

Rheinische Friedrich-Wilhelms-Universität Bonn  
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# **Applying an adjusted Cultural Ecosystem Services concept on spatiotemporal perception and non-material usage patterns of Urban Green Spaces**

## **A social media data analysis on the example of Bonn**

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# 1 Introduction

The common understanding of nature is that without doubt it's somewhat important to humans. There appears to be some quality of nature, something that can happen only there almost exclusively between humans and nature. Scientifically, it contributes to the physical, mental/psychological and social well-being (CLABEN & BUNZ 2018, HAMSTEAD et al. 2018, JOHNSON et al. 2019) which in turn makes it important for urban and park planning/management, policy-making and active marketing strategies (EUROPEAN COMISSION 2013, LEE et al. 2015, DAI et al. 2019, JOHNSON et al. 2019).

But how can we access these hidden qualities of nature? How can one unbox the common blackbox of nature and look deeply into it?

Cultural ecosystem services (CES) – the “[...] nonmaterial benefits people obtain from ecosystems [...]” (MILLENNIUM ECOSYSTEM ASSESSMENT (MEA) 2005: 40) – provide a commonly used conceptual framework for the analysis of urban green spaces (UGS). Their mapping is politically intended (EUROPEAN COMISSION 2013) due to its known benefits to human well-being and the ascertained degradation of CES by MEA (2005: 6). Different – rather conservative – methods have been applied to investigate the CES that UGS provide around the globe. Recent research projects, however, have led to a few combinations with social media data as an additional and alternative methodological approach, though the number of studies is relatively scarce: “While other researchers have been attuned to the advantages of big data in social science research, researchers in landscape architecture and urban planning rarely use big data analytics” (SIM & MILLER 2019) albeit “[social media] content can show us the ways that people enjoy and value these locations [UGS]” (SONG et al. 2020: 813). The few studies which have utilized a combination of UGS, CES(-based) concepts and social media have so far been done only outside of the European mainland, especially in the context of UK, New York City and Southeast Asia. An exhaustive knowledge on this topic is however reasonable, since “a comparison of urban greenspaces across countries could illuminate whether [...] social aspects of urban greenspace are specific to a particular park or are universally present” (JOHNSON et al. 2019: 6151). This study aims to contribute towards closing this research gap. By examining perception and non-material usage patterns of Bonn’s UGS using social media data and an adjusted CES-concept, it is the first of its kind in central Europe and especially in the German-speaking area. The city of Bonn is home to and therefore well known by the researchers and offers a heterogeneous compilation of UGS, varying greatly in size, location and provision of facilities. Hence, the UGS of Bonn offer a suitable area of investigation for a first approach towards bringing social media-based research on CES in an urban green context to Europe.

That said, the research question to be answered is: which perception and non-material usage patterns are conveyed on Instagram within the city of Bonn?

For this purpose of investigation, approximately 16,000 geo-tagged Instagram hashtags for the entire Instagram lifespan from 2010 to 2019 were mined, classified in two respects into perception and non-material usage categories (PNUCs) and analyzed for each UGS in Bonn on the one hand. Grounded

theory served in this process of categorizing posts using a steadily developed and a necessarily adjusted concept of CES which goes beyond benefits comprising well-being effects. On the other hand, the same data was used to conduct a sentiment analysis (SA), investigating the user's sentiments (positive, neutral and negative) towards each of the UGS in Bonn. By doing so, the objective of this study was to provide a precise inventory of spatiotemporal perception and non-material usage patterns of the UGS in Bonn that are conveyed on Instagram. Simultaneously, the study aimed at introducing a methodological approach that fulfills the needs to investigate the heterogeneity of UGS in Bonn.

A first meeting in September 2020 with members of the UGS department of the municipality of Bonn ("Amt für Stadtgrün") showed, that the results of this study can be of great value to the city. They offer practical inputs for future urban planning, management and marketing strategies, possibly promoting developments towards a more well-being focused and sustainable city, suited to the citizen's needs and demands. A high applicability as such has not been subject to many of the studies within this field of research. Here, we pioneered a reproducible application-oriented methodological approach which is cost-effective, fast, extensive and time-independent and which simultaneously contributes towards the understanding of the complexity of spatiotemporal perceptions and non-material usage patterns in UGS.

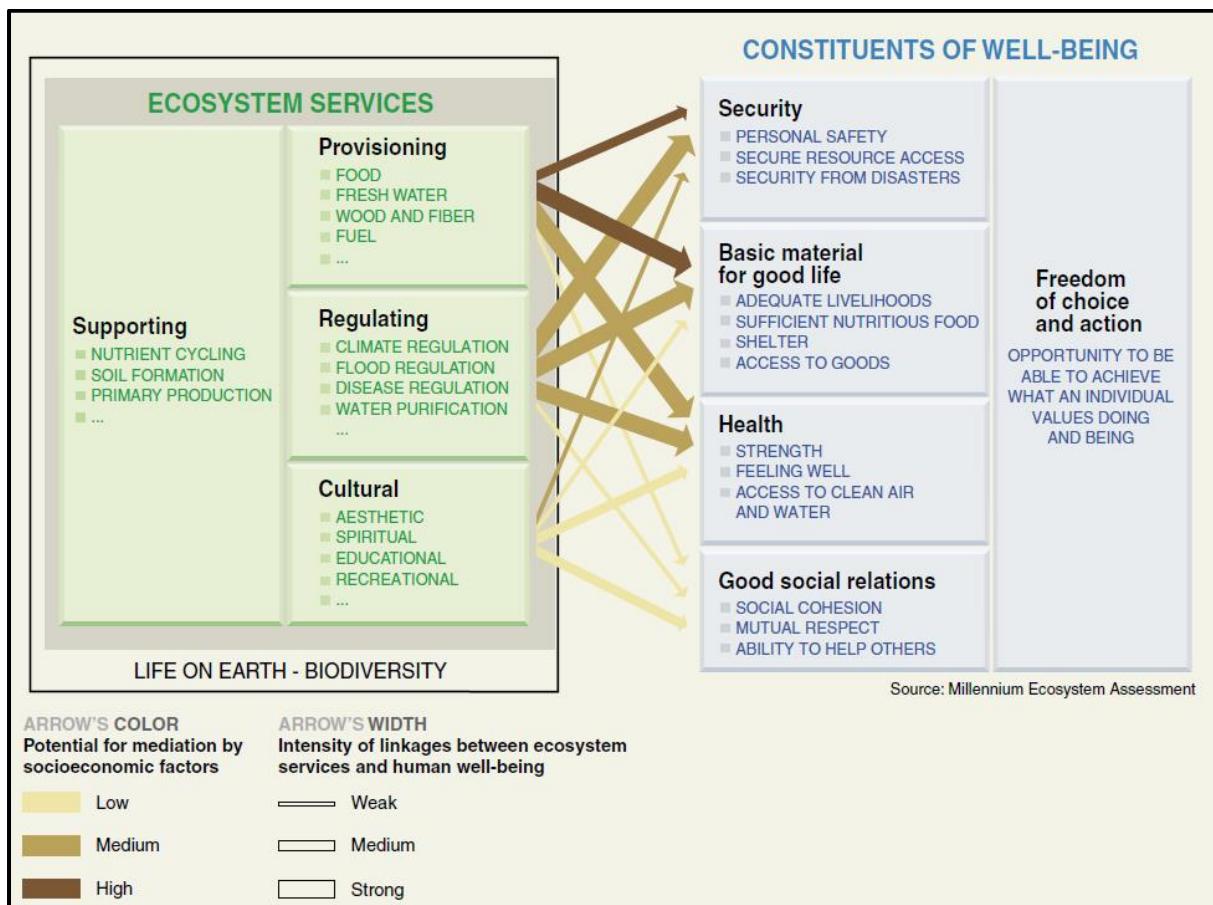
## 2 State of the art

### 2.1 Urban Green Spaces

UGS are "public and private open spaces in urban areas, primarily covered by vegetation, which are directly (e.g. active or passive recreation) or indirectly (e.g. positive influence on the urban environment) available for the users" (HAQ 2011: 601). They may include "parks and reserves, sporting fields, riparian areas like stream and river banks, greenways and trails, community gardens, street trees, and nature conservation areas, as well as less conventional spaces such as green walls, green alleyways, and cemeteries" (WOLCH et al. 2014: 234). UGS may provide non-material benefits to their users and thereby positively influencing their well-being, a matter recently being picked up in research by using social media data as an alternative data basis. CES provide a commonly used conceptual framework for the analysis of the non-material benefits people obtain from UGS. However, benefits from UGS do not necessarily stay within the scopes of well-being and the CES concept within UGS may not comprise all benefits that city dwellers obtain. For this reason, the following chapters will not only include an introduction to the advantages of the CES concept and well-being within the context of research on UGS. They will also address the critique on using the CES concept for research on UGS and their contribution to the well-being given in research to date. On this basis we give an overview of literature that justifies our idea of perception and non-material usage patterns.

## 2.2 The CES concept

CES are defined by MEA (2005) as the “[...] nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences [...]” (40) as one category of ecosystem services providing the basis for well-being next to “Provisioning Services”, “Regulating Services” and “Supporting Services” – see [Figure 1](#). These are subdivided again into 10 categories that are defined as illustrated in [Table 1](#).



**Figure 1: Linkages between Ecosystem Services and Human Well-Being (MEA 2005: 50)**

**Table 1: CES and their definitions by MEA (2005: 40)**

| CES                                   | Definition   |
|---------------------------------------|--|
| <b>Cultural diversity</b>             | The diversity of ecosystems is one factor influencing the diversity of cultures  |
| <b>Spiritual and religious values</b> | Many religions attach spiritual and religious values to ecosystems or their components.  |
| <b>Knowledge systems</b>              | Ecosystems influence the types of knowledge systems developed by different cultures  |
| <b>Educational values</b>             | Ecosystems and their components and processes provide the basis for both formal and informal education in many societies   |
| <b>Inspiration</b>                    | Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising   |
| <b>Aesthetic values</b>               | Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing location   |
| <b>Social relations</b>               | Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies |
| <b>Sense of place</b>                 | Many people value the “sense of place” that is associated with recognized features of their environment, including aspects of the ecosystem  |
| <b>Cultural heritage</b>              | Many societies place high value on the maintenance of either historically important landscapes (“cultural landscapes”) or culturally significant species   |
| <b>Recreation and ecotourism</b>      | People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area  |

CES are regarded as the intangible effects of ecosystems to people (see MILCU et al. 2013), which embody one basis for human well-being, with differing intensities stemming only from the ecosystem side – see [Figure 1](#). With the ascertained degrade of approximately 70% of CES worldwide (MEA 2005: 6) a mapping of CES is necessary due to its important practical implications for urban, spatial and political planning (EUROPEAN COMISSION 2013, EUROPEAN ENVIRONMENT AGENCY 2014). However, there are methodological troubles: “The particularities of intangibility, subjectivity and lack of standardized assessment methods that characterize many CES [...]” (LANGEMEYER et al. 2018: 542) make them difficult to be mapped and quantified (see DANIEL et al. 2012, MILCU et al. 2013, SCHRÖTER et al. 2014, UN 2014, as cited in LANGENMEYER et al. 2018: 542). Consequently, the CES concept gained attention to capture and categorize individual perceptions and usages of human environment on the human-environment interface (e.g. PTOCK 2016, OTEROS-ROZAS et al. 2018, JOHNSON et al. 2019, DAI et al. 2019, ROSSI et al. 2020). The CES influences on well-being and an idea of its application in human-environmental studies will be briefly outlined.

## 2.3 Well-Being within the context of UGS

The non-material benefits that CES provide are important for the experience and relationship of city dwellers to nature (DICKINSON & HOBBS 2017). The MEA (2005) defines well-being as “the basic material needs for a good life, health, good social relations, security, and freedom of choice and action” (49). To date, more than half of the world’s population lives in urban areas, with tendencies rising (UNITED NATIONS 2018). However, urban areas may put human health at risk (MOORE et al. 2003), as they reduce biodiversity (BUCZKOWSKI & RICHMOND 2012) and tend to isolate people from experiencing nature (MILLER 2005). Contrarily, city dwellers increasingly seek natural environments to relieve stress (FRUMKIN 2001) and numerous studies indicate the positive effects UGS can have on people (see JAMES et al. 2015 for a synthesis paper). Interactions with nature and the physical environment have been identified to enhance well-being (SUMMERS et al. 2012) and even are one of its main components (SMITH et al. 2013).

Already in the 1980s, research engaged with the restorative influences of natural environments. ULRICH (1984) describes how patients overlooking trees from their hospital window experienced more rapid recovery than those looking at a brick wall. KAPLAN (1984) suggests a framework for interpreting the role of urban nature and depicts its beneficial psychological processes. Especially since the turn of the millennium, the beneficial aspects of natural environments and their implementations on city planning guidelines are part of UGS (SHANAHAN et al. 2015, CLAßEN 2018). Generally, the effects of UGS may either be health-protective or health-building (CLAßEN 2018). Health-protective aspects may include protection from air pollution and noise, and the support of a well-balanced climate in urban areas (CLAßEN & VÖLKER 2015). Health-building aspects include psychological, physical and social benefits (CLAßEN 2018).

*Psychological well-being:* The Psychological well-being of people is linked to positive emotional bonds towards nature, a sense of identity, and enabling reflection and regeneration from mental fatigue (PROSHANSKY et al. 1983, KAPLAN & KAPLAN 1989). An overview of numerous studies depicting the (generally) positive effects of UGS on various mental health problems is given by GASCON et al. (2015).

*Physical well-being:* UGS may decrease stress-levels (HARTIG et al. 2003, BOWLER et al. 2010), reduce mortality (RICHARDSON & MITCHELL 2010) and obesity (ELLAWAY et al. 2005), increase life expectancy (TAKANO et al. 2002) and encourage physical activity (e.g. PIKORA et al. 2003). A study by FRANK et al. (2004) found UGS to be used as alternative traffic route, while the majority of questioned city dwellers actively visit UGS for physical activity.

*Social well-being* UGS may function as meeting places and systems of social environment, opening the possibility for developing and maintaining social contacts. Urban parks can function as gathering spots for people of different social groups (e.g. age, gender and ethnicity) and hold potential for social integration and inclusion (STROHMEIEF & ULRICH 2007).

The interactions people have with nature and the positive effects that may derive from such interactions are diverse. Ultimately, it is an interplay of environmental cues together with other factors such as

weather, types of activity, group dynamics and observations the proceedings around an individual that shape the overall experience and well-being aspects in an UGS (ULRICH 1993, ROBERTS et al. 2018).

## **2.4 UGS, CES and social media in human-environmental studies**

Traditionally, these human-environmental interactions were and still are analyzed by classic methods, e.g. survey or interview methods. With the appearance of the internet and especially social media platforms, a new data basis emerged that was used and still is also by spatial sciences for investigating human-environmental interactions (e.g. DUNKEL 2015, OTEROS-ROZAS et al. 2018, ROSSI et al. 2019, BARROS et al. 2020), including those taking place in UGS. First studies of the latter varied, mainly due to the novelty of the data basis and the therefore explorative approaches, extremely regarding their purposes – categorization of parks (KOVACS-GYÖRI et al. 2018), park usage (ROBERTS et al. 2017, PLUNZ et al. 2019, SIM & MILLER 2019, SONG et al. 2020) and their visitors (KOVACS-GYÖRI et al. 2018, SONG et al. 2020), perception and sentiment patterns (PLUNZ et al. 2019), event screening (ROBERTS 2017), methodological comparison (BRINDLEY et al. 2019, ROBERTS et al. 2018), potential analysis of social media data as an instant frequency indicator (HAMSTEAD et al. 2018) – as well as the examined social media platforms – “Flickr”, “Twitter”, “Panoramio” or “Instagram”. Some of the studies employed CES(-based) concepts – traditionally applied in connection with classic methodological approaches (e.g. PTOCK 2016) – also on the basis of social media data which revealed a promising approach of classifying and quantifying human-environmental interactions in the first instance. By analyzing Twitter data posted in Prospect Park, Brooklyn, New York City, JOHNSON et al. (2019) “[...] found that all CES were to some extent elicited through tweets, demonstrating that text-based social media content can be used to elicit CES presence and abundance in urban parks” (6149). Moreover, “Social relations” and “Recreation” were the most frequent CES whereas “Education” and “Knowledge systems” had the lowest amounts (ib.: 6145). Different CES category shares were found by DAI et al. (2019) who studied on the basis of Chinese travelling platform data urban parks in Xuzhou, China in which “Cultural heritage”, “Aesthetic” and “Recreation” were the most frequent ones (5396). In contrast to JOHNSON et al. (2019), DAI et al. (2019) made use of a modified categorization scheme based both on the CES concept and on the actual park usages so that only “Aesthetic”, “Recreation”, “Sports”, “Inspiration”, “Education”, “Cultural Heritage” and “Spiritual satisfaction” were identified and applied (5391). Furthermore, they detected several cross-UGS correlations between CES categories (ib.: 5394). On the basis of Twitter data, parks in Birmingham, UK were examined in two studies that dedicated themselves more precisely to single or partial aspects, respectively, of the CES: As for “Sports”, ROBERTS et al. (2017) show i. a. seasonal, daytime and weather dependent differences in the usage for physical activities whereas ROBERTS et al. (2017) revealed the possibility of acquiring broad information concerning events taking place in UGS.

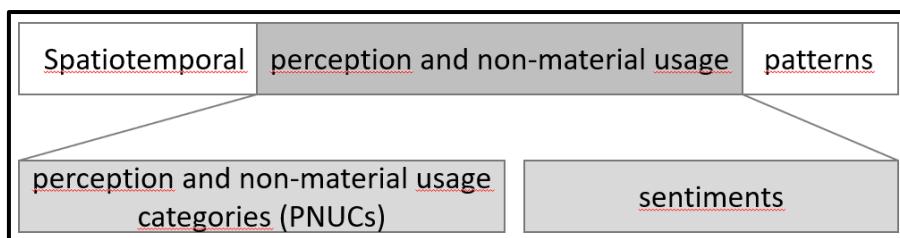
## 2.5 Critique, challenges and adjustment of the CES concept

Despite numerous studies using the CES concept as a framework within UGS research (including traditional as well as first research approaches utilizing social media data) there are certain limitations to its measurability and applicability. Starting off with unclear definitions of the concept due to various ways that human-environment relations can be conceptualized, it can also be argued that the concept is prone to intangibility and incommensurability (DICKINSON & HOBBS 2017). For instance, immaterial CES categories such as “sense of place”, “inspiration” or “knowledge” are benefits which are hard to measure and thereby intangible (SATTERFIELD 2013). Questions which may also arise, are whether the choice of words themselves (“cultural”, “ecosystem”, “services”) and the associations with them provide an appropriate idea of which contents exactly the CES concept means to conceive (DICKINSON & HOBBS 2017). The term “culture” is a multifaceted term that is not necessarily measurable in discrete static values (SATTERFIELD 2013). Concerning the term “ecosystem services”, “services” tend to imply an economic connotation, leaving out human-environment interactions such as “spiritual/religious” that actually are a category of the CES concept (KULL et al. 2015). Also: what constitutes a service? It is argued, that the pathway leading from the biophysical environment to the human well-being via an ecosystem service can be interpreted and thereby conceptualized differently (DICKINSON & HOBBS 2017). FISH et al. (2016: 211) argue that CES are not “[...] a priori products of nature that people utilize for a particular benefit to well-being [as Figure 1 could possibly suggest] but rather as relational processes and entities that people actively create and express through interactions with ecosystems”. This becomes especially relevant within the urban context, since UGS are “deeply situated in the functioning of society” (HAASE et al. 2014: 407). The researchers therefore repeal the assumption that well-being effects by UGS may only be reached through factors solely coming from ecosystems themselves and expand the concept with possible interactions between the ecosystem and the human realm. Their definition bases on deliberations by CHAN et al. (2011: 207) who reason that CES are co-produced by people and environment by feedback mechanisms in the human-environment relation. This human-environment co-production is further divided by socio-cultural and demographic feature of cities, the biophysical attributes of UGS as well as the personal characteristics of the observers of UGS (e.g. held values, socio-economic background, gender, age, personal experience, behavior and judgement) (GEE & BURKHARD 2010, ANDERSSON et al. 2015, DE LANGE et al. 2016, KREMER et al., 2016, VAN ZANTEN et al. 2016). A specific urban park (here considered as the ecosystem’s side) does not simply emerge out of nothing and evokes perceptions to it. It rather develops CES with society (here considered as the human realm) that attach feelings and values to it by using, creating and modifying it. An example is the “[...] important role [of CES] in motivating public support for protection of ecosystems” (DANIEL et al. 2012: 8817) being “[...] fundamental for conservation policies and civic engagement in environmental stewardship” (ANDERSSON et al. 2014 as cited in LANGEMEYER et al. 2018). People can influence their own perceptions of ecosystems, e.g. by using UGS as a spatial platform for environmental protests – e.g. the current Fridays For Future demonstrations – resulting in changed

perceptions and raised awareness of the same UGS. Consequently, the CES concept should be adjusted regarding bilateral interactions between the human and ecosystem realm as well as the assumed character that it leads not only to social well-being in the form of benefits but rather provokes human actions that try to raise awareness for deficiencies of the provision of a fundament for social well-being. The pivotal element of the formerly mentioned studies criticizing CES is the insufficiency of CES categories. Crucial to this criticism is the argument of FISH et al. (2016: 211) who argue for the necessity of a redefinition of CES as relational processes instead of a priori existent services. UGS in the context of CES suddenly fall short of fundamental services not covered yet by the common concept of CES. DAI et al. (2019) proposed an original adjustment to CES by slowly developing and checking CES against the Instagram data in data-analysis-categorization-cycles based on grounded theory. This approach will be picked up in this study, meaning that through sighting and categorizing the data the CES will be adjusted and categories added to those already present in the CES concept if necessary. For instance, a first sighting of our data – as depicted more precisely below in chapter 4 – illustrate the “Fridays For Future” (FFF) movement as considerably present in “Hofgarten”. This indicated that the CES lack to include political services of UGS which are in fact necessary within the scopes of this particular study and emphasized that further categories may need to be arranged throughout research.

### 3 Methodological framework

Hence, due to the here necessary considered openness and adjustment of the CES concept and its categories, we did not ask for spatiotemporal distributions of CES categories but for spatiotemporal patterns of “perception and non-material usage” as a more open and more general expression that, on the one hand, still excludes provisioning, regulating and supporting services of ecosystems – see chapter 2.2 – and – on the other hand – contains the possibility to study people’s sentiments in addition. Against this background, we differentiated “perception and non-material usage” into “perception and non-material usage categories (PNUCs)” and “sentiments” – see Figure 2. Thus, we separately investigated spatiotemporal patterns of PNUCs and sentiments that together answer the question of spatiotemporal perception and non-material usage patterns.

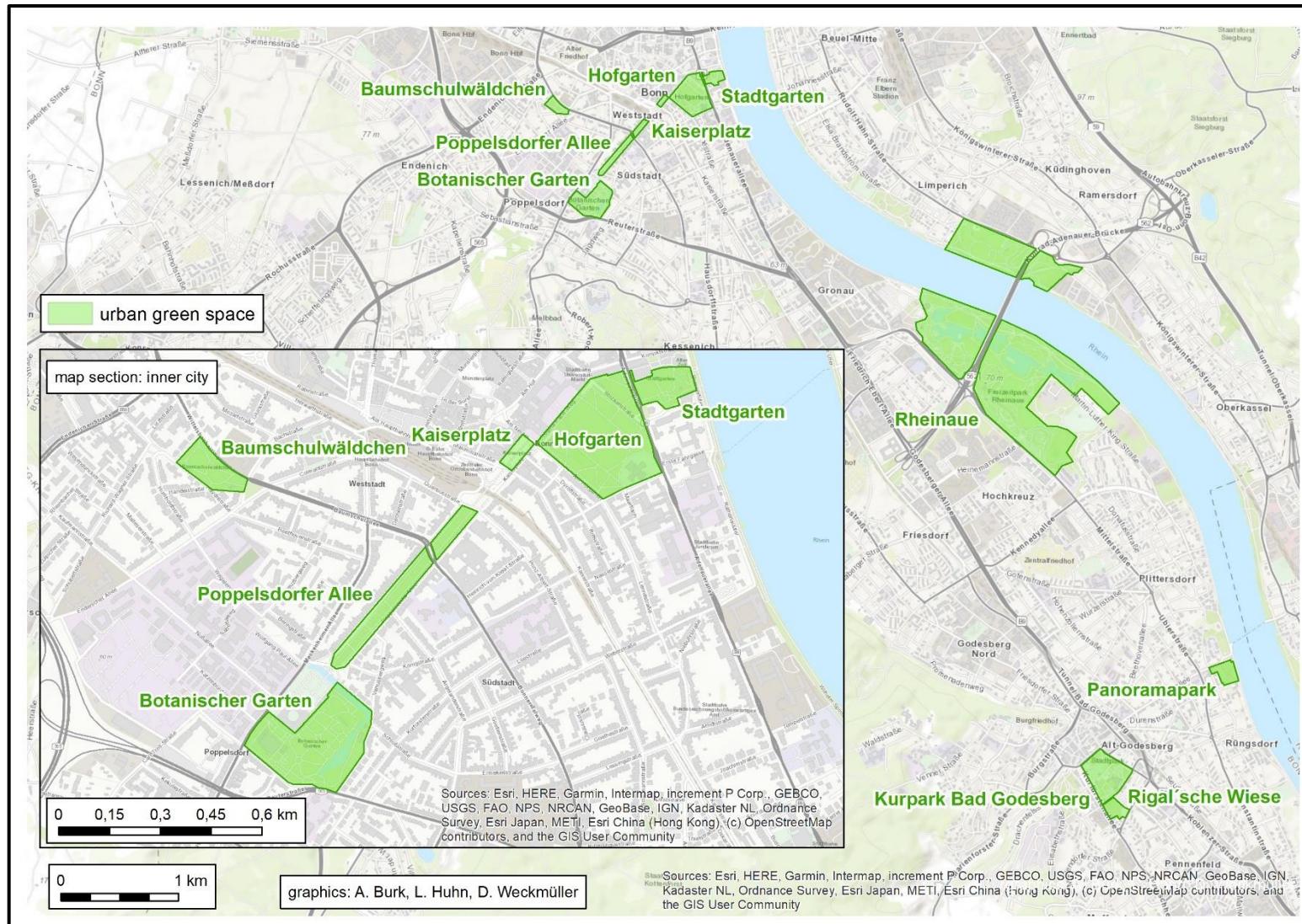


**Figure 2: spatiotemporal perception and non-material usage patterns**

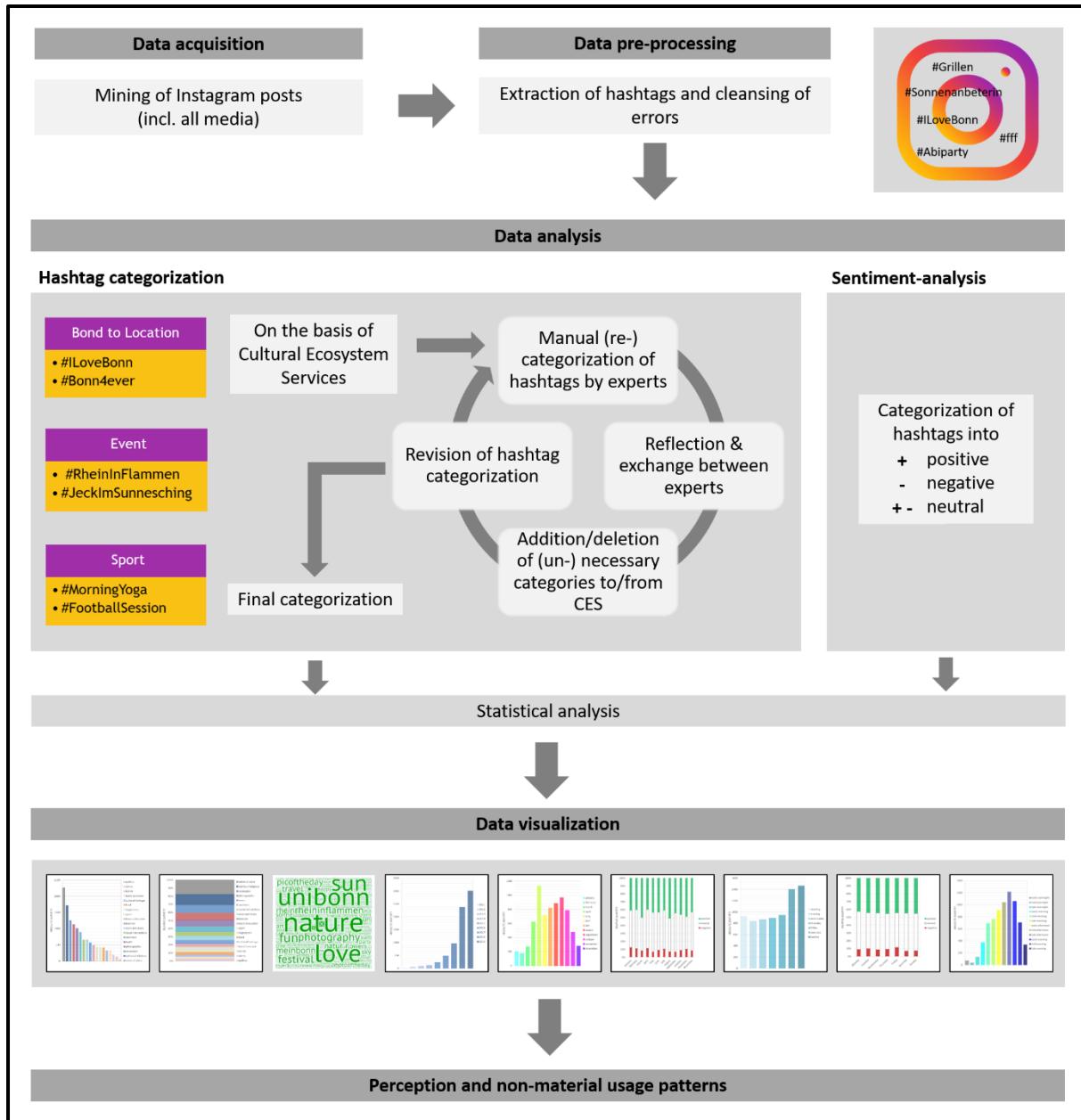
### **3.1 Study sites and study period**

In the first step, potential study sites were detected in the land use plan of the city of Bonn out of which marked green spaces were extracted. In the second step, it was checked whether they possessed any so called “location tag” on Instagram – a reference to a certain place in the city, i.e. “Hofgarten”. If so, the site was taken unless it suggested any form of usage in order to ensure comparability and to avoid contortions regarding usage categories. Hence, location tags like “Biergarten am Alten Zoll” (e.g. “Food” – see chapter 3.3) or “Poppelsdorfer Schloss“ (e.g. “Cultural heritage”) were eliminated. For sites with more than one location tag only the one with most posts was chosen. This consecutive selection resulted in ten study sites, namely Baumschulwäldchen, Botanischer Garten, Hofgarten, Kaiserplatz, Kurpark Bad Godesberg, Panoramapark, Poppelsdorfer Allee, Rheinaue, Rigal’sche Wiese and Stadtgarten – see [Figure 3](#).

