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Tourism carrying capacity reconceptualization: Modelling and management of destinations

Martina Pásková [a], Geoffrey Wall [b], David Zejda [c], Josef Zelenka [c,*]

[a] Faculty of Informatics and Management, University of Hradec Králové (FIM UHK), Rokitanského 62, 500 03, Hradec Králové III, Czech Republic
[b] Department of Geography and Environmental Management, University of Waterloo, Waterloo, ON, N2L 3G1, Canada
[c] FIM UHK, Rokitanského 62, 500 03, Hradec Králové III, Czech Republic

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ABSTRACT

Sustainability of tourism development in protected areas relies largely on the ability of destination management to harmonize the activities of visitors, local communities, entrepreneurs and other tourism actors with the primary aim of nature and landscape protection. Based on conceptual analysis, the manuscript refines tourism carrying capacity theory and operationalizes it into a cohesive systems approach to evidence-based visitor management in protected areas. The proposed modified concept of tourism carrying capacity approaches the protected area as a destination system where the continuous determination, estimation, and attainment of the visitation optimum are the main problems to be solved. The overall aim is to construct a comprehensive destination model which can be embedded into a decision-support system for visitor management. Testing of the proposed system, derived through an inductive process, has been initiated in the Czech Republic's protected area, for which a comprehensive destination model is being created.

1. Introduction

While the global pandemic has reduced foreign tourism demand in many popular destinations, domestic visitor pressures have increased in many rural and natural areas, to cater to pent-up outdoor recreation demands as viral cases decrease. Increasing tourism intensity in many areas as well as ever-changing visitor demands and behaviour patterns (Kuba et al., 2018; Leung et al., 2018, p. 120) require planning and temporal and spatial zoning (Gundersen et al., 2019; Pásková, 2003b; Zelenka & Kacetl, 2013) to implement and enforce limits of acceptable use (Pásková (Pásková, 2003a), (Pásková, 2012), (Pásková, 2014)). While it is easiest to see this in terms of numbers of users, it also includes types of use (Graefe et al., 1984) and other visitor attributes. To achieve this effectively, destination management (DM) should consider inputs from key tourism actors as well as those concerned with resource protection (Leung et al., 2018, p. 120; Pásková, 2014; Pásková & Zelenka, 2018). Modification of visitor behaviour, based on a thorough knowledge of the territory and visitor needs, provides a crucial opportunity for further development of visitor management (Bednar-Friedl et al., 2012; Leung et al., 2018, p. 120).

Protected areas, as specific tourism destinations, are sophisticated systems with many inputs, outputs, actors, and factors, such as the weather, season, accumulated impacts, and various types of pollution including industrial, agricultural, visual, light and noise. Other factors include the level of tourism development and life cycle stage (Butler, 1980), spatial and temporal patterns of visitor behaviour (Hägerstrand, 1970) and functional links between destination actors, including feedback effects. There is a close relationship between the degree of saturation of the TCC by tourist land use, and the causal mechanisms of changes generated primarily by tourism. A frequent cause of undesirable changes in the destination environment when activating the potential of the area for tourism development results from exceeding TCC limits (Wall, 1982). The tourism carrying capacity (TCC) depends on the structure of the destination system (DS), and its parameters (destination type, size, life cycle stage and the above-mentioned factors, including the accumulation of influences over time). Because of its complexity and to achieve responsible, evidence-based visitor management which harmonizes the needs of tourism actors within destination limits, TCC should be approached systemically as suggested by Pásková (2003b) and Zelenka and Kacetl (2014). A systems approach that reflects the functioning and state of the area as a tourism destination, as well as a set of interconnected ecosystems, could be applied, with appropriate interpretation of data, to determine existing and acceptable intensity levels and limits of tourism. Such limits would facilitate comprehension and

* Corresponding author.
E-mail address: josef.zelenka@uhk.cz (J. Zelenka).

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transparency for tourism actors, and compliance with these limits could be enforced by managers.

However, implementing a systems approach in the form of an information system, is hampered by the variability of destinations, their complexity (numerous variables and their connections) and a high level of dynamism (volatility in time). Furthermore, relevant data may be lacking or may not be available in sufficient quality (Goossen, 2014). Pertinent theory is often not sufficiently elaborated for its operationalization, and inconsistent representation of knowledge emanates from different tourism domains (Gretzel, 2011). Just a few years back these problems seemed insurmountable but promising new methods and technologies, including monitoring, data collection and analysis (using both advanced statistics and deep learning), can potentially deal with the issues of complexity and insufficient or fragmented data. However, the theoretical background of TCC must be analysed and then reconceptualized to fully reflect its complexity and dynamism. Also, based on the refined theory, methodological guidelines must be provided to enable its operationalization with the help of the available technology. This is the main goal of the manuscript.

1.1. Evolution of tourism carrying capacity and related concepts

Roots of the theoretical concept of carrying capacity can be tracked at least to the 18th century works on the relationship of population growth and the creation and regeneration of resources (Malthus, 1798). In the 20th century, the concept became known thanks to pivotal works such as of the Club of Rome (Meadows et al., 1972). In both cases it was a study of carrying capacity applied at the global level, dealing with the maximum size of the human population. After being applied in ecology, population ecology (Odum, 1953), and agriculture for determining the maximum number of animals (especially herbivores) or plants that a certain unit of area can support in a given period, the concept entered tourism studies in the 1960s as an indicator of the maximum number of visitors that should be allowed to visit protected areas (Guo & Chung, 2016, p. 199; Wagar, 1964, Wall, 1982, p. 190). The adoption of the concept of territorial TCC in the field of tourism studies has made it a significant exogenous tourism concept of, as it is (in contrast to the concept of the destination life cycle, DLC) applied in the same way as in other scientific disciplines (Wall, 1982, p. 188). In the fields of tourism and recreation, work on carrying capacity originated in protected areas (e.g. Papageorgiou & Brotherton, 1999; Stankey, 1981; Wagar, 1964 (Wagar, 1974),) and that is the context in which the manuscript is placed, although it has since been applied in other situations and, both explicitly and implicitly, underpins discussions of overtourism.

A three-decades-long vigorous debate followed, criticizing the quantification of tourism and recreation carrying capacity as a search for a specific numerical value that does not exist (e.g. Brown et al., 1995; Cole and Stankey 1997; Farrell & Twining-Ward, 2004; McCool & Lime, 2001; Cole and Stankey 1997). Land does not have an inherent capacity, although some plots of land may be more resilient to use than others (Wall, 2019). Capacity, then, only has meaning within the context of goals and objectives (Wall, 1982 (Wall, 2019). For example, the same piece of land could be used as a stadium, a golf course or a nature reserve, and the number of users that can be supported without exceeding the capacity would vary accordingly. In protected areas, the main goal is usually to ensure the maintenance of special environments or specific aspects of those environments, and visitors are welcomed to the extent that they do not undermine this goal. The problem is being approached in the present study from this relativist philosophical stance.

Efforts to increase the practical applicability of TCC involve the Limits of Acceptable Changes (LAC) method (Ahn et al., 2002; Cole and Stankey 1997; Frauman & Banks, 2011; Stankey et al., 1985; criticism by Butler, 2019, p. 208), tourism sustainability indicators (Inskeep & UNWTO, 1998; Pásková, 2012) and visitor management models (Guo & Chung, 2016; Kuba et al., 2018; Leung et al., 2018, p. 120; Zelenka & Kacetl, 2013). These approaches are derived conceptually from the idea of TCC (Canestrelli & Costa, 1991; Marsiglio, 2017; Papageorgiou & Brotherton, 1999; Pásková, 2003b; Salerno et al., 2013; Wall, 1982; Zelenka & Kacetl, 2014) to connect it more closely with real managerial practices. The multidimensional (Papageorgiou & Brotherton, 1999; Pásková, 2003b, (Pásková, 2012), (Pásková, 2014); Salerno et al., 2013; Shelby & Heberlein, 1984) and dynamic nature of capacity has been described previously in the context of its future possible operationalization (Zelenka & Kacetl, 2014).

As TCC-related concepts evolved, conceptual changes gradually increased their applicability to tourism destinations (Fig. 1). Until 2001, areas of development involved regulation for non-exceedance (development within sustainable limits), practical application through visitor management and LAC models, and awareness of interconnectedness with DLC. Critique of the static TCC concept, namely the difficulties of determining limit values of TCC in its multiple dimensions was severe during those years. Starting in 2000, new concepts began to emerge dealing with the complexity and dynamics of TCC. TCC became a management concept, related to the destination system, helping to keep visitation levels below TCC and more complex simulations started to appear. In parallel, the foundations of the systemic concept of destination were laid, allowing a shift of focus from the tolerable state of processes and entities (in protected areas typically the state of its ecosystems) to optimal states as a main goal of DM.

