

# Optimalisation of waste collection and perception of litter in the Utrechtse Heuvelrug

## Topic: 2D – Litter presence

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*Image source: Deben, 2014*

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## Introduction

As a result of the COVID-19 pandemic, social distancing has become the norm. Gathering with friends and family has become difficult due to restrictions. Now, more than a year after its first case in the Netherlands, COVID-19 is still around. In the meantime, people have found alternative ways to socialize with others. This includes various outdoor activities, such as hiking. There is evidence that outdoor spaces are safer than indoors; the chances of infection are massively reduced (Shukman, 2021). It has therefore become more crowded in hiking areas worldwide. Walking has various physical as well as mental benefits (Steinhilber, 2018). However, with the considerable increase in people hiking in forests, there has also been an observed increase in litter around these areas (Roberts et al., n.d.). Litter is defined as any kind of trash left on the ground in small amounts (Cambridge Dictionary, n.d.). It has been decided upon to study the litter problem in the “Utrechtse Heuvelrug” in the province of Utrecht, which is a popular location for recreational activities in the Netherlands. The reason for the lack of trash cans in the Heuvelrug is that it would be dangerous for wild animals, as they will tear apart and climb in trashcans and eat potentially dangerous materials, while also leaving more litter; a ripped trashcan will cause dispersion of trash by wind and rain (Brunekreef, 2020). There are initiatives commissioned by different municipalities to keep the forest clean. For example, “Zeist Zonder Zwerfafval” is a project that calls on volunteers to pick up litter in their surroundings (Omgevingsdienst regio Utrecht, n.d.). The general aim of this research is to collect information about the amount and spread of litter in the Heuvelrug and the attitudes of Heuvelrug visitors towards litter.

The research question is: **How is litter perceived in the Utrechtse Heuvelrug and its collection be optimised?**

The sub-questions are:

- What is the effectiveness of the current trash can (location) in the Heuvelrug?
- Is there a possibility for new trash cans in the Heuvelrug, and if so, where would be most effective?
- How much does the perceived presence of litter affect people’s experience of nature?
- Is there a relation between age group and people’s perceived presence of litter?

## Literature review

Besides being unaesthetically pleasing and creating logistic difficulties in its collection, litter can do a lot of damage to plants, animals, and the ecosystem they are a part of when thrown away in nature. For example, animals can get sick from eating litter; cigarette butts, which are the most littered items in the USA (Keep America Beautiful, 2010), contain toxic substances that are harmful to plant and animal life when released into the soil. The ingestion of plastics and other non-biodegradable trash by animals reduces their stomach capacity with fatal consequences (CENN, n.d.). It takes long for plastic to break down, meaning that the effects are long-lasting: a Styrofoam cup can take up to a million years to be decomposed (Dilthey, 2018), a timespan in which the cup will continuously release microplastics into the surrounding soil and groundwater due to weathering. Litter can also carry various bacteria, fungi and parasites which can be dangerous to both humans and wildlife, such as tetanus bacteria on thrown-away metal (Australian Government Department of Health, 2010). Hazardous chemical and microplastics from litter will also leach out into the soil and ground- and surface water, potentially harming plant life by obstructing growth and harming animals and aquatic plant life due to ingestion of polluted water (Conserve Energy Future, n.d.). In conclusion, litter has potentially severe effects on the functioning of ecosystems like the Heuvelrug.

Research on the effectiveness of recycling containers implies that there is a positive relation between proximity of the containers and their usage. A 2010 study at the University of Houston found that placing additional containers in the areas that already had them (the common areas of the university) did not lead to a significant change in recycling behaviour, while spreading out the placement of bins over classrooms did cause an increase in recycling, even though these classrooms were used by less students than the common areas (O'Connor et al., 2010). A similar study, performed by Brothers et al. in 1994, substantiates this result: they found that by bringing recycling containers closer to employees in an office building, 84% to 98% percent of paper was recycled in the long run. In the old situation, which utilised a central container in a shared area, only 28% of paper was recycled (Brothers et al., 1994). A later and more systematic replication of this study, performed at the Appalachian State University, concluded a similar pattern (Ludwig et al., 1998). According to these studies, concentrating trash disposal facilities has a smaller impact on litter reduction than the spreading of facilities. Therefore it is expected that locating spots for new rubbish bins will have a greater effect on reducing litter than boosting the capacity of the existing trash cans, assuming that the behavioural patterns of people regarding recycling and disposing of trash are mostly similar. These studies were however all performed indoors; it is unclear if the observed patterns and behaviour translate directly to an outdoors scenario like the Heuvelrug, as trash cans in nature areas are generally further spread out than indoors.

A Polish study on the relation between age and waste generation found that relatively, most waste was created by the broad age group of 14-64 years (Talalaj & Walery, 2015). A different study performed in the Czech Republic, however, concluded that the age group of 50-79 created the highest relative amount of waste in the population, while also recycling the least. In contrast, people under thirty accounted for the smallest amount of waste, while recycling the most (Struk & Soukopová, 2016). This difference in results can be attributed to the lack of specification in age structure in the first study; while the second study used nine different age groups, the Polish study only differentiated between working-age (14-64) and non-working age. While young people might create less waste, research data implies that they do litter the most; a study from Krauss et al. found that when someone is twenty years younger, they are up to three times more likely to litter. It must however be pointed out that this study is from 1976: the general increase in environmental awareness among societies since then, especially under young people, could provide different results in present-day research. Survey-based studies in Southern Brazil, the United Kingdom and Southeast Wales all show that visitors of beaches regarded litter as the main problem and biggest annoyance when visiting beaches (Santos et al., 2005). The survey data will show whether visitors of the forest are similarly bothered by litter.

As it is known that litter poses a human health hazard and can have severely negative effects on marine and land ecosystems in nature-areas such as the Heuvelrug, the optimisation of its trash disposal facilities is vital to ensure the long-term health of the Heuvelrug's inhabitants and visitors. By observing the current site of the litter bins and their effectiveness, it becomes possible to identify potential locations for new trash cans; previous research has shown that spreading trash disposal facilities has greater effect in reducing litter than concentrating facilities, so identifying new locations is expected to have a greater effect on litter reduction than increasing the capacity of the current bins or adding new bins at the current sites. While contradictory studies do exist, the most recent and relevant studies also suggest that individual littering increases by age. This research has investigated whether there is a similar relation between age and people's perceived presence of litter and trash disposal facilities within the Utrechtse Heuvelrug. Lastly, multiple studies found that litter is perceived as the biggest annoyance of beach visitors in multiple areas dispersed over the world. As the effect of litter on visitor's experience of the Heuvelrug will be looked at in this study, it is interesting to find out if this also applies to forested recreational areas.



## Method

For conducting the research, the following area of approximately two by four kilometres has been selected: Zeisterbos and Kozakkenput, which contains the walking routes Zeisterbos (6 km) and Kozakkenput (12 km), as can be seen in Figure 1. This area has been selected as it is a tourist-hotspot with multiple parking lots, a cafeteria, and a tourist centre. Therefore, it can be assumed that this area is a good representation of a recreational Heuvelrug.

