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Impact of climate-related changes to the timing of autumn foliage colouration on tourism in Japan

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ABSTRACT

This study introduces plant phenophase as a “bridge” to assessing the impact of climate change on autumn foliage viewing tourism in Japan. The results showed that from 1978 to 2016, the autumnal foliage colouration of four cities in Japan was delayed, the duration of the autumnal leaf discolouration was significantly shortened, and only one city experienced a significant delay in leaf-falling. The delay in the autumn foliage colouration and leaf-falling periods on average increase the December maple viewing tourism volume by 3.64% and 3.02%, respectively. The impact on autumn maple foliage viewing tourism volume also has a 1-year delay effect, and the maple foliage phenophase of different cities have significantly varied influence on maple foliage viewing tourism volume. Overall, the change in the timing of maple leaf discolouration has been advantageous to the Japanese maple tourism industry.

1. Introduction

Annually, as the weather gradually cools, the leaves of plants of the Aceraceae family change from green to yellow to a deep red hue. The leaf discolouration process continues for several weeks. This is the start of the annual maple foliage viewing period in Canada, the New England region of the US, Bavarian Germany, and Beijing China (Inoue & Nagai, 2015). In Japan, autumn foliage viewing is in the same league as that for the legendary cherry blossoms. Autumn maple foliage viewing is referred to as 'Momijigari'. Since the 17th century, ordinary Japanese citizens have been travelling to view maple foliage, which is one of the activities that best represents Japanese autumn tourism. Currently, the autumn foliage culture has spread to Japanese haiku, noh theatre, diets, and other aspects of life. The period between October and December of every year is commonly referred to as the “Momijigari” period in Japan. Many tourist destinations hold the "Momiji Matsuri" (JNTO). Annually, tourist destinations for maple foliage viewing attract numerous tourists, who bring substantial economic benefits. In November 2016, the total number of visitors to Takamatsu Kurimori Park in Southwest Japan reached 98,556 people (Kagawa Prefecture Visitors Dynamics Investigation Reports, 2016).

Maple foliage viewing tourism activities are considerably temporally restricted. The plant phenophase has a significant impact on the start of autumn foliage viewing, duration, visitor experience, and other such factors. Plant phenophase is very sensitive to climate change (Richardson et al., 2013), which may affect autumn foliage viewing tourism by altering the plant leaf phenophase.

In this study, six maple viewing locations in Japan with the longest developed autumn foliage viewing tourism industry, tourism scale, and those that best represent the activity were used as subjects to address the following questions. First, does the climate-related change in autumn foliage phenophase affect the volume of maple viewing tourism? Second, are there differences in the impact of changes in autumn foliage phenophase on different maple viewing scenic spots? Third, what is the mechanism by which the changes in autumn foliage phenophase affect the autumn foliage viewing tourism industry?

Recently, Japan has experienced notable climate change with increases in the annual average temperature of 1.19 °C per century and a temperature increase of 1.20 °C per century in autumn (JMA, 2017). Since the late 1980s, Japan has shown a rapid climatic warming trend. In the 50 years from 1953 to 2003, the foliage discolouration and leaf-falling periods of Japanese maple trees have been delayed by 15.6 and 9.1 days respectively (JMA, 2007). Therefore, the study of the impact of changes in autumn foliage phenophase on the autumn foliage viewing tourism industry and the identification of the regions where the autumn foliage viewing tourism industry is most sensitive to climate change could help stakeholders understand the impact of climate change on the maple foliage viewing tourism industry. Furthermore, this information could provide a scientific basis for stakeholders to propose effective strategies for adaptation.

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2. Literature review

Although the impact of climate change on tourism has been widely confirmed, it has not been fully understood due to some uncertainties. First, there is uncertainty caused by the impact of climate change on different types of tourism activities. From the evidence of climate change impact on tourism in The Intergovernmental Panel on Climate Change (http://www.ipcc.ch/report/ar5/syr/) assessment report, the same climate change may have opposite effects on different types of tourism activities in the same region. For example, in the Alps region, the increase in temperature has had a negative impact on winter ski tourism (Klein, Vitasse, Rixen, Marty, & Rebetez, 2016), but a favourable impact on general tourism activities due to the extension of the tourism season (Camille, 2013). Considering the variety of tourism activities, it is necessary to carry out separate and specific analyses and assessments of some typical tourism activities that have widespread influence. The existing research has focused on winter skiing (Camille, 2013; Liu et al., 2017) and coastal tourism (Fan, Liu, & Quansheng, 2017; Hassanali, 2017; Schliephack & Dickinson, 2017; Toimil, Díaz-Simal, Losada, & Camus, 2018) but not on the impact on plant appreciation tourism. Therefore, it is essential to carry out specific studies on maple leaf tourism in autumn, as it is a globally popular tourism activity. Second, there is the uncertainty caused by regional differences. The impact of climate change varies greatly on the same types of tourism activities in different regions. Currently, in terms of geographical regions, there are many in-depth studies in Europe (Amelung & Moreno, 2012; Malatinszky, Ádám, Falusi, Saláta, & Penksza, 2013), Canada (Hewer & Gough, 2017; Rutty et al., 2017), the United States (Dawson & Scott, 2013; Atzori, Fyall, & Miller, 2018), Australia (Goldberg et al., 2016) and New Zealand (Mackintosh et al., 2017), but relatively few studies in Asia (Ge, Dai, Liu, Zhong, & Liu, 2013). In Japan, a country that has experienced significant climate change, analyses on long-term serial data have revealed the impact of climate change on tourism. These results can be used for comparative analysis and help increase the reliability of assessing the impact of climate change on tourism within the scientific community.

