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Social Media as a Lens for Citizen Science: Investigating Visitor Contributions in a Forest Recreational Area

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Abstract: The primary challenge in collecting biodiversity information using citizen science is to encourage a diverse range of people to participate. This is crucial in fostering a Nature Positive society. Social media approaches have the potential to engage not only nature lovers but also a wider range of citizens, including those indifferent to nature. However, current understanding of the traits of individuals who contribute to widely prevalent social media platforms is limited and insufficient. This study focuses on individuals who contribute to a forest recreational area and the photos they share on a popular social media platform; it sheds light on the untapped potential of social media as a source of citizen science data and contributor sources. We developed a taxonomy of 22 classifications for 1066 photographs that illustrate human–ecosystem interactions and identified the relationship between these subjects and the history of social media activities of the 136 photo contributors. Our findings indicate that different behavioral styles exist among different types of visitors regarding their posting behavior and associated forest recreation types. This can encourage future contributions to the recruitment of citizen scientists and the collection of biodiversity information at small spatial scales.

Keywords: cultural ecosystem services; social media; citizen science; photo analysis; interpretation; phenology monitoring; bird watcher; symbolic species

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1. Introduction

1.1. Citizen Science for Biodiversity Conservation: A Strategy for Nature Positive

Biodiversity conservation is a global challenge, as it contributes to human well-being and sustainable development [1–7]. Despite this, biodiversity loss continues in the 2020s [8]. In December 2022, the world witnessed the Kunming–Montreal Global Biodiversity Framework (KM-GBF) agreement, which aims to achieve the concept of Nature Positive by 2030, a framework that intends to halt and reverse global biodiversity loss [8,9]. Furthermore, KM-GBF urges the transformation of values and actions for human societies to realize Nature Positive. To date, only a few people have participated in nature conservation. Thus, the United Nations Convention on Biological Diversity proposes that diverse people in general society must reconnect values and behavioral changes [10]. KM-GBF "Invites Parties and relevant organizations to support community-based monitoring and information systems and citizen science and their contributions to the implementation" [11].

Citizen science, in which citizens contribute to scientific research, is one of the strategies for attaining Nature Positive. Additional information on local biodiversity is required to inform conservation policies [8,12,13]. Traditionally, scholars have used expert surveys to collect information, but these methods are time-consuming and costly [13–16]. Citizen science enables data collection at a scale that is impossible for scientists alone and helps citizens enhance their understanding of local nature and biodiversity [14–17]. Scientists, public institutions, and companies can organize platforms for citizen science in which many citizens participate not only to realize the collection of biodiversity information on a large scale in various regions but also to permeate the understanding of the value of biodiversity to the general society. Another objective is to transform individual daily life into actions that consider biodiversity. Promoting citizen science can lead to social change through a virtuous cycle [15]. Encouraging contributory science—including citizen and community science—is a crucial global policy goal for achieving a Nature Positive society with the data revolution related to ecosystem services [11,18].

1.2. Challenges in Engaging a Diverse Public in Citizen Science

To expand conservational information using citizen science methods, we must face the challenge of encouraging diverse people to participate in citizen science [19]. The participants in traditional citizen science comprise a minority in society [14,20]. For example, they are nature lovers such as bird watchers. In pursuit of a solution to this challenge, recent studies have identified social media as an essential source of data and participants in contributory science [21–23]. In the social media approach, people who are not nature lovers can be considered targets for information collection. Recently, researchers have developed multiple social media platforms for citizen participation to collect biodiversity information (e.g., eBird [24], iNaturalist [25], ClimateWatch [26], and Biome [27]). They function as information-sharing sites in which many citizens participate and generate big data that are beneficial for biodiversity conservation [19,28]. Some platforms have attracted many new users and collected large amounts of data by developing applications that incorporate gamification elements and motivationally designed features borrowed from games [29,30]. For example, Biome, a mobile application available in Japanese, uses AI-based species identification algorithms and gamification elements and has collected more than six million observations consisting of uploaded photos of living things since its launch in 2019 [27].

1.3. Social Media for Citizen Science: Data Collection and Recruitment

These developments rely on social media users' casual interactions with biodiversity through wildlife photography and posting behaviors on vacation trips and daily walks, which have become typical public information behaviors [31,32]. From the 2020s onward, social media data linked to specific locations have been accumulated. Social media, a space for Internet information, enables the public to share various content with locational information [33]. With the spread of mobile devices and the Internet, citizens can easily share their experiences through social media platforms. Social media use is expanding to a broad range of generations, and the spatial resolution of data is increasing. These developments have enabled researchers to obtain structured data at an unprecedented scale [33,34]. For example, although mainly used by residents, some studies have employed thousands of contributions in a specific recreational area via only one social media platform [35,36]. Simultaneously, many social media users posted photos in this one area. The posting of a photo taken in a natural area on social media implies that the individual sees the benefits of biodiversity as something valuable to share with others [19,21,37,38]. Such people have been given the opportunity to capture wildlife photos, have a low threshold for information behavior on the Internet, and are talented people who can provide data. Humanity is entering an era in which many participants can be recruited and biodiversity information linked to a particular space can be collected using the Internet [17,19,22,23,31,32,39,40]. Indeed, previous researchers who conducted big data analysis of social media have provided quantitative evaluation of recreational use in wildlife-watching, which has become a significant market in recent years [37,41]. Thus, social media are expected to be an alternative source of data for researcher-based surveys and a source of recruitment for citizen scientists [19,34].

1.4. The Next Steps: Unlocking the Full Potential of Social Media Research for Citizen Science

The advancement of social media research necessitates appreciation for the findings of large-scale spatial data analysis studies. The first academic goal of social media studies utilizing data posted by visitors to natural recreational areas was to visualize the benefits of cultural ecosystem services, focusing on the interactions between people and biodiversity [22,37]. Cultural ecosystem services are derived from the nonmaterial benefits of human–nature relationships, making their intangible value challenging to visualize [6,18,42]. Visualization of cultural ecosystem services requires spatial and quantitative methods from diverse social sciences, and social media approaches have been suitable for gathering information on how and where individuals ascribe value across diverse social, political, and ecological boundaries [5,22,37,43,44]. Many studies have quantitatively evaluated the spatial distribution of the cultural benefits of the ecosystem to the general public by aggregating and analyzing contributions on social media at a large spatial scale [5,22,36,39,43–45]. For example, assessing behavior and perceptions of the environment has indicated the most aesthetically valuable landscapes [45] and how biodiversity relates to cultural preferences [21,46]. These insights have provided decision-making support for local conservation policies [15,18,19,47]. One of the most significant findings of social media research is the revelation of human-ecosystem interaction by big data derived from wildlife-watching posts, which were used in citizen science projects and encouraged individuals to become contributors to these projects [19,21,37].

Nevertheless, the field of social media research for citizen science presents opportunities for further development despite the growing field of studies examining human–biodiversity interactions [19,47]. The two key areas for further development are social media as data and recruitment sources. The potential for the development of data sources stems from many studies continuing to use big data analysis, which aggregates posts on many recreational sites and dilutes posting information about individual sites [36,40]. Before the accumulation of data, researchers were confronted with the challenge of data bias introduced by limited data, which would have occurred if the data were extracted from individual sites [47–49]. Currently, the available data have accumulated considerably, with numerous contributions from a multitude of contributors in natural recreational areas on a relatively small spatial scale [35,36]. The utilization of contemporary data that reflect the experience of visiting individual recreation sites enables researchers to elucidate the interactions between human beings and biodiversity at local spatial scales, which can be used as a new data source for citizen science projects.

1.5. Investigating Social Media Users on Popular Platforms: A New Source for Citizen Science?

The scope of the current approach to identifying potential citizen science contributors is limited because it does not extend to users of popular social media platforms [47]. Researchers engaged in citizen science have historically developed limited approaches for individuals with a high interest in nature and biodiversity [19,37,47,50]. This issue stems from citizen science researchers continuing to call out existing nature-loving networks in response to the rapid development of social media. Furthermore, the majority of studies assessing interactions between human beings and ecosystems have employed crowdsourced big data from a few social media platforms, such as Twitter (now X) and Flickr [21,22,36,38,40,41,43,44,51–56]. Different sociodemographic characteristics of social media users may lead to different interactions between social media dedicated to citizen science projects and social media, where general and casual posts are posted [21,31,57]. The current understanding of the traits of individuals who contribute to the widely prevalent social media platform is limited and insufficient [47], impeding the goal of increasing the recruitment of citizen scientists to promote a Nature Positive society.