The entire Instagram lifespan from 2010 up to 2019 was chosen as the study period in order to obtain a large database for broad statistical analysis possibilities with the necessary statistical validity.



**Figure 3:** map of study sites



**Figure 4: methodological workflow**

### 3.2 Data mining and cleansing

Initially, the data was mined and checked via different Python scripts and packages made available online (see INSTAGREENS-BONN 2020) – for a complete overview of the methodological proceeding see Figure 4. As Instagram is selling access to their users' data via a commercial API this step is not trivial. However, as the data are publicly available there are Python packages such as “Instagram-Scraper” (ARCEGA 2013) being able to scrape the necessary data for given location ID's (e.g. Hofgarten: <https://www.instagram.com/explore/locations/648779/>). With the help of this Python package it is possible to mine all Instagram posts including media, such as pictures and videos as well as metadata,

such as timestamps, texts and hashtags. In particular the latter will be of interest for this study. Due to privacy laws we were not allowed to make use of the respective pictures.

Data cleansing in this step is of utmost importance as even though Instagram-Scraper tries to mine as cleanly as possible, errors such as not finding all hashtags in a users' post are very common and needed to be corrected with self-written scripts.

### **3.3 PNUC categorization**

As former research has shown, social media data prove to be of a particular quality for investigating CES in the context of UGS. Hence this study will focus on Instagram as one of the world's largest social media platforms. The aim was to figure out whether different services based on CES can be identified through the users' posts in different UGS by using grounded theory as already proved suitable in other studies (see STÅLHAMMAR & PEDERSEN 2017).

The main challenge was to develop a suitable categorization scheme for analysis which on the one hand was comparable to other studies and on the other hand was fitted to Bonn's UGS. These categories served as base for a systematical hashtag categorization and statistical analysis. For this step we made use of a hermeneutical technique common in the context of qualitative social media data analysis of online communities, so called "netnography" (see KOZINETS 1998). KOZINETS et al. (2014) sum it up as "the notion of hermeneutics, where larger order conceptual readings are garnered from readings of the parts of the text in light of the text as a whole" (270).

Technically, after extracting all unique hashtags every team member went through 1000 hashtags (representing the formerly mentioned part of the whole hashtag list), classified them into CES and if suitable a tentative second preliminary category in the literal sense of grounded theory "from the ground up" (GRUBER & HOLSTEIN 2014: 36). For example, the hashtag "#familyMeeting" would be assigned to "social relations". Here one could add the second preliminary category "family". In this particular case, many hashtags could be assigned to "family", so this category proved suitable. The hermeneutical approach came into play when we refined the final categories since after every iteration (approximately 1000 hashtags) we discussed each individual's preliminary categories in a team meeting and whenever needed redefined, newly introduced, combined or deleted categories until we obtained a final unique PNUC scheme for Bonn's UGS and could eventually reassigned all hashtags to the now well-defined and tested final PNUC. A list with our final 18 different PNUC in relation to CES and other researcher's definitions can be found in [Table 2](#).

Table 2: PNUCs, CES, definitions and hashtags

| CES                          | CES definition MEA 2005  | Definition Johnson et al. 2019   | Definition Dai et al. 2019                       | PNUC                | Definition   | Hashtag examples   |
|------------------------------|--|--|--|---------------------|--|--|
| Cultural diversity           | The diversity of ecosystems is one factor influencing the diversity of cultures  | referring to cultural events and gatherings, such as concerts, dance performances and cultural festivals occurring in public greenspace  | -  | event               | non-political public cultural events   | #rheininflammen, #karneval, #90erparty, #bthvn2020, #ballonfestival2018          |
|                              |  |  |  | demo                | political events raising awareness to "well-being" deficiencies  | #fridaysforfuture, #climatestrike, #studentsforfuture, #proeurope, #criticalmass |
| Spiritual & religious values | Many religions attach spiritual and religious values to ecosystems or their components.  | referring to refuge, solitude, and spiritual and religious experiences   | People's pleasurable mood in the park            | spiritual/religious | people's states of mind, spiritual/religious activities and attachments as well as personal attitudes, values, ideas and expressions regarding way of life | #love, #goodfeeling, #happyme, #passion, #weekenvibes                            |
|                              |  |  |  | politics            | political opinions and activities besides demonstrations   | #europawahl, #weltflüchtlingstag, #lgbtq, #europamachen, #gretathunberg          |
|                              |  |  |  | bond to location    | people's bond to location  | #meinbonn, #bonnlove, #zuhause, #verliebtinbonn, #wahlheimat                     |
|                              |  |  |  | bond to nature      | people's bond to nature or ecosystem features  | #naturelover, #plantsarefriends, #animallove, #flora_addict, #treelove           |
| Knowledge systems            | Ecosystems influence the types of knowledge systems developed by different cultures  | referring to drawing upon a body of knowledge  | Park broadens people's knowledge                 | -                   | -  | -  |
| Educational values           | Ecosystems and their components and processes provide the basis for both formal and informal education in many societies   | referring to educational events or educational groups  | -  | -                   | -  | -  |
| Inspiration                  | Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising   | referring to creating or being inspired by what is observed in the Park (natural features, built features such as architecture and sculpture, and/or cultural interactions and events) | Park provides material for artistic creation     | photography         | photography as a creative activity   | #photography, #meinsommerfoto, #naturephotography, #analog, #flowersphotography  |
|                              |  |  |  | inspiration         | people's residual creative activities based on inspiration evoked by ecosystem features  | #creative, #pencildrawing, #poetry, #sketching, #schreiben                       |
| Aesthetic values             | Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing location   | referring to views, beauty, or other visual aspects of urban greenspace  | Beautiful natural landscape of park              | aesthetic           | people's perceptions of the environment expressed by beauty, visual and aesthetic related terms  | #green, #fallcolors, #farbenspiel, #goldenerherbst, #wunderschön                 |
| Social relations             | Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies | referring to social interactions   | -  | family              | interactions/activites between family members  | #family, #familytime, #elternzeit, #mommylife, #bruderundschwester               |
|                              |  |  |  | social interactions | residual social interactions   | #friends, #freundinnenzeit, #friendsdayout, #lieblingsmensch, #besties           |
| Sense of place               | Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem  | referring to interactions with specific places, animals or plants, or natural or built features  | -  | sense of place      | recognition of natural, particular ecosystem and non-historic built features   | #sun, #seerose, #puddle, #schwäne, #libelle                                      |
| Cultural heritage            | Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species   | referring to park history or popular cultural experiences in the park  | Preservation of historical and cultural heritage | cultural heritage   | recognition of particular historic and cultural important features of the environment  | #poppeldorferschloss, #beethovenstatue, #posttower, #kreuzkirche, #löffelwald    |
| Recreation and ecotourism    | People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area  | referring to nature or sports-based recreation   | Park provides sports venues and facilities       | sports              | physical activities/sport  | #workout, #parkrun, #outdooryoga, #outdoorfitness, #skate                        |
|                              |  |  |  | food                | food and drinks  | #muffins, #lecker, #kaffe, #wurst, #melone                                       |
|                              |  |  | Park offers tours and relaxing places            | tourism             | tourism and travelling   | #bonntravel, #discoverbonn, #travels, #reisenistschön, #citytour                 |
|                              |  |  |  | recreation          | residual recreational activities   | #relax, #walk, #urlaub, #chillen, #abschalten                                    |
|                              |  |  |  | work & study        | work & study related activities  | #study, #studium, #business, #workinghard, #lernen                               |

### **3.4 Sentiment analysis**

In addition to the CES-based categorization we investigated the sentiment and emotions individuals have towards UGS in Bonn. By applying a SA, got a deeper and clearer view of how city dwellers relate to UGS. How do people respond to UGS in Bonn? What opinions do they have about these places and how are these opinions underpinned by emotions? Generally, a SA is concerned with the analysis of opinions, attitudes and emotions that individuals have towards specific entities (e.g. products, organizations, events and services) (LIU 2012: 7). Having been a common method in the field of politics, business, economics and healthcare this method has also been used within the context of UGS before (see e.g. KOVACS-GYÖRI et al. 2018, ROBERTS et al. 2018, ROBERTS et al. 2019). A post can be categorized as rather positive, neutral or negative. Due to the nature of SA and its systematic approach which cannot be explained in further detail (for a state-of-the art introduction see LIU (2012)) an important particularity needs to be dealt with. Negatively classified text might not only include typical “negative” emotions such as anger, fury or sadness but also nostalgia, melancholy or wistfulness. Not going to much in detail this could pose problems when text is classified as negative but the meaning is positive. For example, “I suffer so much because I cannot be in Bonn anymore” is hence to be interpreted with care. Negatively classified posts could therefore theoretically have the opposite meaning. Overlooking SA results manually this rarely happened and still falls under a general acceptable error quota.

Having to deal with unsorted and unclassified data, an appropriate SA method was to be chosen. Unfortunately, most available engines for languages other than English such as “textblob-de” for German (LORIA 2020a) are less developed (BALAHUR & TURCHI 2014: 56) and as we can confirm on our data show poor results. Thus, we needed to rely on a well-developed and approved SA algorithm, here “textblob” (LORIA 2020b). The challenge was to make sure that the posts were translated correctly without losing or even misunderstanding their original intention. For this step we counterchecked the SA results for two different AI-powered translation engines, DeepL Translator (DEEPL 2020) and Google Translator (GOOGLE 2020) as they were freely accessible and overall delivered good translations. This method is common in SA and is considered methodologically legitimate as AI-powered translation engines “[...] have reached a reasonable level of maturity [...]” (ib.: 69). Verifying the results manually we improved the results and assured a higher quality translation as an accurate text basis for SA.

### 3.5 Statistical analysis

**Table 3: Variables and possible values of posts**

| Variable                   | Possible values  |
|----------------------------|--|
| <b>UGS</b>                 | Baumschulwäldchen; Botanischer Garten; Hofgarten; Kaiserplatz; Kurpark Bad Godesberg; Panoramapark; Poppelsdorfer Allee; Rheinaue; Rigal'sche Wiese; Stadtgarten                   |
| <b>PNUC aesthetic</b>      | 0, 1   |
| <b>PNUC ...</b>            | 0, 1   |
| <b>PNUC work and study</b> | 0, 1   |
| <b>Sentiment</b>           | negative; neutral; positive  |
| <b>Year</b>                | 2011; 2012; ... 2019   |
| <b>Month</b>               | january; ... december  |
| <b>Weekday</b>             | monday; ... sunday   |
| <b>Daytime</b>             | early overnight, mid overnight; late overnight; early morning; mid morning; late morning; early afternoon; mid afternoon; late afternoon; early evening; mid evening; late evening |

Table 3 shows a synopsis of variables and possible values of the posts which either already possessed a nominal scale of measurement or which were allowed to be treated (year) or to be classified (daytime) to a nominal scale (see MÜLLER-BENEDICT 2011: 31ff). Since posts could feature multiple PNUCs, each PNUC was handled as a single variable and their values were dichotomized as follows: 1 = having the respective PNUC – no matter how often –; 0 = not having the respective PNUC (see MÜLLER-BENEDICT 2011: 77). On the basis of frequencies of values and value combinations – besides the representation of absolute and relative frequencies within a variable –, chi-square tests as statistical tests for both equal distribution and independence between variables could be performed as well as correlations (see HEDDERICH & SACHS 2018: 479ff and ARRENBERG 2019: 239ff; BEHR 2019: 146ff). Absolute and relative frequencies were calculated for:

- a) PNUCs and
- b) sentiments

**Table 4: fictive examples of variable combinations**

| fictive example A |                  |         |           |          |        |          |        |
|-------------------|------------------|---------|-----------|----------|--------|----------|--------|
|                   | Monday           | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| <b>positive</b>   | 5                | 5       | 7         | 11       | 5      | 8        | 9      |
| <b>neutral</b>    | 4                | 5       | 5         | 4        | 3      | 7        | 7      |
| <b>negative</b>   | 0                | 7       | 1         | 2        | 5      | 6        | 2      |
|                   |                  |         |           |          |        |          |        |
| fictive example B |                  |         |           |          |        |          |        |
|                   | Monday           | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| <b>positive</b>   | 5                | 5       | 7         | 11       | 5      | 8        | 9      |
| <b>neutral</b>    | 7                | 5       | 5         | 5        | 7      | 7        | 7      |
| <b>negative</b>   | 5                | 7       | 5         | 6        | 5      | 6        | 6      |
|                   |                  |         |           |          |        |          |        |
|                   | post amount < 5  |         |           |          |        |          |        |
|                   | post amount >= 5 |         |           |          |        |          |        |

For the following variable combinations that fulfilled the criterion of at least a necessary frequency of five in each combination (HEDDERICH & SACHS 2018: 473 and ARRENBERG 2019: 242) – explained in [Table 4](#) with the fictive example B – , chi-square tests could be run to test for:

- c) equal distribution of PNUCs over
  - c.a) months and
  - c.b) weekdays,
- d) independence of sentiments on
  - d.a) months and
  - d.b) weekdays,
- e) independence of PNUCs on UGS and
- f) independence of sentiments on UGS,

In some cases, these statistical tests were run for only for a certain section for which indications will be given at the appropriate place in chapter [4.3](#). All other statistical tests for other theoretically possible variable combinations had to be left out due to too few frequencies in the combinations and the consequent insufficient statistical validity.

Correlations were computed among

- g) PNUCs and between
- h) PNUCs and sentiments.

The respective p-values ( $p$ ) and Pearson correlation coefficients will be given. P-values  $< 0.05$ , both for chi-square tests and correlations, indicate a statistically significant dependence/unequal distribution and correlation, respectively (see HEDDERICH & SACHS 2018: 479ff and ARRENBERG 2019: 239ff; BEHR 2019: 146ff).

## 4 Results

### 4.1 Scope of analysis

Within the period 2010-2019 7,336 posts tagged with one of the location IDs were found and analyzed that are distributed over the UGS as shown in [Figure 5](#). These posts contained 54,067 hashtags of which 15,931 were unique. 8,797 of the unique hashtags and 29,371 of all hashtags could be attributed with a PNUC ( $\approx 55.22\%$  and  $54.32\%$ , respectively). To the respective rests, no PNUC could be found due to mainly two reasons: Either they were written in a foreign language unfamiliar to the authors or no PNUC was assignable which was, e.g., the case for simple location or time designations.

Based on this, due to the possibility of possessing several PNUCs and the dichotomization of the PNUCs, 12,922 resulting PNUCs were detected in the 7,336 posts of which 2,916 did not have any PNUC attributed due to the circumstances mentioned above or simply due to the fact that a specific post did not contain any hashtag; the remaining posts (4,420 posts  $\approx 60.25\%$ ) ranged between one and nine PNUC per post decreasing linearly (see [Figure 6](#)). The resulting distribution of PNUCs over UGS is as shown in [Figure 7](#).

To 74.15 % of the 7,336 posts ( $\approx 5,440$  posts) could be ascribed a negative, neutral or positive sentiment. The hereafter mentioned frequencies refer to the respective categorized amounts of posts.

### 4.2 On the municipality level

#### 4.2.1 Frequencies of PNUCs and sentiments

With 17.5 %, “sense of place” is the major PNUC (see [Figure 8](#), [Figure 9](#)). Besides “#nature” (422 times) as the overall most frequently mentioned categorized hashtag, this PNUC contained many dominant hashtags, such as “#sun”, “#natur”, “#flowers”, “#sky”, “#trees”, “#rhein”, etc (see [Figure 10](#), [Table 5](#)). As the second most frequent PNUC “spiritual/religious” was found with the very salient hashtag “#love” as the third most used hashtag (241 times). Amounts then declined linearly from the third most utilized PNUC “recreation” with 9.7 % over “photography” and “event” to “aesthetic” with 6.9 %. “Recreation” contained with “#fun” one quite dominant hashtag and was rounded up by more minor hashtags. Remarkable for “event” was the huge influence of festival-related hashtags like “#festival”, “#rheininflammen” or “#jeckimsunnesching”; “aesthetic” was mainly characterized by the two notable adjectives “#green” and “#beautiful”. The upper middle range was completed by “social interactions” (5.1 %) and the CES derived PNUCs “work and study” (5.1 %) for which a massive influence of the university could be identified “#unibonn” was the second most used categorized hashtag (253 times); the first non-university-related hashtag “#work” came ninth place within the PNUC. The midfield then was completed by further three CES derivates “tourism” (4.4 %), “bond to location” (3.8 %), “sport” (3.4 %) which did not contain any focus but contains a broad spectrum of forms of physical activity, “inspiration” (3.3 %) and “food” (3.2 %) whose four top hashtags “#kölsch”, “#bier”, “#beer” and

“#gaffel” were related to beer and even to the local beer type “Kölsch”. In the back midfield with 2.5 % each, “cultural heritage”, whose main hashtags were a mix of general like “#architecture”, “#schloss”, “#building” and Bonn-related hashtags “#posttower”, “#augustmacke” or “#beethoven”, and “bond to nature” followed. Distant but not with insignificant shares, “family” (1.5 %), “demo” (1.1 %) which was extremely characterized by various “Fridays for future”-related hashtags and “politics” (0.3 %) were found. The original CES “Educational values” and “Knowledge systems” were extremely marginally represented in the hashtags with the seven hashtags “#education”, “#biology”, “#pflanzenwissen”, “#plantsience”, “#evolutionarybiology”, “#biochemistry” and “#biolkläuft” which together would have possessed a by far negligible share. These hashtags were integrated into “work and study” for data volume purposes instead of introducing “Educational values”/ “Knowledge systems” as categories for which no statistical test due to its poor data volume could have been performed anyway.

Concerning the sentiments of the posts, the shares of positive and neutral sentiments were with 44.9 % and 46.3 %, respectively, fairly similar whereas the share of negative sentiments was by far lower amounting to 8.8 %.

#### 4.2.2 Temporal distributions and (in-)dependences of PNUCs and sentiments

The first post in the investigated UGS was posted in 2011. Since then the amount of posts increased constantly until 2019 included (see Figure 11). The chronological sequence seemed exponential until 2018. The latest turn of the year in the data from 2018 to 2019 suggests a flattening of the growth of post frequencies.

The average course of the year of the nine studied years, considering the level of months, was primarily an undulation between February as the minimum point and August as a local maximum point which is outnumbered by May as the absolute maximum (see Figure 12). This presumably highly unequal distribution of posts over months was confirmed by a chi-square test revealing a  $p < 0.001$ . This unequal distribution could also be proven for each PNUC (except “demo”, “family” and “politics” due to too few data; see Table 6) where the minimum and maximum points however differ between December-March and May-November, respectively; in the latter case the intermediate months of June and July did not constitute any maximum point in any PNUC. Significant deviations of sentiment shares could not be detected between the months implying no dependence of sentiments on months (see Figure 13, Table 7).

For the average course of the week on the level of weekdays a post emphasis on the weekend could be detected (see Figure 14) and was approved with a high significance by a chi-square test ( $p > 0.001$ ). A significance is also the case for almost each PNUC ( $p < 0.05$ ; see Table 8) – all with an emphasis on the weekend days Saturday and Sunday except “demo” on Friday. As the only two exceptions, for “inspiration” and “cultural heritage” no unequal distribution over the weekdays could be found. No dependence of neutral and positive sentiment on weekdays could be detected (see Figure 15, Table 9).

In contrast, negative sentiments depended significantly on the weekdays revealing on the one hand a relatively high share on Friday and on the other hand relatively low shares on the weekend.

The course of the day was characterized by a quite smooth and negatively skewed undulation between mid overnight as the minimum point and late afternoon as the maximum point (see [Figure 16](#)).

## 4.3 On the UGS level – spatial comparisons and (in-)dependences

Referring to post and PNUC frequencies (see [Figure 5-Figure 7](#)) UGS were classified into “Big 3” (Rheinaue, Hofgarten, Botanischer Garten), medium-sized parks (Poppelsdorfer Allee, Stadtgarten, Rigal’sche Wiese, Panoramapark, Kaiserplatz) and small parks (Baumschulwäldchen, Kurpark Bad Godesberg). Due to very few data in the small parks, relatively few data in medium-sized parks and the consequent statistical uncertainty – see chapter [3.5](#) –, the small parks were left out both in the descriptive statistical viewing and chi-square tests whereas medium-sized parks were left out in the chi square-tests marked with “\*\*”.

### 4.3.1 Frequencies and spatial (in-)dependences of PNUCs and sentiments

The distributions of PNUCs between UGS varied highly significantly; an influence of UGS\* on PNUCs could be ascertained by reference to  $p < 0.001$ . This implied considerable variations between UGS within respective PNUCs evoking respective hotspots and minuscule locations (see [Figure 17-Figure 19](#)). Within “sense of place” both the highest absolute (757) and relative (27.0 %) values could be found in Botanischer Garten. The influence of park features and the park theme on the basis of pregnant hashtags like “#flowers”, “#nature”, “#natur”, “#blumen”, “#seerosen”, “#lotus”, etc. was unmistakable (see [Figure 20](#)). Similarly distributed was “bond to nature” with a striking hotspot in Botanischer Garten, on a large scale represented by various hashtags testifying this affinity (e.g. “#naturelove”, “#naturelovers”). “Recreation” possessed relatively low shares in Botanischer Garten and Kaiserplatz (6.2 % and 7.6 %, respectively) whereas shares in Panoramapark and Rigal’sche Wiese were noticeably higher (15.7 % and 15.2 %, respectively). In Rigal’sche Wiese “photography” was with on single post almost immaterial, hotspots, however, could not be detected. Rheinaue, could be manifested as the outstanding hotspot of “events”. Rigal’sche Wiese and Stadtgarten could register even bigger shares (21.3 % and 17.7 %, respectively) possessing, as medium-sized parks yet similar absolute amounts to Hofgarten and Botanischer Garten of the “Big 3”. Under consideration of the hashtags (see [Figure 21-Figure 23](#)) emerge different emphases within the PNUC: Whereas in Rheinaue could be found an emphasis on festivals (“#rheinflammen”, “#jeckimsunnesching”, “#festival”, “#panamaopenair”, “#querbeat”), the foci in Rigal’sche Wiese was on “Abitur”(-festivals) (“#abitur”, “#abi”, “#abi2018”, etc.) and funfairs (“#kirmes”, “#karussell”, etc.) and in Stadtgarten mainly on circuses (“#circusroncalli”, “#circus”, “#roncalli”, “#zirkus”, etc.). As the “aesthetic” hotspot could be designated Botanischer Garten, having both the biggest absolute amount (314) and relative (11.2 %)

share in this PNUC and exceedingly considered as “#green”. With a large share of “social interactions”, Rigal’sche Wiese (21.3 %) could be detected as widely used for respective purposes whereas the shares in other UGS were distantly lower (Rheinaue: 7.4 %) or even marginal (Botanischer Garten: 1.4 %). Hofgarten could be identified as the distinctive hotspot of “work and study”. Additionally, Poppelsdorfer Allee recorded another noticeable share of 6.1 %. Both showed a big influence of the university (see [Figure 24](#), [Figure 25](#)). Moreover, Poppelsdorfer Allee occupied a special position for “tourism” (8.5 %) whereas respective shares ranged between 2.4 % and 5.4 % with the exception of Rigal’sche Wiese with only one post ( $\approx 0.6\%$ ). Without any emphasis on a specific UGS, “bond to location” however was non-existent in Rigal’sche Wiese. Within “sport” could be found out a discrepancy between Rigal’sche Wiese, Stadtgarten, Panoramapark, Kaiserplatz (ranging between 6.6 % and 8.5 %) and the resulting UGS (ranging between 3.5 and 3.9 %) with the outlier Botanischer Garten (1.1 %). At a closer look (see [Figure 26](#), [Figure 27](#)) even differences within “sport” could be made out: Whereas in Kaiserplatz skating was dominantly present, the focus in Panoramapark seemed to be more on fitness and workout as physical activities. With by far the highest share of 12.7 % within “cultural heritage” Kaiserplatz was, seen relatively, quite heavily used for this PNUC; seen instead absolutely, Hofgarten registered by far the largest amount (214). As to “family” activities, Panoramapark and Rigal’sche Wiese could record by far the highest shares (6.3 % and 4.9 %, respectively) while the resulting shares are less than 1.6 %. With relevant shares “demo” was used on a relatively big scale in Kaiserplatz (5.9 %) and Hofgarten (2.4 %) while other UGS did not show shares higher than 1.1 %.

Just as for PNUCs, an influence of UGS could also be found on the sentiments ( $p < 0.001$ ; see [Figure 28](#)-[Figure 30](#)). Poppelsdorfer Allee registered both the biggest share of positive sentiments (57.5 %) and the least of negative (5.7 %). Extremely alike were the shares of positive and negative sentiments in Stadtgarten (54.3 % and 6.4 %, respectively) and Kaiserplatz (54.5 % and 6.1 %, respectively). With a similar share of negative (6.0 %) but a markedly lower share of positive sentiments (46.5 %), was placed Rheinaue, followed by Rigal’sche Wiese with an alike share of positive sentiments (46.3 %) but the highest share of negative sentiments (11.6 %). Hofgarten and Botanischer Garten behaved similarly with the least shares of positive sentiments (42.2 % and 42.0 %, respectively) and negative sentiment shares of 9.8 % and 11.1 %, respectively.

### **4.3.2 Temporal distributions and (in-)dependences of PNUCs and sentiments**

The temporal development of posts over the years was very heterogenous (see [Figure 31](#)-[Figure 33](#)). With the exceptions Rheinaue (peak 2018), Hofgarten (peak 2017) and Rigal’sche Wiese (peak 2017) the post frequencies increased in the study period peaking in 2019. This increase however proceeded heterogeneously as well. Whereas Hofgarten recorded a steady increase of posts since 2011, the amounts in Rheinaue, Poppelsdorfer Allee and Kaiserplatz increased rapidly by the turns of the year 2016/2017, 2018/2019 and again 2018/2019, respectively. The resulting UGS behaved therebetween.

Likewise heterogeneously acted the course of the year over the months (see [Figure 34](#)-[Figure 36](#)). A highly significant influence also on the months could be attributed to the UGS\* ( $p > 0.001$ ). The form of the annual imbalance was of different intensities and extrema: A very strong imbalance could be found in Rheinaue with an absolute maximum in May. Less strong disequilibria were detected in Botanischer Garten, Poppelsdorfer Allee and Hofgarten the latter was characterized by a twofold wave with the elevations April-May and September-October. Prominent spatiotemporal hotspots could moreover be localized in Rheinaue in May, in Rigal'sche Wiese with an extraordinary share in April, in Stadtgarten in May as well and in Kaiserplatz in May, August and October. The test for equal distribution of PNUCs over the months revealed a highly significant imbalance of PNUCs over the months in the “Big 3”\* (see [Table 6](#)). While in Botanischer Garten the respective PNUC peaks in September/October, all peaks in Hofgarten were in April and September and in Rheinaue in May. They shared their minima, ranging – with the exception “photography” in Rheinaue – between December and February. Corresponding to the level of all UGS, neither on the level of UGS no dependences of sentiments on months could be discovered (see [Table 7](#)).