Changes in plant phenophase resulting from the interannual variability of climatic factors such as temperature and precipitation have been widely studied (Gunderson et al., 2012; Ibanez et al., 2010; Piao et al., 2015). However, because of the complexity of autumn phenology and its drivers (Estiarte & Peñuelas, 2015), the number of autumn phenology-related studies has been less than half that of spring phenology, and the study of autumn phenology and its effects have been largely ignored (Gallinat, Primack, & Wagner, 2015). In the Northern Hemisphere, the autumn phenophase was on average postponed by 0.18 ± 0.38 days per year. The impact of different regional, temperature, precipitation, and other meteorological factors on the autumn phenology has not been consistent (Liu et al., 2016). The leaf-falling periods of European beech and quercus have been delayed by 1.4–2.3 days every 10 years (Vitasse et al., 2011). In Japan, elevated temperatures in autumn delay the foliage phenophase, which is more responsive to climate change at low altitudes than at high latitudes (Doi & Takahashi, 2008). Research studies on the effects of climate change on plant blooming and the leaf discolouration period have been more in-depth. However, studies on the impact of plant phenophase changes on human tourism are still relatively few, and related research on the autumn leaf discolouration period is still more scarce.

A few studies have explored the possible impact of climate change-altering phenophase on plant viewing tourism. The opening dates of the flower festivals in many regions do not match the actual flowering dates because of the lack of forecasts (Sparks, 2014; Wang, Ning, Wang, & Ge, 2017). In each of the 12 cities in China, the best foliage viewing period of leaf discolouration has been delayed for 2.98 days for every 1 °C increase in temperature over the past 50 years. Among them, the peaks of leaf discolouration in Beijing and Xi'an were delayed by an average of 0.16 and 0.21 days per year, respectively (Tao, Ge, Wang, & Dai, 2015). The economic benefits of the Sakura Festival operators have also been negatively affected by climate change (Sakurai et al., 2011). These studies speculated only on the possible impact of plant phenophase on the timing and income of these viewing activities but did not quantify the impact of phenophase changes on the number of tourists. The impact of climate-related changes in plant phenophase on tourism activities also needs more accurate analysis and demonstration in more regions. The changes in the leaf phenophase of autumn plants, especially those people flock to view, such as maple trees, and the impact mechanisms on plant viewing tourism also requires further study.

Compared with the existing studies, the contributions of this article are as follows: first, this study focuses on Japan, where climate change has been significant, and investigates the sensitivity of the popular maple leaf tourism in autumn to climate change. Our research helps reduce the uncertainty in the impact of climate change on tourism caused by differences in tourism types and regions. Second, existing studies in the field of phenology focus more on the ecological and environmental effects resulting from the changes in phenological phases and less on the effects of vegetation changes on human economic activities. Our study provides perspectives to study tourism and climate change with the use of long-term, time-series phenological data, which helps resolve the lack of observational data in tourism research and further deepens the study of the relationship between tourism and climate change. At the same time, it expands the field of phenology.

3. Study area

The study selected the following six sites in four cities (34 °N-45 °N) in the mid-latitude region of Japan (24 °N-45 °N), Shosen kyo Valley and Art Park in Kofu, Shirotori Garden and Higashiyama Zoo and Botanical Gardens in Nagoya, Okayama Korakuen and Ritsurin Park in Takamatsu (Fig. 1). All scenic maple attractions were chosen from the 2017 Japan Maple Tours website (http://www.nihon-kankou.or.jp/kouyou/). Shosen kyo Valley is known as Japan's number one valley, and was ranked eighth in Japan's National Maple Viewing in 2017. The Art Forest Park is famous for the Yamanashi Prefectural Art Museum, which features a combination of artistic and natural beauty. Shirotori Garden is the only large-scale courtyard in Nagoya with famous attractions such as pavilions and suikinkutsu. It has beautiful scenery all year round. Higashiyama Zoo and Botanical Gardens is the ninth most visited maple attraction in Aichi Prefecture. There are botanical gardens, a zoo, amusement park, courtyard, and other areas for excursions. Okayama Korakuen is one of Japan's three most famous parks. Among them, the maple forest is one of the most popular attractions in the park. Ritsurin Park ranks number one in Kagawa Prefecture for viewing maple foliage and has a nearly 400-year-old famous tour around the renowned garden. Furthermore, Shosen kyo Valley, Ritsurin Park, and Okayama Korakuen are all classified as examples of the 36 special attractions in Japan.

4. Methodology

4.1. Research data

The study selected autumn foliage colouration and leaf-falling dates of Kofu, Nagoya, Okayama, and Takamatsu from 1978 to 2016 to analyse the annual change of phenophase. The observed species was maple, and the autumn foliage colouration represented the date when most of the leaves of the observed plants turned red. The leaf-falling period was the date when 80% of the leaves of the plant were observed to have fallen. Phenological data was obtained from the Japan Meteorological website (http://tenki.wet.co.jp/kisetsu/index.html). All data analyses used those of October 1 as the benchmark data and all subsequent data were modified for uniformity (i.e. 30 represents October 31). Due to the limited data on yearly tourist volume statistics, the tourist volume in November and December in the six scenic spots