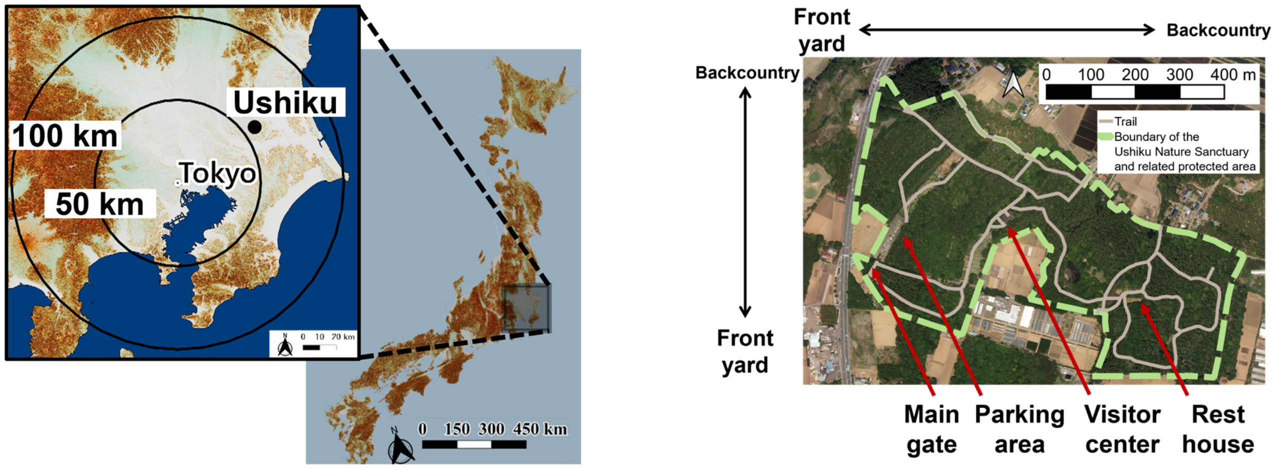
Despite the current availability of large amounts of spatially dense data, a critical limitation is the insufficient understanding of how users' posts on natural recreational experiences on popular social media platforms and the information they can provide facilitate the aims of citizen science. Therefore, this study explored the potential of widely used social media platforms for citizen science initiatives. We reveal that analyzing user contribution behavior on social media can help identify a distinct pool of citizen science contributors. This research focused on contributions from individuals visiting a recreational forest area, specifically analyzing the photographs they shared on a social media platform. We developed a taxonomy of photographic subjects that illustrates human–ecosystem interactions and identified the relationship between these subjects and the history of social media activities of the photo contributors. Based on these results, we propose recommendations to attract contributors as future citizen scientists.

2. Materials and Methods

The primary objective of this study was to investigate the visitors of a specific forest recreational area and their online contributions to one social media platform. The analysis of user characteristics revealed those who contributed to biodiversity information. In an attempt to identify potential contributors based on their past contributions, this study applied the insights of electronic commerce marketing analysis, which aims to acquire information on users of an online purchasing platform by analyzing their behavioral history. This analysis involves related data (e.g., number of purchases and categories of items bought) and an understanding of the user's purchasing behavior (e.g., number of visits to the site before making a purchase and level of engagement with the platform). The analysis of social media data considered factors such as the number of photos posted, frequency of the user's contributions to the site, and total number of contributions to the platform [40].

The study site was the Ushiku Nature Sanctuary, Ushiku City, Ibaraki Prefecture, Japan. Figure 1a shows the location of the study site in Japan. The study site was situated at the edge of the Tokyo metropolitan area. The Tokyo metropolitan area is the most extensive urbanized plain in Japan. Ushiku City has been developing as a suburban natural resource supply area for approximately 300 years, and its land use is a mixture of residential areas, fields, and forests [58]. In 1990, the Japanese Ministry of the Environment and the local government established a sanctuary to promote recreational, educational, and cultural uses of forests with a history of natural resource supply in traditional agricultural landscapes [59]. The study area is one of the few remaining rural forests in the urban environment. The site received an average of approximately 50,000 users annually in the 2010s, primarily from citizens of Ushiku [60]. Figure 1b depicts a map of the site, including the locations of user facilities. This site covers an area of 21 ha. It comprises a parking lot with a capacity of over 100 vehicles, a visitor center staffed by a full-time ranger, circular forest trails, and rest facilities such as restrooms, benches, rest houses, and bird hides located along the use paths. The site was subdivided into more than 20 distinct areas, each with specific recreational and nature conservation purposes. In essence, zoning is front yard-like in the southwestern part of the site, although the northeastern area has backcountry components. The southwestern area is the most visited area, with a concentration of visitor facilities such as parking lots and visitor centers. Managers frequently manage vegetation in the area to recreate the landscape created by the high frequency of natural resource use by rural populations. In contrast, the northeastern area is managed exclusively along trails to ensure visitor safety and prioritize nature preservation (Figures 1b and S1).

This study chose Google Maps, a widely used social media platform in Japan with locational data, as the primary source for collecting site information. Google Maps was the optimal platform for gathering data on visitors' recreational use at a detailed spatial scale, as evidenced by a case study on an urban park in Indonesia, which highlighted Google Maps as an exemplary resource for collecting such information [61]. Google Maps proved to be the most valuable resource among various social media platforms for gathering data related to the study site. Flickr, Twitter (now X), eBird, and iNaturalist contributions to the Ushiku Nature Sanctuary were limited to a few users. Instagram includes a few appropriate contributions for identifying users' preferred objects in forests. The majority of these users' content was primarily composed of movie media and focused on the human face, although the number of total contributions on the site was comparable to Google Maps posts.



(**a**) (**b**)

Figure 1. Study site in (**a**) Japan, Kanto region, including Tokyo and Ushiku City. The Japan and Kanto region maps are CS 3D maps based on the digital map (Basic Geospatial Information) published by the Geospatial Information Authority of Japan. Dark brown indicates a high elevation, high slope, and high curvature. (**b**) is the map with trails and amenities in Ushiku Nature Sanctuary. The background is based on the seamless photo layer published by the Geospatial Information Authority of Japan http://maps.gsi.go.jp/development/ichiran.html (accessed on 30 April 2024).

Figure 2 shows a flowchart of the analysis. We accessed posted photos of the Ushiku Nature Sanctuary and related Places on Google Maps. This study utilized the Google Places Application Programming Interface (API) to retrieve detailed information about the Place. Additionally, contributor characteristics were extracted based on the data displayed for each post. Finally, photo subjects were classified by multiple experts and integrated into a framework examining their relationships with forest recreational use.

This study selected six Places based on their geographical positioning and the number of user contributions. All Places were located within the area of the Ushiku Nature Sanctuary and had a certain number of contributions as of 2023. The study collected data from all available contributions with photos and generated accessible URL lists from the Places on Google Maps web page. Each photo underwent individual review, with the primary objects subsequently classified. Simultaneously, contributor information displayed alongside the posts was extracted. By accessing contributor profiles, the study compiled scores reflecting the activity level of each contributor on Google Maps. This score refers to the total number of reviews, photographs, and ratings a user posts on Google Maps. These values were also utilized to assess the contribution level of Google Local Guides, who participated in the Google Maps Community Program. This information was collected through manual web scraping.

Examination of the data revealed the need for ethical considerations regarding social media post content. Posts were publicly available on the Internet at the discretion of the contributors. However, whether contributors fully understood the extent to which their data could be used and whether they would have granted permission for its use in further applications is unclear. This raises the question of whether the implicit consent to publish the data is sufficient or expressed consent is necessary [22,37,50]. Thus, the constructed database anonymized the account names of contributors and excluded personally identifiable posts. The data collected included the number of contributions, types of contributions with media, frequency of visits by each contributor, and contributors' profiles. Invalid data were removed from the analysis, such as posts unrelated to the site, posts by location owners on advertisements, and posts with insufficient information.

