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Geocaching in Austrian National Parks

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Abstract

Geocaching started in the year 2000 as a leisure activity in which the recreationists try to find containers (so-called *geocaches*) based on coordinates. Since geocaches are often hidden off-trail in natural surroundings, protected areas might be affected. This paper analyses the situation in Austrian national parks and discusses possible effects on conservation goals. The study is based on online- and GIS-based analyses. To assess environmental impact and disturbance, the following indicators were used: types of hiding places, surrounding area, frequency of finds, and distances between the hiding places and the nearest trails. The results show that geocaching takes place in all six Austrian national parks, but to different extents; that caches are most commonly hidden in natural environments; that the frequency of finds differs significantly between the various parks, and that parks closer to urban areas tend to be used more for geocaching.

Introduction

Geocaching resembles an outdoor orienteering race or scavenger hunt. The information required to find a cache, based on GPS-data, is uploaded to geocaching websites by the person who has hidden the cache. The most popular countries for this outdoor recreation activity are the USA, Germany, and Canada. But Austria also belongs to the top ten countries worldwide for the number of active geocaches (Groundspeak Inc. 2013).

Geocaching started in 2000 when the website *geocaching.com* was created explicitly for the activity. In addition to other major websites such as *opencaching.de* and *navicache.com*, there are also numerous smaller websites and databases dedicated to geocaching.

Specific rules and guidelines were created for geocachers concerning access to the land and possible conflicts (Groundspeak Inc. 2011, 2016), including:

- Cache owners need to have the landowner's and / or manager's permission before hiding a cache on private or public property.
- Geocaches should not be buried in the ground and their placement must not damage the surrounding environment.
- Geocaches in sensitive areas might be disabled during certain times of the year.
- Landowners or managers can report unwanted caches in order to have them temporarily disabled or permanently archived.
- Park officials can apply for a free Premium Membership to better monitor caches.
- The cache contents must be appropriate for outdoor life. Food and scented items which might attract animals are forbidden.

Even though there is a review process for new caches that checks them against the existing guidelines (Groundspeak Inc. n.d. a), the reviewers typically do not visit physical cache locations or require proof of the landowner's permission. Given the ongoing popularity of geocaching, park managers and outdoor recreation researchers discuss the possible impact of, and ways for regulating, geocaching, especially in protected areas (Reams & West 2008; Brost & Quinn 2011; Parks Canada 2017; Florida State Parks n.d.; State of California n.d.).

Although walking off-trail is not forbidden by law in the whole territory of every Austrian national park (NP) (Stock 2013), visitors are generally asked to stay on the designated trails to reduce possible disturbance to wildlife and the natural environment and to ensure visitor safety, e.g. in mountainous regions. Contacting park officials in late 2012 / early 2013 by e-mail revealed various opinions when it comes to managing geocaching in Austria. For example, Donau-Auen NP started to remove some geocaches in the summer of 2012. However, the park does not yet have a clear policy about geocaching, since it is hard to judge the pros and cons of this relatively new leisure activity. Gesäuse NP follows a different approach by itself offering geocaches as well as introductory geocaching-courses for visitors. Neusiedler See-Seewinkel NP is, according to one of its officials, largely unaffected by geocaching, since walking off-trail is not considered an issue due to strict rules and a rather limited path network, mainly consisting of public roads.

Against this background, this paper aims to evaluate the significance of geocaching in Austria's national parks (Figure 1), and to discuss whether the activity requires specific management actions.

Background

Terminology of geocaches

Since its start in the USA in 2000, geocaching has evolved into a multifaceted leisure activity with a complex terminology and different cache types. Table 1 presents the most common types and their characteristics (for a full list of existing geocache types see *geocaching.com*).

The difficulty and accessibility of each cache are independently rated using a 5-star scale (Table 2).

