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# The Relative Concentration of Interaction—A Proposal for an Integrated Understanding of Centrality and Central Places

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**Abstract:** The importance of a place can be assessed via an analysis of its centrality. However, although central place research has a long history, there is no generally accepted theoretical base, leading to continuous debates about the core elements of centrality and those features that ultimately constitute the centrality of a place. We propose a generalized definition that understands centrality as the relative concentration of interaction. Using this definition, we are able to integrate various social, cultural, and natural aspects in the analysis of a central place and its landscape setting. We present a semi-quantitative method to assess the actual and potential centrality and that enables us (a) to draw conclusions about the type and characteristics of central places, (b) to investigate their development throughout time, and (c) to compare them to each other. We sketch the application of the method using two exemplary sites: the Iron Age site Heuneburg and the Roman palace Felix Romuliana

**Keywords:** central place; social networks; landscape archaeology; settlement location; interaction

## 1. Introduction

Archaeological research shows that societies are in continuous growth or decline. The focal points and stage of these dynamics have mostly been large settlements and cities. The concentration of people at certain locations constitutes the nodes for structurally coupled networks of human–landscape as well as human–human interactions. Such complex networks of various interrelated factors, ranging from ordinary production up to state-wide politics is revealed when we try to understand the history of individual places. Since the adaptation of the theory from Christaller [1], we refer to these places as *central places*. However, since the beginning of investigations on central places and centrality, there is no common definition or frame and no agreed upon criteria of what makes a place a central place. This theoretical and methodological ambiguity mirrors the great amount of factors and parameters that are worth considering in the study of places. Furthermore, the difficulties of measuring centrality also affect the definition of centrality. It follows that an investigation of central places necessitates concurrently studying its environs, its landscape context, its socio-cultural relatedness, and its history [2].

Despite this conceptual heterogeneity, we have certain *topoi* about the characteristics and localization of central places. Of particular interest in this regard is the study of marginal habitats or "un-central" landscapes [3] that offers a great deal of understanding about the vigor and spirit of past societies and cultures. What makes such landscapes marginal or "un-central" is our surprise about the fact that seemingly insensible decisions still led to the development of sometimes extraordinary

central places, such as Petra [4]. It is these "un-central" places that offer the highest potential for deep insights into our own nature, since they have the potential to uncover what we are not able to ask for or think of. Nakoinz [2] collected different examples of such central places in "un-central" landscapes and integrates them into a joined explanatory framework.

Based upon Nakoinz [2], we propose a conceptual rethinking of centrality and present a methodological tool that can be used to study central places and help to communicate whether, why, or to what degree their landscape setting can be seen as "un-central". Based on a short historical outline of central place theory and network ideas, we discuss how to deal with incomplete archaeological data in order to analyze the centrality of a place. Based on a sketch of two exemplary case studies, we show that a shared methodology allows a comparison of central places that would normally be incommensurable. If developed further, such comparative approaches offer detailed insights into the nature of our own scientific terms and their high level of implicitness in specific research traditions.

## 2. Central Place Theory

Central place theory was developed by Christaller [1] to understand the laws and principles that determine the number, size, and distribution of towns ([5], foreword). Although there were earlier attempts that aim to describe these aspects (see, e.g., Kohl [6] or Reynaud [7]), it was Christaller's achievement to present a first formalization. For Christaller, it does not seem to be possible to understand the amount, distribution, or size of a city based on its natural location ([5], p. 13 ). Furthermore, he thought that it is not possible to derive the ordering principles of cities based on historical studies or statistical analyses alone ([5], p. 13). Such questions can only be answered based on a deductive, economic-geographical theory ([5], pp. 14, 16). Hence, he developed an economy-centered spatial-equilibrium theory to predict an optimal pattern of cities. After its introduction, the theory was optimized and modified to fit better to certain situations, e.g., economy as mirrored in the work of Lösch [8] or Lösch [9] as well as contexts, e.g., Hudson [10], von Böventer [11], Parr [12], Parr [13], Parr [14], or Arlinghaus [15]. However, since Christaller's version gives the original idea and the most general picture, we use it here.

Referring to (Gradmann [16], p. 427), Christaller states that the main purpose of a town is to be the center of an area ([5], p. 23). This center has a surplus of meaning because it provides goods and services to its hinterland, i.e., its complementary region ([5], pp. 28–30). These goods and services are called central functions. *Centrality* is the relative degree to which a place serves its complementary region with these central functions ([5], pp. 27, 28). Relative refers to a surplus of meaning above the level that would be expected with regard to the population density.

Christaller's theory is based upon different assumptions (summarized after Ref. [17], p. 125): the region is an unbounded, uniform, isotropic plain with a proportionality of transport costs and distance. People are evenly distributed and considered equal in terms of income and demand. They are *homo oeconomici*: as consumers, they visit the nearest place to minimize distance; as suppliers, they aim to maximize their profits and will locate as far away as possible from one another to maximize their market areas. Several central places occupy the region and provide their complementary regions with central functions. In the end, these assumptions lead to a hexagonal pattern of market areas ([5], pp. 65–72; Figure 1).

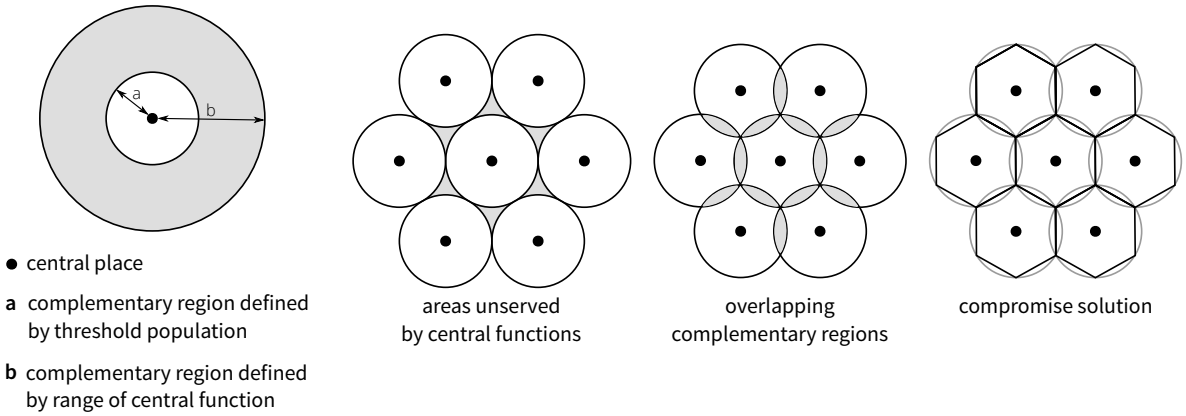


**Figure 1.** Each offered central function has an upper limit (determined by the maximum distance people will travel to access it) and lower limit (determined by the minimum population required to sustain a central function). Based on this, each central place has a circular complementary region. In this configuration, some areas are served by more than one central place while other areas are not served at all. A hexagonal configuration of complementary regions is the most efficient way to ensure that everybody has access to the central function (after Ref. [5], pp. 65–72).