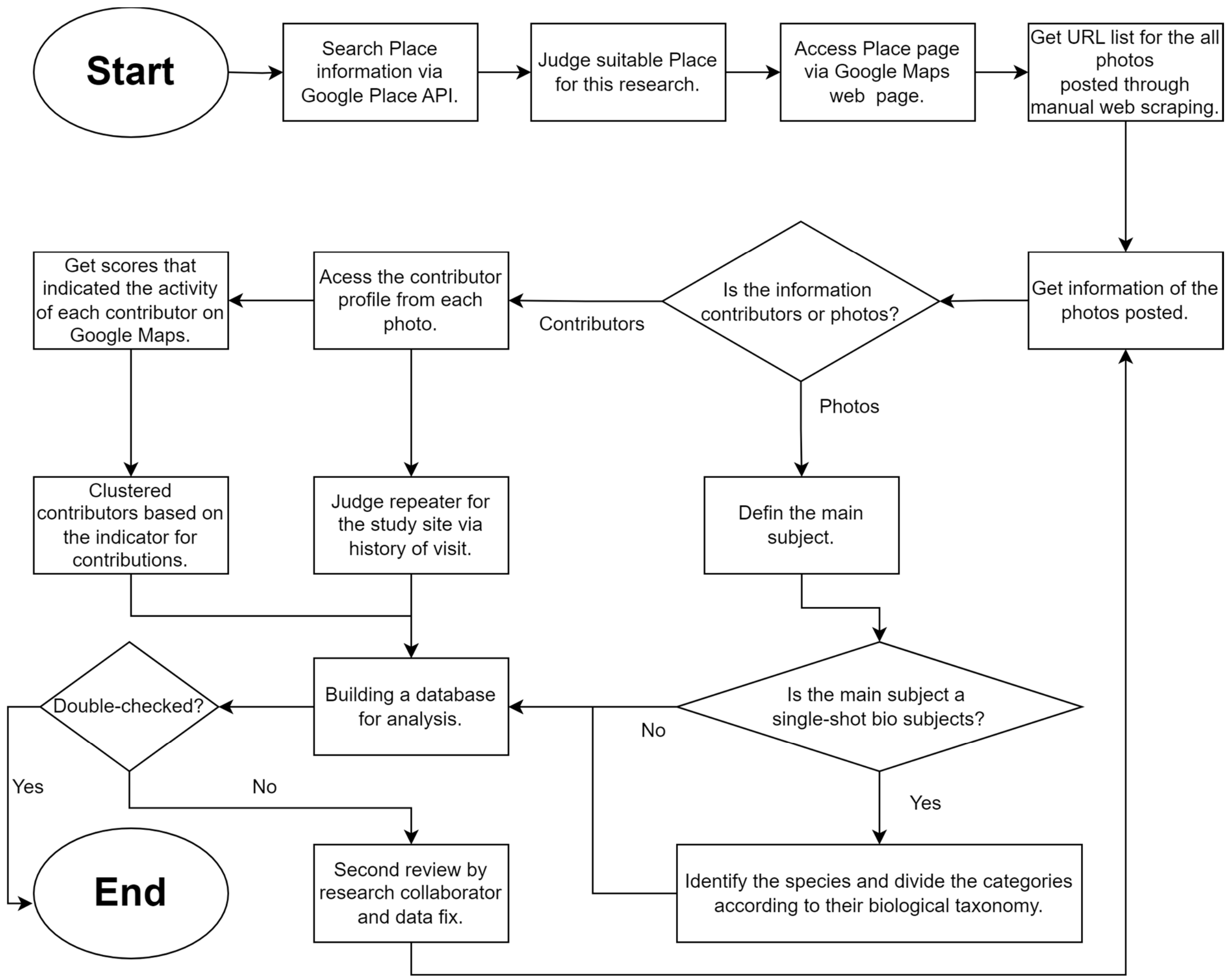


Figure 2. Flowchart for analysis using data obtained from Google Maps.

This study organized the posted data and categorized contributor characteristics alongside the main subject of the photos. The characteristics of the contributors included the frequency of contributions to the area, the number of photos posted about the area, and the frequency of social media use. Contributor clustering was conducted based on their Google Maps contribution patterns. Contributors who post more photos on the site and actively utilize social media through contributions to various sites substantially enrich the information on Google Maps.

This study employed k-means clustering, a well-established and computationally efficient algorithm suitable for grouping similar data points. The silhouette score was utilized to evaluate the quality of each clustering configuration. K-means clustering is a classical statistical method of analysis employed in outdoor recreation research using social media data [50]. The clustering employed two factors to classify contributors: total number of photos posted on the site and Google Maps activity scores. Four categories were generated using a two × two combination scheme, denoted by "L" (large) or "S" (small) for photo count and activity scores.

Additionally, the potential change in recreational use at the forest site with repeated visits was investigated. This investigation aimed to determine if contributor preferences shifted based on the frequency of their check-ins by comparing the content of initial contributions with subsequent submissions within each cluster. The analysis employed a three-step approach. First, it examined both the contributors themselves and the number of photos included in their initial contributions. Second, it identified the subject matters depicted in the photographs submitted during later visits for specific clusters. Finally, the analysis explored how these content preferences changed as the number of visits increased.

To define the main subject and corresponding classification for each photo, this study established a framework based on the type of forest recreational activities in the Ushiku Nature Sanctuary. First, a literature review explored the sanctuary to create criteria for photo analysis. Annual management reports from the 2010s provided information on facility management and ranger interpretation programs [60]. Additionally, this study analyzed the master plan for the establishment of the sanctuary in the 1980s to determine whether any species that appeared were wild or had been introduced during the development [62,63]. Second, photos were categorized based on indoor or outdoor activities, considering the visitor center's permanent exhibits and ranger presence as features of an environmental education facility. Third, the analysis identified the main subject matter within each photographs, with further detailed classifications based on three main categories: man-made objects, landscapes, and biological elements (denoted as "bio") representing forest recreational use. Man-made object categories were further divided by location and type. For single-shot bio subjects with sufficient existing data for species identification, classifications were based on biological taxonomy. This study documented all identifiable species, along with their treatment within the region.

Multiple experts evaluated and categorized valid subjects. The first author demonstrated a comprehensive understanding of the objects photographed at the site, having conducted 5 years of participant observations related to environmental education and nature guidance at the Ushiku Nature Sanctuary in the 2010s. Additionally, the first author exhibited profound familiarity with the taxonomy of photographed objects of living organisms. A research collaborator served as the second reviewer to verify the photographs identified by the first author. He has documented the history of research on the quantitative evaluation of cultural ecosystem services in traditional Japanese rural landscapes.

3. Results

3.1. Data Collection from Google Maps Related to Ushiku Nature Sanctuary

An initial data set of 1116 photos from 143 contributors was obtained. Following data validation, 50 photos were excluded due to invalid information, resulting in the removal of seven contributors. The final analysis included 1066 photos from 136 unique contributors who made a total of 190 visits to the Ushiku Nature Sanctuary (Tables S1 and S2). Due to the predominantly image-based nature of the contributions, the main subject of each photo was successfully identified.

Specifically, 31 contributors posted on the sanctuary multiple times, with one returning up to seven times (Figure 3a). The first contribution to the Ushiku Nature Sanctuary was made in October 2009. In 2016, there were only six contributions and 12 photos per year. In 2017, however, the number increased to 24 contributions and 71 photos; since then, the number has remained in the range of 24–30 contributions and 71–159 photos per year. In 2020, the site was closed for an extended period due to COVID-19, with only 18 contributions and 135 photos. The number continued to increase, reaching a maximum of 26 contributions and 275 photos in 2022. The analysis of photo submissions reveals seasonal trends. Spring (March–May) attracts the most visitors, with around 30 contributions and 100–200 photos per month (Figure 3c). Conversely, winter (December–February) witnessed the lowest participation, with a maximum of 15 contributions and 77 photos per month (Figure 3c).

3.2. Classifications of Subjects in Each Photo

3.2.1. Outline of the Main Subjects

Visitors documented various man-made objects within the sanctuary in their photos (Figures 4 and 5). Outdoor features were more prominent, with 286 photos capturing subcategories of buildings, symbolic structures, trail signs, and amenities along trails. A total of 243 indoor photos captured subcategories of aquarium exhibits, wooden toys, and amenities in the buildings.

