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EDITED BY

Wei-Ching Wang,
Nanfeng College of Sun Yat-sen
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REVIEWED BY

C. K. Ceng,
National Taiwan University, Taiwan
Po-Ching Wang,
National Chiayi University, Taiwan

*CORRESPONDENCE

Nagai Shin
✉ nagais@jamstec.go.jp

[†]These authors have contributed equally to this work

RECEIVED 10 June 2024

ACCEPTED 18 November 2024

PUBLISHED 17 December 2024

CITATION

Shin N, Nakagawa H, Morimoto H and Kotani A (2024) A Google Trends analysis of people's sense of seasons in Hokkaido. *Front. Sustain. Tour.* 3:1446528. doi: 10.3389/frsut.2024.1446528

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A Google Trends analysis of people's sense of seasons in Hokkaido

Nagai Shin^{1*†}, Hiromi Nakagawa^{1†}, Hiroshi Morimoto² and Ayumi Kotani³

¹Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan, ²Nagoya University, Nagoya, Japan, ³Graduate School of Bioagricultural Sciences, Nagoya University, Nagoya, Japan

Accurate evaluation of the spatiotemporal variability of people's interest in seasons (i.e., their "sense of seasons") is required to deeply understand temporal changes in the relationship between people and landscape under climate and societal changes. To this end, it is useful to analyze the time series of relative search volume (RSV) for relevant search terms extracted from Google Trends (GT) for any target period and target area. We examined the presence and absence of 12-month seasonality of the time series of RSV for about 300 representative search terms for Hokkaido in Japan, which has vast natural resources and is visited year-round by many tourists from Japan and abroad. In the case of searchers in both all of Japan and Hokkaido alone, search terms categorized into the foods, leisure, natural scenic spots, and seafood fields showed a strong trend toward 12-month seasonality of the time series of RSV, whereas those categorized into the Ainu (indigenous people) and people fields had weak trends for 12-month seasonality. People's sense of seasons in all of Japan or Hokkaido alone was likely associated with tourism (search terms in the animals, festivals, foods, leisure, natural scenic spots, seafood, tourist spots, and vegetation fields), as well as with animal and plant phenology (terms in the animals and vegetation fields), provisioning ecosystem services (terms in the foods and seafood fields), climate (terms in the climate field), and cultural ecosystem services (terms in the animals, festival, foods, leisure, natural scenic spots, seafoods, and vegetation fields). However, search terms with no 12-month seasonality were included in the tourist spots fields: they included many tourist spots visited by tourists all year around. Despite the need to appropriately select a huge number of representative search terms to reduce the effect of GT limitations and the uncertainty caused by unexpected and rapid temporal changes in RSV, the GT analysis allowed us to evaluate the spatiotemporal variability of people's sense of seasons regarding various objects in the landscape, including those related to tourism, under climate and societal changes.

KEYWORDS

autocorrelation coefficient, people's interests, phenology, tourism, 12-month seasonality

1 Introduction

To understand the temporal changes in the relationship between people and landscape in the face of climate and societal changes, we require accurate evaluation of the spatiotemporal variability of people's interest in seasons (hereafter, their "sense of seasons"). A landscape consists of multiple layers, such as the atmosphere, water, living things,

nutrients, livelihoods, society, and information that change seasonally and annually (Shin et al., 2024). In prehistoric times, when people obtained various kinds of seasonal foods, clothes, and residences through the hunting and gathering of animals and plants, people's sense of seasons was likely associated with plant and animal phenology (in relation to provisioning ecosystem services) and climate. From the agricultural era onward, when people lived their daily lives according to the crop calendar, people's sense of seasons likely became associated with not only traditional plant and animal phenology and climate but also beliefs and religious ceremonies (cultural ecosystem services) as society and philosophical thought developed. Currently, direct interaction between people and nature has decreased markedly because of urbanization and globalization. However, tourism is expanding as people seek to enjoy beautiful natural scenery, gourmet foods, festivals and events, presentations of artworks, and leisure. The recent spread and development of the Internet—especially social networking services and online video-sharing platforms such as YouTube—have accelerated the quality and diversity of tourism. Hence, people's sense of seasons never fades, but rather creates new values (i.e., cultural ecosystem services). These new values have improved people's lives and enhanced their mental calm. Ultimately, tourism is likely becoming important to people's sense of seasons in the landscape.

Stephens-Davidowitz and Varian (2015) indicated the utility of Google Trends (hereafter "GT"; Google LLC, 2024) for the quantitative evaluation of temporal changes in people's interests. We can retrieve the temporal changes in people's interests in any search term in any target period (from 2004 to the current day) and target area (country or local administrative area) as a time series of the relative search volume (RSV). By analyzing the time series of RSV, we can detect long-term trends, interannual changes in the seasonal peak, and unexpected and rapid temporal changes—stirring—of people's interests. Conventional examinations of people's sense of seasons have been limited to questionnaire surveys and interviews (e.g., Naumov et al., 2020; Gotow et al., 2022; Régnier et al., 2022). In labor-intensive interviews, it is difficult to gather data on various kinds of items in multiple locations for long periods of time. For this reason, the sampling data of collected by conventional questionnaire surveys and interviews is problematic, because they include uncertainty caused by representational (i.e., sampling limitation and bias), spatial, and temporal gaps (Shin et al., 2024). In contrast, GT has merit in that we can use it to examine the spatiotemporal variability of people's interests with sufficient representativeness, because the time series of the RSV for any search term is retrieved from sampling data that are part of a larger population. Many previous analyses of the time series of RSV can be found in infodemiology (e.g., influenza: Dugas et al., 2013; Kang et al., 2013; Yang et al., 2015; COVID-19: Mavragani and Gkillas, 2020; Anastasiou et al., 2021; Amusa et al., 2022; melanoma: Zhang et al., 2021) and in human activities and economics under COVID-19 (Ahundjanov et al., 2020; Lee, 2020; Strzelecki et al., 2020; Brimblecombe and Lai, 2021; Kardeş, 2021). However, there is only a limited number of such studies of people's sense of seasons (timing of appearance of insects: Takada, 2012; usage of berries: Kotani et al., 2021; Shin et al., 2022a; cherry-flowering phenology: Shin et al., 2022b; demand for mushrooms: Diaz-Balteiro et al., 2023; fashion: Silva et al., 2019). In addition, Shin et al. (2024)

examined people's sense of seasons in Russia by using multiple search terms (dozens or more) categorized into various fields, but they did not provide a detailed consideration of their results.

To develop a method for evaluating people's sense of seasons by using GT, here, as a case study, we examined the presence and absence of 12-month seasonality of the time series of RSV for about 300 search terms that were categorized into various fields and that represented Hokkaido in Japan. We can expect nature's contributions to people (Díaz et al., 2018) to be large in Hokkaido, which is endowed with an abundance of natural features. Many people from Japan and abroad visit Hokkaido throughout the year. For these reasons, we considered Hokkaido to be a suitable area for validating our study aims. In addition, for us to understand the background of people's sense of seasons, it was important to be familiar with the geography, traditions, and culture of the target area. For this reason, we selected our native country, Japan. Our aims were to clarify (1) the search terms with 12-month seasonality and the characteristics of their seasonal peaks; and (2) the usefulness, limitations, and perspectives of evaluating people's sense of seasons by using GT.

