Abstract

Event inventories: Estimating the temporality of landscape scenic resources from user-contributed geodata.

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Thematic Area: Scenic Resource Valuation

Presentation Format: Paper

Keywords
temporality; landscape change; event inventories; photo content

1. Theoretical context

Time and space are not separable. Landscapes and their character are in constant flux. This significantly affects human-environment interaction, perceived meaning and value of landscapes (Bell 2012). But, unlike the predominantly perceived spatial aspects, landscape change often occurs subconsciously, underlying our everyday decisions and passing of experiences. This makes evaluation of the temporality of scenic landscape resources difficult. In an attempt to improve the empirical assessment of ephemeral landscape features, Hull & McCarthy (1987) proposed a concept they called "change in the landscape". While a specific focus is given to wildlife, the authors describe a broad range of processes relating to change: "[…] day changes to night, autumn to winter and flowers to fruit; there is plant succession, bird migration, wind, rain, fire and flood [...]" (ibd., p. 266). These changes are characterized by nine types, such as slow changes (gentrification of neighborhoods, growth of vegetation), sudden (fluctuations of weather), regular (seasonal changes in plants, animal migration, sunrises), frequent (presence of wildlife, wind, sounds), infrequent (fire, flood), long duration (buildings, roads, consequences of natural disasters), medium duration (harvesting of trees, seasons), ephemeral-irregular, -occasional, and -periodic (wildlife, weather, hiking, evidence of other hikers). In their conclusion, Hull & McCarthy (1987) raise a warning that ignoring these conditions causes biasing effects on landscape quality assessments.

Since then, conceptually, several frameworks for landscape character assessment with specific emphasis on temporal characteristics have been put forward. Tveit, Ode, and Fry (2006) suggest a scheme of nine visual concepts, with "ephemera" representing a distinct category for human imposed and natural changes in the landscape. For this category, they suggested indicators that are either based on a percentage of land cover affected by seasonal change, or based on the presence of ephemeral features such as wildlife (ibd., p.246). Stephenson (2008) proposes a model of five dimensions in which landscape qualities can be portrayed. The list starts with the most common static-spatial portrayal (emphasis on the physical landscape), to dynamic-spatial (emphasis on interactions at a point in time), static-temporal (emphasis on historic associations), dynamic-temporal (emphasis on interactions over time), and dynamic-spatial-temporal (emphasis on interactions over space and time). In practice, however, common temporal assessments remain focused on physical manifestations of change, such as in biotopes (Käyhkö, Niina, and Helle Skånes 2006) and assessed using remote-sensing technologies (Fichera et al. 2012).

A limited number of approaches focus on people's perceptions of, attitudes towards and responses to environment change such as Photo-elicitation (Beilin 2005) and mental mapping (Soini 2001). With the advent of large user-generated content collections shared on the internet, several publications have focused on evaluating temporal aspects. Juhász and Hochmair (2019) compare temporal activity patterns between geo-located posts shared on Snapchat, Twitter and Flickr and find that the different active groups on these platforms elicit significant differences in the spatial patterns observed. Paldino et al. (2016) study the temporal distribution of activity from domestic tourists, foreigners and residents in New York, focusing on daily, weekly and monthly activity patterns and differences between these groups. They use seasonal decomposition as a method to separate measures of attractiveness in time series into trend, seasonality and random variations (noise). Mancini et al. (2018) use 'Wavelet coherence' between two time series collected from social media and survey data. They specifically compare spatial wildlife watching activities and conclude that day trips have the biggest impact on differences between survey and social media data. Tenkanen et al. (2017) demonstrate how Instagram, Flickr and Twitter can be used to monitor visitation of protected areas in Finland and Sourth Africa. Their findings suggest that data volumes and quality vary widely between the three platforms. The biggest agreement with official visitation statistics is found for highlty frequented parks and areas.

Our own research has focused on a bottom-up conceptualization of events and reaction to events in user-generated content (Dunkel 2019). Many authors argue that events function as the temporal counterpart of objects in the spatial domain (Zacks and Tversky 2007, Chen 2003, Worboys 2005). From this perspective, it can be argued that humans perceive, structure and memorize landscape through a sequence of discrete events of varying experienced importance (Zacks and Tversky 2007, p. 58). In our definition, events range from simple atomic changes that people perceive and react to, such as a rumble of thunder or a sunset (etc.), to more complex events or collections of events, arranged in a particular pattern and sequence (e.g. spring, the Burning Man festival etc.). Individual photographs can be considered as atomic artifacts of these experiences, shared online for purposes of evidence in place and time (Steels 2006).

