Chapter 1
Introduction

Stephen J. Carver and Steffen Fritz

Abstract Wilderness and wilderness definitions are complex and problematic and therefore present particular difficulties for mapping and GIS, both of which depend largely on carefully defined attributes and discrete criteria. The rationale for mapping wilderness is described and our interest in the topic justified in terms of wilderness protection, conservation, human benefits and nature. The threats to wilderness are legion and somewhat obvious to anyone with even a basic understanding of the planet. Human population growth and associated demand for land, food and resources is the key impact on wilderness. Road construction opens up wilderness areas for exploitation, farming and settlement. Even our attempts to lessen our impact on global climate and ecosystems can lead to further reductions in wildness (e.g. renewable energy technologies while reducing our carbon footprint can have marked impacts on wild landscapes). The basic concepts of wilderness mapping are outlined and a brief history of wilderness mapping described including key developments at global, regional and local scales. The structure and contents of the book are given.

Keywords Wilderness • Definition • Mapping

1.1 Towards a (Spatial) Definition of Wilderness

> One man's wilderness is another's roadside picnic ground (Nash 1993, p. 1)

As definitions of wilderness go, this is perhaps both helpful and problematic in equal measure. It is helpful in that it underlines the vagueness of the concept and the fact that different people, with different backgrounds and life experiences, will perceive wild landscapes in different ways. Ultimately it is our familiarity with the wilderness condition that will determine where on a scale of human modification from most to least modified that

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we feel wilderness begins and ends. Conversely, Nash's definition is also problematic in that it gives us nothing by way of any kind of "yardstick" or definitive criteria against which we can measure, and therefore map, this thing we call wilderness.

This book focuses uniquely on the approaches, techniques and attempts to map and model wilderness from a geographical perspective at a range of spatial scales covering a variety areas. There is a steadily increasing literature on wilderness mapping that attempts in a rigorous, robust and repeatable manner to say exactly what we are talking about when we speak of wild places and map where they are, such that we can best manage our influence on them and design policies for their protection. In this respect, Nash's definition actually isn't a bad place to start as it succinctly, in just one sentence, points simultaneously to both the problem and the solution. The problem is that there is no single accepted definition of what wilderness is (and isn't) and that it depends very much on the point of view of the individual. As such, the solution to what wilderness is and where it can be found or said to exist is, at least from a spatial science perspective, a classic ill-defined and fuzzy multi-criteria spatial concept and can be largely addressed using existing methods and tools.

Nash's "one man's wilderness" definition is a sociological one. While it is philosophically interesting and points towards a solution, it is hardly a useful legal definition nor is it all that helpful in tight geographical terms. Other definitions have been developed, however, developing over time in sophistication and clarity. Some present a better set of indicators that lend themselves to being mapped. Perhaps the best known of which is that which accompanies the 1964 US Wilderness Act.

> A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value. The Wilderness Act, Public Law 88–577 (16 U.S. C. 1131–1136) 88th Congress, Second Session September 3, 1964

The Wilderness Act talks of absence of human artefacts and management, lack of human settlement, remoteness, opportunity for solitude, ecological condition and size. All of these criteria can to a greater or lesser extent be mapped using modern digital datasets and computer software. It has also been influential in expanding wilderness definition and protection worldwide. The IUCN now defines wilderness under Category 1 either as Category 1a (Strict Nature Reserve), which are areas set aside primarily for research, or Category 1b (Wilderness) defined as:

> Large areas of unmodified or slightly modified land and/or sea, retaining its natural character and influence, which is protected and managed so as to preserve its natural condition… [wherein the primary objectives are] To protect the long-term ecological integrity of natural areas that are undisturbed by significant human activity, free of modern infrastructure and where natural forces and processes predominate, so that current and future generations have the opportunity to experience such areas. (IUCN 2008).

Looking at this definition and comparing it to the text from the US Wilderness Act (1964) it is easy to see where the inspiration for the IUCN definition comes from. The language and wording may be different but the message and meaning is exactly the same.

The following year a European Parliament Resolution on Wilderness called for the development of guidelines on managing wilderness within Natura 2000,[1] a unified European definition of wilderness and a register of remaining areas. The document "*Guidelines on Wilderness in Natura 2000: Management of terrestrial wilderness and wild areas within the Natura 2000 network*" was published in 2013 and contains the following definition:

> 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. (EC 2013, p. 10)

Again, like the US Wilderness Act that precedes them, spatial criteria or attributes of wilderness are evident within the text of these definitions. This then begs the question as to how we can translate these definitions into reliable maps that would be useful in policy-making and decision support roles?