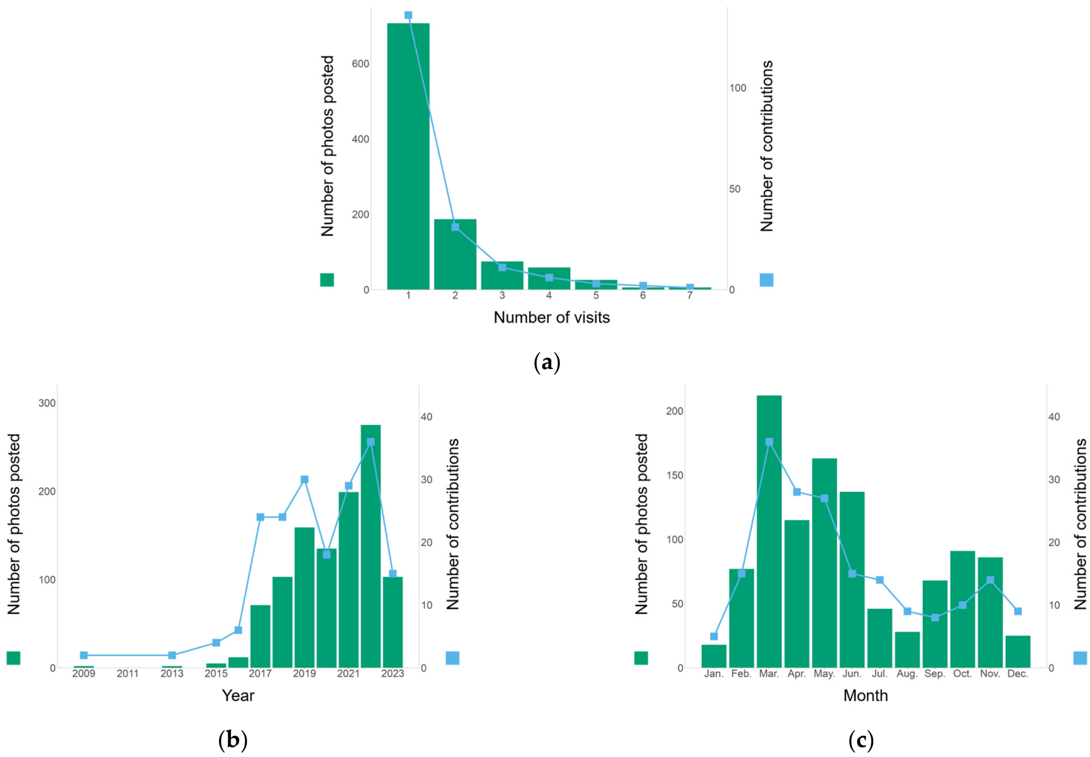


Figure 3. Distribution of the number of photos posted by 190 submissions related to Ushiku Nature Sanctuary on Google Maps. (**a**) is broken down by the number of visits to the Ushiku Nature Sanctuary. (**b**) Furthermore, (**c**) is categorized by year and month.

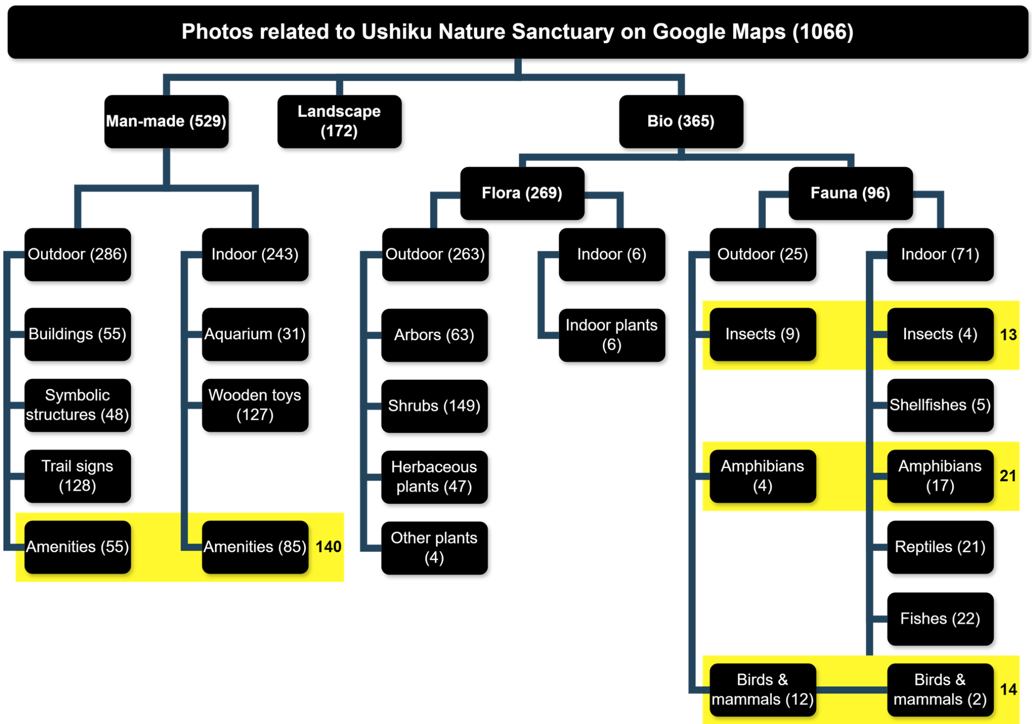


Figure 4. Classification of photos posted related to the Ushiku Nature Sanctuary on Google Maps. Each bounding box shows the classification and the number in parentheses indicates number of photos. The yellow boxes indicate a grouping of subcategories that are the same subcategory, but divided by the location of the photo (outdoor or indoor).

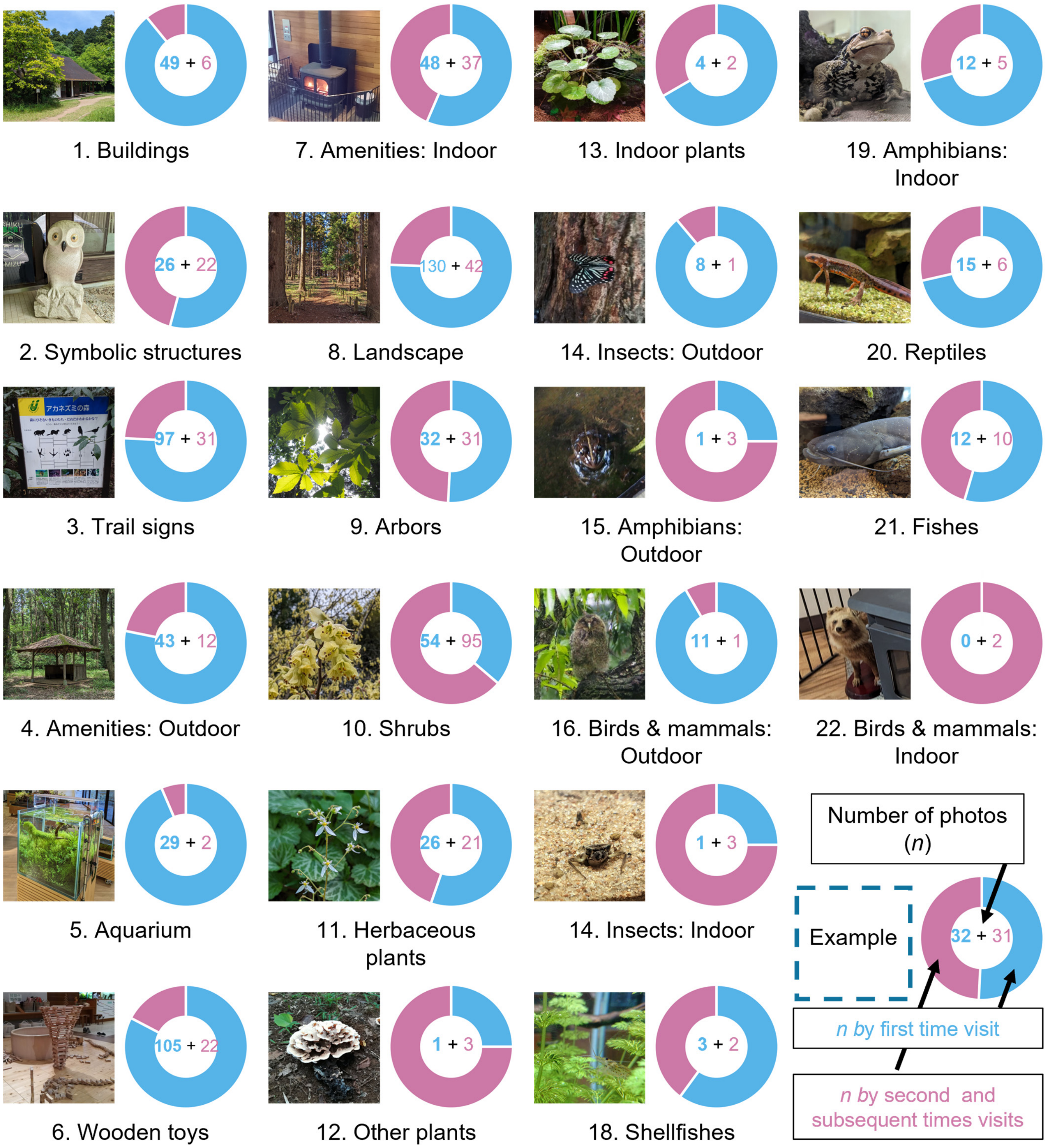


Figure 5. Photographs taken in the Ushiku Nature Sanctuary symbolize each classification and the number of photographs analyzed. The photos are further categorized based on the contributor's check-in frequency: total number of photos, those submitted during the first visit, and those submitted during subsequent visits. Shoma Jingu, the lead author, captured these representative images. The photographs were taken at the same locations and aimed to depict similar subject matter as the original Google Maps submissions, using those submissions as a reference. These representative images are original and have not been previously published.