To sum up, the management of a protected area has to reflect the mission and objectives of the given area in its management plan; however, processes of setting and implementing concrete goals (regarding form and intensity of land use) have to be supported continuously by expertise and communication. Since its inception, TCC has evolved into a complicated concept reflecting the complexity and dynamics of the destination environment itself. Though its operationalization remains a challenge, recent advancements in tourism studies, information technology (in areas such as big data collection, advanced data analysis and modelling), improved legal frameworks and increased participatory management, can facilitate practical utilization of TCC as never before.

1.2. Evolution of visitor management approaches in protected areas

Visitor management in protected areas has a long history, originating with the designation of such places. The first generation of visitor management in protected areas in the late 19th century was "anthropocentric", i.e. primarily aimed at meeting visitor needs by promoting tourism and building infrastructure (Weaver & Lawton, 2017). Increased visitation, driven by changes in society such as population growth, improved social conditions, transport advances, and increases in the popularity of recreational activities in nature, often resulted in excessive use with adverse and often irreversible impacts on ecosystems and communities (Bella, 1987; Parsons et al., 1986; Ripple & Larsen, 2000). This triggered a shift to the opposite extreme, i.e. to a "biocentric" approach that focused on the elimination of human pressures on nature, often through strict regulatory measures (Eagles, 1993; Hammitt & Cole, 1998).

For long-term sustainability, it is undoubtedly necessary to ensure that tourism intensity does not exceed destination TCC (Canestrelli & Costa, 1991; Pásková, 2003a; Pásková, 2003b; Pásková, 2012; Pásková, 2014; Wall, 1982; Zelenka & Kacetl, 2014; Marsiglio, 2017; Mihalic, 2020). At the same time, sustainable tourism can play an important role in stimulating and diversifying local economies (Amir et al., 2015; Pásková, 2003a; Pásková, 2012; Pásková, 2014), especially in communities in the vicinity of protected areas. It can also be a source of funding for nature conservation (Iranah et al., 2018; Schuhmann et al., 2019). Therefore, extreme policies, the first generation leading to excessive visitation and the second insufficiently acknowledging visitors' interests and positive local economic effects, are untenable (Johnston & Tyrrell, 2005; Weaver & Lawton, 2017).

Third-generation visitor management in protected areas aimed to remove the friction between tourism development and nature

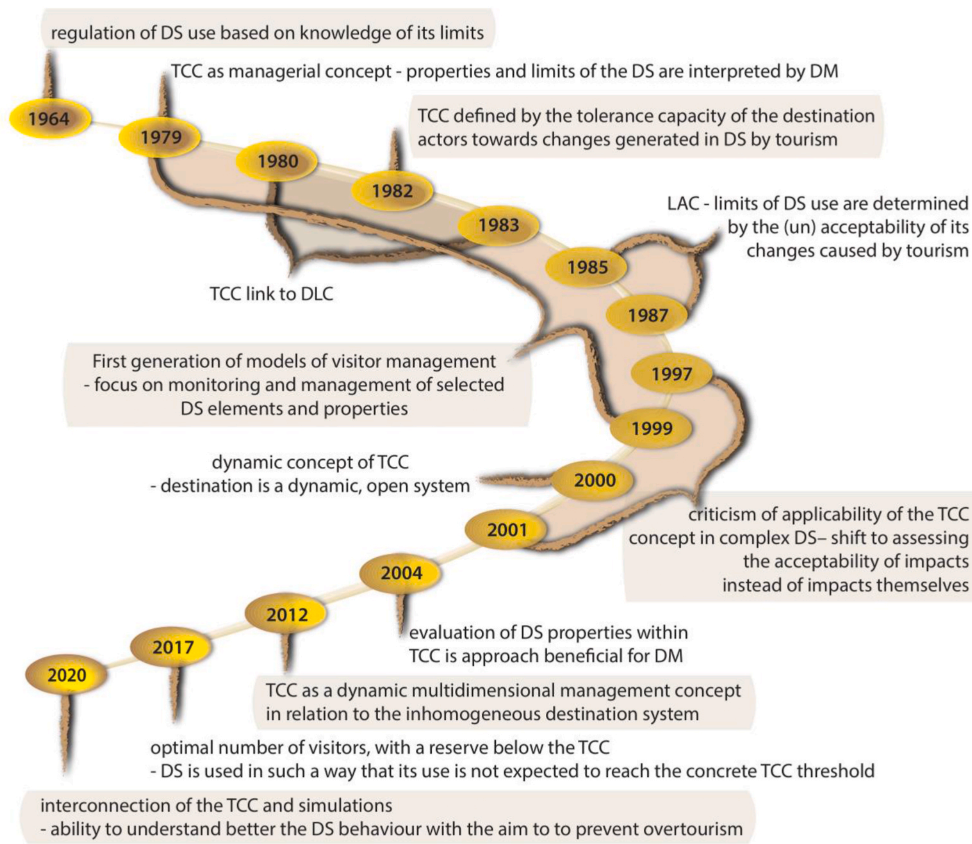

Fig. 1. Time evolution of TCC related concepts. Sources: Bertocchi et al. (2020), Butler (1980), Camatti et al. (2020), Cole and Stankey 1997, McCool and Lime (2001), Marsiglio (2017), Mathieson and Wall (1982); Mexa and Coccossis (2004), Pásková (2003a), Salerno et al. (2013), Saveriades (2000), Stankey and Burch (1979), Stankey et al. (1985), Wagar (1964), Wall (1982, (Wall, 1983), (Wall, 2020), Wang et al. (2020), Zelenka (2012), Zelenka and Kacetl (2013, (Zelenka & Kacetl, 2014).

conservation and to achieve harmonious coexistence between visitors and nature (Weaver & Lawton, 2017). Excessive visitation can negatively impact not just ecosystems but also the integrity and authenticity of the site and its *genius loci* (Bušek et al., 2016; Prokopis et al., 2019). A form of nature conservation that is conceived to be beneficial for both visitors and residents is more likely to be supported by them.

The need to reconcile the aforementioned tensions resulted in two major reactions: a renewed emphasis on visitor management (see below) and the proliferation of supposedly new types of tourism. In quick succession, the concepts of ecotourism (Weaver & Lawton, 2007), sustainable tourism (Clarke, 1997; Pásková, 2012; Pásková, 2014), responsible tourism (Goodwin, 2002; Pásková & Zelenka, 2016; Pásková & Zelenka, 2018), volunteer tourism (Pásková & Zelenka,; Wearing, 2001) and geotourism (Dowling and Newsome 2006; Guo & Chung, 2016; Hose, 2000; Pásková, 2018; Pásková & Zelenka, 2018), to name a few, were proposed. Although each had its nuances, their proponents accepted that, in addition to economic benefits, a rediscovered respect for nature could influence the well-being, decision making and behaviour of both visitors (Ryan et al., 2010; Taylor, 1981) and local inhabitants (Pásková, 2018). Education and increased adoption of personal responsibility, among both visitors and residents, were expected to change their approach from consumeristic to participatory, and even make tourism a tool for the protection of local ecosystems instead of being a threat to them (Weaver & Lawton, 2017).

1.3. *Towards systemic evidence-based responsible visitor management*

Each tourism destination is a complex of interconnected ecosystems and social systems (e.g. Baggio, 2008 (Baggio, 2014),), which can absorb certain amounts of tourism without substantial deterioration of their potential to support further tourism development (Baggio, 2008; Butler 1980; Wall, 1982; Weaver, 1990, 2000; Lazanski Jakulin, 2017; Pásková, 2012; Schianetz & Kavanagh, 2008). The destination system can be described through its elements and the links that exist among them (Pásková, 1999). The effects generated or absorbed by individual elements can be understood, according to the "Papiercomputer" (Vester, 1992 cited in Pásková, 1999), as active/passive or positive/negative. Once key elements of the destination system, such as attractions, infrastructure units, actors, and environmental and social elements, have been identified, their horizontal (geographical) position and their vertical position, representing their role and importance in the destination system, can be described (Pásková, 1999). Furthermore, destinations should be consistently understood as complex *adaptive* systems (e.g. Hartman, 2016; Hartman, 2018; Yang et al., 2019). Schianetz and Kavanagh (2008) regard all natural and social systems as "*interdependent, and nonlinear with feedback at many different levels that allow these systems to self-organise, adapt continually and change in an unpredictable manner*".