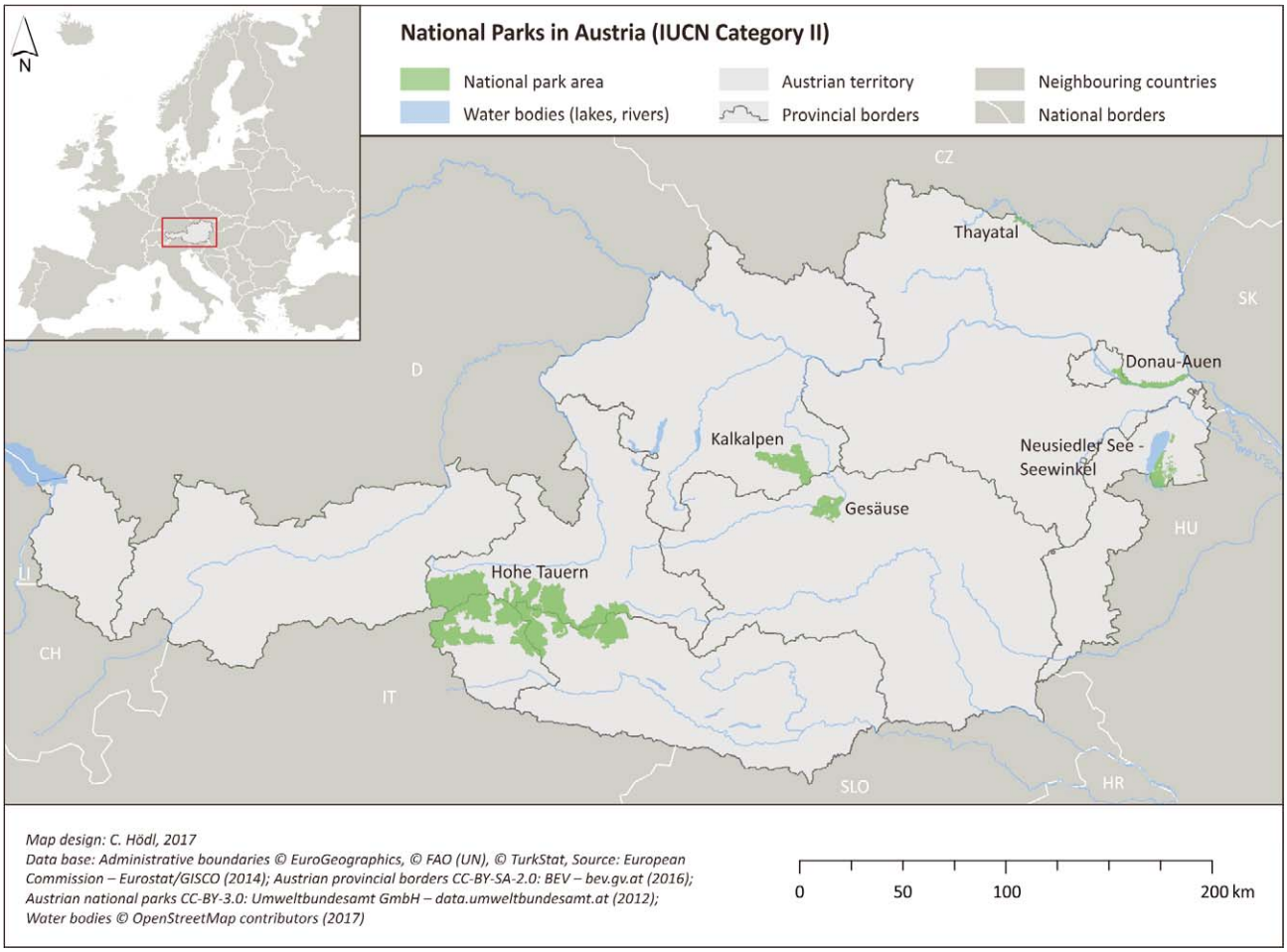

Figure 1 – Location of the national parks in Austria. Data source: Umweltbundesamt GmbH 2012; European Commission – EUROSTAT/GISCO 2014; BEV 2016; OpenStreetMap 2017

State of knowledge

Current research mainly focuses on the following fields:

- participation in geocaching (demographics, motivations, general behaviour and sociocultural dimensions) (O'Hara 2008; Gram-Hansen 2009; Schütze 2010; Schneider et al. 2011; Teelar et al. 2014);
- opportunities for environmental education (Hartl et al. 2006; Zecha 2012);
- stimulation of tourism development (Schütze 2010; Laufer 2013);
- use of the land by geocachers and legal aspects (Louis et al. 2011a, 2011b; Weber & Haug 2012);
- geographical context of geocaching (Santos et al. 2012; Nogueira Mendes et al. 2013);
- environmental impacts and disturbances (Patubo 2010; Brost & Quinn 2011).

Patubo (2010) highlights the likelihood of affecting sensitive habitats and protected areas. In addition, he assumes that geocaching attracts visitor groups who are not familiar with the required behaviour in sensi-

Table 1 – Terminology for the types of caches appearing in this paper.

Type of cache	Definitions and requirements
Traditional cache	Original and most common type; coordinates are provided on website.
Mystery cache	Given coordinates are deliberately approximate; actual hiding places are generally within 3 km of them (Temper 2011); finding the accurate coordinates of the hiding places requires solving a puzzle.
Multi cache	Given coordinates mark the starting point; one or more stages have to be visited to gain information necessary to find the cache; stages can be physical (e. g. hidden containers) or virtual (e. g. answering questions about surroundings).
Earth cache	Deals with earth science and geological processes; no physical container; certain tasks have to be fulfilled to log the cache (e. g. answering geological questions, measuring or estimating the size of a geological feature etc.).
Virtual cache	No physical container; certain tasks have to be fulfilled to log the cache (e. g. answering questions related to the surroundings); no new caches of this type are published on *geocaching.com* but old ones can still be found.
Event cache	Cache type marking a meeting of geocachers at given coordinates on a particular date; themes, organizational effort required, and number of participants vary.

Table 2 – Cache ratings for difficulty and terrain (based on definitions suggested by Groundspeak Inc. n.d. b).

