

Quantifying effects of tourist activities on the environment, tourists, and park services in nature protected areas

Tin Klanjšček, Rudjer Bošković Institute, Croatia, tin@irb.hr

Jasminka Klanjšček, Rudjer Bošković Institute, Croatia

Sunčana Geček, Rudjer Bošković Institute, Croatia

Hrvoje Carić, Institute for Tourism, Croatia

Tarzan Legović, Rudjer Bošković Institute, Croatia

Nature protected areas (NPAs) are cornerstones of all national and international environmental conservation strategies. While activities in NPAs are limited, tourism and the related tourist activities are often encouraged, sometimes as a means of funding environmental protection programs in the NPAs. However, the tourist activities can damage the environment and, therefore, threaten protection goals of NPAs. Since number of tourists in NPAs is increasing globally (Balmford et al., 2009), the threat is increasing. Additionally, the increase in the number of tourists and, therefore, intensity and variety of tourist activities, can adversely affect park services and tourist satisfaction. Only a balance between the competing goals and activities can guarantee long-term coexistence between nature protection and tourism uses of NPAs.

NPA management achieves this balance by providing NPA services such as crowd management, mitigation of negative impacts, and ecological restoration. To provide an optimal set of the services, the management first needs to relate the effects of tourist activities on all entities of the NPA (including the environment). In practice, park managers use adaptive management approaches such as VERP, TOMM, ROS, LAC and VIM. In these approaches, feasible monitoring systems and simple indicators are used in conjunction with adaptive approaches and quick in-house responses to keep the indicators in the acceptable range. The responses include infrastructural improvements, crowd management, partial closures, etc. Despite its efficiency, the adaptive response method has several disadvantages: (i) its responsive rather than preventive nature can cause delays in reactions, (ii) the simple indicators cannot capture complex causalities between activity types, intensities, and their (potentially delayed) effects on the environment and, consequently, (iii) the simple indicators with a fairly narrow focus are not always able to detect when changes become irreversible. High tourist densities cause more damage at a greater rate, thus exacerbating the disadvantages. Assuaging those disadvantages requires the ability to predict effects of possible activities on the environment, i.e. quantitatively analyze interdependencies of relevant processes. This, in turn requires an analytical framework that relates types and intensities of tourist activities to complex processes in ecosystems.

Here we present such a framework based on the DPSIR (Driving forces-Pressures-State-Impact-Response) causal framework. DPSIR has been used to assess environmental impact of human activities by the European Environment Agency (EEA

1999; EEA 2014), United Nation Environment Programme (UNEP 1997; UNEP 2012), and - more recently - to environmental impact of visitors in PAs (Navarro et al. 2012; Salerno 2013). However, the focus of DPSIR is on the state of the environment and impact on humans, while other important factors such as impact on the visitor satisfaction, and park services, are not included in the analysis.

Our framework treats tourist activities as the driving forces, and connects the causal chain of Activities – Pressures – State – Impact – Response and Services (APSIRS, Figure). Unlike prior frameworks, we interpret the state as the state of all entities in the NPA, not just the environment. The entities are composed of four types of objects: people, cultural heritage, NPA services, and the environment. The state of the objects is quantified by indicators compatible with EU regulations and conducive to valuation of ecosystem services (ES), and can be evaluated subjectively (e.g. through opinion polls) or objectively (e.g. through sensors).

The framework serves as a platform for integrating models into a decision support system for NPA management, and is not meant to replace, but enhance current adaptive NPA management frameworks. The main goal is to complement the understanding of causal relationships impacting nature preservation and visitor satisfaction as a part of the decision-making process. Therefore, in contrast to other frameworks that include all stakeholders and surrounding areas, we exclusively address visitors and other entities within the NPA. APSIRS can be especially useful for NPAs with high tourist densities when costs of nature protection are funded by tourists.