Central places that offer a variety of central functions are called higher-order centers; places that provide fewer functions are lower-order centers ([5], p. 26). Higher-order centers offer all the functions that are provided by lower-order centers and they provide specific functions that are not offered by lower-order centers. In combination with the upper and lower limits of central functions, this leads to a hierarchical organization of space, with centers that dominate their complementary region in nested hexagons ([18], p. 188). Three types of settlement hierarchies were distinguished by Christaller [5] that correspond to different principles:

- market principle: maximizing the number of centers for the best supply ([5], pp. 77–79),
- transportation principle: reducing the transport distance of centers ([5], pp. 79–81),
- administration principle: no competition between centers by including all lower order centers in the market area of the higher order center ([5], pp. 82, 83).

Based on the integration of central place theory and its empirical affirmation, law-like statements of the distribution of central places can be derived ([5], p. 252): the market principle, i.e., the distribution of central places in a way that seeks a most cost efficient supply, is most common in not densely settled, agricultural areas ([5], p. 252). By contrast, the traffic principle, i.e., the distribution of central places along a line from one central place of the specific hierarchical level to another is most common in well crossable areas. Furthermore, orographic obstacles may force the places to arrange in a layout that corresponds to this principle ([5], p. 252). In the latter case, Christaller [5] calls this a *pseudo-traffic principle* because the locations were determined by the natural characteristics and not by the advantages of a traffic-oriented layout ([5], p. 253). The traffic principle is common in areas where supra-regional exchange is of prime importance ([5], p. 253). A distribution that follows the administration principle is most difficult to detect and might only be possible by historical studies. Only the presence of two central places of lower-order at the theoretical position of a higher-order central place might give hints for the presence of this configuration ([5], p. 254).

Based on the analysis of his study area in southern Germany, Christaller [5] concludes that the market principle is the main law of settlement distribution. The traffic and the administrative principle are secondary deviations that are only present under specific conditions ([5], pp. 254–259). However, subsequent studies showed that neither in contemporary nor in archaeological contexts is one distinct principle present; it is mostly a complex combination of these three principles (e.g., [19], p. 171).

## 3. A Generalized Definition of Centrality

The short outline of Christaller's theory does not cover all aspects of his work but is sufficient to show some points that allow a modification of his approach. In particular, we need to overcome two important restrictions: the economy-based definition and the focus on Christaller's models. A definition based on *interaction* and an integration of centrality concepts from network theory provide us with a generalized approach and avoids the restrictions as resulting from Christaller's simplifying assumptions. We present (a) different dimensions of centrality, (b) conceptual ideas on potential as well as actual centrality, and (c) a semi-quantitative and easy to use method to complement our modified/extended definition of centrality that results from recent work [2,20,21]. With an integrative approach that is based on *interaction*, we follow a philosophy that is different from those usually published that are characterized by an alternating usage of the term, modifications of central place approaches, and on rejection and avoidance (for a general overview and corresponding references, see [22,23]). These waves of the centrality discourse ignore the fact that, although the centrality approaches do have their limitations, they are still useful for certain purposes. The continuous debate on and application of centrality ideas, which are expanded by the contribution from various disciplines, indicates that a persistent core of centrality approaches exists and that centrality has become a permanent part of the interdisciplinary discourse (more on the history of research in: Ref. [23,24]). With the integrative approach, we aim to synthesize the approaches previously understood as competing paradigms into one consistent concept.

A severe limitation of Christaller's approach is its restriction to economy, although he also includes non-economic parameters and hence has a general concept in mind ([5], foreword). The use of the term *central* in social contexts makes clear that this restriction is inappropriate and hinders an understanding of the concept of centrality. It is necessary to replace Christaller's central functions with more abstract ones that cover non-economical aspects. We utilize the term and idea of *interaction* that provides a sufficiently abstract concept for such a replacement [25]. Since each central function represents specific interactions between two interacting partners, i.e., two interacting places, we can use interaction as a generalizing concept. This leads us to our generalized definition of centrality:

*Centrality is the relative concentration of interaction*

A central place possesses a higher degree of interaction when it provides more central functions to its complementary region than would be expected by its size. Furthermore, we are now able to define central elements also in social, cultural, and other non-economic contexts. For instance, a central person in a social structure is one that maintains many interactions with other individuals and, in particular, more interactions than expected by the person's prestige or social standing. This leads us to social network theory that provides an alternative understanding of centrality, one that needs to be considered in our interaction-based generalization of centrality.

## 4. Christaller Centrality and Network Centrality

Social network ideas have a long history, going back to at least the 18th century scientist Auguste Comte ([26], pp. 10–14). Social network analyses derive from Gestalt-psychology approaches and were developed since the 1930s ([27], pp. 8–9). In the 1970s, the term centrality was used in the context of social networks [26,28,29]. The aim is to understand interactions among social actors using a structural approach ([26], p. 2). While Christaller offered one clear definition of centrality, three models of centrality, and a very restrictive centrality measure, social network theories offer a fuzzy definition, several general interaction measures and no general model of centrality (Figure 2; e.g., [30,31]).

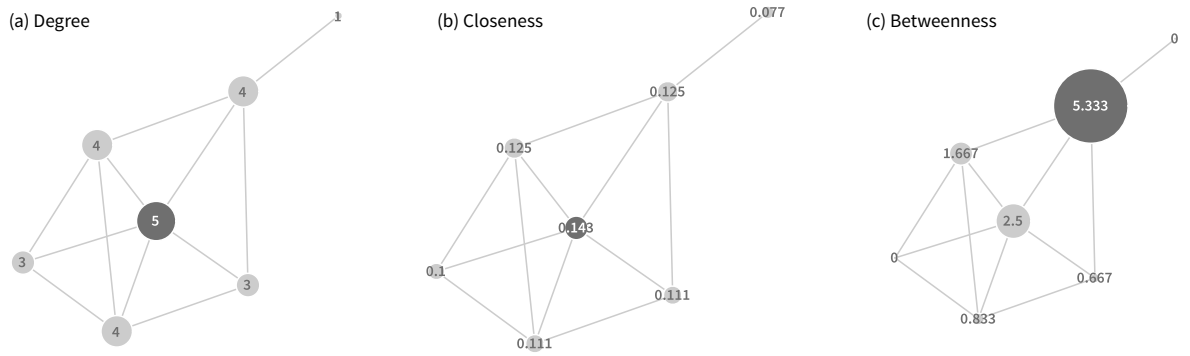


**Figure 2.** There are various measures of centrality in social network theory that describe different characteristics of a social network and its interacting individuals. The most common node centrality measures are: (**a**) degree, i.e., the number of adjacent nodes; (**b**) closeness that measures the centrality by calculating the average shortest distances to all other nodes; (**c**) betweenness that highlights critical nodes in the network structure by measuring to what degree a certain node lies in the shortest paths of other nodes ([32], pp. 180–182). Equations and a more detailed characterization is given in Freeman [28].