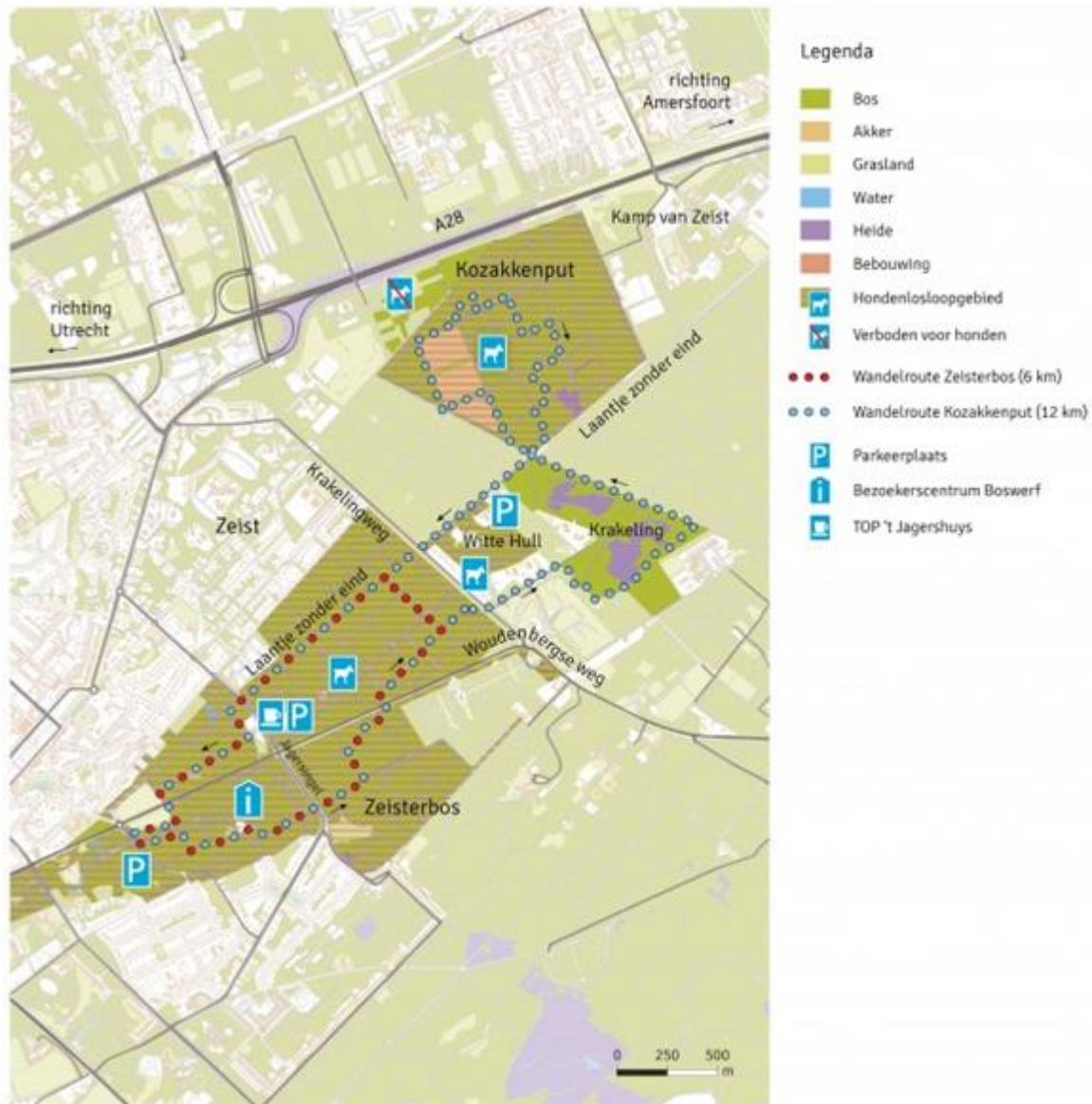


Figure 1: The Utrechtse Heuvelrug area Kozakkenput and Zeisterbos near Zeist. (Utrechts Landschap, n.d.)

### GIS mapping

To answer sub-question 1 and 2, the effectiveness of the current trash can needs to be determined and the most optimal location for new trash cans must be analysed. The first step towards answering these two questions is the identification, mapping, and collection of all found litter in the designated research area. This mapping has been done through entering the locations of litter into GIS using the Survey123 app. Only the litter on the hiking trails, including 2 meters on each side, has been noted

down, as this is where most of the litter can be found. Two teams of two researchers have carried out this mapping; one team has tackled the Kozakkenput hiking trail and the other the Zeisterbos trail. The different types of trash that have been found are classified according to the products they are made of in the Survey123 app, differentiating between plastic, glass, cardboard, facemasks, biodegradable, and other. This is done to later be able to compare the optimal location of trash cans for diverse types of litter.

Sub-question 1, the effectiveness of the current trash cans, has been tested using the “mean coordinates”-function in GIS. By having GIS calculate this optimum, which has the shortest average distance to all litter points in the research area, it can be compared with the only trash cans in the area, located in the Zeisterbos visitor's centre.

Sub-question 2, identifying possible locations for new trash cans, is analysed in the same way: the optimal trash can location, calculated by GIS through the “mean coordinates”-function, can be interpreted as a possible new trash can location, depending on the distance between this imaginary point and the current bin locations. By not only doing the “mean coordinates”-analysis for all the litter points but also for each litter category individually, differences in where litter of a certain category is concentrated can be identified. Consequently, it will be shown where the optimal location for a trash bin for that litter type would be.

The locations of the found litter, trash cans, and potential suggestions for new bin locations have been visualized in GIS-maps, with each litter category and the optimal trash can location attached to it shown on a second map. The GIS-map will be used to check if the current bins are in or close to the optimal location.

### Survey

For the second part of the research, a Survey123-survey has been created, which visitors have filled out either on paper or through the Survey123 app. The supervised self-administered type of survey has been conducted in the research area of Zeisterbos and Kozakkenput. The individuals that participated in the survey have been approached randomly to avoid as much bias as possible. The questions that are included in the survey and the research questions they will address are as follows:

### **Survey Questions:**

#### **1. How often did you visit the Utrechtse Heuvelrug in the last year?**

*Question 1 is not intended to answer a research question but rather stimulate the participant's memory of their previous visits.*

#### **2. How does the presence of litter in the Utrechtse Heuvelrug affect your experience?**

Very strongly - Strongly - A fair amount – Little – Not at all

This relates to research sub-questions 3 and 4:

*“How much does the perceived presence of litter affect people's experience of nature?”*

*“Is there a relation between age group and people's perceived presence of litter?”*

#### **3. When I am carrying trash in the Utrechtse Heuvelrug I can dispose of it in a timely manner**

Strongly disagree - Disagree – Neutral - Agree – Strongly agree

This relates to research sub-questions 1 and 2:

*“What is the effectiveness of the current trash can (locations) in the Heuvelrug?”*  
*“Is there a possibility for new trash cans in the Heuvelrug?”*

#### **4. How does the presence of trash cans affect your experience of nature in the Utrechtse Heuvelrug?**

Very negatively - Negatively – Neutral - Positively – Very positively

This relates to research sub-questions 2:

*“Is there a possibility for new trash cans in the Heuvelrug?”*

#### **5. How satisfied are you with the locations of trash cans in the Utrechtse Heuvelrug?**

Strongly satisfied - Satisfied – Neutral - Dissatisfied – Strongly dissatisfied

This relates to research sub-questions 1 and 2:

*“What is the effectiveness of the current trash can (locations) in the Heuvelrug?”*  
*“Is there a possibility for new trash cans in the Heuvelrug?”*

#### **6. When I use a trash can in the Utrechtse Heuvelrug, it is generally:**

Empty – Slightly filled – Half-full – Almost full – Full

This relates to research sub-questions 1:

*“What is the effectiveness of the current trash can (locations) in the Heuvelrug?”*

#### **7. What is your age?**

Participants will answer with their exact age. These ages will be divided into three age categories after the surveys have been conducted.