Responsible visitor management in a protected area strives for an evidence-based approach for determining the optimal intensity and form of tourism. A systems perspective and an interdisciplinary approach are prerequisites for sustainable tourism management (Farrell & Twining-Ward, 2004; Liu, 2003; Pásková, 2012; Pásková & Zelenka, 2016). The impact of tourism on the temporal and spatial patterns of natural and social processes in the protected territory must first be understood (Pásková, 2003a). This analysis should include the understanding of the various endogenous resources, such as human and financial resources of destination management, and external factors, such as the legal and economic situation of the protected area, likely manifestations of climate change, industrial pollution, urbanization, the penetration of invasive species, and the loss of biodiversity in adjacent territories (Pásková, (Pásková, 2003a); Zelenka & Kacetl, 2014), as well as the optimal number and segment composition of visitors, their spatial and temporal distributions, and the foci of their activities, including how they impinge upon the fragile features of local ecosystems, local communities and the economy (Pásková & Zelenka, (Pásková & Zelenka, 2018),). The roles, needs and behaviour patterns of the different tourism actors (Albrecht, 2016) also have to be considered. The number and behaviours of visitors, as well as their impacts on ecosystems and communities, are also influenced by other tourism actors. Socially responsible behaviour of tourism actors, including visitors, destination agencies, local service providers and local authorities, is another prerequisite for optimizing the tourism effects in protected areas (Pásková & Zelenka, 2018) where each group of actors may be heterogeneous, further increasing the complexity of the system. The above observations imply the need for a substantial research agenda and the existence of a monitoring system.

Visitor management should be based on an ongoing determination of ever-changing capacities and subsequent application of management for sustainability (Pásková, 2003b). The long-term collection, analyses and interpretation of pertinent data enable the identification of potentials, optimums and limits, as well as the application of sustainability management (Pásková, 2003b; Pásková & Zelenka, 2018). Modelling a destination as a system constitutes a promising tool to support the management of tourism for sustainability (Cole, 2005; Gimblett & Skov-Petersen, 2008; Skov-Petersen, 2005). A destination model may be used to estimate the optimal numbers of visitors that are in line with the specific characteristics of a particular territory (Lanchava et al., 2018). Also, it can capture the spatial and temporal behaviour of visitors (Gimblett et al., 2001), and indicate tourism impacts in terms of costs and benefits among tourism-dependent and independent residents who encounter a mix of different visitor segments (Canestrelli & Costa, 1991; Pásková, 2012). These transdisciplinary approaches represent an application of social exchange theory (Doxey, 1975; Pásková, 2002; Pásková, 2003a; Pásková, 2012; Pásková, 2014). Destination models may be used to implement concepts dealing with market failure defined in neoclassical economics, such as the tragedy of the commons (Hardin, 1968; Pintassilgo & Silva, 2007; Vreja, Bălan and Mavrodin 2016; Wozniak & Buchs, 2013) or market externalities. Optimal tourism intensity from an environmental and economic point of view may be inferred by modelling interactions between visitors, and animal and plant species, their habitats and natural processes (Bednar-Friedl et al., 2012).

An important phase in the evolution of visitor management was the creation of visitor management frameworks to guide managers in their decision making (Guo & Chung, 2016; Zelenka & Kacetl, 2013) such as VIM (Visitor Impact Management), VAMP (Visitor Activity Management Process), VERP (Visitor Experience Resource Protection) and TOMM (Tourism Optimization Management Model). Brief introductions to these initiatives and pertinent references can be found in Newsome et al. (2013) and Wall (2019). While they attracted attention among academics, practical applications lagged because of the high costs of implementation due to the data intensity of those frameworks. However, examples involve cave management in Australia (Manidis Roberts Consultants 1995), plans for Kangaroo Island, Australia (Roberts Consultants 1997), and more recently New Caledonia coastal areas (Gonson et al., 2018) and cave management in China (Demas et al., 2015).

Visitor management has a long history in protected areas. Managers have sought to be guided by the capacity concept but it has proven to be a frustrating idea to work with and it has often been viewed from a static rather than a dynamic perspective. Furthermore, the complexities of protected areas, with many interacting elements drawn from both human and natural systems, suggest the potential utility of a systems approach through model development and implementation. Although not widely discussed in the early TCC research, the utility of the participatory engagement of interested individuals is desirable for visitor management in this multi-stakeholder environment. A solid knowledge of the research-based critique of the applicability of TCC is a good starting point for the incorporation of technological, legal, social, political and environmental changes for its further conceptual development.

2. Materials and methods

To overcome the above-reflected complications and inconsistencies of the practical application of the TCC concept, the authors have modified it into a flexible systems approach to visitor management based on an improved understanding of the processes occurring within a destination in order to reconcile tensions between tourism development and nature conservation in protected areas. Therefore the study reconceptualizes the TCC concept in the light of a systems approach which enables the application of current knowledge and destination modelling technology, respecting the spatial structure, dynamic character as well as multi-stakeholder and multi-variable attributes of the protected areas as a fragile type of tourism destination. This aim is framed by the following research questions:

- How do TCC and related concepts differ regarding their theoretical foundations, methods, practical applicability and limitations?
- How could TCC be further refined and extended to serve as a universal framework for destination modelling, practically applicable in evidence-based visitor management in protected areas and, conversely, how can advancements in data acquisition, data processing and modelling inform further evolution of TCC?
- How to define the visitation intensity level, implementable in the destination model, which at the same time respects the regenerative capacity of the area and is acceptable to destination actors?

To achieve the research objective the conceptual analysis was carried out. It consisted of the analysis of the TCC concept and related concepts (LAC, visitation optimization such as TOMM, systems approach applied in the tourism sector, etc). They were assessed with the use of the following criteria: (1) objective of the concept, (2) the theory behind it, (3) its practical application, (4) key methods, (5) philosophical approach, (6) main variables, (7) complexity level and (8) main drawbacks or challenges. For this purpose, a thorough literature review was conducted. The resulting matrix enabled differentiation between the still valid and less useful elements of the analysed concepts as well as modified ones in the proposed reconceptualized TCC approach. The research builds also upon the authors' previous work and experiences (Mathieson & Wall, 1982; Pásková, 1999; Pásková, 2002; Pásková, 2003a; Pásková, 2003b; Pásková, 2012; Pásková, 2014; Wall, 1982 ; Wall, 1983; Wall, 2019; Wall, 2020; Zejda & Zelenka, 2019; Zelenka & Kacetl, 2013; Zelenka & Kacetl, 2014).

The results of the conceptual analysis are being aligned with the knowledge obtained from selected protected areas of the Czech Republic, namely Protected Landscape Areas Železné hory (Iron Mountains), Broumovsko, and Český ráj (Bohemian Paradise) and National Park České Švýcarsko (Bohemian Switzerland). The areas have been chosen based on the following criteria: (1) existence of visitor management, (2) sandstone phenomena sensitive to erosion as one of the key attractions, (3) proximity to the authors' university, and (4) willingness to cooperate in the research. In addition to the authors, the research team includes nature conservation experts from the aforementioned protected areas and from the Nature Conservation Agency of the Czech Republic, which is a user of the research results, as well as academics and university students. Testing of the initial destination model with an emphasis on optimizing the nature and intensity of visitation has been launched in the Protected Landscape Area of Železné hory.

As an input for the destination model, a systematic destination analysis has been conducted according to the methodology crafted for this purpose. It involved semi-structured meetings with representatives of stakeholders, analysis of management plans and other strategic and conceptual documents relevant for destination management as well as secondary research of publications on the involved destinations. The spatial structure of the destination has been described thoroughly, taking into account its importance, fragility, intensity and impacts of tourism. Field research was conducted accordingly, consisting of systematic photographic documentation, further detailed characterization of sites, and collection of data for primary research of visitor segmentation. To construct a comprehensive analysis of the physical destination system, time series data had to be acquired and connected in the model, utilizing data-cleaning procedures; more time-series data are being calculated by the model according to defined relationships.

In the field of statistical modelling, the use of various statistical methods such as regression, factor analysis and clustering have been evaluated on data from questionnaire surveys. Experiments with different statistical models were carried out with data from automatic *in situ* visitor monitoring devices. Correlations between measurements in different locations were examined and possible explanatory factors were tested. Three strong periodic components were revealed in the data, with an occasional occurrence of barely predictable changes in the character of visitation. So far, the best predictive results have been achieved using the neural network sequential model. In the area of visitation modelling, the usability of new data sources is being examined, such as Google traffic. High-quality open meteorological data sets from ECA&D are being tested as a potential source of explanatory variables. As a supplementary resource about mobility and traffic, residual data from mobile operators will be analysed. Partial experimental agent-based models and systemic dynamics models have been constructed, which allowed us to formulate and partially verify specific hypotheses about visitation in the destination. The results were discussed in expert groups.

