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A decision support model for traffic congestion in protected areas: A case study of Shiretoko National Park

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ABSTRACT

Increasingly there is a call for appropriate management policies to be implemented in national parks to minimize the impacts of tourism on both ecosystems and recreational settings. One facet of such problems is that of traffic congestion as car ownership grows. This study applies a traffic Cellular Automaton Model (CAM) as a decision support tool to ease traffic congestion at Shiretoko National Park in Japan. Despite serious traffic congestion having been reported in the park, a new guiding system and the regulation of private car use was started in the same year. This study shows that a probable increase in traffic congestion can be expected after the introduction of these new management systems, but congestion can be relieved by a slight modification of the temporal and spatial daily inflow of visitors. This study highlights the benefits of computational modeling to support decision-making regarding traffic management in protected areas.

1. Introduction

Tourism in protected areas has become a popular leisure activity as urban residents have become more interested in the natural environment. Although increased public interest can help to conserve natural parks and improve the livelihoods of local residents, it can also threaten wildlife and cultural heritage, leading to degraded recreational experiences (Gunther et al., 2004; Lynn & Brown, 2003). Traffic congestion in natural parks is one source of these problems. With more visitors traveling by private automobile, problems of traffic congestion, parking shortage, visitor congestion, and air pollution have increased (Hallo & Manning, 2009a, 2009b). Several management policies have been introduced to mitigate traffic-related problems. Examples include bans on private car use inside natural parks and improvement of public transportation systems (Shiftan, Vary, & Geyer, 2006). However, although successful in some instances, these management practices tend to be opposed by visitors (Regnerus, Beunrn, & Jaarsma, 2007; Steiner & Bristow, 2000; White, 2007). Thus, effective management practices that balance tourism experience and nature protection are a pressing need for the sustainable use of natural parks as recreational settings.

The computational approach is a useful decision support tool for park management (Daniel & Gimblett, 2000; Gimblett, Richards, & Itami, 2000; Lawson, 2006; Lawson & Manning, 2003a; Wang & Manning, 1999), and has been previously applied to study the adaptive management of social carrying capacity at Arches National Park in Utah (Lawson, Manning, Valliere, & Wang, 2003) and the migration patterns of visitors in the Sierra Nevada Wilderness in California (Gimblett, Lynch, Daniel, Ribes, & Oye, 2003). Here, we employ a traffic cellular automaton model (traffic CAM) to predict the impacts of visitation systems on traffic patterns at Shiretoko National Park (SHNP), a UNESCO-designated World Natural Heritage site in Japan. SHNP is an ideal case study to understand the dynamics of traffic congestion at natural parks because two new visitation systems were implemented in 2011, but traffic patterns have not been quantitatively assessed since the systems were introduced. The traffic CAM is an efficient and realistic traffic simulator that is based on rules for the movement of individual vehicles into road networks (Nagel & Schreckenberg, 1992; Simon & Nagel, 1998). Similar traffic CAMs have been used for understanding mechanisms of traffic congestion (Fukui & Ishibashi, 1996; Fukui, Nishinari, Yokoya, & Ishibashi, 2009; Gutowitz, 1991), but have never been used as a tool for sustainable tourism at natural parks.

The model was able to reproduce the spectrum of traffic congestion patterns observed at SHNP during summer holidays before and after the introduction of the new policies. We then used the traffic CAM to predict future traffic scenarios, considering alternative visitation systems, and found plausible solutions to traffic congestion. Our study illustrates the usefulness of computational modeling to understand and minimize traffic problems in natural parks worldwide and to make decisions regarding the management of natural parks.

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2. Material and methods

2.1. Shiretoko National Park (SHNP)

Shiretoko National Park (SHNP) is located in eastern Hokkaido, Japan (43°56′N, 144°57′E; Fig. 1a). Currently, SHNP has serious problems of traffic congestion, mainly during the summer holiday season. Serious traffic congestion emerged after SHNP was designated as a World Natural Heritage site in 2005, when the influx of tourists increased by more than 20% in comparison with previous years (McCullough, Kaji, & Yamanaka, 2006). One of the reasons for the traffic congestion was the undeveloped public transportation system, which encouraged tourists to use private cars to enter the park. Tourists sometimes needed to wait for more than 2 h in a long line to enter the Shiretoko Five Lakes (SFL), one of the most popular sightseeing spots in the park (Fig. 1a). Sometimes traffic jams can last for up to 8 h.

Despite the traffic problems described above, the Japanese Ministry of the Environment and the local community have introduced two new visiting systems since 2011. First, there has been a relaxation of regulation on private car use. Until 2010, access to Kamuiwakka Waterfall (KW), another popular sightseeing site in SHNP (Fig. 1a), was limited to shuttle buses because of the risk of traffic congestion. Private cars were not allowed to enter this road and visitors were transported by shuttle buses. But visitors and local travel agencies demanded free traffic transportation. The park managers decided to relax the regulation on private cars starting in May 2011, and the road was opened to private cars under several restrictions (summarized in Table 1).