2 Materials and methods

2.1 Target area

Our target area was Hokkaido in northern Japan, which accounts for about 22% of the country's total area (83,424 km² as of 2020; Figure 1; Hokkaido Prefecture, 2023b). Indigenous Ainu people created their own lifestyle and culture in this area fifteen centuries ago, and Hokkaido was called Ezo by the Japanese people during this period. After fifteen centuries, interaction, trade, and conflict arose between Ainu and the Japanese people. In 1869, the Japanese government established the land development bureau and renamed the area Ezo Hokkaido (Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 2021). The population of Hokkaido is about 5.09 million (as of 1 January 2024; Hokkaido Prefecture, 2024a), of whom 13,000 identify as Ainu (as of 2017; Comprehensive Ainu Policy Office, Cabinet Secretariat, Government of Japan, 2012). Primary industry employs 4.7% of workers in Hokkaido, secondary industry 17.6%, and tertiary industry 73.9% (as of 2017; Hokkaido Prefecture, 2023a). Hokkaido, which is classified as Dfb (warm-summer humid continental climate) according to the Köppen climate classification, has four distinct seasons. However, climate varies locally because of the influence of the sea and mountains (Japan Meteorological Agency, 2024). Agricultural land (rice paddies and cropland) and natural forests (mixed forests of deciduous broad-leaved trees and evergreen coniferous trees) are widely distributed in Hokkaido, except in the metropolitan areas. Many people from Japan and abroad visit Hokkaido for recreation in the natural environment or to savor the abundant seafood and other gourmet foods, enjoy seasonal leisure activities, and attend festivals: a total of 46.01 million people from Hokkaido traveled within the prefecture in 2018, along with a total of 6.07 million Japanese people from outside Hokkaido and a total of 3.12 million people from overseas (before the COVID-19 era; Hokkaido Prefecture, 2024b).

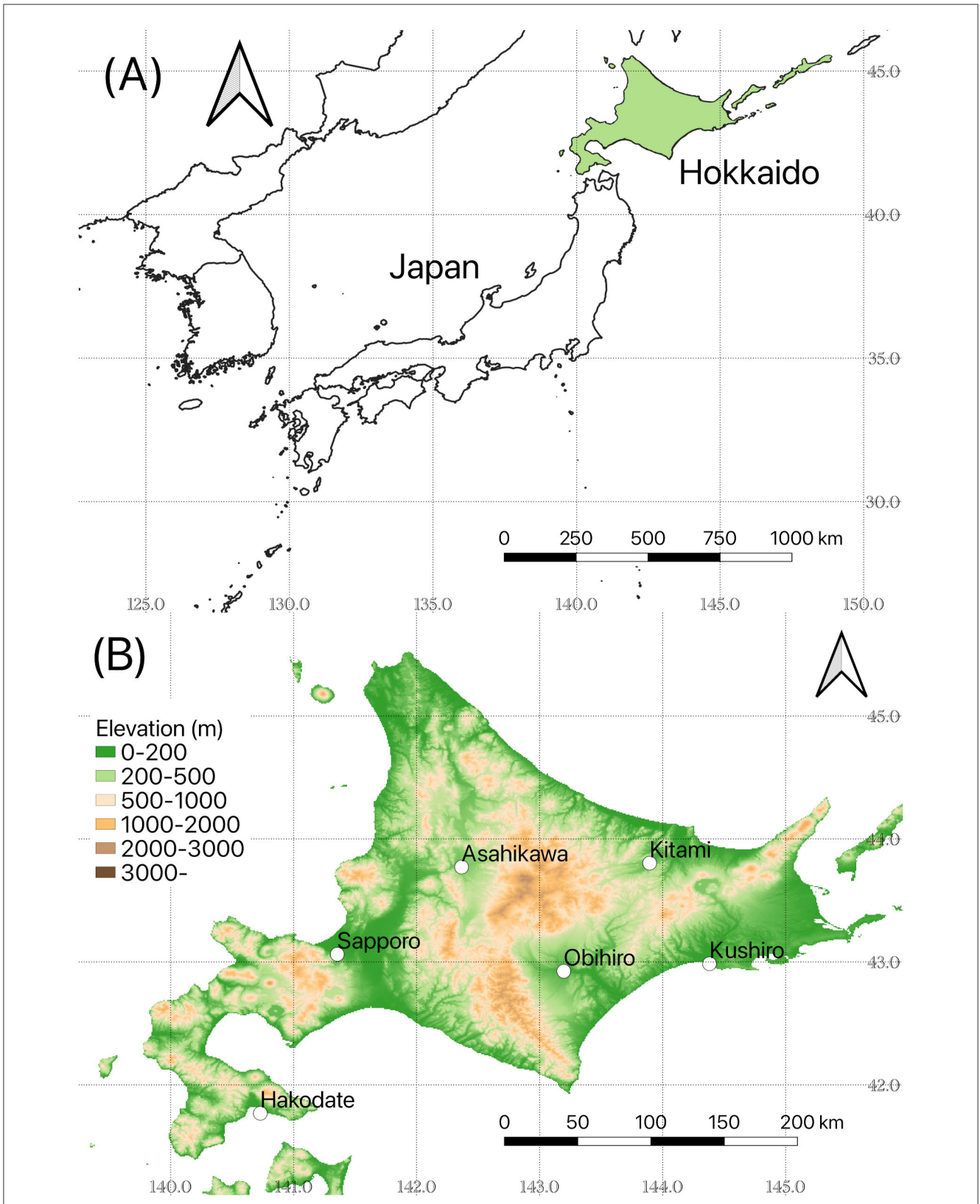


FIGURE 1
(A) Location and **(B)** topographic map of Hokkaido in Japan. The map was sourced from Natural Earth's 1:10 m cultural vectors (Natural Earth, 2024) and Global 30 Arc-Second Elevation (GTOPO30; USGS, 2024).

2.2 Google Trends

We examined a total of 319 search terms representing Hokkaido. They were categorized into 11 fields (Ainu, animals, climate, festivals, foods, leisure, natural scenic spots, people, seafood, tourist spots, and vegetation). The number of search terms in each field ranged from 11 (climate and leisure) to 44 (foods). The average number of search terms per field was 29. To accurately evaluate the sense of seasons in Hokkaido, we assumed that we needed to select search terms that were both specific to Hokkaido and common to other regions. These terms were selected by coauthor HN, who is a native of Hokkaido. She selected these terms in as unbiased a way as possible by using her experience and knowledge, as well as relevant Internet websites. The location of each search term categorized into the festivals, natural scenic spots, and tourist spots fields is shown in [Supplementary Figure 1](#).

In GT, a search can be done in two ways, namely (a) by “topic” (a group of terms preliminarily registered by Google that share the same concept in any language) or (b) by “keyword” (a literal term that includes data only from the language that is selected). To clarify the target field of the search term, we selected the “topic” search as much as possible. For instance, when we searched for “cherry blossom” as vegetation, we selected the “topic” search in order to remove people’s interest in items other than vegetation, such as people’s names and product names. When we could not select a “topic” search (i.e., when there was no preselected GT registration of the corresponding topic), we selected the “keyword” search. The accuracy of GT has been developed through three specification changes (1 January 2011; 1 January 2016; and 1 January 2022; [Google LLC, 2024](#)). We set the search period from 1 January 2018 to 31 December 2022. Therefore, the time series of RSV_x ($x = 1, 2, 3, \dots, 319$) at a weekly time step consisted of 260 values ($0 \leq RSV_x \leq 100$).