An experimental system for capturing the destination model is being developed as a containerized set of individual services, concerning its scalability. For modelling of logical relationships within the model, network graphs are used; specialized data structures serve for multidimensional time series and spatial data. The system is being implemented in Python language, with the help of the web2py framework.

Processes for determining and simulating potential, optimal and threshold visitation values are gradually being delineated and results of destination system analysis are being synthesized into the Protected Landscape Area Železné hory comprehensive destination model by the means of system analysis (Firsov, 2016). The ongoing construction of the destination model involves further formalization of the findings through destination system analysis, the final selection of system elements, a definition of constraints, parameter estimates, and integration of data sources. The identification of the visitation optimum under given conditions represents the problem to be solved. Attention was paid to ensure reasonable complexity of the model to avoid its overfitting. Scenario simulation capabilities, including combinations of measures modulating visitation towards the optimum, will be implemented. The destination model is intended as a key component of a decision-support system to facilitate evidence-based visitor management of the area.

The ongoing model implementation deepened the authors' understanding of how visitation influences elements of a destination system as well as practical aspects of visitor management. Details pertaining to the specific case are eschewed in the present study. Rather, in harmony with the research questions, the authors focus upon TCC concept refinement that is crucial for model implementation; namely, the concepts of visitation optimum together with parameterized potential and effective carrying capacities are introduced, defined, discussed and illustrated by scenarios. The TCC concept refinement is at the core of the destination model which, the authors believe, has general relevance and strong theoretical significance.

3. Results

3.1. Conceptual analysis

To determine how TCC and related concepts (LAC, visitation optimization such as TOMM, systems approach applied in tourism sector) differ regarding their theoretical foundations, methods, practical applicability and limitations, a conceptual analysis has been conducted (Table 1). Approaching the assessed TCC as thesis and the related concepts as antitheses, the proposed reconceptualization represents a kind of synthesis enriched by current knowledge and the possibilities of destination modelling. This brings a comprehensive systems approach to destination modelling and management. Such a TCC reconceptualization extends potential application and addresses limitations.

3.2. Optimized visitation as a framework for the tourism carrying capacity reconceptualization

Early definitions of TCC referred to the maximum number of users that could be supported without an unacceptable decline in the quality of the environment or in the quality of visitor experiences (e.g. O'Reilly 1986; Stankey, 1981). However, the authors acknowledge that there are other types of capacity, such as the capacity of ancillary facilities, e.g. the maximum number of parking spaces, campsites, or accommodation units that are available, which can be used to regulate use. Also, capacities can change over time reflecting, among other things, managerial inputs. Furthermore, even if goals are widely accepted, they may be interpreted differently by different stakeholders. Thus, unlike early formulations, the authors reject the view of TCC as a magic number that can be approached with impunity and exceeded at peril, and accept that there is more than one capacity and that these change over time. They offer an enhanced framework of the TCC concept which is based on scientific expertise combined with local knowledge and values. According to McCool and Lime (2001), such approaches are reflecting not only the responsibilities of managers but also of the involved local public.

As a central concept of tourism management in protected areas considering the balance of economic, ecological and socio-cultural aspects, including the experience of visitors, the authors propose a shift of attention from the threshold visitation level to the optimal visitation level. From the systemic point-of-view, it can be formulated as a state of the destination system that delivers the highest possible compound benefits at a given moment, assessed through expert multifactorial cost-benefit analysis. TCC in its refined form described further in the manuscript serves as an integral part of the analysis. Parameterized TCC (chap. 3.5) builds on the current conception of TCC (e.g. Mexa and Coccossis 2004; Zejda & Zelenka, 2019; Zelenka & Kacetl, 2014), is multidimensional, reflects the inhomogeneity of the destination and evolves in time (accumulation of impacts, external ever-evolving conditions, changing visitation characteristics and other manifestations of process dynamics). Effective TCC (where most factors remain unalterable) is contrasted with the potential TCC (considering the potential of knowledge-driven optimizing visitor management interventions) of the whole destination system (represented by its destination model). Visitor management relies on monitoring and data collection, process modelling (including predictive capabilities), and influencing both real-time visitor traffic and long-term visitation characteristics, thus moving the effective TCC towards the potential TCC.

3.3. Foundations of the destination model

An impact caused by a change in the value of a primary independent variable (e.g. the number of visitors) on a dependent variable (e.g. the state of an ecosystem in the protected area) takes place through the interaction of individual impacts (Pásková, 2003a; Pásková, 2012; Zelenka & Kacetl, 2014). These can be both desirable and undesirable. Changes in traffic density and congestion, local price increases, soil degradation and increased waste are all negative impacts. Increased tourism revenues and more investments in nature conservation are positive impacts. However, values of dependent variables are not completely determined by independent variables alone, but are also affected by other internal, manageable and external, unmanageable factors.

As a step towards the operationalization of TCC for evidence-based

Table 1
A conceptual analysis of approaches to the TCC.

Concept/ Criteria	Tourism Carrying Capacity (TCC)	Limits of Acceptable Change (LAC)	Visitation Optimization (e.g. TOMM)	Comprehensive Systems Approach in Tourism
Objective	Determine the limits of destination use on the basis of the professionally assessed regenerative capacity of the destination's ecosystems and social system.	Determine the limits of destination use while considering the needs of stakeholders by setting the acceptable level of adverse changes.	Determine the optimal use of destination resources with regards to the needs of stakeholders. The target optimum is a compromise between minimizing risks (sub-optimal visitation) and maximizing benefits in the long run.	Approach the destination as a complex, open and adaptive system and capture the key processes in the destination including the links between tourism, nature and stakeholders for analytical and managerial purposes, considering both positive and negative feedbacks, mutual influences between variables and the acceptability of professionally determined limits of the regenerative capacity.
Theoretical foundations	Correlations between the intensity and type of influence on primary destination resources (formerly natural resources) and their consequences in long run. Based on the population theory, limits of use and CC in farming, urbanism, economy etc.	Social exchange theory-based consensus on the limits of destination resource uses.	Integrated approach to tourism management with focusing on participatory research and long-term monitoring of a set of indicators. Based on motivation (Maslow, 1943, heuristics and optimization theory.	Dynamic optimum inferred from recognizable impacts of tourism on the primary destination sources, interpreted through their acceptability to stakeholders over the course of the destination life cycle. Based on reconceptualized TCC, systems theory, system dynamics, population dynamics, qualitative modelling, operations research and social dynamics.
Applicability in destination management	Tourism intensity dimensioning (mainly through the type and capacity of the destination infrastructure) so that primary destination resources are protected.	Tourism intensity dimensioning (mainly through the type and capacity of the destination infrastructure) to protect needs or interests of key stakeholders.	Continuous tourism intensity dimensioning towards the visitation optimum using key performance indicators negotiated by stakeholders, leading to results acceptable for most actors.	Continuous information support for evidence-based proactive participative destination management, allowing predictive analysis and visualizations, leading to comprehensive planning, fast and integrated decision-making and strategy implementation. Potential to augment self-regulatory mechanisms by influencing flows, behaviours, preferences and motivation of visitors.
Key methods	Longitudinal monitoring of sets of potentially correlated variables (determined by experts), determination of a threshold value under given conditions, bottleneck monitoring and analysis.	Participative negotiation and knowledge-collection methods (Delphi method, focus groups, brainstorming), monitoring and data collection, participatory research, stakeholder analysis.	Participatory management as a collaborative visitor management frame utilizing a continuous process of (key performance indicators (KPIs) negotiation as a way of compromise-seeking and mutual learning among stakeholders.	Participatory research, stakeholder analysis, knowledge management, systems analysis, sensor-based monitoring, big data collection, processing and analysis, multivariate statistics, systems of differential equations, convolutional networks and related artificial intelligence approaches, data and systems integration, systems engineering, sensitivity analysis, scenario simulation, specific modelling methods related to the selected type of model.
Philosophy	Nomothetic, absolutist, deterministic.	Idiographic, relativistic, deterministic.	Idiographic, relativistic, usually deterministic.	Holistic (organic), rather idiographic though general (nomothetic) principles may be involved; relativistic, but can be probabilistic (stochastic).
Independent variables	The number of visitors per unit may be measured by a variety of methods.	Visitation, which may involve also visitor characteristics.	Visitation, which may involve also visitor characteristics.	A multitude of input variables including visitation data (either independent variables or factors) is chosen according to data availability, the managerial goal or the purpose of the analysis.
Dependent variables	Consumption of the given destination resource (or a negative impact on the resource) resulting from visitation, regardless of stakeholder.	The adverse impact of resource depletion resulting from visitation on stakeholders (or perception of the impact by stakeholders).	Both positive and negative impacts of visitation on stakeholders (or perception of the impact by stakeholders) reflected in a negotiated set of KPIs covering economic, environmental and socio-cultural aspects.	The overall state of the system represented in numerous variables. A specific dependent variable may be determined by the managerial goal or the purpose of the analysis, such as risks (impacts) or benefits for stakeholders.
Complexity level	Just a correlation (with implied causation) between the independent variable and one or more dependent variables). "Dimensions": parameters are typically not included or the level of parameterization is very low.	Low level of mathematical sophistication.	May be implemented with moderate complexity with some level of parameterization, depending on how the negotiation process defines KPIs.	Typically highly complex, composed of a multitude of elements (geographical, organisational, functional), variables (both measured and calculated, categorical or qualitative, typically in the form of