The analysis identified 172 photos classified as landscapes (Figures 4 and 5). These photos captured broader views, often featuring both man-made elements like trails and natural elements like waterfronts and vegetation, without a single dominant subject (Figure 5). Species identification was not applicable to these landscape photos due to their focus on the overall scene rather than specific organisms.

The study also analyzed 365 photos of living things (bio) with enough detail for identification (Figures 4 and 5). These photos primarily captured outdoor subjects (288) but also included some indoor ones (77). A classification system categorized flora (plants) into five subcategories and fauna (animals) into six (Table 1 and Figures 4 and 5). Among the 269 flora photos were images of arbors, shrubs, herbaceous plants, other plants, and indoor plants. The fauna category comprises 96 photos representing insects, shellfish, amphibians, reptiles, fishes, birds, and mammals.

Table 1. Classification of photos focusing on biological subjects.

Classifications Based on Biology		The Place Where the Photos Were Taken	Number of Photos	Number of Species (Native)	Primary Species Name in the Classification
Flora	Arbors	Outdoor	63	9 (9)	Japanese oak, Japanese cedar, and cherry blossom
	Shrubs	Outdoor	149	17 * (17)	Japanese spindle tree, Japanese beautyberry, and Japanese plum
	Herbaceous plants	Outdoor	47	32 * (30)	Golden orchid, Japanese kerria, and silver grass
	Other plants	Outdoor	4	2 * (2)	Bryophyte
	Indoor plants	Indoor	6	3 * (3)	Ferns and other plants for the nature aquarium
Fauna	Insects	Outdoor	9	7 (6)	Walking stick, Chinese windmill, and red ring skirt
		Indoor	4	3 (3)	Predaceous diving beetles in aquarium and hornet specimens
	Shellfishes	Indoor	5	4 (3)	Amano shrimp, red swamp crawfish and Japanese freshwater crab
	Amphibians	Outdoor	4	3 (3)	Japanese tree frog, and Tokyo daruma pond frog
		Indoor	17	2 (2)	Japanese common toad and Japanese newt
	Reptiles	Indoor	21	2 (2)	Reeves' pond turtle and Japanese pond turtle
	Fishes	Indoor	22	6 (6)	Japanese eel, Amur catfish, and oriental weatherfish
	Birds & mammals	Outdoor	12	5 * (4)	Common kingfisher, owl, and free-roaming cat
		Indoor	2	2 (2)	Raccoon dog specimens

The number of species was the total number of species in the classification and the number in parentheses indicates the number of native Japanese species in that taxon. However, if species identification was only possible at the genus level, an asterisk (*) was added. In such cases, the actual number of photographed species might be higher.

This study describes subcategories for man-made and biological elements photographed within the sanctuary and presents the classification results for each subcategory.

3.2.2. Man-Made Subcategory

1. Buildings: This study analyzed 55 photographs depicting three man-made structures with accessible interiors: the visitor center, the traditional rustic-style rest house, and the car park toilet. The locations of these buildings serve distinct purposes for visitors. The visitor center and rest house are situated in the front yard, one in the middle and one at the end. The car park toilet lies at the beginning of the front yard, convenient for arriving visitors who primarily access the sanctuary by car. A well-maintained forest track leads visitors to the visitor center within a 10-min walk from the car park. Those venturing

deeper into the forest reach the rest house after a similar 10-min trek along designated trails. Beyond the rest house, maintenance of the forest zone becomes less frequent and the environment seems more like wilderness.

2. Symbolic structures: The analysis revealed 48 symbolic structures, including small buildings and objects symbolizing recreational sites. These symbols were categorized into two groups: those representing a modern connection with nature since the establishment of the sanctuary and those representing a traditional perspective on nature linked to rural community beliefs. For instance, some visitors took pictures of a statue of an owl, a symbolic species in rural landscapes of Japan, sitting at the visitor center entrance. Additionally, some took photographs of the Ushiku Nature Sanctuary plaque at the main gate. Others photographed a shrine and an object of worship in the forest.

3. Trail signs: The analysis identified 128 trail signs along the trails, serving either as facility use instructions or interpretive displays. These signs offered a variety of informational content, including area maps, natural history details, and data about wildlife-watching. Additionally, the study documented the location of these signs throughout the sanctuary, from the front entrance to the backcountry trails.

4 and 7. Amenities: A total of 140 images were classified, with 55 categorized as outdoor amenities and 85 classified as indoor amenities. This classification system denotes the functionality of these elements as visitor comfort facilities. Among the outdoor amenities, resting areas featuring benches and shade structures were most prevalent. Bird hides specifically designed for birdwatching were also documented. Notably, visitors photographed trail signs at various locations throughout the park, encompassing the front yard and backcountry.

5. Aquarium: The aquarium exhibits are also part of the environmental education facilities in the visitor center, with 31 photos. These entries are photographs of the aquarium exhibits as a whole, and photos of individual creatures on display are included in the bioclassification, which will be described in subsequent text. The goal of the manager was to create an aesthetically pleasing display by combining local wood cabinets and stylish state-of-the-art aquarium equipment while introducing native species into the aquariums. Visitors evaluated the aesthetics of the manager based on their photographic contributions.

6. Wooden toys: Wooden toys are part of the equipment organized as an educational facility for parents and children in the visitor center, from which 127 photos were posted. In this sanctuary, only the wooden toy area is fee-based.

The literature review revealed that wooden toys and aquarium exhibits were new ventures that began in the 2010s. Managers positioned these programs as interpretive projects intended to communicate with visitors about the local natural environment in an accessible manner and enable easy access to local natural and timber resources.

3.2.3. Bio Subcategory

Finally, bio focuses on photographs of living things with sufficient detail for taxonomic identification. This category included a total of 365 images, with 288 captured outdoors and 77 captured indoors. The biological classification system informed the development of five subcategories for flora and six for fauna. Among the 269 flora photos were images of arbors, shrubs, herbaceous plants, other plants, and indoor plants. The fauna category comprises 96 photos representing insects, shellfish, amphibians, reptiles, fishes, birds, and mammals.

9. Arbors: The arbors subcategory consisted of 63 photos. Specifically, Japanese oak, Japanese cedar, and cherry blossoms fall under this category. Cherry blossom, which has reached 50 photographs, is a blooming arbor that traditionally symbolizes spring in Japan. These blooming structures line the front yard of the sanctuary. The other arbors are native species commonly found in this area.

10. Shrubs: The shrub subcategory identified 149 photos, including the Japanese spindle tree, Japanese beautyberry, and Japanese plum. Notably, the Japanese plum, known for its early spring blooms and serving as a symbol of agricultural landscapes of Japan, is documented in 102 photographs. The Ushiku Nature Sanctuary itself features a dedicated

zone designed as a plum garden. Other shrubs within this category represent native species traditionally associated with rural landscapes. While some of these native species may have been introduced as part of the cultivated garden area, they remain typical inclusions in traditional Japanese gardens [62,63].

11. Herbaceous plants: The herbaceous plant subcategory documented 47 photographs representing more than 30 native plant species, including golden orchids, Japanese kerria, and silver grass. The analysis also documented two non-native species that have recently become invasive in the area. Analysis revealed that a majority of the images captured the specimens during their flowering stage.

12. Other plants and 13. Indoor plants: The other plants subcategory consist of four bryophyte specimens. A separate category was created for six photographs featuring indoor plants, including ferns and other aquarium flora. This distinction acknowledges their unique display purpose in the visitor center, despite potential overlap with the previously mentioned flora classification.

14 and 17. Insects: The insects subcategory included 13 photographs captured outdoors. Analysis revealed three recurring opportunities for visitors to observe walking sticks, while encounters with other outdoor insects appeared less frequent. Butterfly submissions documented four species, including the Chinese windmill and red ring skirt. Additionally, four indoor photographs depicted native species displayed in aquarium exhibits, alongside hornet specimens.

18. Shellfishes: The shellfish subcategory consisted of five native species exhibited in the aquarium exhibits. The Invasive Alien Species Act of Japan regulates the breeding and movement of red swamp crawfish; however, these creatures are essential for explaining the waterside landscapes in the country. The nature aquariums frequently use other species of shellfish, but they are also common (and were previously common) in aquatic ecosystems in this region.

