Indicating fragility of socio-ecological tourism-based systems

I. Petrosillo*, G. Zurlini, E. Grato, N. Zaccarelli

Department of Biological and Environmental Sciences and Technologies, University of Lecce, Ecotekne, Landscape Ecology Laboratory, 73100 Lecce, Italy

Abstract

The analysis of socio-ecological systems requires new, qualitatively different evaluation schemes that enable an integrated assessment of ecological, social, and economic factors through the use of appropriate indicators. This paper addresses the risk assessment of negative impacts from tourism pressure for 10 socio-ecological systems in the Salento region of southern Italy. Two models are combined to perform the assessment. The first is Holling’s conceptual sustainability model, which is proposed as an alternative to Butler’s Life Cycle model. The second is a fragility model, where fragility is modelled as resource value combined with stress (pressure). Pressure is the number of tourists in each sub-region, and resource value is the proportion of protected area that draws tourists to a sub-region. In this way, the fragility model has a combination of socio- and ecological terms. A new approach is developed to improve the estimates of pressure and fragility, and to provide relevant operational indicators. The number of official (counted) tourist visits generally underestimates the true number of visits, but the discrepancy varies among sub-regions. In order to estimate underhand (uncounted) tourist visits, a separate procedure relating “number of people” to “solid urban waste production” is developed, and then it is used to correct the official estimates. The results suggest that relative risk of sub-regions from tourism pressure may not be adequately represented by official counted visits. The set of developed indicators allow identifying two specific sub-regions as the highest risk areas, and these are discussed in terms of Holling’s sustainability model.

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1. Introduction

Areas on earth show capacity to sustain various durations, frequencies, intensities and types of human activity. In many parts of the world, human activities exploit natural processes, degrade aquatic, terrestrial and atmospheric resources, and cause irreversible losses of biological diversity (Vitousek et al., 1986; Daly and Cobb, 1989; Goodland, 1991). Tourism is a tool for promoting territory resources but it is a driving force, which could affect environmental quality since it could degrade natural non-renewable resources. So beautiful sceneries, natural hydrologic structures, clean water, fresh air, and species diversity can suffer from pollution and, therefore, lose their attractiveness (Mihalić, 2000). The exponential growth of tourist
numbers and their spread to previously quite remote regions of the world has highlighted the potentially paradoxical character of nature-based tourism. The more a site is characterized by rich biological and cultural values, the more it becomes popular and more likely it could be degraded by heavy visitation, that also reduces the quality of tourist experience (Hillery et al., 2001). Ecosystems change in response to the stress imposed by human use, and human societies try to adjust their behaviour affecting ecosystems in response to perceived changes in these systems (Scheffer et al., 2000). This because people begin to understand more clearly that human societies are dependent on the “services” (Lubchenco, 1998) and “functions” provided by the earth’s physical, chemical and biological systems (Luck et al., 2003). Ecosystem services include the production of goods (seafood, timber, and precursors to many industrial and pharmaceutical products), basic life-support processes (pollination, water purification, and climate regulation), life-fulfilling conditions (serenity, beauty, and cultural inspiration), preservation of options (conserving genetic and species diversity for future use), and the assimilation of waste products (Daily, 1997). There is an urgent need for a locally, regionally, and globally ecological characterization of ecosystem services and of their supplier, i.e. the natural capital, to inform decision-makers about the ecological trade-offs associated with alternative courses of action (Daily, 2000). This is possible only through a socio-ecological approach, which combines ecological, economic, and social issues (Gunderson and Holling, 2002). Often, scientists examine either social or natural systems, rather than the linkage between the two (Folke et al., 1998), which could emphasize the integrated, systemic concept of human and nature interactions (Berkes and Folke, 1994; Gunderson and Holling, 2002).

This work intends to provide estimates of fragility of real socio-ecological tourism-based systems. Such estimates are important because when a tourist resort becomes brittle, its resilience is low and the system is unable to supply services as before; its life cycle would be interrupted. Fragility estimates are related to risk assessment (Zurlini et al., 2003), which generally evaluates the potential adverse effects that human activities, like tourism, can have on resource values. Risk assessment needs to be considered in a specific context with clear assessment endpoints, which are explicit expressions of the environmental values that are to be protected (EPA, 1992).