Rating	Difficulty		Terrain	
1	Increasing mental effort ↓	**Easy**, can be found or solved within a **few minutes**	Increasing physical effort ↓	**Wheelchair accessible**, most likely flat and paved terrain, requires a very short walk (< 0.8 km)
1.5		**Easy**, can be found or solved within **10–15 minutes**		Most likely **flat terrain** but not necessarily wheelchair accessible, requires a very short walk (< 0.8km)
2		**Relatively easy**, can be found or solved within **30 minutes**		**No steep elevation changes or heavy overgrowth**, requires a short walk (< 3km) along well-defined paths
2.5		A **mild challenge**, but relatively easy for an experienced geocacher		**Small elevation changes or moderate overgrowth**
3		A **somewhat challenging** puzzle or hiding spot		**Varied terrain**, not suitable for riding bikes due to elevation changes or significant overgrowth, longer and more demanding hikes are possible (> 3 km)
3.5		**Quite difficult**, poses a mental challenge		**Widely varied terrain**, quite strenuous, extended hike
4		**Very difficult**, may take special knowledge, advanced preparation or multiple trips		**Very strenuous physically**; may include significant distance, overgrowth, swimming, or elevation changes
4.5		**Extremely difficult**, most likely requires special knowledge or skills		**Extremely demanding physically**, potentially hazardous terrain
5		**Extreme**, serious mental challenge, may require special skills to solve, find or open the geocache		**Requires specialized equipment**, e. g. scuba gear, a boat, or rock climbing gear

tive environments and increases the risk of introducing invasive species or pathogens. Also, walking off-trail while geocaching may lead to a deterioration of the vegetation (trampling of plants), soil compaction, reduced rate of water infiltration, and erosion (Hammit & Cole 1998). Further impacts by trampling have been described, for example, by Cole (1995) and Leung & Marion (2000).

Brost & Quinn (2011) have investigated visible impacts of geocaching in 21 Minnesota State Parks. In 2006, Minnesota park authorities began to allow the placing of geocaches by private individuals, provided an approval process was successfully completed beforehand. Despite these attempts at regulation, impacts of geocaching started to be observed in 2008, including soil erosion, trampling of vegetation, exposure of bare soil, and damage to woody vegetation. Examining 117 geocaching sites, Brost & Quinn found an area of impact of about 3.65 m² per site. Another finding by them is that impacts to natural surfaces started to occur after about 55 visits per year.

Currently, no empirical studies concerning the effects of geocaching on wildlife exist. Transferring results from other outdoor recreation studies, it must be expected that geocaching activities can potentially cause deterioration of wildlife habitats and may even have effects on a population level as a result of ongoing disturbance (Georgii 2001; Reichholf 2001; Hüppop 2005; Ingold 2005; Guthörl 2006; Ulbricht & Roth 2006).

Methods

Defining relevant geocaches and terminology

Geocaches were identified by using the website *ajgps.net*, which shows every active cache in Austria that is listed on *geocaching.com*, *opencaching.de* or *navicache.com*.

Characteristics such as type of cache, terrain, difficulty and hiding date were gained from the cache descriptions. By analysing so-called *spoilers*, usually photos or encrypted hints, details about the various hiding places were gathered. These clues were given either by the owners themselves in the cache listing or by geocachers in their log-entries.

To determine the missing coordinates of Mystery Caches that could not be solved, and of Multi Caches (combined total: 46), their owners (34 in total) were contacted via their geocaching profiles. Altogether, 17 owners replied, of whom ten provided the coordinates of 16 caches; four owners were only willing to give estimated distances of their caches from the nearest trails. While another three owners did reply, they did not provide any information.

Table 3 – GIS data sources.

National park	GIS data sources	
	Park boundaries	**Road and trail network**
Hohe Tauern	Hohe Tauern NP Salzburg, Province of Salzburg – SAGIS, Province of Carinthia – KAGIS	Hohe Tauern NP Tirol – tiris; Province of Carinthia – KAGIS; Province of Salzburg – SAGIS; OSM
Kalkalpen	Kalkalpen NP	Kalkalpen NP; OSM
Gesäuse	Gesäuse NP	Gesäuse NP; OSM
Donau-Auen	BMLFUW / Environmental Agency Austria (*Umweltbundesamt*)	Austrian Federal Forests (ÖBf); OSM
Neusiedler See – Seewinkel	BMLFUW / Environmental Agency Austria (*Umweltbundesamt*)	OSM
Thayatal	Thayatal NP	Thayatal NP, OSM

Table 4 – Likelihood of environmental impacts.

Assessment	Classification	Description
Category **1**	**Little/no impact**	- calculated distance to trails < 2 m - hidden at (recreational) infrastructure (e.g. buildings or similar structures, signposts, information boards, fences, benches, official climbing routes, viewing points, summits/summit crosses etc.) - information given online states that leaving the trail is not necessary to reach the coordinates - coordinates located directly on a trail (according to satellite images)
Category **2**	**Moderate likelihood of impact**	- calculated distance to trails 2–50 m - predominantly natural hiding places - natural or semi-natural surroundings (e.g. buildings and trails in further distance) - information given online states that the caches are hidden *not too far away* from existing trails - area of the hiding place can be reached by canyoning (official tours)
Category **3**	**High likelihood of impact**	- calculated distance to trails > 50 m - exclusively natural hiding places - natural surroundings - tree-climbing caches

Because of the different cache types, missing coordinates and different types of analysis performed, this paper distinguishes between *caches* and *cache-points*:

- Caches: all geocaches relevant for this study (including Event Caches, Mystery and Multi Caches with missing coordinates, and Multi Caches with at least one stage but no hiding place in the study area); used for general analysis.
- Cache-points; these include: (a) all available final coordinates (marking the actual hiding places); (b) all stages that need to be visited to log a geocache for which the coordinates were available; (c) geocaches for which no final coordinates but only estimated distances from the nearest trails were available; used for GIS-based analysis.