Courses of the week of posts varied significantly between the UGS (see [Figure 37](#)-[Figure 39](#)) resulting in an ascertained dependence of posts per daytime on UGS ( $p < 0.001$ ). Only Poppelsdorfer Allee and Stadtgarten could register a nonsignificant unequal distribution over the weekdays ( $p$ : 0.079 and 0.778, respectively). All other UGS displayed at least a statistically significant disbalance between the weekdays ( $p < 0.05$ ). Panoramapark and Rheinaue were lucidly more used on the two weekend days whereas Hofgarten and Rigal'sche Wiese were mostly used only on Saturday. The situation was different in Botanischer Garten in which Saturday recorded relatively few posts and Kaiserplatz which was mostly used on Wednesday. This was reflected also under consideration of PNUC in the UGS\* (see [Table 8](#)): Except for “work and study” in Botanischer Garten (maximum Thursday and minimum Tuesday;  $p = 0.049$ ), each PNUC in Hofgarten and Botanischer Garten was distributed equally over the weekdays. Contrarily, Rheinaue contained with “cultural heritage” only one PNUC that was not significantly unequally distributed ( $p = 0.403$ ) over the weekdays while all others arranged towards the weekend. As opposed to the findings on the level of Bonn, in the “Big 3”\* no dependences of sentiments on weekdays could be identified (see [Table 9](#)).

Another dependence on UGS could be found for the course of the day ( $p < 0.001$ ; 8:00 am – 11:59 pm). Each UGS exhibited, roughly speaking, an undulation between midnight – 03:59 am as the minimum and 04:00 – 05:59 pm as the maximum point with spatiotemporal deviations and peaks in Rigal'sche Wiese from noon – 01:59 pm and Kaiserplatz from 08:00 – 09:59 am as a second peak (see [Figure 40](#)-[Figure 42](#)). Furthermore, the big share of the late afternoon in Panoramapark was remarkable.

## 4.4 Cross-UGS correlations

### 4.4.1 Between PNUCs

Numerous correlations were revealed between PNUCs (see [Table 10](#)) which tendentially could be classified into two categories: Either a PNUC had a high frequency of correlations with other PNUCs ( $\geq 10$ ) or a clearly lower amount of correlations with other PNUCs ( $\leq 5$ ). In between, only one case with “event” (seven correlations) could be found. For the first case could be mentioned “politics”, “tourism”, “spiritual/religious”, “food”, “sport”, “inspiration”, “family”, “bond to location”, “cultural heritage”, “sense of place”, “recreation”, “photography”, “aesthetic” and “social interactions”. These contrasted with “work and study”, “bond to nature” and “demo” as the respective other.

### 4.4.2 Between PNUCs and sentiments

In this analysis, “bond to nature” and “demo” occupied a special position as the only two PNUCs without any correlation to any of the sentiment categories (see [Table 11](#)). “Sport” and “social interactions” were linked only to neutral and positive sentiments whereas all other PNUC were related to all sentiment categories which, nevertheless, differ in their correlation strength between the sentiment categories: “Spiritual/religious”, “food”, “inspiration”, “family” and “recreation” showed alongside with “sport” and “social interactions” considerably stronger connections ( $\Delta$  correlation coefficient  $> 0.1$ ) with positive sentiments as with negative sentiments.

## 5 Discussion

### 5.1 Reference to related studies

Mathematically, a comparison of shares of PNUCs may suggest interesting differences and similarities between geographical contexts but, substantially, there is a presumable possibility of contortions leading to wrong interpretations which will be explained on the example of “food” on two fictive parks. Both of which were used similarly by 1,000 people each for food consumption. One is used exclusively for this particular purpose, the other, however, is used also for many other activities due to its imaginable park infrastructures or features, e.g. for physical activity owing to outdoor gyms or the like – let us say by 10,000 physically active people. This results in a dramatically lower share of “food” in the latter park (10 % vs. 100 % “food” in the first park) despite the identical use in terms of absolute frequencies (1,000 people) in both of the parks. Therefore, comparisons regarding shares generally should be treated with caution – for an appropriate evaluation, a simultaneous observation of absolute frequencies is inevitable. “Cultural heritage” was detected in Xuzhou by DAI et al. (2019: 11) with a share of 36.25 % – in some of Xuzhou’s parks with shares of more than 66 % – as the mostly present category which was ascribed by the authors to the more than 2,600 years of history of the city which possesses numerous mausoleums

or the famous Terracotta Army. Such an outstanding status of “cultural heritage” could not be found in Bonn, presumably because such long-lasting human artifacts are not present in Bonn. “#Posttower”, “#Schloss” (no matter if Poppelsdorfer or Kurfürstliches Schloss was mentioned), “#Beethoven” or “#Kreuzkirche” as examples of the mostly used hashtags in “cultural heritage” do not feature a history longer than 250 years. This absence could explain the huge difference to the share of 2.5 % on the level of Bonn and 12.7 % in Kaiserplatz as the UGS with the PNUC’s highest share in the present work. Furthermore, this disparity could have emerged from the application of seven CES categories whereas in this work 18 both derivates and new ones were used evoking different shares. Finally, even the social media platform could have caused different shares. It is assumable that the studied Chinese social media platforms for travelling were used for a different purpose than Instagram having an augmented focus on i.a. “cultural heritage”. These circumstances could explain the resulting discrepancies of “aesthetic” and “recreation” (Xuzhou: 21.36 % and 16.51 %, respectively; Bonn: 6.9 % and 9.7 %, respectively) (ib.), as well. Regarding absolute frequencies, many of the correlations found in Xuzhou could also be found in Bonn. Differences unfailingly affected correlations regarding either “aesthetic” or “cultural heritage”: The three correlations of “cultural heritage” with “aesthetic”, “recreation” and “sport” detected in this work show no relation to each other in Xuzhou. This presumably emerges from the fact that “cultural heritage” in Xuzhou is extraordinarily present in two parks which could be considered hotspots of this category whereas, on the one hand, this category was barely present in other parks and, on the other hand, the other three categories are present in other parks with not irrelevant amounts (ib.: 9).

Added to the troubles mentioned above, further difficulties emerge when comparing results found for Prospect Park, Brooklyn, New York City (JOHNSON et al. 2019) to this work’s parks. The comparison of the shares found in Prospect Park as the only possibility of relation reveals that Prospect Park was most likely akin to Rigal’sche Wiese with approximately similar shares of “social relations” and “recreation” as the two most frequently found categories in Prospect Park (Prospect Park: 23.3 % and 21.5 %, respectively; Bonn: 23.7 % “social interactions”, 28.7 % “social interactions” including the derivate “family” and 23.8 % “recreation” including the derivates “food” and “sport”) (ib.: 9). In contrast to this stood numerical deviations such as “sense of place” and “aesthetic” (Prospect Park: 13.7 % and 9.8 %, respectively; Rigal’sche Wiese: 3.0 % and 1.2 %, respectively) which, according to the above-mentioned aspects, should be taken with a grain of salt (ib.). Moreover, the lack of comparisons to other parks in New York does not allow any statements concerning higher or lower frequencies within categories, not to mention being able to declare Prospect Park as a hotspot in a specific category. On the one hand, Prospect Park could have served with its shares in the different geographical context of Brooklyn/NYC as a hotspot for social interactions and/or recreation suppressing relatively significant absolute amounts of “aesthetic” and/or “sense of place”. On the other hand, the “social interactions” and/or “recreation” shares could have been appropriate to the average of its geographical context and the “aesthetic” of the park could have been in fact negligible and expandable. Therefore, it should be observed and studied the total stock of urban parks for a better comparability and classification at the

municipality level. A comparison to correlations between categories found in Prospect Park would be inappropriate by virtue of the different scales (Prospect Park: park level – different park zones; Bonn: city level – different parks) and is therefore not performed here. Ultimately, however, extremely low findings of „Educational values“ and „Knowledge systems“ in Prospect Park are consistent with the results in this work.

The here found seasonal divergences between summer and winter and the broad variety of types of physical activity regarding “sport” are corresponding with the respective findings by ROBERTS et al. (2017) for Birmingham, UK with Twitter data.

Although no claim can be laid to completeness of events recognized in the data of this work, Instagram seems to be suitable for gathering information regarding events, as well, matching the findings of ROBERTS (2017) for Birmingham, UK.

## 5.2 Limitations

Applying the above outlined methodological approach will evoke limitations which have to be mentioned briefly.

In the very beginning the selection of UGS was dependent on the technical availability of a location ID on Instagram and the amount of posts with the respective geotag. Several UGS could not be analyzed due to missing location IDs or a very low number of posts. Within the remaining UGS also due to the way posts are tagged on Instagram a spatial differentiation is not possible but could be particularly interesting for bigger sites like Rheinaue (e.g. western and eastern bank, sublocations and hotspots within a UGS (see WATANABE et al. 2011)).

Further on data protection laws caused unavailability to gather sociodemographic data of people posting content (RUTHS & PFEFFER 2014: 1063f, BOY & UITERMARK 2016: 14, KOVACS-GYÖRI et al. 2018: 20) as well as performing deep learning image analysis on the users’ pictures.

Possible over- or underrepresentation biases could likely emerge due to varying social media usage habits of different social cohorts (age, nationality, religion etc.) being more or less familiar with or likely to use Instagram or simply refraining entirely from social media usage. FIETKIEWICZ et al. (2016) pointed out a significant dependence of social media platform choice and age (3833ff) – and found that in general younger people tend to use Instagram (3834).

The following iterative process of categorization, evaluation and recategorization was necessarily subject to our subjectivity. As such, there cannot be an objective categorization as “multiple interpretations and understandings [...] may be correct” (COPE 2005: 292). We emphasized a maximum of transparency and reproducibility by making all definitions, scripts and algorithms used available online.

However, some usage and perception patterns could not be captured because they could be too common (SIM & MILLER 2019: 3826) to be posted by users and results could contain an overrepresentation of

event-dependent content (JOHNSON et al. 2019: 6152) as well as an underrepresentation of other categories such as “spirituality” (ib.: 6151).

With respect to the high number of mined posts (7,336) we can claim an overall statistical representativeness. Still, for particular UGS there were too few posts available to conduct statistical analysis (e.g. Kurpark Bad Godesberg:  $n = 10$ ).

With regard to sentiment analysis, different languages, the incoherent use of punctuation marks and the occasionally specific, heterogenous style of hashtags containing several words without spaces (e.g. “#Ilikethispark”) caused issues (ALVARI 2017: 1) due to the unavailability of suited analysis algorithms. In spite of our efforts by translating all occurring languages to English by matching two different translation engines (DeepL and Google Translator) checking and correcting samples, we cannot guarantee a flawless translation. Hence, without performing – for this study – disproportionate work of translating every single post manually, a certain error rate for sentiment analysis must be accepted.

As mentioned earlier it is important to emphasize again the meaning of a “positive” and “negative” sentiment. They cannot be equated with “good” or “bad” emotions but are rather complex and ambiguous like nostalgia, melancholy or wistfulness. Amongst others, i.e. complex comparative phrases cause issues to SA (LIU 2012: 117). Generally, SA needs to be interpreted with care. WATERLOO et al. (2018: 1813) additionally point out that there is an overall social media positivity bias towards posting positive content.

### 5.3 Practical significance

Generally, the methodology used in this study is not intended to replace classical qualitative socio-scientific methods but – due to its particular advantages – rather provides a cost-effective and efficient method to support and enrich classic research. With the help of its results, spatiotemporal coherences, trends, clusters and deficiencies can rapidly be detected. On the basis of this profound insight, foci for further investigation can be identified which should be confirmed by more valid methods possibly both for the Instagram user group – if there are aims of urban or park planning regarding particularly that user group – or – presumably rather the case – a representative sample of all park users. Opposite to classic methodological approaches it should not be kept secret that the methodology applied in this work does not evoke any interviewer effects, provides the possibility to collect data of points of time in the past and requires disproportionately less time and financial resources. With its development and free availability – based on the open-source-idea – as well as its scalability and potential for automatization on the one hand, and in the light of avoidance of methodological breaks on the other hand, this methodological approach not only promises the above-mentioned insight but can be repeatedly applied i.e. in an analysis-action-analysis-loop to evaluate communal measures and check if the desired outcome has been achieved by the preceding actions.

At a concrete level for the municipality of Bonn, the results promise various interesting insights from which measures – not only affecting well-being aspects – can be deduced that are shown in an exemplary

way below for urban and especially park planning institutions. Basically, the causes of the non-existence of posts in all the UGS beyond the ten studied ones should be probed. The question arises whether some UGS are merely sparsely used by Instagram users or generally. The scarce findings of “Education” and “Knowledge” should be taken seriously and should result in further investigation whether these CES are simply not conveyed on Instagram or are actually not present in UGS in Bonn. For a broader variety of PNUCs and an enhanced positivity as presumed park planning aims, it might be beneficial to place an analytical and planning focus on “sport” on the one hand, and “spiritual/religious”, “food”, “family” and “recreation” on the other hand. These showed positive correlations with numerous other categories and were either positively related only to positive sentiments or were noticeably stronger related to positive than to negative sentiments respectively. Moreover, “social interactions” correlated strongly positively with positive sentiments, as well. Spatial and temporal emphases could hereby be set on UGS in which the respective categories and/or sentiments show deficiencies, e.g. the non-existent “family” PNUC in Kaiserplatz or the very poor “food” category in Rigal’sche Wiese – two UGS with expandable positivity. As for location marketing purposes, the promotion and conservation of beneficial conditions of single UGS or Bonn as a whole could turn out to be smart, e.g. Botanischer Garten as the hotspot of “sense of place”, “bond to nature” and “aesthetic”, Rheinaue with its emphasis on the weekend, that could be attractive for tourists, and its function as an “event” location, Poppeisdorfer Allee for “tourism” – presumably ascribed to its urbanistic particularity –, Kaiserplatz and Hofgarten for “cultural heritage” or Panoramapark for “family” and weekend activities. In combination, all this could not only improve the spheres of well-being directly but also raise the attention of both the local population and tourists which, secondarily, could also entail regional economic effects in favor of the city of Bonn.

## 5.4 Future research

Thus, it would be highly interesting how the results found on Instagram interrelate with a representative example of all park users. This could and should be realized with an approach in which only the data collection method differs whereas study sites, study period and the underlying PNUCs are exactly the same. Results already obtained – be it those in this work or those in other contexts (see chapter 2.4) – do not prove themselves as a useful basis for comparison due to the fact that study periods would differ. Corresponding findings could reveal either a consonance of Instagram data with data gathered with classic methods which could minimize the effort for detecting the perception and usage patterns of all park users, or in the other case will inevitably unveil differences among Instagram users and all users with the help of which conflicts of usage among different groups of park users could be identified.

In addition to this, a classification in and a comparison to other geographical contexts would be worth knowing. The necessary stocktaking for comparison is not only politically intended but the juxtaposition could potentially show cross-context commonalities as well as differences and, based on this, spatial as well as temporal strengths and potentials within a category or sentiment of the respective study site which provides the possibility of UGS benchmarking. Also, for this purpose the methodological

approaches should be identical which is not yet the case neither for this work in comparison to the related studies outlined above nor in comparison only between the latter.

With respect to our manual categorization due to hashtag specific difficulties (see chapter 3.3), further research is needed in the field of automatized machine learning algorithms being able to decipher and categorize hashtags accurately.

## 6 Conclusion

The aim of this study was to provide a precise inventory of spatiotemporal perception and non-material usage patterns of the UGS in Bonn. Although certain limitations apply, the methodological approach proved itself to be suitable. By manually categorizing roughly 16,000 Instagram hashtags in data-analysis-categorization-cycles in 18 PNUCs based on grounded theory and depicting the respective post sentiments, it was possible to identify fundamental spatial and temporal differences and similarities between the UGS as well as (sentiment-)PNUC correlations.

Given that “Amt für Stadtgrün” Bonn (Office for City Greenery) already showed interest in the results of this study, it is evident that further investigations of the data used here would be worthwhile. Particular research questions – such as figuring out different sport types and their perceptions as requested by the “Amt für Stadtgrün” Bonn – would be easy to answer and bring about even more differentiated knowledge for accurate and UGS-specific planning strategies.

Thanks to our self-written scripts under a creative commons license (see INSTAGREENS-BONN 2020), a straightforward analysis continuation with future Instagram data from the same UGS is guaranteed and will increase the high knowledge potential.

If combined with classical qualitative socio-scientific methods, the perception and non-material usage patterns of the UGS in Bonn could be consolidated or of course questioned where necessary, but in any case, foster a deeper insight to concrete municipal challenges. It is up to the degree of interest of the city of Bonn how much further the data of this study will be used for management, marketing and policy-making purposes.

This study is the first of its kind on European mainland. Further research developments towards reaching a more exhaustive collection of studies using the same or similar methodological approach could be of great value for comparison purposes. To which degree would these patterns differ between cities within the same country? Which new scientific findings would arise when comparing the results on an international level? By working more towards a corresponding methodological approach in order to uniformly investigate how people use UGS and which benefits concerning well-being and beyond they obtain, it will be possible to commonly work out a detailed synopsis of UGS around the globe. The method used here is a cost-effective, fast, extensive and time-independent approach and therefore easily applicable in different urban contexts, especially because it allows a manual adjustment of the CES categories in order to individually suit the area of investigation. We highly encourage further work with our approach and welcome any kind of cooperation. For a visually appealing and interactive summary

of our results as well as all of our used scripts see our homepage <http://instagreens-bonn.de/> and contact us under [contact@instagreens-bonn.de](mailto:contact@instagreens-bonn.de).

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## Appendix

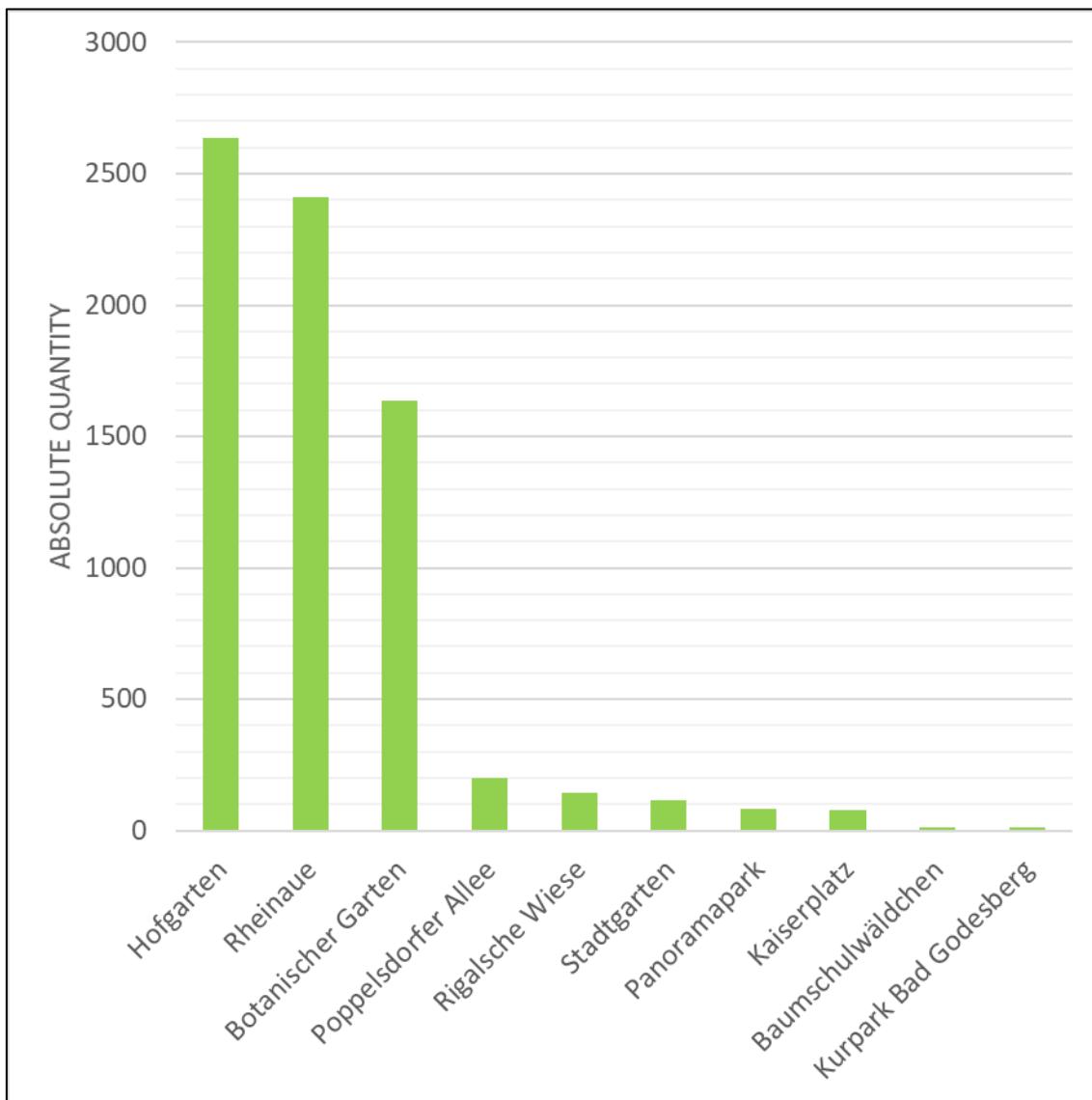
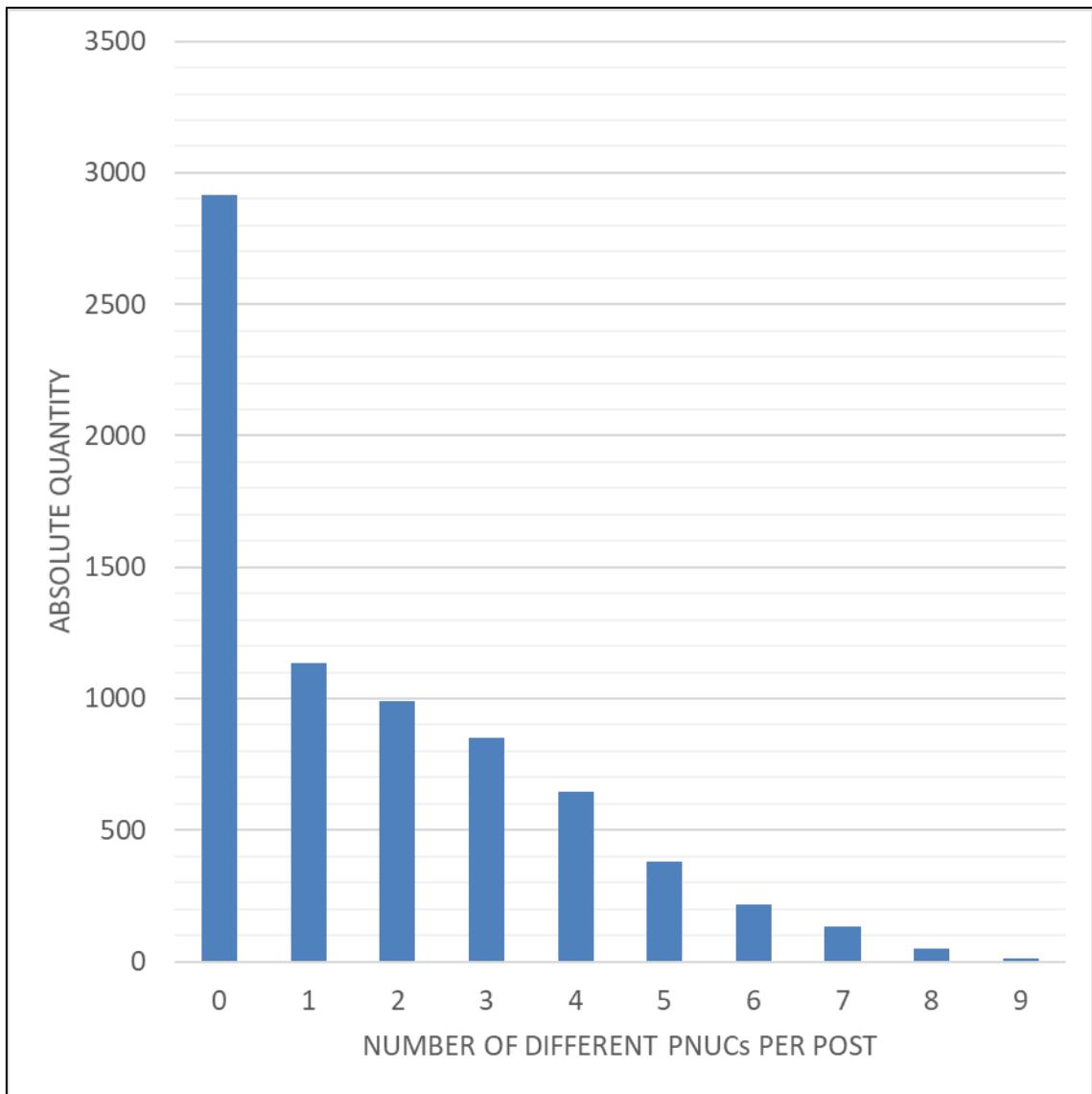
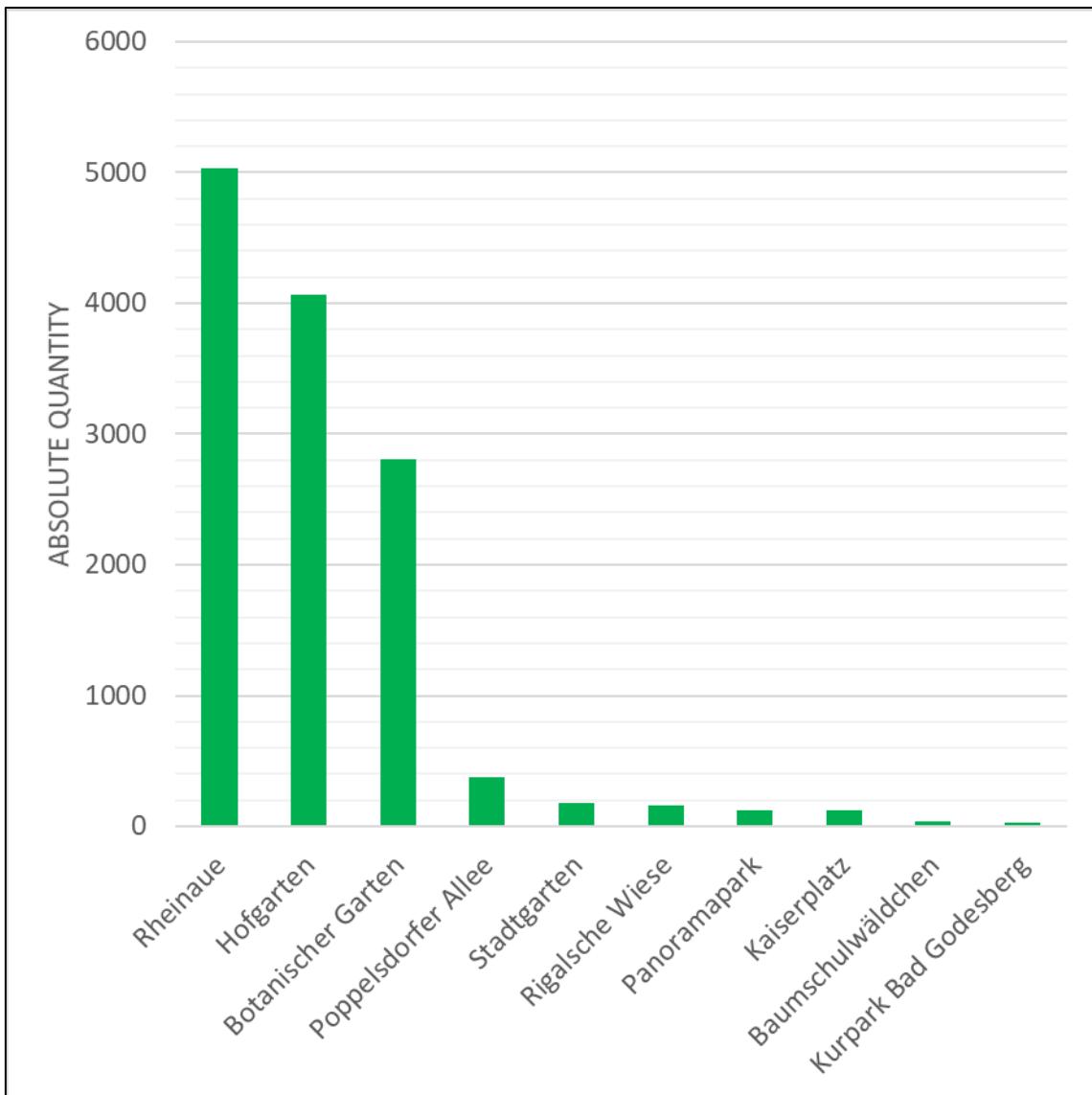