1.2 Why Wilderness?

While definitions are usually a good place to start any book on a particular subject, it is also useful to identify just why it is worth studying a particular topic. Wilderness is in many ways the ultimate and pristine resource. It is the very stuff from which we have made the human world. It is where we have come from and it may be where we are going. It is where we have carved out civilisations and cultures, and drawn our resources of land, water, oil, gas, minerals, timber, fish and game, etc. Over the millennia humans have pretty much exploited, with only a few exceptions, every last ecosystem of the planet. We have cut down forests, ploughed up the land and built huge cities connected by dense and efficient networks transporting people, goods, resources and information. In the process we have greatly modified whole landscapes and ecosystems and have easily become the dominant species on the planet, making thousands, perhaps millions, of others extinct in the process.

The US Wilderness Act came into being as a result of a gradual realisation over the preceding years that the frontier was fast disappearing and that something needed to be done to preserve America's last wilderness areas and the wildlife that depends on them. This was significant as the frontier is arguably what made America (notwithstanding the indigenous native population) and by 1964 there was no longer a frontier in the lower forty eight. A long-running campaign of lobbying for and promotion of the wilderness ideal preceded the signing of the Wilderness Act on 3rd September 1964 by President Lyndon B Johnson. In fact it took Howard Zahniser no less than 15 years to draft the text of the Act and see it through Senate.[2] The list

[1] Natura 2000 is the pan European nature protection network.

[2] Zahniser tragically died just a few months before the final signing of the Act.

of those involved in the run up to this moment reads something like a "who's who" roll call of the most famous names in wilderness advocacy… John Muir, Aldo Leopold, Sigurd Olsen, Arthur Carhart, Bob Marshall, to name but a few. Their concern for the loss of wilderness as the frontier receded was driven variously by their own need or desire for wild spaces to be wild in …

> Man always kills the thing he loves, and so we the pioneers have killed our wilderness. Some say we had to. Be that as it may, I am glad I shall never be young without wild country to be young in. Of what avail are forty freedoms without a blank spot on the map? (Aldo Leopold 1949)

… but also out of a realisation that the loss of wilderness also meant something much, much more. Wilderness represents more than just landscapes empty of human endeavour. Wilderness itself is important for free flowing rivers and for the clean water supplied to nearby conurbations. Wilderness provides a habitat and refuge for wildlife. Wilderness areas are important for science, providing as they do control environments against which we can gauge, measure and monitor our impact on the natural world. In today's language we might call these ecosystem services. De Groot et al. (2002) split these into four types: provisioning, regulating, supporting and cultural. Table 1.1 gives examples of these services and how these are best provided and modulated in wilderness as opposed to human modified ecosystems.

One "service" that doesn't fit easily into such a classification – for the classification itself always stresses the anthropogenic benefits – is the intrinsic value of wilderness. That is to say, do natural processes, landscapes, species and the ecosystems they represent (i.e. nature herself[3]) have to be commodified to have value, and does

Table 1.1 Ecosystem services and wilderness

Service class	Traditional/extractive	Sustainable/non-extractive
Provisioning	Timber, (bush)meat and other foodstuffs, fibre/furs, minerals, oil and gas, renewable energy	Clean water,[a] carbon storage, genetic material, clean air
Regulating		River flows, erosion control and influence on sediment yields, nutrient supply, carbon sequestration, pollution stripping, climate regulation
Supporting		Natural cycles (e.g. hydrological cycle, carbon cycle, nitrogen cycle, etc.), wildlife habitats, climate systems
Cultural	Hunting and fishing grounds, wildlife herding/harvesting, timber harvesting, collecting foodstuffs (fungi, berries, plant material, etc.)	Recreational landscapes, wildlife observation, landscape aesthetics/ appreciation, artistic inspiration, cultural heritage,[b] intrinsic values

[a]Abstraction from rivers flowing out of wilderness areas or ground water abstraction tapping into resources recharged within wilderness areas

[b]Often evidenced as archaeological remains or written/oral histories and legends

[3] The origin of the word "Nature" is from the Latin *natura* meaning "birth" and thus gives rise to early representations of nature as female and the popular image of "Mother Earth".

that value have to accrue in any tangible way to us as humans? Wilderness, like nature in "raw" form (for that is what wilderness surely is in the final analysis) has value beyond human needs for all other species we share the planet with. Contrary to the flawed reasoning of the modern green movement whose positivist approach maintains that human dominion is natural in of itself and we can engineer, plan and design our way out of ecological disaster, wilderness is a necessity for planetary survival. This was recognised as early as 1862 when Henry David Thoreau penned the immortal words *"In wildness is the preservation of the world"*.

