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Factors Driving the Decline in the Publication of Geocaches

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Abstract

Geocaching is a popular outdoor recreational pastime that uses GPS to navigate to specific coordinates where the geocacher usually has to find a hidden container. Geocaching has many benefits including promoting exercise and learning. The number of new geocaches being published has started to decline. Here I present the first analysis of what factors might be contributing to that decline. Data on the geocache placement patterns of 116 geocachers were derived using the geocaching statistics analytical tool, Project GC. Two generalised linear mixed models were conducted on the resulting dataset. The study suggested that more active participants in the game are more likely to hide geocaches. The rate of hiding of geocaches declines over time. A quadratic relationship was identified with number of caches owned which suggests that individual geocachers have limits to the number of geocaches they can maintain. Perhaps, surprisingly the study suggested that cache saturation was only having a relatively small impact compared to these other potential drivers of the decline. Individual limits on geocaches owned and reduced activity over time appear to be the key drivers of the decline. Consequently the study suggests that a continuing influx of new participants to the pastime is required to maintain high levels of geocache placements. A range of measures to make geocaching more attractive to both current and future participants is suggested, for example increasing efforts to remove abandoned geocaches, making it easier for geocachers to identify the locations of high quality geocaches and increasing the variety of geocache types by the introduction of Citizen Science geocaches. By contrast, the study suggests that relaxing the rules on cache saturation is not likely to have much of an impact upon future levels of geocache placement.

Keywords: geocaching, location-based gaming, GPS, outdoor recreation, motivations

1. Introduction

Geocaching usually involves navigating to specific coordinates in order to find a container where the geocacher enters their name in the logbook (O'Hara 2008; Telaar et al.2014). Geocaches come in various sizes (O'Hara 2008) and larger containers often contain trinkets which can be exchanged. There are different styles of cache with some requiring an online or field puzzle to be solved before the final coordinates are revealed (O'Hara 2008). Some geocaches also do not have a physical container such as event caches where groups of geocachers gather at the coordinates at a predetermined time and date, and earthcaches where participants have to demonstrate learning by answering questions on the geology of the location.

The main motivations for geocaching have been reported as being relaxation, discovering new places and exploring nature and the environment (Telaar et al 2014; Falcao et al 2017). It encourages exercise and a healthy lifestyle at a time when an increasing number of people are becoming less healthy as a result of physical inactivity (Lim et al. 2012). In addition to acting as a motivator for people to exercise it also can encourage socialisation whilst doing so (O'Hara 2008). Geocaching can help people who live in urban environments seek out local green spaces (Cord et al 2015) and assist families to engage in activities together (Robinson and Hardcastle 2016). Geocaching has also been found to have educational benefits as it encourages learning activities (Ihamäki 2014) and educates participants on local geography and history. These many positive aspects of geocaching have been successfully utilised as a mechanism of encouraging geotourism (Boys et al 2017).

Geocaching has recently come of age with the first geocache being placed in May 2000. When geocaching first started participants would use hand held GPS devices (O'Hara 2008). The advent of smart phones, and geocaching apps such as c:geo and Cachly, has

made geocaching more accessible and now many geocachers use a phone rather than a dedicated GPS device. Since c:geo was launched in 2011 it has been downloaded over one million times by users with Android devices. Geocaching.com celebrated having one million active listed caches in March 2010. It reached the landmark of two million caches in February 2013 and three million actively listed geocaches in April 2017. There were nearly 3,153,000 in November 2018 suggesting that the rate of growth in the number of active geocaches has slowed despite increased accessibility. Considering all the benefits provided by geocaching this slowdown in the growth in the number of caches is of potential interest and worthy of analysis. Consequently it seems timely to conduct a study into the current status of geocaching and in particular into the factors associated with patterns of cache placement by individual geocachers.

A range of factors could be reducing the rate of growth in active caches. Geocaching relies on participants to hide caches. As a consequence a range of factors could be involved in the decline in geocache placements. These include the limited capacity of individual geocache owners to maintain geocaches and a decline in interest in the pastime over time. Geocaches cannot be placed within 161m of each other. Consequently in areas with high density of geocaches, saturation could be driving the decline in the number of new geocaches being placed (Telaar et al. 2014). Here I present the first analysis of hiding patterns amongst participants to determine whether individual maintenance capacity, decline in interest over time and geocache saturation are contributing to the current slowdown in the rate of growth of active geocaches.