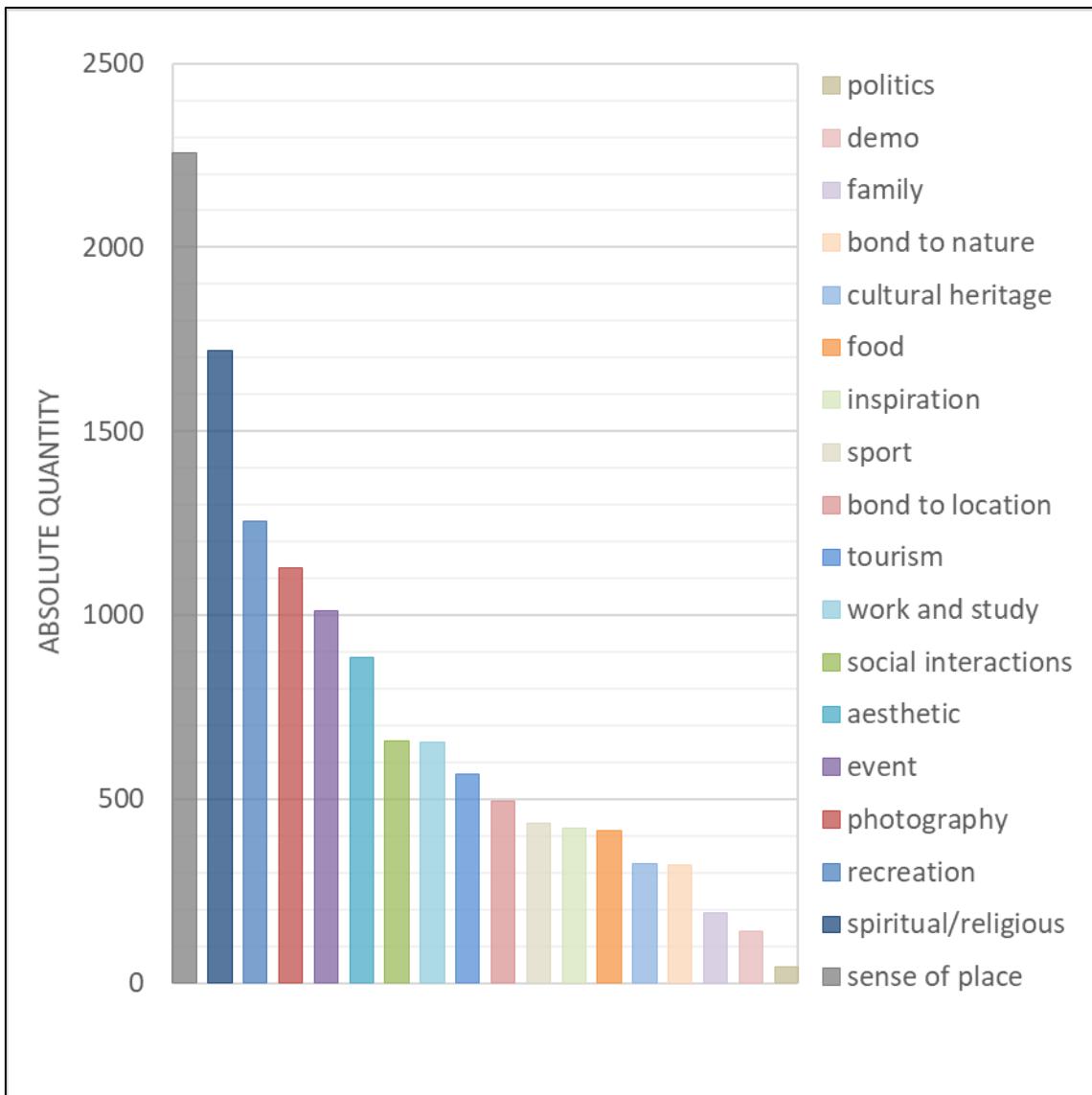
Figure 5: posts per UGS – absolute frequencies



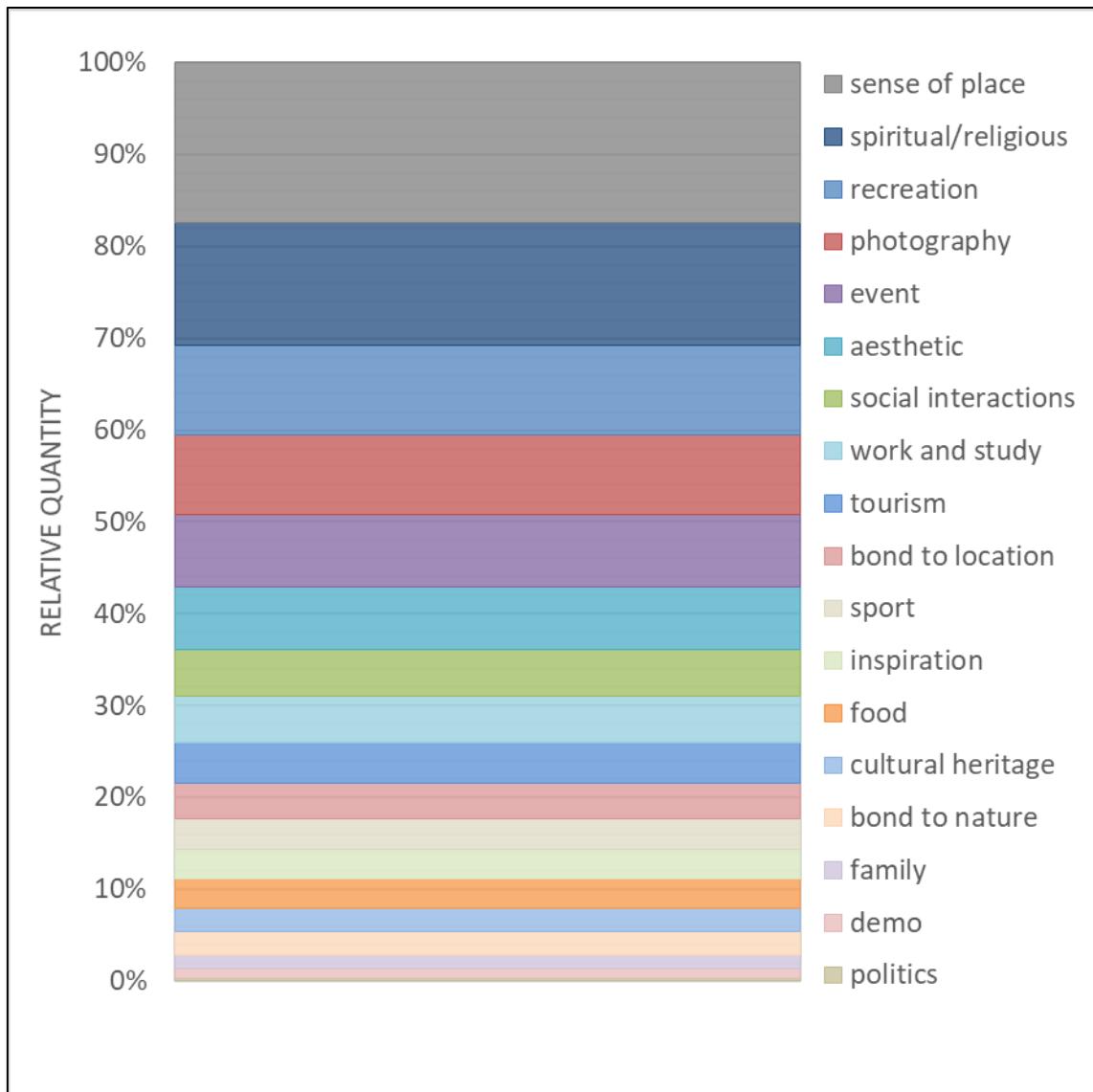
**Figure 6: number of different PNUCs per post – absolute frequencies**



**Figure 7: PNUCs per UGS – absolute frequencies**



**Figure 8: posts per PNUC in all UGS – absolute frequencies**



**Figure 9: posts per PNUC in all UGS – relative frequencies**

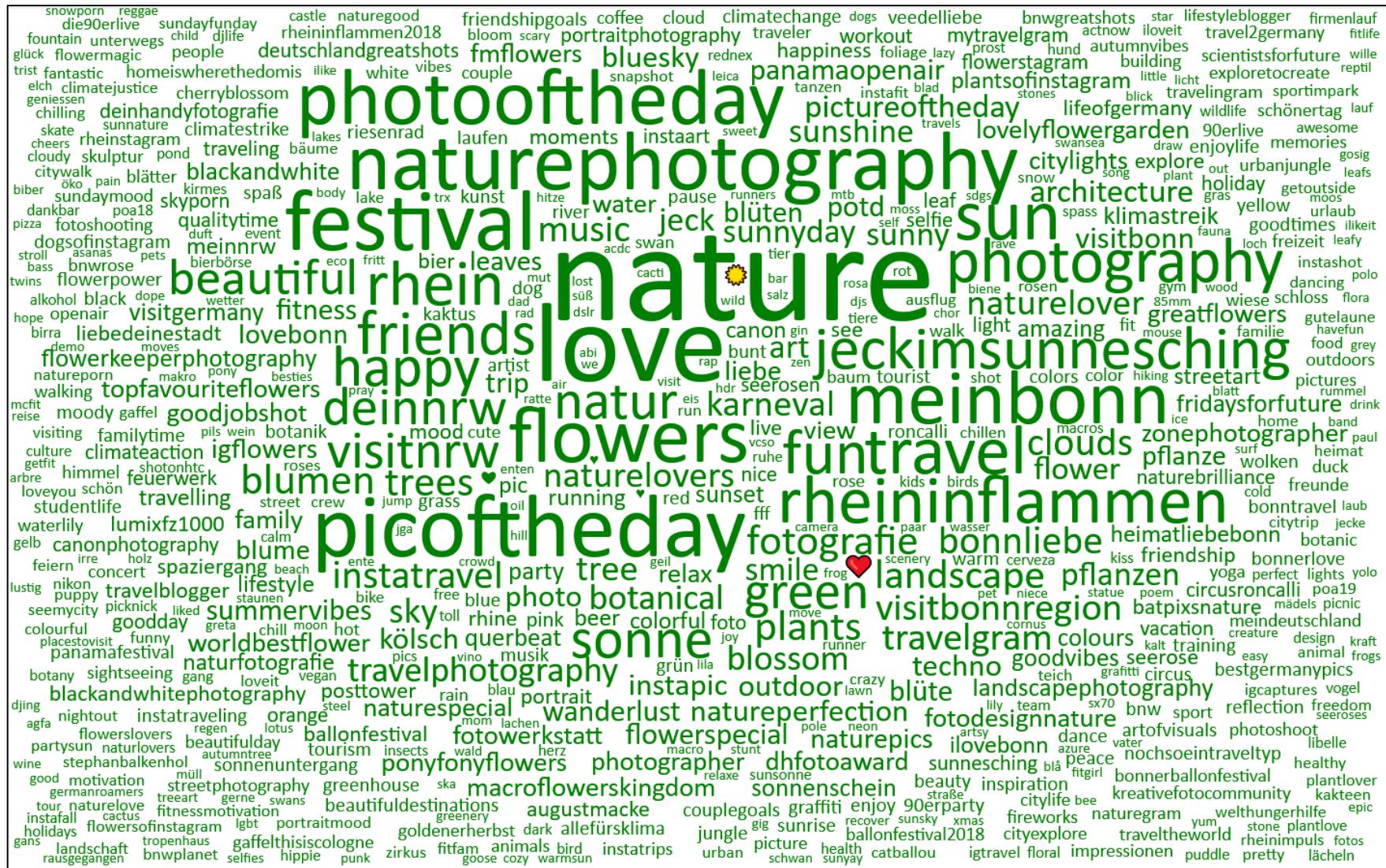
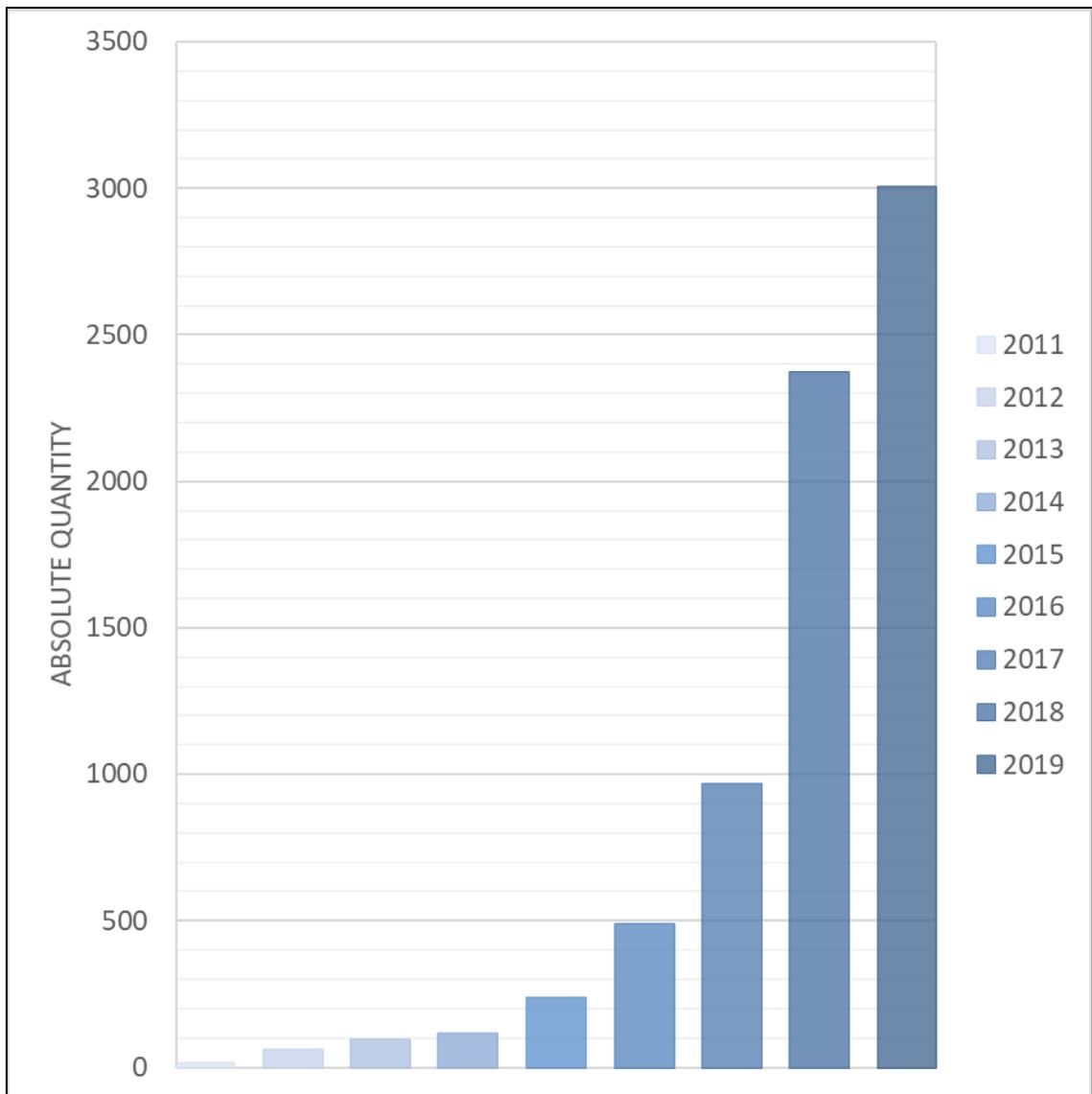


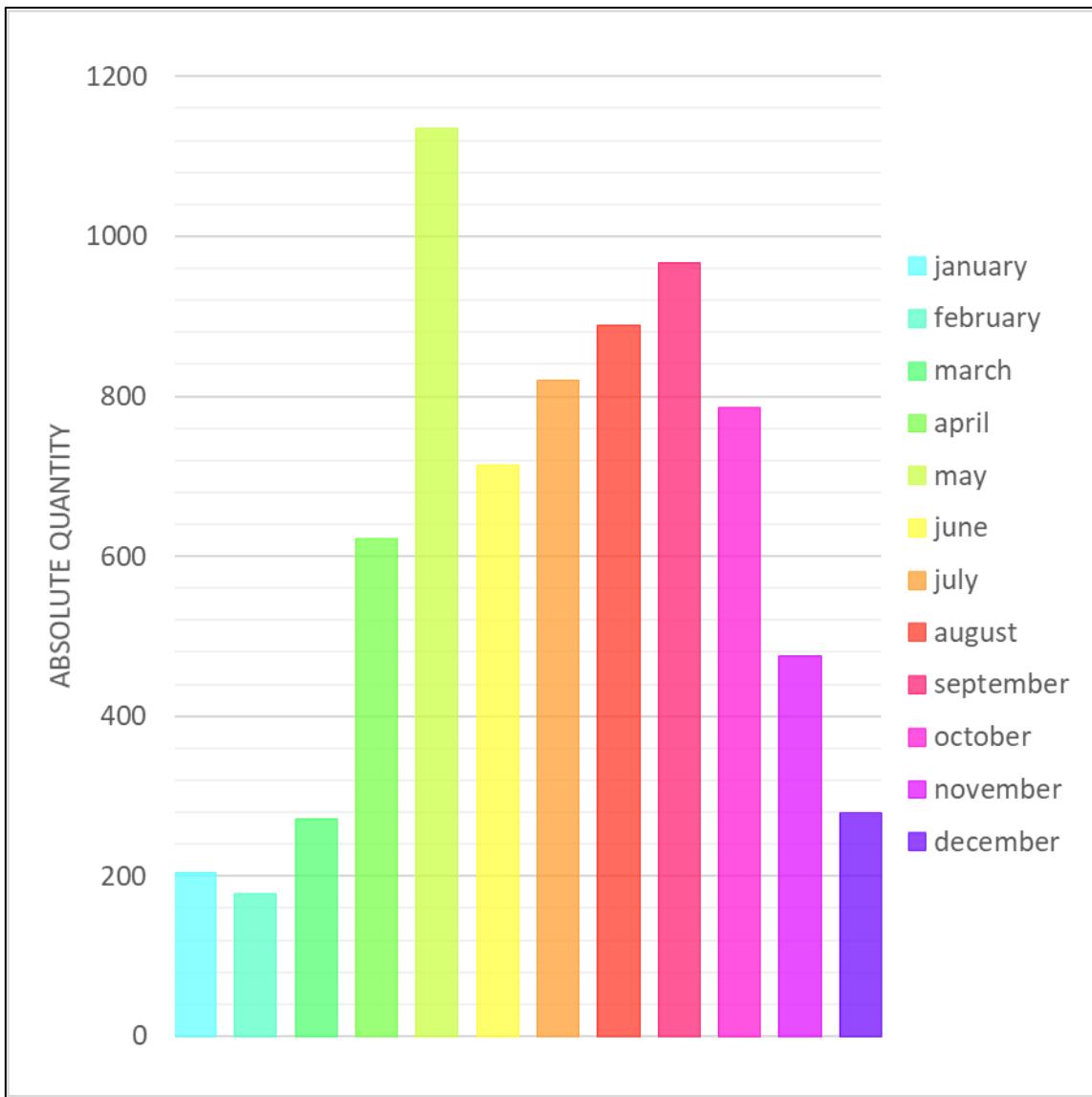
Figure 10: word cloud of categorized (PNUC) hashtags in all UGS

**Table 5: top ten hashtags per PNUC in all UGS**

| PNUC                |                   | 1                | 2             | 3                 | 4                   | 5               | 6                   | 7                 | 8                      | 9               | 10             |
|---------------------|-------------------|------------------|---------------|-------------------|---------------------|-----------------|---------------------|-------------------|------------------------|-----------------|----------------|
| aesthetic           | hashtag           | green            | beautiful     | colors            | lovely_flowergarden | colorful        | colours             | beauty            | bonnitschön            | pink            | grün           |
|                     | absolute quantity | 121              | 105           | 31                | 30                  | 29              | 28                  | 28                | 26                     | 25              | 24             |
| bond to location    | hashtag           | meinbonn         | deinnrw       | bonnliebe         | lovebonn            | bonnichmagdlich | liebedeinestadt     | ilovebonn         | heimatliebe_bonn       | meinrrw         | bonnerlove     |
|                     | absolute quantity | 181              | 120           | 60                | 40                  | 32              | 30                  | 30                | 28                     | 25              | 21             |
| bond to nature      | hashtag           | naturelovers     | naturelover   | nature_perfection | naturelove          | plantlover      | pflanzenliebe       | flowerslovers     | nature_good            | natureporn      | mothernature   |
|                     | absolute quantity | 91               | 58            | 38                | 14                  | 14              | 11                  | 11                | 10                     | 10              | 10             |
| cultural heritage   | hashtag           | architecture     | posttower     | schloss           | augustmacke         | castle          | beethoven           | building          | stephanbalkenhol       | skulptur        | architektur    |
|                     | absolute quantity | 63               | 31            | 28                | 27                  | 17              | 14                  | 13                | 13                     | 12              | 10             |
| demo                | hashtag           | fridaysforfuture | allefürsklima | klimastreik       | climatestrike       | climatechange   | climateaction       | ffff              | parentsforfuture       | welthungerhilfe | climatejustice |
|                     | absolute quantity | 61               | 32            | 31                | 24                  | 22              | 19                  | 15                | 15                     | 12              | 12             |
| event               | hashtag           | rheininflammen   | festival      | jeckimsunnesching | panamaopenair       | karneval        | jeck                | querbeat          | openair                | 90erlive        | 90erparty      |
|                     | absolute quantity | 184              | 184           | 168               | 75                  | 63              | 49                  | 43                | 40                     | 36              | 34             |
| family              | hashtag           | family           | familytime    | familie           | kids                | brother         | twins               | babytime          | familyfirst            | familygoals     | momlife        |
|                     | absolute quantity | 52               | 23            | 13                | 8                   | 8               | 6                   | 5                 | 5                      | 5               | 5              |
| food                | hashtag           | kölsch           | bier          | beer              | gauffel             | coffee          | food                | picnic            | picknick               | lecker          | gauffelkölsch  |
|                     | absolute quantity | 42               | 36            | 29                | 25                  | 17              | 14                  | 12                | 11                     | 9               | 8              |
| inspiration         | hashtag           | art              | techno        | streetart         | inspiration         | graffiti        | artist              | kunst             | instaart               | picture         | artofvisuals   |
|                     | absolute quantity | 60               | 45            | 35                | 24                  | 22              | 21                  | 21                | 19                     | 19              | 16             |
| photography         | hashtag           | photography      | picoftheday   | photooftheday     | naturephotography   | fotografie      | pictureoftheday     | travelphotography | instapic               | potd            | photo          |
|                     | absolute quantity | 217              | 195           | 173               | 163                 | 83              | 51                  | 50                | 50                     | 48              | 46             |
| politics            | hashtag           | europawahl2019   | gretathunberg | lgbt              | europawahl          | actnow          | extinctionrebellion | weltohnehunger    | arbeitundsozialordnung | cdu             | bundesminister |
|                     | absolute quantity | 6                | 6             | 5                 | 5                   | 5               | 5                   | 3                 | 2                      | 2               | 2              |
| recreation          | hashtag           | fun              | music         | outdoor           | relax               | trip            | spaziergang         | riesenrad         | walk                   | vacation        | dog            |
|                     | absolute quantity | 159              | 63            | 48                | 46                  | 44              | 35                  | 30                | 29                     | 27              | 23             |
| sense of place      | hashtag           | nature           | sun           | flowers           | rhein               | natur           | sonne               | sunnyday          | trees                  | sunshine        | sunset         |
|                     | absolute quantity | 422              | 206           | 171               | 158                 | 142             | 138                 | 89                | 77                     | 75              | 74             |
| social interactions | hashtag           | friends          | party         | friendship        | friendshipgoals     | freunde         | couple              | couplegoals       | people                 | feiern          | abitur         |
|                     | absolute quantity | 141              | 116           | 32                | 25                  | 21              | 19                  | 19                | 16                     | 15              | 15             |
| spiritual/religious | hashtag           | love             | happy         | wanderlust        | goodvibes           | smile           | summervibes         | liebe             | lifestyle              | ♥               | amazing        |
|                     | absolute quantity | 241              | 130           | 61                | 56                  | 55              | 48                  | 39                | 37                     | 35              | 30             |
| sport               | hashtag           | fitness          | running       | sport             | laufen              | dance           | workout             | sportimpark       | run                    | training        | fit            |
|                     | absolute quantity | 39               | 31            | 30                | 25                  | 21              | 19                  | 19                | 18                     | 17              | 14             |
| tourism             | hashtag           | travel           | visitnrw      | visitbonnregion   | instatravel         | travelgram      | visitbonn           | visitgermany      | travelling             | travelblogger   | explore        |
|                     | absolute quantity | 177              | 105           | 73                | 64                  | 57              | 51                  | 28                | 27                     | 24              | 24             |
| work & study        | hashtag           | unibonn          | university    | uni               | universitätbonn     | universität     | student             | universityofbonn  | bonnuniversity         | work            | erasmus        |
|                     | absolute quantity | 253              | 109           | 64                | 50                  | 50              | 22                  | 21                | 17                     | 15              | 13             |



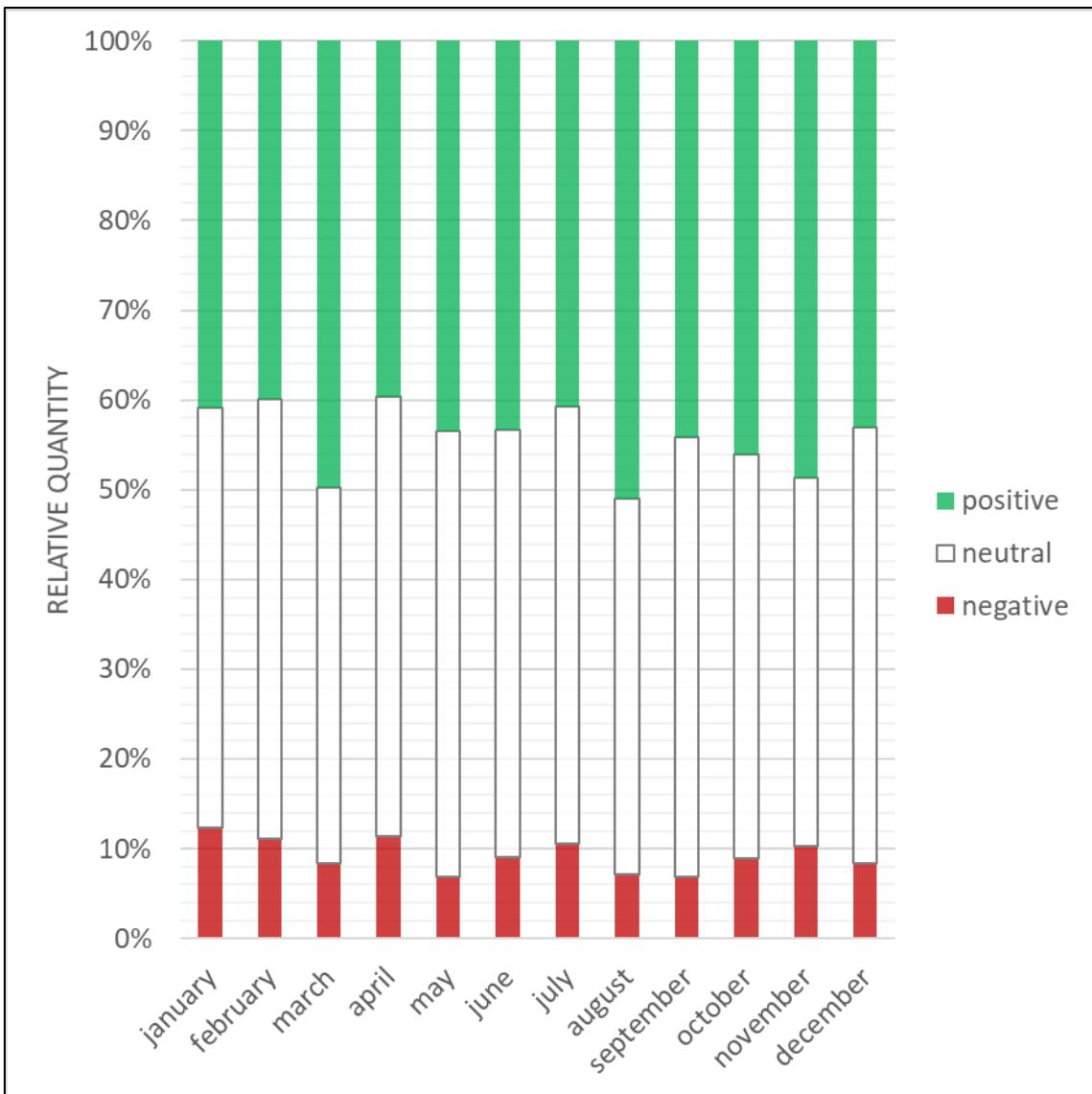
**Figure 11: posts per year in all UGS – absolute frequencies**