It becomes obvious that the two concepts, Christaller and network centrality, are very different. The measures and models of both approaches do rely on different assumptions and are in their basic form incompatible. In particular, the differences are the modeling approach as well as the definition and understanding of space. Christaller's models are based on a minimization of transport costs while there is no general optimization model in network theories. Network theories mainly map assumed or actual relationships according to simple rules. Social networks generally do not use transport costs, distances, or similar parameters as edge weights. Although it is possible to involve spatial attributes, by default, they follow a non-spatial configuration of networks, causing an understanding of centrality that is defined without an explicit reference to space.

However, we can apply our interaction-based definition of centrality to both. Taking into account the mentioned differences, we adjust the model of Christaller [5] and create one that integrates the ideas of the social network theory: Christaller's centrality model is not a general model of centrality but describes just *one* structure for minimizing transport costs which results in the existence of central places. Accordingly, Christaller's approach is concerned with *node* synergies while network centrality is concerned with *edge* synergies. The models of Christaller minimize transport costs by directing all interactions towards the closest node. A center can be detected by the relative accumulation of interaction at these nodes. Network centrality, and this is the missing model in the general discussion, can minimize interaction costs by bundling interactions along network edges. The interaction costs comprise transport as well as access costs of the nodes. This approach of optimizing systems of interactions is known under the term of *central flow* in geographic networks [33,34].

These two main types of centrality, Christaller centrality on the one hand and network centrality and central flow on the other, are complementary. One type can be dominant and this is an important characterization of a site, but every place has to be assessed according to both types.

## 5. Centrality Potential and Actual Centrality

Based on the above consideration, we can look at the centrality of certain places in networks from a different perspective. According to network centrality measures, such as betweenness (Figure 2c), it is possible that certain nodes have a high centrality only because they hold a geometrically strategic position. Analogously, a place can have many central functions and a high degree of interaction just because the population is high. However, is this centrality? According to Christaller [5], it is not. He emphasizes that centrality emerges when the degree of fulfilling central functions, i.e., the interaction intensity according to our approach, exceeds what we would expect based on the

population ([1], p. 27). Centrality is the relative meaning of a place and the absolute intensity of interaction has to be normalized by the population. This highlights the general idea of centrality that central places are not only important for themselves but particularly for their surrounding places; the interaction from these places that gather at the central place constitutes its centrality.

A large population is a supporting factor of centrality since a small village with just a few people cannot provide central functions for a territory with thousands of people. In addition, there are other factors attracting people such as natural resources, a strategic location, the occurrence of administrative institutions securing cultural functions, a high carrying capacity (e.g., in terms of agricultural productivity), the presence of a ritually important natural or cultural feature, etc. These factors, in combination with the population, set up the level of *potential centrality* (Figures 3 and 4b). This centrality potential is a theoretical construct. Its differentiation in four categories allows for comprehensively assessing the potential of a place to attract interactions in relation to the general configuration of its hinterland. It indicates the degree of centrality that is possible at a certain place under specific pre- and assumptions. The level of potential centrality can be exceeded for some time due to, e.g., "willpower" or political strength, but, eventually, centrality will fall back. The antique city of Pergamon under the realm of the Attalid dynasty is one example of a politically constituted central place [35]. The *actual centrality*, i.e., the measure of the central functions that are actually present at a central place (Figures 3 and 4a) can be lower than the centrality potential. This can be caused by historical contingency or the lack of a crystallization nucleus for the development of the central place.

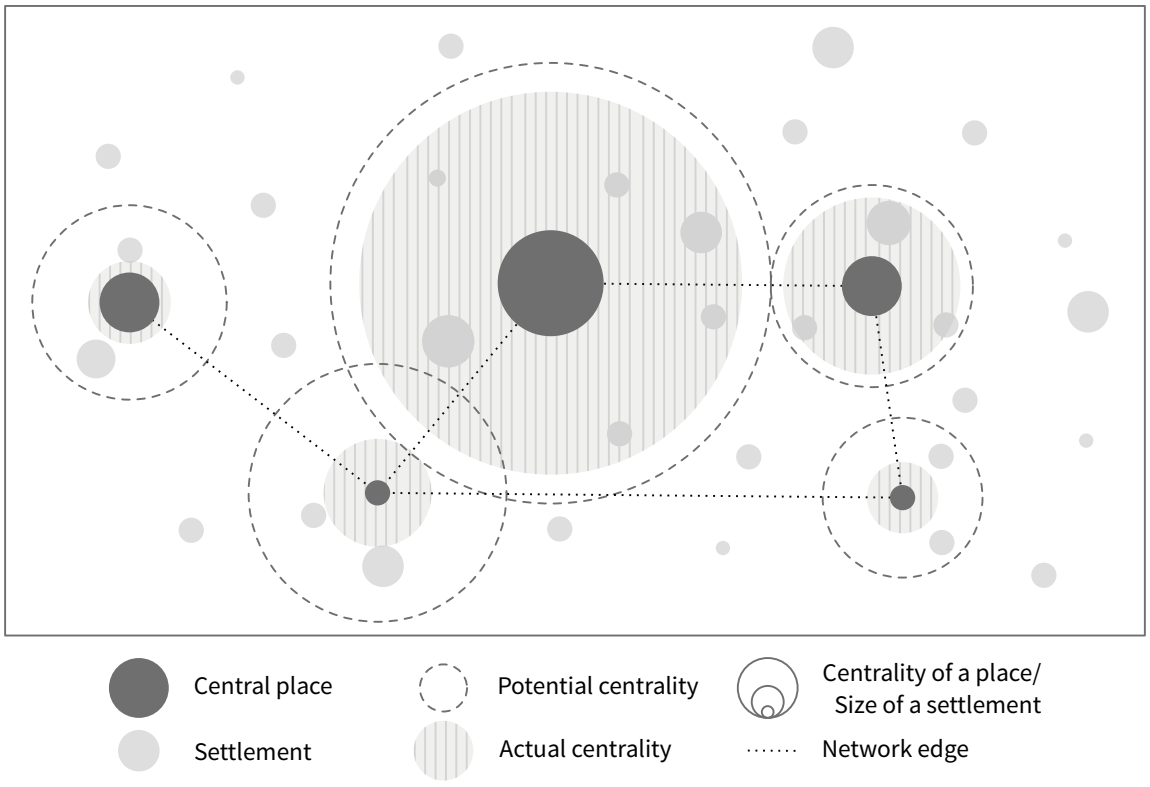


**Figure 3.** Sketch of the different centrality concepts. Not every settlement is a central place. For a place to be central, it has to offer central functions to its complementary region. This region can be defined based on Christaller or network centrality. The network edges in the figure show that only some sites interact, i.e., exchanging central functions. The differences between actual and potential centrality result from the combination of network integration of central places and their ability to serve their complementary region with central functions. Large deviations between potential and actual centrality point to the importance of historical contingency or intervening opportunities that influence the flows of interaction.