15 and 19. Amphibians: The amphibians subcategory consisted of 21 photos, of which four were from frogs observed outdoors. The other 17 photos were of the Japanese common toad and newt, displayed in an indoor aquarium. The toad (seven photos) is famous as the main character of fairy tales in the region but is endangered in this region [64]. The Japanese common newt is famous as a pet and water feature in rural landscapes. It is also a famous collector item and is listed as endangered [64].

20. Reptiles and 21. Fishes: Photos of 21 reptiles and 22 fishes are displayed in the aquarium, all of which have historically inhabited the region. These species were likely chosen due to their prevalence in traditional Japanese rural landscapes (native turtles and catfish) and their connection to the area's food culture (eel). Some of these species are currently listed as locally threatened and difficult to encounter in the wild [64].

16 and 22. Birds and mammals: The birds and mammals subcategory included 14 photographs. Two indoor photos depicted specimens of raccoon dogs, traditionally symbolic of the rural forest landscape. The remaining 12 field images captured live birds. Analysis revealed the use of telephoto lenses to achieve adequate magnification in these bird photographs. It is important to note that owls, a symbolic species for this site, can be observed with ranger guidance when their young leave their nest, eliminating the need for specialized photographic equipment.

3.3. Clustering for Contributors

Table 2 shows the results of the clustering for contributors. The analysis investigated behavioral changes between first-time check-in and those returning for subsequent visits (Table 3). Contributor data and submitted photos were categorized based on these two visit frequencies. Results showed that 136 people contributed 707 photos during their first check-in. In comparison, only 31 contributors submitted 359 photos on their second or subsequent visits.

Table 2. Clustering of contributors based on the total number of photos and scores of activities as users of Google Maps.

Cluster Name	**LL**	**LS**	**SL**	**SS**
Interpretation of cluster members	Contributors who post many photos in the Ushiku Nature Sanctuary and frequently post in different locations on Google Maps.	Contributors who post many photos in the Ushiku Nature Sanctuary but rarely post on Google Maps.	Contributors who post a few photos in the Ushiku Nature Sanctuary but frequently post in different locations on Google Maps.	Contributors who post a few photos in the Ushiku Nature Sanctuary and rarely post on Google Maps.
Number of contributors classified in the cluster	21	24	13	78
Total number of photos in the cluster	584	259	43	180
Number of photos posted per person	27.8	10.8	3.31	2.31
Number of check-ins per person	2.05	1.71	1.15	1.17
Google Maps posting performance per person	68,963	3472	22,893	2105

Table 3. Changes in behavior between the first check-in and the second and subsequent check-ins for each cluster.

Cluster Name	**LL**		**LS**		**SL**		**SS**		**Total**	
Number of check-ins	First time	Second and subsequent times	First time	Second and subsequent times	First time	Second and subsequent times	First time	Second and subsequent times	First time	Second and subsequent times
Number of contributors	21	10	24	9	13	2	78	10	136	31
Total number of photos	310	274	194	65	41	2	162	18	707	359

Cluster LL emerged as the group with the highest photo count (584 photos, representing 54.8% of the total), which represents contributors who posted many photos in the Ushiku Nature Sanctuary and frequently posted in different locations on Google Maps. However, this cluster comprised only 21 individuals (15.4% of all contributors). Notably, contributors in cluster LL boasted the highest average number of photos submitted to the Ushiku Nature Sanctuary per person (27.8 photos) compared to the other clusters. Additionally, they displayed the highest average number of visits to the sanctuary (2.05 times) and the highest average Google Maps posting performance (68,963 points).

Analysis revealed cluster LL as the group with the most consistent photo submissions. Ten out of twenty-one contributors (47.6%) from this cluster returned for a second visit and submitted photographs. Interestingly, despite only half the cluster returning, those who did remained active participants, with photo contributions continuing across their subsequent visits. The number of photos submitted by this group ranged from 310 during the first check-in to 274 photos during later visits. Cluster LL also boasted five particularly enthusiastic contributors who made three or more return visits. One especially dedicated visitor made seven visits and contributed 24 photos.

Cluster LS ranked second in terms of photo contributions, with 259 photos constituting 24.3% of the total. These contributors primarily focused their photography efforts within the Ushiku Nature Sanctuary, rarely posting photos on Google Maps outside the sanctuary. However, this group comprised only 24 individuals (17.6% of all contributors). Interestingly, contributors from clusters LL and LS, totaling 45 individuals (33.1%), were responsible for a significant portion of the photos (843 photos, or 79.1% of the total). While LS contributed the second-highest number of photos per person to the Ushiku Nature Sanctuary

(10.8 photos), their average visit frequency remained 1.71 times. Notably, their total Google Maps contributions were lower (3472 points).

Cluster LS ranked second in frequency, with 37.5% of its contributors (9 out of 24) visiting the Ushiku Nature Sanctuary a second time. Notably, contributors from both LL and LS clusters collectively made 61.3% (19 out of 31) of the continuous visits to the sanctuary. These contributors were also responsible for a significant portion of the photos (94.4%, or 339 out of 359 photos). Within cluster LS, one contributor made six visits and captured 34 photos.

Cluster SL achieved the second-highest Google Maps posting performance (22,893 points). Contributors in this cluster primarily posted photos on Google Maps in various locations, but their contributions within the Ushiku Nature Sanctuary itself were minimal. Notably, this cluster comprised the fewest individuals (13 people, or 9.6% of all contributors) and the lowest photo count (43 photos, representing 4.0% of the total). On average, each contributor within SL submitted a relatively low number of photos (3.31 photos) to the Ushiku Nature Sanctuary, with an average visit frequency of nearly once (1.15 times). Cluster SS comprised the largest group of contributors (78 people, representing 57.4% of all contributors). These contributors primarily focused on posting to the Ushiku Nature Sanctuary. While this cluster boasted the highest number of individuals, their photo contributions were minimal, totaling 180 images (or 16.9% of the total). On average, each contributor within SS submitted the fewest photos (2.31 photos) to the Ushiku Nature Sanctuary and had limited visit opportunities (averaging 1.17 times). Furthermore, their Google Maps contributions were the lowest among all clusters (2105 points).

Contributors from clusters SL and SS collectively posted 20 photos after the second visit, with a total of 12 individuals participating. This translates to 38.7% of contributors returning for a second visit. However, photos from these clusters represent only 5.6% of the images captured during or after the second visit. One visitor within cluster SS made three visits but captured only one or two photos per visit.

A significant disparity emerges when comparing the Google Maps activity between clusters LL and SS. According to the Google Local Guide Help Center, if these points were solely earned through photo contributions, each LL contributor (average of 68,963 points) would have posted an estimated 13,793 photos. Alternatively, using the average score of 2105 points from cluster SS as a conversion factor, this translates to an estimated 421 photos per LL contributor.

3.4. Analysis of Changes in Recreational Use with Repeated Visits

Man-made: Analysis of man-made subjects submitted during the first check-in revealed a trend of unbiased contributions across most clusters, with the exception of cluster SL (Figure 6a). Within each cluster, fewer than half the participants contributed photos to any particular artifact category. Additionally, for most clusters other than SL, initial submissions of artifact photographs constituted a larger proportion of the total photos submitted compared to landscape and biological classifications (Figure 7a). Furthermore, clusters LL and SL diverged from LS and SS in their initial preferences for outdoor and indoor recreational features. LL and SL prioritized outdoor elements such as symbols, trail signs, and rest amenities in their first contributions, as evidenced by a higher percentage of submissions and photos in these categories (Figures 6a and 7a). Conversely, LS and SS exhibited greater initial interest in indoor facilities like rest amenities in the visitor center, aquarium displays, and wooden toys (Figures 6a and 7a).

Analysis revealed a shift in preferences for certain artifact classifications among repeat visitors compared to their first check-in (Figure 6b). LL repeaters who heavily relied on Google Maps, for example, placed a greater value on photographing small outdoor symbols and signs along backcountry trails (Figures 6b and 7b).

