A System Dynamics Model for Visitor Choice of Transport Mode To and From National Parks

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Concern is felt in a number of countries at the environmental impacts of increasing visitor numbers to national parks and other similar areas, where travel to, from and within the area is dominated by the private car. It is commonly desired to reduce these impacts by bringing about a change in mode of transport to more environmentally friendly forms.

The consensus of opinion suggests that a balance of 'carrot and stick' initiatives is needed to bring about the desired change of mode. However in general these opinions remain to be tested in practice. For example, although attitudinal surveys of national park visitors suggest that a balance of "hard" and "soft" policies would induce behaviour change, these conclusions are not always reflected in subsequent behaviour.

Clearly, one of the major problems facing transport practitioners is how best to predict the results or estimate the impacts of various initiatives and measures, which emerge as part of the process of formulating an overall transport policy. One way of testing such initiatives, short of actual implementation is to develop models of the situation.

A range of transportation models have been developed for use in urban transport policies and include: transport demand models; strategic transportation models; land use/transport interaction models; traffic assignment models, and simplified demand models. By contrast very few studies have been undertaken into rural transport modelling.

Although attempts to implement urban models into rural environments have been made, they appear to have had little impact and indeed many have failed to even address the reasons and motivations behind the chosen mode of transport used. The application of urban models to rural scenarios appears to be inappropriate, due for example to the much greater proportion of optional leisure trips and a more limited range of alternative modes of transport. Urban models also fail to address factors, which may affect transport usage in rural areas, which would not affect urban areas e.g. weather, motivation, choice of location etc. Further problems highlighted with urban transport models are that they are time-consuming, expensive and the outputs (i.e. predicted levels of demand for movement and trip patterns for specified dates in the future) have also proved to be unreliable.

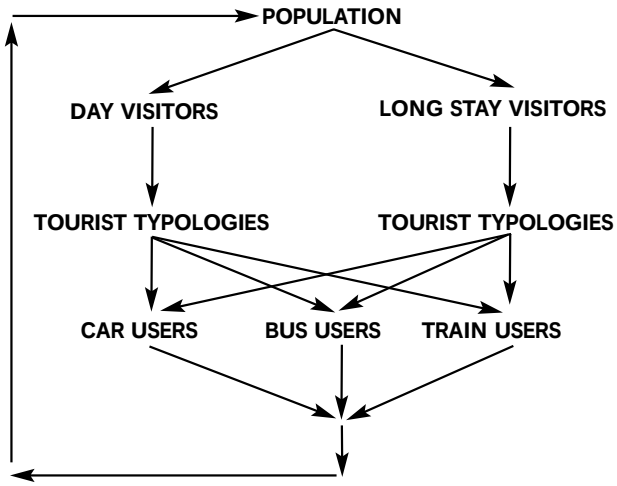
In attempting to understand the determinants of behaviour of visitors to national parks (in particular in their choice of transport mode) it is fundamental that the complex social systems and causal effects are examined. System dynamics modelling, (developed by Jay Forrester in the late 1950s and gained world prominence through the 'Club of Rome' Report in the mid 1960s) is one discipline which is specifically designed to tackle such problems. The past few decades has seen the use of system dynamics

increase dramatically, in particular for attempting to model environmental systems. Although system dynamics has been used in a variety of transport modelling areas, the author is not aware of it being used as a tool for investigating the implementation of transport policies within U.K. national parks.

The use of a system dynamics approach can provide a framework for investigating the likely outcomes of UK transport policies in national parks if certain traffic initiatives ('carrots' and 'sticks') are implemented. Hence, system dynamics modelling may help in assessing the likely impact of different initiatives and in the subsequent formulation of a transport policy for national parks, by providing a model of the major influences that affect people's behaviour and mode of transport they choose when visiting national parks. Once developed, it can aid policy makers by allowing them immediate feedback and analysis of how different transport policies may or may not work, which has clearly been lacking for rural transport practitioners in the past.

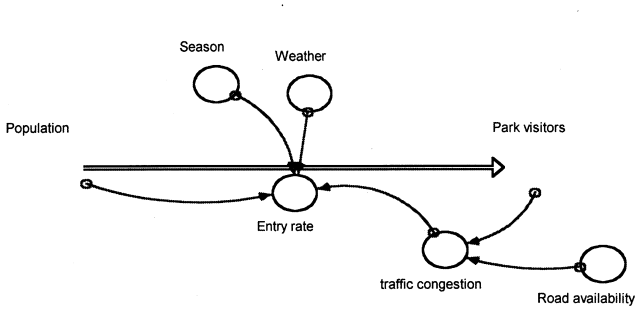
Research work at the University of Northumbria is currently developing a system dynamics model relating to visitors to the North York Moors National Park and the mode of transport they choose. In attempting to build such a model, one must be aware of the key variables within the system and their interconnections. Stocks and flows are the building blocks that are used to construct system dynamics. The stocks represent accumulations within a model, which are measurable quantities of any resources in a system at any point in time. Figure 1 illustrates the main stocks (physical entities) used to describe the visitors within the North York Moors National Park.

Fig.1 - System Representation of Stocks



Flows represent the rates at which people are transferred between the different stock categories. Figure 2 provides a simple illustration of the flow of people, from a given population, that decide to visit the park (and thus become Park visitors) are represented by the 'entry rate'. In this particular case the entry rate is influenced by two exogenous variables (represented by converters), the weather and the season and by several indigenous variables, traffic congestion and the size of the population. Additionally it also illustrates that traffic congestion is itself influenced by the number of park visitors and the availability of roads to handle the traffic.

Fig. 2 - System Dynamics Diagram for a Resource Flow



Some of the variables currently within the model under study are presented in Table 1.