(continued on next page)

Table 1 (*continued*)

Concept/ Criteria	Tourism Carrying Capacity (TCC)	Limits of Acceptable Change (LAC)	Visitation Optimization (e.g. TOMM)	Comprehensive Systems Approach in Tourism
				time series data) and relations between them, reflecting different semantic layers (including TCC dimensions), the spatial structure of the destination, its multiple stakeholders and temporal transformations of the whole system; allows a high level of parameterization.
The main drawbacks or challenges	Factors of importance are omitted from the model.	Deals only with the negative effects of tourism.	Difficulties in the KPI negotiations because of the lack of data and understanding about the destination system behaviour.	Relevant theory is emerging and must undergo more scrutiny by experts. Relevant methods and approaches are yet to be evaluated systematically. Implementation requires extensive use of technology. Data and resources intensive, systems analysis and subsequent implementation, as well as maintenance, may be demanding, thus costly.
Key sources	Lindberg McCool and Stankey (1997), Mathieson and Wall (1982), Mexa and Coccossis (2004), Stankey and Burch (1979), Wagar (1964), Wall (1982)	Ahn et al. (2002), Cole and Stankey (1997), Frauman and Banks (2011), Stankey et al. (1985)	Newsome et al. (2013), Jiricka, Salak, Pröbstl, Arnberger, and Eder (2011), Manidis Roberts Consultants (1995), Marsiglio (2017)	Bertocchi et al. (2020)Bertocchi et al. (2020), Buchta and Dolnicar (2003), Butler (1980), Camatti et al. (2020), Forrester (1994), Lazanski Jakulin, (2006a), Lazanski Jakulin et al. (2006b), Walker et al. (1998), Zejda and Zelenka (2019)

visitor management, the destination models for real-world protected areas can be built (Fig. 2).

The destination model captures the partial impacts of a certain monitored independent variable (e.g. the number of visitors over time) on dependent variables in different destination dimensions (e.g. socio-cultural, ecological and psychological) as well as the aggregation of these partial impacts within the defined dimensions (e.g. the combination of noise and light pollution; Pásková, 2012). In this way, the model represents particular related phenomena, such as the socio-cultural influence of tourism.

3.4. Parametrized impacts

To reflect the significance of partial impacts, weights are assigned to each of them either by the consensus of experts (or even potentially through public input) or statistically if data are available; weights may be constant or may vary over time or depend upon other variables (technically becoming functions within the destination model). *Factors* (conditions) can intervene and influence the independent variable, the partial impacts of the independent variable, or the aggregation of interacting partial impacts. Some factors manifest themselves only in

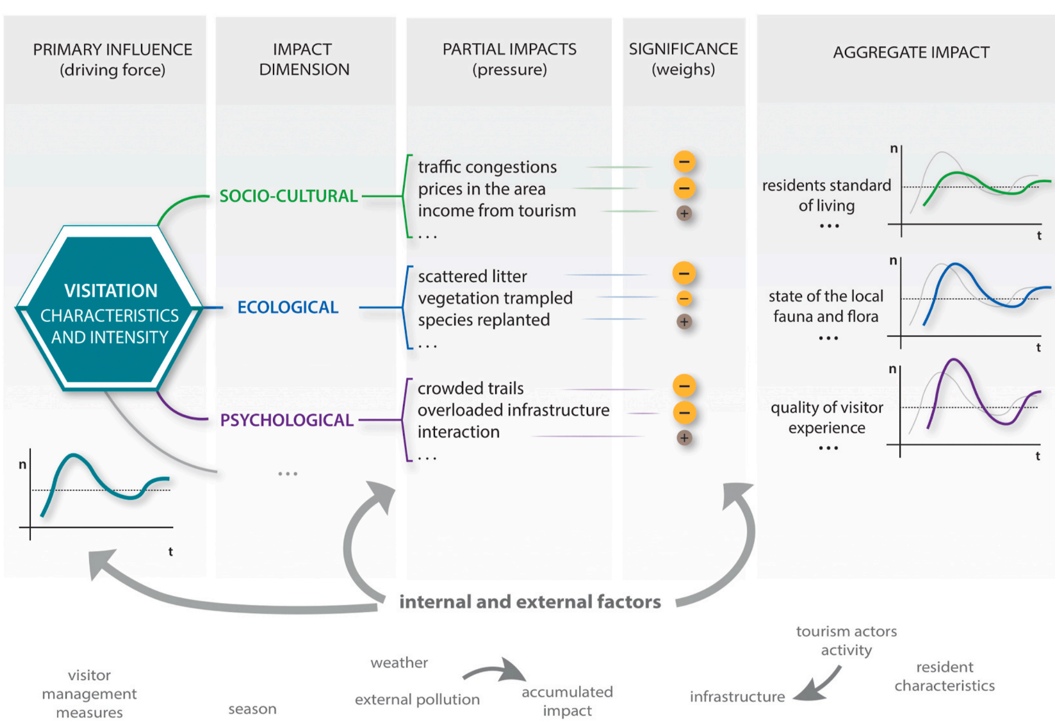

Fig. 2. Functional model of a destination and a reconceptualized derivation of TCC.

one of these phases; others in several. At each stage, they may reinforce or suppress the size of the impact, acting in either desirable or undesirable ways. For example, weather is an external factor, and rain deters visitors from coming – an independent variable is influenced, reducing the pressure on the ecological dimension. Further, visitors are likely to spend less time in exposed locations (reduced impact in the second phase). However, as the soil and trails are more vulnerable in wet conditions, the impact of the presence and movement of each visitor will be more serious for vegetation, which is an undesirable effect of the factor in the third phase. So, rain may have both desirable and undesirable effects; therefore the final effect depends on the strength of each of its influences.

3.5. Parametrized tourism carrying capacity

Carrying capacity in the destination model is the highest acceptable aggregate pressure caused by an independent variable on dependent variables. Unacceptable and/or irreversible changes in the ecological, socio-cultural and other dimensions of the destination would occur if this threshold is exceeded. The irreversibility threshold or interval of critical values are usually determined by the expertise based on the long-term monitoring and evaluations of selective indicators, such as population size of endemic or endangered species. The development of the dependent variable over time can be evaluated in relation to its defined limit, which is a minimal or maximal value, depending on the character of the dependent variable. For example, it could be the highest acceptable negative change in the quality of life of the local population, including the impact on their living environment. If the level of the dependent variable moves beyond the limit, then the corresponding TCC dimension is exceeded. The difference between the limit value of the dependent variable and its actual measured or calculated value indicates the extent to which the TCC in this dimension is either exceeded or not reached. In addition, as the TCC in the model may change over time, depending on internal and external factors, it can be called *parameterized TCC*. The *conditional TCC* is the parametrized TCC under fixed parameters.

3.6. Variable characteristics

Both evident and unknown functional relationships may exist between individual partial impacts and factors, causing either synergistic strengthening of effects or their mutual reduction and eventual elimination. In addition, weights may change over time, especially if an instantaneous or accumulated partial impact value is close to a specified limit. For example, traffic may initially have little impact on the quality of life of local residents. However, as soon as it exceeds a *threshold* and becomes uncomfortable, congestion will be perceived and it will be an increasingly pressing issue for local people. The occurrence of self-dependency of variables can be expected, with both positive (amplifying) and negative (self-regulating) feedback possible.

In order to implement the destination model, it may be appropriate to define *artificial variables* that express an interaction or a sum of two or more variables, *dummy variables* as a replacement for categorical variables, or to introduce variables that express only approximations. Such items may provide clues regarding future research needs. It is important to keep track of such steps in the destination model construction, so they can be taken into account in the interpretation of the model results. The utilization of an irritation indicator in order to capture the total impact of tourism perceived by the local community (Doxey, 1975; Pásková, 2002; Pásková, 2003a; Pásková, 2012; Pásková, 2014; Zelenka & Kacetl, 2014) is an example of an artificial variable that can be interpreted meaningfully.