This relates to research sub-questions 4:

*“Is there a relation between age group and people’s perceived presence of litter?”*

#### Differences in litter perception between age groups

To measure the relation between age and effect of litter on experience, three different age groups have been generated: “Lower age” (1-30, starting at 14), “Middle age” (31-50), and “Higher age” (51-90). To determine whether there are significant differences between the three groups, the Kruskal-Wallis test has been used. Subsequently, the Mann-Whitney test was conducted three times to measure the differences between each possible pairing of groups. To find out whether there is a correlation between the two variables the Spearman’s rho test was used.

#### Visualising results

To visualise possible relations between age and litter perception, a column chart is used. In this chart the response frequencies to question 2 are shown for three different age groups. The three different age groups are the following: “Lower age” (1-30), “Middle age” (31-50), and “Higher age” (51-90). Using the statistical tests, it will be possible to determine whether there is a significant difference in responses between the age groups, and if their waste perceptions are therefore different as well. The responses to questions 2 to 6 are visualised using ungrouped column charts to show which responses contribute the most to the total amount.

#### Combining results

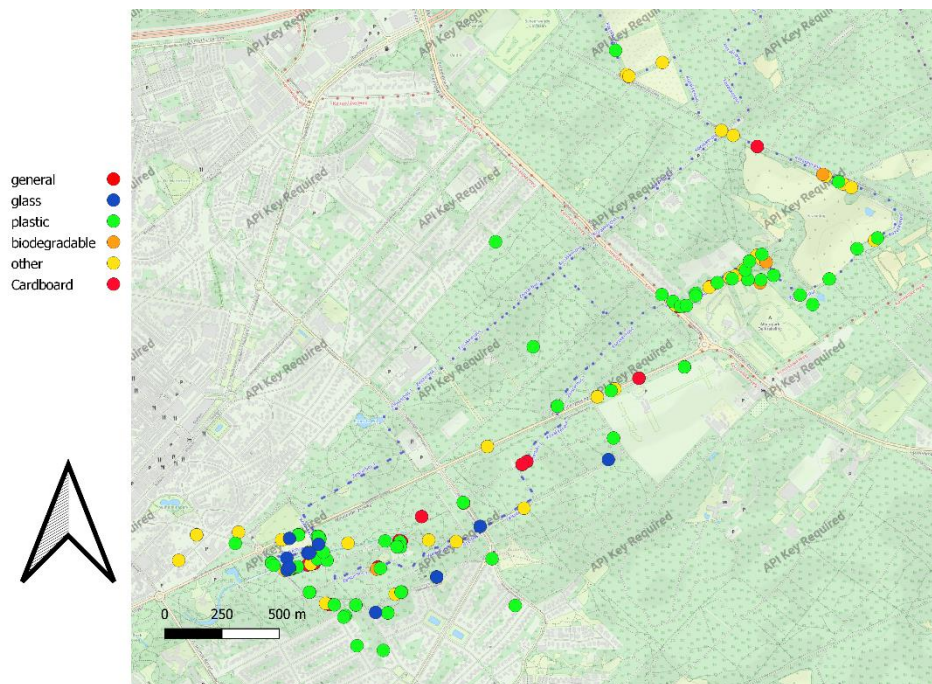
After having conducted the GIS mapping and the survey, the results of both components have been combined to answer the research questions “What is the effectiveness of the current trash can

(locations) in the Heuvelrug?” and “Is there a possibility for new trash cans in the Heuvelrug, and if so, where would be most effective?”. The GIS map has given an objective indication of how effective the current trash can locations are, and the survey will be able to show whether this is reflected in people’s answers. The GIS map has also helped to answer the second question by providing an overview of areas where there is a large litter presence. Based on the survey answers it can be concluded whether people are open or resistant to the introduction of more trash cans in the park and thus if there is a possibility for new trash cans.

## Results

### GIS mapping results

The measurements performed during the fieldwork week showcase several interesting observations.



*Figure 3: Results of the litter mapping using GIS.*

When looking at the general results the first impression is that there are two major concentrations of litter in the measured area, namely the south-western area and the north-eastern area. A possible explanation is the fact that the former area includes parking accommodations and a deer camp. The second area, along a public road right next to a public area, also showcases a higher amount of waste than other areas. Another important observation is the noticeable difference in the various kinds of litter, with the categories “plastic” and “other” having a significantly larger share than the other types.

Considering the many distinct types of litter, it is important to analyse them all separately. This is achieved by establishing the shortest distance between all the points i.e., by finding the mean coordinate using GIS. Carrying out this analysis for all litter categories gives the following data:



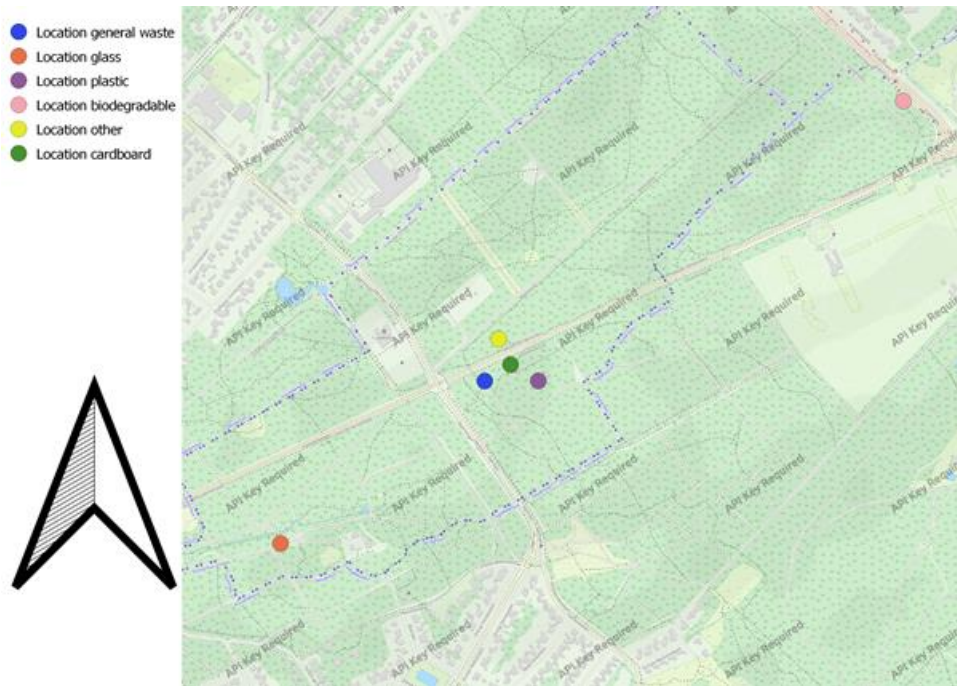


Figure 4: Results of the “mean coordinate”-function for all litter categories using GIS.