Table 1 - Examples of Variables in the Current System Dynamics Model

Stocks	Flows	Converters (other influences on flows)
Population - Visitors	Park Entry Rate	Climate (Weather, Day of Week, Season)
Day Visitors - Typology	Rate of Car Freaks	Attitudes (Public Transport, Environment)
Typology - Car User	Car User Rate	Congestion (Road Capacity, Car Park Spaces)
		Sticks (Road Tolls, Increase in Car Park Prices)
Typology - Bus User	Bus User Rate	Decision Factors (Awareness, Convenience)
		Carrots (Increase in Bus Services, Reduced Fares)

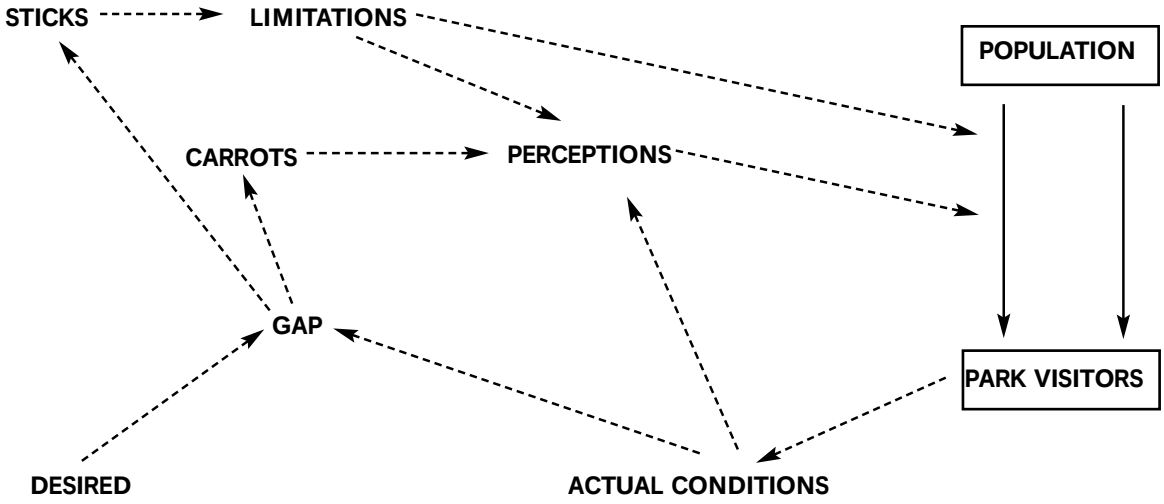
The combination of stocks and flows provide the model with its physical structure whilst the converters provide informational links surrounding the structure. It is the combination of these features that form feedback loops, which in turn help, explain the dynamic behaviour of visitors to national parks.

The analysis and modelling of such loops are extremely important and form a major part of system dynamics. It is the analysis of such loops that help facilitate how a system works and how infrastructures interrelate with one another. Feedback can occur in two main forms, namely positive (reinforcing) and negative (balancing). Reinforcing feedback causes a system to grow, for example; increased advertising of public transport may result in increased public transport patronage that in turn leads to a higher budget being available for advertising. Balancing feedback neutralises any change in the system. For example, increased public transport patronage may cause overcrowding or use up all the available public transport facilities, thus limiting the further transfer of visitors from cars to public transport as well as causing some people who have transferred to revert back to car use. Attempting to model such behaviours will be dependent upon the feedback loops which are built into the model.

Figure 3 illustrates how park users influence conditions in the park (i.e. congestion and pollution), which in turn influences people's perceptions of the park and their decision to visit the park. The traffic related conditions in the park also influence the traffic initiatives implemented within the park, which again influences people's decisions to visit the park. The model can be described as a 'limits to growth' model, within this type of model a reinforcing process is set in motion to produce a desired result. It creates a spiral of success but also creates an inadvertent secondary effect (resulting in a balancing process) which eventually slows down the process. The 'gap' highlighted in the model represents whether the situation requires the implementation of a 'stick' or 'carrot'. For example, the difference between the 'desired' number of cars entering a national park and the 'actual' number of cars entering a national park is defined as the 'gap'. The 'gap' will then determine whether the implementation of a 'stick' or alternatively a 'carrot' is deemed necessary.

Information on visitor's attitudes, motivation and behaviour is currently being gathered and collated, which will help gain a greater understanding into how the transport aspects of a decision to visit a national park might be influenced. The data which

Figure 3. Some policy influences on National Park visitors



will be used to represent values for variables in the model, is being collected by various methods (i.e. questionnaires, traffic counts etc.).

The model structure, together with the data will be transferred into a computer software package, STELLA II. This software package is an 'expert system' that facilitates the development of system dynamics models. It automates the development process by creating the mathematical model from a system dynamics diagram and permits the rapid evaluation of alternative policies and models.

It is hoped that the system will enable transport planners and the management bodies associated with the park to assess the likely outcome of different traffic initiatives that may be implemented within the park and the impact they will have on the visitors' mode of transport. If the problems and concerns of the National Park Authorities are to be addressed and acted upon, then clearly such new and more productive approaches are needed in traffic management initiatives within national parks.

Ruth Crabtree is currently a Lecturer in Sports Management in the Division of Sport Sciences at the University of Northumbria. She holds a Masters from Loughborough University where she specialised in Countryside Recreation, undertaking research in public perceptions and awareness of the North York Moors National Park. For the past three years she has been undertaking her current research (as highlighted in the article) travelling to many European and North American National Parks to study the traffic initiatives there. Ruth may be contacted at Newcastle Business School, the University of Northumbria, e-mail: r.crabtree@unn.ac.uk .