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The ecological implications of visitor transportation in parks and protected areas: Examples from research in US National Parks

Christopher Monz [a,*], Ashley D'Antonio [b], Steve Lawson [c], Jesse Barber [d], Peter Newman [e]

[a] Department of Environment and Society, The Ecology Center, Utah State University, Logan, UT 84231, United States
[b] Department of Environment and Society, Utah State University, Logan, UT 84231, United States
[c] Resource Systems Group, Inc., 55 Railroad Row, White River Junction, VT 05001, United States
[d] Department of Biology, Boise State University, Boise, ID 83725-1515, United States
[e] Department of Recreation, Park and Tourism Management, Penn State University, University Park, PA 16802, United States

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ABSTRACT

The demand for recreation and nature-based tourism experiences in parks and protected areas continues to grow in many locations worldwide and in response, many parks are employing transit services designed to improve visitor access. Transit services (e.g., public bus service) are a component of the overall park transportation system and are very desirable in park settings as they yield many advantages over personal auto access including reduced congestion in parking areas, a reduced carbon footprint, and an enhanced visitor experience. However, a growing body of research also suggests that the delivery of visitors via transit to destinations within a park or protected area may have unique ecological disturbance implications resulting from increased visitor use, density, and altered spatial and temporal use patterns. In this paper, we examine the relevant literature and present examples from recent research that illustrates the potential range of ecologic impacts from visitor deliveries via park transportation systems. We conclude while transit systems remain very desirable in park settings, depending on a range of situational factors, conventional, demand-driven planning and management approaches may result in unintended impacts to ecological conditions. Overall, this discussion provides a framework for improved management of the potential ecological impacts of protected area transportation systems.

1. Introduction

Worldwide, recreation and tourism activities in parks, wilderness, and protected areas continue to show trends of increasing participation (Cordell, 2008; Balmford et al., 2009). With the increase in urbanization worldwide, experiences in parks and protected areas are a primary means for people to interact with and experience nature. Combined with the potential for economic diversification and development, government agencies and local communities generally perceive nature-based tourism and recreation as social goods and often accommodate and encourage the increased demand by providing more services for visitors. Associated with this increasing visitation, and the increased services being provided, are concerns regarding both declining quality of visitor experiences and degradation of natural area resources (Manning et al., 2014).

One such strategy to accommodate increasing demand for recreation and tourism in parks and protected areas is the use of transportation systems as a visitor service. Transportation systems are often designed to provide opportunities for visitors to experience protected areas and to deliver visitors to key destinations so visitors can engage in desired activities. Recent reviews of these approaches suggest that in US National Parks, transportation systems are integral to not only delivering visitors to key destinations, but also to managing visitors and providing park experiences (Manning et al., 2014). For example, transportation can be designed in such a way as to serve as a primary means of experiencing the natural and cultural landscapes expressed in parks and protected areas. In the United States, many of the roads built in iconic parks such as Yosemite and Glacier were designed for visitors to experience the parks from their cars and demonstrate the longstanding connection among transportation, national parks, and outdoor recreation. More recently, these same roads are now serviced by transit systems, designed and operated by the parks to both relieve traffic congestion and provide a more convenient park experience. Moreover, several units of the US national park system were specifically designed to accommodate the demand for "driving for pleasure"—historically one of America's most popular recreation activities (Manning, 2011).

Recent literature also suggests that transportation systems are potentially powerful tools for managing visitor use in national parks and protected areas. The transportation networks and linkages in parks define where park visitors travel and accordingly can be managed by parks

* Corresponding author.
E-mail address: chris.monz@usu.edu (C. Monz).

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to help deliver visitors to locations according to resource and/or social capacities (Manning, 2007; Lawson et al., 2009; Lawson et al., 2011; Meldrum and DeGroot, 2012). In this way, transportation can be used to manage parks and outdoor recreation in a more appropriate way that serves to both protect park resources and quality visitor experiences (Manning, 2007; 2011). Recent work also suggests that to accomplish this, management perspectives must shift from "conventional, demand-driven" approaches to more sustainable solutions based on park management and conservation goals (Manning et al., 2014). In demand-driven scenarios, management responds to current and projected visitation with transportation services designed and operated according to demand. Expansion of services (i.e., more delivery of visitors to destinations) typically occurs when demand exceeds supply. A more sustainable approach to transportation management has been suggested by Manning et al., (2014) where transportation planning and management is conducted within an adaptive management framework based on park resource (ecological) and visitor experience condition indicators and associated standards. This approach can then lead to more intentional improvements in transportation systems while accomplishing park resource and experiential goals. Consequently, transportation systems become a solution to help manage parks in a more sustainable manner (i.e., to meet resource protection and visitor experience goals), rather than the cause of unintended degradation of ecological and social conditions.