In addition, the difference between *instantaneous* and *cumulative* quantities must be distinguished consistently, both during the destination model construction and when interpreting the results. For example, the condition of vegetation cover at a site is a cumulative variable. The continual trampling of the flora by visitors in relation to particular conditions (accompanied by disturbances caused by other factors) affects the state of the vegetation cover; however, at the same time, natural regeneration also takes place (Johnston & Tyrrell, 2005).

This difference is also reflected by the character of partial impacts on aggregate dependent variables and, ultimately, in the character of each TCC dimension. Ecological TCC typically reflects cumulative effects from long-term aggregate impacts. Psychological TCC, on the other hand, is more immediate. Socio-cultural capacity reflects both immediate and long-term effects. These may include the immediate impact of a large number of visitors and the occupancy of parking lots, congestion of public spaces, and also long-term effects like the transformation of residences into tourism infrastructure or building new tourism infrastructure which interferes with local lifestyles, an increase in the price of products, etc. In addition, measures to regulate visitor traffic may also have delayed effects. Therefore, it is possible that when a particular measure is implemented, it is no longer desirable. It indicates that real-time knowledge about the destination system may not be enough to fully inform evidence-based visitor management: a well-defined destination model may also allow predictions and scenario modelling to occur.

3.7. Destination model spatiality

Carrying capacity has a spatial structure. According to Lawton and Weaver, (2001), the movement of up to 95% of national park visitors is limited to a very small part (about 5%) of park territory. So, even if there are objectives regarding the whole area, individual sites may require specific attention. These are places where tourism and nature conservation collide intensely, whether caused by high visitor numbers, type of visitor activity, visitors' social concerns, the site's high environmental sensitivity, or any combination of such parameters. A destination model can be built either for a large protected area (e.g. a national park) or for an individual site within it. A site can be, for example, a national nature reserve, part of a trail, a scenic point, a camping site, a habitat or site-specific ecosystem, or almost any sufficiently homogeneous space within a larger heterogeneous area. However, it is impractical to address numerous territorial units, especially for the environmental dimension. Therefore, aggregate values for larger territorial units may have to be used (Zelenka & Kacetl, 2014). Separate destination models for specific sites may be integrated into a composite model of the wider area, honouring the relationships among the variables in the sub-models (e.g. the measured or estimated numbers of visitors and their flows between specific sites).

3.8. Visitation optimum

Following earlier research (Bednar-Friedl et al., 2012; Bertocchi et al., 2020; Camatti et al., 2020; Pásková, 2014; Weaver & Lawton, 2017; Zelenka & Kacetl, 2014) and inspired by neoclassical economic theory, the new concept *visitation optimum* is introduced to express the optimal rate of land use by tourism over time. The visitation optimum for a given area at any given time is defined as the intensity level and form of visitation in the destination which generates the optimal impact on that area. It means that the TCC of any relevant dimension is not exceeded while, at the same time, providing the highest possible utility for the key tourism actors, including visitors, the local community, the local economy and the natural environment. A rise or drop from the visitation optimum will exceed the TCC or lead to decreased utility for involved actors.

3.9. Effective and potential tourism carrying capacity

It is possible to distinguish the effective and potential TCC of a territory (Pásková, 2014). *Effective TCC* corresponds to the structure and status of the destination at any given moment. It is determined mainly by the spatial and temporal distribution of the visitor/interpretative infrastructure and services, as well as other elements of visitor management. It is also influenced by the segmentation structure of visitors, taking their level of social responsibility as a segmentation base. *Potential TCC* (Fig. 3) is the maximum visitation intensity that a protected area can accommodate without exceeding the TCC of its territorial units, assuming the best available space-time distribution of visitors, and space distribution and types of visitor/interpretative infrastructure and services.

It is necessary to acknowledge the difference between the practical and theoretical visitation optimum. The *practical visitation optimum*, related to effective TCC, is the optimal intensity of visitor attendance corresponding to the structure and state of the territory at a given moment and segmentation structure of visitors. The potential TCC relates to the theoretical optimum level of visitor intensity that can be accommodated with the best possible visitor management, leading to the best spatial and temporal distribution of visitors and their best segmentation structure. As the theoretical visitation optimum is a purely theoretical construct that is hard to be achieved in reality, the potential TCC is likely unattainable in practice. However, the gap between effective and potential capacities can reveal untapped potential for sustainable tourism in otherwise constant conditions. Therefore, the task of visitor management should be to reduce the gap between the theoretical and practical visitation optima.

3.10. Scenario

The proposed theory, including the concepts of visitation optimum, and effective and potential capacities, is illustrated in the following visitor management scenarios (Fig. 4). Visitors are few during the initial phase of tourism development and tourism potential is not sufficiently activated (v1 curve). However, visitor attendance gradually increases over time, thus exceeding TCC. It is suboptimal and unsustainable in terms of both immediate visitor benefits and the state of local nature. Exceeding the psychological dimension of TCC leads to a spontaneous decline of visitor interest and subsequently to the return to a desirable use level below the TCC (Pásková, 2014, pp. 87–139). The implementation of restrictive visitor management measures (Pásková, 2014, pp. 196–200) results in a situation illustrated by curve v2 with smaller fluctuations. However, if visitor management measures are not implemented quickly enough, irreversible changes may have already occurred, typically erosion around trails, damage to natural formations, and change in the species composition of flora and fauna. These undesirable changes of the parameters of the destination system reduce the social acceptance of tourism, state of local ecosystems and quality of visitors' experiences. This situation results in reduction of the TCC of the destination area.

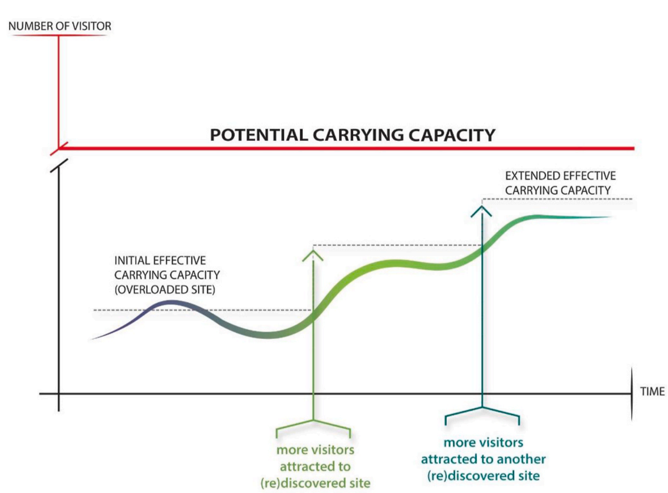

Fig. 3. Potential TCC of the site.

Proactive and preventive visitor management (Albrecht, 2016) would have been better in this case (v3 curve). Tourist use of the area could have been stimulated and regulated through coordination of the destination agency with a protected area authority in order to reach the visitor optimum and subsequently maintain it at the desired level by a combination of proactive and reactive measures. Through this management approach, the added portion of time and space of the destination could have been used for tourism, enabling a higher level of spatial and temporal dispersion of tourism flows. Together with the other visitor management tools, this leads to an increase in the TCC of the destination as illustrated in Figs. 3, Figs. 4 and 6. A prerequisite for proactive visitor management is a profound knowledge of the destination and its processes, of the TCC levels, of the development of key variables over time, and the availability of tools that can influence visitor flows and use intensity. Failure to meet these prerequisites is an important reason why proactive visitor management is not implemented on a larger scale even though its advantages are well-documented.

3.11. The role of the destination model and the destination decision-support system in proactive visitor management

Proactive protected area management may combine complementary measures to carry out both restrictive and stimulating actions. Direct bans may be involved, such as forbidden entry, supplemented by sanctions for violations, economic measures such as admission prices, parking charges, taxes and other fees, infrastructural calibration including manipulation of the capacity of parking lots, accommodation facilities and public transport, informational or marketing-based promotions of selected places, or even discouraging visits to some places, and targeted advice provided in information centres. The extent to which a protected area authority may use these measures and benefit from their effects varies. Some of them may be fully within their reach and responsibility, whereas others may only be used through cooperation with other destination actors, such as destination management organizations or tourism associations. Good coordination with other tourism actors is necessary to enhance the effectiveness of individual measures synergistically. Effects of various combinations of measures may be evaluated in simulated scenarios within the destination model. Analysis of differences between the simulation results and real observed values may be used to assess the quality of the destination model and refine its contents. Such continually improved evidence-based visitor management may be called *systemic*. Fig. 5 tracks visitor management activities from analyses of the destination system through strategic management to movement towards the visitor optimum.