To validate the characteristics of these RSV_x values that were associated with the geographic distribution of Google searchers, we set up two search areas: (1) the whole of Japan (henceforth referred to simply as “Japan”) and (2) Hokkaido only. We obtained 308 time series of RSV_x for searchers in Japan and 301 time series of RSV_x for searchers in Hokkaido. To confirm the validity of the RSV_x values for each search term, we checked three attributes of the RSV_x values, namely “Interested by sub-region,” “Top related topics,” and “Top related queries.” We checked the top 5 for each of the attributes (please see details in [Shin et al., 2022a](#); [Google LLC, 2024](#)).

Previous studies have reported that systematic error of RSV values can be caused by differences in the search dates ([Rovetta, 2021](#); [Cebrián and Domenech, 2023](#)). However, we assumed that this error would not have a substantial influence on the results of our analysis because we evaluated only the presence and absence of 12-month seasonality of the time series of RSV. Each term was accessed only once from 11 June 2023 to 3 July 2023.

2.3 Detection of 12-month seasonality

To detect the presence and absence of 12-month seasonality of the time series of RSV_x , we calculated the autocorrelation

coefficient explained by [Equation 1](#), where s is the time lag in weeks and t is the time in weeks.

$$\rho_{xx}(s) = \frac{\frac{1}{n} \sum_{t=s+1}^n (RSV_x[t] - \overline{RSV_x}) (RSV_x[t-s] - \overline{RSV_x})}{\frac{1}{n} \sum_{t=1}^n (RSV_x[t] - \overline{RSV_x})^2}, \quad (1)$$

where $n = 260$ (52 weeks \times 5 years) and $\overline{RSV_x} = \frac{1}{n} \sum_{t=1}^n RSV_x[t]$.

When a statistically significant peak value of the autocorrelation coefficient occurred at about $s = 51, 52$, or 53 , we defined the time series of RSV_x as having 12-month seasonality. Typical examples of the presence and absence of 12-month seasonality are shown in [Supplementary Figure 2](#). The peak season of the time series of RSV_x was detected by visual inspection. The analysis was conducted in R ver. 3.6.3 ([The R Foundation, 2024](#)) and LibreOffice ver. 7.5.0.3.

3 Results

[Table 1](#) shows the presence and absence of 12-month seasonality for each search term. In the case of searchers in both Japan and Hokkaido combined, the number of search terms with 12-month seasonality (total from the “topic” and “keyword” searches combined) in the Ainu field was 0; animals, 2; climate, 2; festivals, 4; foods, 12; leisure, 4; natural scenic spots, 14; people, 0; seafood, 15; tourist spots, 7; and vegetation, 8. In the case of searchers in either Japan or Hokkaido, some search terms with 12-month seasonality were found. The total number of search terms in the “topic” search was 250. The percentage of search terms in the “topic” search for each field ranged from 45% (climate and festivals) to 98% (natural scenic spots). The average was 75% and the standard deviation (SD) was 19%.

We cross-tabulated the presence and absence of 12-month seasonality of the time series of RSV categorized into the 11 fields ([Figure 2](#)). In the case of searchers in Japan, the percentage of search terms with 12-month seasonality ranged from 0% (Ainu) to 64% (climate). The average was 34% (SD = 19%). In the case of searchers in Hokkaido, the percentage of search terms with 12-month seasonality ranged from 0% (people) to 52% (seafood). The average was 28% (SD = 16%). In the case of both searchers in Japan and searchers in Hokkaido, the percentages of search terms with 12-month seasonality in the foods, leisure, natural scenic spots, and seafood fields were 33% or more. The percentages of search terms with 12-month seasonality in the animals, climate, festivals, and vegetation fields were higher among searchers in Japan than among those in Hokkaido. In the case of both searchers in Japan and searchers in Hokkaido, the percentage of search terms with 12-month seasonality in the Ainu field was either zero or under 11%; this was also the case in the people field.

We examined the peak seasons of the time series of RSV_x for each search term in the case of searchers in Japan ([Table 2](#)) and those in Hokkaido ([Table 3](#)). The following eight characteristics were observed: (1) RSV peaks in the animals (mainly in the case of searchers in Japan), festivals, and tourist spots fields were observed

TABLE 1 Presence and absence of 12-month seasonality of the time-series of relative search volume for each search term.

