Chapter 7
Towards an Interdisciplinary Understanding of Landscape Qualities: Wilderness, Tranquillity and Dark Skies

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Abstract The need to assess landscape qualities has become increasingly important over the past decades, with landscapes being continuously shaped and re-shaped through dynamic natural and anthropogenic processes. It is now widely recognised that landscapes need to be studied both in terms of their physical and ecological elements as well as how people living in or visiting landscapes perceive and interact with them. Different approaches have been developed over time for assessing these variegated aspects of landscape qualities, which range from methods in the natural sciences to the social sciences and humanities. Using the three examples of wilderness, tranquillity and dark skies as landscape qualities, we review existing quantitative and qualitative approaches to illustrate the potential of interdisciplinary landscape research. Furthermore, we highlight the potential of novel methodologies and data sources to study these landscape qualities, including the use of machine learning for automated image recognition, analysis of social media data (tags, location and image content), as well as citizen science approaches.

Keywords Landscape qualities · Landscape research · Landscape perception · Wilderness mapping · Tranquillity mapping · Nightscapes · Dark skies · Soundscapes

7.1 Introduction

Landscapes are rapidly changing across the world. For Western Europe, two simultaneous but contrasting trends are observed: firstly, abandonment of agricultural lands followed by spontaneous reforestation in marginal areas, and secondly,

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high socio-economic pressure on urban and peri-urban areas leading to conversion of cultivated and natural land into built-up areas. The first trend leads to wilderness areas with high recreational quality, while the second trend results in increasing numbers of recreationists from growing population centres seeking landscapes exhibiting qualities such as wilderness, tranquillity or dark skies. However, assessing and maintaining these landscape qualities is challenging. Consequently, these qualities run the risk of being neglected in policies and decision-making impacting future landscapes. In this chapter, we focus on these 'neglected' landscape qualities of *wilderness*, *tranquillity* and *dark skies*. We first introduce general approaches for 'sensing landscapes' using different sources of information and analysis methods. Using the three examples of wilderness, tranquillity and dark skies, we then describe state-of-the-art methods for assessing and modelling landscape qualities through qualitative and quantitative approaches, as well as highlight innovative new methodologies and data sources that are emerging. Finally, we discuss the challenges and opportunities of modelling perceived landscape qualities in the context of landscape research.

7.1.1 Capacities in the Sensing of Landscapes

Landscapes can be sensed by the individual (experiential), through digital sensors (often as earth observations), and they can be modelled using surrogate variables. In combination with a wide variety of qualitative and quantitative techniques, it is possible to classify, detect change and generally model different characteristics of the landscape. The free sharing of global datasets (of increasing recency and often of high resolution), coupled with bespoke, intuitive to use, mobile apps able to record many of the attributes of landscape, has facilitated a significant growth in citizen science. Thus human and digital sensor networks coupled with analytical techniques can produce a wide range of outputs and perceptions that are critical to public engagement and policy-making (Fig. 7.1).

Well established is the combination of remote sensing (RS), geographic information systems (GIS) and spatial analysis techniques to characterise landscape, monitor change and model landscape ecologies (Yang et al. 2013). Remote sensing gives emphasis to the physical properties of landscape, but the human dimension to experiencing landscape is equally important (Cosgrove 1984). In this respect, citizen science has been transformative to research, a myriad of projects are testament to the importance of user-generated content in experiencing and monitoring landscape. The potential and benefit of public participation in modelling and mapping qualities of the landscape is well understood (Dickinson and Bonney 2012). Bespoke mobile apps, open-source software and data portals have hugely facilitated the gathering and sharing of geographical data in support of the earth observation agenda (Fritz et al. 2017). This direct and active involvement of a large number of contributors has been termed *active crowdsourcing*. In addition to these directed citizen projects, imagery and related user-generated text-data from social media has
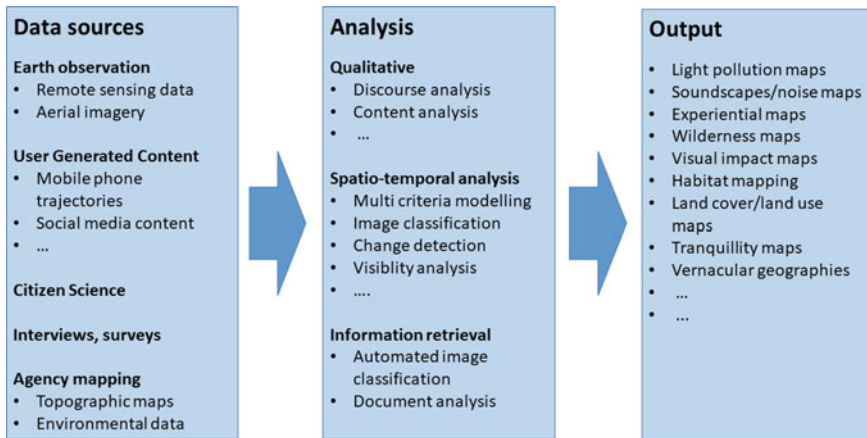
Data sources	Analysis	Output
Earth observation • Remote sensing data • Aerial imagery **User Generated Content** • Mobile phone trajectories • Social media content • … **Citizen Science** **Interviews, surveys** **Agency mapping** • Topographic maps • Environmental data	**Qualitative** • Discourse analysis • Content analysis • … **Spatio-temporal analysis** • Multi criteria modelling • Image classification • Change detection • Visiblity analysis • …. **Information retrieval** • Automated image classification • Document analysis	• Light pollution maps • Soundscapes/noise maps • Experiential maps • Wilderness maps • Visual impact maps • Habitat mapping • Land cover/land use maps • Tranquillity maps • Vernacular geographies • … • …

Fig. 7.1 Overview of examples of data sources, analysis methods and outputs to assess landscapes

been used as a data source (for example from platforms including Flickr, Instagram, Geograph and Pinterest). The analysis and use of such data has been termed *passive crowdsourcing*. Notwithstanding issues of data quality (in particular, recorder bias, completeness and currency), user-generated data have enabled the creation of vernacular geographies with an emphasis on understanding the perception and experience of 'place'—important in understanding how we perceive and value landscape (Purves et al. 2011). In summary, what Fig. 7.1 seeks to convey is a multi-methodological approach to understanding qualities of landscapes that draws on a fusion of human and digital sensor networks that results in a deeper comprehension of what landscapes mean—culturally and ecologically. In the following sections, we explore these ideas with reference to three important qualities of landscape (wilderness, tranquillity and dark skies), and discuss approaches of how we might model and characterise these qualities.