This provides several important pieces of information. Firstly, four of the six points are in close proximity, showing that there is an optimal location for a trash can. However, two points deviate significantly. This can be explained by the absence of a large enough sample size of their respective litter types. Therefore, these points do not give an accurate representation of the averages and thus cannot be considered the appropriate locations. The four points which are valid provide enough information to safely assume that in the approximate area that has been found there is an ideal location for either a universal trash can or four designated trash cans.



Figure 5: The optimal area for the placement of a new trash can

During the fieldwork, only a cluster of trash cans at the visitor's centre was found and mapped. When comparing the location of these trash cans to the results of the GIS analysis, the difference is quite significant.

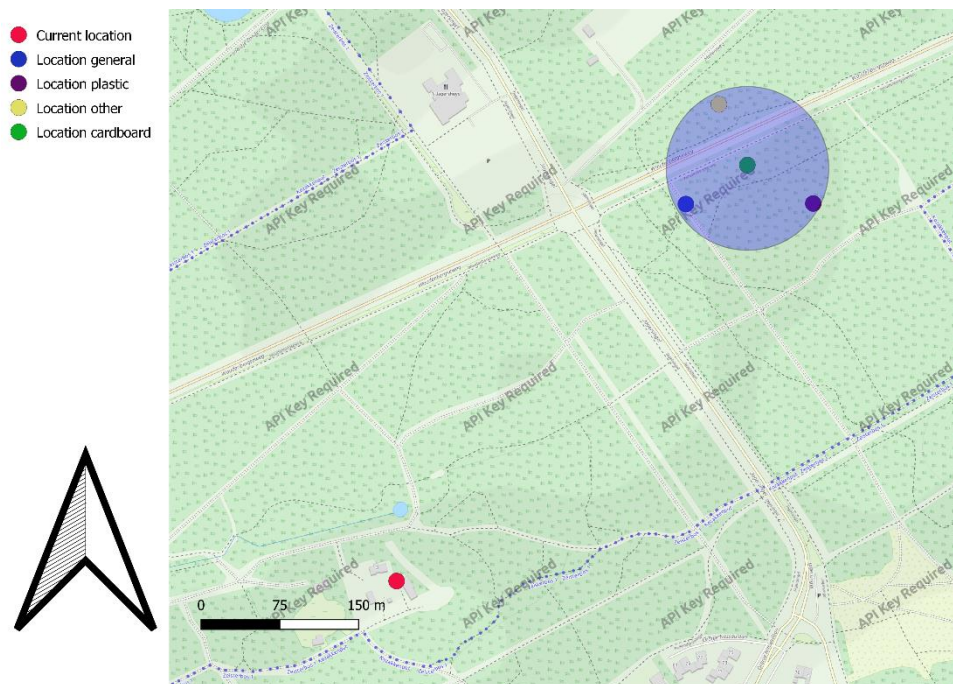


Figure 6: The optimal area for the placement of a new trash can versus the current location

### Survey results

The total response frequencies for each survey question can be found in annex A. Included below are bar charts showing the responses to survey questions two to six.

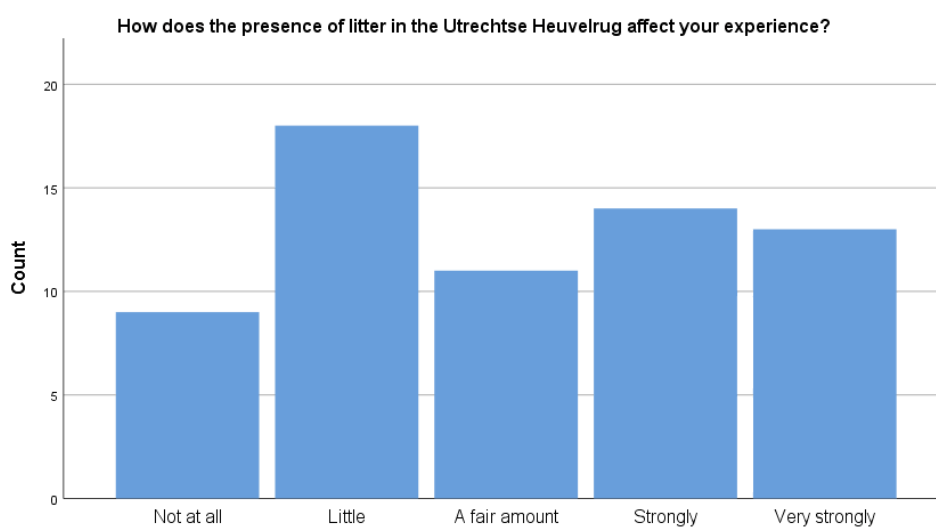


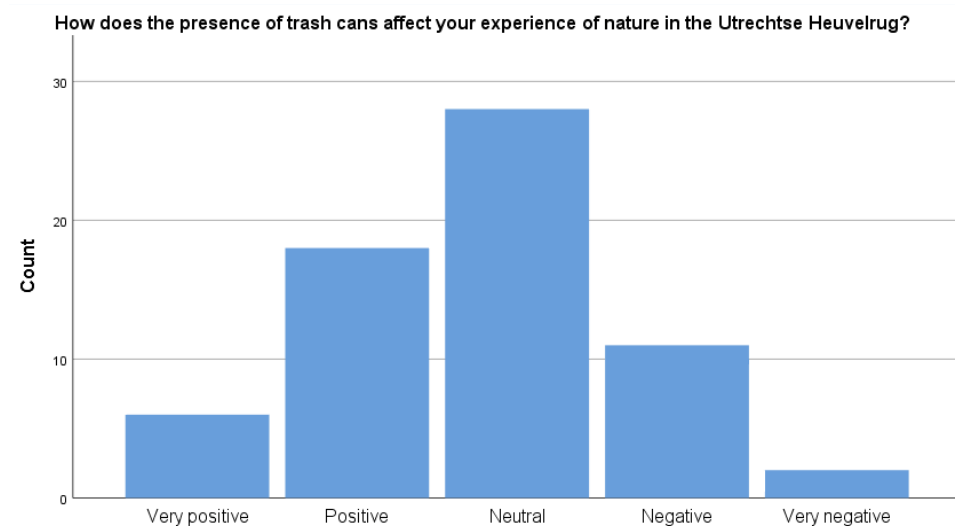
Figure 7: Responses to question two

In figure 7 it can be observed that 41.5% of the respondents say that their experience in the Utrechtse Heuvelrug is very strongly or strongly affected by litter. This is almost equal to the 40.0% that claims their experience to be affected little or not at all. This distribution indicates that there is a strong but even division between experiences.



*Figure 8: Responses to question three*

In figure 8 there is a clearer agreement among the respondents: 38.5% disagree and 32.3% strongly disagree with the statement saying they can dispose of their trash in a timely manner. This would suggest that these respondents desire more trash cans in the areas of the Utrechtse Heuvelrug they have visited.



*Figure 9: Responses to question four*

Most of the responses to question four are neutral (43.1%). This indicates that most respondents do not think their experience of nature is affected by trash cans in any way. 20.0% of the respondents say that their experience is affected either negatively or very negatively by trash cans. These people might be more opposed to the introduction of new trash cans.