To develop risk assessment we first introduce some basic concepts of the life cycle and fragility of a tourist resort. Then, we analyze tourist phenomena in real socio-ecological systems in southern Italy, where tourism is the main driving force. In southern Italy, there is a significant natural heritage, which has to be conserved. Often the number of official (counted) tourist visits generally underestimates the true number of visits. As a result, it is difficult to evaluate properly the relative tourist pressure among regions. In order to reduce uncertainties that cannot be fully quantified in socio-ecological systems (Walker et al., 2002), we suggest a more reliable estimate of tourist pressure by using solid urban waste (SUW) records as a covariate indicator of tourist dynamics. Estimates, once corrected, identify different tourist patterns among tourist resorts as well as the resorts at highest risk of adverse impact from tourism. To quantify fragility within the framework of the Adaptive Cycles (Gunderson and Holling, 2002), we employ a model of fragility (Zurlini et al., 1999), which allows us to evaluate the development stage in the life cycle of each tourist resort. The fragility estimates of different tourist resorts are discussed within the context of Holling’s Adaptive Cycle (Gunderson and Holling, 2002) and risk assessment of socio-ecological systems.

1.1. The life cycle of a tourist resort

Socio-ecological tourism-based systems are usually described through Butler’s Life Cycle (Fig. 1a) of a resort (Butler, 1980). This model shows three fixed phases (exploitation, development, and conservation), followed by three alternative phases (standstill, decline, or reorganization). During the exploitation and development phases, visitor numbers increase up to the conservation phase; later on, the resort could pass through standstill, reorganization, or decline phases. The model is mainly economic and based on the life cycle of a product that is supposed to experience a period of slow growth, followed by a rapid growth and, finally, a period of stability. If product improvements are not made, its appeal could decline and sales will fall, and eventually it will be taken off the market. There are several analogies with
tourist resorts since they can be expected to increase in popularity as they develop, only if they have the right marketing and facilities.

The early steps and the shape of Butler’s model resembles that of Holling’s Adaptive Cycle (Holling, 1973) (Fig. 1b). Holling’s model has two more phases and it has been proposed by the Resilience Alliance to implement the traditional theory of ecosystem succession as a fundamental unit for understanding complex systems (Holling et al., 2002), such as socio-ecological tourism-based systems. In Holling’s Adaptive Cycle, the system can pass from the conservation phase through a release phase, because of increasing connectedness, the decrease of resilience, and the consequent increase of fragility. Connectedness reflects the strength of internal interdependencies that mediate and regulate influences between processes inside system and the outside world; that is, essentially, the degree of internal control that a system can exert over external variability (Holling and Gunderson, 2002). In the case of tourism-based system, the connectedness of a site is related to the degree of specialization in tourist activities, which allow it to be competitive in comparison with other tourist resorts. Resilience represents the capacity of a system to experience disturbance and still maintain its ongoing functions and controls (Holling, 1973, 1996; Holling and Meffe, 1996). It depends on the existence of multistable states, for it concerns the likelihood of flipping from one state to another (Holling and Gunderson, 2002). Resilience determines how fragile, or brittle, the system is to unexpected disturbances and surprises that may exceed those controls. When controls are exceeded, the system can reorganize itself, or it can flip into another stability domain. The actual result depends on the circumstances that caused the change, for example, a change from an economy based on a certain kind of tourism to that of another kind, degradation of ecosystem services, loss of biodiversity, or loss of socio-cultural heritage and identity. Holling’s Adaptive Cycle (Fig. 1b) allows understanding what could happen after the release phase, related to the decline phase in Butler’s Life Cycle (Fig. 1a), and it helps to explain the life cycle of a tourist resort in terms of connectedness and resilience instead of the number of visitors. Furthermore, Butler’s Life Cycle does not consider the possibility of reorganization after the decline phase.

2. Study area and methods

The study area includes 10 municipalities of the Salento Peninsula (Apulian Region) in the south of Italy (Fig. 2) belonging to the administration provinces of Brindisi and Lecce. This area experiences the main characteristics of tourism industry in the regions of southern Europe where tourism products are mainly based on sun and sea (Fernández-Morales, 2003). Salento was selected because of the absence of other significant human activities. In the Salento Peninsula, tourism mostly shows the typical peculiarities of seaside tourism since it is concentrated in time and space, and affects coastal zones. Another typical aspect concerns the presence of underhand (uncounted) tourism. Underhand tourist visits are very difficult to quantify, and are not included in official
estimates. All these features tend to produce adverse effects on the environment due to the overuse of resources during peak periods.