Field	Presence of 12-month seasonality		Absence of 12-month seasonality	
	Topic search	Keyword search	Topic search	Keyword search
Ainu	None	Ainu people (H), Ainu kotan (village) (H)	<i>Iomante</i> (bear-sacrifice ceremony) (JH), <i>Mukkuri</i> (mouth harp) (JH), Golden Kamuy (Manga) (JH), Wenkamuy (evil god) (JH), <i>Makiri</i> (penknife) (JH), Nipopo (doll) (JH), <i>attus</i> (fabric) (JH), <i>Nibutani Ita</i> (carved wooden tray) (JH), <i>chise</i> (traditional Ainu house) (JH), <i>inaw</i> (ritual utensil) (JH), <i>matampus</i> (headband) (JH), <i>tonkori</i> (stringed instrument) (JH)	<i>Kamuy</i> (god) (JH), <i>tekunpe</i> (gauntlet) (JH), <i>upopo</i> (folk music) (JH), Kamuy-Yukar (mythology) (JH), Ainu pattern (JH), <i>utari</i> (comrade) (JH), Ainu people (J), Ainu kotan (village) (J)
Animals	Stag beetle (JH), giant stag beetle (JH), Steller's sea eagle (J), small stag beetle (J), Japanese tree frog (J), Japanese tit (<i>Parus minor</i>) (J), varied tit (<i>Sittiparus varius</i>) (J), black-backed wagtail (<i>Motacilla alba lugens</i>) (J), pygmy woodpecker (J), <i>Terpnosia nigricosta</i> (J), <i>Lyristes japonicus</i> (J)	None	swan (JH), Blakiston's fish owl (JH), Japanese crane (JH), <i>Poecile palustris</i> (JH), brown bear (JH), coal tit (JH), nuthatch (JH), black woodpecker (JH), white-tailed eagle (JH), great spotted woodpecker (JH), white-backed woodpecker (<i>Dendrocopos leucotos</i>) (JH), gray-headed woodpecker (JH), hazel grouse (<i>Tetrastes bonasia</i>) (JH), Yezo deer (<i>Cervus nippon yesoensis</i>) (JH), <i>Lepus timidus ainu</i> (JH), <i>Ochotona hyperborea yesoensis</i> (JH), chipmunk (<i>Tamias sibiricus lineatus</i>) (JH), <i>Sciurus vulgaris</i> (JH), Ezo red fox (JH), sea otter (JH), sea lion (JH), clone (JH), <i>Tibicen bihamatus</i> (JH), <i>Auritibicen flammatus</i> (JH), <i>Parnassius eversmanni</i> (JH), <i>Lefua nikkonis</i> (JH), <i>Hynobius retardatus</i> (JH), <i>Rana pirica</i> (JH), Steller's sea eagle (H), small stag beetle (H), Japanese tree frog (H), Japanese tit (<i>Parus minor</i>) (H), varied tit (<i>Sittiparus varius</i>) (H), black-backed wagtail (<i>Motacilla alba lugens</i>) (H), pygmy woodpecker (H), <i>Terpnosia nigricosta</i> (H), <i>Lyristes japonicus</i> (H)	Long-tailed tit (JH), seal (JH), <i>Kosemia yezoensis</i> (JH), <i>Vacciniina optilete daisetsuzana</i> (JH)
Climate	Drift ice (JH), snow shovel (J), road heating (J), powder snow (J), water pipe (H)	Stove (JH), studless tire (J), ice burn (J)	Heavy snow (JH), water pipe (J), snow shovel (H), road heating (H)	Diamond dust (JH), rut (JH), studless tire (H), ice burn (H)
Festivals	Sapporo Lilac Festival (JH), Sapporo Snow Festival (JH), Kachimai Fireworks Festival (J), Otaru Tide Festival (J), Noboribetsu Jigoku Hell Festival (J), Hokkai Heso Festival (J), Yosakoi Soran Festival (H)	Sapporo Odori Beer Garden (JH), Lake Shikotsu Ice Festival (JH)	Yubari International Fantastic Film Festival (JH), Orochon Fire Festival (JH), Yosakoi Soran Festival (J), Otaru Tide Festival (H), Noboribetsu Jigoku Hell Festival (H), Hokkai Heso Festival (H), Kachimai Fireworks Festival (H)	Toyohira River Fireworks Festival (JH), Hakodate Port Festival (JH), Higashimokoto Shibazakura Festival (JH), Akkeshi Oyster Festival (JH), Hokkaido Jingu Festival (JH), Mikasa Hokkai Bon festival dance (JH), Kitami Kiku (Chrysanthemum) Festival (JH), Monbetsu Drift Ice Festival (JH), Onuma Lake Festival (JH)
Foods	Yubari melon (JH), Matsumae pickles (JH), <i>izushi</i> fermented sushi (JH), <i>ishikari-nabe</i> (Hokkaido salmon hot pot) (JH), <i>chanchan yaki</i> (Hokkaido-style salmon and vegetable hotpot) (JH), <i>kazunoko</i> (herring roe) (JH), <i>sujiko</i> salmon roe (JH), beetroot (JH), <i>nama</i> chocolate ganache (JH), <i>saketoba</i> (skin-on salmon filets) (JH), dried fileted herring (J), Densuke watermelon (J), <i>soba</i> noodle soup with herring (J), <i>bekomochi</i> (rice cake) (H), <i>ikura</i> (salmon roe) (H), <i>imomochi</i> (potato rice cake) (H)	Pickled herring (JH), Alpine leek (<i>Allium ochotense</i>) (JH), miso ramen (J), soy-boiled squid filled with rice (J), horseradish (H)	Soft Katsugen (yogurt drink) (JH), Genghis Khan barbecue (JH), ramen (JH), <i>sanpei</i> -style fish and vegetable soup (JH), <i>zangi</i> (deep-fried chicken) (JH), <i>ruibe</i> (sliced frozen salmon) (JH), hops (JH), guarana beverage (JH), Miyoshino Sapporo (restaurant) (JH), bread roll (JH), Tan Taka Tan (<i>shochu</i>) (JH), <i>bekomochi</i> (rice cake) (J), <i>ikura</i> (salmon roe) (J), <i>imomochi</i> (potato rice cake) (J), Densuke watermelon (H), <i>soba</i> noodle soup with herring (H), dried fileted herring (H)	Raiden watermelon (JH), <i>supakatsu</i> (spaghetti with cutlet) (JH), Tokachi <i>butadon</i> (pork bowl) (JH), <i>robatayaki</i> (Japanese-style barbecue) (JH), <i>teppo-jiru</i> (crab miso soup) (JH), soft roe miso soup (JH), <i>kankai</i> (dried saffron cod) (JH), boiled Lindberg skate (JH), Muroran <i>yakitori</i> (baked pork) (JH), bread stuffed with <i>chikuwa</i> (JH), horseradish (J)
Leisure	Skiing (JH), snowboarding (JH), rafting (JH), snowshoeing (JH), ice hockey (H)	None	Ballooning (JH), <i>banei</i> horse racing (JH), curling (JH), speed skating (JH), canoe sports (JH), ice hockey (J)	Horse trekking (JH)

(Continued)

TABLE 1 (Continued)

