# *Setting the Thresholds of Potential Concern for Invasive Species*

## *Rationale*

The principle that the KNP is not an island and is substantially impacted upon by actions beyond its borders is a central tenet of understanding and managing alien species invasions (as is river management). Working in concert with this is the acceptance of the paradigm of spatial and temporal flux within the ecosystem (Pickett, Cadenasso and Benning 2003, Rogers 2003). This needs to be embraced in the context of invasions as well (Foxcroft 2004a). Although desirable, the eradication or control of all alien species is neither feasible nor practical. Thus fluxes in invasions and alien species populations must be accepted as well, although this is contrary to most alien species ideals. This means that most managers concerned with alien species would strive to eradicate or manage all alien species and suppress the populations to as close to zero as possible. We contend that this approach is not possible in the KNP, due mainly to the size of the KNP, and the number of species present. We suggest that management will be more effective by placing its resources on the most problematic species only and in the areas where they are becoming problematic. As long as the species is present at below acceptable thresholds, for a determined period of time, the species should not be a management priority. Thus, the TPC system allows for the system to fluctuate, including alien species, but highlights critical 'turning points' of concern in biodiversity effects of aliens (Foxcroft 2004a).

The first invasive species TPCs (Foxcroft & Richardson 2003) provided a list of various criteria for evaluation. Experience however highlighted the need to adapt the system due to repeat excedances of the same TPCs. In other words, the TPC system was not able to sensibly deal with repeat invasions, which were no longer cause for the same level of concern. This led to the development of multiple-level TPCs to avoid raising 'false alarms' (Foxcroft 2004a).

The basis of the principles adopted for the development of these TPCs is captured in the 'barriers' model of Richardson et al. (2000). Using this approach, the 'points of concern' are reflected as the barriers or filters to invasion, and overcoming the barrier invokes the next level TPC (Fig. 1). As a species approaches the KNP, the management response will be to prevent the introduction (point **a** in Fig. 1). This will entail, where possible, the KNP controlling the population itself, or partnering with institutions such as provincial alien clearing project (for example Working for Water) or by co-operative agreements with landowners. Once the species has invaded the KNP, the next level of TPC monitors the spread of the species, where eradication (if possible) or

containment strategies are called into force (point **b**). There may however be examples where the tabling of a TPC would lead to a well considered "do nothing" option. Theoretically at least, the next level will be once all available habitat has been invaded. At this point the main concern will be the abundance of the species (point **c**). However, although a species may not have expanded its range to include the entire available habitat in the KNP, it is assumed that at a local scale, patches will have reached a density that will have some level of impact on biodiversity (composition or function) (point **d**).

The invasive species TPCs, while already having undergone revision (see Biggs and Rogers 2003, Foxcroft and Richardson 2003, Freitag-Ronaldson & Foxcroft 2003, Foxcroft 2004, Foxcroft and Downey in prep,) do not yet fully incorporate biodiversity impacts. Rather, the current TPCs represent management or operational TPCs, which have loosely been termed "tracking" TPCs. which focus on the alien species rather than on their biodiversity effects. This therefore means that the negative biodiversity impacts are implied and the presence of alien species unacceptable to the biodiversity conservation values of the organisation.

**Relation to KNP objectives**

The revised objectives provide for a holistic approach to invasive species management (KNP 2005) and include all alien species. We deliberately use the term "alien" as opposed to various synonyms such as "exotic", due to the potential confusion it creates. Alien species that actively invade are termed "invasive" and the most serious invasive species that change the character or function of the system are termed "transformers" (Richardson et al. 2000). Falling under the 'ecosystem objective', the main aim of the 'alien impact objective' is "To anticipate, prevent entry and where feasible and/or necessary control invasive alien species in an effort to minimize the impact on, and maintain the integrity of indigenous biodiversity". For the purposes of the KNP, alien species are defined as "Any species or organisms which have been introduced into, or entered the park on its own accord, from outside its borders". The implication of this would therefore be that:

1) any species from outside the boundaries of South Africa would be considered alien (except in the case of the Mozambique and Zimbabwe sections of the Trans Frontier Conservation Area (TFCA)- which is a natural extension of the KNP ecosystem),
2) any species that may be indigenous to South Africa, but not occur within the KNP ecosystem, would be considered alien to the KNP ecosystem.