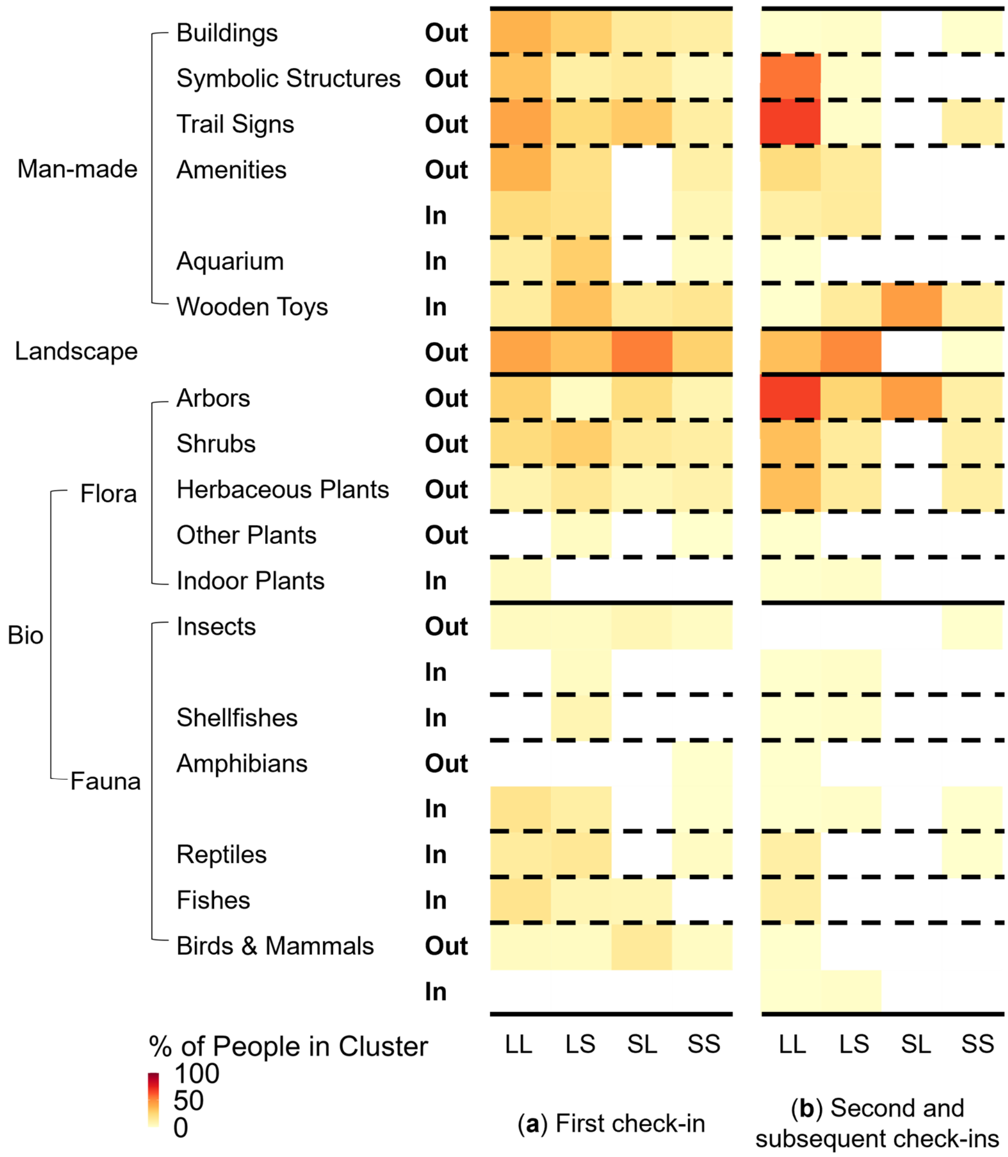
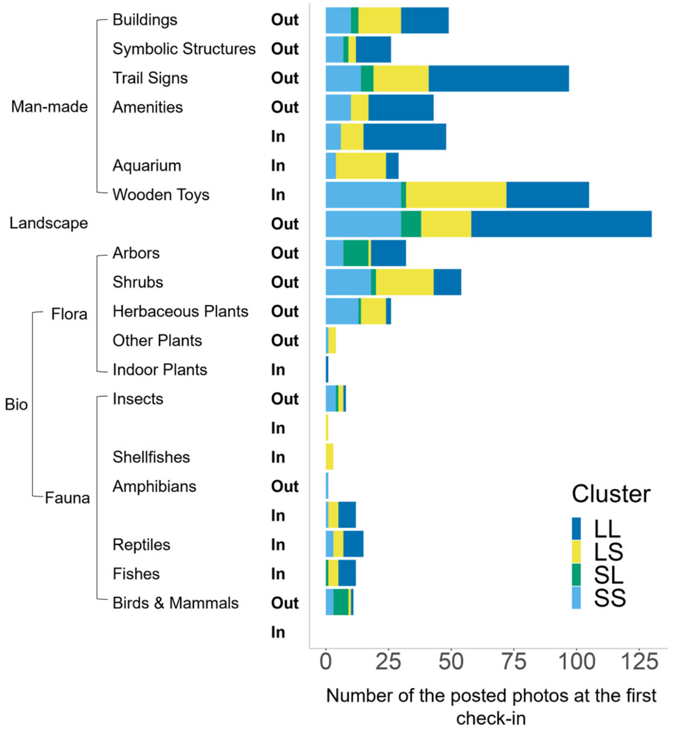


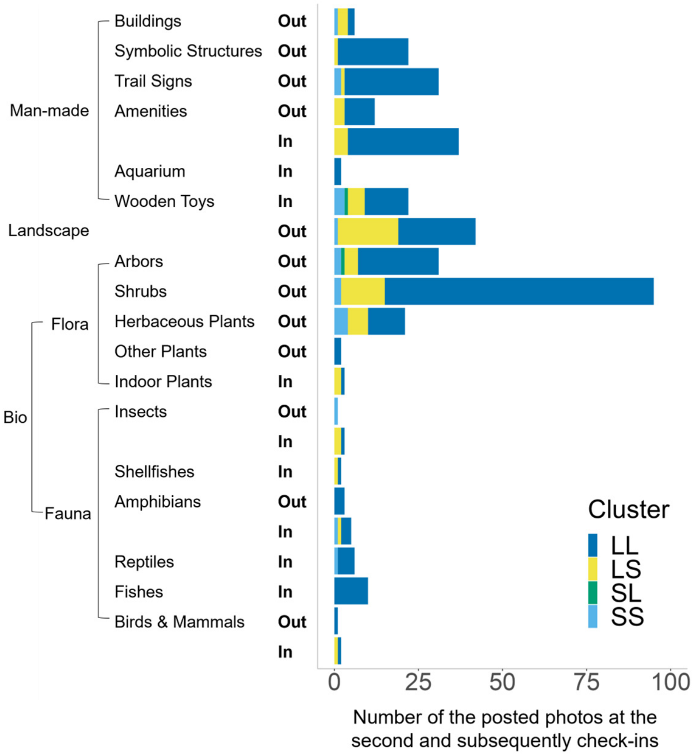
Figure 6. This figure depicts a breakdown of the number of contributors in each cluster and the main subjects. In (**a**), a contributor posted photos on Google Maps to share their recreational use in the Ushiku Nature Sanctuary at the first check-in. (**b**) shows when a contributor posted photos at the second and subsequent check-ins. The heat map displays the number of contributors who posted photos of each main subject/cluster. The more people posted photos of the main subject/cluster, the darker the red, and if the post was posted only by a certain number of people, then the lighter the red. In or Out indicates whether the photos were related to indoor or outdoor activities. Lines indicate main category or classification boundaries; dashed lines indicate subcategory boundaries.

Landscape: Landscape photographs emerged as a common subject across all clusters during the first and subsequent contributions check-in. Notably, clusters LL and SL placed greater emphasis on scenic landscape photos compared to LS and SS, as evidenced by a higher percentage of submissions and photos in this category (Figures 6a and 7a).

Bio: Analysis of initial biological photo submissions revealed variations in outdoor and indoor subject preferences between clusters (Figure 6a). LS and SS contributors showed a greater inclination towards photographing indoor displays during their first visit compared to LL and SL. Interestingly, despite having a lower overall contribution rate (both in participants and photos submitted), cluster SL exhibited a relative preference for capturing wild insects and birds in their initial submissions (Figures 6a and 7a).



(**a**)



(**b**)

Figure 7. Distribution of the number of photos posted by the main subjects, including the distribution of each cluster. In (**a**), a contributor posted photos on Google Maps to share their recreational use in the Ushiku Nature Sanctuary at the first check-in. (**b**) shows when a contributor posted photos at the second and subsequent check-ins. In or Out indicates whether the photos were related to indoor or outdoor activities.