7.2 Wilderness

Wilderness has become an important concept in nature conservation, as well as in tourism and outdoor recreation. On the one hand, the continued expansion of human infrastructure and intensive land use means we continue to loose wilderness as the human footprint on the land is growing larger (Sanderson et al. 2002). On the other hand, many rural areas, for instance, in Europe, face agricultural land abandonment, and lacking intervention, will revert to some form of 'wilderness' (Höchtl et al. 2005). The need to conserve wilderness areas has been recognised in politics and nature conservation (Jones-Walters and Čivić 2010), and the European parliament put wilderness on its political agenda (European Parliament 2009). In

parallel, WildEurope, a conglomerate of NGOs and other institutions, was established to operationalise the resolution (Fisher et al. 2010). But what exactly do we mean when we talk about wilderness?

Wilderness is a vague concept—different people may understand different things as wilderness (Lutz et al. 1999; Bauer 2005a, b). The concept is also understood differently in different languages and cultures. For example, the German term 'Wildnis' differs in its conceptual history from the English term 'wilderness' (Cronon 1996; Stremlow and Sidler 2002) and in many non-European cultures, the notion of wilderness as a kind of nature alienated from people is a foreign concept (Descola 1996). Even in the Western context, definitions of wilderness are complex and diverse. One of the perhaps broadest is by Nash: '*It is tempting to let the term define itself: to accept as wilderness those places people call wilderness* (Nash 2014, p. 5)'. While this phrase highlights the social constructedness of the concept, it is perhaps less helpful in providing guidelines for those who need to take decisions on the management and protection of wilderness.

If we want to provide tangible evidence for policy-making and planning that will aid in protecting wilderness as an important quality of landscapes, it becomes necessary to define what wilderness is, how people perceive it and where we can still find wild places. A growing body of literature in a range of different research areas deals with these questions. One strand of research is concerned with producing robust and repeatable models in geographic information systems (GIS) that tell us where we can still find wilderness (Kliskey and Kearsley 1993; Fritz et al. 2000; Carver et al. 2012, 2013; Orsi et al. 2013; Carver and Fritz 2016b). Another strand of research investigates public perception of wilderness (Habron 1998; Bauer 2005a, b; Mc Morran et al. 2008; Bauer et al. 2018). In the following, we provide an overview of these two different strands, acknowledging that they are not distinct areas of research but can be seen as a spectrum from more perception-focused research to GIS modelling. We also include more critical views of the concept of wilderness as a cultural invention (Cronon 1996). Finally, we introduce novel potential approaches for wilderness mapping using automated image classification approaches that allow the detection of potential 'wilderness' from photographs.

7.2.1 Mapping Wilderness

Nash's definition of wilderness being what people think it serves to illustrate wilderness as a sociocultural construct, but mapping wilderness characteristics in GIS requires operationalisable definitions and selecting criteria and attributes (Carver and Fritz 2016a). In the USA, for example, the Wilderness Act of 1964 defines wilderness through terms such as '*untrammeled*', '*undeveloped*', '*natural*', '*opportunities for solitude and unconfined recreation*' (US Congress 1964). The federal agencies involved in managing wilderness areas in the National Wilderness Preservation System published a conceptual framework that links management actions directly to these qualities described in the Wilderness Act (Landres et al. 2008).

At the global level, the IUCN defines Wilderness areas (IUCN Category Ib) as: '*Protected areas that are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition*' (IUCN 2018). In most wilderness definitions, particularly those that became the basis for mapping, we can identify an ecological component of the degree of naturalness or modification, as well as a perceptual component (Lesslie and Taylor 1985). In the literature, an important distinction is made between wilderness quality and wilderness areas. Wilderness qualities are defined as '*the extent to which any specified unit area is remote from and undisturbed by the impacts and influence of modern technological society*' (Lesslie 2016, p. 21). Wilderness areas are defined as '*relatively large intact natural areas—places where wilderness quality is defined using agreed thresholds recognised by society*' (Lesslie 2016, p. 21). In their guidelines for the management of wilderness in Natura 2000 areas, the European Commission defines wilderness as: '*A wilderness is an area governed by natural processes. It is composed of native habitats and species, and large enough for the effective ecological functioning of natural processes. It is unmodified or only slightly modified and without intrusive or extractive human activity, settlements, infrastructure or visual disturbance* (European Commission 2013, p. 10).

Different definitions and notions of wilderness exist, and are still being debated. The issue of definition is not merely an academic concern, but is of direct consequence for mapping, as we can only map what we have clearly defined. It is also paramount for policy-making and planning (Mc Morran et al. 2008), as a lack of clear definitions may hamper the effectiveness of protecting wilderness. In this respect, mapping wilderness quality is considered an important endeavour to assess the status of this landscape quality. Carver and Fritz (2016b) highlight the paradox of mapping wilderness and elaborate why it is better to map than not to map: mapping wilderness helps to localise where more or less wild places exist, providing hard proof that is needed to convince decision-makers and politicians of the need to protect wilderness. Even before GIS became mainstream technology, McCloskey and Spalding (1989) mapped the world's remaining wilderness areas using two criteria: areas more than 4000 km^2 in extent and more than 6 km from recorded human features were identified based on Jet Navigation Charts at a scale of 1:2 million. The resulting map showed that around a third of the world's area could be seen as wilderness, with the largest areas located at high latitudes and in desert areas (McCloskey and Spalding 1989).

Most wilderness mapping conceptualises the quality of wilderness as a spectrum of the 'degree to which a place is remote from and undisturbed by the influences of modern technological society', which Lesslie and Taylor (1985) and Nash (2014) described as the 'wilderness continuum'. This continuum avoids drawing sharp distinctions between what is, and what is not wilderness, acknowledging that the drawing of such an (imaginary) boundary is highly dependent on social and cultural norms. It also incorporates the notion of 'modern technological society's impact', and not of indigenous and traditional societies. In inventorying wilderness in South

Australia, Lesslie and Taylor (1985) implemented the wilderness continuum concept in a spatial manner, defining wilderness as 'four wilderness quality indicators (Lesslie and Taylor 1985). Using similar indicators for the national scale map of Australia (remoteness from settlement, remoteness from access, distance from human artefacts and naturalness of the land at national scale), the *Australian National Wilderness Inventory* was arguably the first comprehensive use of GIS to map wilderness quality (Lesslie and Maslen 1995). Many wilderness mapping initiatives have followed, but the two basic factors of the Australian Inventory, *naturalness* and *remoteness* are, in some form, used in almost all models of wilderness quality today (Carver and Fritz 2016a). Some models extended the criteria to four components: naturalness, remoteness, ruggedness (as a measure of the terrain) and human impact (Fritz et al. 2000; Carver et al. 2002; Carver and Fritz 2016b). Different methods have been applied to wilderness mapping, with Comber et al. (2010) empirically demonstrating how different models lead to different wilds, highlighting the importance of selecting criteria and weightings. For example, for the UK, Fritz et al. (2000) implemented weighted distance decay models (e.g. of population) to avoid defining rigid thresholds and included differential weighting of wilderness quality data layers through multi-criteria evaluation (Fritz et al. 2000). Weighting of GIS layers has been done through expert-consultation (Radford et al. 2019), and public participation GIS has also been tested as a means to gage different perspectives and provide weightings for wilderness models in a participatory manner (Carver et al. 2002).