Without the biophysical diversity that characterises intact ecosystems and the natural processes that drive these, we are ultimately doomed, for life on Earth depends on these provisioning, supporting and regulating services to make the planet habitable. If policy-makers, planners and commercial enterprise feel more comfortable with financial devices and arguments, then it has been calculated that the total annual economic worth of the natural environment to the global economy is in the region of $44 trillion, or roughly twice that of global GNP (Costanza et al. 1997). Of course, there will be some that say these benefits will still accrue regardless of whether there is wilderness or not, but it seems a safer bet that wilderness ecosystems taken as a whole provide a far greater economic benefit in terms of their ecosystem services than do the equivalent area of human modified systems.

A new movement was launched at the end of 9th World Wilderness Congress (WILD9) held in Merida, Mexico in 2009. This was Nature Needs Half (NNH), the central tenet of which is that we should aim to protect at least half of the world (both terrestrial and marine) for nature. The basic concept here is an ethical argument that reasons that if humans manage half the planet for agriculture, industry and settlement, and the other half is devoted to nature conservation then this provides a reasonable basis for a sustainable planet. NNH *"recognizes that human well-being and security depend greatly on a healthy, resilient, and abundant natural world… and also that Nature itself has a right to exist freely"*. Of course the key question is "where?" as well as what ecosystems might reasonably be represented? These are spatial questions to which the methods, techniques and approaches in this book might well be applied.

1.3 Mapping the Wild

There are a number of existing mapping projects that have attempted to illustrate exactly where the world's wilderness areas are and the ecosystems represented therein. The first such project was a global reconnaissance of wilderness areas carried out by McCloskey and Spalding for the 4th World Wilderness Congress in 1987. The subsequent paper in Ambio published a figure suggesting 34 % of the world's land area could be classified as wilderness (McCloskey and Spalding 1989). This was a simple rule-based map for which they used two principal Boolean criteria: areas more than 400,000 ha in extent and greater than 6 km from any recorded human feature – as based on data derived from Jet Navigation Charts at a scale of 1:2 million. This was a remarkable feat given that all the work was done by hand with paper maps before GIS was mainstream technology.

1.4 Here Be Dragons

Although the McCloskey and Spalding map was the first coordinated attempt at mapping global wilderness we have arguably been doing it for hundreds of years, not by dint of what we have mapped, but rather what we haven't. Take a close look at any old map of the world produced before around 1800 and invariably you'll find examples of Leopold's blank spots. These are sometimes labelled "Parts unknown" indicating the cartographer had no knowledge or information as to what lay over the horizons of the known world with which to fill the white space on the page. In some older maps cartographers often used their imagination and filled in the empty spaces with flights of fancy including imaginary lands and seas inhabited by strange and wonderful beasts and equally wild and savage people. The Latin phrase "HC SVNT DRACONES" (meaning literally "here be dragons") was sometimes used to indicate such wild and fearful places. Even as recently as the mid 1700s, navigation charts of the north Atlantic eluded to the presence of Buss Island, an uncharted island that has since been proved not to exist. The advent of aerial photography and earth observation satellites in the twentieth century means that every inch of the planet is now mapped and "known" even if, as in some parts of Antarctica for example, we can be confident that no human has ever set foot there and so remain inviolate. Of course, this view of the "known world" is a particularly Eurocentric one and we acknowledge that nearly all lands were already discovered, and therefore known, by indigenous native populations long before Europeans arrived to chart their existence and exploit their bounties.