3.12. The spatial structure of tourism carrying capacity

Visitor flows and behaviour analyses may show that most visitors are heading to a site where capacity has already been reached, while other interesting sites may be able to absorb higher numbers of visitors. Measures can then be taken, such as adjustments to trails, signage and navigation/information systems, promotion in printed materials and social media, and pricing policy. Consequently, a substantial portion of visitors will decide to visit an alternative location instead of the intensively used site (Fig. 6). The originally fully utilized location is no longer a bottleneck for the whole territory and the capacity of the protected area is increased. In this way, visitor attendance can grow sustainably towards this extended TCC.

In-depth knowledge of the spatial structure of visitation to the area and specific impacts on the destination system allows for the implementation of a set of measures, which modulate the visitor attraction and interest in specific sites. In this way, time-space behaviour of visitors is changed and their sensitivity increased which gradually extends the effective TCC and keeps the numbers of visitors below this limit (Fig. 3). Although the measures have succeeded in increasing the effective TCC

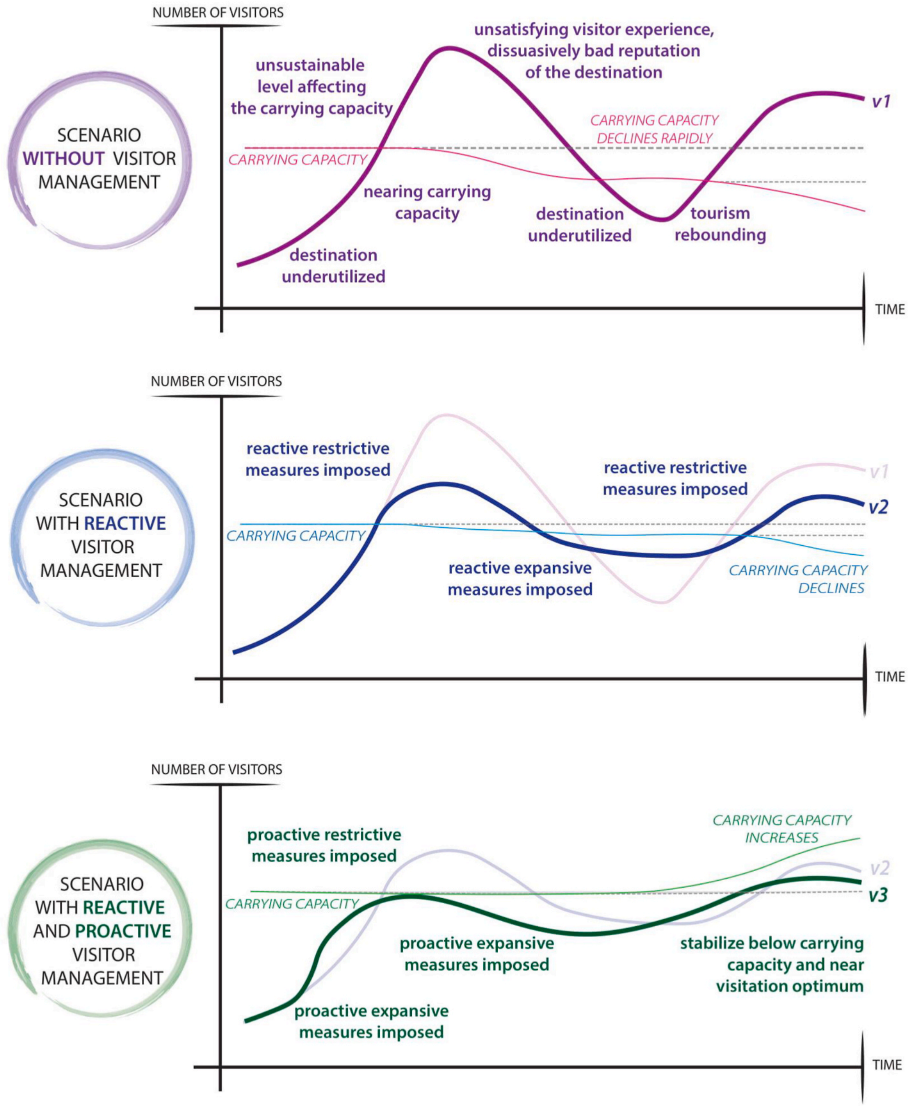

Fig. 4. Scenarios of visitor management and TCCs development (without any visitor management - v1 curve, with reactive management - v2 curve, or proactive management - v3 curve).

and acceptable numbers of visitors (leading to various positive outcomes), the potential TCC of the area is not yet reached.

4. Discussion

4.1. Vast complexity of the system

The potential of a destination description as a system as well as description of the behaviour of its elements are limited mainly by the number of external factors and accumulation effects. The direction of causation may not be obvious for some relationships. A high number of variables in the model may reduce its robustness and interpretability. The nonlinear behaviour of the ecosystem, the instances of multiple correlation and autocorrelation, population dynamics of various species, or fundamental changes in the behaviour of the destination system over time are some of the complications for data predictability, simulation of destination processes and, finally, for destination model operability. Consequently, applying the methodology may be hindered by the excessive complexity of the destination system, which may thwart efforts to create a sufficiently precise, robust, manageable and interpretable destination model. The destination model has to be based on available current as well as historical data. One of the future research goals is to indicate conditional carrying capacities (maximum acceptable number of visitors under different conditions) and their specific locations, considering also the non-linear character of relationships.

4.2. Selection of variables for the destination model

When constructing the destination model for a particular territory, from a potentially huge set of variables and interrelations among them, the variables that manifest themselves most strongly, i.e. with highest frequency and intensity of influence on dependent variables, have to be identified by an expert estimate or preferably by a sensitivity analysis whenever data are available. Less-influential variables and relationships

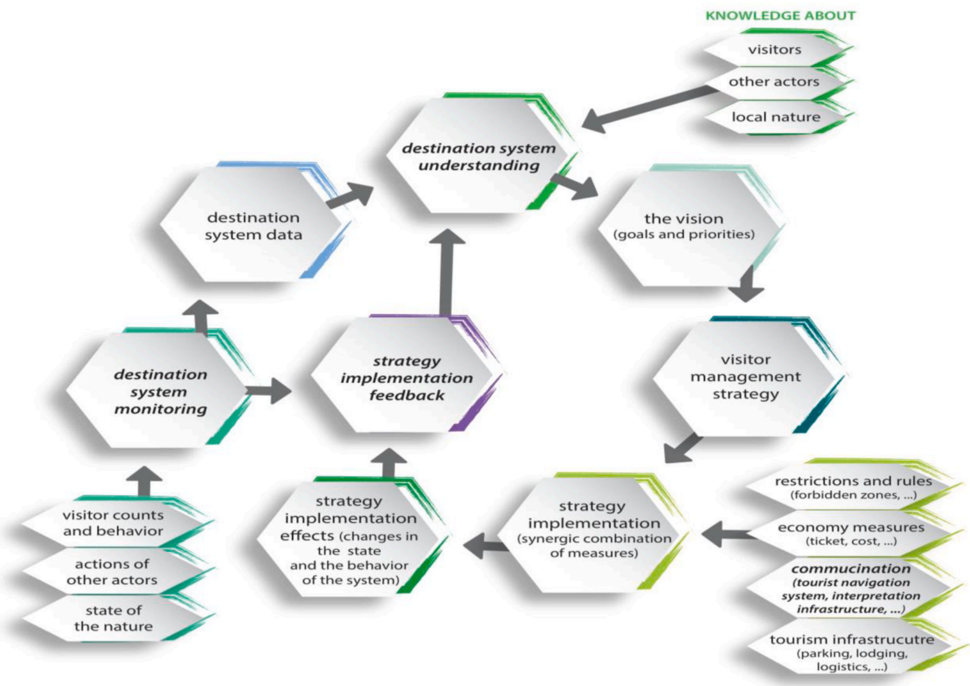

Fig. 5. Systemic visitor management; areas in which implementation of the destination model may bring the highest added value are highlighted by bold type.