**Figure 12: posts per month in all UGS – absolute frequencies**

Table 6: test for equal distribution of PNUCs over months in all UGS and “Big 3”

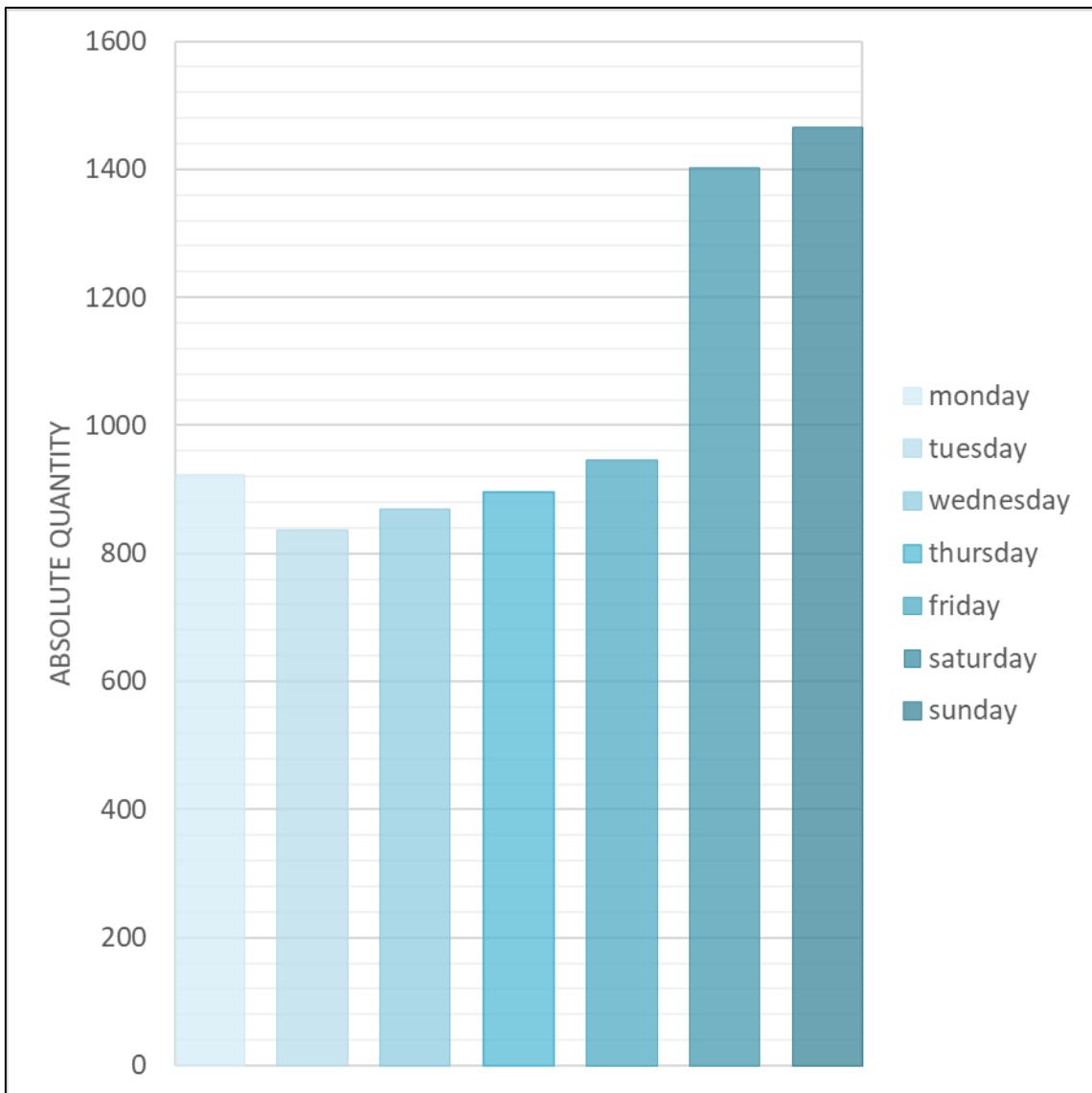
| UGS                 | PNUC                            | p      | min       | max       |
|---------------------|---------------------------------|--------|-----------|-----------|
| all UGS             | <b>tourism</b>                  | 0.0000 | feb,      | oct,      |
|                     | <b>work and study</b>           | 0.0000 | jan,      | may, oct, |
|                     | <b>spiritual/religious</b>      | 0.0000 | jan,      | may,      |
|                     | <b>bond to nature</b>           | 0.0000 | jan,      | oct,      |
|                     | <b>food</b>                     | 0.0000 | feb,      | aug,      |
|                     | <b>event</b>                    | 0.0000 | jan,      | may,      |
|                     | <b>inspiration</b>              | 0.0000 | jan, feb, | may,      |
|                     | <b>sport</b>                    | 0.0000 | feb, mar, | may,      |
|                     | <b>bond to location</b>         | 0.0000 | jan, feb, | sep,      |
|                     | <b>cultural heritage</b>        | 0.0000 | feb,      | nov,      |
|                     | <b>sense of place</b>           | 0.0000 | feb,      | may,      |
|                     | <b>recreation</b>               | 0.0000 | feb,      | may,      |
|                     | <b>social interactions</b>      | 0.0000 | dec       | aug,      |
|                     | <b>aesthetic</b>                | 0.0000 | feb,      | oct,      |
|                     | <b>photography</b>              | 0.0000 | feb,      | may,      |
| Botani-scher Garten | <b>sense of place</b>           | 0.0000 | jan,      | sep,      |
|                     | <b>aesthetic</b>                | 0.0000 | jan,      | oct,      |
|                     | <b>photography</b>              | 0.0000 | feb,      | sep,      |
| Hofgarten           | <b>work and study</b>           | 0.0000 | jan, feb, | apr,      |
|                     | <b>spiritual/religious</b>      | 0.0000 | jan,      | apr,      |
|                     | <b>bond to location</b>         | 0.0003 | jan,      | sep,      |
|                     | <b>cultural heritage</b>        | 0.0008 | jan,      | sep,      |
|                     | <b>sense of place</b>           | 0.0000 | feb,      | apr,      |
|                     | <b>recreation</b>               | 0.0000 | feb,      | apr,      |
|                     | <b>aesthetic</b>                | 0.0000 | feb,      | sep,      |
| Rhein-aue           | <b>photography</b>              | 0.0000 | jan, dec  | apr,      |
|                     | <b>spiritual/religious</b>      | 0.0000 | jan, dec  | may,      |
|                     | <b>sense of place</b>           | 0.0000 | dec       | may,      |
|                     | <b>photography</b>              | 0.0000 | mar,      | may,      |
|                     | significance at the 0.05 level  |        |           |           |
|                     | significance at the 0.01 level  |        |           |           |
|                     | significance at the 0.001 level |        |           |           |



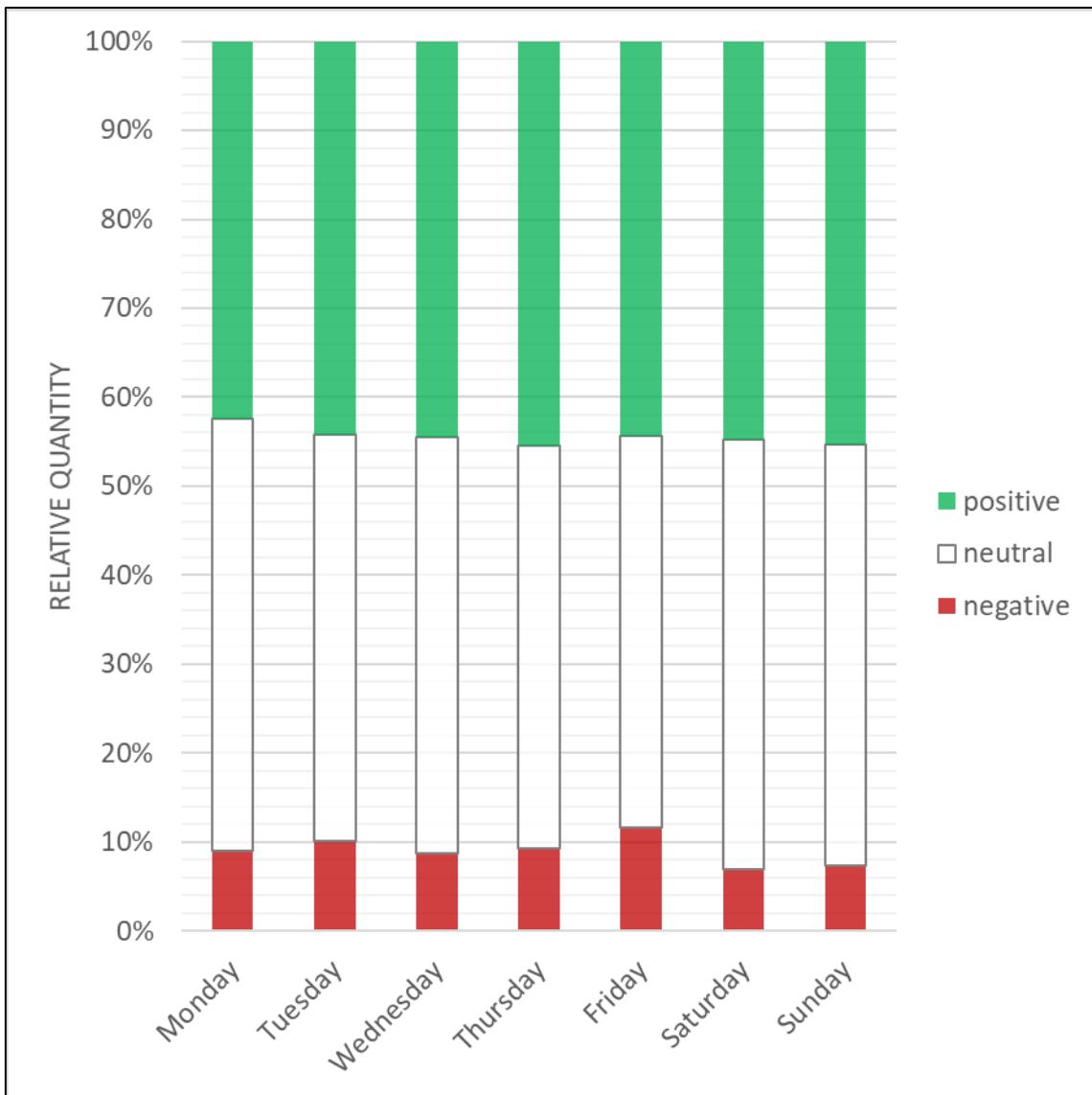
**Figure 13: posts per sentiment and month in all UGS – relative frequencies**

**Table 7: test for independence of sentiments on months in all UGS and the “Big 3”**

| UGS                       | sentiment       | p      |
|---------------------------|-----------------|--------|
| <i>all UGS</i>            | <b>negative</b> | 0.0777 |
|                           | <b>neutral</b>  | 0.4548 |
|                           | <b>positive</b> | 0.1765 |
| <i>Botanischer Garten</i> | <b>neutral</b>  | 0.4487 |
|                           | <b>positive</b> | 0.1008 |
| <i>Hofgarten</i>          | <b>negative</b> | 0.5727 |
|                           | <b>neutral</b>  | 0.9991 |
|                           | <b>positive</b> | 0.9593 |
| <i>Rheinaue</i>           | <b>neutral</b>  | 0.4144 |
|                           | <b>positive</b> | 0.5619 |



**Figure 14: posts per weekday in all UGS – absolute frequencies**



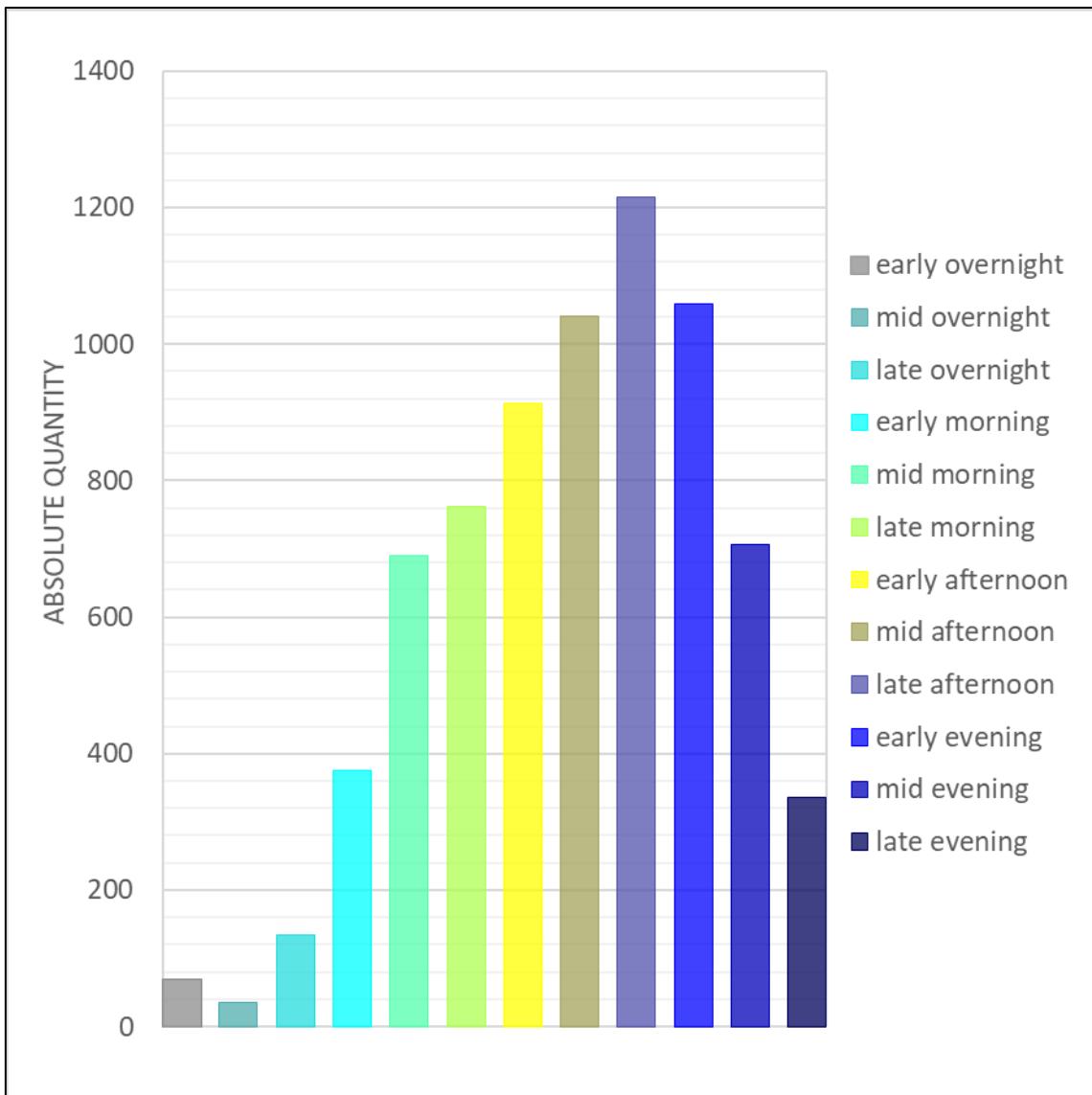
**Figure 15: posts per sentiment and weekday in all UGS – relative frequencies**

**Table 8: test for equal distribution of PNUCs over weekdays in all UGS and “Big 3”**

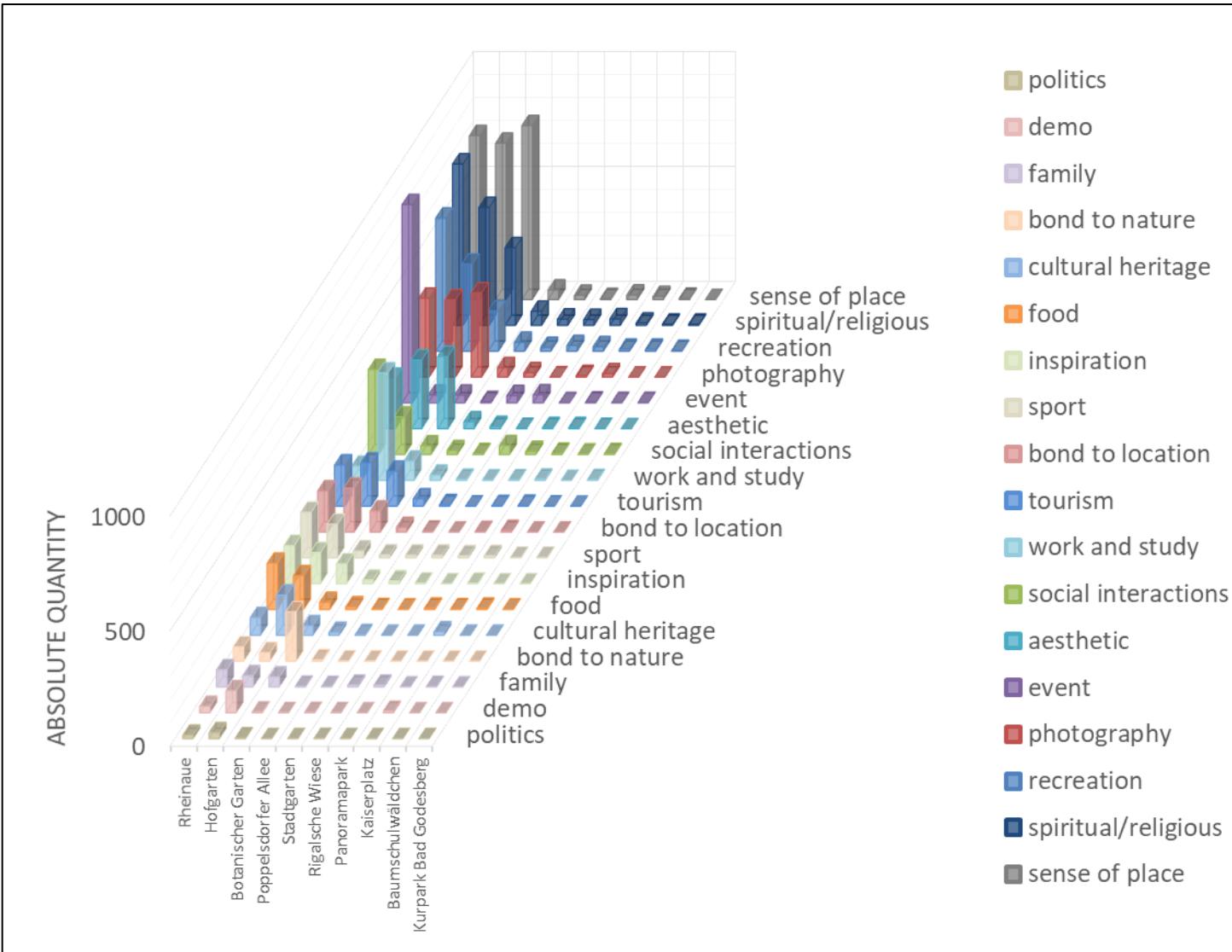
| UGS                             | PNUC                | p      | min       | max  |
|---------------------------------|---------------------|--------|-----------|------|
| all UGS                         | tourism             | 0.0027 | wed,      | sun, |
|                                 | work and study      | 0.0486 | fri,      | thu, |
|                                 | spiritual/religious | 0.0000 | tue,      | sun, |
|                                 | bond to nature      | 0.0254 | mon, tue, | sun, |
|                                 | food                | 0.0000 | mon,      | sat, |
|                                 | event               | 0.0000 | wed,      | sat, |
|                                 | inspiration         | 0.1348 |           |      |
|                                 | sport               | 0.0000 | tue,      | sun, |
|                                 | family              | 0.0001 | thu,      | sun, |
|                                 | bond to location    | 0.0000 | tue,      | sat, |
|                                 | demo                | 0.0000 | mon,      | fri, |
|                                 | cultural heritage   | 0.5231 |           |      |
|                                 | sense of place      | 0.0000 | fri,      | sun, |
|                                 | recreation          | 0.0000 | thu,      | sun, |
|                                 | social interactions | 0.0000 | tue,      | sat, |
|                                 | aesthetic           | 0.0000 | fri,      | sun, |
|                                 | photography         | 0.0000 | fri,      | sun, |
| Botanischer Garten              | tourism             | 0.1241 |           |      |
|                                 | work and study      | 0.0486 | tue,      | thu, |
|                                 | spiritual/religious | 0.5979 |           |      |
|                                 | bond to nature      | 0.6350 |           |      |
|                                 | inspiration         | 0.1885 |           |      |
|                                 | bond to location    | 0.8184 |           |      |
|                                 | sense of place      | 0.1656 |           |      |
|                                 | recreation          | 0.9338 |           |      |
|                                 | aesthetic           | 0.7796 |           |      |
|                                 | photography         | 0.0532 |           |      |
| Hofgarten                       | tourism             | 0.5797 |           |      |
|                                 | work and study      | 0.1491 |           |      |
|                                 | spiritual/religious | 0.9056 |           |      |
|                                 | food                | 0.2674 |           |      |
|                                 | inspiration         | 0.9425 |           |      |
|                                 | sport               | 0.0923 |           |      |
|                                 | bond to location    | 0.0784 |           |      |
|                                 | cultural heritage   | 0.6983 |           |      |
|                                 | sense of place      | 0.1011 |           |      |
|                                 | recreation          | 0.6261 |           |      |
|                                 | social interactions | 0.2191 |           |      |
|                                 | aesthetic           | 0.4688 |           |      |
|                                 | photography         | 0.0810 |           |      |
|                                 | tourism             | 0.0001 | wed,      | sun, |
| Rheinaue                        | spiritual/religious | 0.0000 | tue,      | sun, |
|                                 | food                | 0.0000 | tue,      | sat, |
|                                 | event               | 0.0000 | wed,      | sat, |
|                                 | inspiration         | 0.0001 | tue,      | sun, |
|                                 | sport               | 0.0000 | mon,      | sun, |
|                                 | bond to location    | 0.0000 | wed,      | sat, |
|                                 | cultural heritage   | 0.4031 |           |      |
|                                 | sense of place      | 0.0000 | thu,      | sun, |
|                                 | recreation          | 0.0000 | thu,      | sun, |
|                                 | social interactions | 0.0000 | tue,      | sat, |
|                                 | aesthetic           | 0.0000 | thu,      | sun, |
|                                 | photography         | 0.0000 | fri,      | sun, |
| significance at the 0.05 level  |                     |        |           |      |
| significance at the 0.01 level  |                     |        |           |      |
| significance at the 0.001 level |                     |        |           |      |

**Table 9: test for independence of sentiments on weekdays in all UGS and the “Big 3”**

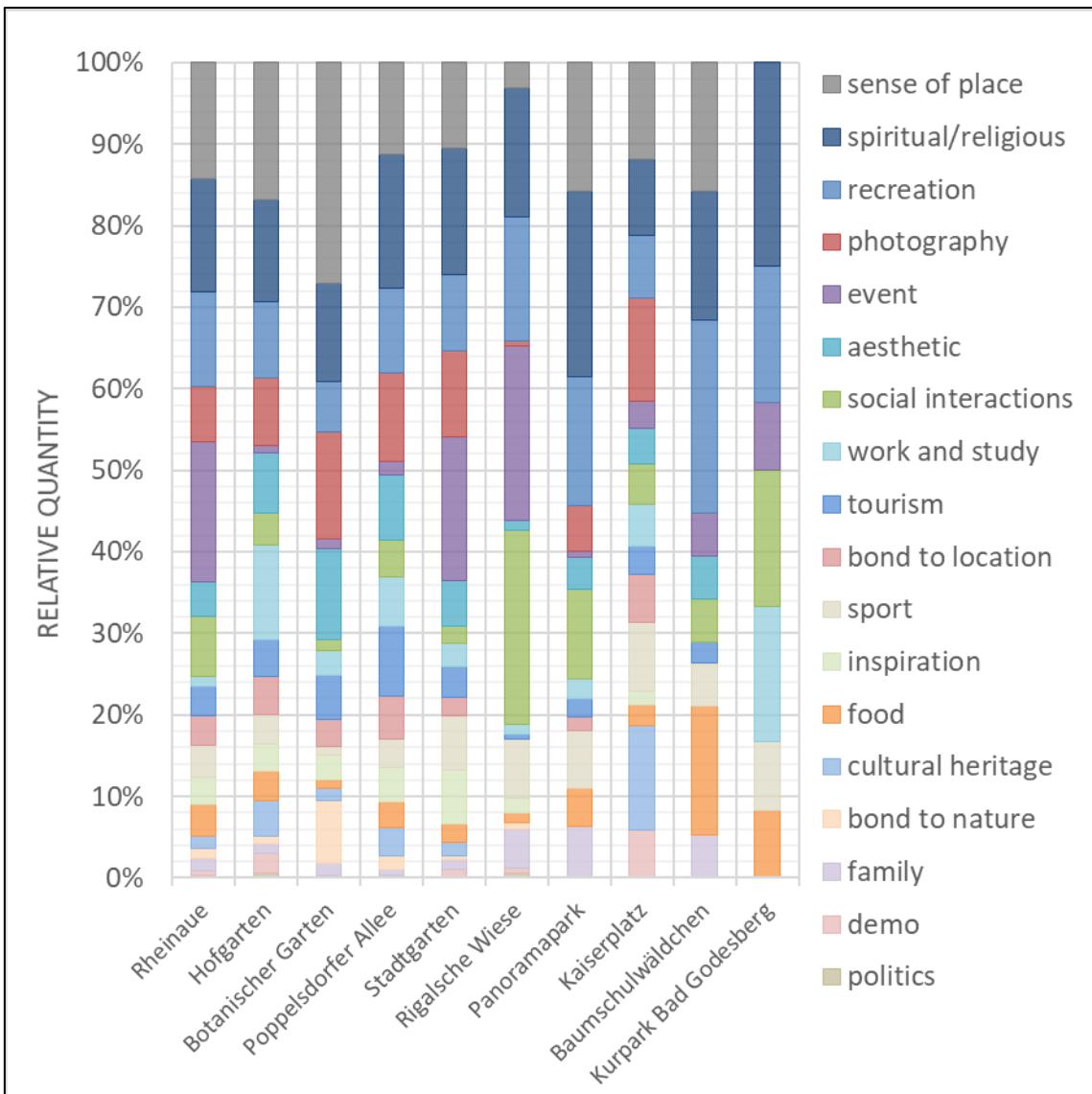
| UGS                            | sentiment       | p      |
|--------------------------------|-----------------|--------|
| <i>all UGS</i>                 | <b>negative</b> | 0.0282 |
|                                | <b>neutral</b>  | 0.8528 |
|                                | <b>positive</b> | 0.9842 |
| Botanischer Garten             | <b>positive</b> | 0.9360 |
|                                | <b>neutral</b>  | 0.7940 |
|                                | <b>positive</b> | 0.6271 |
| Hofgarten                      | <b>negative</b> | 0.8272 |
|                                | <b>neutral</b>  | 0.9237 |
|                                | <b>positive</b> | 0.8239 |
| Rheinaue                       | <b>positive</b> | 0.0513 |
|                                | <b>neutral</b>  | 0.5566 |
|                                | <b>positive</b> | 0.7536 |
| significance at the 0.05 level |                 |        |