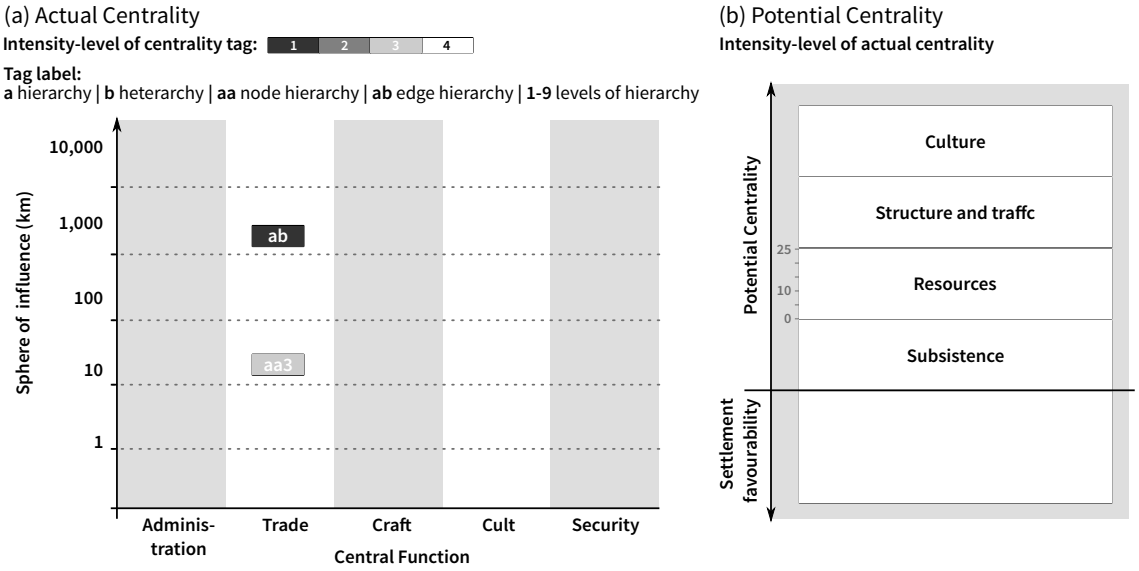


**Figure 4.** Centrality Graph as a tool to visualize and compare the different aspects of settlement characteristics, Christaller and network centrality (see text for a detailed explanation of the different elements).

These considerations can also be applied to the concept of network centrality: betweenness and similar measures show that network centrality is a structural property. This does not necessarily mean that important network nodes, according to centrality indices, show a high centrality in reality. In a network, those nodes are connected that have a certain relationship. The quality of the relationship and in particular the flows between the nodes are mostly not considered because they are not strictly required—this is an advantage of network approaches because such flows are seldom known. Due to this, the network centrality indices usually provide only the potential level of centrality. The main pieces of information for measuring the real, i.e., actual centrality, are not considered. In order to derive information on the actual centrality, a weighted graph has to be calculated, where the interaction and flows are used as weights and emerge as differences in centrality scores between the simple and weighted graph. Weighted networks require modified or new network centrality indices such as the c-index [36–39].

## 6. Centrality Vector

So far, we have shown that the different concepts of centrality complement each other and that different centrality indices are applicable. This enables us to view places from various perspectives and under different scenarios. In addition, it becomes clear that one measure alone is not sufficient since the various measures represent different kinds, aspects or dimensions of centrality. In order to assess which aspect constitutes the context-specific centrality of a place we introduce a centrality vector with four dimensions [2]:

1. The *intensity* of centrality that can be understood as the sum of interactions with other places. The number of central functions supplied by a center can be used as a simple estimator for the intensity of centrality. The use of actual flows offers a higher accuracy but requires more data. The degree of centrality can be used to measure the intensity of centrality in networks when the edges are weighted with flows.
2. Considering two places, one with a higher intensity but a limited range and the other one with a lower intensity but very remote connections, it is not easy to say which place is more central. Hence, the *range* or *sphere of influence* of a central place, is another dimension of centrality. It is

a measure of the longest distance of an activity in which a central place is involved. For networks, we can use the closeness as an appropriate measure to assess the sphere of influence of a place.

3. A place with many subordinated places but just two levels of *hierarchy* may have the same centrality as a place with few subordinated places but many levels of hierarchy. While Christaller's approach allows us to estimate the hierarchical level of a place, this is not necessarily possible for networks which often are intended to be non-hierarchical. Hence, there is no appropriate network centrality index for this purpose.
4. Is a place passively receiving interactions or actively controlling its own and other interactions? How many connections have to pass a certain node in a network? Betweenness is the index to answer such a question of *control of interaction*, i.e., a measure of the network location of a place in terms of assumed flows of information. The original concept of Christaller [5] does not cover this aspect, but it is possible to ask how exclusive a Christaller-center is as an interaction partner for the other places of a region—especially when we consider its network integration.

The four dimensions of the centrality vector reveal differences between Christaller and network centers. Concerning intensity, Christaller and network theory approaches show similar aspects. Differences become obvious in terms of the sphere of influence: network centers tend to have a wider range than Christaller centers. This is mainly due to the fact that the Christaller centers focus on a certain area. The hierarchy component is better mirrored in Christaller centers. However, under certain conditions, networks are also able to express hierarchies, e.g., using tree-graphs. The control of interaction is more typical for network centers.

These four dimensions of centrality can help to estimate the centrality type, but they are not sufficient for their classification. In practice, the classification of different organizational structures such as Christaller and network models is usually based on both, quantitative parameters and less precise, qualitative information. This leads us to our semiquantitative approach, which integrates these aspects.