The challenges involved in mapping wilderness quality notwithstanding, mapping wilderness have become an important tool for conservation, and a range of wilderness mappings have been conducted across different scales, from global to local. At a global level, Lesslie (1998), in work for the World Conservation Monitoring Centre, extended the Australian concept to cover the entire world. Other global mapping initiatives include the Global Methodology for Mapping Human Impacts on the Biosphere (GLOBIO, UNEP 2002) and the Human Footprint and the 'Last of the Wild' map (Sanderson et al. 2002). Recent global wilderness mappings highlight the decline in wilderness areas over the past decades (Watson et al. 2016) and how the world's largest remaining wilderness areas are concentrated in a handful of countries, including Russia, Canada, Australia, the USA and Brazil (Watson et al. 2018). For Europe, a Wilderness Quality Index has been published that maps wilderness quality as a continuous surface (EEA 2011), highlighting Northern Scandinavia, Iceland and Northern Scotland as areas where pockets of wilderness remain. Fritz et al. (2000) mapped wilderness quality across the UK. Examples of wilderness maps at national scale include the aforementioned example of Australia (Lesslie and Taylor 1985), Austria (Plutzar et al. 2016), Iceland (Ólafsdóttir et al. 2016), Scotland (SNH 2013) and Switzerland (Radford et al. 2019). The Swiss case study confirmed the important role of mountains, showing how the largest contiguous areas with high wilderness quality are to be found in the Swiss alps (Fig. 7.2).

In another case study for two mountainous regions in Southern Switzerland, the focus was on mapping the quality of remoteness rather than wilderness through the
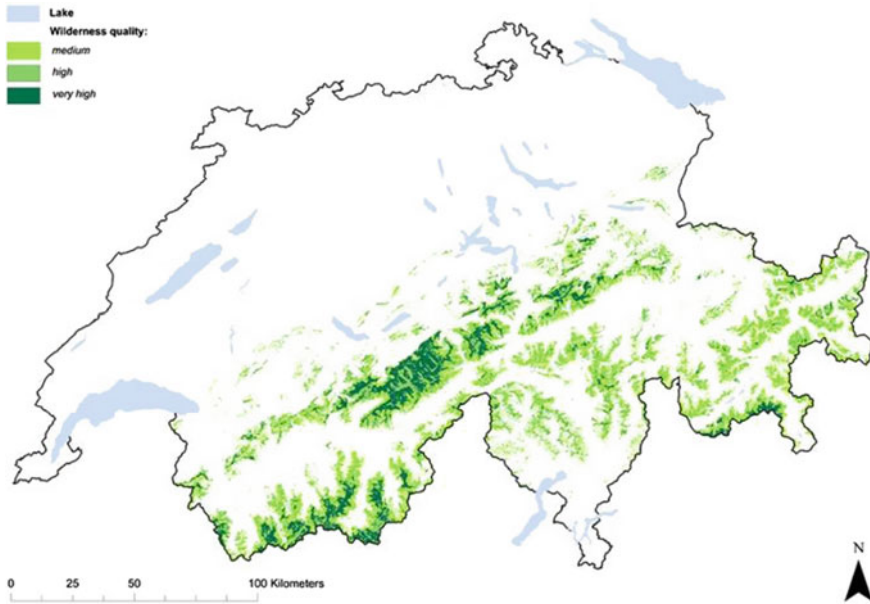
Fig. 7.2 Last remaining continuous areas with high wilderness quality are to be found in the alpine areas of Switzerland (Own illustration. Data sources: basemap data from BFS GEOSTAT/ Federal Office of Topography swisstopo, data on wilderness quality from Radford et al. 2019)

use of a remoteness measure developed specifically for that study (Boller et al. 2010). Boller et al., argued the concept of remoteness was better suited to mountainous regions of Europe as areas that have long been settled and managed by alpine communities, and where the cultural heritage and traditional land use form an important part of the experience of alpine landscapes.

Case studies of wilderness mappings at local scale that can guide protected area management include, for instance, the Death Valley National Park in the USA (Carver et al. 2013), the Cairngorms and the Loch Lomond and The Trossachs National Park in Scotland (Comber et al. 2010; Carver et al. 2012) or the Carpathian mountains in Romania (Măntoiu et al. 2016).

One of the areas where wilderness quality has been most comprehensively mapped is Scotland, which has been mapped at global, regional and local scales. Comparing these different maps highlights how wilderness is, to some extent, a scale-dependant concept. On global wilderness maps, Scotland does not show up as an area with high wilderness quality (UNEP 2002). On a wilderness map of Europe (EEA 2011), we start to see small pockets in Scotland emerging as some of the wildest areas, the largest areas within Europe being located in Iceland and Scandinavia (Kuiters et al. 2013). For Great Britain, wilderness mapping with public participation GIS showed that Scotland contained most of the top 10% areas considered 'wildest' (Carver et al. 2002). At the national scale, the Scottish Natural Heritage mapping highlighted areas of Northern and Northwestern Scotland as

Fig. 7.3 Cairngorms is one of Scotland's largest Wild Land Areas and protected through the Cairngorms National Park. Image: 'Munros Trip 9/08 (ct28)' by Ted and Jen on Flickr (CC BY 2.0)

areas with high wilderness quality, whereas the Southern part of Scotland showed low levels (SNH 2013). At the local scale, wilderness maps for the two national parks in Scotland (Cairngorms and the Loch Lomond and The Trossachs) highlight differences in wilderness quality between two protected areas (Carver et al. 2012), with generally higher levels of wilderness quality in the Cairngorms (Fig. 7.3). Such wilderness maps at the local level can form an empirical basis for managing development within a protected area, and guide recreational planning.

The Scottish case also illustrates how wilderness mapping can have an influence on policy-making. The data from the national mapping (SNH 2013) was used to directly inform Scottish policy (SNH 2014a). In a later phase, the largest and most wild areas were identified, which are now listed as 42 'Wild Land Areas' (SNH 2014b). The list includes small areas, e.g., around single mountains such as Ben More on Mull, or parts of the island of Rum. Larger Wild Land Areas are the Cairngorms (Fig. 7.3) and parts of the Scottish Highlands.