**Figure 16: posts per daytime in all UGS – absolute frequencies**



**Figure 17: posts per PNUCs and UGS – absolute frequencies**



**Figure 18: posts per PNUC and UGS – relative frequencies**

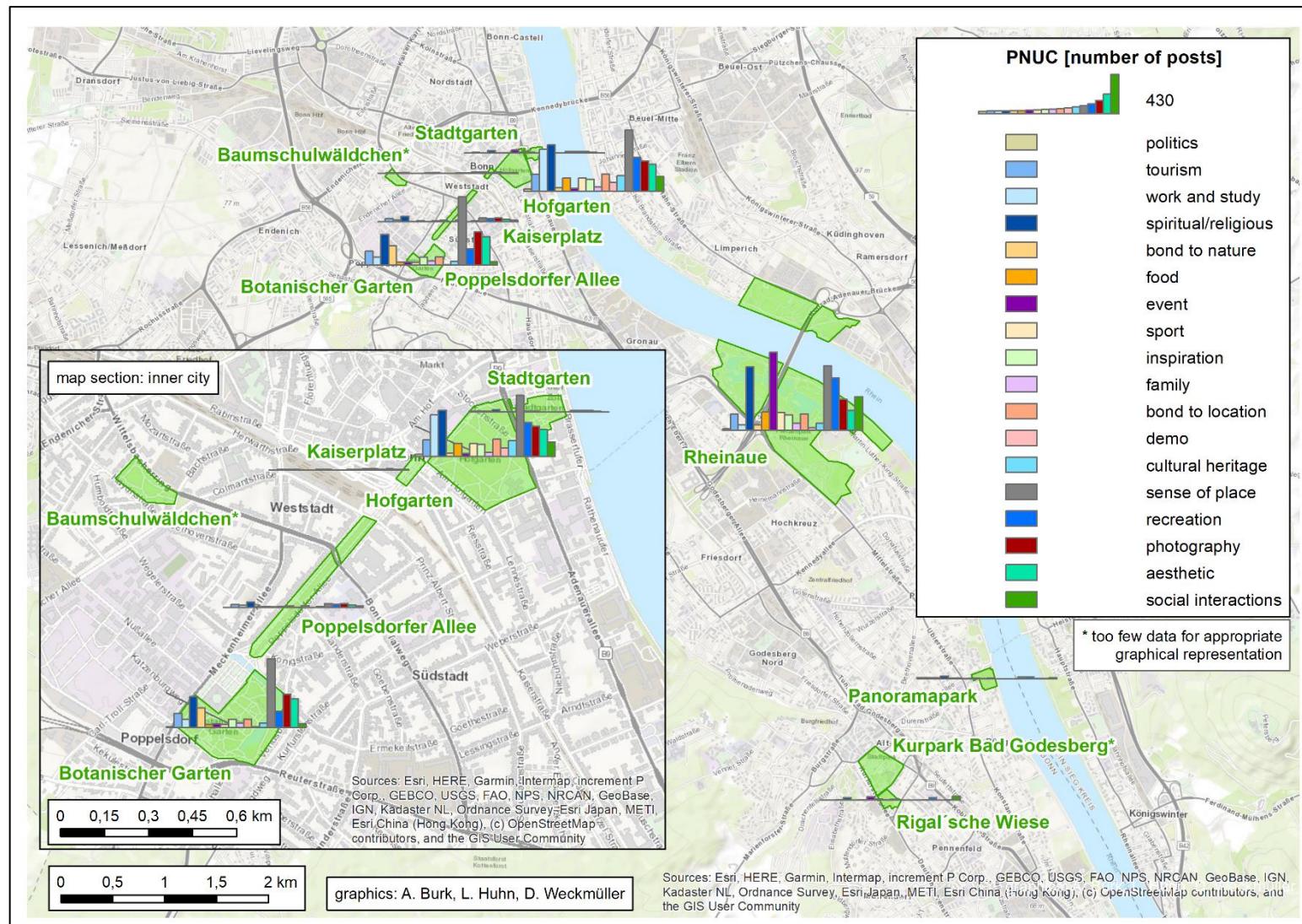
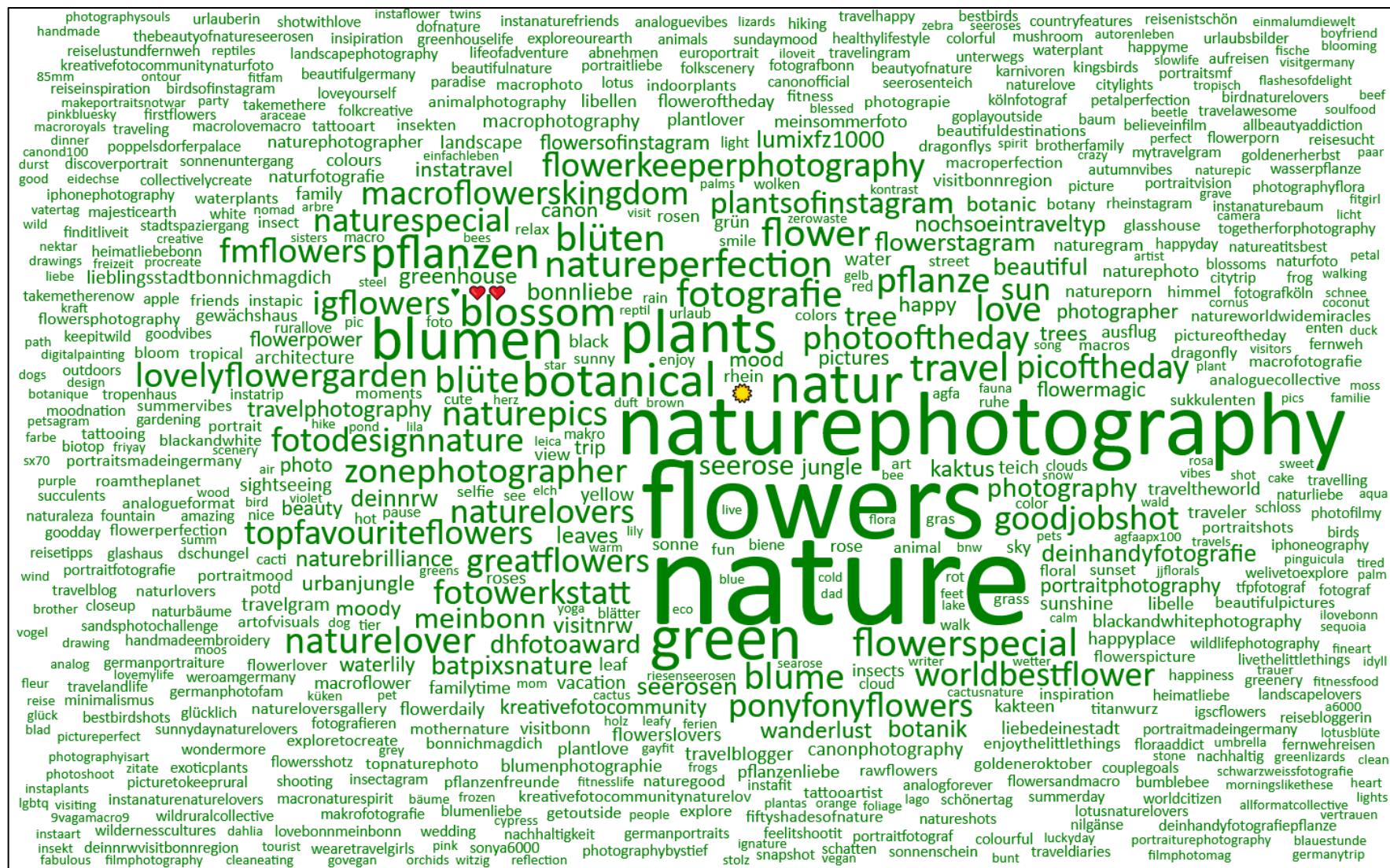


Figure 19: map of posts per PNUC and UGS – absolute frequencies



**Figure 20:** word cloud of categorized (PNUC) hashtags in Botanischer Garten

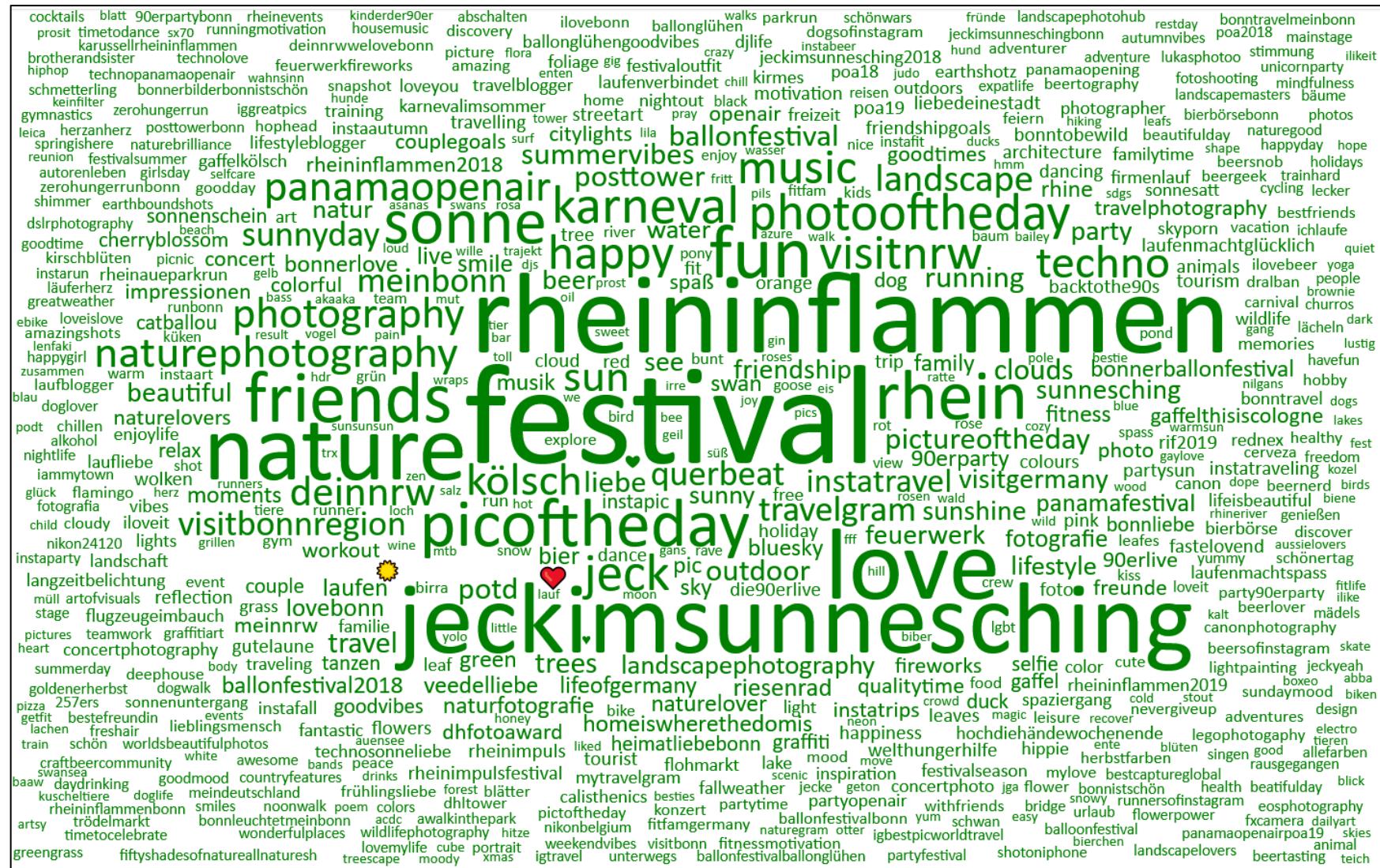
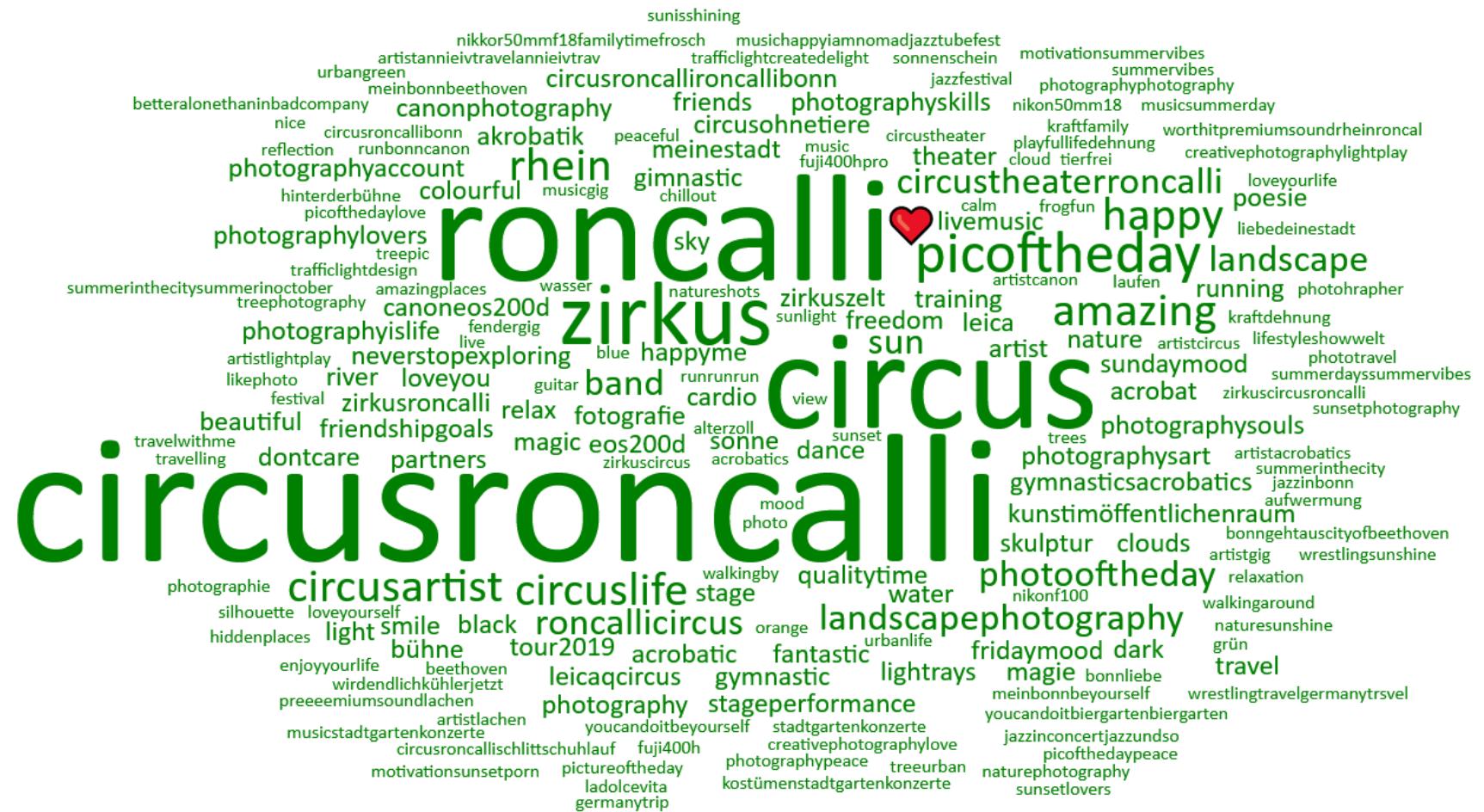


Figure 21: word cloud of categorized (PNUC) hashtags in Rheinaue



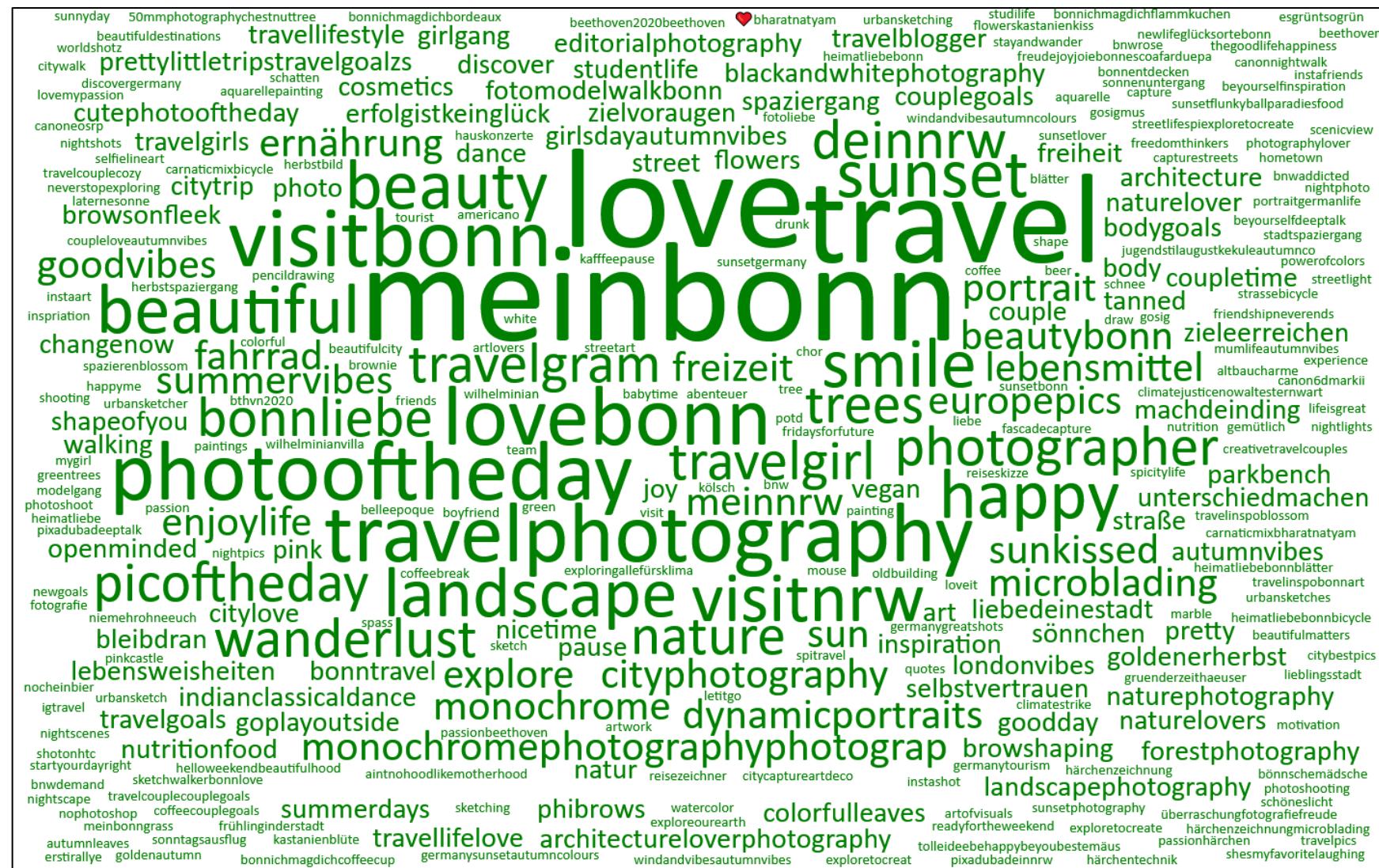
**Figure 22:** word cloud of categorized (PNUC) hashtags in Rigal'sche Wiese



**Figure 23:** word cloud of categorized (PNUC) hashtags in Stadtgarten



Figure 24: word cloud of categorized (PNUC) hashtags in Hofgarten



**Figure 25:** word cloud of categorized (PNUC) hashtags in Poppelsdorfer Allee



**Figure 26:** word cloud of categorized (PNUC) hashtags in Kaiserplatz

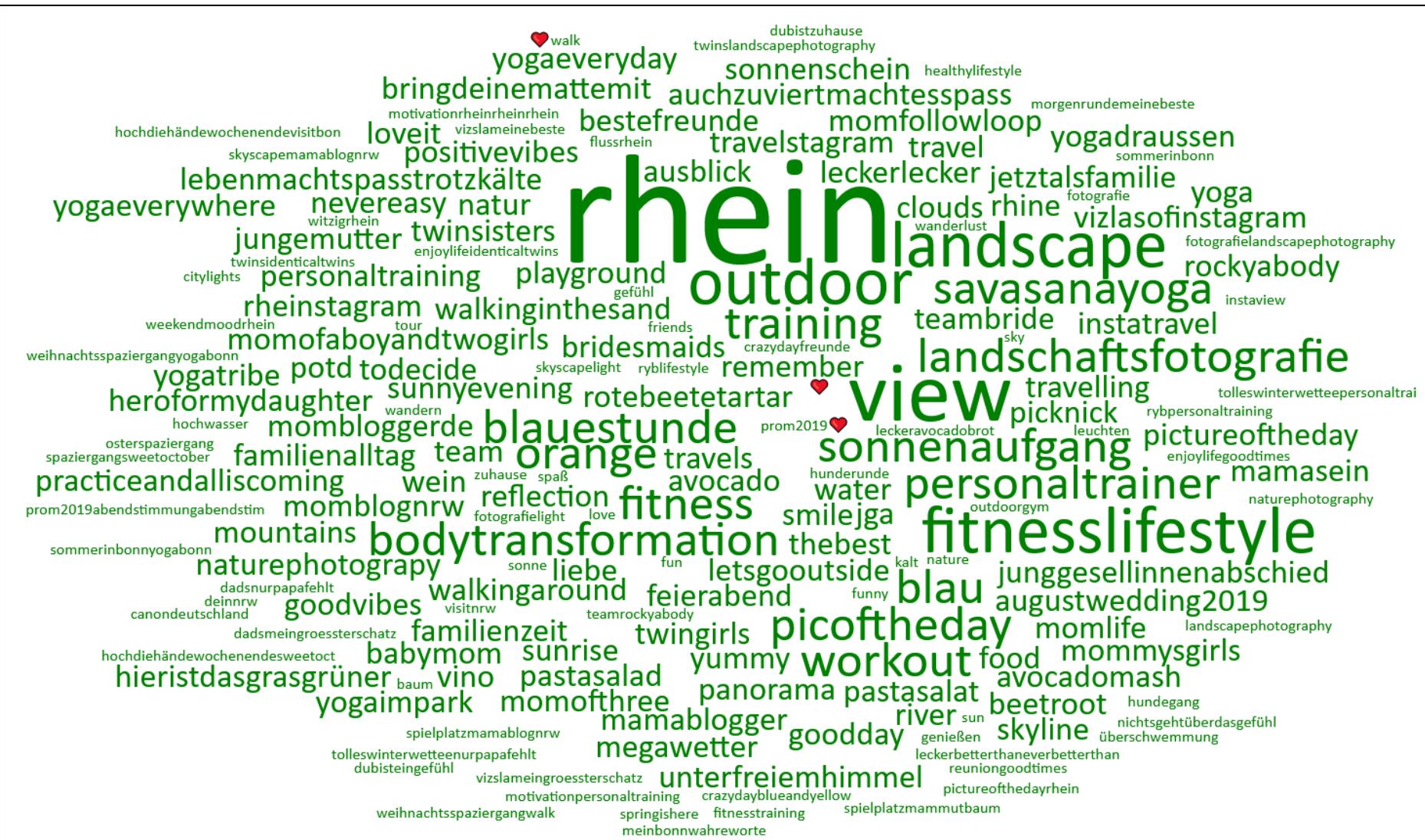
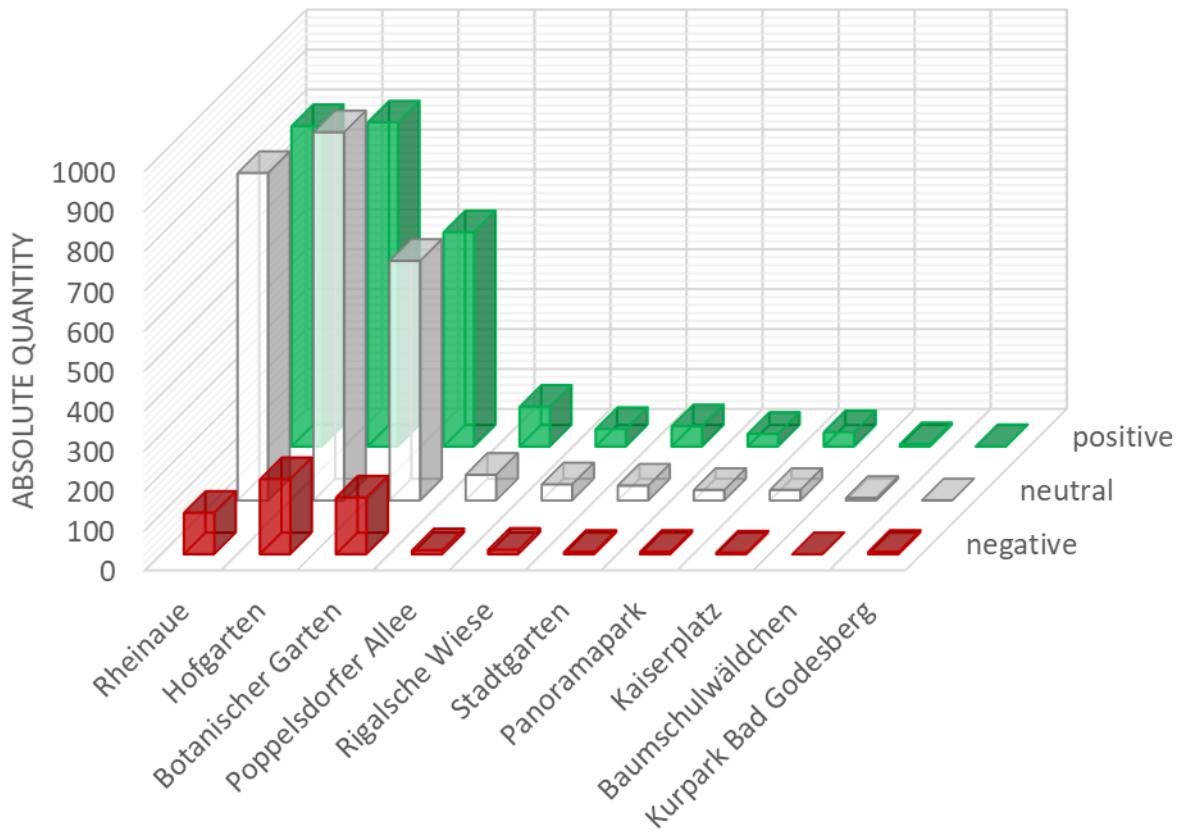
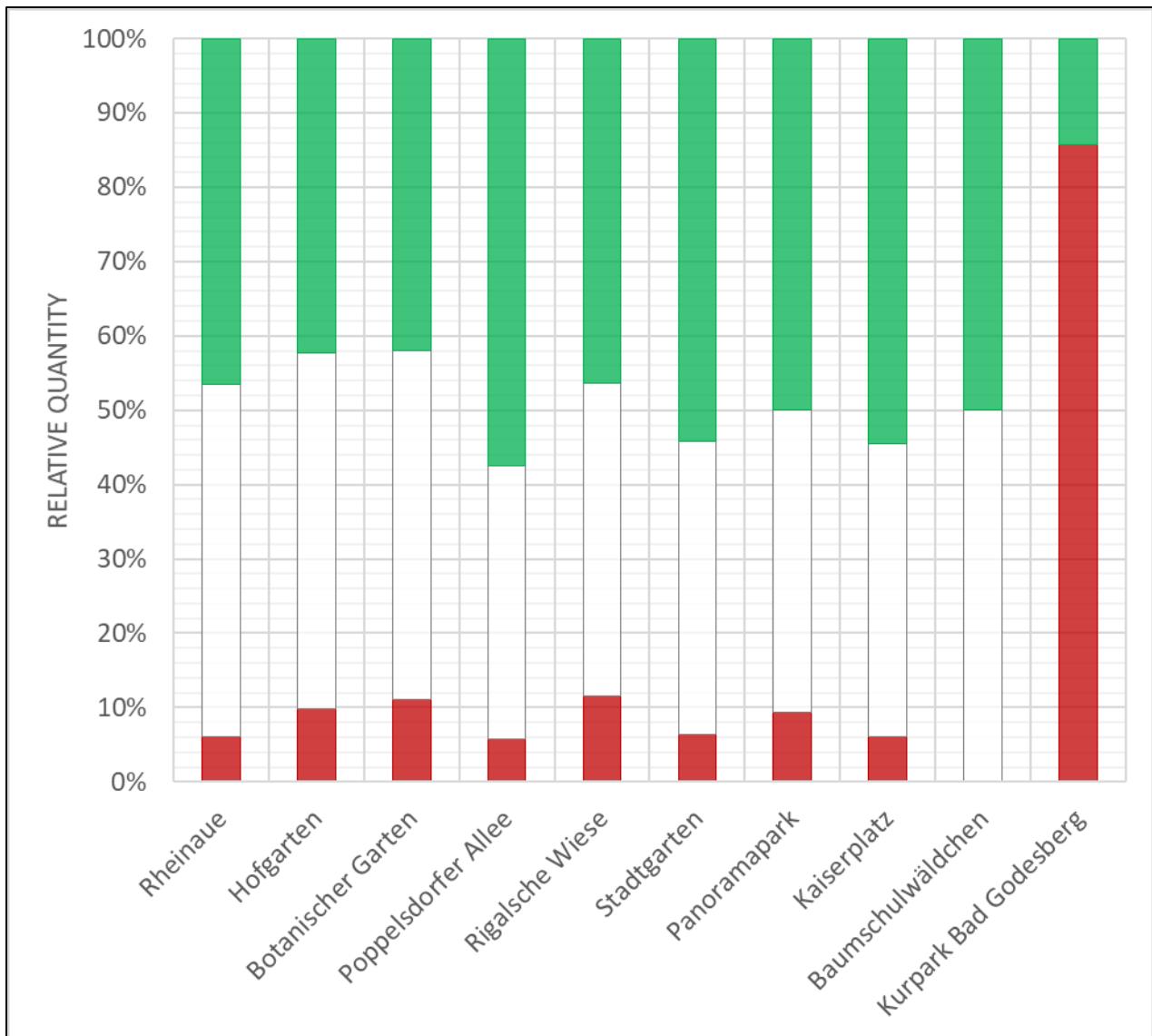