GIS-based analyses

To gain data that was as up-to-date data as possible concerning the park boundaries as well as the road and trail networks, members of staff at each national park were contacted directly. If the required data was not available, free alternatives from the websites *data.gv.at* and *openstreetmap.org* (OSM) were used (Table 3).

Caches placed just outside a park's boundarie might still affect flora and fauna within the park if people are searching for them in an extended area, e.g. due to poor GPS reception. Therefore, all geocaches within a buffer of 10 m around each national park were included in this study.

Information about the surrounding area was based on the online basemap *World Imagery* in ArcMap. Since some owners only provided the estimated distances from the nearest trail and no coordinates, the seven caches concerned could not be included in the analysis of the surrounding area.

Frequency of finds

The numbers of logged finds were gathered from the website on which the various caches were registered. If a cache was registered on more than one website, the entries were compared to avoid double counting. The period of recording was from 1 June to 30 November 2012, during which time the finds for each cache were observed. In addition, the mean number of finds per year was calculated, using the total number of finds since the hiding date, excluding caches that were hidden in 2012.

Assessment of environmental impacts

The assessment is based on the information about the hiding places (photos and written hints), the calculated distances from the nearest trails, and the information about the surrounding area, gained by using the online basemap *World Imagery* in ArcMap as well as satellite data in Google Maps. All cache locations and stages for which coordinates were available were assigned to one of three categories (Table 4). The assessment also considers the possible impact caused when accessing the cache. For example, having to walk a short distance off-trail to access a cache underneath a wooden walkway is classified as *moderate likelihood of impact*, though the cache is calculated as being very close to infrastructure.

Results

General cache characteristics

In total, 260 caches and 292 cache-points were included in this study (Figure 2). Twenty of the cache-points were located in the predefined 10 m buffer zone around the national park boundaries: four in the Neusiedler See NP, and eight each in the Donau-Auen and the Hohe Tauern NP.

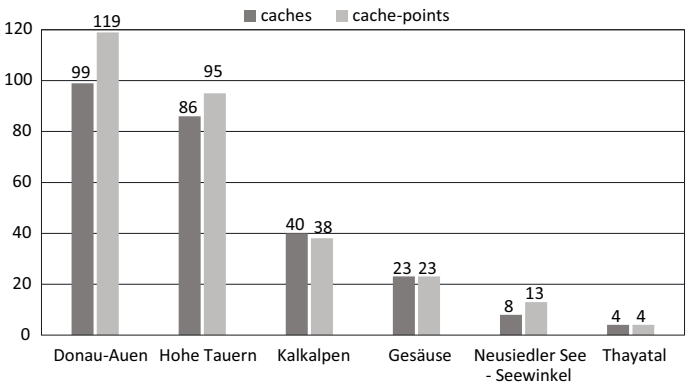

Figure 2 – Distribution of caches (N = 260) and cache-points (N = 292).

Table 5 – Numbers of logged finds.

	National Park					
	Thayatal	Neusiedler See - Seewinkel	Gesäuse	Kalkalpen	Hohe Tauern	Donau-Auen
	Numbers of finds: 1 June 2012 – 30 Nov. 2012					
max.	37	101	40	64	121	234
min.	5	0	0	0	0	0
mean	18	43.9	15.3	13.3	10.8	87.3
median	15	34.5	12	6	6	66
	Numbers of finds: Hiding date – 30 Nov. 2012					
max.	184	488	278	112	608	1222
min.	54	50	3	0	0	7
mean	107.5	222.5	70.2	32.1	35.1	408.9
median	96	202	38	23	22	229
	Finds/year: Hiding date – 30 Nov. 2012					
max.	70	150	83	66	118	679
min.	13	8	2	3	1	17
mean	35.3	72	29.6	18.4	15.1	264.9
median	29	62	13	9	8	151

Table 6 – Number of caches with 50 or more logged finds / year (N = 61).

Finds / year	National Park					
	Thayatal	Neusiedler See - Seewinkel	Gesäuse	Kalkalpen	Hohe Tauern	Donau-Auen
50–55	0	1	2	2	0	0
≥ 55	1	4	4	2	2	43

Table 7– Distances of cache-points from trails (N = 290, excluding cache-points on islands).