2. Methods

A random number generator was used to select geocache GC codes published between May 2000 and May 2018. The cache owner of each geocache was identified by accessing Geocaching.com (Geocaching 2018). Any owners who had not found a cache or placed a

cache by the end of 2017 were excluded. The following statistics were generated for each cache owner from Geocaching.com: the number of geocaches placed each year, the number of days spent geocaching each year, the mean number of geocaches found per day for each year. The period from 2001 until 2017 was used. 2000 was excluded due to insufficient data. In total 116 geocache owners were included in the study. These came from the following countries: United States (47), United Kingdom (16), France (11), Germany (11), Canada (8), Netherlands (4), Australia (3), Austria (2), Denmark (2), Finland (2), Japan (2), Sweden (2), Belgium (1), Czechia (1), Norway (1), Poland (1), Portugal (1), Switzerland (1).

An additional set of statistics was generated using Project GC (Project GC 2018) which is a website that uses the geocaching.live API (<https://apidevelopers.geocaching.com/>) to extract information from Geocaching.com. A geocache from within the centre of each owner's distribution of hides was selected to determine an estimate of the home location for each geocacher as this information is not available for reasons of privacy. This location was then used to generate another set of statistics based upon the number of geocaches hidden each year within a 10km radius of that geocache's coordinates. These data were generated using the Map Compare function within the Project GC analytical tool (Project GC 2018). Any caches that had subsequently been archived were still included in the analyses.

Analysis of archival rates found that approximately 10% of existing caches per year are archived so this was used to model the cache density within each 10km radius by adding the number of new caches placed each year to 90% of the caches present from the previous year. A generalised linear mixed model with a negative binomial error distribution was used to model geocache placement. The model used the glmer function in the lme4 R package using R version 3.4.4 (R Core Team 2018). The model was chosen because the standard poisson model was overdispersed whilst the negative binomial model passed a Chi-Squared goodness of fit test. This is likely to be due to the dataset being zero-inflated. The following explanatory variables were included in the model.

- 1) Year (2001-2017)
- 2) number of days spent geocaching each year
- 3) mean number of geocaches found per day for each year
- 4) number of years since the geocache owner first started geocaching (i.e. Current year minus start year).
- 5) number of geocaches owned at the start of each year,
- 6) number of existing geocaches within 10kms of the start of the year.

All explanatory variables were scaled to have a mean of zero and a standard deviation of one. Quadratic terms were included for year, years since started geocaching, number of geocaches owned at the start of the year and density of geocaches within their local 10km diameter. The identity of the geocacher was included as a random effect. A generalized linear mixed model with a negative binomial error distribution was also used to model geocaching activity. The log of number of days spent geocaching per year plus one was modelled using the following explanatory variables: year, years since started geocaching, number of geocaches owned at the start of the year and quadratic terms for all three. All explanatory variables were scaled to have a mean of zero and a standard deviation of one. The best models were selected using the minimum AIC score obtained.

3. Results

3.1 Has there been a decline in the number of geocaches placed?

Based upon the geocaches published within the 116 randomly selected 10km diameter areas the number of geocaches placed reaches a peak around 2012 and 2013 (Figure 1) with more than a 25% decline from that peak being evident by 2017.

3.2 What factors affect the number of caches placed by individual geocachers?

The pattern of geocaches placed by these 116 geocache owners mirrors the worldwide pattern seen in Figure 1 with a peak in placement in 2013 (Figure 2) suggesting that they are a representative sample of the geocaching community. A generalized linear mixed model retained several explanatory variables (Table 1). The most important predictor was the number of geocaches already owned which showed a significant positive linear effect and a negative quadratic effect. The number of days spent geocaching also showed a highly significant positive association with the number of geocaches placed. The years since the geocacher started geocaching showed a highly significant negative association with geocaches placed (Table 1). Weaker significant associations were found with number of geocaches found per geocaching day (positive) and local geocache density (negative).

3.3 What factors determine how many days per year that geocachers are active?

A generalized linear mixed model retained several explanatory variables (Table 2). The most important predictor was the number of years spent geocaching which showed a highly significant negative association with days spent geocaching (Table 2). A weaker significant association was found with number of geocaches owned (positive).