Figure 27: word cloud of categorized (PNUC) hashtags in Panoramapark



**Figure 28: posts per sentiment and UGS – absolute frequencies**



**Figure 29: posts per sentiment and UGS – relative frequencies**

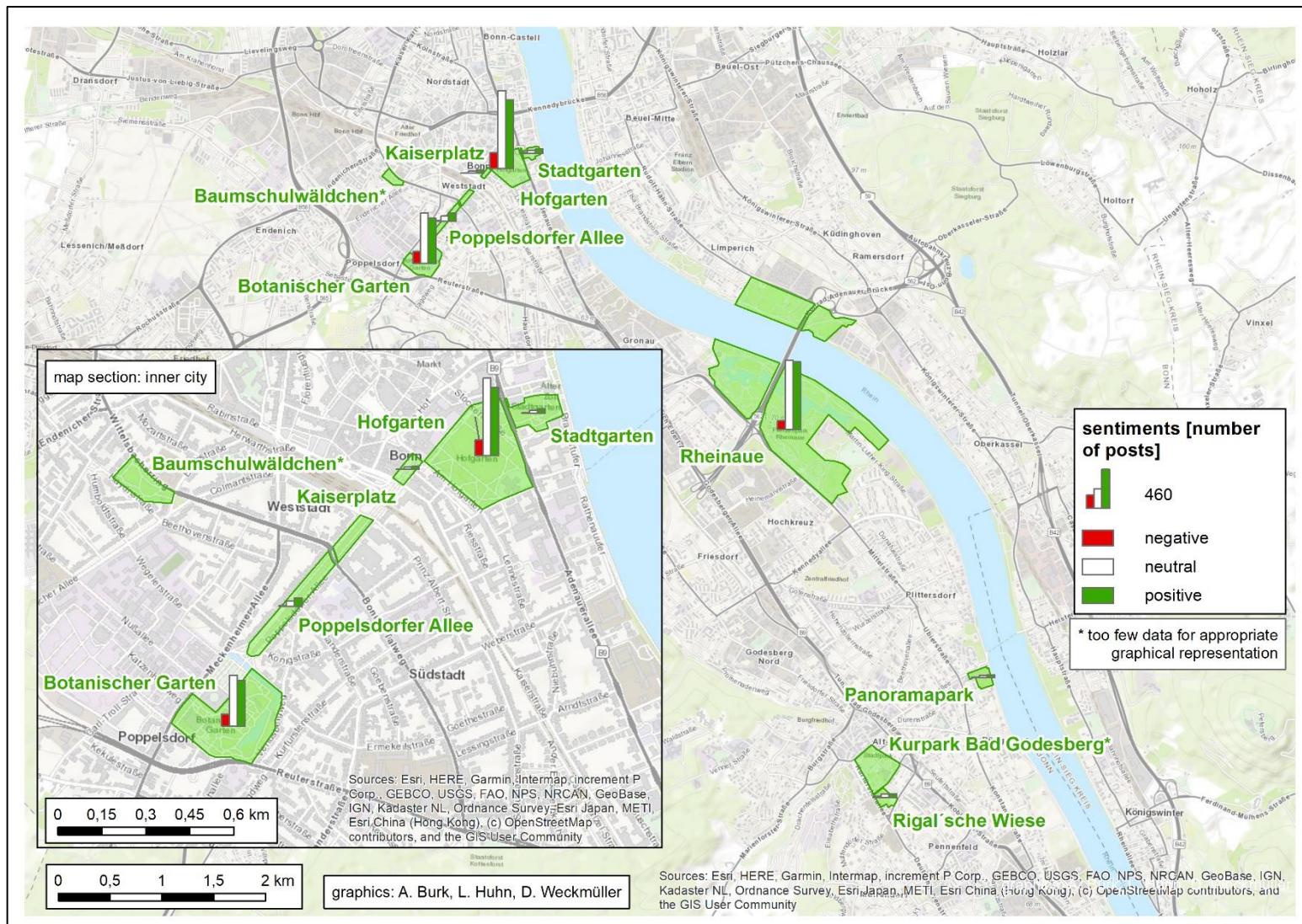
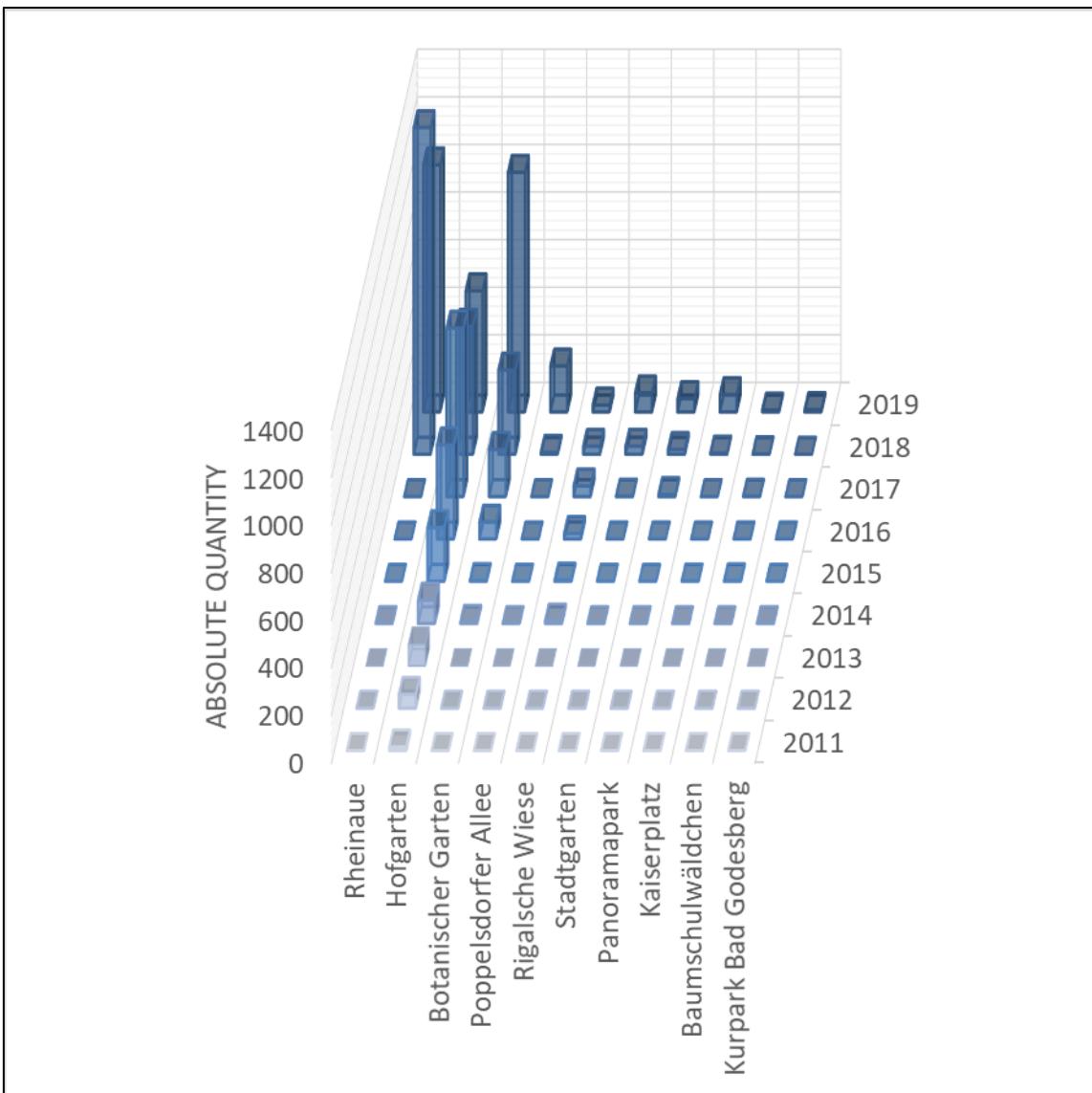
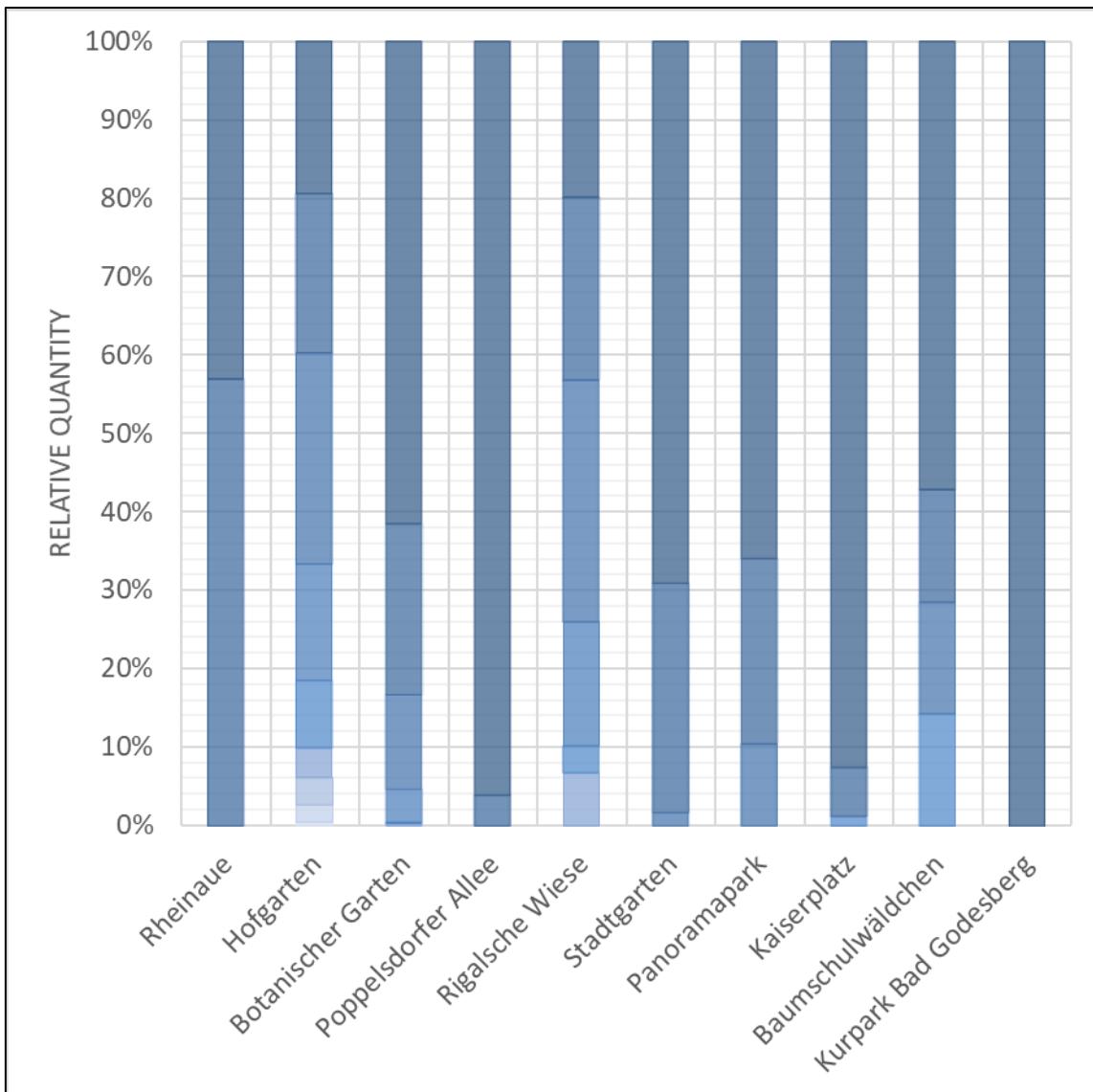


Figure 30: map of posts per sentiment and UGS – absolute frequencies



**Figure 31: posts per year and UGS – absolute frequencies**



**Figure 32: posts per year and UGS – relative frequencies**

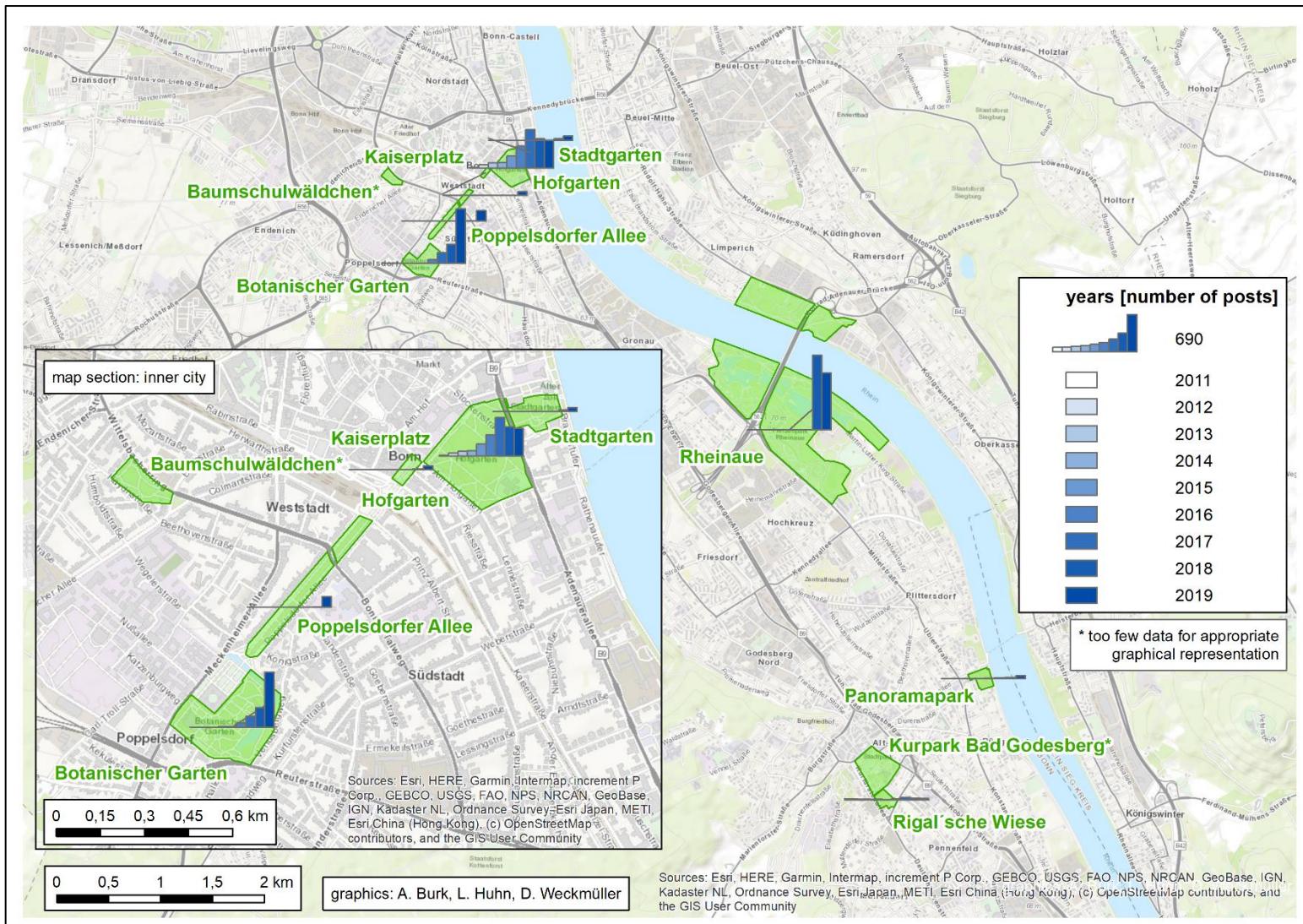
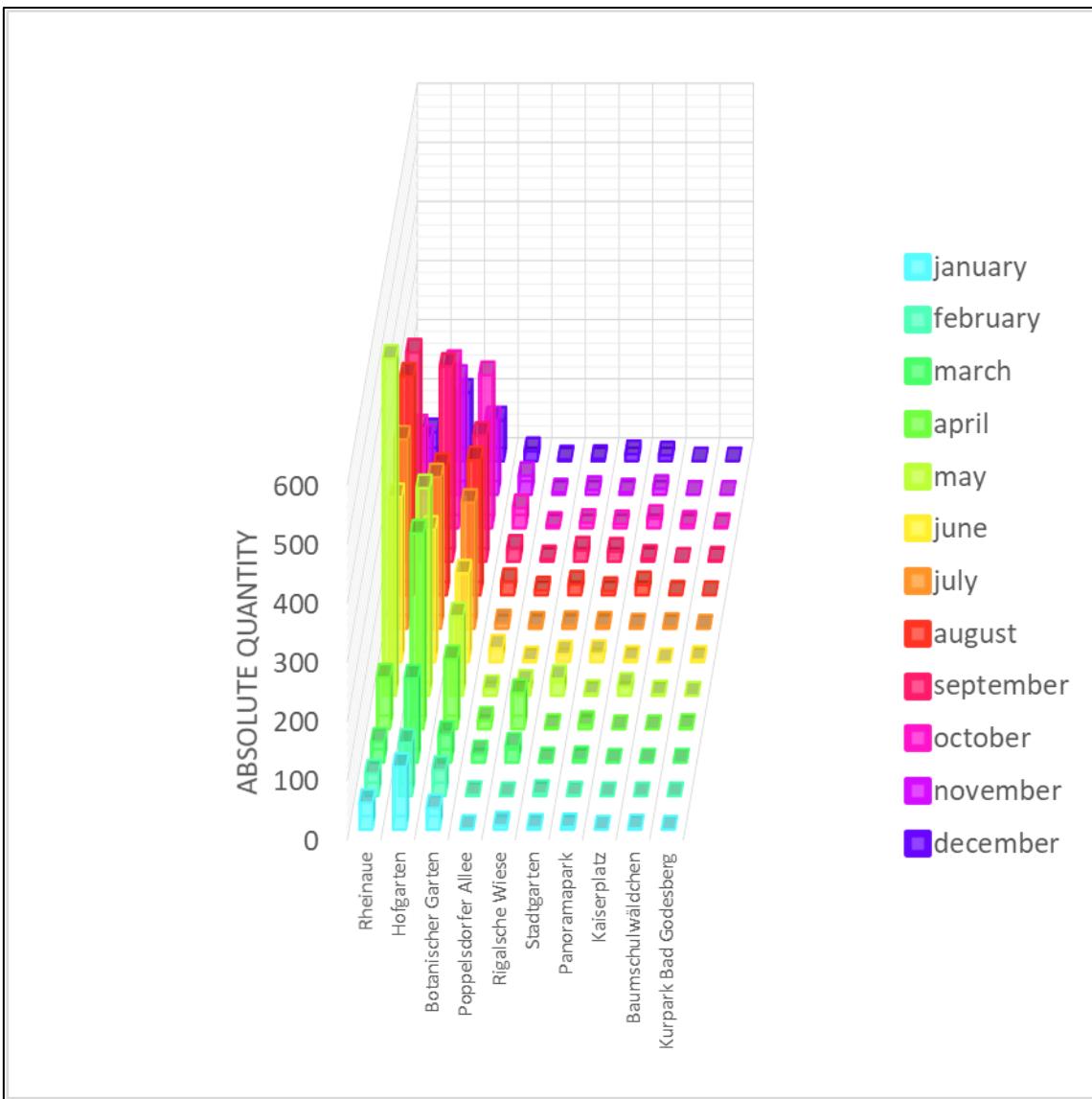
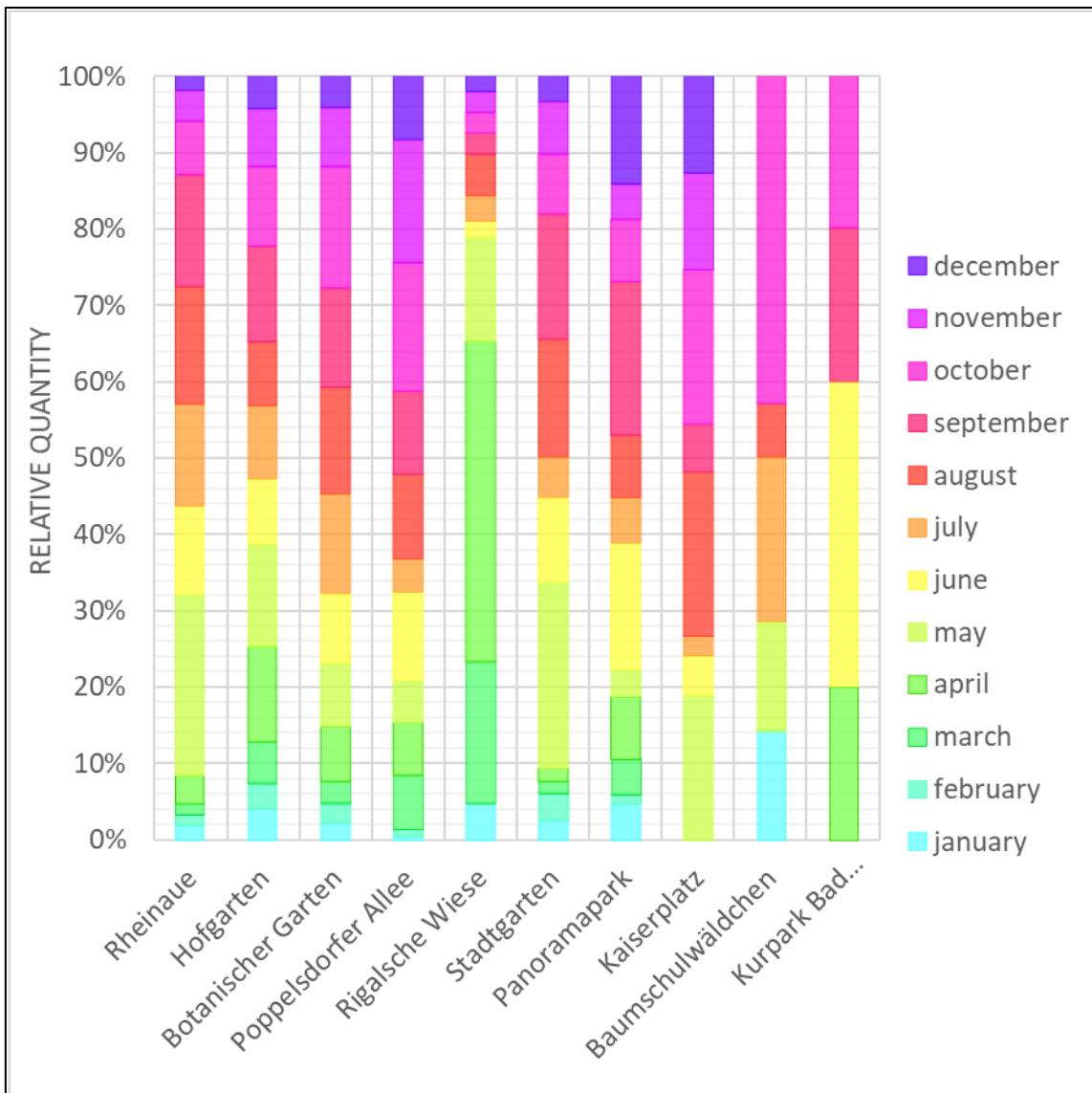