	National Park					
	Thayatal	Neusiedler See - Seewinkel	Gesäuse	Kalkalpen	Hohe Tauern	Donau-Auen
	Distance from trails [m]					
max.	375.8	40.5	500.3	451.0	1419.3	188.7
min.	1.5	1.6	1.4	0.8	0.2	0.0
mean	96.3	11.8	65.6	50.5	51.3	16.7
median	3.9	3.5	11.4	23.9	9.4	6.7

The caches were hidden between 2002 and 2012. The number of new caches overall increased during this period, the highest single yearly increase being in 2011. Dominant cache types are Traditional Caches (71%), followed by Multi (12%) and Mystery Caches (12%). Special educational caches (Earth Caches, 4%) are located only in Hohe Tauern NP and Neusiedler See-Seewinkel NP. Only three Virtual Caches exist, all of them in the Hohe-Tauern NP. One Event Cache, which attracted 57 participants, took place in August 2012 in the Kalkalpen NP.

For the majority of caches (78%), the difficulty rating is quite low, varying between 1 and 2 (Table 2). The terrain ratings show greater variation: 40% of all examined caches are rated between 1 and 2 and therefore are relatively easily accessible. 21% have ratings between 2.5 and 3, which means that arriving at the coordinates requires a higher level of physical effort. About 33% are rated between 3.5 and 4.5 and are therefore (very) physically demanding. The remaining

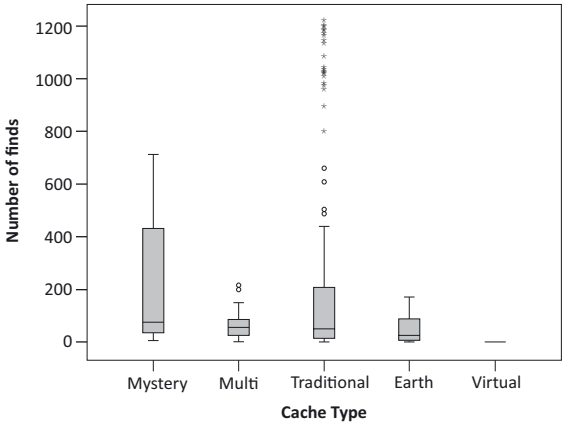

Figure 3 – Number of finds in relation to cache types (N = 259).

6% are so-called *terrain-5* caches, which are especially hard to reach.

Frequency of finds

The frequency of finds from 1 June to 30 November 2012 shows great differences between the various national parks. The Donau-Auen NP is characterized by the highest maximum, mean and median numbers of finds (Table 5).

Although the Hohe Tauern NP shows the second highest maximum count, it has the lowest mean and median numbers of finds of all Austrian national parks. This is due to several especially popular caches (e.g. close to the Krimml Waterfalls), whereas the majority are noticeably less frequented. When we look at the total number of finds that were logged between the original hiding dates of the caches and 30 November 2012, we see that the caches in the Donau-Auen NP were those found most often, followed by the ones in the Neusiedler See-Seewinkel NP. Also, the finds per year are noticeably higher in the Donau-Auen NP than in any of the other parks.

Table 6 uses the threshold of about 55 visits / year as leading to soil and vegetation damage (Brost & Quinn 2011) and shows the number of caches with 50 or more logged finds / year in each national park.

In SPSS, for caches with physical hiding places (N = 246), bivariate Kendall correlation showed a significant negative relationship between the total number of finds and the ratings for difficulty (tau-b = –0.242; $p \leq 1\%$; 2-tailed) and terrain (tau-b = –0.488; $p \leq 1\%$; 2-tailed). Amongst all examined cache types, Traditional Caches showed the highest numbers of finds (hiding date: 30 November 2012) (Figure 3). In total, there were 21 caches, all Traditional, with more than 900 finds, of which 20 had a low rating for both terrain (1.5) and difficulty (1).

Distances from trails

Table 7 shows the results of the distances from the nearest trails. Cache-points located on islands were

not included in this table, although there were only two of them: one located in Neusiedler See-Seewinkel NP (calculated distance 2375.9 m), and one in Hohe Tauern NP (calculated distance 63.5 m).

Given the sometimes small number of cache-points in the different national parks, using the median distances seems to be the best choice to make comparisons: using mean distances might lead to the wrong conclusion that caches in one national park are generally hidden farther off-trail than in another, when in reality there are only a small number of caches (or even only a single cache), hidden especially far off-trail, responsible for the calculated mean distances. The national parks with the lowest median distances are Neusiedler See-Seewinkel, Thayatal and Donau-Auen. Associating the calculated distances with the numbers of finds shows that those caches with the highest numbers of finds are located within relatively short distances from the nearest trails (Figure 4). The majority of cache-points examined (55%) are located within a distance of 0–10 m from the nearest trails.

In some cases, the distances were especially high, well in excess of 100 m (Table 8). According to information available online, these caches are predominantly located in mountainous regions or hidden at summits. In the latter cases, the calculated distances are probably the result of incomplete trail data, whereas in other cases they are a result of the hiding places themselves. For example, one cache in the Neusiedler See-Seewinkel NP is located on an island, and two caches located in the Gesäuse NP are hidden in a gorge, which can be visited during official canyoning tours.