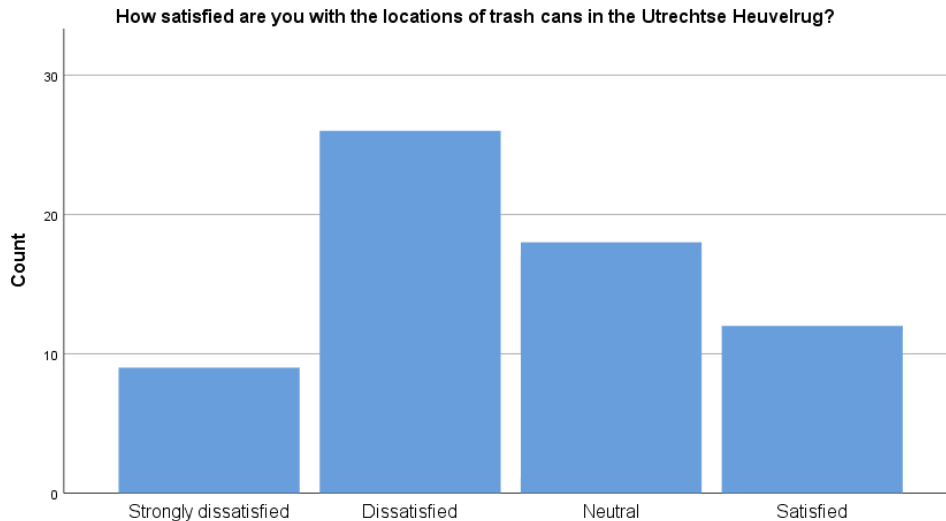


Figure 10: Responses to question five

As can be seen in figure 10, 41.5% of respondents are dissatisfied with the locations of the trash cans in the Utrechtse Heuvelrug, followed by 27.7% of respondents who are neutral. It is notable that nobody answered with strongly satisfied, which implies there is room for improvement in choosing the locations.

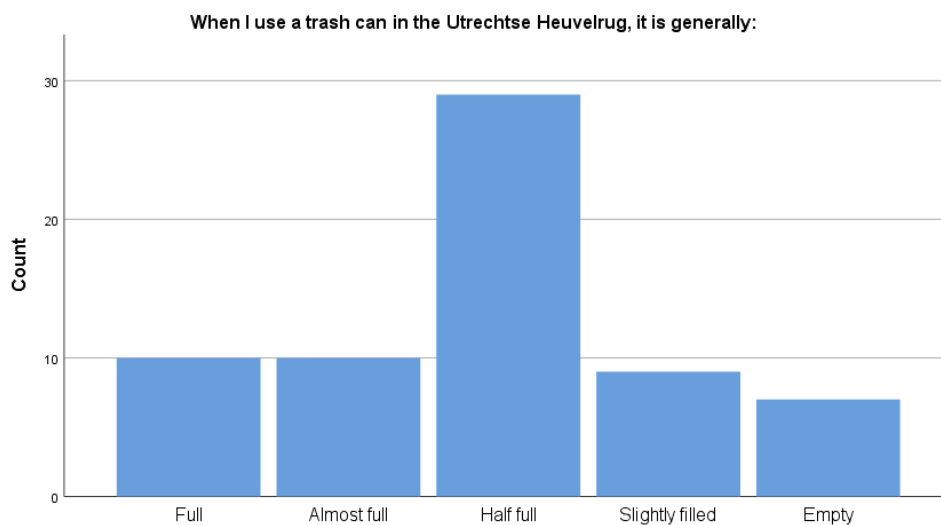


Figure 11: Responses to question six

Figure 11 shows that 44.6% of respondents encounter half full trash cans in the Utrechtse Heuvelrug. The other categories are almost equal in size, with “full” and “almost full” both accounting for 15.4%.

#### Differences in litter perception between age groups

The results of the Kruskal-Wallis and Mann-Whitney tests for the generated age groups are the following:

Ranks & Statistics					
	<u>Age groups</u>	<u>N</u>	<u>Mean Rank</u>	<u>Kruskal-Wallis H</u>	<u>Exact Sig.</u>
Effect of litter on experience	Lower age group	13	22.19		
	Middle age group	30	33.3		
	Higher age group	21	37.74		
	<b>Total</b>	64		5.985	<b>0.048</b>

Table 1: Results of the Kruskal-Wallis test for the three age groups

Ranks & Statistics			Test 1		Test 2		Test 3	
	<u>Age groups</u>	<u>N</u>	<u>Mean Rank</u>	<u>Sum of Ranks</u>	<u>Mean Rank</u>	<u>Sum of Ranks</u>	<u>Mean Rank</u>	<u>Sum of Ranks</u>
Effect of litter on experience	Lower age group	13	16.19	210.5	13	169		
	Middle age group	30	24.52	735.5			24.28	728.5
	Higher age group	21			20.29	426	28.45	597.5
<u>Mann-Whitney U</u>			119.500		78.000		263.500	
<u>Exact Sig. (2-tailed)</u>			<b>0.040</b>		<b>0.034</b>		<b>0.317</b>	

Table 2: Results of the three Mann-Whitney tests for the three age groups

Based on the significances found by the Kruskal-Wallis test it can be determined that there is a significant difference in perceived litter presence between the three age groups as the exact significance is  $p = 0.048 < 0.05$ . A higher ranking in the statistical results indicates that the age group's experience is affected more by the presence of litter.

The Mann-Whitney tests also shows that the middle and higher age group have higher rankings than the lower age group, but significance cannot be proven. Because three tests had to be run, the chance of a Type 1 error occurring had increased. To make up for this, the  $\alpha$  for the three tests has been adjusted to  $0.05 / 3 = 0.0167$  using a Bonferroni correction. After this adjustment, none of the differences between any two groups can be called significant. When choosing not to make a Bonferroni correction and keeping  $\alpha$  at 0.05, there are two significant differences. In this case, the middle age group is more affected than the lower age group, and the higher age group is more affected than the lower group as well. However, no significant difference can be found between the middle and higher age groups even without the correction.



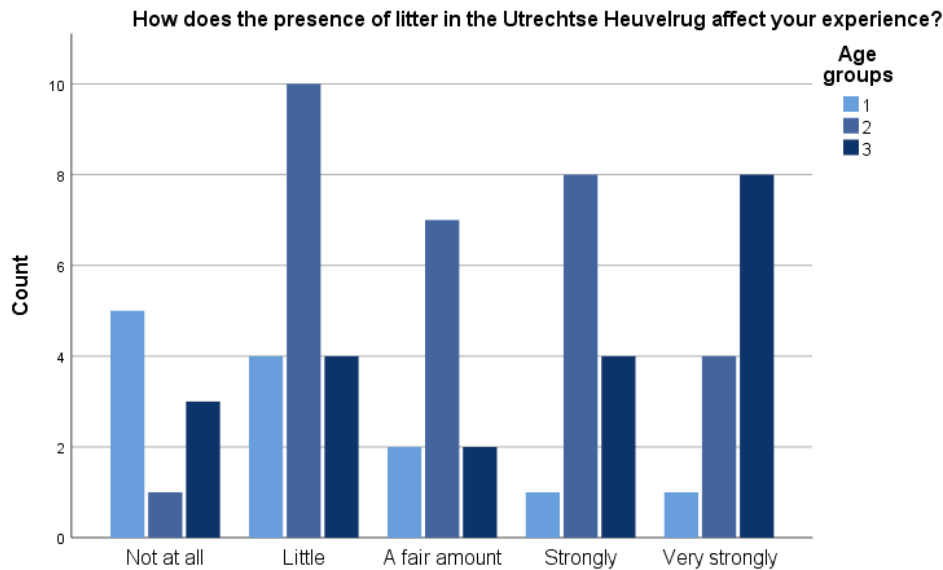


Figure 12: Responses to question two, divided by age groups (note that 1: N = 13, 2: N = 30, 3: N = 21)

When the division between age groups is removed, it can also be investigated whether there is a correlation between age and the effect of litter on experience. After making use of Spearman's rho test, it can be determined that there is no significant correlation between these two variables. There is however a correlation coefficient of 0.212, which indicates that the validity of the previous tests is not diminished.