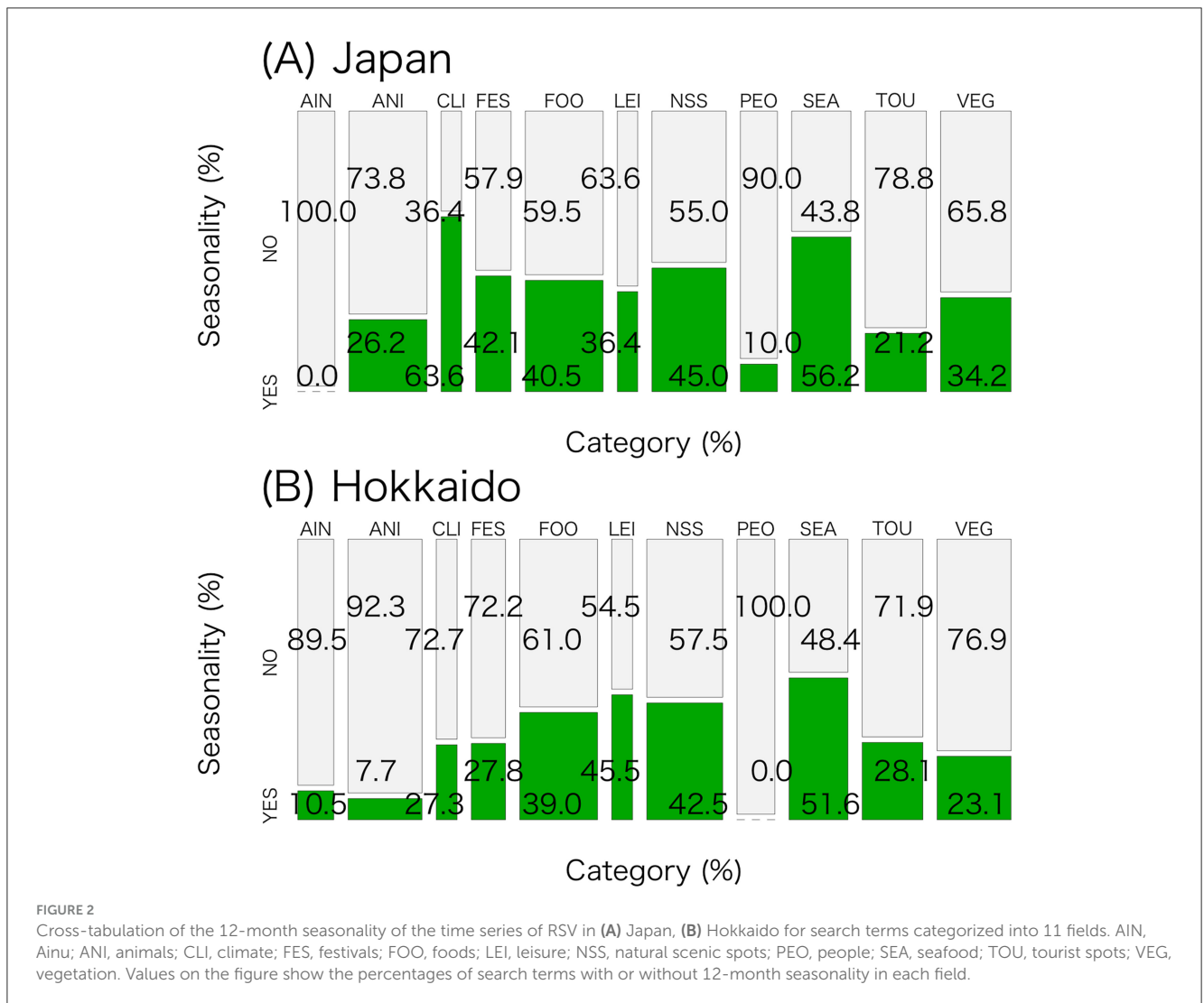
Field	Presence of 12-month seasonality		Absence of 12-month seasonality	
	Topic search	Keyword search	Topic search	Keyword search
Natural scenic spots	Kushiro Shitsugen National Park (JH), Shakotan Peninsula (JH), Hoheikyō Dam (JH), Sounkyō (JH), Lake Toya (JH), Lake Shikotsu (JH), Lake Kussharo (JH), Lake Mashu (JH), Lake Akan (JH), Cape Kamui (JH), Mt. Yotei (JH), Mt. Hakodate (JH), Mt. Daisetsuzan (JH), Nakayama Pass (JH), Mt. Rishiri (J), Toyohira River (J), Sosei River (J), Bihoro Pass (J), Cape Soya (H), Cape Erimo (H), Lake Saroma (H)	None	The Northern Territories (JH), Sea of Okhotsk (JH), Notsuke Peninsula (JH), Nemuro Peninsula (JH), Kamuiwakka Hot Falls (JH), Oshinkoshin Falls (JH), Chikyu Misaki Observatory (JH), Cape Nosappu (JH), Mt. Showa-Shinzan (JH), Mt. Usu (JH), Atosa-Nupuri (JH), Teshio River (JH), Ishikari River (JH), Tokachi River (JH), Kushiro River (JH), Chitose River (JH), Orofure Pass (JH), Shiretoko Peninsula (JH), Cape Soya (J), Cape Erimo (J), Lake Saroma (J), Mt. Rishiri (H), Toyohira River (H), Sosei River (H), Bihoro Pass (H)	Cape Kiritappu (JH)
People	Taiho Koki (Sumo wrestler) (J)	None	Matsuura Takeshiro (explorer) (JH), Viscount Enomoto Takeaki (politician) (JH), Hijikata Toshizo (military officer) (JH), Kayano Shigeru (politician/researcher) (JH), Chiri Yukie (author) (JH), Nagayama Takeshiro (serviceperson) (JH), Kanda Nissho (artist) (JH), Migishi Kotaro (artist) (JH), Saksaynu (Ainu chieftain) (JH), Sarashina Genzo (poet) (JH), Shima Yoshitake (politician) (JH), Monkey Punch (manga artist) (JH), Miura Ayako (author) (JH), Watanabe Jun'ichi (author) (JH), Kobayashi Takiji (author) (JH), William Smith Clark (educator) (JH), Ishikawa Takuboku (poet) (JH), Sakamoto Kyu (singer) (JH), Ishihara Yujiro (actor) (JH), Taiho Koki (Sumo wrestler) (H)	Koshyamainn (Ainu chieftain) (JH)
Seafood	King crab (JH), horsehair crab (JH), whelk (JH), sea kelp (JH), Japanese fluvial sculpin (JH), Pacific saury (JH), flatfish (JH), cherry salmon (JH), pink salmon (JH), oyster (J), greenling (J)	Sakhalin surf clam (<i>Pseudocardium sachalinensis</i>) (JH), scallop (JH), salmon (JH), Alaskan pink shrimp (<i>Pandalus eous</i>) (JH), shishamo smelt (JH), Atka mackerel (JH), smooth lump sucker (J), Alaska pollock (H)	Red snow crab (JH), dolly varden (<i>Salvelinus curilus</i>) (JH), lamprey (JH), rainbow smelt (<i>Osmerus dentex</i>) (JH), <i>Hypomesus japonicus</i> (JH), saffron cod (JH), herring (JH), chinook salmon (JH), sockeye salmon (JH), Hanasaki crab (<i>Paralithodes brevipes</i>) (JH), Alaska pollock (J), oyster (H), greenling (H), smooth lump sucker (<i>Aptocyclus ventricosus</i>) (H)	Hokkai shrimp (JH), <i>Bathyraja lindbergi</i> (JH), summer-catch salmon (JH)
Tourist spots	Sapporo City Maruyama Zoo (JH), Hokkaido Shrine (JH), icebreaker <i>Garinko II</i> (JH), Higashimokoto Shibazakura Park (JH), Northern Horse Park (JH), Ekorin Village (JH), Usuzan Ropeway (H), Abashiri Prison Museum (H)	Nijukken Road (JH)	Hokkaido Government (JH), Susukino (JH), Sapporo TV Tower (JH), Sapporo City Clock Tower (JH), Odori Park Nishi 8-chome (JH), Hokkaido University row of poplar trees (JH), Shiroy Koibito Park (JH), Hokkaido Prefectural Museum of Northern Peoples (JH), Noboribetsu Bear Farm (JH), Showa Shinzan Bear Ranch (JH), Yubari City Coal Museum (JH), National Ainu Museum and Park (JH), Kitaichi Glass (JH), Otaru Canal (JH), Mt. Moiwa Observation Deck (JH), Nusamai Bridge (JH), Sapporo Hitsujigaoka Observatory (JH), Asahiyama Zoo (JH), Fort Goryokaku (JH), Mt. Moiwa Ropeway (JH), Mt. Hakodate Ropeway (JH), Hakucho Bridge (JH), Usuzan Ropeway (J), Abashiri Prison Museum (J)	Mt. Hakodate Observation Deck (JH), Ikeda Wine Castle (JH)
Vegetation	Lilac (JH), ginkgo (JH), lavender (JH), lily of the valley (JH), moss phlox (JH), <i>Salicornia europaea</i> (JH), Asian skunk cabbage (<i>Lysichiton camtschatcensis</i>) (JH), Japanese white birch (<i>Betula platyphylla</i>) (JH), rowan (<i>Sorbus commixta</i>) (J), rose of Sharon (<i>Hibiscus syriacus</i>) (J), <i>Corydalis ambigua</i> (J), soft windflower (<i>Anemone flaccida</i>) (J), pheasant's eye (<i>Adonis amurensis</i>) (J), <i>Caltha fistulosa</i> (H)	Japanese butterbur (J)	<i>Picea glehnii</i> (JH), Sakhalin fir (JH), Japanese yew (JH), Japanese walnut (JH), <i>Quercus crispula</i> (JH), <i>Betula ermani</i> (JH), Todowara (JH), <i>Acer pictum</i> (JH), <i>Toxicodendron trichocarpum</i> (JH), poison ivy (<i>Toxicodendron orientale</i>) (JH), poplar (JH), larch (JH), lingonberry (JH), <i>Lilium pensylvanicum</i> (JH), plantain (<i>Plantago asiatica</i>) (JH), black lily (JH), <i>Gentiana triflora</i> var. <i>japonica</i> (JH), <i>Cardiocrinum cordatum</i> var. <i>glehnii</i> (JH),	Cucumber tree (<i>Magnolia kobus</i>) (JH), <i>Ledum palustre</i> subsp. <i>diversipilosum</i> (JH), <i>Hemerocallis dumortieri</i> var. <i>esculenta</i> (JH), Japanese butterbur (H)

(Continued)

TABLE 1 (Continued)

Field	Presence of 12-month seasonality		Absence of 12-month seasonality	
	Topic search	Keyword search	Topic search	Keyword search
			<i>Rosa rugosa</i> (JH), <i>Trillium smallii</i> (JH), Arctic iris (<i>Iris setosa</i>) (JH), kuma bamboo grass (<i>Sasa veitchii</i>) (JH), <i>Caltha fistulosa</i> (I), rowan (<i>Sorbus commixta</i>) (H), rose of Sharon (<i>Hibiscus syriacus</i>) (H), <i>Corydalis ambigua</i> (H), soft windflower (<i>Anemone flaccida</i>) (H), pheasant's eye (<i>Adonis amurensis</i>) (H)	