## 7. A Semi-Quantitative Method to Analyze Centrality

As described above, in an analysis of centrality, a wide range of factors have to be considered. We need to deal with the different dimensions of the centrality vector and with potential and actual centrality. Even if measures for some components exist, the required data are rarely available at the preferred quality level. This contrast of concepts and available data have been present in centrality research since its infancy.

### *7.1. Central Functions as a Tool to Assess Centrality*

In contrast to other studies that relate centrality to demographic factors based on Zipf's ([40], 1949) rank-size rule and indirect population measures (e.g., [41,42]), the *functional* aspect of places is focused in centrality analyses. This can be referred back to Christaller's definition of central places that are at first not settlements but spatial manifestations of central functions ([5], p. 25). In general, central places are clusters of functions that supply their complementary region ([43], p. 1307). To assess functional aspects of central places in a historical and archaeological context, Christaller's catalogue of central institutions had to be simplified to correspond to the smaller and less reliable database. For historical epochs, this was done by Denecke [44]. He classifies the functions and institutions that define central places in a historical context into ten categories, i.e., (1) political and administrative functions and institutions; (2) institutions of law; (3) institutions of security; (4) cultic and spiritual institutions; (5) cultural institutions; (6) institutions of charity; (7) institutions of agricultural economy and administration; (8) institutions of craft and production; (9) institutions of trade; and (10) institutions of traffic and transport ([44], p. 43).

However, an assessment of the central functions within an area necessitates the collection of the complete set of occurring central functions ([44], p. 43). Concerning earlier epochs, only a fragment of these functions are preserved or can only be accessed indirectly via archaeological sources ([44], p. 51). Gringmuth-Dallmer [45] further simplifies the concept by defining five central functions that characterize central places from prehistory until the Middle Ages: (1) administration; (2) security; (3) craft and industry; (4) trade; and (5) cult ([45], p. 8). The more of these functions that are present at a site, the more complex it is. Hence, central functions can be used to reconstruct settlement hierarchies—assuming the settlement sample is complete ([46], p. 431). Besides reconstructing settlement hierarchies, the occurrence and sphere of influence of central functions can be used to compare different archaeological sites in order to trace their different diachronic development (e.g., [2,35]).

### *7.2. Central Functions as Part of the Generalized Definition of Centrality*

We propose a semi-quantitative approach which applies the simplified central functions and does not require a full-scale quantitative analysis (Figure 4). It was developed at the Excellence Cluster Topoi (Exc264) in Berlin via a comparative investigation of assumed and differently characterized central places of various prehistoric, classical, and historic periods [2,20,21,35]. The idea is to estimate the different dimensions of the centrality vectors on different scales and to map the results on a graph respecting the different central functions according to Gringmuth-Dallmer [45].

The centrality intensity is the most essential aspect, but its estimation is difficult due to the high data demand. According to this, we only use four classes of centrality intensity, indicated by the color of the centrality tag (Figure 4):[1]

- Class 1 (dark gray): Extraordinary occurrence of centrality indicators; the centrality intensity is assumed to be very high.
- Class 2 (gray): Centrality indicators are well observable and indicate a high level of centrality intensity.
- Class 3 (light gray): Only few centrality indicators occur. The centrality intensity is medium to low.
- Class 4 (white): None or only marginal traces of centrality indicators are observable. This indicates a very low level of centrality intensity.

The range of the central places, i.e., the distance up to which interactions are observable is simply indicated by placing the coloured centrality tag at the appropriate location along the *y*-axis ("Sphere of influence", Figure 4). Different functions and even different organizational structures have their own tag. Therefore, numerous tags can be put inside the different columns of central functions at different ranges.

The control of interaction is addressed by the organizational structure and specified by a label on the centrality tag. The organizational structures canalize interactions to certain network structures. The network can represent a hierarchy (label *a*) or a heterarchy (see [47,48]) without any subordinated places (label *b*). Hierarchies are subdivided into node hierarchies (label *aa*) and edge hierarchies (label *ab*). A hierarchy of nodes corresponds to Christaller's concept of central places and the idea of synergies at nodes while a hierarchy of edges corresponds to network centrality and the related idea of synergies at edges.[2] Up to a certain degree, the number of central functions indicates the hierarchy level. If a precise level is observable, the number can be added to the centrality tag. A label *aa3* translates to a hierarchy of nodes with two subordinated hierarchy levels.

If a place is a local trading center according to the model of Christaller with a sphere of influence of 50 km and two subordinate hierarchical levels and at the same time a supra-regional trading centre according to the network model, with interactions up to 2000 km, the column "Trade" contains

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[1] If required, or supported by the available data, more classes—shades of grey in the figure—can be used to express a wider range of intensity values.

[2] The original concept included further subdivisions which are not presented in this paper due to the better readability of the reduced concept; interested readers are referred to Nakoinz [2].

a centrality tag with the label *aa3* at 50 km and another tag with the label *ab* at 2000 km. The different shades of gray of the tags indicate a dominance of one organizational principle; in this case, the network centrality, over the other (Figure 4a).

In the case of trade (Figure 4), we estimate the maximal distance of commodities traded from or to the central place from other places which seem to be exclusively connected to the actual centre according to the spatial distribution of imports and places. Hence, we add the *aa* label at the corresponding range. Afterwards, we search for more remote imports and hence the overall maximal distance of imports to place the *ab* label. The other factors such as centrality intensity are less prominent in the diagram than range since it is more difficult to estimate them.

The centrality potential is presented in the right part of the graph (Figure 4b). This part is split into two sections. Above the horizontal axis, subsistence, resources, structure and traffic, and culture are factors summing up the centrality potential. Below the horizontal axis, the settlement favourability is assessed. The idea is that, above the horizontal line, only those factors are present that attract central functions and hence promote centrality. Below this line, the factors attract settlements in general and do not account for the concentration of interaction. This lower part shows how likely it is for a nucleus of a central place to appear while the upper part shows the likeliness of central functions to emerge. This is especially useful to visualize the "un-centrality" of an area in terms of resources or socio-cultural variables. The height of the blocks is rather relative. A 'normal' situation with not extraordinary low and high potentials would be half of the height while smaller or bigger blocks indicate good or bad conditions. Due to the changing factors (e.g., new settlement structure, overused soil, etc.), centrality potential can change over time.

In our example, the different blocks in the upper part of the centrality potential figure can each contribute up to 25% to the total potential, indicating the maximum attractiveness. If available, real measurements can be used to normalize this graph, but, usually, they will not be available and intuitive estimations used.