3.4 Has there been a decline in the number of people taking up geocaching?

This was not a primary question asked by the study however the data generated allowed an opportunity to investigate if any clear relationship exists over time. The year that each of the

116 geocache owners included in the study found their first geocache is shown in Figure 3. Although this sample size is small it does show that the number of new geocachers seems to be declining with the peak in new geocachers occurring around 2011.

4. Discussion

4.1 Factors driving the decline in the placement of geocaches

Here I report a worldwide decline in the placement of geocaches and explore the factors playing a role in driving this decline. Geocaching placement relies upon volunteer participants. The most important factor associated with geocache placement by an individual geocacher was how active a participant in the game they were, with those that geocache on more days of a particular year more likely to place more geocaches that year. As those most actively participating in finding geocaches are those most likely to hide geocaches, maintaining interest in finding caches is likely to be crucial in sustaining the placement of new geocaches, particularly considering the apparent decline in the number of new geocachers.

The second most important factor associated with cache placement was the current number of geocaches already owned by that geocacher. The linear association is positive suggesting that geocachers who own more caches are more likely to place more new geocaches however, there was a highly significant quadratic component suggesting that individual geocachers have a limit to the number of geocaches that they can maintain. This suggests that attracting new geocachers to the game is likely to be essential for maintaining high levels of future cache placement as more existing geocachers reach their individual maintenance capacity.

A third major factor in determining cache placement was identified as the number of years someone had been geocaching. The longer someone had been geocaching for the less likely they were to place new geocaches. This suggests an overall decline in interest in the game over time which again suggests that recruitment of new geocachers to the game is vital for maintaining high levels of placement of new geocaches.

Two additional factors were also identified. The first was the number of geocaches found per day. This was about a factor of ten less important than the other indicator of activity level, the number of days spent geocaching. but did still significantly associate with the level of geocache placement suggesting that those geocachers that find larger number of geocaches per caching trip are more likely to place more new geocaches. This could occur as a result of geocachers who are particularly motivated by the number of their finds putting out more geocaches for others who are similarly motivated. The final significant factor was the local density of geocaches. This shows a weak significant negative association with geocache placement suggesting a local geocache saturation impact. The extent of this impact was relatively minor compared to the individual limit to geocache maintenance identified which suggests that although geocache saturation does exist is it not the most important factor in driving the current decline in geocache placement and that individual capacity is more of a limit to placement.

As it was revealed that how many days participants in the game spend geocaching per year was the most important predictor of geocache placement a second model of what factors affect days spent geocaching was developed. This found that the most important predictor was how long people have been participating in geocaching with a decline in participation over time. This adds further weight to the conclusion that it is important to continue to attract new participants to the game to keep it thriving and also that developing mechanisms of maintaining the interest of existing geocachers is likely to be vital especially if the number of new geocachers is declining.

4.2 How could the activity level of existing geocachers be better maintained?

The overall conclusion from the study is that the level of geocaching activity is the primary driver of the number of new geocaches placed and that established geocachers exhibit a decline in activity over time. This suggests that it is important to keep attracting new participants to the hobby to maintain the publication of new geocaches. In addition it is worth exploring the factors that are contributing to a decline in the activity of existing geocachers. Geocaching could be considered to be becoming a victim of its own success. The surge in the publication of new geocaches at the start of the current decade is now fuelling a mirrored surge in the number of abandoned or missing geocaches that receive no owner maintenance. This could be playing a role in discouraging existing geocachers from participating and also providing new geocachers with a poor impression of the hobby. An additional problem associated with missing geocaches is that search times can increase resulting in potential damage to fragile and protected environments (Hödl & Pröbstl-Haider 2017). Geocache maintenance is the responsibility of the owner so when they leave the game without removing their geocaches no one is responsible for their maintenance. Many geocachers contribute to community maintenance, for example by replacing a wet log book (Neustaedter et al 2010), however, some geocachers actively discourage others from carrying such maintenance insisting it is the geocache owner's responsibility which only increases the problem of poor maintenance of abandoned geocaches. These geocaches can then only be removed from geocaching map by a community reviewer who has been alerted to an issue by a geocacher reporting the geocache as needing maintenance or needing to be archived. This places a considerable burden of responsibility on volunteer reviewers. It also creates a potential problem with geolitter (abandoned archived geocaches where some or all the cache are still in place). At the moment different sectors of the geocaching community are responding to abandoned caches in different ways creating conflict between these groups of geocachers. The reliance of one geocacher to report

another geocacher's poor maintenance is also a source of conflict and many geocachers are reluctant to use needs maintenance logs for fear of getting negative responses from owners.