Spearman's rho - Correlations			
		Age	Effect of litter on experience
Effect of litter on experience	Correlation Coefficient	0.212	1
	Sig. (2-tailed)	0.093	.
	N	64	65

Table 3: Correlation between age and effect of litter on experience

## Discussion

### Interpretation of the results

The research question is: "How is litter perceived in the Utrechtse Heuvelrug and how can its collection be optimised?". From the results considering the first subquestion "What is the effectiveness of the current trash can (location) in the Heuvelrug?", the conclusion can be made that the current location is not optimal. Both the survey and the GIS-analysis lead to this conclusion. The second sub question is "Is there a possibility for new trash cans in the Heuvelrug, and if so, where would be most effective?". By doing a GIS analysis, the optimal placement for a new trash can was found, as is shown in the results. As no previous research has been done regarding the placement of trash cans in this specific area, the results of the first two subquestions cannot be compared with other findings. This report and its findings can be used for new research that might focus on this area.

In the literature review, it was mentioned that litter is a big annoyance to people on the beach. This is related to one of the subquestions: "How much does the perceived presence of litter

affect people's experience of nature?". The findings confirm that this is also the case in forests, as 41.5% of the people who filled in the survey say that their experience in the Utrechtse Heuvelrug is very strongly or strongly affected by litter.

The last subquestion is: "Is there a relation between age group and people's perceived presence of litter?". Previous studies suggest that littering increases with age. The findings showed that the perceived presence of litter was on average most negative in the age group 51-90, but a significant correlation between age and litter perception could not be found.

#### Limitations of the research

There were several limitations to this research that should be taken into consideration when looking at the results. Regarding the locations of the trash, one of the main problems is that there were other people who were collecting trash as well. As they removed litter, that litter could not be put in Survey123. Consequently, they influenced the data. The places they were cleaning contained less litter than other areas, however, there might have been just as much discarded trash over there.

Another problem with the litter collection is that the research was conducted at only one moment in time. This limits the reliability of the data for two reasons. Firstly, the amount of litter might vary at different moments. It is possible that there is more litter in the weekends, contrary to the weekdays when the mapping of the litter was carried out. There are also other variables that could have had an impact, such as the weather or sporadic events that could cause serious deviations in the amount of trash compared to the average. Secondly, by only measuring the litter at one moment, no insight is gained on the frequency that the litter is thrown away at. This was especially relevant since most of the litter that was found was already quite old. This was concluded based on the appearance of the litter. This could mean that not that much litter was thrown away every day, and the litter that was found had been thrown away infrequently over a prolonged period of time. Both these problems could have been solved by collecting data during several moments instead of only once.

Furthermore, not all the litter was collected all at once, as the research in various parts of the forest was done during different days. This could also have influenced the data. For example, the number of visitors might differ per day, which could have had impact on the amount of litter thrown away. Additionally, the forest may be cleaned at certain moments, and the interval between the last cleaning moment and the days on which the mapping took place could cause deviations in the data. This could have been solved by collecting data on only one day or by inquiring about a cleaning schedule.

The benches in the national park were often surrounded with a disproportionately large amount of trash, which had an impact on the results. As the locations of benches were not included in the calculations, this should be considered when looking at the results. It may also mean that it would be more effective to place trash cans near benches instead of the calculated location.

There were also some limitations to the survey. One limitation is that each individual has a different interpretation of the Utrechtse Heuvelrug. Some people may have only thought of the Zeisterbos and Kozakkenput area the survey was conducted in when answering the questions, while others may also have included residential areas when deciding upon their response. Another limitation of the survey is that only 65 people filled it in, which is a relatively small number of respondents. This influenced the reliability of the results. This problem could be solved by asking more people to fill in the survey.

Additionally, the area where the research was done is not likely to be representative of the entire Utrechtse Heuvelrug. This could have an impact on both the litter collection and the survey results. For example, the area was close to a relatively wealthy neighbourhood, which might have influenced

the results. Other factors such as size of the area, the current amount of trash cans and the presence of the Boswerf, an educational centre for primary school children, might have caused the situation to be different from other areas in the Utrechtse Heuvelrug. These limitations are related to the fact that this research was conducted in only one area, so the problem could be solved by also investigating other parts of the Utrechtse Heuvelrug.

Lastly, the assumption that a trash can will solve the litter problem might not be right. The calculations that are done with GIS are based on that assumption, as the placement of new trash cans is based on the amount of litter. However, birds might pick garbage out of trashcans and spread more litter. Besides, a lot of respondents said that they always take their trash home anyways. It could be that the people that leave most of the current litter would not bother putting it in a trash can, making the placement of new bins ineffective in solving the Heuvelrug's litter problem.

#### Suggestions for further research

There are numerous ways to follow up on the research that has been conducted for this report. First, it was not possible to find optimal locations for multiple trash cans at once due to software limitations. Further research in the same or in a different area would benefit from this option because it is unlikely that adding merely one trash can will always be sufficient. Doing this would allow for more efficient trash can allocation in larger areas.

Another possibility for follow-up research is the investigation of intervening variables between age and litter perception. The research was not focused on this aspect, but our results showed quite a strong relationship between those factors. It would be interesting to find out what leads people to perceive litter differently and how age plays a role in this.

Additionally, further research would benefit from collecting data during different moments in time. This would lead to much better insight into the frequency that the litter is thrown away with. It would also make the findings more reliable as more data is collected, and unexpected external variables will not be able to influence the amount of litter as much. Furthermore, further research would benefit from collecting more survey data. By asking more people to fill it in, more data can be collected, which will make the results more reliable.

Further research could also be conducted in different areas. By collecting data in various parts of the Utrechtse Heuvelrug, one gets more reliable data that can better represent the litter situation of the entire area. It could also be interesting to do research in other national parks in the Netherlands and compare those with the Utrechtse Heuvelrug.

## **Conclusion**

Overall, the perception of litter is divided among residents; some of them are greatly bothered by it while others barely notice it. However, most residents agree that more waste bins are needed. The GIS mapping has shown that a suitable location for this would be the blue dot shown in figure 3, but one single trash can may not be enough.

When observing the GIS analysis, it becomes apparent that the current trash can location is not adequate, with the new advised location deviating significantly from the current ones. The advice is to either reallocate the current trash cans or to introduce new ones. A possible solution would be to place them at the restaurant 't Jagershuys since it is a tourist- and recreation-hotspot which is located only approximately 100m from the ideal location. As said in question three, people do not

feel that they can throw away their trash in time. The responses to question five indicate that most respondents are not satisfied with the locations of the trash cans. These results argue that the current trash bins and their locations are ineffective. When the respondents used a bin, the majority encountered it half full. 15.4% encountered it full, but the introduction of new trash cans will better solve this problem than increasing the size as concluded in the literature review.