Hiding places of physical cache-containers

The significance of environmental impacts is also influenced by the hiding places selected. While geocaches hidden at man-made infrastructure, such as signposts, are likely to cause minor impact, hiding places which are at the same time valuable habitats, such as crevices, trees and deadwood, are more likely to be of concern from a conservation perspective (Figure 5).

About 18% of the caches are hidden at artificial structures, such as signs, benches, bridges, observation platforms, buildings or summit / wayside crosses. Hiding places of higher environmental sensitivity, such as deadwood, stumps, stools, knotholes and hollows in trees, are also quite common (about 17%). This also applies to living trees, where geocaches are attached to branches and stems or placed at their foot and root area (about 21%). The largest number of caches in this study were hidden in crevices or under / between large rocks (about 30%), most of them located in the Hohe Tauern NP.

Surrounding area

Most cache-points were located in or at the edge of forests and in (high-)alpine open landscapes such as *glacier / snow field*, *alpine pasture*, *mountain pine* and *rocks*. The category *strongly anthropogenically influenced* is represented by 43 cases and therefore also quite common. In total, 285 cache-points were examined and then assigned to one of eleven categories (Figure 6).

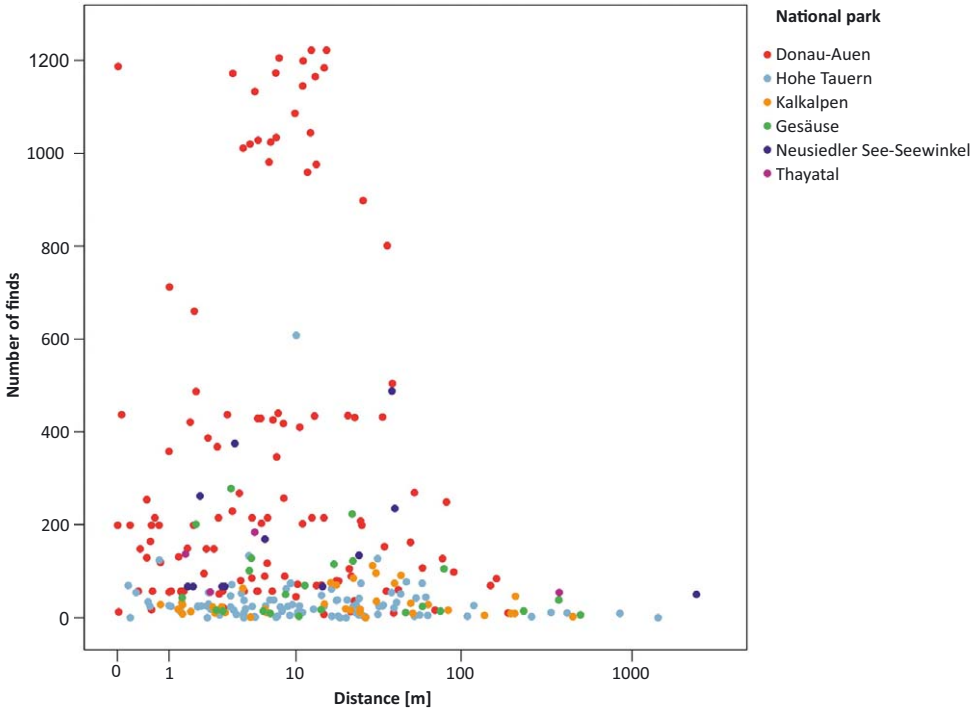

Figure 4 – Distance of cache-points from trails in relation to number of finds (N = 292).

Table 8 – Distances of cache-points from trails > 100 m.

National park	Calculated distance [m]	Nearest trail (source)	Hiding place
Hohe Tauern	418.0	trail/Arlscharte (SAGIS)	summit (Arlhöhe)
	118.8	trail/Arnoweg (SAGIS)	ruin (former Radhaus)
	336.4	path/Wasserfallerlebnisweg (OSM)	summit (Walcherhörndl)
	849.6	trail/no name (SAGIS)	summit (Tauernkogel)
	259.2	footway/no name (tiris)	x
	1419.3	trail/no name (OSM)	summit (Bauernbrachkopf)
	108.8	trail/GI718 (KAGIS)	x
Kalkalpen	137.2	forest road (national park)	official climbing route
	208.5	footway (national park)	summit (Wasserklotz)
	206.4	path/Brandlsteig (OSM)	x
	196.0	footway/no name (national park)	cave entrance (Rettenbach cave)
	451.0	path/Salzwipfelsteig (OSM)	summit (Hahnbaum)
Gesäuse	232.8	trail/Schneelochweg-Hochtor (national park)	x
	373.2	theme trail/Lettmairau (national park)	gorge (reached by canyoning)
	500.3	track/no name (OSM)	gorge (reached by canyoning)
Donau-Auen	161.3	road (Austrian Federal Forests/ÖBf)	tree
	148.9	road (Austrian Federal Forests/ÖBf)	tree
	188.7	track/no name (OSM)	x
Neusiedler See - Seewinkel	2375.9	footway/no name (OSM)	island (marking the national border)
Thayatal	375.8	forest road (national park)	popular viewpoint (Heimatkreuz)

Assessment of environmental impacts

The assessment is based on 291 cache-points, including 285 cache-points with known coordinates and 6 caches with missing final coordinates (Table 9). Thanks to posted photos, log comments or information from the owner, it was still possible to assign the caches for which final coordinates were missing to categories 1 (little/no impact: four cases), 2 (moderate likelihood of impact: one case) or 3 (high likelihood of impact: one tree-climbing cache).