7.2.2 Wilderness as a Cultural Notion

It is important to note that some of the areas now identified as Wild Land Areas in Scotland were once populated and the basis for rural farming communities. This changed during the Clearances in the late eighteenth and early nineteenth century.

Fig. 7.4 Suisnish ruins on the Isle of Skye in Scotland. During the Clearances, thousands of families were forcefully removed from their homes to make way for commercial sheep farming. Image: 'Suisnish Ruins' by Ross Collins on Flickr (CC BY 2.0)

Landowners, sometimes forcefully and involving human atrocities, evicted rural communities from the land they were living on to make way for more lucrative commercial sheep farming (Richards 2012). It is this human suffering of highland communities that eventually resulted in what many people today perceive as wilderness (Fig. 7.4). Perhaps unsurprisingly, notions of wilderness and wild land are still controversially discussed in Scotland (Mc Morran et al. 2008). The continued erasure of people from the land through environmental narratives of nature is criticised, with writers such as James Hunter advocating for acknowledging people's history and connection to place (Hunter 2014).

The case of erasing people from the landscape is not unique to the Highlands of Scotland. Other examples include conservation initiatives across the globe that, with the aim of protecting idealised (Western) notions of wilderness, displaced indigenous people from the land they inhabited (Neumann 1998; Agrawal and Redford 2009). Acknowledging that wilderness is a social and cultural construct makes it possible to also critically engage with this concept. In his essay 'The Trouble with Wilderness, or, Getting Back to the Wrong Nature', Cronon (1996) investigates wilderness from a historical perspective, critical of the separation of people and nature, and calling for a rethinking of the human–nature relationship. Stremlow and Sidler (2002) explore the concept of wilderness ('Wildnis' in German) as a cultural phenomenon through its use in modern literary and journalistic texts to study societally rooted perceptions of wilderness, showing

how wilderness is constructed conflictingly, as a place of fear, and as a place of the idyllic. In more applied research, a case study on the Isle of Harris in Scotland shows how cultural notions of wilderness, which are related to the exclusion of crofting communities, can be re-thought as a more inclusive concept that integrates conservation and crofter's stewardship of the land that creates possibilities for more socially just future landscapes (Mackenzie 2006). To shape landscapes where the importance of people and their ties to place as well as nature conservation are acknowledged, it is important to understand and take into account public opinion towards nature and wilderness.

7.2.3 The Perception of Wilderness

In the highly urbanised and developed continent of Europe, only few areas of wilderness remain, not all of which are formally protected and thus risk being encroached upon by infrastructure development. At the same time, we observe continuing agricultural abandonment creating new possibilities for (secondary) wilderness areas. In order to safeguard the continued existence of wilderness areas in the future and potentially enable some formerly used areas to revert to secondary wilderness, it is important to understand how people who live in and around such areas perceive wilderness and nature to design appropriate landscape management policies that will be supported by the public.

People's attitudes towards wilderness have been studied with respect to their expectations and experiences in specific areas (Durrant and Shumway 2004; Wallner et al. 2007; Bauer et al. 2018), as well as independently of whether they are visitors or residents in a particular area (Lutz et al. 1999; Cordell et al. 2003; Johnson et al. 2004; Bauer 2005a, b; Bauer et al. 2009).

Regarding general opinions about wilderness, a study in Canada found that respondents to a questionnaire survey had relatively positive opinions and favoured wilderness protection, irrespective of whether they lived in rural or urban areas (Lutz et al. 1999). However, a photograph-rating task in the same study revealed that rural dwellers had higher thresholds for what they considered as wild than urban dwellers. For instance, only 11% of rural dwellers considered a photograph of a valley with agriculture in the foreground as wilderness compared to 43% of the urban dwellers (Lutz et al. 1999). This shows that while opinions about wilderness were overall positive, people had different understandings about what wilderness is. Based on the US National Survey on Recreation and the Environment (NSRE) in the year 2000, a study on the influence of ethnic background showed that while there were differences in visitation rates and use-values between different groups, less differences were observed for intrinsic and non-use values attributed to wilderness (Johnson et al. 2004). In the same survey younger people, residents in the East of the USA and ethnic minorities were more likely to be in favour of expanding the system of wilderness areas (Cordell et al. 2003). Results from a comparison of the NSRE survey results between 1994 and 2000 indicated that

awareness of wilderness and the importance of non-use values had increased in the overall population, but this did not translate to an increased acceptance of expanding wilderness areas (Cordell et al. 2003).

In a comprehensive study on the public understanding of wilderness in Switzerland, Bauer (2005b) investigated public attitudes towards wilderness with over 1500 written questionnaires sent out to a representative sample of the population. The public understanding of wilderness in Switzerland was relatively congruent with scientific criteria, including the lack of visible human impact and the degree of naturalness. A difference in public and scientific understanding was that for the public, areas with dense vegetation are seen as wild, irrespective of their development history (Bauer 2005b). Several socio-demographic factors influenced opinions about wilderness, including age, place of residence (rural, urban) and general attitudes towards nature (e.g. nature conservationists). Critical opinions towards wilderness were more likely from people living in rural areas, older people and people who grew up in rural areas. More positive opinions were likely from nature conservationists, younger people and city dwellers (Bauer 2005b). Proponents of wilderness were less tolerant of visible human influences in wilderness areas. Opponents were more tolerant of the presence of infrastructure and perceived areas with higher human influence as wilderness than the proponents. People in the French- and Italian-speaking parts of Switzerland also held more critical opinions about wilderness, whereas people in the German-speaking part were more positive, which may reflect sociocultural differences in wilderness perception between regions but could also be linked to more general differences with the terms used in German, French and Italian. Based on these findings, Bauer (2005b) presents region-specific management suggestions that include the creations of different 'wilds' to satisfy the needs and wishes of different groups.

In a survey about attitudes towards wilderness in the South-Western Carpathians in Romania, attitudes of people living within protected areas were divided into two groups (Bauer et al. 2018). One group that had a more utilitarian attitude towards nature and wished for nature to stay unchanged and be aesthetically pleasing while another group favoured unrestricted access to wilderness and considered it important for wilderness to be remote. While attitudes towards nature and wilderness were positive for both groups, they were more critical of protected areas, highlighting how the local population differentiates between wilderness in general and protected areas, a finding similar to the study on wilderness areas in Utah (Durrant and Shumway 2004).

Research into perception of wilderness thus brought forth the various and diverse factors that influence people's perception of and attitudes towards wilderness, ranging from factors at societal to more individual level.