Apart from relocating the current trash cans to more optimal locations, it could be effective to introduce more trash cans. The analysis shows that there are two concentrations of trash, at the parking area and near the camping spot. Due to the location and the services these areas provide it would be useful to add trash cans here. In response to question three, people stated that they cannot find a trash can in time when they need one. This certainly indicates that there is a lack of trash cans where they would be necessary in the Heuvelrug. Additionally, a high percentage of the respondents mentioned in question five that they are not satisfied with the locations of the trash cans. Therefore, it would be beneficial to relocate the current trash cans, but it also shows that there may be a possibility for new trash cans within the area. As shown in figure 9, most of the respondents hold either a neutral or positive attitude towards the presence of trash cans in nature, which means there will most likely be limited resistance to the introduction of new ones.

Figure 7 shows a clear division between those who say the presence of litter affects their experience strongly or very strongly and those whose experience is not at all affected or only little. This distribution may be explained by the fact that some people do not notice litter as often as others, but there are many possible factors to consider. Still, the respondents who are bothered by litter account for a relatively high percentage and should not be ignored. If there would be less litter, these individuals would enjoy nature more and possibly go out into nature more frequently.

Several tests were performed to find out whether there are differences between age groups and their perceived presence of litter. The Kruskal-Wallis test was the sole one which proved to be significant and showed that on average, older age groups say that their experience is affected more by litter than younger ones do. This shows that there are differences between the groups, but which intervening variables play a role is not clear.

## **Relevance and integration possibilities**

### Integration

The overarching research question of the project is: How can the different recreational activities in the Utrechtse Heuvelrug be managed in a sustainable way? The results of the litter subtopic will help to answer this question. People who go to the Utrechtse Heuvelrug for recreational activities could litter. They do not wish to hold on to their garbage for too long, which is one reason most of it will end up in nature if trash can allocation is not properly executed. Through researching how litter is perceived and how to optimise the waste collection in the area, a more sustainable way to manage recreation can be established. By knowing how effective the positioning of the current trash cans is, it will be possible to determine new locations to place trash cans. By asking people how they perceive trash in nature and the current way of waste collection, it can be determined how the problem of litter is perceived by different age groups and how substantial the problem is considered in the area. These subquestions provide more insights on how to combine people's opinions and behaviour with their recreational activities and the health of the forest in a sustainable manner. Together with the other subtopics: recreation inventory, density of recreationist doing sports, perceptions on nature, visitor mobility, and mobility preferences of Heuvelrug users, this research on litter presence and visitors' perception of it will contribute to sustainable management of recreational activities in the Utrechtse Heuvelrug. It explains how litter that recreationists bring

into the area, and consequently the impact of recreation on the Heuvelrug ecosystem, can be minimized.

### Relevance

It would be difficult to externalise the GIS mapping results of the investigated area to the entire Utrechtse Heuvelrug, but the same method used in this research could be applied to the complete Heuvelrug. It would make the placement of new trash cans more efficient and easier to decide upon. The survey results are more relevant to the entirety of the Heuvelrug as it is less likely that opinions differ much within the greater area and because the questions concerned the Utrechtse Heuvelrug in general. The findings are useful to the individuals in charge of recreation within the region because they reflect on how satisfied people are with the current trash collection system and whether more trash cans are desired. The conclusion that older age groups are affected more by the presence of litter than younger ones may be the most generalisable. It shows that it is important to involve a variety of age groups in recreation management because there are differences between the groups in how nature and problems such as littering are viewed.

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## Appendix

### Part A

#### Survey links

Dutch version: <https://arcg.is/mnvqK>

English version: <https://arcg.is/0jSPXW>

## Survey results

### Response statistics for questions 1 & 7

Statistics		Times visited in last year	Age
N	Valid	65	64
	Missing	0	1
Mean		161,85	45,56
Median		104,00	42,00
Mode		365	49
Std. Deviation		155,125	17,370
Range		365	76
Minimum		0	14
Maximum		365	90
Percentiles	25	10,00	32,25
	50	104,00	42,00
	75	365,00	62,50

Table 4: Response statistics for questions one and seven

### Response statistics for questions 2 to 6

#### How does the presence of litter in the Utrechtse Heuvelrug affect your experience?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	8	12,3	12,3	12,3
	Little	18	27,7	27,7	40,0
	A fair amount	12	18,5	18,5	58,5
	Strongly	14	21,5	21,5	80,0
	Very strongly	13	20,0	20,0	100,0
	Total	65	100,0	100,0	

Table 5: Response statistics for question two

#### When I am carrying trash in the Utrechtse Heuvelrug I can dispose of it in a timely manner

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	21	32,3	32,3	32,3
	Disagree	25	38,5	38,5	70,8
	Neutral	12	18,5	18,5	89,2

Agree	5	7,7	7,7	96,9
Strongly agree	2	3,1	3,1	100,0
Total	65	100,0	100,0	

Table 6: Response statistics for question three

**How does the presence of trash cans affect your experience of nature in the Utrechtse Heuvelrug?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very negatively	2	3,1	3,1	3,1
	Negatively	11	16,9	16,9	20,0
	Neutral	28	43,1	43,1	63,1
	Positively	18	27,7	27,7	90,8
	Very positively	6	9,2	9,2	100,0
	Total	65	100,0	100,0	

Table 7: Response statistics for question four

**How satisfied are you with the locations of trash cans in the Utrechtse Heuvelrug?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly dissatisfied	9	13,8	13,8	13,8
	Dissatisfied	27	41,5	41,5	55,4
	Neutral	18	27,7	27,7	83,1
	Satisfied	11	16,9	16,9	100,0
	Total	65	100,0	100,0	

Table 8: Response statistics for question five

**When I use a trash can in the Utrechtse Heuvelrug, it is generally:**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Empty	7	10,8	10,8	10,8
	Slightly filled	9	13,8	13,8	24,6
	Half full	29	44,6	44,6	69,2
	Almost full	10	15,4	15,4	84,6
	Full	10	15,4	15,4	100,0
	Total	65	100,0	100,0	

Table 9: Response statistics for question six

Column charts for the response distribution of different age groups to questions 3 to 6.