1.4.1 Digital Worlds

Nevertheless, the McCloskey and Spalding map marks the start of a period of intensive mapping activity across the globe aimed at mapping human impact and the last wild places. Arguably the first proper use of GIS to map wilderness quality was the Australian National Wilderness Inventory (NWI) as described by Rob Lesslie in the following chapter of this book (see Fig. 2.2). Here national digital datasets are used within a cartographic model to rate wilderness quality based on four criteria: remoteness from mechanised access, remoteness from settlement, apparent naturalness (distance from modern human artefacts) and biophysical naturalness (naturalness of the land cover) (Lesslie and Maslen 1995). These two basic factors – remoteness and naturalness – are used in one form or another in nearly all models of wilderness quality. Lesslie (1998) expanded the NWI concept to the whole world in work done for the World Conservation Monitoring Centre (WCMC) (see Fig. 2.3). Eric Sanderson and his team at Wildlife Conservation Society (WCS) and the Columbia University Center for International Earth Science Information Network (CIESIN) adapted this approach using multi-criteria mapping techniques to create a global map of the Human Footprint showing the degree of human influence according to

nine global data layers covering human population pressure, human land use and infrastructure, and human access (Sanderson et al. 2002). This map is then used to map The Last of the Wild based on an interpretation of the Human Footprint data within global biomes.

Other mapping programmes have followed a similar approach. The Globio map accompanying the UN Global Biodiversity Outlook programme is a good global scale example, while regional and local scale mapping follows a similar model though often making use of more complex mapping tools that the opportunity of higher resolution datasets and smaller areas afford (see Chap. 5). Two country-level maps and a local scale map are presented here in this book for Iceland (see Chap. 11 and Fig. 11.1), Austria (see Chap. 12 and Fig. 12.1) and the Carpathian Mountains in Romania (see Chap. 10 and Fig. 10.3).

Some areas are mapped across multiple spatial scales and at varying levels of detail. Perhaps the best mapped area in terms wilderness quality is Scotland which has been mapped at a global, continental, national and local scale. The methods used to do this are essentially the same, but vary the indicators, data and models used to best suit the scale in question. The maps from the Human Footprint, Globio and WCMC place Scotland in a global context. At this scale, Scotland doesn't appear to contribute anything to global wilderness. Looking closer, a new European scale wilderness quality map has recently been developed for the European Environment Agency (EEA) based on naturalness of vegetation (measured as departure from the potential natural vegetation in the absence of human modification), and remoteness from roads and settlement at a 1 km^2 resolution (Kuiters et al. 2013). At this scale, parts of Scotland do appear to figure in the top 5 and 10 % wildest areas in Europe. Parallel to the European mapping, Scotland has produced its own wild land map at a resolution of 50 m. This is being used to directly inform Scottish planning policy and decision-making on development (SNH 2014). This was a three stage process, with a wildness continuum map (Phase 1) based on measures of naturalness of land cover, absence of modern human artefacts, ruggedness and remoteness, being used to identify core wild land areas based on a statistical reclassification of the continuum (Phase 2) and a final drawing of wild land area boundaries using information from stage 2 in coordination with local knowledge and on-the-ground boundaries such as rivers and ridge lines (Phase 3). Further detail within the Scottish national parks is provided by local level mapping at even finer resolution of 20 m. Both national parks – the Cairngorm National Park and the Loch Lomond and The Trossachs National Park – were mapped to inform developing national park planning policies on wild land (Carver et al. 2012) and acted as a feasibility study and methodological template for the national map.

A similar approach to the Human Footprint mapping has been developed for the world's seas and oceans in work by Ben Halpern's team at the National Center for Ecological Analysis and Synthesis, Santa Barbara (Halpern et al. 2008). Here no less than seventeen different datasets covering human impacts on marine ecosystems from fishing, climate change, and pollution are combined to produce an overall score of vulnerability to human activities. Marine wilderness areas remain comparatively under studied, perhaps as a result of a paucity of good quality data and the

need for different spatial models that take the 2D surface and 3D submarine nature of "seascapes" into account.

A recent departure from the largely multi-criteria based work is the Roadless Areas map produced using Google Map road data which again echoes Leopold's quote about the blank spots on the map. This makes the simple assumption that virtually all human impact on the world's land area is associated with road construction and therefore a map showing distance from nearest road makes for a very good indicator of probable wilderness quality. Experience shows that where road construction takes place, people and development generally follow. A good example is where oil, gas and mineral exploration roads built into virgin forest have, in themselves, a very limited footprint but then provide easy access for logging. Over time agriculture and settlement usually follow. Thus, the impact of human development can be seen not only in a spatial but also a temporal framework.