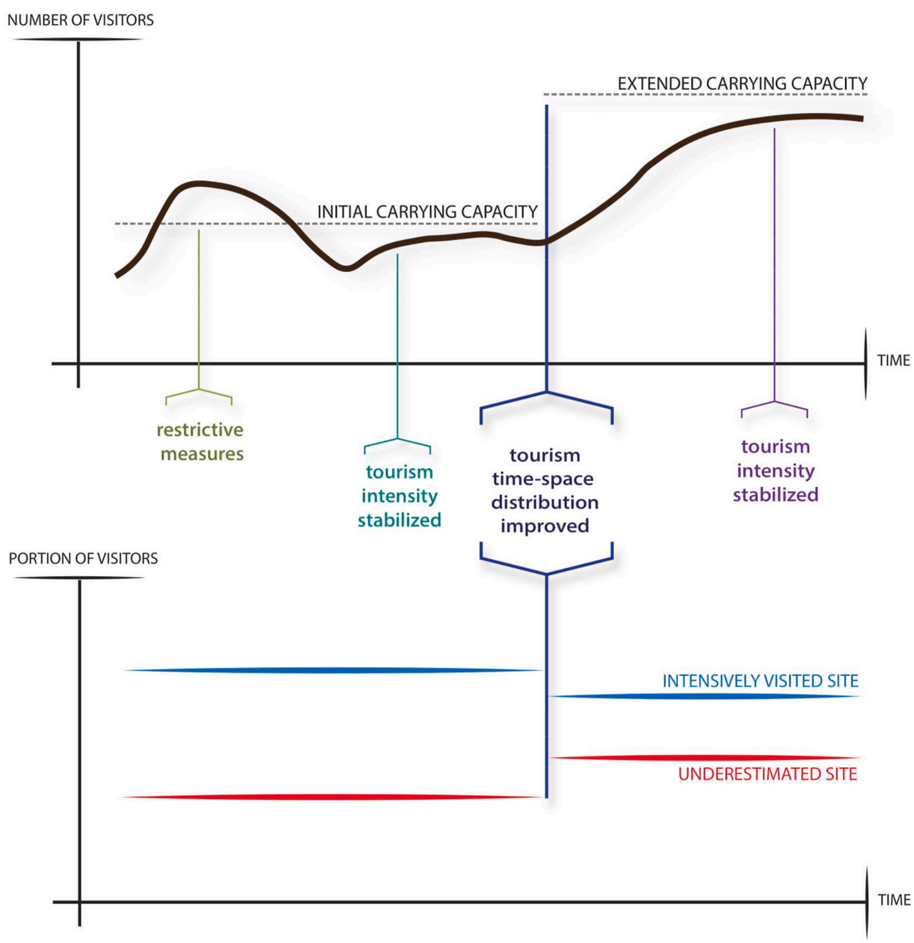

Fig. 6. Carrying capacity extension through the improvement of visitor management.

may, and to prevent model overfitting even must, be neglected. Certain variables may have to be omitted if no data are available. Intentionally neglected variables and relationships will need to be considered when interpreting model results. As statistical proofs about causation usually require controlled experiments, the direction of each relationship (expressing causation) usually cannot be derived from observed data by statistical means. Such experiments are not always feasible. Therefore, to decide about causation, expert evaluation of the available data in the light of well-established general scientific knowledge may have to be used.

4.3. Low quality of inputs

In practice, an insufficient range and quality of data (e.g. the number of visitors or the current state of monitored natural phenomena) and sometimes the inability of protected area management to analyze available data efficiently may hinder understanding of destination system behaviour. Moreover, data may need to be cleaned, transformed, or otherwise modified prior to their utilization, for which protected area personnel may not have adequate tools or knowledge. Strategies and measures that are not supported by a credible theoretical basis and systematic monitoring of tourist traffic and its impacts will be more difficult to promote to other tourism actors involved in participatory management.

4.4. Expert input and quantification

Visitor management, including the calculation of capacities, because of the complexities involved, has customarily required the input of experts. Furthermore, the key output of capacity planning has often been articulated as the production of a numerical capacity that is used to guide the selection of management strategies. Expert input and quantification are, therefore, linked. Proponents of the application of a capacity approach have often overlooked the fact that they may be unwittingly promoting a top-down management approach. Steps can be taken to counter this. For example, advocacy of a LAC approach raises the question of not only "What changes are acceptable?", but also "Who should decide what is acceptable", thereby potentially opening the discussion to more actors.

Quantification of complex inputs risks the commitment of errors of false precision, particularly where data are lacking. However, the process of quantification may lay bare assumptions and data deficiencies, thereby promoting transparency and focusing discussion on a common set of information. Yet, the focus on numbers, as is usually the case in capacity calculations where arrival at a number is often portrayed as a primary objective, may encourage an unnecessarily narrow perspective for, for example, the types and distribution of visitors and impacts may be as important as the number *per se*, and these things may also be amenable to managerial manipulation.

5. Conclusion

Visitor management in a protected area should be based upon information regarding the optimal form and intensity of tourism, such as the visitation level, its spatio-temporal pattern, and the character of visitors' activities, which affect all of the destination dimensions and actors. A systems approach facilitates gaining in-depth knowledge of the structure and the state of the destination system and the formulation of strategies to keep visitor numbers of individual sites near to their visitor optima. Then, measures can be taken to increase gradually the effective TCC towards the potential TCC.

The behaviour of the destination and each of its sites is a result of the interaction of a number of actors and factors that vary at different rates over time. Visitors form a heterogeneous group showing different behaviour patterns and, hence, different impacts. Given the enormous complexity of a destination system, it is hard to imagine that sustainable, evidence-based visitor management can occur without the help of a decision-support system that is able to capture and reflect a selection of the characteristics of the destination system. It is, therefore, appropriate to focus further theoretical and applied research on refinement of the TCC concept regarding optimum visitation. This study has introduced approaches that involve system destination analysis and the derivation of a location-specific destination model that fully utilize available data. It has been shown that the effectiveness of existing visitor management tools can be increased by the analytical, explanatory and predictive capabilities of a destination model based on a refined TCC concept.

Based on a conceptual analysis, involving a combination of deductive reasoning with an inductive approach drawing upon the experience and knowledge of the authors, ongoing pilot testing of the initial destination model, and interaction with experts from selected protected areas, the theory of TCC has been reconceptualized and operationalized. In particular, the notion of TCC as a fixed figure that is inherent to the natural resources has been modified to recognize that capacities can be modified by managerial inputs and will vary over time and with management goals and objectives. The concept of visitation optimum was introduced so that the tourism potential of the territory can be activated to its sustainable maximum without exceeding the effective TCC. To achieve this, both the temporal and spatial structure of carrying capacities must be understood and reflected in the destination model as well as in the visitor management strategy. Destination modelling can support visitor management decision-making processes, resulting in systemic visitor management.

The proposed concepts and methodology, which are currently being applied experimentally in several protected areas of the Czech Republic, need to be further refined and verified. The validation of the methodology in other protected areas to discern general patterns among their respective destination systems is intended. In future research, the refinement of a more dynamic TCC formulation and visitation optimum should be emphasized to further improve both TCC theory and visitor management performance in protected areas.

In line with the origins of TCC thinking and the development of visitor management systems, the presented discussion has focused upon parks and protected areas. However, the authors believe that capacity reconceptualisations have wide applicability and the proposed approach to destination management has the potential to be applied to destinations of other types, including those that were recently suffering from overtourism and are now looking forward to the time when visitors return in greater numbers.

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Availability of data and material (data transparency)

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Credit author statement

Pásková Martina: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing Geoffrey Wall: Contextual inputs, Writing – review & editing Zejda David: Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization Zelenka Josef: Conceptualization, Validation, Formal analysis, Writing – original draft, Supervision, Project administration, Funding acquisition

Declaration of competing interest

The authors declare that they have no conflicts of interest.

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Martina Pásková, Assistant Professor, Faculty of Informatics and Management, University of Hradec Králové (FIM UHK), Hradec Králové, Czech Republic Rokitanského 62, 500 03 Hradec Králové III, Czech Republic, +420 493 332 336, fax: +420 493 332 239, martina.paskova@uhk.cz, ORCID: https://orcid.org/0000-0002-9022-6374

Geoffrey Wall, Distinguished Professor Emeritus, Department of Geography and Environmental Management, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. Phone: 519-886-1445, E-mail: gwall@uwaterloo.ca, ORCID: https://orcid.org/0000-0001-5649-8715

David Zejda, researcher, FIM UHK, Hradec Králové, Czech Republic Rokitanského 62, 500 03 Hradec Králové III, Czech Republic, +420 493 332 336, fax: +420 493 332 239, david.zejda@uhk.cz, ORCID: https://orcid.org/0000-0002-5769-3552

Josef Zelenka, Professor, FIM UHK, Hradec Králové, Czech Republic Rokitanského 62, 500 03 Hradec Králové III, Czech Republic, +420 493 332 337, fax: +420 493 332 239, josef.zelenka@uhk.cz, ORCID: https://orcid.org/0000-0001-6678-0722