Although using transportation systems as a tool to manage parks and protected areas more sustainably is gaining acceptance as a viable strategy, to date the majority of research has examined the effect of transportation on visitor experience conditions, investigating via various approaches, the effect of transportation deliveries on attributes such as crowding at park destinations (Manning, 2014; Lawson et al., 2011 Newman et al., 2010). A more limited, but equally relevant line of research has begun to examine the ecological consequences of park transportation systems to ecological conditions (Manning, 2014, D'Antonio et al., 2013, Monz et al., 2014). It should be noted that a well-developed literature exists on the negative effects of roads on the biotic integrity of both aquatic and terrestrial communities (e.g., Trombulak and Frissell, 2000) and on mass transit as a means of reducing carbon emissions and other pollutants produce by automobile travel (e.g., Betsill, 2001). Although these are clearly important considerations in protected area transit system design and planning, they are beyond the scope of this paper.

Here, we focus the discussion specifically on developing a better understanding of the ecological consequences resulting from the delivery of visitors via transportation systems to destinations within a park of protected area. For purposes of this discussion, we take a broad view of "transportation systems" and include all aspects of park design and services that function to deliver visitors to destinations within a park, including public transit services (typically bus service), automobile roads and parking, intelligent transportation systems (ITS), bike/pedestrian paths and associated facilities. We use the term "transit" to specifically identify public transportation, provided as a service to park visitors. To begin, we provide a basic discussion of the ways in which the typical visitor activities in parks can act as agents of ecological disturbance and then introduce a conceptual framework for understanding how transportation systems act as an influential factor. Some of the ideas presented are conceptual and uninvestigated to date, while others are illustrated with examples from several recent studies in US National Parks where an examination of the ecological consequences of transportation systems was a component of the study. We conclude with several recommendations to help managers of park transportation systems limit ecological disturbances and suggestions for future research.

2. Park and protected area visitor use and ecological change

Parks and protected areas are focal locations for visitors to engage in outdoor recreation and nature-based tourism activities. A considerable body of research has examined these human activities as agents of ecological change in parks and protected areas, with possible effects to soil, vegetation, wildlife, water, air and soundscape quality (Buckley, 2004; Monz et al., 2010; Hammitt et al., 2015). Various conceptual models have been presented illustrating how changes in the quantity, density, activity type, and spatial and temporal distributions of use can result in disturbance to the biological and physical ecosystem properties. These disturbances, particularly when combined with other use-related stressors such as the introduction and spread of invasive species, can ultimately lead to lasting changes in ecologic conditions. Moreover, in parks and protected areas, where preserving nature is often a management priority, a focus must be placed on preventing disturbances from exceeding thresholds of tolerance more than site modification to limit impacts. Therefore, it is important to understand the tolerance of the ecosystem and how to accommodate use without undesirable change.

Although a full review of recreation ecology knowledge is not possible here, several comprehensive reviews are available (e.g., Hammitt et al., 2015; Monz et al., 2013; Monz et al., 2010; Newsome et al., 2012; Buckley 2004). These detailed reviews suggest several general principles:

- Outdoor recreation and nature-based tourism activities often directly affect the soil, vegetation, wildlife, water, air and soundscape components of ecosystems.
- Recreation-caused disturbance varies spatially and temporally from the natural disturbance regimes to which ecosystems are adapted. Consequently, higher order ecosystem attributes of structure and function can be affected.
- For a given finite space, the relationship between ecologic change and use can be described with curvilinear, step, and linear functions. While not applicable to every response, the curvilinear response is a useful generalization since in many situations the majority of change occurs with initial use.
- Although some generalizations apply, the ability to withstand recreation disturbance (resistance) and the ability to rebound after disturbance (resilience) is ecosystem and often species specific.
- Visitor behavior, the amount of use, and the spatial and temporal distributions of use, are primary driving variables in determining the amount of ecological disturbance.

Several authors (e.g., Hammitt et al., 2015; Monz et al., 2010) have noted that from the perspective of minimizing ecological change, it is most important to understand the factors that influence the intensity and area of recreation disturbance such as the amount and type of use, behavior of users, timing of use, and type and condition of the environment. Managers of parks can often influence these factors and therefore understanding the nature of the relationship with ecological impact has important implications for sustainable management (Hammitt et al., 2015). The design and management of transit systems within a park or protected area has the ability to influence many of the aforementioned factors regarding visitor use, and thus it has also been suggested that transit services can be used to manage visitors in accord with park conservation objectives in addition to just accommodating demand (Manning, 2014).

3. Role of transit systems in visitor-related disturbance

Park transportation services historically have been managed by what might be described as a "demand-driven" approach (Manning et al., 2014; Lawson et al., 2011). Under this paradigm, as visitation increases in a park, capacity is added to transportation systems to meet the increased demand. This additional capacity may be manifest in various forms such as additional auto parking (formal or informal), road improvements, introduction of new bus service, higher capacity busses,