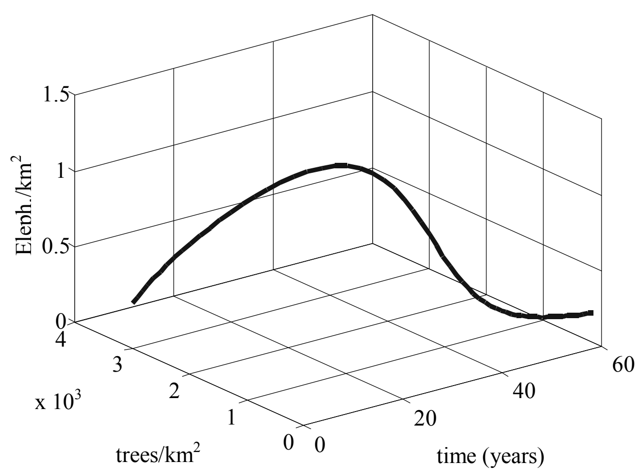

Figure 1 Model trajectory for tree density against elephant density over time for PGR. Initial conditions are: trees =30000 trees/km^2 and elephant =0.3 elephant/km$^{2)}$; the trajectory tends to an equilibrium (E_0=0.2 elephant/km^2 and T_0=1000 trees/km^2) representing low tree density

Conclusions The differential equation model used here is simple and these types of model have been considered theoretically in detail before. They can be used to understand the dynamic trends of a system if parameterisation is done. For a specific situation the parameterisation can be difficult. Certain parameters depend on the characteristics of the exact environmental conditions, especially in cases where reserves are small. However, combining these with grid methods, global trends can be considered.

References

Duffy, K., R. van Os, S. Vos, J. van Aarde, G. Ellish & A. Stretch (2002). Estimating the impact of reintroduced elephant on the trees of a small reserve. *South African Journal of Wildlife Research,* 32, 23-29.

Stretch, A-M. & K. Duffy (2003). Understanding global elephant and tree dynamics with ode's. *Mathematics and Computer Education*, 37, 184-192.