1.4.2 Patterns, Drivers and Threats

At a global scale work by Erle Ellis and his team in the Laboratory for Anthropogenic Landscape Ecology at the University of Maryland have used historical data on population density and land use to map long-term anthropogenic changes in the terrestrial biosphere, as compared to the Potential Natural Vegetation (PNV) in the absence of humans, over a period of 300 years from 1700 to 2000 (Ellis et al. 2010). The key findings show that while in 1700 just under half the world's land surface area was wilderness (wildwood and wild treeless barren land) only 5 % could be described as intensively used. Since 1700 wildlands have reduced to only 23 % with the rest being used (40 %) and novel (i.e. anthropogenically created or modified) ecosystems (37 %). The rapid growth in the total human population, which reached seven billion people in 2012 and is projected to reach between 9 and 12 billion by 2100, is the obvious driver in terms of demand for land (for agriculture and living space) and resources meeting our ever increasing demand for goods and services. This generates an ever-increasing threat to the world's remaining wilderness areas. However, as much of the global scale mapping work shows, these remaining wilderness areas are primarily in the Earth's coldest and driest regions and so likely to show some resilience to settlement and agriculture, though not resource extraction pressures as higher prices and greater demand mean "hard to get at" resources in remote locations become economically viable, witness the recent expansion in mineral exploration in Greenland (Schønwandt and Dawes 1993).

Population growth and road construction may be the main drivers at the global scale, but subtly different forces may influence trends at regional and local scales. Work at the United Nations Environment Programme (UNEP) Arendal site in Norway provides a nice example of how road construction, urbanisation and other human infrastructure have markedly reduced the remaining areas of undeveloped land in Norway over the last 100 years (Brun 1986; Grid Arendal 1992). Carver and Wrightham (2003) show how wild land areas in Scotland have reduced over the last

150 years driven by expansion and upgrades to the road and rail network, but also from plantation forestry operations and exploitation of renewable energy sources. Initially impacts from renewables were driven by the building of hydroelectric schemes, but recently the main threat can seen as coming from large scale industrial wind farms (Carver and Markieta 2012). This is a classic "green-on-green" impact with renewable energy ostensibly trying to reduce our carbon footprint while having a damaging effect on carbon stores, ecology and amenity values (Drewitt and Langston 2006; Smith et al. 2014; Warren et al. 2005). Work by SNH has shown that the area without visual influence from built development fell from 41 to 31 % between 2002 and 2008 and then to just 28 % by the end of 2009. Much of this is attributable to wind farm development.[4] Other research within the Scottish national parks has shown plantation forestry, hill track construction and renewable energy developments to be the key impacts on wild land quality in these areas (Carver et al. 2012).

While the most obvious problem arising from the gradual, sometimes rapid, attrition of wilderness over time is the shrinkage in total area, it does come with a series of associated problems that will be familiar to anyone with a background in spatial ecology. These include fragmentation and isolation. The general pattern is directional, well-known and largely predictable, though the rate and exact spatial pattern is more difficult to predict. Given a "blank canvas" of pristine wilderness human development will occur in patches usually around the perimeter, thus generating "holes" the canvas. This is the "frontier" state wherein there is still more wilderness than developed land. Over time settlement and cleared land gradually erode the undeveloped wilderness areas and ground transportation links built to connect settlements start to fragment and divide up the hitherto contiguous wilderness area into separate core areas. There is now more developed land than wilderness giving rise to a "torn" canvas (Tin and Carver 2014). As development progresses settlements and cleared land begins to merge, assisted by expanding transport networks, and the remaining wilderness shrinks to a few core areas resulting in isolation. This process is shown in Figs. 1.1a, 1.1b, 1.1c, and 1.1d.