(I) Results for searchers in the whole of Japan; (H) results for searchers in Hokkaido only; (JH) results for searchers in both areas combined.



in three seasons: December–February, March–May, and June–August. (2) RSV peaks in the climate field were observed in two seasons: December–February and September–November. (3) RSV peaks in the foods and seafood fields were observed in all seasons. (4) RSV peaks in the natural scenic spots field were observed mainly in two seasons: June–August and September–November. (5) RSV peaks in the leisure field were observed in two seasons: December–February and June–August. (6) RSV peaks in the vegetation field were observed in three seasons: March–May, June–August, and

September–November. (7) In the case of searchers in either Japan or Hokkaido, RSV peaks for several search terms (Lake Akan and Mt. Hakodate in the natural scenic spots field; Taiho Koki in the people field; Abashiri Prison Museum, Northern Horse Park, and Ekorin Village in the tourist spots field; salmon in the seafood field; and Japanese white birch in the vegetation field) were observed in multiple seasons. (8) The number of search terms with obscure or unknown RSV peak seasons was greater in the case of searchers in Japan than for searchers in Hokkaido.

TABLE 2 Peak seasons of the time series of relative search volume for each search term in the case of searchers in the whole of Japan.

Category	Dec.–Feb.	Mar.–May	June–Aug.	Sep.–Nov.	Obscure/unknown
Ainu	None	None	None	None	None
Animals	Black-backed wagtail (<i>Motacilla alba lugens</i>), Steller's sea eagle	Japanese tit (<i>Parus minor</i>), varied tit (<i>Sittiparus varius</i>), black-backed wagtail (<i>Motacilla alba lugens</i>)	Black-backed wagtail (<i>Motacilla alba lugens</i>), <i>Lyristes japonicus</i> , stag beetle, small stag beetle, giant stag beetle, Japanese tree frog	None	Pygmy woodpecker, <i>Terpnosia nigricosta</i>
Climate	Drift ice, stove, studless tire, snow shovel, ice burn	None	None	None	Powder snow, road heating
Festivals	Lake Shikotsu Ice Festival, Sapporo Snow Festival	Sapporo Lilac Festival	Otaru Tide Festival, Sapporo Odori Beer Garden, Kachimai Fireworks Festival	None	Noboribetsu Jigoku Hell Festival, Hokkai Heso Festival
Foods	Matsumae pickles, <i>izushi</i> fermented sushi, <i>ishikari-nabe</i> (Hokkaido salmon hot pot), <i>kazunoko</i> (herring roe), dried fileted herring, <i>soba</i> noodle soup with herring, <i>nama</i> chocolate ganache	Alpine leek (<i>Allium ochotense</i>)	Yubari melon, Densuke watermelon, beetroot	Pickled herring, <i>chanchan yaki</i> (Hokkaido-style salmon and vegetable hotpot), <i>sujiko</i> (salmon roe)	Miso ramen, soy-boiled squid filled with rice, <i>saketoba</i> (skin-on salmon filets)
Leisure	Skiing, snowboarding, snowshoeing	None	Rafting	None	None
Natural scenic spots	None	None	Kushiro Shitsugen, Shakotan Peninsula, Lake Shikotsu, Lake Kussharo, Lake Mashu, Lake Akan, Cape Kamui, Mt. Yotei, Mt. Hakodate, Mt. Rishiri, Toyohira River, Bihoro Pass	Hoheikyo, Sounkyo, Lake Toya, Lake Shikotsu, Mt. Hakodate, Mt. Daisetsuzan, Nakayama Pass	Sosei River
People	Taiho Koki ^a	Taiho Koki ^a	Taiho Koki ^a	Taiho Koki ^a	Migishi Kotaro
Seafood	King crab, horsehair crab, oyster, sea kelp	Greenling, flatfish, Atka mackerel, cherry salmon	Whelk, pink salmon, salmon	Japanese fluvial sculpin, shishamo smelt, Pacific saury, greenling, salmon	Sakhalin surf clam (<i>Pseudocardium sachalinensis</i>), scallop, smooth lump sucker, Alaska pink shrimp (<i>Pandalus eous</i>)
Tourist spots	Hokkaido Shrine, icebreaker <i>Garinko II</i>	Sapporo City Maruyama Zoo, Higashimokoto Shibazakura Park, Nijukken Road, Northern Horse Park, Ekorin Village	Hokkaido Shrine, Northern Horse Park, Ekorin Village	None	None
Vegetation	None	Japanese white birch (<i>Betula platyphylla</i>), lilac, lily of the valley, moss phlox, soft windflower (<i>Anemone flaccida</i>), Asian skunk cabbage (<i>Lysichiton camtschatcensis</i>), pheasant's eye (<i>Adonis amurensis</i>)	Rose of Sharon (<i>Hibiscus syriacus</i>), lavender	Japanese white birch (<i>Betula platyphylla</i>), ginkgo	Rowan (<i>Sorbus commixta</i>), <i>Salicornia europaea</i> , <i>Corydalis ambigua</i> , Japanese butterbur

^aPeaks in January, March, May, July, September, and November.

4 Discussion

4.1 Characteristics of people's sense of seasons

In the case of both searchers in Japan and those in Hokkaido, a high trend was observed in the percentages of search terms

with 12-month seasonality in the foods, leisure, natural scenic spots, and seafood fields, whereas a low trend was observed in the percentages in the Ainu and people fields (Figure 2, Table 1). The RSV peak seasons in each field (Tables 2, 3) may have been associated with the following. Search terms categorized into the animals field were likely associated with the peak appearance of each animal. Search terms categorized into the climate field were

TABLE 3 Peak seasons of the time series of relative search volume for each search term in the case of searchers in Hokkaido only.

Category	Dec.–Feb.	Mar.–May	June–Aug.	Sep.–Nov.	Obscure/unknown
Ainu	None	None	None	None	Ainu people, Ainu <i>kotan</i> (village)
Animals	None	None	Stag beetle, giant stag beetle	None	Swan
Climate	Drift ice, water pipe	None	None	Stove	None
Festivals	Lake Shikotsu Ice Festival, Sapporo Snow Festival	Sapporo Lilac Festival, Yosakoi Soran Festival	Sapporo Odori Beer Garden	None	None
Foods	<i>Izushi</i> fermented sushi, <i>kazunoko</i> (herring roe), <i>nama</i> chocolate ganache	Alpine leek (<i>Allium ochotense</i>), <i>bekomochi</i> , horseradish	Yubari melon	Pickled herring, <i>chanchan yaki</i> (Hokkaido-style salmon and vegetable hotpot), <i>sujiko</i> (salmon roe), <i>imomochi</i> (potato rice cake), <i>ishikari-nabe</i> (Hokkaido salmon hot pot), <i>ikura</i> (salmon roe), <i>saketoba</i> , beetroot	Matsumae pickles
Leisure	Skiing, snowboarding, snowshoeing, ice hockey	None	rafting	None	None
Natural scenic spots	None	Mt. Hakodate	Kushiro Shitsugen, Shakotan Peninsula, Lake Shikotsu, Lake Kussharo, Lake Mashu, Lake Akan, Cape Kamui, Mt. Yotei, Mt. Hakodate, Lake Toya, Lake Saroma, Cape Soya, Cape Erimo	Hoheikyo, Sounkyo, Mt. Daisetsuzan, Nakayama Pass, Lake Akan, Mt. Yotei	None
People	None	None	None	None	None
Seafood	King crab, horsehair crab, sea kelp, Alaska pollock	Atka mackerel, cherry salmon, scallop, flatfish	Pink salmon, Alaska pink shrimp (<i>Pandalus eous</i>), whelk	Japanese fluvial sculpin, shishamo smelt, Pacific saury, salmon	Sakhalin surf clam (<i>Pseudocardium sachalinensis</i>)
Tourist spots	Hokkaido Shrine, Icebreaker Garinko II	Sapporo City Maruyama Zoo, Higashimokoto Shibazakura Park, Nijukken Road, Northern Horse Park, Ekorin Village, Abashiri Prison Museum	Northern Horse Park, Ekorin Village, Abashiri Prison Museum	None	Usuzan Ropeway
Vegetation	None	Japanese white birch (<i>Betula platyphylla</i>), lilac, lily of the valley, moss phlox, Asian skunk cabbage (<i>Lysichiton camtschat-censis</i>)	Lavender	Ginkgo	<i>Salicornia europaea</i> , <i>Caltha fistulosa</i>