Table 1
The seasonal change of traffic regulation at Kamuiwakka Waterfall (KW) and guide system at Shiretoko Five lakes (SFL).

Period	Traffic regulation at KW	Guide system at SFL
5/10 (opening)–7/31	Visitors are allowed to use private cars.	Visitors need to hire a trained guide.
8/1–8/25	Only shuttle buses are available.	There is no need to hire a trained guide, but 10 min lecture is mandatory.
8/26–9/14	Visitors are allowed to use private cars.	
9/15–9/24	Only shuttle buses are available.	
9/25–11/25 (closing)	Visitors are allowed to use private cars.	

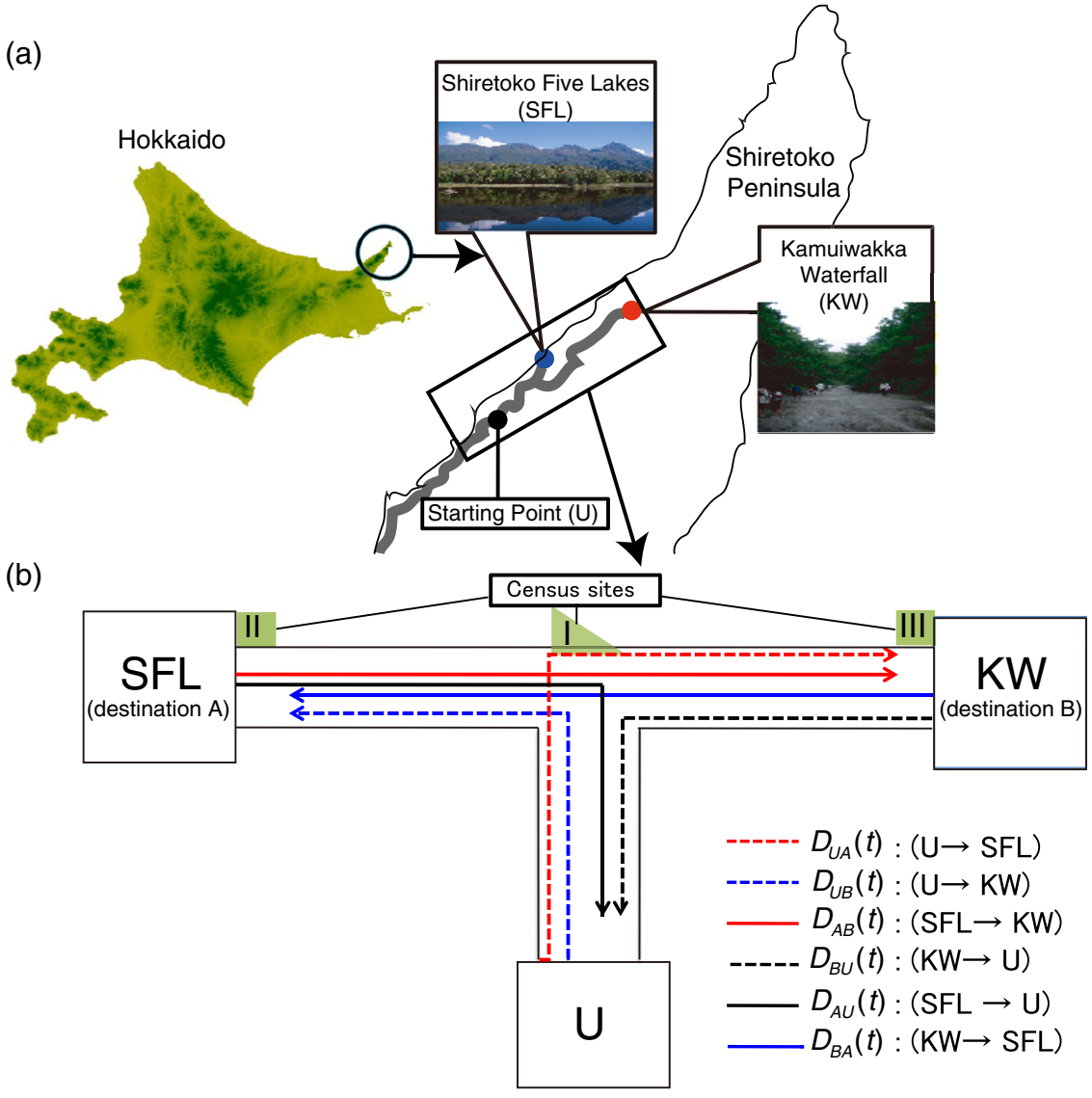

Fig. 1. (a) Map of Shiretoko National Park in Japan. Pictures depict each sightseeing spot. The matrix shows distances between each nodes, the starting point (U), Shiretoko Five Lakes (SFL), and Kamuiwakka Waterfall (KW). (b) Road network among U, SFL, and KW. Six travel routes and three census sites are shown.