Over much of the developed world we have already reached the state shown in Fig. 1.1d. Many small and highly developed nations have no real wilderness areas left at all and haven't had for centuries. This is true for much of central, western and southern Europe. Where wilderness areas do remain they tend to be small and isolated. The larger the country, the greater the opportunity for intact wilderness areas to remain. The USA is an interesting example. The lower 48 states of the conterminous US has seen wilderness largely reduced to a few pockets, mainly in the west (the "torn" canvas shown in Fig. 1.1d). Much of the remaining wilderness is found in Alaska, which is arguably still a frontier state and an example of a "holey" canvas (Fig. 1.1b). Nevertheless, the National Wilderness Preservation System that arose from the 1964 Wilderness Act now protects over 750 areas totalling over 109 million acres (44.3 million hectares) of wilderness across the US of which near half of

[4] Scottish Natural Heritage (2013) Natural Heritage Indicator: N3 Visual Influence of built development http://www.snh.gov.uk/docs/B551051.pdf

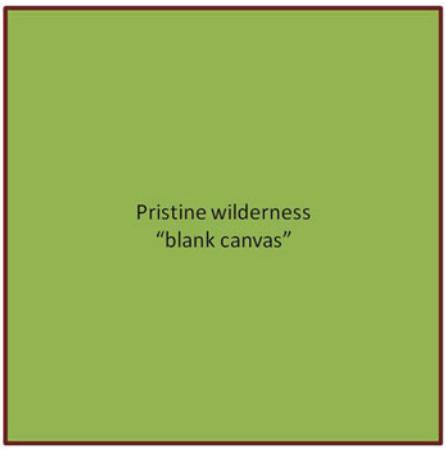

Fig. 1.1a Patterns of human development in wilderness lands: Blank canvas

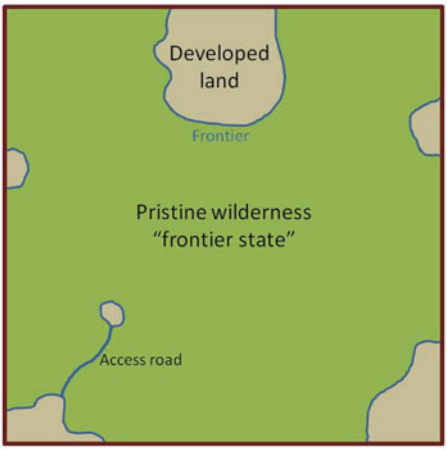

Fig. 1.1b Patterns of human development in wilderness lands: Frontier state

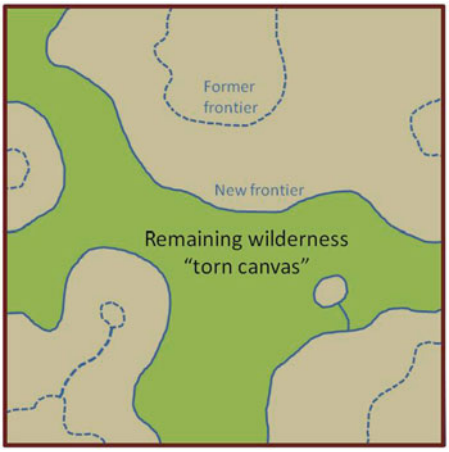

Fig. 1.1c Patterns of human development in wilderness lands: Torn canvas

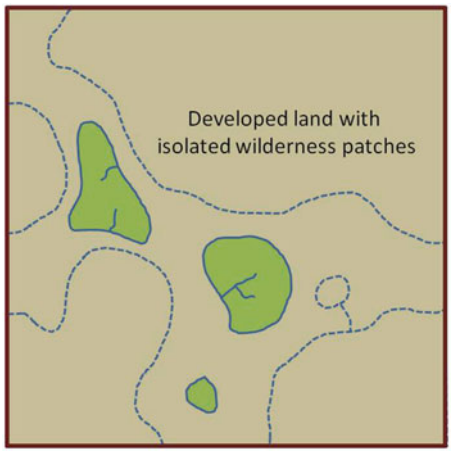

Fig. 1.1d Patterns of human development in wilderness lands: Isolation

which by area is in Alaska. This pattern is similar in other large countries (e.g. Canada, Brazil, Russia and Australia) where developed land gives way to wilderness in the interior. The same can arguably be said for Europe if taken as a whole. A recent register of protected wilderness areas across the EU has revealed a pattern of isolated core areas in the central hinterland (France, Italy, Germany, Switzerland) with more extensive and connected areas in the periphery (Scandinavia and eastern Europe). Greenland, although technically part of the North American plate, is legally part of Europe (being an autonomous country within the state of Denmark) and is, by anyone's definition, mainly wilderness. As with Alaska and the USA, Greenland (together with Svalbard) greatly skews the distribution of legally protected wilderness in Europe.