3) any species within the KNP, but moved from within one particular landscape to another where it does not naturally occur, would be considered alien in that landscape.

Although the list of objectives is fully described in KNP (2005), the five main alien impact objectives are summarised here. These objectives closely follow the principles advocated by international best management practice standards (see Wittenberg and Cock 2001, 2005).

1. *Strategy and support*: To develop a long-term strategy for the management of IAS, by evaluating the current and projected future overall scale of threat, addressing organisational and infrastructural capacity, developing policy and building support for continued high level commitment.
2. *Prevention*: To anticipate and evaluate imminent or potential risks to the KNP, as well as pathways of invasion and develop effective mechanisms to monitor, manage or mitigate these.
3. *Control*: To ensure the effective and timely development and implementation of integrated control strategies, in such a manner that both rapid response and long-term maintenance goals are met.
4. *Research*: To promote and develop a coordinated research programme in order to develop a clearer understanding of the dynamics and impacts of alien species invasions.
5. *Awareness*: To develop an awareness programme to inform and educate on especially the dangers and consequences of invasive alien species, in order to facilitate global invasive alien species initiatives.

The current TPCs link directly to prevention and control, in that acceptable limits of spread are set. The research objectives cover the development of programmes to evaluate the impacts of invasions at various scales and levels.

**TPC**

Although all the TPCs are nested within the framework outlined, the following section discusses the hypotheses and theory behind each of the individual TPC criteria.

**Level 1 TPCs**: TPCs that deal with new invasions of a species in the KNP

- Imminent external threat (a species on the boundary, that will invade within 12 months)
- First ever record in the KNP

Principles:

1) The introduction of any new alien species is contrary to the mandate of SANParks (KNP 2005, Foxcroft 2005b).
2) The potential negative impacts of biological invasions far outweigh the risk that the alien species will be benign (for example see Mooney et al. 2005, and the numerous references therein).
3) A 12 month period of likely entry into the KNP should provide sufficient time for developing management strategies and controlling the population appropriately outside of the KNP. This should however be considered per species and adjusted accordingly where necessary. Although this is not stated as a hypothesis backed by a body of scientific literature, this is based on experience gained by the author working in the KNP managing alien plant invasions.

**Level 2 TPCs:** TPCs that deal with an increase in distribution of a species (or all species combined) in the KNP, over a 12 month period.

- First ever record from a new grid cell
- Any new grid cell invaded that is not contiguous with the previous distribution
- Expansion of invasive species through contiguous grid cells which represent more than a 5% increase over the number of grid cells recorded as invaded in the reference (base) year.

Principles:

1) The early detection of new incursions of invasive species will allow timely response and potential for eradication. This principle is widely accepted (Wittenberg and Cock 2001, 2005) as a standard procedure for the successful control of invasions. Further, studies suggest that once an invasion has increased to an area of over 100ha, the chances for eradiation are minimal (Rejmanek & Pitcairn 2002). The increase of propagule pressure will at some stage reach a critical mass, at which point management will be compromised. This is based on the "long-fuse, big bang" theory, which states that although a build-up of alien species may be slow initially, this is followed by a rapid and

exponential increase in the population and propagative individuals and is seldom manageable once reaching this point (Wilkinson 1995, Chapman, Le Maitre and Richardson 2001).

2) The eradication of newly formed invasion foci will increase the probability of containing the invasion at its current extent (Moody and Mack 1988). Although the criteria stated above were already determined in the first iteration, only the 'first ever record from a new grid cell was used'.
3) Although expansion and contraction of alien species is expected to occur through natural processes (the acceptance of a flux paradigm), the total area of the invasion should not be allowed to increase above a stated maximum tolerable "ceiling" level, from the base scenario. This level is currently stated as 5%, but is a guess and requires refinement.