2.1. Improving tourist pressure estimates

Official tourist pressure \( (P_O) \) is usually calculated as:

\[
P_O = \frac{N_O}{N_R},
\]

where \( N_O \) is the number of official tourist presences and \( N_R \) is the number of residents. Relevant data were obtained from the statistical offices of Brindisi and Lecce province administrations, concerning the period from 1998 to 2002.

Ideally, several covariate indicators should be used to improve tourist pressure estimates, such as energy use, water use, and SUW production. Data relative to the last indicator are obtained from the local official waste office, and are used in this study because the trend of standardized SUW production mirrors that of standardized tourist presences (Fig. 3a) and it also includes underhand tourism. We randomly selected some non-tourist sites, which can be considered as benchmarks of SUW production for residents (Fig. 2). We used SUW production in non-tourist sites to estimate the average resident (AR) SUW production,
and then to correct tourist pressure \( (P_C) \) in resorts under the assumption that tourist behaviour was similar to that of residents with respect to SUW production.

In general, monthly SUW production tends to increase year by year in non-tourist sites. To explore similarity patterns among benchmark locations from 1996 to 2002, principal component analysis (PCA; Cooley and Lohnes, 1971) was used to analyze monthly SUW production per resident for every year. Average monthly SUW production per resident was estimated every year for benchmark locations (Fig. 3b), and used to correct tourist pressure, by means of the following two-step procedure:

1. We used average resident SUW production for estimating potential resident and official tourist production in a tourist resort. The former (SUW\(_R\)) for every year is equal to:
   \[
   \text{SUW}_R = N_R \cdot \text{SUW}_{mAR} \tag{2}
   \]
   where \( N_R \) stands for the number of residents and SUW\(_{mAR}\) stands for the monthly production of average resident for every year. The second (SUW\(_O\)) for every year is equal to:
   \[
   \text{SUW}_O = N_O \cdot \text{SUW}_{dAR} \tag{3}
   \]
   where \( N_O \) stands for the number of official tourist presences and SUW\(_{dAR}\) stands for the daily production of average resident for every year.

2. We estimated the number of underhand tourists, considering both potential and official data on SUW production in each tourist resort. The estimated SUW production of underhand tourists (SUW\(_U\)) for every year is equal to:
   \[
   \text{SUW}_U = \text{SUW}_T - (\text{SUW}_R + \text{SUW}_O) \tag{4}
   \]
   where SUW\(_T\) stands for the total SUW production recorded in a tourist resort.

Then, the number of underhand tourist presences (\( N_U \)) for every year can be estimated as follows:

\[
N_U = \frac{\text{SUW}_U}{\text{SUW}_{dAR}} \tag{5}
\]

Now it is possible to correct official tourist pressure, by adding underhand tourist presences to official data in (1) for every year:

\[
P_C = \frac{N_O + N_U}{N_R} \tag{6}
\]

### 2.2. A conceptual fragility model

In order to define the development phase of a tourist resort in the framework of the Adaptive Cycle we need a model to quantify fragility. Fragility has been commonly estimated by semi-quantitative scores (Nilsson and Grelsson, 1995), but human disturbances and ecological sensitivities have not been explicitly considered. Ratcliffe’s (1977) definition of fragility of biological systems is useful since it distinguishes intrinsic factors from extrinsic factors; fragility is related to the degree of change expected or observed in species abundance and composition following disturbance. Examples of intrinsic factors at the species population level are size of the species range, trophic status, habitat fidelity, and other aspects related to feeding, breeding, and reproductive strategies. Extrinsic factors include human and natural stresses. We can state that fragility \( (F_t) \) of an ecosystem at time \( t \) depends on the sensitivity of the system \( (\alpha) \) and stresses \( (U) \), given by disturbances and perturbations. Zurlini et al. (1999) proposed a conceptual linear model to quantify these features of fragility:

\[
F_t = K + \alpha(U) \tag{7}
\]

In Eq. (7), \( K \) stands for constant background fragility typical of the hierarchical level considered. It is related to specific adaptive mechanisms to expected periodic stresses (disturbances) that are embodied in the memory of the system, including human disturbances that mimic or simulate natural disturbances. The coefficient \( \alpha \) stands for sensitivity, which is an intrinsic feature of the system, and \( U \) stands for either disturbances (expected) or perturbations (unexpected), which systems have to cope with. The amount of stress, coupled with intrinsic factors, determines fragility or vulnerability. The type, magnitude, and timing of the stressor, its predictability, the response of natural resources, and the resource inherent sensitivity have important interactive relationships, which determine the overall system fragility.