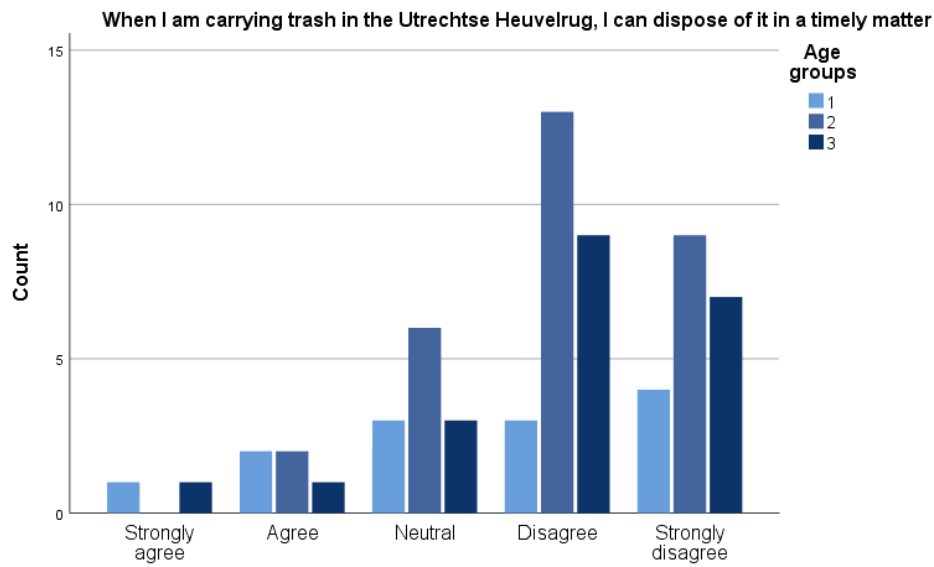


Figure 13: Column chart with responses to question three

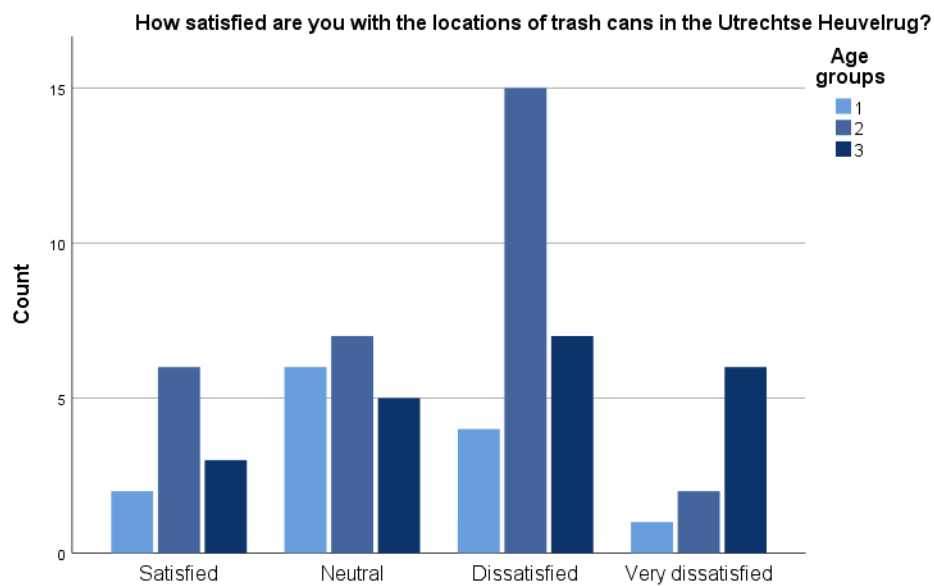


Figure 14: Column chart with responses to question four

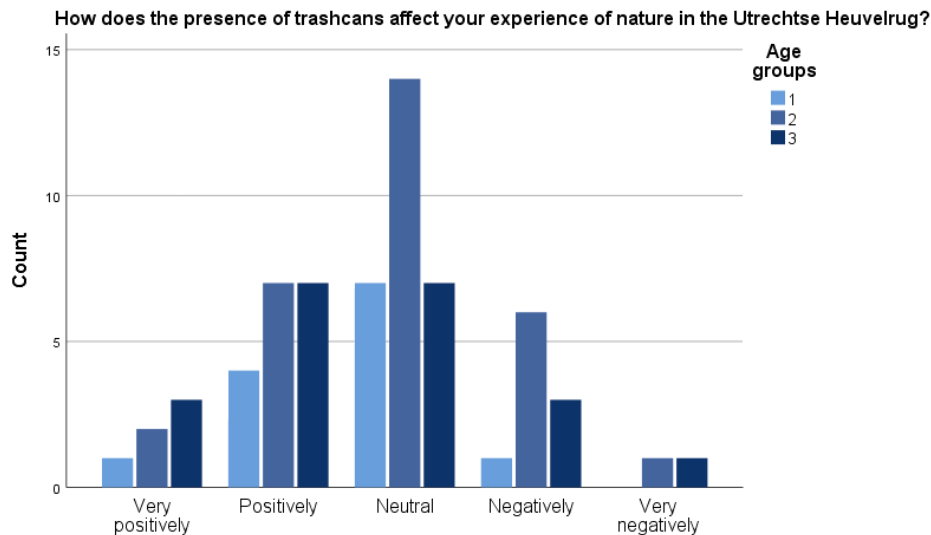


Figure 15: Column chart with responses to question five

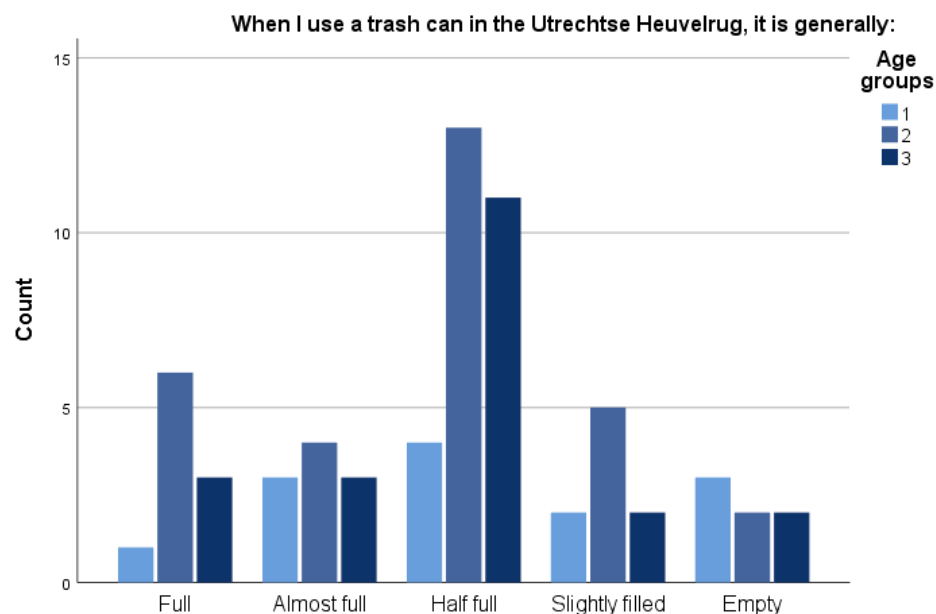


Figure 16: Column chart with responses to question six

## Part B

### Data management plan

When people inquired about what would happen with their answers, the following response was given:

English:

You will remain anonymous after filling in this survey; the data cannot be linked back to you. The data that has been collected will be saved in a secure server of Utrecht University which cannot be accessed by anyone except for the students who have conducted the survey. The results of the survey may be published by Stichting Utrechtse Heuvelrug or other related organisations, but you will remain anonymous if this happens.



Dutch:

U zult anoniem blijven na het invullen van deze vragenlijst en de verzamelde data kan niet met u in verband worden gebracht. Deze data zullen veilig op een server van de Universiteit Utrecht opgeslagen worden waar alleen de studenten die de vragenlijst uitgedeeld hebben toegang tot zullen hebben. De resultaten van de vragenlijst kunnen gepubliceerd worden door Stichting Utrechtse Heuvelrug of andere gerelateerde instanties, maar in dit geval zullen uw gegevens nog steeds anoniem blijven.