One possible solution to the problem of abandoned active geocaches would be to use indicators of abandonment to identify them. There are many indicators that a geocache might have been abandoned. The lack of any geocaching activity by the geocache owner is often a good indicator that their geocaches are no longer being maintained. In addition the date since the geocacher last logged onto their Geocaching.com account is another indicator. If a geocache owner has neither used their Geocaching account nor found a geocache for a year then they could be contacted to ask whether or not they intend to continue maintaining their geocaches. If the geocache owner doesn't respond then their caches could be temporarily disabled and then archived after a period of warning. One caveat to this would be to not include particularly old geocaches to avoid losing any historic geocaches that are still being maintained by the geocaching community. So for example this process might only be applied to geocaches that were placed after a fixed date for example 2005. Geocaches with a large number of favourite points might also be similarly excluded to avoid an outcry from local geocachers.

An additional method of improving the geocaching experience would be for the geocaching map and apps to provide more information to geocachers to aid them to planning trips associated with the quality of the cache. The geocaching map enables geocachers to better contextualise their expectations of a geocaching trip prior to departure (O'Hara 2008). Adding more optional information to the map could enhance this process. For example, providing an option to see the number of favourite points each geocache has earned on the map could allow geocachers to identify good areas to visit. In addition an option that flags whether whether the last log on a geocache was a "Found" or a "Did Not Find" could allow geocachers to avoid areas with missing or challenging caches. This might be particularly useful when for example geocaching with children who might be particularly disappointed by failing to find a geocache. Such features would help geocachers to improve

their geocaching experience by directing geocaching trips to areas they are likely to enjoy and avoid trips to areas blighted by poor quality or missing geocaches.

Encouraging the placement of high quality geocaches could also help maintain the interest of existing geocachers. The virtual reward geocaches did generate considerable interest and these geocaches have very successfully generated geocaching activity (Geocaching Blog 2017). For example in the United Kingdom the virtual reward geocaches placed in September 2017 had received an average of 383 logs which is about 10 times higher than the rate of logging of other geocache types placed in the same month (Gilburn unpublished). A more general programme of rewarding high quality geocaches could be introduced, for example awarding a virtual reward for every 500 favourite points an owner receives on their geocaches.

4.3 Attracting new geocachers to the pastime.

The more geocaching is mentioned in the media the greater the likelihood that exposure will attract new participants to the hobby particularly if the media coverage is positive. Cache In Trash Out Events (CITOs) already provide a positive image to geocaching but other new geocache types could potentially do the same, and possibly to a greater extent. One such geocache type could be based upon using geocachers to take part in citizen science surveys (Dunlap et al 2015). This would not only create a new type of geocache to maintain the interest of existing geocachers but could also generate considerable media coverage as most large universities and other research organisations have media officers dedicated to promoting their research to relevant media outlets. Geocaching has considerable potential to mobilise its large number of participants to engage in a range of location based citizen science projects benefitting everyone involved.

4.4 Management Implications

This study has identified key factors associated with the current decline in geocache placements and has identified alterations to the management of the game that could mediate some of these effects. It remains to be seen whether or not the planet will ever have 4,000,000 active geocaches. The current trajectory suggests not, however actions could be taken which could alter this trajectory. In particular this study suggests key to continue to attract new participants to the pastime. This could be done by increasing cache type variety and improving the quality of existing geocaches and the ability of geocachers to identify their locations.