1.5 Applied Mapping

In terms of total remaining wilderness by area, the figure of 34 % from McCloskey and Spalding's 1989 reconnaissance map may seem encouraging, but we need to recognise that much of this is tied up within a limited number of biomes – mainly high latitude and desert areas. Many of the biomes that are conducive to human settlement and agriculture (e.g. temperate woodland and savannah) are highly under-represented having been exploited and modified by humans for centuries. What little remains of these biomes tend to be highly fragmented and isolated leading to a need to restore and expand these areas and improve connectivity within an otherwise human modified landscape. Left alone these small fragments will most likely succumb to gradual erosion in their extent and reduction in their genetic and compositional sustainability by dint of their isolation.

This is now a well recognised problem and much work has been done on developing a more connected view of nature and wilderness conservation based largely

around the so called "Cores, Corridors and Carnivores" (CCC) model (Worboys et al. 2010) or "Greenways" (see Chap. 3). The problem with the nineteenth and twentieth century model of protected areas was one of isolation. Putting a line, and sometimes literally a fence, around a natural area and keeping it "wild" by keeping development out is all well and good but in a changing world, such a model is dangerously inflexible and a risky strategy. Protecting core wilderness areas with buffer zones of extensive use and connecting them together using corridors and stepping stones across more permeable, wildlife-friendly landscapes – bridging impermeable barriers with built structures (e.g. wildlife under/overpasses across highways) where necessary – is now an accepted model. There are several examples of such connectivity projects operating across a range of spatial scales from continental (e.g. Yellowstone-to-Yukon) through country level (e.g. the Dutch EHS) to local level (e.g. Scottish Integrated Habitat Networks).

GIS has been brought to bear on this problem, using connectivity modelling techniques and toolkits available as add-ons to existing GIS software (e.g. Corridor Design). These tend to work by creating a habitat suitability model for a target species, often a keystone carnivore, and using this to identify least cost path routes or corridors between core areas where the target species is known to inhabit. Various methods exist to identify key linkages between core areas, for example using graph theory, and use these to plan the location of eco-bridges at critical pinch points and identify corridors and intermediate stepping stones for habitat restoration work and barrier removal (Pascual-Hortal and Saura 2006).

Another area of applied wilderness mapping is in targeting areas for habitat restoration or species reintroductions. This is generally referred to as "rewilding". The best locations to actively rewild (e.g. by removing human influences such as infrastructure and land use, assisted regeneration of native vegetation or reintroduction of missing native species) can be informed by careful analysis of the wilderness quality maps described here and in this book. Rewilding if done correctly and over sufficiently long time periods (e.g. 50 years or longer), can contribute new (albeit secondary) wilderness areas. Such a progression from isolated parks, through the CCC model to rewilding and new wilderness is illustrated in Figs. 1.2a, 1.2b, and 1.2c.

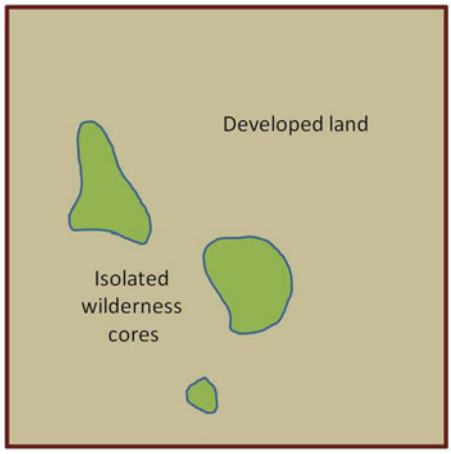

Fig. 1.2a Restoration of wilderness: Isolated core areas

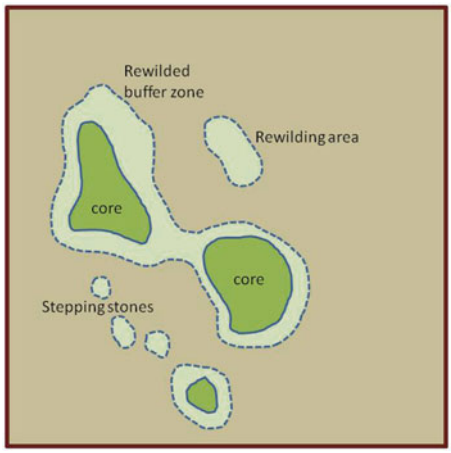

Fig. 1.2b Restoration of wilderness: Rewilding

Fig. 1.2c Restoration of wilderness: Creating new wilderness

Often the simplest solution is the best. Areas that possess all the characteristics of wilderness but have none of the legal protection can be mapped against their formally protected counterparts. This is important for informing developing policies and strategies on protection as wilderness area without formal protection remain at risk from human activities and consequent degradation/reduction in wilderness quality.