likely associated with snowfall (studless tires, snow shovel, road heating, powder snow, and ice burn), coldness (stoves and water pipes), and winter events (drift ice). Search terms categorized into the festivals field were likely associated with the dates of each festival (see details in [Supplementary Table 4](#)). Search terms categorized into the foods field were likely associated with the dates of traditional events (New Year's Eve: dried fileted herring and soba noodle soup with herring; New Year: *izushi* fermented sushi and *kazunoko* herring roe; Valentine's Day: *nama* chocolate ganache), harvest time (alpine leek, Densuke watermelon, Yubari melon, and beetroot), and seasonal foods (e.g., Matsumae pickles, *ishikari-nabe* Hokkaido salmon hot pot, *chanchan yaki* Hokkaido-style salmon and vegetable hotpot, and *sujiko* salmon roe). Despite advances in refrigeration and transportation technology, as well as increased satiation and globalization, it was interesting to find that a clear sense of seasons was observed for search terms

associated with traditional food culture (e.g., *kazunoko* herring roe and *izushi* fermented sushi). Search terms categorized into the leisure field were likely associated with summer (rafting) and winter (skiing, snowboarding, snowshoeing, and ice hockey) sports. Search terms categorized into the natural scenic spots field were likely associated with the high tourism seasons (summer and autumn). Searches for Taiho Koki (a highest-ranking *yokozuna* sumo wrestler from Hokkaido, 1940–2013), categorized into the people field, were likely associated with the period of the year when the six annual sumo tournaments are held (each lasting 15 days). Many search terms categorized into the seafood field were likely associated with the peak commercial fishing season (see details in [Supplementary Table 5](#)). Search terms categorized into the tourist spots field were likely associated with Shinto ritual (Hokkaido Shrine), winter events (cruises of the icebreaker *Garinko II*), a cherry flowering spot (Nijukken Road), a moss

phlox flowering spot (Higashimokoto Shibazakura Park), and high tourism seasons (spring and summer). Search terms categorized into the vegetation field were likely associated with flowering (all search terms, excluding Japanese white birch and ginkgo), new green leaves (Japanese white birch), and leaf coloring (Japanese white birch and ginkgo).

People's sense of seasons may have been associated with a variety of objects in the landscape. The search terms with 12-month seasonality in the animals and vegetation fields were likely associated mainly with animal and plant phenology and cultural ecosystem services. Those in the climate field were associated mainly with climate. Those in the festivals field were likely associated mainly with cultural ecosystem services. Those in the foods and seafood fields likely associated mainly with the provisioning ecosystem services caused by animal and plant phenology, and with cultural ecosystem services. Those in the leisure, natural scenic spots, and tourist spots field were likely associated mainly with tourism. The leisure and natural scenic spots fields also included search terms that were likely associated with cultural ecosystem services.

Notably, the search terms with 12-month seasonality in the animals, festivals, foods, seafood, and vegetation fields also appeared to be associated with tourism for the enjoyment of nature, living things, culture, festivals, and gourmet foods. All of these findings suggest that the spatiotemporal variability of people's sense of seasons in Hokkaido is derived from tourism, as well as from animal and plant phenology, provisioning ecosystem services, cultural ecosystem services, and climate. There were, however, search terms with no 12-month seasonality in the tourist spots field; they included many tourist spots visited by tourists all year around. In addition, people have a low sense of seasons in the Ainu and people fields in Hokkaido, despite the inclusion of tourism factors in these fields.

4.2 Characteristics of RSV peak season

Overall, the time series of RSV detected as RSV peak seasons had the following three patterns (Supplementary Figure 3). Type 1: Rapid increases and decreases were observed in a short period of time (mainly in the festivals and climate fields, and partly in the foods field). This may have been caused by the fact that festival events and the consumption of special foods in relation to events are limited to short periods. In addition, drift ice and ice burn (in the climate field) are natural phenomena that occur over short periods of time. Type 2: Bell-shaped increases and decreases were observed in certain periods (mainly in the animals, climate, foods, seafood, and vegetation fields). This may have been caused by the fact that the peak of appearance of animals, the initial yearly need for cold protection, the peak commercial fishing season, and flowering are observed over periods of 1 week to 1 month. Type 3: Compared with type 2, more gradual increases and decreases, with mountain-shaped peaks in the graph, were observed (mainly in the natural scenic spots field and partly in the tourist spots field). This may have resulted from the fact that the high seasons for natural scenic and tourist spots generally continue for multiple months.

Although 12-month seasonality was detected in our analysis of the autocorrelation coefficient of the time series of RSV, there were cases in which an RSV peak season could not be detected successfully by visual inspection (Tables 2, 3). This may have been caused by the following. The time series of RSV included 12-month periodic components. However, it had a complex pattern because it included non-periodic components. As a result, in these cases it was difficult to detect the RSV peak season. In contrast, in other cases, although 12-month seasonality in multiple years was detectable by visual inspection, some search terms did not detect it through analysis of the autocorrelation coefficient (examples are, in the case of searchers in Japan: heavy snow categorized into the climate field, and Toyohira River Fireworks Festival, Hakodate Port Festival, and Yosakoi Soran Festival categorized into the festivals field; in the case of searchers in Hokkaido: Otaru Tide Festival, Katsumai Fireworks Festival, and Hakodate Port Festival categorized into the festivals field, and Asahiyama Zoo categorized into the tourist spots field; these terms therefore do not appear in Tables 2, 3). Many of these time series of RSV did not show clear peak seasons in 2020 and 2021. This may have been caused by a substantial decrease in the number of Google searches because of the cancellation of festivals and events during the COVID-19 epidemic.

Unexpected and rapid temporal changes in RSV values in a short time period with no relationship to 12-month seasonality may have hindered our detection of the 12-month periodic component of the time series of RSV. The time series of RSV for the Shiretoko Peninsula (categorized into the natural scenic spots field) had an unexpected and rapid increase from 24 April to 30 April 2022 because of a marine accident (Fire Disaster Management Agency, 2022). For this reason, the 12-month periodic component that peaked in about August every year was not detected by our analysis of the autocorrelation coefficient. A rapid increase in people's interest in a short time period often occurs in response to movies, TV programs, animations, and news reports. We can guess the reason for unexpected and rapid temporal changes in the RSV values to some extent by carefully validating the attributes of RSV values (i.e., "Top related topics" and "Top related queries"; Shin et al., 2022a). However, in the case of the analysis of huge numbers of search terms, it is unrealistic to verify all attributes. For this reason, the inclusion of unexpected and rapid temporal changes in RSV values that have no relationship to 12-month seasonality (i.e., that can be considered to be systematic errors) will mislead any evaluation of people's sense of seasons.