**Level 3 TPCs**: TPCs that deal with an increase in density of a species (or overall alien species density) in the KNP. These TPCs are not yet operational however, due to the lack of data and efficient cost-effective monitoring options to date. They are nonetheless described hypothetically and may in future have the potential to be used as surrogates for biodiversity impacts.

- Any increase by 2 density classes or more in any grid cell
- Any increase of 1 density class upwards of "medium density" in any grid cell.

Density is currently measured in the following classes, but will be reviewed as monitoring options are evaluated:

- Rare: The species is present in the area but at very low densities with individuals being seen here and there; density = 0.01%
- Occasional: Plants are widely spaced, occurring here and there – on average more than 10 canopy covers apart; density = 0.02 – 1%
- Very Scattered: The plants average 3 – 10 canopy diameters apart; density = 1.1 – 5%
- Scattered: The plants average 1 – 3 canopy diameters apart; density = 5.1 – 25%
- Medium: There are clear and plentiful gaps between the canopies of the plants and other vegetation is still present and vigorous; plants average 0.3 – 1 canopy diameters apart; density = 25.1 – 50%
- Dense: There are small gaps between canopies and no canopy overlap and the other vegetation is still present; plants average 0.1 – 0.3 canopy diameters apart; density = 50.1 – 75%
- Closed: Plant canopies are closed, touching or overlapping and other vegetation is generally suppressed, sparse or lacking; the plants average less than 0.1 canopy diameters apart; density > 75%

**Hypothesis:**

1) The increase in density of invasive species will lead to an impact on indigenous biodiversity, in terms of composition, function or structure. However, this hypothesis has not been tested in the KNP and only arbitrary density values have been assigned as evaluation criteria thus far.

***Future work***

An important issue that will need attention in the next five years is developing an understanding of invasions in the KNP context (in terms of ecology and impacts). From this we can then refine or develop new "biodiversity impact" TPCs that either directly, or through use of appropriate surrogates, address the issue of negative biodiversity impacts. This was highlighted in the 'postview' of the objectives hierarchy as an important avenue of future research (KNP 2005). A start has been made on this through research that aims to quantify impacts on selected biodiversity indicators. This however clearly needs to be expanded to measure impacts on other ecosystem components such as ecosystem services and provisions. Useful studies have been done on the water use impacts of various land-use practices (commercial forestry using alien trees) and naturalised and invasive plant species (for examples see Versveld 1998, Le Maitre 2000, 2001). Similarly, we need to develop an understanding of the relationship between abundance, distribution and impacts on the ecosystem. Do you mean you need to develop the ability to express impacts in terms of biodiversity loss?

The idea of 'rate of change' and 'buffer capacity' TPCs has also been suggested. 'Rate of change' refers to the speed at which the system is approaching the point of ecosystem change. The concept of 'buffer capacity' should address the ability of the system to respond to the suite of potential management actions before changing to an undesirable state. This is a philosophical change in and refinement of the 'old' TPCs and requires more careful consideration and modelling approaches. For example, if we gained an understanding of the time it takes to reach an alternative state, dominated by alien species, we could model potential invasions and set TPCs according to these rates. Following control or removal of the invaders, the legacy effects, for example persistent nutrient or soil chemistry changes, would determine the buffer capacity of the ecosystem to recovering from invasion.

## Conclusion

The development of TPCs for managing invasive species presents an approach to management, which is fundamentally proactive in nature. The system allows for natural ecosystem flux, but within pre-defined thresholds of acceptability. This represents a pragmatic approach to a substantial biodiversity concern over a vast area.

## References


Biggs H.C. and Rogers K.H. 2003. An adaptive system to link science, monitoring and management in practice. In J.T. Du Toit, K.H. Rogers and Biggs, H.C. (eds.) The Kruger Experience: ecology and management of savanna heterogeneity. pp. 59-80. Island Press, Washington.