Analysis of biological photo submissions revealed a shift in emphasis among repeat visitors, with an increased focus on plant watching compared to animals (Figure 5). While the difference in the total number of biological photos remained modest (180 photos for the first check-in and 185 photos for subsequent visits), there was a significant change in subject matter (Figures 5–7). Notably, the biological subjects documented during the first check-in displayed greater uniformity (Figure 6a). Repeat contributors from clusters LL and LS, particularly those from LL, focused on photographing and sharing seasonal plants found in consistent locations (Figure 6b). Subsequent submissions from LL were particularly characterized by an emphasis on plants, particularly shrubs (Figures 6b and 7b). These repeated contributors continued to document and share plant species, signifying the arrival of spring, such as cherry blossoms, Japanese plums, and Japanese kerria. This trend suggests that repeated contributors to Google Maps and the Ushiku Nature Sanctuary may function as seasonal ecological observers.

4. Discussion

4.1. Innovative Use of Social Media Platform for Contributive Science

This study is one of the few to discuss the relationship between people's recreational use of nature and its applicability to contributory science, drawing on social media data collected over a limited space [35,40,65], potentially valuable for forest management and conservation. These results contribute to the recruitment of citizen scientists and the collection of biodiversity information at small spatial scales previously unattainable by citizen science. The novel finding of this study identifies different behavioral styles across clusters of visitors concerning their posting behavior and associated forest recreation types. The strength of this study lies in its innovative use of social media data, which provides a rich and diverse source of information that is not typically available in traditional surveys. Through Google Maps, a platform allowing people around the world to share their immediate recreational use of nature where they live, as a data source, we access communities that have historically been excluded from science, opening up a future that links citizen science with broader efforts toward diversity, equity, inclusion, and justice [35,47].

4.2. Recreational Uses Estimated from Small-Scale Location-Explicit Cloud Platforms

We estimated that recent location-explicit cloud platforms have sufficient data to observe human–ecosystem interactions at a local scale because we obtained >1000 photos showing these interactions posted to a single social media brand in a local public recreational forest of only 21 ha. Herein, we inferred the diversity of forest recreational use in the study area due to well-managed forest recreational areas concerning several shared experiences of nature. Moreover, we found that the level of contributions to social media was associated with the posted preference for nature recreational use, such as landscapes, artifacts, and living things that visitors encountered and photographed. Active contributors to the Ushiku Nature Sanctuary (LL and LS) may mention helpful information for other visitors in their initial contributions. They exhibited their recreational use in the sanctuary by posting photos of specific subjects. In addition, those who made positive contributions to social media (LL and SL) could be "geeks" and experts, who consistently reported their natural recreational use. For example, those who extensively used Google Maps (LL and SL) mostly posted photos of more specialized objects they encountered by going deeper into the Ushiku Nature Sanctuary than light users. Specifically, they individually post photos visitors have limited opportunities to encounter, such as backcountry trail signs, landscapes, and birds.

4.3. Considerations for Recruiting Contributors and Using Data from Social Media

This study suggests a practical method for recruiting social media users to participate in citizen science. Similar to previous studies [40,66–68], we propose considering the number of visits by contributors to a particular site to reveal human–ecosystem interactions without creating over- or under-reporting. These results revealed that the destinations of the contributions selected from the natural recreational use of visitors changed substantially between their first and subsequent visits. In particular, repeat visitors to the Ushiku Nature Sanctuary, who used Google Maps extensively, began to report encounters with organisms expected at a particular location or time of year. Reports of budding vegetation and spring flowers were typical contributions. We also observed that lightly contributional Google Maps users valued the indoor experiences managers began in the 2010s, including the aquarium exhibit and wooden toys. They may have been attracted to these indoor experiences, created to attract new visitors, because they were novice outdoor users who needed to experience nature. The importance of nature education in addressing the extinction of nature experiences has been noted [2], providing an essential perspective for promoting interpretation in areas of forest recreation. High-quality indoor experiences can encourage people not interested in experiencing nature to visit places where nature experiences are available, such as beautiful, easy-to-understand displays of native species or woodland experiences for parents and children. In addition, increasing the quantity of data used to understand human–ecosystem interactions by attracting visitors and encouraging them to visit more often and post on social media is possible [48,68–70]. However, we must consider the possibility that photographers report negative and positive aspects of their recreational use of nature [35,40,71]. Nevertheless, the nature of social media implies that engaging posts will attract new visitors and posts. This cycle can lead to a virtuous circle of increased data quality, quantity, and public interest. Researchers should help create communities and develop policies for the active use of social media to increase the number of visitors and data providers interested in the natural environment [47].

These results suggest that scientists should know the type and amount of contributions hoped for when recruiting participants from social media to scientific programs [28,51]. These findings indicate that extensive Google Maps users and contributors to the Ushiku Nature Sanctuary are excellent seasonal biological observers, who repeatedly provide large amounts of data. For example, suppose that researchers are planning a citizen science project to detect changes in plant phenology associated with global warming [26]. In this case, Google Maps is an ideal resource because it constitutes a direct source of biological information and a target for recruiting active citizen scientists.

However, this approach allowed us to observe a few rarely sighted iconic and charismatic species, such as birds and insects, frequently expected in citizen science [21,32,34,72]. Contributors to Google Maps may differ from Flickr users, whereas photo-sharing social media sites often focus on symbolic and iconic birds observed in natural urban environments [21,38,46,68]. Previous research has found that the generation of cultural ecosystem benefits is a product of an encounter between a unique user and a specific living thing at a particular time [46]. Because human–animal encounters differ from human–plant encounters, in that in the former, the coordinates of two moving individuals coincide, previous studies have found that contributors tend to post plants that are easier to photograph near their residence [38]. Because humans and animals pass each other, the probability of their encounters is very low. For example, it can be compared to molecular collision models, which have been applied to models of wildlife–vehicle collisions, showing that there are far more near misses than the observed coincidence of coordinates (occurrence of roadkill) [73]. In addition to the low probability of a collision, social media data add additional selectivity: whether a camera can capture the creature (the same issues pointed out in citizen science, using hunting data [74]) or a photo was posted to an open hosting site [67]. Consequently, these small sample of wild birds and insects is valuable. Researchers should actively encourage the use of field animal photographs for biodiversity data, even though few people consume small amounts [17,34,47,75]. Herein, we focus on photographing the animals exhibited by the heavy contributors to the Ushiku Nature Sanctuary. These contributors valued photographs of animals and shared them globally. Targeting them with activities such as lectures on biological detection methods and publicizing the benefits of sharing for biodiversity conservation, we can rapidly increase the number of citizen science participants and data accumulation.

5. Conclusions

This study provides valuable insights into human–ecosystem interactions and their relevance to citizen science by analyzing data on visitor behavior in one forest recreational area obtained from a widely used social media platform. These findings indicate that recent location-explicit cloud platforms, comprising a significant number of data contributors, possess the requisite data to observe human–ecosystem interactions at a local scale. We also proposed practical strategies for promoting citizen science that targets social media users by examining the behavioral histories of contributors who posted biodiversity information. Notably, despite the chaotic nature of information on the Internet, our examination of the management context related to posts and identification of the behavior of specific visitors provides a comprehensive understanding of forest recreational use and related activities and demonstrates the potential of social media data to further elucidate visitor behavior.

A limitation of this study is its dependence on publicly available social media data, which may partially represent the diversity of visitor recreational use and behaviors [38,40,41,47,67]. Actual visits may not match those posted on Google Maps. In retrospect, the possibility exists that contributions may no longer be visible due to the deletion of Google accounts, such that we cannot obtain a consistent total number of contributions and photos. In addition, the generalizability of the findings may be limited because this study focused on only one forest recreation area and one social media platform. For example, extensive users of Google Maps may seek out and photograph numerous natural conservation sites, including the Ushiku Nature Sanctuary, and share their posts on the same social media platforms. These data may be biased, as researchers have mentioned concerning social media data and users when evaluating human–ecosystem interactions [47–49]. However, understanding the nature of their contributions and comparing them to other contributors could provide the information required for citizen science and identify accessible contributors at a lower cost.

Future studies should be conducted to elucidate participants' posting behavior to those found in other locations to determine how their relationship with nature changes as a result of visiting forests, and how their usual preferred objects change in forests. In this case, we may gain insights into optimizing the contributing behavior of specialized people. Our findings can inform political and conservative strategies for engaging visitors to promote citizen science. Finally, the accumulation of research using social media data on recreational areas in which individuals engage with nature, with consideration of the contextual factors specific to each site, could serve as a reference for promoting citizen science and advancing a Nature Positive society.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16135804/s1, Figure S1: Visitor facilities along the trails and photo examples; Table S1: List of contributors; Table S2: List of photos.

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