7.2.4 New Methods for Wilderness Research: Automated Image Annotation

Wilderness is perception-based—it is what people perceive it to be. For instance, the absence of infrastructure, wide open lands, or rough terrain. This makes wilderness an interesting concept to be studied through the use of methods such as automated image annotation, a process through which keywords are automatically assigned to an image. This is possible through machine learning, where a computer algorithm 'learns' to recognise certain elements in a picture, say the presence of people, or a dog, and then scans new pictures for being more, or less likely, to also depict these elements it has been trained to detect. It does so through a training dataset that is manually annotated, where human annotators have decided whether a picture depicts people, dogs or any other elements that are of interest to users (e.g. cars, houses, etc.). This annotated dataset is then provided as an input for the algorithm for learning to recognise similar pictures and label them. Some companies are offering pre-trained algorithms that can be applied to any images and will automatically annotate them with tags. One such example is the Google Vision API, where interestingly, the algorithm has been trained to use the label 'wilderness'. For instance, it labelled Figs. 7.3 and 7.4 as 'wilderness'. Automated image recognition thus opens new research avenues, where landscape characteristics based on perception can be inferred from images. In combination with user-generated images from social media platforms such as Instagram or Flickr, where users often add coordinates to an image uploaded (i.e. geotags), it is now possible to study spatial patterns of wilderness through user-generated image content.

7.3 Tranquillity

Today, the term tranquillity is widespread, including for marketing and place promotion. Tranquillity is therefore something that people seek and value, but what does tranquillity mean? Dictionaries provide definitions such as 'the quality or state of being tranquil' and synonyms include 'peacefulness', 'quietness', 'serenity'. The Roman philosopher Seneca (ca. 4 BC–65 AD) wrote in his work 'de tranquillitate animi' (c.f. Reynolds 1998) about tranquillity as a state of mind that is the opposite to anxiety and worry. Achieving such a state of mind is a challenge that can be made easier through the presence of certain environmental or landscape characteristics. For example, in Japanese aesthetics, high importance is ascribed to harmonious environments promoting a tranquil state of mind, as illustrated, for example, in design principles of Japanese gardens (van Tonder and Lyons 2005).

Although tranquillity is something that is individually perceived, many would agree that some landscape characteristics are more likely to instil tranquillity. Seeking tranquillity, peace and quietness away from the hustle and bustle of everyday life was shown to be a driver of recreation behaviour (Beard and Ragheb

1983; Frick et al. 2007), with recreationists visiting areas that exhibit these qualities. In the UK, for example, tranquillity was found to be among the main reasons why people visited the countryside (NBS 2004). Apart from attracting visitors, there are positive health effects associated with tranquil areas (Ulrich et al. 1991; De Vries et al. 2003; Velarde et al. 2007; Shepherd et al. 2013; Seresinhe et al. 2015; Vienneau et al. 2017).

Given its importance for health and recreation, tranquillity has become recognised as an important quality of landscapes that is reflected at the policy level. The UK, for instance, included the protection of tranquillity in its National Planning Policy Framework, stating that: '*Planning policies and decisions should aim to: […] identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason*' (National Planning Policy Framework 2012, p. §123). At the European level, the focus has been on environmental noise, which can be seen as an important aspect of the more holistic notion of tranquillity. The Environmental Noise Directive (END2002/49/EC) (END 2002) relates to the assessment and management of environmental noise, and requires member states to prepare noise maps and action plans, including the identification of noise exposure levels and preserving areas with low environmental noise levels. We see tranquillity as a more all-encompassing concept because we can imagine an area that is completely silent (e.g. an abandoned industrial area), but this area does not necessarily instil tranquillity.

From a research perspective, tranquillity is a multifarious concept that has been investigated in different fields, using various approaches. In the following, we provide a brief overview of strands of research and different methodologies relating to the exploration and study of tranquillity. We highlight how user-generated content in the form of geotagged social media photographs provide a novel source of information for investigating tranquillity as a landscape quality.

7.3.1 Image Rating Experiments About Tranquillity and Landscape Preference

In environmental psychology, the attention restoration theory by Kaplan and Kaplan (1989) states that natural environments facilitate restoration through 'soft fascination', a combination of capturing our attention effortlessly ('moderate fascination') and pleasure (preference or aesthetic quality). Based on this theoretical framework, Herzog and Bosley (1992) conducted image rating experiments to investigate the relationship between landscape preference and tranquillity. Images with different landscape settings, including fields and forests, mountains and water bodies were shown to participants. Results showed a high correlation of preference and tranquillity ratings, but for some landscape settings such as standing bodies of water, tranquillity was rated higher than preference. These experiments established

tranquillity and landscape preference as two related, but distinct concepts (Herzog and Bosley 1992). In a follow-up study, Herzog and Barnes (1999) investigated the influence of the factors 'unstructured openness', 'mistiness' and 'surface calmness' in predicting tranquillity and preference ratings in three landscape settings (desert, large water body and field/forest), showing that surface calmness was a predictor in some settings (including large water bodies), but not all. Another study investigated differences of tranquillity ratings for images with urban and natural scenes, where tranquillity was rated significantly higher for natural than urban scenes (Herzog and Chernick 2000). Factors that were positively correlated with tranquillity in natural surroundings were how well a setting appeared to be cared for (neatness), the amount of foliage visible (nature) and the amount of visible open space (Herzog and Chernick 2000). In these experiments, the focus had been on rating visual stimuli. In the next section, we summarise research on soundscapes that takes into account noise levels in addition to visual stimuli.

7.3.2 Measuring Soundscapes

Various efforts have been made to develop tools that predict tranquillity based on visual landscapes and their associated soundscapes. Pheasant et al. (2008) investigated the relationship between perceived naturalness of a scene, sound levels and tranquillity ratings by presenting visual and acoustic data of 11 English rural and urban landscapes to 44 subjects. Based on their findings, they developed a tranquillity rating prediction tool (TRAPT) that consists of an equation combining sound measures and visual stimuli (Pheasant et al. 2009). To validate and further develop this prediction tool, 18 subjects were presented with various imagery and pre-recorded sounds from three locations (a city garden, an urban park and a rural churchyard). The subsequent analysis revealed a linear relationship between tranquillity ratings with naturalness and recorded sound levels. Tranquillity ratings increasing with naturalness (percentage of natural features present in a scene) and decreased with increasing sound levels (Pheasant et al. 2009). This work demonstrated the possibility of predicting tranquillity based on features perceived in the surroundings (including natural features such as water, foliage, rock, but also including cultural heritage and traditional farm buildings) and sound levels from human sources. Arguing that due to their accessibility and population numbers in urban settings, tranquil urban spaces may be relatively more important to the overall population than tranquil rural spaces, Watts et al. (2011) investigated three urban recreation areas, where levels of tranquillity were estimated based on the prediction tool and compared to ratings from visitors in field-based surveys. In a subsequent study, eight urban green areas were examined and visitor questionnaires with 252 respondents were used to explore potential refinements to the prediction tool (Watts et al. 2013). Though able to produce good predictions, potential refinements to the model include giving penalty points for parks where graffiti and litter, is noticeably present, as this was shown to influence visitors' sense of tranquillity and improved