Overall, the total number of cache-points which are very likely to impact wildlife and the natural environment of national parks is fairly limited. Only 17 (6%) belong to category 3 (high likelihood of impact).

Discussion

Timeliness of data and methodological approach

As stated by Nogueira Mendes et al. (2013), the number of caches available in an area can vary on a daily basis. But although the data on which this study is based was gathered in 2012, almost four years later (1 November 2016) the majority of the caches exam-

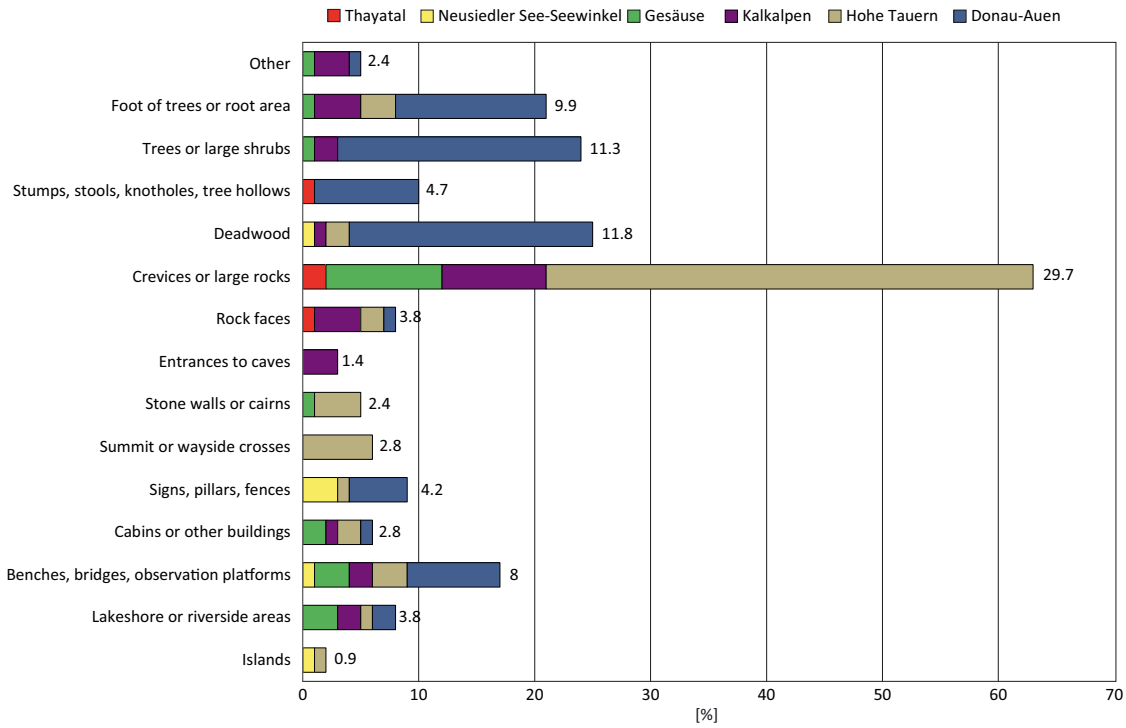

Figure 5 – Hiding places of physical cache-containers for which information was available (N = 212).

Table 9 – Distribution of cache-points to categories of ecological impact (N = 291).

Impact category	National Park						in total
	Thayatal	Neusiedler See - Seewinkel	Gesäuse	Kalkalpen	Hohe Tauern	Donau-Auen	
1 (little / no impact)	3 (75%)	13 (100%)	10 (44%)	13 (37%)	52 (54%)	55 (46%)	**146 (50%)**
2 (Moderate likelihood of impact)	1 (45%)	0	9 (39%)	16 (46%)	41 (43%)	59 (49%)	**128 (44%)**
3 (High likelihood of impact)	0	0	4 (17%)	6 (17%)	3 (3%)	6 (5%)	**17 (6%)**
Σ	**4 (100%)**	**13 (100%)**	**23 (100%)**	**35 (100%)**	**96 (100%)**	**120 (100%)**	**291 (100%)**

ined were still available: Donau-Auen NP (56%), Hohe Tauern NP (86%), Kalkalpen NP (82%), Gesäuse NP (70%), Neusiedler See – Seewinkel and Thayatal NP (100% each). Therefore, the findings can still be considered valid.

This study was based on desk research only, which is a significant limitation because the assessment does not include any fieldwork or inventory. On the other hand, given the limited amount of money required for this type of study, the findings are still helpful for park managers in deciding whether the likelihood of significant impacts is high or low.

Based on this rough overview and screening process, further investigations can be planned including both the motivation and behaviour of recreationists and a more detailed evaluation of environmental impacts. To protect wildlife, further investigations should place a special emphasis on seasonality, duration and the significance of the disturbance for various species.