The centrality graph intends to provide a simple tool to visualize and compare different aspects of centrality. The various aspects of centrality and central functions are explicitly shown. This allows a much deeper understanding of the processes and relationships than would be possible by simple checklists of central functions or size-based maps of central places. The centrality graph is based on the idea that central places do not follow a general scheme but are forming a heterogeneous, though related, corpus of places. Since the available data is usually limited and patchy, the main advantage of this approach is the moderate requirement of input data. Centrality graphs integrate quantitative and qualitative information, sound data, and general estimations to a synthesis of the main factors characterizing place.

## 8. Case Studies

The focus of our paper is on the theoretical aspects of centrality and central places. Hence, the two following examples should be considered conceptually. Detailed, data driven investigations will provide a more nuanced reading and interpretation. Two sites, the Iron Age princely seat Heuneburg in Southern Germany and the Roman Imperial palace Felix Romuliana in Serbia, are used to sketch the application of the semi-quantitative centrality assessment (Figure 5).

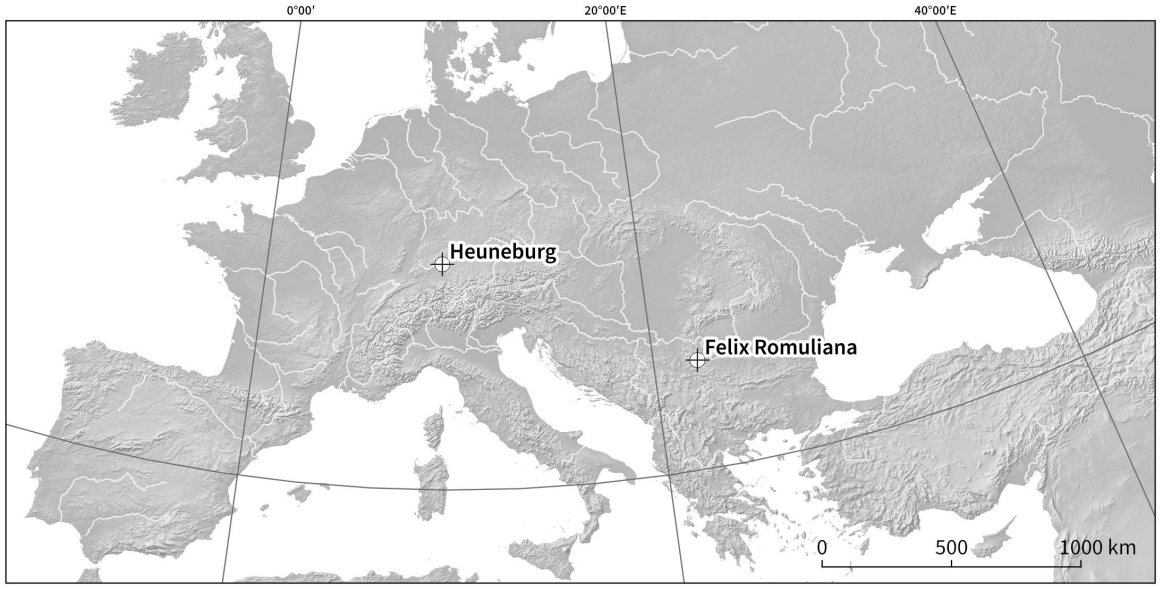


**Figure 5.** Location of Iron Age princely seat Heuneburg and Roman Imperial palace Felix Romuliana.

### *8.1. Felix Romuliana*

The personal will of people in power is reflected in the erection of an imperial palace, the UNESCO world heritage site of Felix Romuliana, in a remote, rural area of modern Serbia, 50 km West of the Danube and close to the provincial town of Zaječar.

Felix Romuliana was erected at the beginning of the fourth century CE. It is located at the place of origin of *Gaius Galerius Valerius Maximianus*, Emperor from 305–311, and named after his mother Romula ([49], p. 124). The palace was built on an older fortification and extended with representative buildings and baths to serve the emperor as his summer and retirement residence ([50], pp. 275–277). The site shares the function as a residence seat with other places, so that a polyhierarchic structure can be assumed [51,52]. The environmental characteristics of the site and its surroundings are suitable for agricultural production [53,54]; this is mirrored in an intensive settling activity since the Bronze Age [55,56]. In addition, in the vicinity of the site are important long-distance routes that were used to trade mineral resources that were exploited here and that could be controlled by numerous forts along the accompanying mountains ([57], p. 130).

As part of the first tetrarchy, Galerius was appointed Cesar in 293 CE and in charge for the Eastern part of the Roman Empire. Diocletian's abdication in 305 CE promoted Galerius to the rank of Augustus. This initiated the second tetrarchy ([58], pp. 782–783). The tetrarchy structure of senior and junior emperor was a system that aimed to conserve the imperial structure and its stability. In the short phase of tetrarchy, Felix Romuliana played an exceptional role, which can only be attributed to the Galerius affinity to its mother and/or its place of origin. The atypical location decision is nicely reflected by Srejović and Čedomir [49]:

> "The place chosen for the resting place of a mighty ruler, Diocletian's adopted son and, consequently, member of Jove's family, must have had quite a special architectural character. Galerius, glorified as a new Romulus and Alexander throughout the Empire after his triumph over King Narseus of Persia, was certainly not likely to consent that the edifice dedicated to him in the place where he was born and which was to bear the name of his mother should look like a provincial civil or military settlement" ([49], p. 124).

However, after the finding of an archivolt with the carved inscription *FELIX ROMULIANA*, there is no doubt that the palace was the chosen emperor's seat ([49], p. 127). Accordingly, Galerius' decision

caused the supra-regional importance of the central function *administration*, as mirrored in the erection of administrative buildings at the site that would have served the needs of the highest administrator in the Roman Empire.

Opposite the palace are two tumuli, erected on top of prehistoric cult places, where Galerius and his mother were buried ([59], p. 242); Felix Romuliana became not just a political-administrative but also a cult center, though the sphere of influence of the central function *cult* was most likely smaller ([49], p. 141).

After Galerius' death, the residence was abandoned and only a local center of metal production remained, causing the influence of the place on the regional interaction structure in terms of *craft* and *trade* [60]. The area became an important shelter for early Christians as mirrored in the erection of numerous churches within and in the surroundings of the former palace walls ([61], p. 122). Hence, the place offered the central function, *security*, on a regional scale.

Based on these different observations, we can draw a preliminary sketch of the change of centrality at the site that can be useful to guide future research: before and after the erection of the imperial palace, Felix Romuliana can be considered as a Christaller central place with a regional sphere of influence (Figure 6a, top). The place was integrated in supra-regional networks but did not offer central functions on this scale. The older fortification and its location close to important routes was of regional importance during the political changes after the Dacian retreat. The peak in the sites' centrality occurred when Galerius selected his focal point in the fortification network (Figure 6a, bottom). After his death, the political power to influence the flows of interactions vanished and likewise the supra-regional importance of the site. Like before, the area remained as an interaction node of regional importance.