predictions (Pheasant et al. 2009). Other applications of the tranquillity rating prediction tool include exploring its relevance to wind farm siting and discusses the impact of differing expectations about tranquillity in urban areas and the countryside, highlighting the need for high levels of precision in defining anthropogenic disturbance both visual and acoustic (Watts and Pheasant 2015a). Further exploring the utility of the prediction tool in natural surroundings, a set of controlled experiments were used in which video footage was captured for 46 different natural scenes in Scotland and various noise sources were added to study the effect of different sources of noise and tranquillity and wildness ratings (Watts and Pheasant 2015b). Ratings from respondents show that tranquillity is a different construct from wilderness, and that tranquillity was much more impacted by acoustic variables, including human noise. Interestingly, adding natural sounds did not significantly improve tranquillity ratings. Overall, their analysis led Watts and Pheasant to argue that soundscape is an integral factor in people's sense of tranquillity and should therefore be an integral part of the assessment process (Watts and Pheasant 2015b).

Collectively, research on soundscapes shows that sound needs to be included as part of any assessment process while also revealing the complex and subtle nature of anthropogenic and natural sound in terms of its frequency, level and people's expectations.

7.3.3 Mapping Tranquillity

As one of the most active institutions for raising awareness about tranquillity and the protection of tranquil areas since the 1990s, the non-governmental organisation 'Campaign to Protect Rural England' (CPRE) commissioned a series of research and mapping projects (CPRE and the Countryside Commission 1995; Levett 2000; MacFarlane et al. 2004; CPRE 2005, 2007, Jackson et al. 2008). In his pioneering work for ASH consulting, Simon Rendel conducted the first mapping of tranquil areas in 1991 in a study for the Department of Transport. Rendel's map showed how significant areas so far unaffected by development, but undesignated and unprotected, were vulnerable to a proposed transportation corridor. Based on this work, the CPRE and the Countryside Agency (1995) produced a set of 'Tranquil Area' maps for England. This approach to tranquillity mapping was based on modelling the impact of audio-visual disturbances in the form of roads, railways, power stations and settlements, defining thresholds to these sources of noise. One of the main critiques of this early approach was that fixed thresholds from noise sources were used, and that the definitions of the thresholds and sources of disturbance were based on expert-opinions, rather than public consultations (Levett 2000). In aiming to address these critiques and to include the views of the public, a subsequent project in the Northumberland National Park and West Durham Coalfield in England conducted a comprehensive participatory appraisal to determine what people considered as tranquil (MacFarlane et al. 2004). In a second step,

the researchers operationalised the factors contributing to and diminishing tranquillity in a GIS model that included as layers such as remoteness, naturalness of land cover, openness and noise sources. The different layers were weighted again through a public consultation exercise. In a subsequent study, a similar approach was also applied to the Chilterns in the South East of England (Jackson et al. 2008), and then scaled-up to produce a tranquillity map for England (CPRE 2007). To produce the tranquillity map for England, over 1000 people were consulted and the thresholds applied to the GIS layers (for instance, the distance at which the impact of a road on tranquillity decreases) were determined through photograph-rating tasks with the public (Jackson et al. 2008). The importance of taking into account public opinion was also recognised in a study in the Dorset Area of Outstanding Beauty, which incorporated views from different stakeholders, including parts of the population considered hard to reach. In total, views of over 800 participants were collected through participatory appraisals including focus groups, household and on-site surveys (Hewlett et al. 2017). The criteria that people deemed important were open landscape, the absence of human-made noise, traffic and the presence of other people. Based on this information a GIS model was created, using over 70 input layers (Terradillos and Wilkinson 2015).

7.3.4 New Methods for Tranquillity Research: Analysing Tags from Geotagged Social Media Photographs

One of the challenges in research on landscape qualities such as tranquillity or wilderness is that these qualities are based on people's perception, and such perceptions have commonly been cost-intensive to assess across larger areas. If national surveys are used, sample sizes that can be achieved are limited given common financial constraints. As a consequence, the data are often not available at spatial granularities that allow detailed spatial modelling. In this respect, social media data generated by users is a novel form of data that enables researchers to study place-based experiences of people in landscapes (Guerrero et al. 2016; van Zanten et al. 2016; Chesnokova and Purves 2018; Wartmann et al. 2018). This body of work is based on people contributing content to social media platforms such as Instagram, Flickr or Twitter in the form of photographs, associated text (i.e. 'tags' or 'hashtags') and often also provide coordinates for their photographs ('geotags').

Through the tags associated with images, we can, for instance, select images that have been tagged with words such as 'tranquillity', 'tranquil', 'peaceful' or 'quiet'—which provide us with a dataset of images that are likely to have been taken at locations where people experienced tranquillity (Fig. 7.5).

Mapping the spatial distribution of these locations while controlling for the underlying distribution of all images provides us with an assessment of areas where people experience tranquillity based on social media data such as Flickr images (Wartmann et al. 2019; Wartmann and Mackaness, in review).
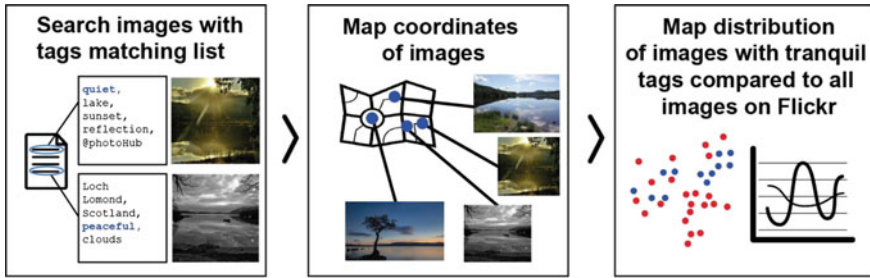
Fig. 7.5 Methodology for assessing tranquillity based on selecting geotagged photographs from social media through keywords associated with tranquillity

7.4   Dark Skies

Artificial light at night is an important driver of global change in the twenty-first century (Davies and Smyth 2018). In European cities, artificial light at night has become omnipresent: from streetlamps, illuminated buildings and soccer courts, restaurants, shop windows, and blinking billboards to our homes, where we illuminate front doors with security lights or decorate lawns and windows with artificial lighting. Artificial light at night provides a range of benefits, including safety on roads at night for traffic and pedestrians, as well as aspects of convenience. The unprecedented increase in lighting also has negative impacts, including the disappearance of dark skies (e.g. Fig. 7.6), which makes it impossible for people to observe the stars at night (CfDS 2009).