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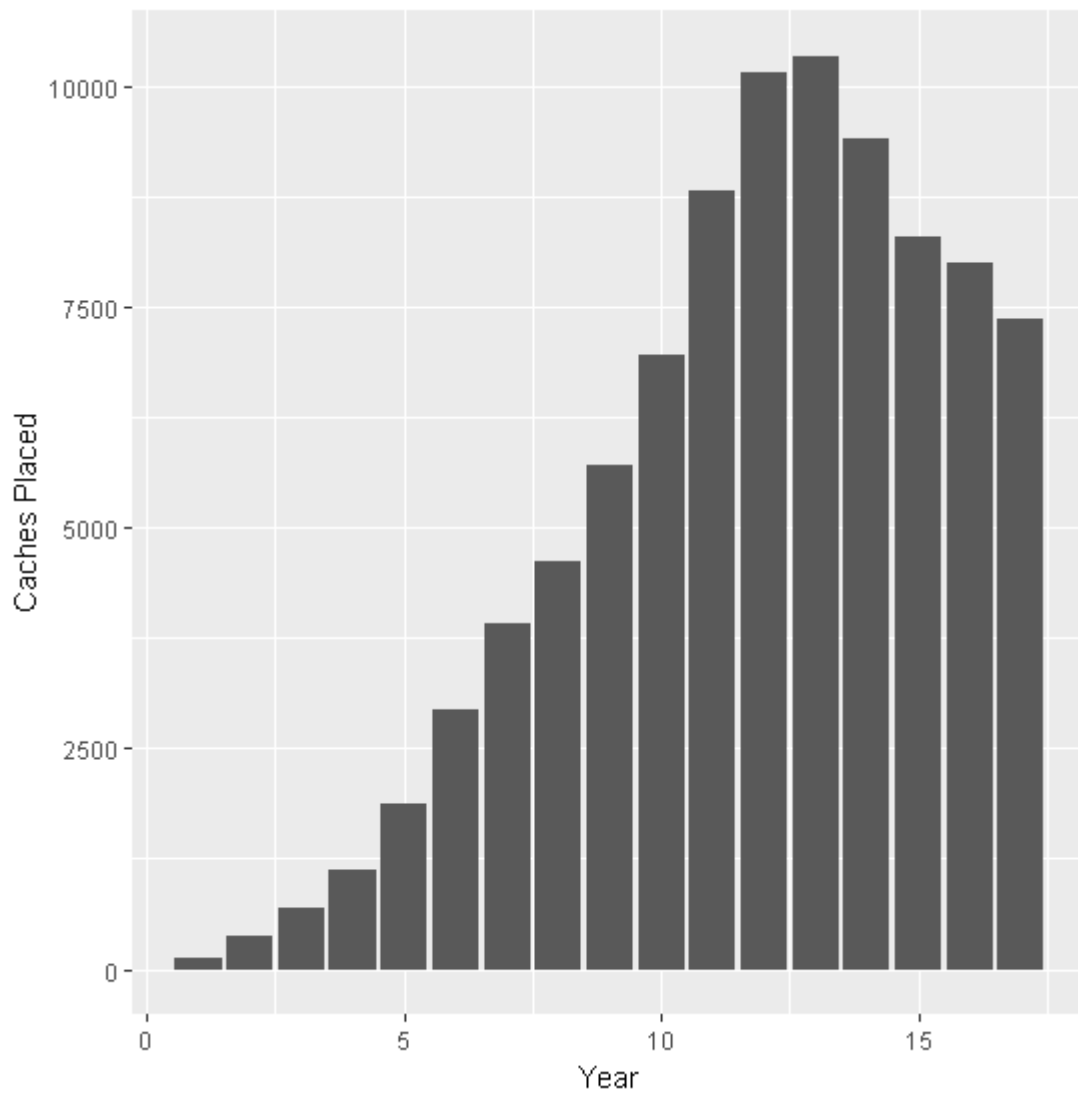


Figure 1. The number of geocaches published by year from 2000 to 2017 within 10kms of 116 randomly selected geocaches worldwide.