2. Method

In a recent study on worldwide reactions to the sunset and sunrise (Dunkel 2023), the signed chi equation has been used to visualize spatial over- and underrepresentation. This approach allowed us to identify collectively valued places and areas largely independent of overall visitation frequencies. Conversely, the study showed that the common approach of using absolute counts or proportions (photo count, user days or user count) may mislead practitioners. As a result, landscape preference in urban areas and highly frequented popular places are often overemphasized in studies using user-generated content. The chi equation was developed by Visvalingam (1978) and the UK Census Research Unit (1980) for visualizing relative importance of spatial phenomena. It is based on two components, a generic query (*exp*) to normalize local observations (a single grid cell) of a specific query (*obs*) based on the global (all cells) average ratio of frequencies (*norm*).

$$chi = \frac{\left((obs * norm) - exp\right)}{\sqrt{exp}} \quad norm = \frac{\Sigma_{exp}}{\Sigma_{obs}}$$

A specific query could be the frequency of photographs in a single grid cell relating to a specific topic or theme (e.g. number of photos relating to the sunset or the sunrise). A generic query, on the other hand, ideally requires a random sample of photographs, both globally (all grid cells) and locally (a single grid cell under investigation). The random sampling is usually difficult to obtain, given the opaque nature of platform Application Programming Interfaces (APIs). The easiest way to guarantee randomness is sampling of all photographs of a platform. For Flickr, this was possible and all photographs that are geotagged have been queried for the period from 2007 to 2020. The resulting dataset consists of metadata of 350 Million photographs. For Instagram, a different sampling strategy was used, querying individual places for a random sample of 20 Million photographs and a five-month period in 2017. Despite these differences, both datasets produced a strong consistency of spatial preference patterns worldwide for watching these two events. Selected differences have been observed in places where user preferences largely differ, such as at the Burning Man festival in Nevada, a place that ranked second worldwide for watching the sunrise on Instagram, compared to almost no photographs shared by Flickr users — a pattern that we explain with the different user make-up of these platforms. In our conclusion, we suggest 'Event Inventories', as a means to better capture the transient nature of human-landscape interactions and landscape change.

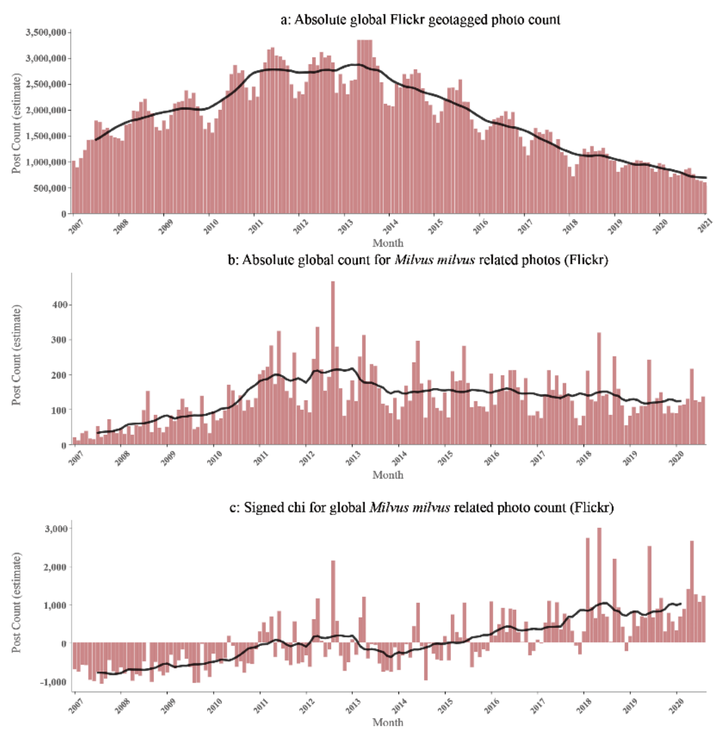

Figure 1. Temporal distribution of (a) all Flickr geotagged photographs globally; (b) *Milvus milvus* related photographs globally; and (c) signed chi for *Milvus milvus* related photographs, normalized based on global Flickr trends. The trend lines were added using seasonal decomposition (Statsmodels).