Fig. 7.6 Night sky above Domat/Ems and Tamins in the Canton of Grisons, Switzerland (image courtesy of B. and C. Wartmann)

Concerns have also been raised about ecological and health effects of increased night-time lighting (Smith 2008). The term 'light pollution' is often used in connection with dark skies and is defined as '*artificial light that is excessive or intrudes where it is not wanted*' (Claudio 2009, p. 29). Artificial light at night has largely negative effects on biodiversity (Hölker et al. 2010; Gaston et al. 2013; Brüning et al. 2016; Knop et al. 2017), organisms' physiology (Hölker et al. 2010; Brüning et al. 2016) and behaviour (Knop et al. 2017). Negative impacts were found for a large variety of animal species (Rich and Longcore 2013). Both terrestrial and aquatic insects are negatively affected (Perkin et al. 2014). Street lamps effectively act as light traps and can kill billions of insects throughout the year, in turn reducing food availability for predators, which affects entire ecosystems (Rich and Longcore 2013). In sea turtles, artificial light was shown to impact nesting behaviour and to be negatively related to nest densities (Silva et al. 2017; Hu et al. 2018), as well as reduce survival rates of turtle hatching by disorienting them away from the sea towards illuminated beach infrastructure (Lorne and Salmon 2007). Negative effects were also demonstrated for nocturnal mammals such as beach mice (Bird et al. 2004) and bats (Polak et al. 2011; Russo et al. 2017; Rydell et al. 2017; Azam et al. 2018).

Furthermore, there is now increasing empirical evidence that light pollution also has detrimental and potentially far-reaching effects on people's health (Navara and Nelson 2007; Cho et al. 2015). Artificial light at night may be associated with increased risk of different types of cancer (Kloog et al. 2008; Stevens 2009), obesity (Fonken et al. 2010) and diabetes (Spiegel et al. 2005). The internal (circadian) clock regulates various bodily functions and is closely linked to the daily change from light to dark. The hormone melatonin, for example, is only produced in dark phases. If melatonin production is disrupted, sleep disturbances or changes in the immune system can occur (Chepesiuk 2009). An economic study estimates the damage caused by light pollution to the USA alone at US\$ 7 billion per year (Gallaway et al. 2010).

From a landscape perspective, the loss of dark skies changes not only the way organisms and ecosystems function, but also the way people (can't) experience dark skies, which is considered a cultural loss. Across the world, large natural areas with dark skies are disappearing and in many cities and nearby areas, the night skies are lightened-up so much that a fifth of all people in the world can no longer observe the milky way with their naked eyes (Cinzano et al. 2001). Exceptions are some areas in highly developed European nations, where night skies in some (small) areas have become darker again. This development is linked to the decline in primary industries and the reduced need for lighting linked to industrial processes, which lead to less artificial light emissions at night in some parts of northern Germany or South-West England (Bennie et al. 2014). The prevailing trend, however, continues to be an increase in night lighting, particularly in urbanised areas (Fig. 7.7).

With increased awareness about light pollution, actions are being taken to reduce artificial light emissions (Gaston et al. 2012). Initiatives to mitigate light emissions related to public infrastructure include advanced street-light technologies. These

Fig. 7.7 'Earth's City Lights'. Marc Imhoff/NASA GSFC, Christopher Elvidge/NOAA NGDC, Image: Craig Mayhew and Robert Simmon/NASA GSFC (Creative Commons CC0)

may rely on energy-efficient, long-lived and robust LED illuminants, which have been shown to considerably reduce light pollution (Bennie et al. 2014; Poiani et al. 2015; Shahzad et al. 2016). Despite some promising examples, light pollution levels are still increasing across most European countries, which brings the monitoring of nightscapes and their perception by the public onto the research agenda.

7.4.1   The Perception of Artificial Light Pollution and Dark Skies

For example, the reduction of light pollution is an ambition of the Campaign to Protect Rural England—their interactive map revealing England's darkest and most light-polluted skies (CPRE 2018). In Switzerland, the public perceives light emissions as a new source of environmental pollution that has to be limited (Zumthor et al. 2005). In areas such as the Val Müstair in the Canton of Grisons that are still relatively little affected by night pollution, dark skies are perceived positively by inhabitants as well as visitors (Mazenauer 2015). Despite positive associations with dark skies in Val Müstair, no consensus was found to further enhance this landscape quality through specific measures, such as turning off street lighting between one and five in the morning every day or reducing the availability of artificially led ski slopes and sledging trails. Interview participants were in favour of

such artificial lighting for snowsport activities, but also supported guided star gazing walks as touristic activity (Mazenauer 2015). However, with increasing light pollutions across Europe, the future of localised initiatives related to dark skies remains unsure. According to a survey by the Swiss Federal Office for the Environment (FOEN) among the Cantons of Switzerland, there is a demand for standards about light emissions, but so far, only few cantons have provided guidelines on reducing artificial light emissions, for example, Basel-Landschaft (AuE 2004).

In order to inform the public and to provide baseline measures of the landscape quality of dark skies, it is important for environmental monitoring programmes to include observations of light pollution. The Swiss landscape monitoring program (LABES) provides such time series from 1992 onwards (FOEN and WSL 2013; Kienast et al. 2015). The indicator light emissions aggregate many processes such as urbanisation, land abandonment or remoteness in one measure, without being able to distinguish between the processes. From a landscape monitoring perspective, on the one hand, the comprehensiveness of this indicator is welcome and cost-efficient new measure. On the other hand, it does not allow evaluations of the effectiveness of specific environmental policies.

7.4.2 Modelling Light Emissions

Light emissions can be modelled using satellite imagery (Cinzano et al. 2001). For Switzerland, light emission modelling showed that these emissions have increased by 70% between 1994 and 2009, with fewer areas being dark at night. For example, on the Swiss plateau and in the Jura mountains, there is no cell that is entirely dark at night (Fig. 7.8), the last dark 1×1 km cell in the Jura mountain disappeared. The total area with night-darkness decreased significantly between 1992 and 2000, but afterwards, the curve flattens out considerably. Such a flattening is not observed in the values of night brightness/total light emission (not shown) for the last ten years, which increases continuously. This indicates a certain concentration of light-lit areas since the turn of the millennium.