Error assessment

It is important to note that the accuracy of GPS coordinates may vary due to the strength of satellite signals and type of receiver used. Our own observations showed that geocachers do state in their log entries if they consider the coordinates provided by the owner to be insufficiently accurate, as a result of which the owner will usually update them accordingly. Therefore, this error factor is considered to be of minor importance for our study.

Another possible source of error is the quality of available trail data. Originally, calculations of the distances from the nearest trails were run using data provided by officials only (national parks, state GIS services and Austrian Federal Forests / ÖBf). But since this resulted in much higher distances than some of the online cache descriptions suggested, an additional analysis was performed using data from *openstreetmap.org* (OSM). This was done to gain data about informal trails, which are not part of official records. Since OSM is a community-based open source service that is known to be used by geocachers, it was considered a good source for additional trail data.

Although these efforts did reduce the calculated distances, a few caches remain that seem to be located especially far off-trail (> 100 m), most of them in mountainous regions. It can only be assumed that neither OSM data nor trail data provided by officials was sufficiently accurate to perform this analysis in mountainous regions.

Impact on parks

Number of caches and frequency of visits

The results clearly show that we need to distinguish between parks near urban agglomerations on the one hand, such as the national parks Donau-Auen and Neusiedler See-Seewinkel, and national parks in more remote, less easily accessible areas, such as Hohe Tauern, Kalkalpen, Gesäuse and Thayatal. The finding that there is a significant negative relationship between the number of finds and the terrain rating of the geocaches examined further underlines this conclusion.

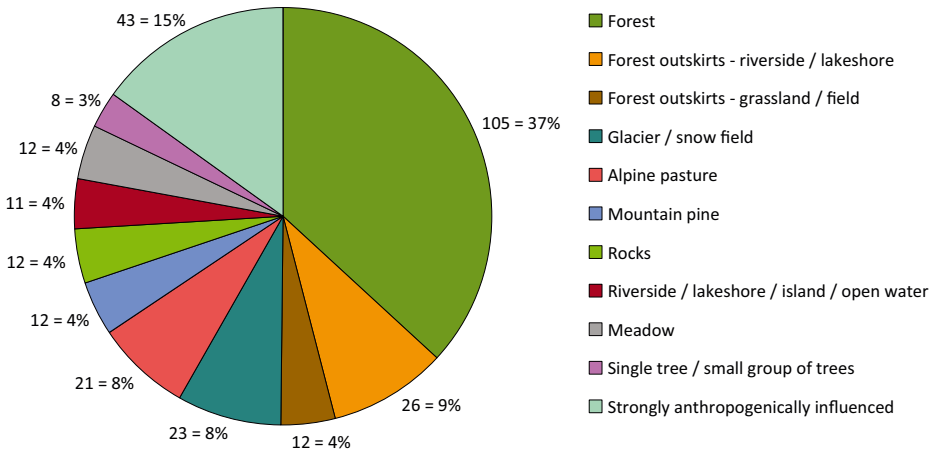

Figure 6 – Cache-points and their surrounding area categories (N = 285).

So-called *did not find* entries were not included when calculating the frequency of visits, since they often state that an actual search for the cache was not possible due to lack of time or the presence of other park visitors. Nevertheless, searching for a cache which cannot be found may lead to the same or even stronger impacts as a logged find, due to an especially intense search in an extended area. It is also very likely that not all failed attempts to find a cache are logged and reported on the internet. Therefore, the figures given online probably under-represent the frequency of visits and associated disturbances.

Types of hiding places and environmental impacts

The assumption that, due to existing geocaching guidelines as well as to guidelines for national park visitors (see Introduction), caches are mostly hidden in ecologically compatible locations, such as at buildings or other forms of recreational infrastructure, is in most parks not true. Searching for suitable deadwood, stumps, trees and rocks bears a considerable risk of causing disturbances. In all alpine national parks, the assessment of ecological risks revealed several caches assigned to category 2 (moderate likelihood of impact) or 3 (high likelihood of impact). Therefore, also in these less-frequented parks, geocaching seems to be an issue for management that should be further investigated. Table 9 also shows that with the increase of caches in parks located close to urban areas, such as Donau-Auen NP, the number of caches with a moderate likelihood of environmental impact and disturbances also increases. The high number of caches classified in categories 2 and 3 in the Donau-Auen NP strongly suggests the need for related management strategies.

Conclusion

The results of this study prove geocaching to be present in all six Austrian national parks, but to varying degrees. Some parks have a higher risk of being negatively affected by geocaching than others. Overall, the analysis of the number of caches, the frequency of visits, and the types of hiding places underlines the necessity to manage this activity. An increasing number of caches is likely to lead to more sophisticated hiding places and to greater environmental impact and disturbance.

Since it is possible to hide geocaches in national parks without the risk of creating an adverse impact, and since this leisure activity provides the opportunity to promote an appreciation for national parks and to distribute knowledge about their natural resources (Reams & West 2008; Zecha 2012), it would be beneficial for both the parks and visitors to find a way of allowing geocaching in a regulated fashion.

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