The environmental fragility of a tourist resort can be thought of as the degree of sensitivity of resource values (e.g. beautiful sceneries, natural hydrologic...
structures, clean water, fresh air, species diversity, and habitats) to environmental changes imposed by human and natural stresses. Tourism is a kind of human stress as it exploits ecosystem capital such as energy, water, territory, and food, and ecosystem services such as climate regulation, recreation, and naturalness. Tourism usually has an annual temporal pattern, often with increasing intensity. Tourism produces some adverse impacts such as coastal marine system degradation, urbanization, solid urban waste production, atmospheric pollution, etc.

2.3. Estimating fragility of tourist resorts

Tourist pressure in (6) can be a suitable surrogate for $U$ in (7). Considering only seaside tourism pattern, which is the most frequent and mostly attracted by natural beauties, suitable surrogates for $\alpha$ in (7) could be the presence of “concentrated naturalness” such as natural parks, protected marine areas, sites of community importance (SCI), or special protection areas (SPA). These features have value because they are irreplaceable (Pressey et al., 1994) and related to the exclusive biodiversity of a region (Kerr, 1997), which makes them a good first approximation of why one site is more sensitive than another to tourist pressure. So, omitting $K$ in (7), the model of fragility for a tourist resort becomes:

$$F^r_t = A^r \left( \frac{N_D + N_U}{N_R} \right)^x$$  \hspace{2cm} (8)

where $F^r_t$ is ranked fragility given by scores on a semi-quantitative scale, $A^r$ the ranked proportion of area under legal protection, and the last quantity in (8) is the ranked corrected tourist pressure. In the present study, fragility is estimated with reference to the most recent data (August 2002). To estimate $A^r$, raster files of protected areas boundaries were acquired from the Apulia Region web site (Apulian Region, 2002), and then geo-coded, by means of ArcGis® 8.3 (ESRI, 2003).

3. Results

Results from principal component analysis allowed to identify similarity patterns among bench-
mark locations from 1996 to 2002, as regards monthly SUW production per resident for every year. In particular, the first PCA component extracted identified the most similar non-tourist sites most associated with the largest component of monthly SUW variation for every year, that were used to corrected tourist pressure. Corrected tourist pressures showed that, from 1998 to 2002, deviations of corrected from official tourist pressures varied among tourist resorts. The strongest deviations affected the municipalities of the south-west coast, whereas weaker deviations pertained to the municipalities of Brindisi and Lecce. With a marine protected area, Porto Cesareo showed the strongest deviations and therefore the most evidence that underhand tourism was significant. Corrected tourist pressures allowed us to identify three main tourism patterns—transitional, cultural, and seaside tourism. Transitional tourism showed two peaks, the first between February and May, and the second between July and November. The municipality characterized by transitional tourism was Brindisi, where tourists visit while embarking for Greece, Albania, and Turkey. In contrast, cultural tourism was more or less constant throughout the year. For example, tourists are attracted to Lecce throughout the year by historical and socio-cultural heritages. Finally, the most common tourist pattern was seaside tourism, showing one single peak in July–August. This type of nature-based tourism was attracted by the sea and natural beauties.

The application of the simple fragility model in (8) allowed the identification of three groups of tourist resorts with different fragility levels (Fig. 4), as well as the highest fragility levels for Porto Cesareo and Otranto (Fig. 5). Since fragility, as we defined it, is the result of the interplay of sensitivity ($\alpha$) and pressure ($U$), we found tourist resorts with similar fragility level but with quite different sensitivities or pressures.

4. Discussion and conclusion

Tourism impacts on the environment, society, and economy are complex (Kuss et al., 1990; Hunter and
Nature-based tourism is strongly dependent on the quality of the environment more than any other form of tourism. Even eco-tourism, however benign it may be, will have some impacts on the environment, and therefore it requires management and control like any other resource exploitation activity. The amount by which resources are exploited is a critical tourism parameter because tourism must satisfy two constraints at the same time. First, ecological quality and integrity of resources must be maintained, to make sure they remain attractive to tourists as well as to residents. Second, the quality of recreational experience by tourists must be maintained, and this is based not only on the quality of natural environment, but also on the levels and the nature of interactions between groups of users and residents (Daily, 1997; Mihalič, 2000).