Chapman R.A., Le Maitre D.C. and Richardson, D.M. 2001. Scenario planning: understanding and managing biological invasions in South Africa. In McNeely, J.A. (ed.) The great reshuffling: Human dimensions of invasive alien species. IUCN, Gland, Switzerland and Cambridge, UK.

Du Toit J.T., Rogers K.H. and Biggs H.C. (eds.) 2003. The Kruger Experience: ecology and management of savanna heterogeneity. Island Press, Washington.

Foxcroft, L.C. 2005a. An adaptive management framework for linking science and management of invasive alien plants. Weed Technology 18: 1275-1277.

Foxcroft, L.C. 2005b. Alien species in Kruger National Park. Over-arching policy document, version 1. South African National Parks (SANParks).

Foxcroft, L.C. and Downey, P.O. *In prep*. Protecting biodiversity by managing alien plants in national parks: Perspectives from South Africa and Australia.

Foxcroft, L.C. and Richardson, D.M. 2003. Managing alien plant invasions in the Kruger National Park, South Africa. In: Plant invasions: ecological threats and management solutions (ed.) by L.E. Child, J.H. Brock, G. Brundu, K. Prach, P. Pyšek, P.M. Wade and M. Williamson, pp. 385–403. Backhuys Publishers, Leiden, The Netherlands.

Freitag-Ronaldson, S. and Foxcroft, L.C. 2003. Anthropogenic influences at the ecosystem level. In J.T. Du Toit, K.H. Rogers and Biggs, H.C. (eds.) The Kruger Experience: ecology and management of savanna heterogeneity. pp. 391-421. Island Press, Washington.

Kruger National Park (KNP). 2005. Revision of the Management plan for the Kruger National Park, Part 1: Objectives Hierarchy. S. Freitag-Ronaldson (ed). South African National Parks.

Le Maitre, D.C., Versfeld, D.B. and Chapman, R.A. 2000. The impact of invading alien plants on surface water resources in South Africa: A preliminary assessment. Water South Africa 26, 397-408.

Le Maitre, D.C., van Wilgen, B.W., Gelderblom, C.M., Bailey, C., Chapman, R.A. and Nel, J.A. 2001. Invasive alien trees and water resources in South Africa: case studies of the costs and benefits of management. Forest Ecology and Management 5538, 1-17.

Moody, M.B. and Mack, R.N. 1988. Controlling the spread of plant invasions: the importance of nascent foci. Journal of Applied Ecology 25: 1009-1029.

Mooney, H.A., Mack, R.N., McNeely, J.A., Neille, L.A., Schei, P.J. and Waage, J.K. (eds.) 2005. Invasive alien species: a new synthesis. Scientific Committee on Problems of the Environment (SCOPE): 63. Island Press, Washington, Covello, London.

Pickett, S.T.A, Cadenasso, M.L. and Benning, T.L. 2003. Biotic and abiotic variability as key determinants of savanna heterogeneity at multiple spatiotemporal scales. In J.T. Du Toit, K.H. Rogers and Biggs, H.C. (eds.) The Kruger Experience: ecology and management of savanna heterogeneity. pp. 22-40. Island Press, Washington.

Rejmánek, M. & Pitcairn, M.J. 2002. When is eradication of exotic pest plats a realistic goal? In C.R. Veitch and M.N. Clout (eds.) Turning the tide: the eradication of invasive species. pp. 249-253. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Richardson, D.M., Pyšek, P., Rejmánek, M., Barbour, M.G., Panetta, D.F. & West, C.J. 2000. Naturalization and invasion of alien plants — concepts and definitions. Diversity and Distributions, 6, 93–107.

Rogers, K.H. 2003. Adopting a heterogeneity paradigm: implications for management of protected savannas. In J.T. Du Toit, K.H. Rogers and Biggs, H.C. (eds.) The Kruger Experience: ecology and management of savanna heterogeneity. pp. 41-58. Island Press, Washington.