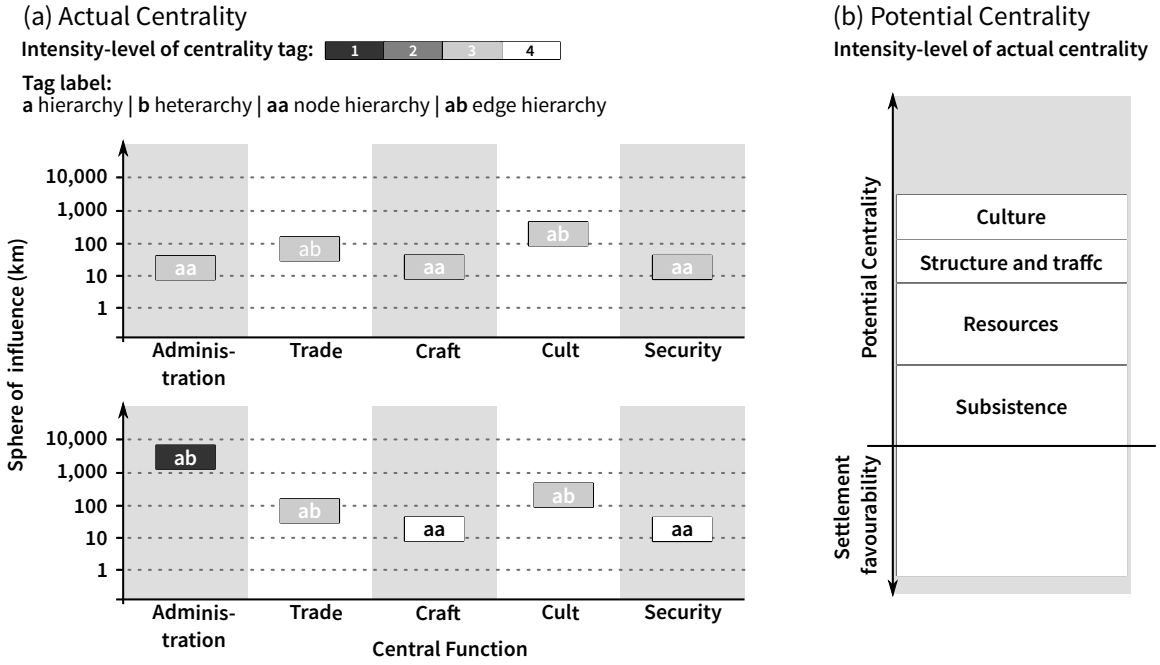


**Figure 6.** Centrality Graph of Felix Romuliana. (**a**) actual centrality of the place and its environs; top: before and after the palace phase; bottom: during the palace phase; (**b**) potential centrality of the site (see text for a detailed description).

The high centrality potential (Figure 6b) is in contrast to the relatively low actual centrality. This can be attributed to the fact that other places offered even better conditions and that networks of interaction with supra-regional importance were in place before. The different central functions

offered by the area of Felix Romuliana and its short increase in importance due to political will were not sufficient to sustainably change the flows of supra-regional interactions. On the local scale, it was and remained a complex center. Taken together, the site can be considered as a classical example of an *ephemeral increase of centrality due to arbitrary reasons*.

### *8.2. Heuneburg*

The Heuneburg is one of the so-called "princely seats" from the Early Iron Age, located at the Upper Danube in southwest Germany [62]. Traditionally, these fortified places are assumed to be centers of power and seats of the elites that rule over big territories. The Iron Age settlement existed from the end of the seventh century until the first half of the fifth century BCE. The Heuneburg is assumed to be the antique place of "Pyrene" as mentioned by Herodotus [62]. The site had a phase of prosperity and growth in the *Ha D1* period which ended abruptly at the turn to *Ha D2* in the second half of the sixth century BCE. In *Ha D2* and *Ha D3*, the structure and population of the Heuneburg differed. In particular, the external settlement ceased to exist in *Ha D2*, causing a decrease of population from ca. 5000 to ca. 3500 [63–65]. The end of the *gateway* Heuneburg can be attributed to the fact that the main attracting factor of the location, i.e., its location as a network hub, became obsolete. Although the crossing of important transport routes persisted, the border of different organized areas moved northwards to the next line of princely seats. After the loss of the network-related central function, the place had no influence on the interaction structure and flows between two different areas [66].

Without substantial written sources, *administration* can hardly be assessed. The evidence of extraordinary rich graves with gold objects, imports and other precious objects is interpreted in different ways: some colleagues think of royal dynasties and kings [62], others consider different kinds of elites [66] and even a strong competition between groups [67]. The concept of prestige in contrast to status is also relevant here [68]. The elites might not have had a fixed status as rulers, but they reflected their strong ambitions by showing prestige artifacts and wealth. Nonetheless, we can assume a certain level of centrality intensity according to the prestige finds and the accumulated wealth. The range is also difficult to estimate. Since the idea of ruling big territories is only an assumption and there are indicators for rather small exclusive territories, we should not set the sphere of influence too large [66]. Based on the analysis of different social categories of the burials, we can deduce several social classes and perhaps social hierarchical levels. The collapse of the Heuneburg community at the turn of *Ha D1* to *Ha D2* could also be linked to a population that exceeds a population threshold for non-hierarchical societies [65]. This questions the hierarchical interpretation of social classes but even if the social hierarchy were clear it unfortunately cannot simply be transferred to the settlement hierarchy. Concerning the control of interaction, we can assume a mono-hierarchy with an exclusive core area. In addition, similarities of the princely seats indicate a social and perhaps political network between the different sites represented by an *ab*-model (Figure 7a).

Trade connections can be estimated by recording the incoming objects. In terms of spatial interactions, the central function *trade* has a high intensity. The regional trade can, on the one hand, be estimated based on the distribution of objects produced at the Heuneburg and on the other hand based on the origin of objects. In the case of stable isotope analysis, the origin is not known, but the minimal distance to regions with the required isotope profile can be given. For animal bones, this is about 50 to 60 km ([62], p. 478). The various kinds of Mediterranean imports can be used to indicate trade using network organization.

Concerning *craft*, there are traces of ceramic and metal production. The red-white painted ceramics distributed in the area until Lake Constance were probably produced at the Heuneburg [69]. Metal production was not specialized and seems to have only local importance [70]. Fibulae probably produced at the Heuneburg have been distributed in the region. For this regional distribution, a Christaller-like system, i.e., an *aa*-model has to be assumed (Figure 7a). A wider distribution throughout a network cannot be excluded, but the evidence is not available.