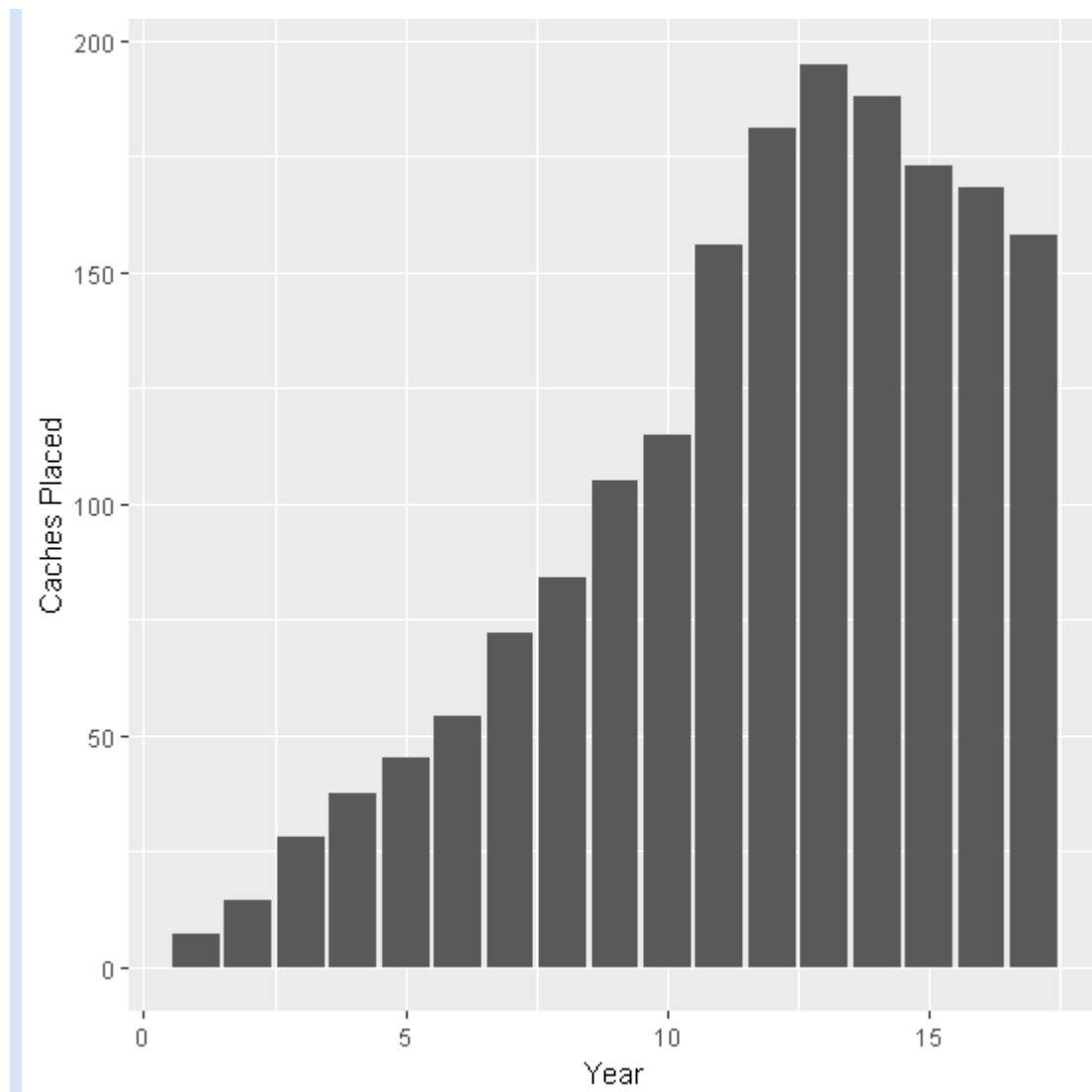


Figure 2. The sum of the log of the number of caches placed per year for all the geocachers included in the study.