Stankey, G. H., D. N. Cole, R. C. Lucas, M.E. Petersen, and S. S. Frissell. 1985. The limits of acceptable change (LAC) system for wilderness planning. U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah, USA. Gen. Tech. Rep. INT-176.

Versfeld, D.B., Le Maitre, D.C. and Chapman, R.A. 1998. Alien invading plants and water resources in South Africa: a preliminary assessment. CSIR Division of Water, Environment and Forestry Technology, Stellenbosch. WRC Report No. TT 99/98. CSIR No. ENV/S-C 97154.

Wilkinson, L. 1995. How to build scenarios: planning for long fuse, big bang problems in an era of uncertainty. Wired (special edition, Scenarios: The future of the future): 74-81.

Wittenberg, R. and Cock, M.J.W. (eds.) 2001. Invasive alien species: A toolkit of best prevention and management practices. CAB International, Wallingford, Oxon, UK, xii-228.

Wittenberg, R. and Cock, M.J.W. 2005. Best practices for the prevention and management of invasive alien species. In H.A. Mooney, R.N. Mack, J.A. Mcneely, L.E. Neville, P.J. Schei and J.K. Waage (eds.) Invasive alien species: a new synthesis. Scientific Committee on Problems of the Environment (SCOPE): 63. Island Press, Washington, Covello, London.

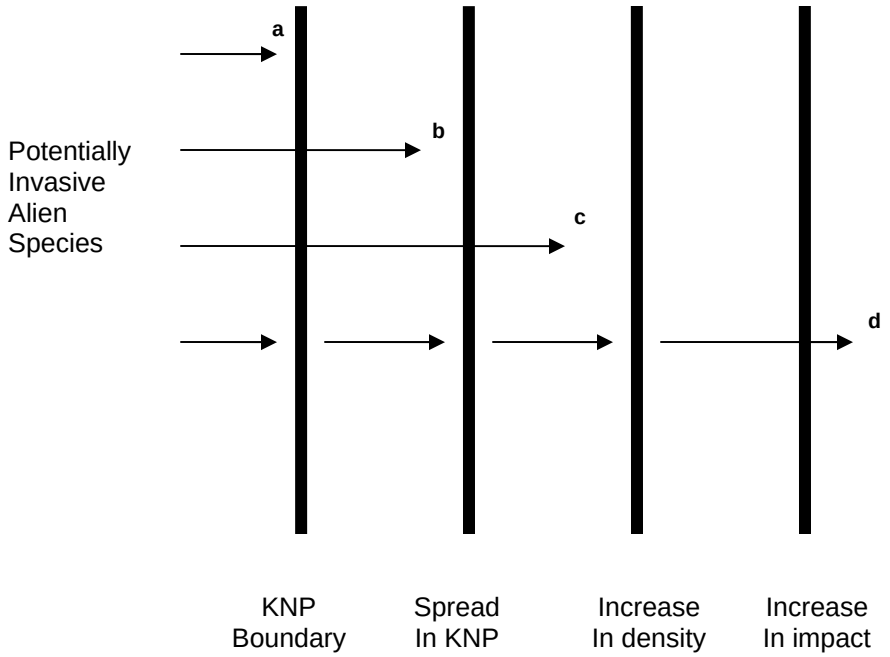


**Figure 1:** Model hypothesis underpinning the development of TPCs for understanding invasion process in the KNP. a) arrival of a potentially invasive alien species at the boundary of the KNP, b) invasion into the KNP, c) successful invasion into and spread within the KNP, and d) occupation of all available habitat, increase in density and increase in impacts on ecosystem services and processes. However, due to the patchy nature of species, an increase in density and impact may be observed at any scale (thus the broken arrow line) and not necessarily only once densities are high across the KNP landscape. Substantial impacts are expected at this point though. (This framework follows the model approach by Richardson et al. 2001).