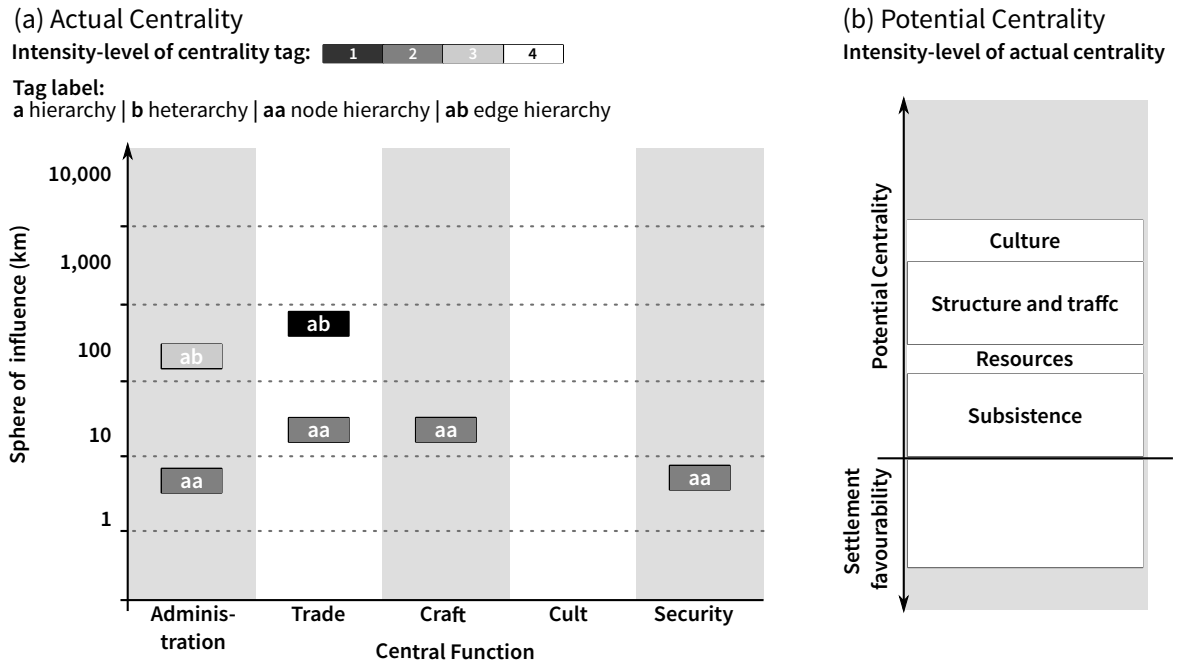


**Figure 7.** Centrality Graph of Heuneburg (see text for a detailed explanation of the different elements).

At the Heuneburg, there are no indicators for *cult*. The walls are clear evidence of the central function *security*. The symbolic value of the fortification, which was built as a mud brick wall, sometime around 600 BC probably inspired by Mediterranean prototypes, is certainly high. The fortification itself was hardly used to protect more people than the population of the Heuneburg. This function reflects an *aa*-model.

The settlement favourability of the Heuneburg can be estimated as being a little below average (Figure 7b). The same can be said about resources and culture. In terms of subsistence as well as structure and traffic, the potential centrality is higher: the Heuneburg is located at the edge of the Swabian Alb providing access to different areas, different types of land use and hence different subsistence strategies providing rather stable subsistence opportunities. The Heuneburg is also located at the shore of the Danube, an important waterway and transport route, and at the same time at a crossing of the Swabian Alb. The combination of these factors is the reason why the Heuneburg developed to a kind of gateway, structuring the exchange between two differently organized areas south and north of the site [66,71].

## 9. Discussion

Both examples show places which possess a certain degree of centrality for some time and a loss of it after a significant change of parameters. In the case of Felix Romuliana, the centrality was caused by an outstanding central person: located close by but not along supra-regional exchange and communication routes, Felix Romuliana is a typical example of a central place in an "un-central" landscape. Thanks to the power of a "central person", the natural centrality potential of the place was exceeded for some time. This effect is mirrored in the centrality diagram that shows an increase of one function while the others stay at the same level or even decrease in their intensity. In the case of the Heuneburg, we infer that the centrality was caused by the situation of the site at the border between two differently organized areas. Such a location demands a *gateway* and the organization of exchange. The more important the inter-regional exchange, the higher the demand for a gateway and the larger the centrality potential. Since this centrality potential is directly based on the network configuration and only indirectly linked to the environment, we can refer to such situations as (1) "central" landscapes

in the sense of a socio-economic and political landscape as well as (2) "un-central"—in the sense of un-necessary—landscapes in terms of natural resources.

Although both sites show a similar development according to some general factors, the examples represent completely different historical processes and highlight the fact that it is important to consider the context and the individual processes. There is no standard central place but a multitude of different places with different histories and different parameters gaining certain degrees of centrality based on different centrality profiles. Accordingly, the same holds true for central or un-central landscapes. Economy, historic situations, outstanding persons and structural properties in interaction networks are only some of those factors contributing to individual developments of centrality. Furthermore, there is no static centrality but historic processes, which cause different places to have different degrees and profiles of centrality for certain periods of time. Hence, the two examples demand a diachronic perspectives and pluralistic approaches—that can, for instance, be synthesized within centrality graphs and polyvocal interpretations.

## 10. Conclusions

The approach presented in this paper opens new perspectives of integrated centrality research. It helps to understand the reasons and motivations that caused centrality in a landscape setting that would normally have been described as "un-central". The usage of a centrality vector, the integration of Christaller- and network-centrality, and the consideration of the centrality potential provides comprehensive insights into the actual processes and states of the settlement systems. The interaction-based concept of centrality and the semi-quantitative approach enable and support comparisons and visualizations of the main factors that make up the centrality of a place. The systematization of centrality dimensions in combination with central functions guides research and helps to consistently present heterogeneous and complex results. We achieve a better understanding of various aspects of centralization that are usually ruled out by centrality analysis: for instance, (a) different sites develop different dominant centrality profiles and (b) different central functions are organized according to different structures and strategies. Each central function requires its context, a context that is shaped by a temporal, cultural, and natural relatedness. To acknowledge the complexity of the centralization process and heterogeneity of places, we need to focus on the comparison of sites and the interpretation of individual processes. This comparative and individualized approach, in combination with a straightforward and easy to use semi-quantitative centrality graph helps to circumvent the *cul-de-sac* of oversimplification and inappropriate analytical tools. We are confident that centrality graphs, as presented here, can develop to be the dominant front-end for pluralistic analytical approaches that integrate the different dimensions and facets of centrality.

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