4.3 Limitations

Our approach included the following three limitations on the representativeness of selected search terms: (1) The terms included bias associated with the GT searcher's generation, gender, knowledge, experience, and skill. (2) The terms included various levels of specificity and generality. (3) We could not identify both the attributes of Google searchers (e.g., generation, gender, and nationality) and the absolute, rather than relative, volumes of Google searchers. Regarding the first limitation, comprehensive investigation of printed guidebooks and brochures and of the websites of tourism associations and local governments may be

preferable. However, the information retrieved from these media also includes bias due to the intent or purpose of the publisher or sender and the availability of printed pages. Regarding the second limitation, in a certain search area, more specific terms are likely easier to observe for 12-month seasonality, whereas more general terms may make it difficult to detect such patterns. In fact, the percentages of search terms with 12-month seasonality in the animals, climate, and festivals fields in the case of searchers in Japan were higher than those in the case of searchers in Hokkaido (Figure 2). This may have been because these fields included typical search terms with 12-month seasonality in areas other than Hokkaido (e.g., small stag beetle in the animals field, and rose of Sharon in the vegetation field; Table 1). By referring to the “Interest by sub-region” attribute (e.g., Japanese tree frog in Akita, Gifu, and Tottori, and snow shovel in Akita, Yamagata, and Niigata), we confirmed that the top 5 areas of search terms included areas other than Hokkaido. In other words, these search terms were not specific to Hokkaido. Regarding the third limitation, a search term with high 12-month seasonality but a low search volume (small population) may not be as significant as a search term with low 12-month seasonality but a high search volume (large population). In the case of Google searchers in Hokkaido, the RSV values might have included the search results from both local people in Hokkaido and many tourists from Japan and abroad. Moreover, with regard to the second limitation, the sensitivity of the sense of seasons may vary between local people in Hokkaido and both tourists and Japanese people residing outside Hokkaido. For this reason, in some cases, it is difficult to use search terms with 12-month seasonality to accurately define the sense of seasons of local people, specifically, in Hokkaido. To remove these three limitations as far as possible, increasing the number of search terms is of primary importance from a statistical perspective, because increasing the sample size causes the sample mean to converge to the population mean (Law of Large Numbers). This would require an automatic analysis system that identifies huge numbers of representative search terms on the Internet and then examines the 12-month seasonality of downloaded time series of RSV values for each search term.

4.4 Perspective

On GT, we can extract the time series of RSV at a daily time step by setting the search period to within 8 months (Google LLC, 2024). For this reason, year-to-year variability in the RSV peak season could be examined accurately by extracting the RSV values every year for the same period. In fact, the daily RSV time series of blossoming of the three Great Cherry Trees of Japan show year-to-year variability of the RSV peak season, which is caused by variations in the dates of full bloom (Shin et al., 2022b). The time series of RSV associated with the peak commercial fishing season, the peak of appearance of animals, and flowering can be viewed as proxy data for animal and plant phenology. The time series of RSV associated with seasonal gourmet food consumption, leisure, and visits to natural scenic and tourist spots can be seen as proxy data for seasonal human activities. An analysis of the year-to-year variability of the RSV peak for various search terms

in multiple countries and regions could deepen our understanding of the sensitivities of animal and plant phenology and seasonal human activities to climate change. The analysis of texts on X and Facebook, of videos on Instagram, TikTok, and YouTube, and of human flow data with time stamp and geolocation information will provide supporting evidence of animal and plant phenology and seasonal human activities. By verifying these data, we will be able to improve the accuracy of our evaluation of people’s sense of seasons by using GT.

5 Conclusion

Our analysis of the time series of RSV for over 300 search terms representing Hokkaido, in Japan, allowed us to detect the presence and absence of 12-month seasonality and the characteristics of RSV peak seasons. In the case of searchers in both Hokkaido and the whole of Japan, many search terms with 12-month seasonality were observed in the foods, leisure, natural scenic spots, and seafood fields. In contrast, search terms with 12-month seasonality were barely observed in the Ainu and people fields. In Hokkaido, people’s sense of seasons was likely associated with tourism, as well as with animal and plant phenology, provisioning ecosystem services, climate, and cultural ecosystem services. However, unexpected and rapid temporal RSV value changes that had no relationship to seasonal changes, together with limitations on the representativeness of selected search terms, caused uncertainty in the evaluation of people’s sense of seasons on the basis of the time series of RSV. Although there remains a need for the appropriate selection of huge numbers of representative search terms, we recommend further studies of people’s sense of seasons by using GT of various search terms in countries and regions of interest to deepen our understanding of the temporal changes in the relationship between people and various objects of landscape. From the perspective of people’s sense of seasons, we will be able to evaluate the spatiotemporal variability of the relationship between people and tourism under climate and societal changes.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://trends.google.com/trends/>.

Author contributions

NS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – original draft. HN: Data curation, Investigation, Validation, Writing – review & editing. HM: Methodology, Writing – review & editing. AK: Validation, Writing – original draft.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article.

This research was supported by KAKENHI grants (JP21H05178, JP22H04457, and JP24H00935) from the Japan Society for the Promotion of Science.

Acknowledgments

We thank the editors and two reviewers for their constructive comments.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/frsut.2024.1446528/full#supplementary-material>

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SUPPLEMENTARY FIGURE 1

Location maps of search terms categorized into the (A) festivals, (B) natural scenic spots, and (C) tourist spots fields. The correspondence between numbers and search terms on each map is shown in (A) Supplementary Table 1, (B) Supplementary Table 2, (C) Supplementary Table 3.

SUPPLEMENTARY FIGURE 2

Examples of the time series of relative search volume (RSV) and its autocorrelation coefficient with 12-month seasonality (A, C) and with no 12-month seasonality (B, D). The red and green dotted lines show 95% significance and time lag ($s = 52$), respectively.

SUPPLEMENTARY FIGURE 3

Examples of the three patterns of the peak season of the times series of relative search volume (RSV): (A) type 1, (B) type 2, and (C) type 3. See text for details.

SUPPLEMENTARY TABLE 1

List of the correspondence between numbers on the map in Supplementary Figure 1A and search terms in the festivals field.

SUPPLEMENTARY TABLE 2

List of the correspondence between numbers on the map in Supplementary Figure 1B and search terms in the natural scenic spots field.

SUPPLEMENTARY TABLE 3

List of the correspondence between numbers on the map in Supplementary Figure 1C and search terms in the tourist spots field.

SUPPLEMENTARY TABLE 4

List of relevant websites and event dates for search terms categorized into the festivals field. All relevant websites were accessed on 6 September 2024. (J) Results for searchers in the whole of Japan; (H) results for searchers in Hokkaido only; (JH) results for searchers in both areas combined.

SUPPLEMENTARY TABLE 5

List of the commercial fishing seasons for search terms categorized into the seafood field. (J) Results for searchers in the whole of Japan; (H) results for searchers in Hokkaido only; (JH) results for searchers in both areas combined.

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