Exploring the idea of 'Event inventories' further, a scoping test is shown in Figure 1 for applying the chi equation to temporal observations. The first graph (Fig. 1a) shows the absolute temporal distribution of all Flickr geotagged photographs globally. Seasonality is clearly visible from this distribution. The graph also shows a declining popularity of the Flickr platform since 2013. Using seasonal decomposition, a trend line was added, based on the removal of random and seasonal parts, emphasizing these longer trends in contribution patterns. The second graph (Fig 1b) is based on a dataset using a specific query, sampled for a study by Hartmann et al. (2022), who explored the spatial distribution of pictures of the Red Kite (*Milvus milvus*). This graph is based on absolute counts and not normalized. With frequent peaks during summer season and lows in winter months, the graph indicates a similar seasonal patterns as is visible for all photographs, albeit slightly less noticeable. The trend line for these absolute counts suggests that there is a relatively constant contribution of photographs for the Red Kite, after an initial growth period till 2012. However, this trend line ignores the global declining trend of Flickr and may therefore distort interpretations. The last graph (Fig. 1c) was calculated by using the signed chi equation, based on all photographs per month and the average ratio of Red Kite photographs across the whole period. Here, it becomes obvious that, indeed, there is an increasing trend for Red Kite pictures on Flickr. Two interpretations are possible. Firstly, the community of 'Red Kite photographers' on Flickr could be growing, relative to all other photo interests on Flickr. Secondly, the Red Kite could have become prominently visible in recent years as a photo subject, with supporting evidence based on a continued population growth for this species in the last decade (Stevens 2020).

3. Research questions and summary of anticipated results

Without corroboration, these interpretations remain speculative. Furthermore, visualizing global trends is not suitable for assessing individual landscapes. Our research focuses on two questions:

1. Given a topic or scenic resource, estimate its perceived impact over time and identify trends, by sampling across different platforms and finding relationships in the same direction and at similar strength (event valuation).

2. Given an area or a selection of areas, identify significant events based on common temporal characteristics from georeferenced topics discussed online (event inventory).

Our goal is not to classify events, but to contribute methods to first extract and collect 'Event inventories' for selected landscapes. The term *event inventories* is leaned on the spatial counterpart "descriptive inventory methods" coined by Arthur et al. (1977). Considering that volunteered geographic information (iBird, iNaturalist) or crowdsourced social media data (Flickr, Twitter, Instagram) predominantly captures the human viewer component, we first expect to be able to characterize common known temporal landscape phenomena, such as the waterfalls in Yosemite being most impressive in spring, or the regular pattern of California poppies or Nevada deserts in bloom. Secondly, we hope to be able to identify single events of particular importance, as a means to supplement and corroborate contemporary landscape assessments. Examples are classical human-centered events (the Burning Man festival), or natural events of particular perceived importance (the 'Firewaterfall' in Yosemite, occurring not more than once a year). Lastly, we attempt to contribute to identifying longer trends from user-contributed data, based on the chi-equation and cross-platform validation. Here, what is considered as a 'generic' query can be modulated based on different contexts. For instance, if National Parks become the main scope of our analysis, the temporal chi for a specific park can be normalized based on the 'global' average, referring to the posting behavior observed for all parks under investigation. We expect that such an investigation highlights specific trends for individual parks deviating significantly from the norm.

4. Application significance and Conclusions

The audience of this research are landscape and urban planners, regional resource specialists and researchers focusing on the human-centered impact of landscape change. Given the exponential rise and availability of user-contributed data, both as publicly available geodata from social media and specific Volunteered Geographic Information (VGI), such as from *iNaturalist* or *eBird*, provides for the first time a basis for evaluating longer trends of ephemeral landscape features and collective perceptions of landscape change. However, the variability in platform popularity and intra-dataset biases pose challenges to data assessments, a core focus of our contribution. In the fields of landscape and urban planning, the results may help to better understand the unique transient characteristics of places, areas and landscapes. The proposed event inventories may particularly support protecting and developing specific ephemeral scenic values, or proposing action for changing negative influences. With an increasing pace of change in the landscape, user-contributed geodata can contribute indicators with high actuality for monitoring of scenic resources over time, directing focus to missed or undervalued patterns, or for corroborating on-site observations, which contributes to a more balanced and representative assessment of landscapes.

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