The seaside tourism pattern is the most widespread in the region, and it is motivated by attraction to natural beauties offered by the sea and coastal areas. Seasonality is the most significant attribute of this tourism pattern, due to natural and institutional factors. Natural factors depend on favourable weather conditions combined with the presence of natural beauties to permit the full exploitation of tourist resources. Institutional factors are the cultural and social attitudes characterizing the timing of human activities, like holiday periods that are concentrated in the summertime. Seasonality of tourism may show adverse effects on the environment because of the intensity of pressure concentrated in space on fragile resources and their overuse during the peak period. SUW production describes very well the seasonality of tourism, and we have shown that it is a useful indicator of tourist pressure for studying socio-ecological systems where underhand tourism is significant. Using SUW, the spatial distribution of deviations from official tourist pressures could indicate the spatial distribution of second houses, which are usually difficult to quantify and yet are a primary factor affecting underhand tourism during holidays. Tourist resorts showing the seaside tourism pattern are also characterized by strong deviations between official and estimated tourist pressures, therefore, seaside underhand tourism appears to be important mainly in coastal resorts.

Corrected tourist pressure represents a very useful surrogate of \( U \) in the application of the simple fragility model (8). In the case of Porto Cesareo and Otranto, the highest tourist pressure is found together with a very high number of underhand tourists. Among the resorts included in this study, these two appear to be the most brittle and at the highest risk of over-exploitation.

The life of a tourist resort is usually described through Butler’s Life Cycle (1980) from which mathematical models have been developed (Casagrandi and Rinaldi, 2002). We illustrated how a model of fragility allows one to depict the spatially explicit distribution of fragility in the context of Holling’s Adaptive Cycle model (Gunderson and Holling, 2002). This permits us to address tourist resort dynamics in terms of connectedness, resilience, and services supplied by ecosystems. The simple ecological fragility model for tourism appears to be consistent with the Adaptive Cycle model (Holling et al., 2002) because fragility is expected to increase and decrease during the life of a tourist resort. Fragility increases as the cycle moves towards the conservation phase, where the system becomes more brittle, and it decreases towards the re-organization phase. Fragility is expected to be high when the resilience is low and vice versa (Gunderson and Holling, 2002). Where fragility is high, a tourist resort is at the conservation phase and connectedness is also high because of specialization of tourist industry. Resilience is low at this phase since the system can no longer supply the same services like beautiful scenery, serenity, cultural inspiration, preservation of options, and the assimilation of waste products (Daily, 1997). Thus, the spatially explicit distribution of fragility can be described in the framework of the Adaptive Cycle, where the phase state of the tourist resort is represented by the position of a mark along the cycle (Fig. 5).

Of course, fragility of tourist resorts also depends on economic and social factors. We used a relatively simple fragility model to interpret tourism dynamics in the context of ecosystem theory. More complicated fragility models could include social and economic aspects such as impacts of tourism on local populations, local population perceptions of tourism, and employment in the tourist sector. Yet, even a simple fragility model provide useful indications to allow a first comparison to be made among tourist resorts. Two comparable areas can have similar sensitivity but different current fragility because of differ-
ences in the type, frequency, and extent of risk agents like tourism. Tourism is a risk agent that can have adverse impacts on socio-ecological systems and, in this context, current fragility estimates can be regarded as baseline risk assessment of tourist resorts (Zurlini et al., 2004).

Models of fragility can also be extended to include better definitions of sensitivity. Sensitivity is not only a function of concentrated naturalness but also of society and economy. The social sensitivity is in turn a function of resident perception of tourism, which could be measured and monitored through questionnaires. Economic sensitivity is related to how strongly the local economy and welfare are dependent on tourism. This could be measured, for example, through the amount of residents working in the tourist sector, or the number of commercial activities during the tourist season. Furthermore, when tourist pressure is utilized as a surrogate of $U$, tourism management also must be considered. Under the same tourist pressure, different tourism managements could mitigate pressure differently among resorts. Tourism quality management can mitigate tourist pressure by reducing the use of non-renewable resources and adverse impacts. Potentially useful indicators for tourism management include, water deficit in tourist resorts or loss of natural space to parking places.

Ideally, “adaptive management” of tourism-based socio-ecological systems aims to maintain resilience and adaptive capacity in a way that humans become able to learn from experience the best way to use and manage resources (Gunderson and Holling, 2002). We suggest that in so doing, humans will become capable to expand and enrich the understanding of socio-ecological system dynamics and ultimately sustain tourism-based systems in the Salento region of south Italy. Adaptive management of resilience in social–ecological systems requires the close involvement of stakeholders, and it brings together elements from empirical studies, theoretical developments, participatory learning methods, adaptive management, and scenario planning.

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