Figure 33: map of posts per year and UGS – absolute frequencies



**Figure 34: posts per month and UGS – absolute frequencies**



**Figure 35: posts per month and UGS – relative frequencies**

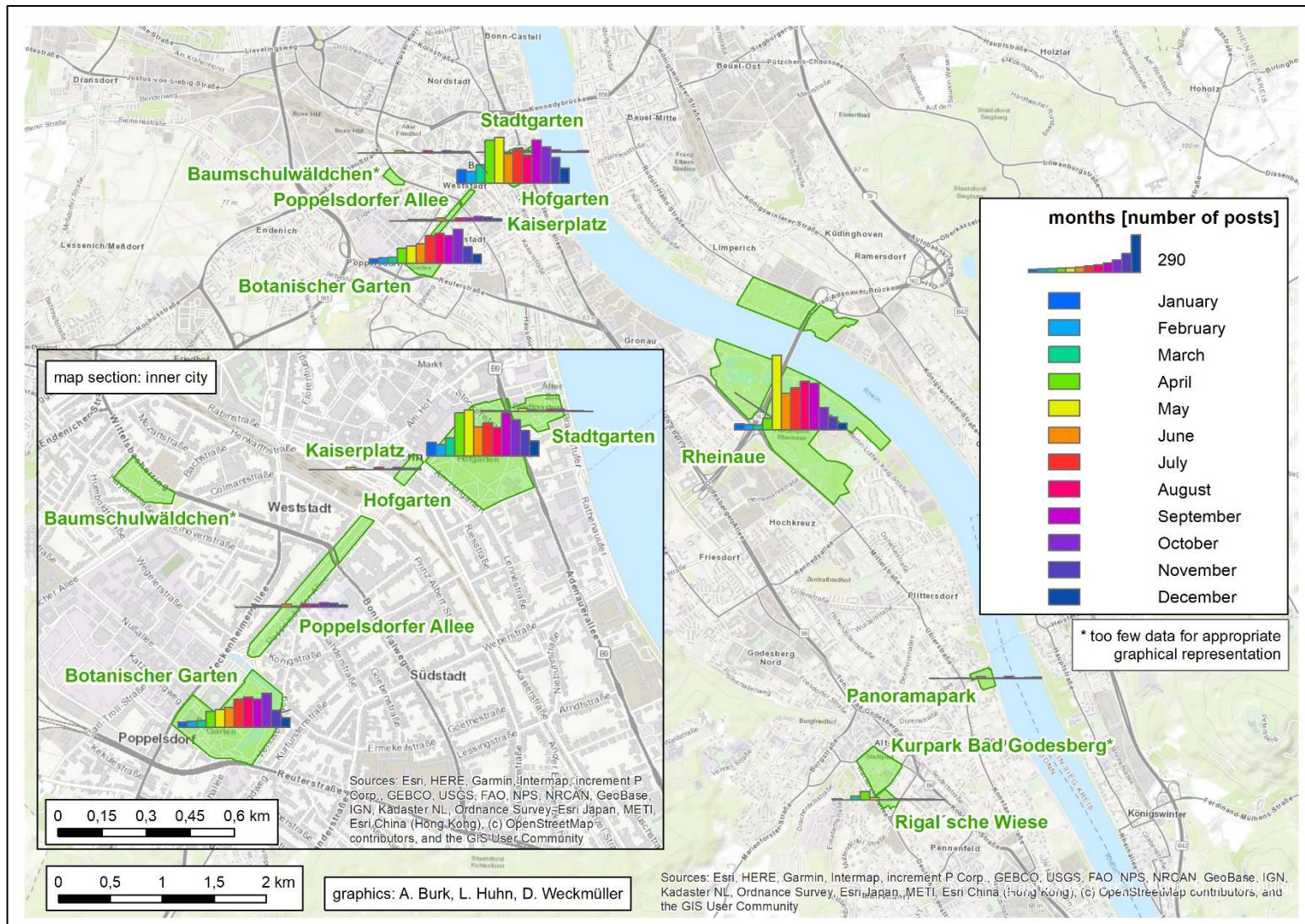


Figure 36: map of posts per month and UGS – absolute frequencies

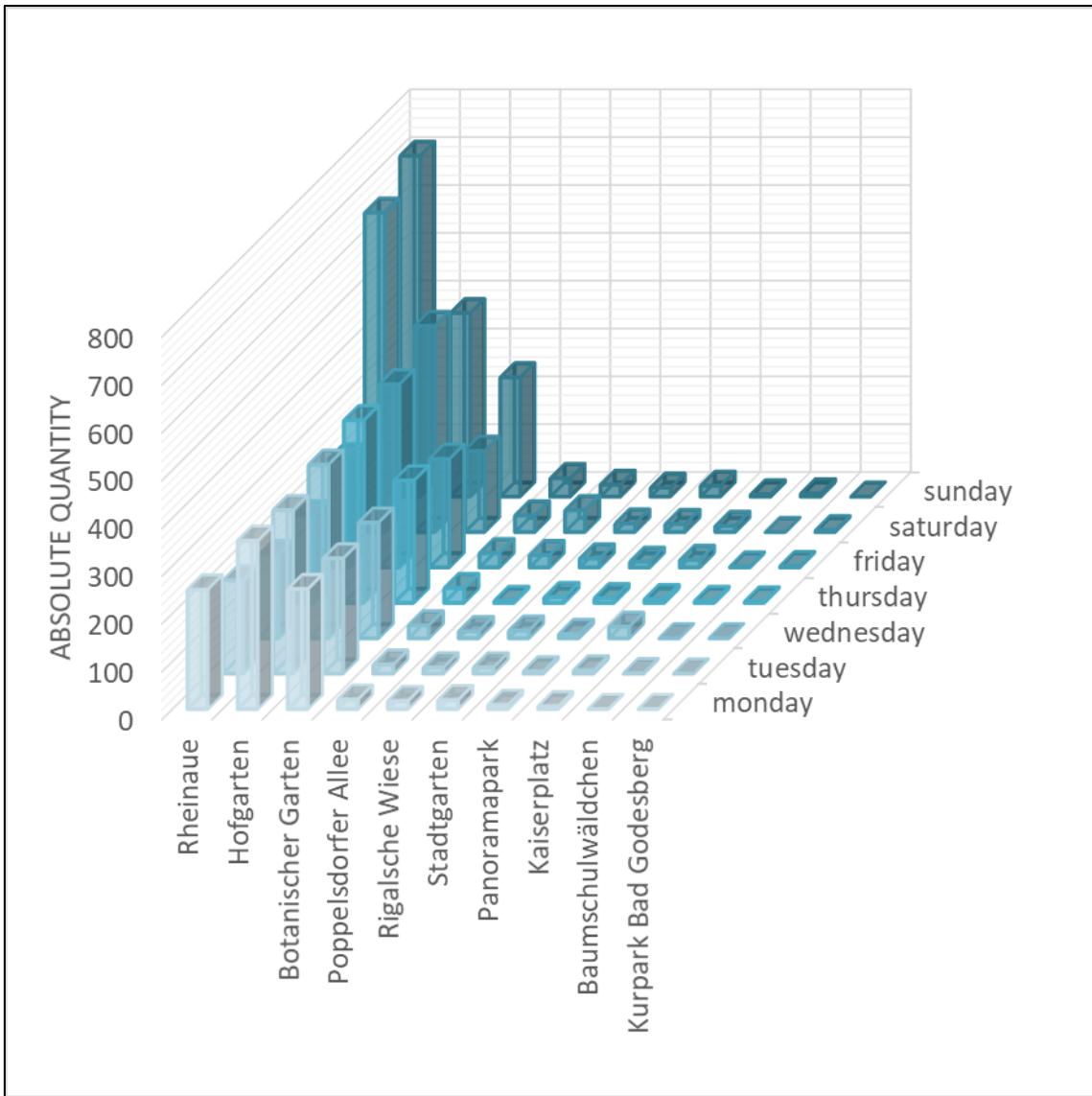
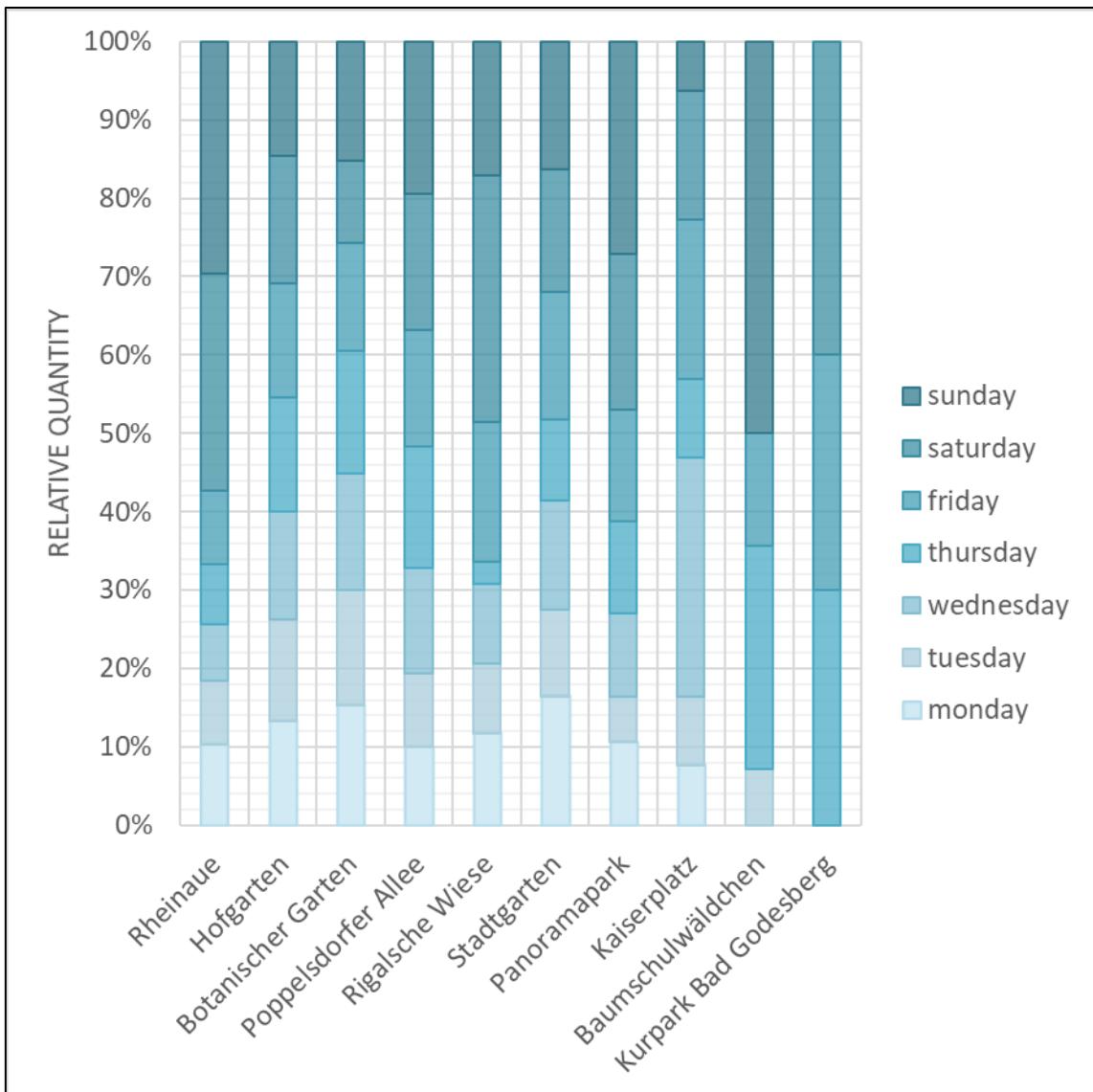


Figure 37: posts per weekday and UGS – absolute frequencies



**Figure 38: posts per weekday and UGS – relative frequencies**

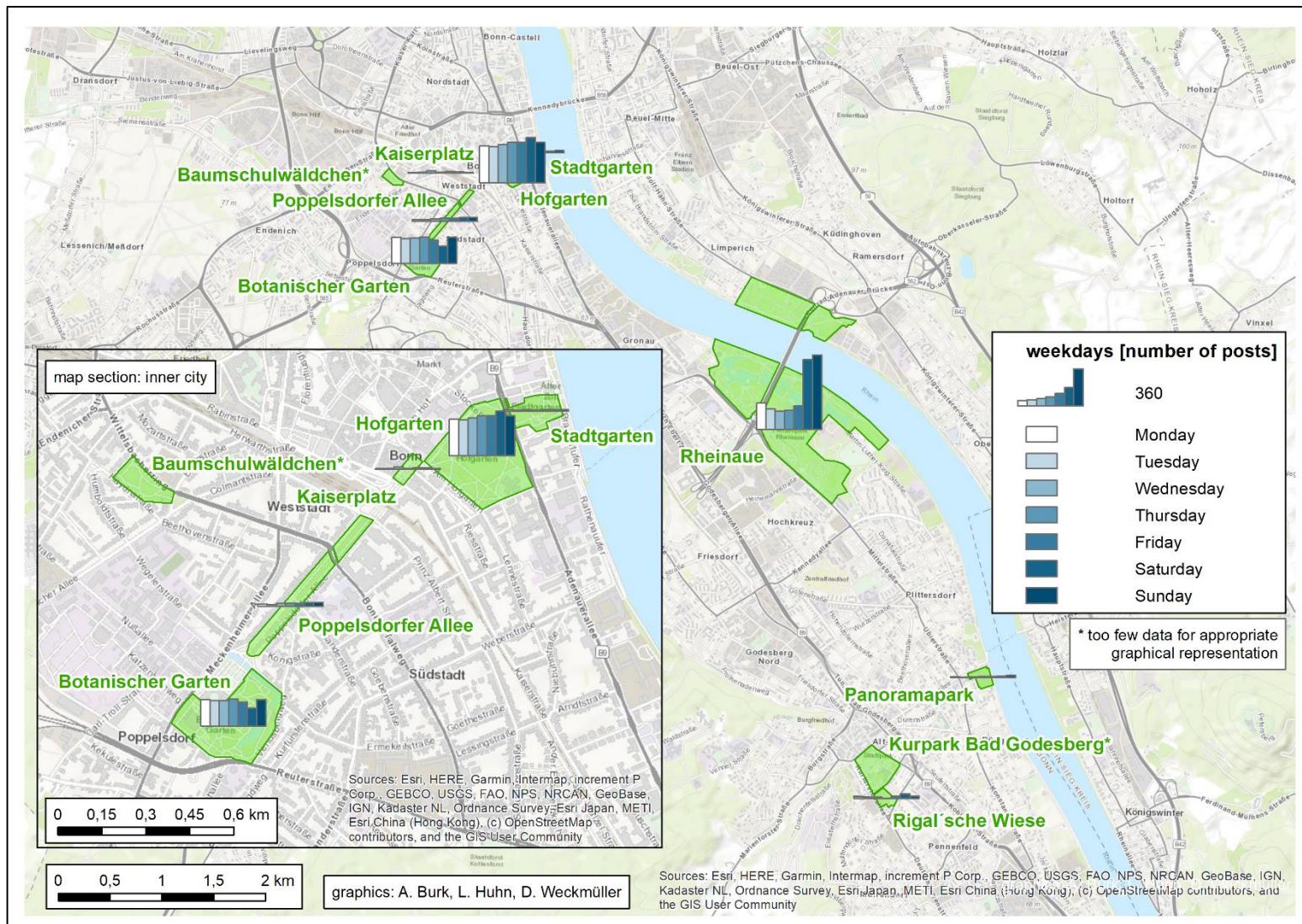


Figure 39: map of posts per weekday and UGS – absolute frequencies

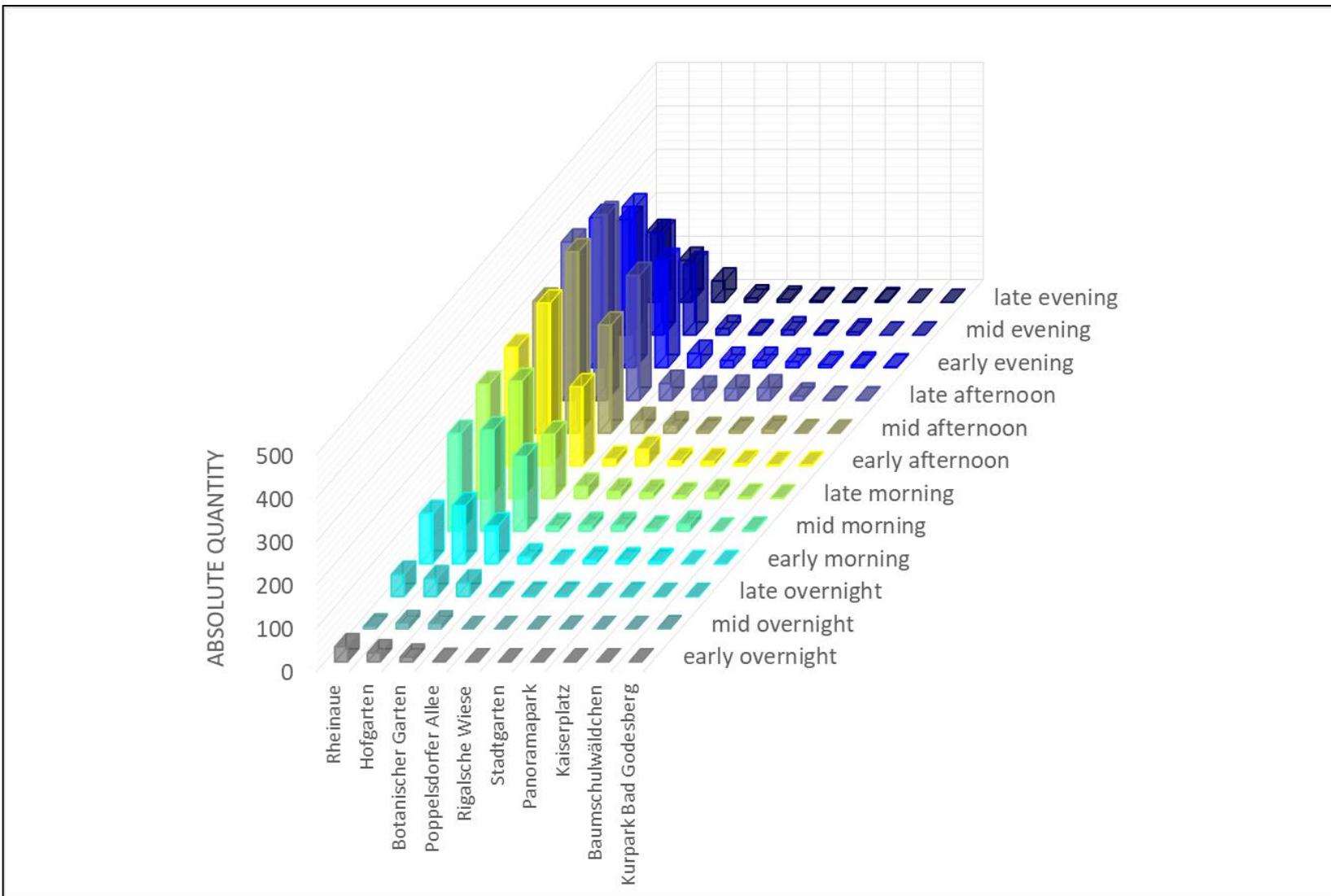
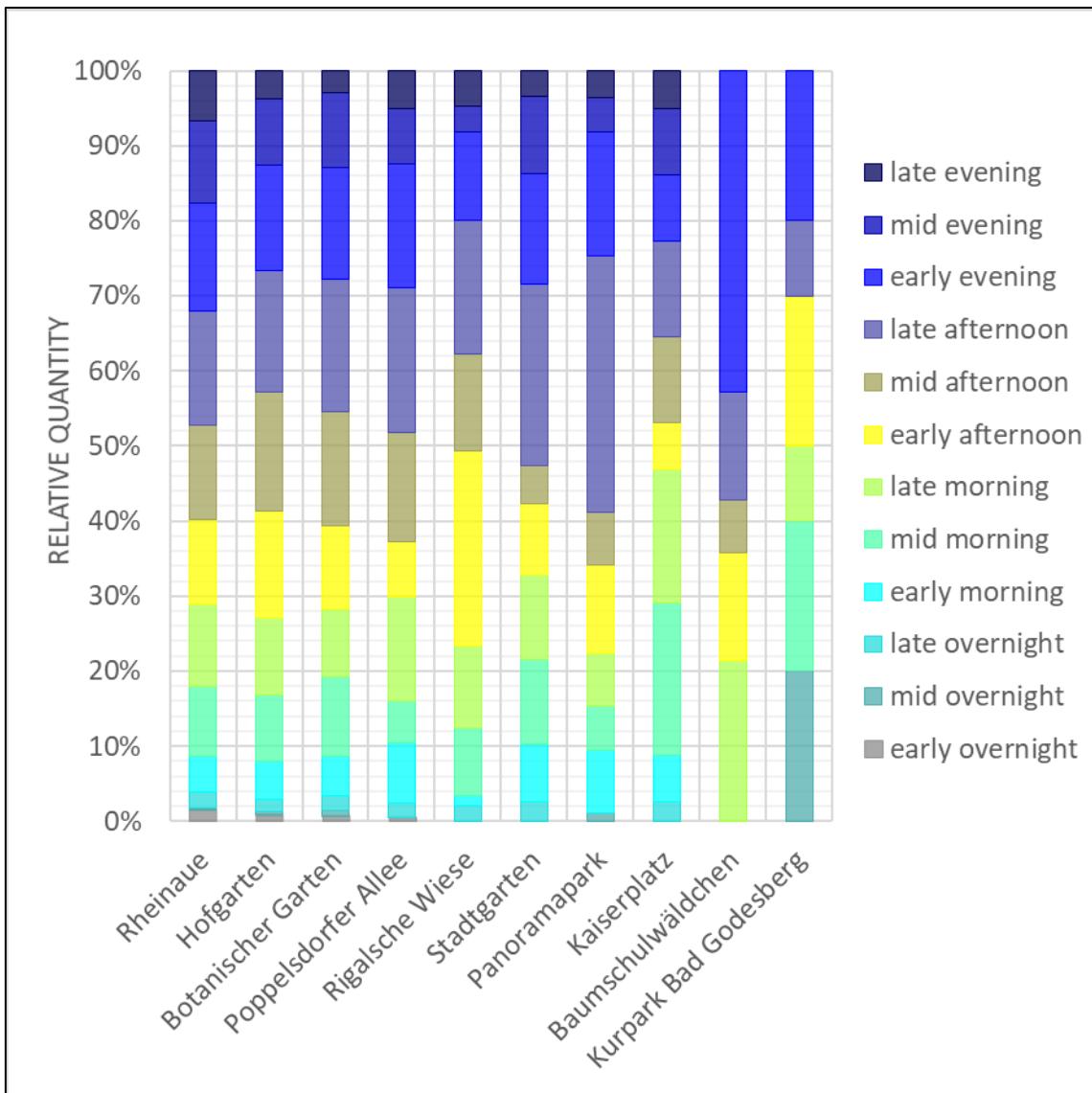


Figure 40: posts per daytime and UGS – absolute frequencies



**Figure 41: posts per daytime and UGS – relative frequencies**

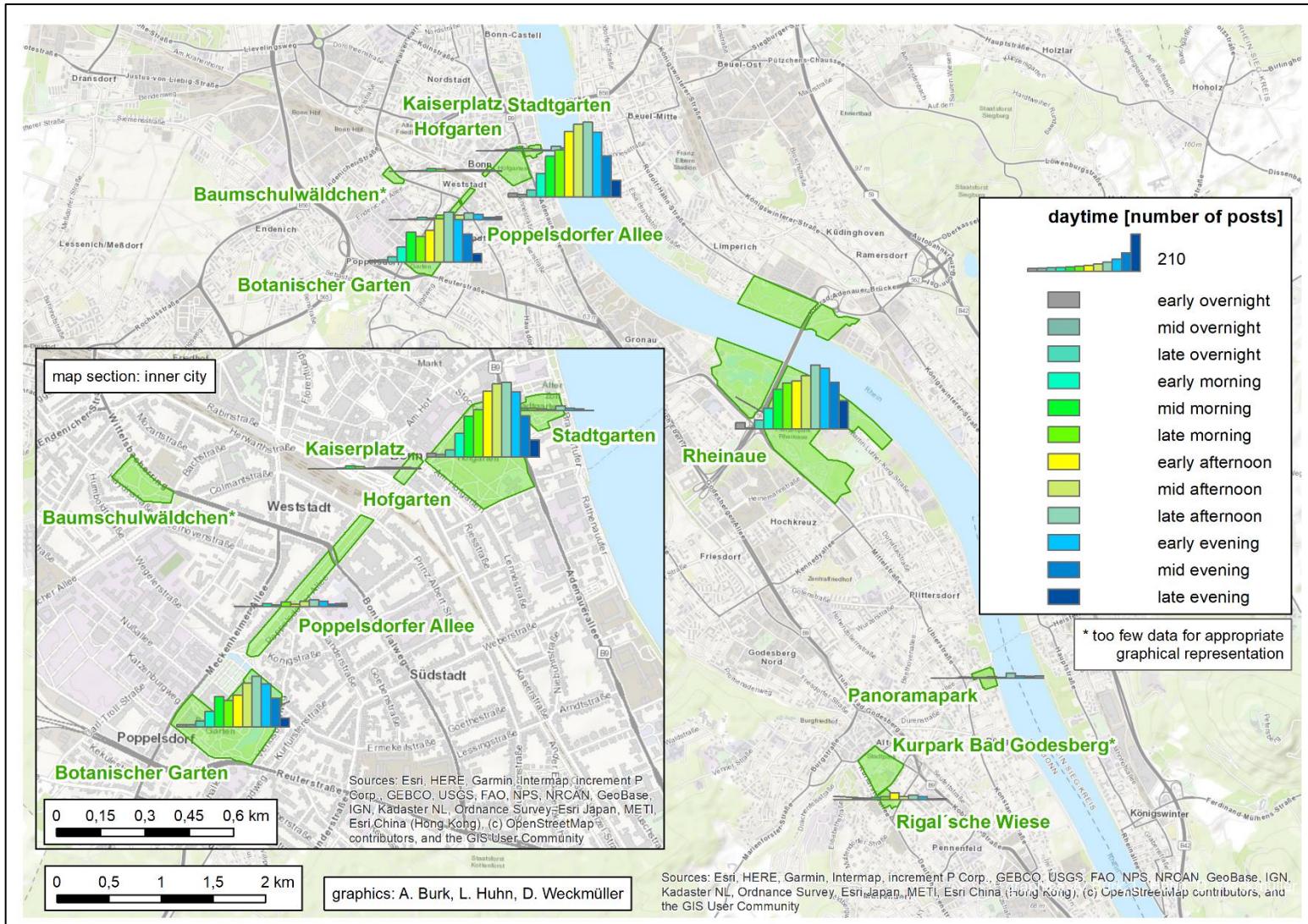


Figure 42: map of posts per daytime and UGS – absolute frequencies

**Table 10: correlation matrix between PNUCs: Pearson's correlation coefficients**

|                                 | politics | tourism | work and study | spiritual/religious | bond to nature | food   | event  | sport  | inspiration | family | bond to location | demo   | cultural heritage | sense of place | recreation | photography | aesthetic | social interactions |
|---------------------------------|----------|---------|----------------|---------------------|----------------|--------|--------|--------|-------------|--------|------------------|--------|-------------------|----------------|------------|-------------|-----------|---------------------|
| <b>politics</b>                 | 1        | .745*   | .911**         | .741                | 0.115          | .837** | 0.365  | .748   | .733        | 0.643  | .854**           | .978** | .977**            | 0.647          | .737       | 0.632       | 0.668     | 0.657               |
| <b>tourism</b>                  | .745*    | 1       | 0.614          | .975**              | 0.656          | .888** | 0.657  | .858** | .994**      | .945** | .972**           | 0.633  | .834**            | .983**         | .921**     | .980**      | .957**    | .819*               |
| <b>work and study</b>           | .911**   | 0.614   | 1              | 0.527               | 0.175          | 0.583  | -0.010 | 0.448  | 0.562       | 0.400  | 0.681            | .959** | .917**            | 0.529          | 0.469      | 0.535       | 0.636     | 0.332               |
| <b>spiritual/religious</b>      | .741*    | .975**  | 0.527          | 1                   | 0.537          | .952** | .797*  | .947** | .990**      | .985** | .979**           | 0.604  | .802*             | .946**         | .984**     | .931**      | .877**    | .925**              |
| <b>bond to nature</b>           | 0.115    | 0.656   | 0.175          | 0.537               | 1              | 0.257  | 0.220  | 0.256  | 0.626       | 0.577  | 0.468            | 0.036  | 0.273             | .771*          | 0.393      | .792*       | .807*     | 0.250               |
| <b>food</b>                     | .837**   | .888**  | 0.583          | .952**              | 0.257          | 1      | .804*  | .986** | .912**      | .914** | .963**           | .716*  | .849**            | .812*          | .980**     | .788*       | .729*     | .956**              |
| <b>event</b>                    | 0.365    | 0.657   | -0.010         | .797*               | 0.220          | .804*  | 1      | .889** | .727*       | .845** | 0.695            | 0.180  | 0.378             | 0.632          | .869**     | 0.598       | 0.454     | .938**              |
| <b>sport</b>                    | .748*    | .858**  | 0.448          | .947**              | 0.256          | .986** | .889** | 1      | .898**      | .932** | .928**           | 0.604  | .757*             | .795*          | .989**     | .767*       | 0.683     | .990**              |
| <b>inspiration</b>              | .733*    | .994**  | 0.562          | .990**              | 0.626          | .912** | .727*  | .898** | 1           | .970** | .976**           | 0.608  | .812*             | .978**         | .951**     | .969**      | .931**    | .867**              |
| <b>family</b>                   | 0.643    | .945**  | 0.400          | .985**              | 0.577          | .914** | .845** | .932** | .970**      | 1      | .933**           | 0.483  | 0.700             | .939**         | .972**     | .920**      | .850**    | .931**              |
| <b>bond to location</b>         | .854**   | .972**  | 0.681          | .979**              | 0.468          | .963** | 0.695  | .928** | .976**      | .933** | 1                | .749*  | .905**            | .921**         | .959**     | .909**      | .882**    | .881**              |
| <b>demo</b>                     | .978*    | 0.633   | .959**         | 0.604               | 0.036          | .716*  | 0.180  | 0.604  | 0.608       | 0.483  | .749*            | 1      | .953**            | 0.527          | 0.592      | 0.520       | 0.584     | 0.498               |
| <b>cultural heritage</b>        | .977**   | .834*   | .917**         | .802*               | 0.273          | .849** | 0.378  | .757*  | .812*       | 0.700  | .905**           | .953** | 1                 | .749*          | .772*      | .744*       | .780*     | 0.665               |
| <b>sense of place</b>           | 0.647    | .983**  | 0.529          | .946**              | .771*          | .812*  | 0.632  | .795*  | .978**      | .939** | .921**           | 0.527  | .749*             | 1              | .874**     | .998**      | .976**    | .765*               |
| <b>recreation</b>               | .737*    | .921**  | 0.469          | .984**              | 0.393          | .980** | .869** | .989** | .951**      | .972** | .959**           | 0.592  | .772*             | .874**         | 1          | .852**      | .777*     | .976**              |
| <b>photography</b>              | 0.632    | .980**  | 0.535          | .931**              | .792*          | .788*  | 0.598  | .767*  | .969**      | .920** | .909**           | 0.520  | .744*             | .998**         | .852**     | 1           | .984**    | .734*               |
| <b>aesthetic</b>                | 0.668    | .957**  | 0.636          | .877**              | .807*          | .729*  | 0.454  | 0.683  | .931**      | .850** | .882**           | 0.584  | .780*             | .976**         | .777*      | .984**      | 1         | 0.633               |
| <b>social interactions</b>      | 0.657    | .819*   | 0.332          | .925*               | 0.250          | .956*  | .938** | .990** | .867**      | .931** | .881**           | 0.498  | 0.665             | .765*          | .976**     | .734*       | 0.633     | 1                   |
| significance at the 0.05 level  |          |         |                |                     |                |        |        |        |             |        |                  |        |                   |                |            |             |           |                     |
| significance at the 0.01 level  |          |         |                |                     |                |        |        |        |             |        |                  |        |                   |                |            |             |           |                     |
| significance at the 0.001 level |          |         |                |                     |                |        |        |        |             |        |                  |        |                   |                |            |             |           |                     |

**Table 11: correlation matrix between PNUCs and sentiments: Pearson's correlation coefficients**

|                                 | politics | tourism | work and study | spiritual religious | bond to nature | food   | event | sport  | inspiration | family | bond to location | demo  | cultural heritage | sense of place | recreation | photography | aesthetic | social interactions |
|---------------------------------|----------|---------|----------------|---------------------|----------------|--------|-------|--------|-------------|--------|------------------|-------|-------------------|----------------|------------|-------------|-----------|---------------------|
| <b>negative</b>                 | .837**   | .952**  | .821*          | .837**              | 0.648          | .719*  | 0.271 | 0.704  | .868**      | .831*  | .906**           | .777* | .887**            | .943**         | .754*      | .946**      | .977**    | 0.556               |
| <b>neutral</b>                  | .892**   | .990**  | .746*          | .961**              | 0.550          | .890** | 0.538 | .879** | .976**      | .945** | .987**           | .769* | .889**            | .960**         | .917**     | .962**      | .941**    | .778*               |
| <b>positive</b>                 | .882**   | .991**  | .710*          | .978**              | 0.538          | .912*  | 0.592 | .902** | .989**      | .959** | .991**           | .745* | .870**            | .957**         | .940**     | .959**      | .926**    | .814*               |
| significance at the 0.05 level  |          |         |                |                     |                |        |       |        |             |        |                  |       |                   |                |            |             |           |                     |
| significance at the 0.01 level  |          |         |                |                     |                |        |       |        |             |        |                  |       |                   |                |            |             |           |                     |
| significance at the 0.001 level |          |         |                |                     |                |        |       |        |             |        |                  |       |                   |                |            |             |           |                     |