The importance of protecting dark skies from becoming 'extinct' with increasing use of, often unnecessary, artificial lighting is increasingly being recognised. Apart from environmental benefits in protecting insects, birds, bats and many other species, reducing artificial lighting helps to save energy. From a landscape perspective, we do not yet know enough how people experience the loss of dark skies, which is a landscape quality that forms part of an extended understanding of wilderness or wild areas. Such dark sky areas in connection with wilderness may become an important economic resource that generates income through tourism. For instance, the International Dark Sky Association has the ambition of creating 'Dark Sky Parks' such as the one designated in the Cairngorms, Scotland. Other examples include the US National Park service launching a successful series of dark sky protection initiatives, such as the designation of the Petrified Forest National
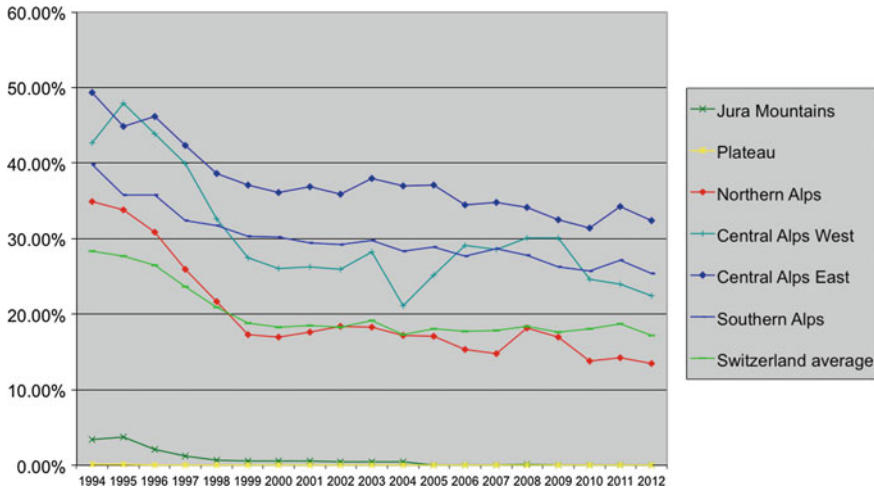
Fig. 7.8 Relative area of complete night-darkness over the years 1992–2012 in the biogeographic regions of Switzerland (definition night-darkness: Radiance < 1 (W $*$ cm^{-2} $*$ sr^{-1} $*$ μm^{-1}) $* 10^{-10}$). Three years are averaged in each case. The spatial resolution is 1 km^2 (own illustration from data source: Kienast et al. 2015)

Park in Arizona as an International Dark Sky Park, and the Yellow Stone National Park launched activities to reduce artificial light (US National Park Service 2018).

7.4.3 New Methods for Dark Sky Research: Citizen Science

Citizen science—often defined as science conducted by citizens who aren't professional scientists—has recently gained popularity not only as a way to engage people in diverse topics, but also as a form of collecting data that would otherwise be unfeasible, be it for bird conservation, galaxy classification or protein structure modelling. Examples of citizen science projects on dark skies show how research on landscape qualities can benefit from engaged people collecting data on the ground.

So far, dark sky research has primarily focused on measuring light emissions through satellite data. However, satellites measure light visible from space, not the brightness on the ground that affects people and other organisms. This information needs to be modelled using the satellite measures as input data and calibrating the model with ground truth data—data which would be impossible to collect without the help of citizen scientists. Several projects concerning dark skies have been launched, which can produce important datasets that complement existing research on dark skies (Kyba et al. 2013). Examples include the 'Globe at Night' web platform (https://www.globeatnight.org/webapp/) where you select how your sky

Fig. 7.9 Globe at Night App allows citizen scientists to report which star constellations they can see at night at a particular location and time, allowing scientists to estimate sky brightness. Image: 'Light pollution: It's not pretty' by jpstanley on Flickr (CC BY 2.0)

looks compared to a series of star charts (Fig. 7.9). The data collected through this platform then allows researchers to track changes in sky brightness over time at the global or national level.

Because 'Globe at Night' provides a distinct number of options showing different levels of sky constellations visible, it does not provide a very exact measurement of sky brightness. Therefore, the 'Loss of the Night' app for mobile phones (http://lossofthenight.blogspot.com/) was designed to complement 'Globe at Night'. Based on the 'Sky Map' app by Google, citizen scientists are asked how many individual starts they can recognise in the night sky. Determining the least bright scar identified enables researchers to determine more accurately the levels of sky brightness as ground truth data. Another approach is the 'The Dark Sky Meter' app (https://www.darkskymeter.com/), which makes use of the smartphone camera to measure sky brightness. All these citizen-collected datasets are made available to the public where anyone interested can view the data (http://www.myskyatnight.com/#map).

Citizen science projects are not without caveats, including the disproportionately large contribution of few participants, difficulties of maintaining participant's motivation and questions revolving around data quality (Cohn 2008; Eveleigh et al. 2014; Lukyanenko et al. 2016). These challenges notwithstanding, citizen science offers a new tool to collect data on landscape qualities, and while we have focused on citizen science for dark skies, such an approach is feasible to apply to other landscape qualities.

7.5   Conclusion

Landscape qualities including tranquillity, wilderness and dark skies are ideal topics through which to illustrate the very essence of landscape research as a multidisciplinary and therefore multi-perspectival research. On the one hand, these concepts can be investigated through a positivistic or essentialist perspective, measuring the physical, in other words, the more tangible aspects of landscapes from a natural science perspective. For instance, we can measure noise levels, light emissions seen from space, and distances from human infrastructure as indications of landscape qualities people perceive. On the other hand, we can assess these landscape qualities from a social science perspective, asking about attitudes towards certain landscape qualities such as wilderness, or how people perceive tranquillity or dark skies in certain landscape settings, and, last but not least, what values and meanings groups of people or societies associate with these qualities. In this chapter, we aimed to illustrate that multiple forms of research can be combined to create a more holistic view on landscape qualities, including physical aspects, as well as how they are perceived and evaluated by individuals and societies. We introduced novel approaches and methodologies to investigate landscape qualities, using, for instance, automated image recognition, analysis of geotagged social media imagery and texts, as well as citizen science approaches, highlighting emerging trends and potential new research directions.

This chapter is not meant as a thorough review of the concepts of wilderness, dark skies and tranquillity and associated methodologies for their assessment. Rather, we see it as an illustration of the potential for landscape research to engage multiple perspectives from diverse research fields and serve as the basis for discussions about multiple and diverse approaches to assess landscapes and their qualities.

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