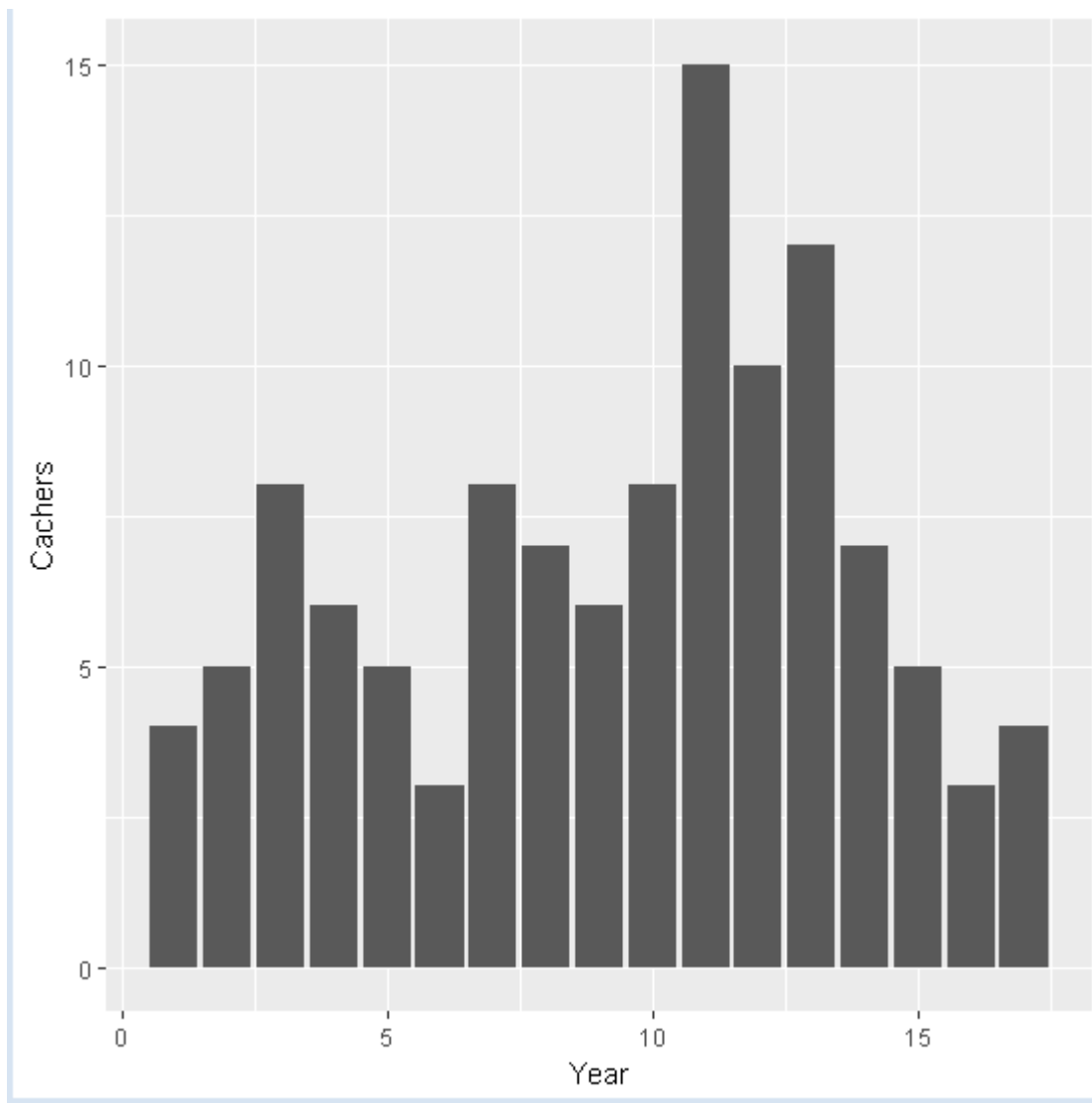


Figure 3: The year that each of the 116 geocachers included in this study started cache from 2000 to 2017.

Table 1. A generalised linear mixed model with a poisson error distribution of the number of caches placed by the 116 randomly selected geocachers. The explanatory variables were the number of days spent geocaching each year, the mean number of geocaches found per geocaching trip, the number of geocaches owned and the number of geocaches owned squared and the local geocache density at the start of each year.

Explanatory variable	Parameter estimate	Standard error	<i>F</i>	<i>P</i>
Intercept	0.263	0.050		<0.001
Days spent geocaching	0.402	0.050	164.2	<0.001
Mean number of geocaches found per trip	0.155	0.050	18.3	0.002
Geocaches owned	0.958	0.091	60.9	<0.001
Geocaches owned ²	-0.626	0.078	37.2	<0.001
Years geocaching	-0.405	0.053	77.9	<0.001
Local geocache density	-0.156	0.052	8.9	0.003

Table 2. A generalised linear mixed model of the factors affecting the number of days an individual geocacher is active per year.

Explanatory variable	Parameter estimate	Standard error	<i>F</i>	<i>P</i>
Intercept	1.149	0.045		<0.001
Caches owned	1.001	0.043	3.9	0.018
Years caching	-0.164	0.047	14.4	<0.001
Year	0.398	0.193	0.5	N.S.
Year ²	-0.371	0.191	3.8	0.052