APSIRS augments the applicability of the DPSIR framework to:

1. focus on tourist activities as driving forces
2. encompass all entities of the protected area (natural and cultural heritage, people, and NPA services)
3. recognize experiential and physical in addition to environmental pressures
4. separate effects of internal factors controlled by the NPA management from external factors outside of the control
5. utilize the carrying capacity for tourists as an indicator in a dynamic way
6. include NPA mandate as a determination of management goals
7. assert NPA services as a way of affecting tourist activities, pressures, and state
8. provide a basis for comprehensive valuation of ES

We use an example of PP Telašćica to show how models connect objects and can be used to quantify interactions between elements of the framework to determine impacts and the carrying capacity of an area for tourists. APSIRS can increase management efficiency by enabling rapid testing of effects of alternative managerial decisions in-silico, reducing the need for field testing that could harm the environment, increase management costs, and/or slow the implementation. Therefore, APSIRS represents a holistic decision support tool meant to inform decision-making and help stakeholder negotiation in any of the existing frameworks, thus improving allocation of resources and, therefore, visitor experience as well as environmental conservation.

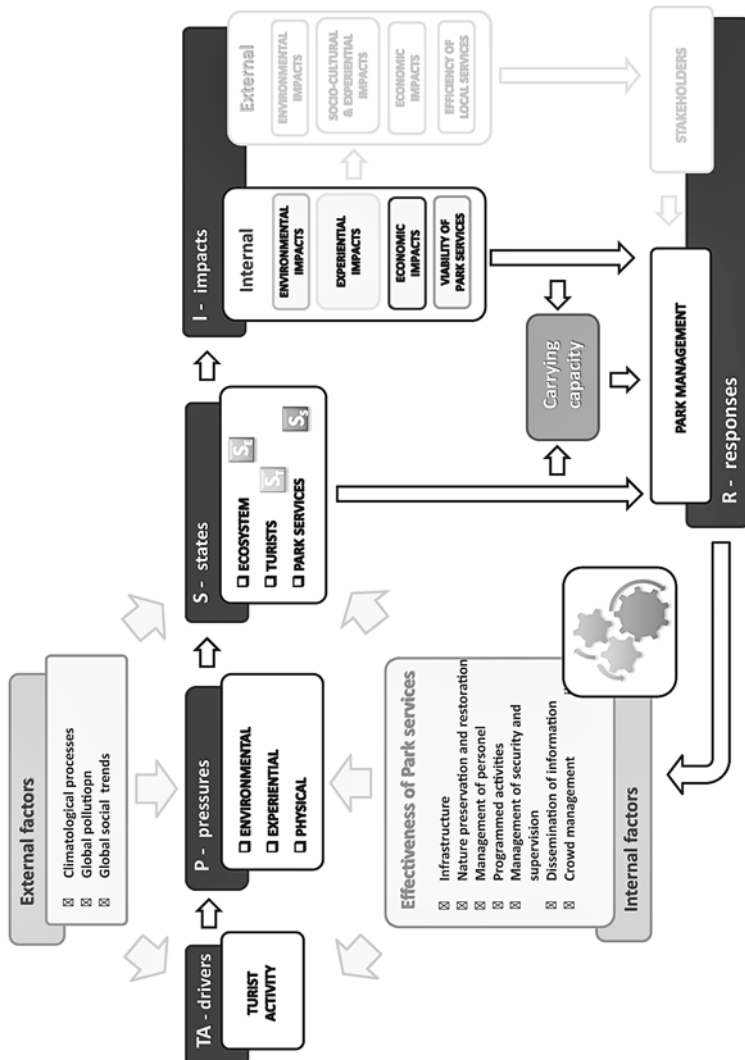


Figure 1. APSIRS analytical framework. Tourist activities (drivers) cause pressures on the environment as well as other objects in the NPA: other tourists (experiential pressures), and the physical infrastructure (park services). The pressures modify states, from which impacts of the tourist activities can be calculated. The states and impacts determine and limit the carrying capacity (which here is a dynamic quantity emerging from the analysis), and serve to inform management response. The response then affects effectiveness of park services and, therefore, the impact of tourist activities on the objects of the NPA. External factors (e.g. demographic trends, climate change etc) also affect the elements of APSIRS, and can be accounted for in the framework



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