1.6 The Book

The book is organised roughly into three sections, the early chapters (including this one) dealing with more conceptual and methodological approaches, the middle section dealing with certain procedural issues, and the final section providing some

examples of regional and national mapping applications. These are described here in brief by way of introduction and to explain some of the logic behind chapter selection and order.

The first chapter (Chap. 2) after this is written by Rob Lesslie and gives us an historical overview of the early development of GIS-based multi-criteria approaches to mapping wilderness quality within the Australian NWI and how this was extended to a global scale for the WCMC. The chapter then describes the further development of these techniques and progression of the wilderness mapping idea in Australia up to the present day together with associated software development.

The next chapter by Roger Catchpole (Chap. 3) provides an overview of issues of connectivity and green networks and builds on the above discussion of the CCC or Greenways concept by providing detail on different mapping approaches such as spatial indices, graph theory, habitat suitability modelling, population models and agent-based models.

Chapter 4 by Lisa Machnik and colleagues looks at the practical use of spatial information technology (principally GPS and GIS) by wilderness managers to support operations in the field, particularly those concerning visitor use patterns and how data gathered in the field and inform decisions about where to allocated limited resources.

Chapter 5 by Neil Sang provides an overview of an increasingly important aspect of wilderness quality mapping, namely that of visibility analysis. Knowledge of what and how much is visible within the landscape is essential in creating an informed view of how the visitor might perceive the relative levels of human impact within a landscape setting. This chapter described various opportunities and problem areas for visibility analysis in the wilderness mapping field from a technical landscape assessment perspective.

Data availability, especially on the true levels of human impact on land cover and landscape structure, is a key potential pitfall for all wilderness quality mapping exercises. Chapter 6 by Linda See and her team develops a novel approach to validating land cover data and adding value to existing datasets through the relatively new field of crowdsourcing. Here, Google Earth imagery and "the crowd" are used to create a global map of human impact via a Geo-Wiki tool for the visualisation, crowdsourcing and validation of global land cover which can then be used to improve wilderness quality indices.

Another area of potential future development in visualisation is explored in Chap. 7 by Ben Hennig. This chapter focuses on the use of non-Cartesian geometries to display key wilderness quality variables such as remoteness as gridded cartograms. This allows remoteness to be better understood and produce high impact, thought-provoking graphs for information and visualisation purposes.

Chapter 8 by Kees Bastmeijer looks at the legal aspects of mapping wilderness and the role of law in its protection. One particular aspect of this concerns the use of GIS and other mapping approaches to inform the drawing of lines on maps to delineate and define wilderness together with the legal implications of doing so.

In Chap. 9 Mark Douglas and Bill Borrie take a long, hard philosophical look at why we may wish to map wilderness and the implications of doing so on wilderness

itself. Reference is made to Heidegger's investigation of technology and links to wilderness mapping. The chapter serves as a useful "wake-up" call to wilderness mapping technologists to be careful about what it is we are mapping and why we should be mindful as to the potential for technology to remove the wildness from wilderness.

The next three chapters provide the reader with specific geographical examples of how GIS has been used to map wilderness quality. Chapter 10 by Dragos Mantoiu and colleagues is a case study of wilderness mapping for the south western Carpathian mountains in Romania. This is followed by two chapters describing national mapping programmes; Chap. 11 by Ranny Ólafsdóttir and colleagues for Iceland, and Chap. 12 by Christoph Plutzar on Austria.

Chapter 13 provides some final conclusions and closes the text with some thoughts on likely future directions and developments.

Overall, the book is designed as a reader and a marker of the current status of thinking and progress in mapping and modelling spatial patterns in wilderness quality across a range of spatial scales and for a range of applications. It is not intended to be comprehensive, rather a starting point from which one can begin to explore this fascinating and burgeoning field of endeavour within the spatial, ecological, social and cultural sciences.

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