Institution: The University of Leeds

Unit of Assessment: UOA 14

Title of case study: New land-management policies and practices implemented across Europe, North America, and China following advances in wilderness mapping

Period when the underpinning research was undertaken: 2007-present

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Steve Carver	Senior Lecturer Director of Wildland Research Institute (WRi)	01/1993-present
Prof. Alexis Comber	Professor of Spatial Data Analytics	2015-present

Period when the claimed impact occurred: 2013 to 2020

Is this case study continued from a case study submitted in 2014? Y/**N**

1. Summary of the impact (indicative maximum 100 words)

Wilderness areas are being lost at an alarming rate and there is a critical need to recognize their value given the climate and biodiversity crises. Research on spatial modelling of wilderness quality has directly informed protection policy and practice around the world. Wildland areas are now included in Scottish Government policy, and this led to the development of an international register of protected wilderness areas across Europe. A new wilderness quality index that developed from the research underpinned wild land policy set out in the EU 2020 Biodiversity Strategy. New wilderness management plans have been developed and implemented by five US National Parks, and national plans have been produced in China and France.

2. Underpinning research (indicative maximum 500 words)

Wilderness is a precious resource that supports much of the world's biodiversity and can act as a buffer against climate change. Without rigorously defined geographical limits, wilderness areas are difficult to define and therefore protect. Work led by Stephen Carver, Alexis Comber and various collaborators has developed novel spatial modelling methods to define robust and defensible wilderness boundaries and so provide effective long-term protection for the benefit of both humans and nature.

Improved methods for modelling ill-defined and fuzzy landscape concepts such as wilderness quality and character were developed, working initially with Areas of Outstanding Natural Beauty (AONB) and then for the Scottish National Parks from 2007 onwards **[1, 2]**. This work stimulated the planting of new native woodlands and protection of core wild land areas.

New software was developed, capable of handling big datasets and very large numbers of line-of-sight visual impact calculations together with new approaches to modelling landscape quality indices. Techniques with unprecedented accuracy and detail were advanced to classify wilderness quality using fuzzy modelling, and to validate results using participatory GIS approaches that capture both public and expert opinion **[2]**. The latter were used to quantify and assess spatially referenced information on ecosystem service values with collaborators from Scotland's Rural College and the University of the Highlands and Islands, enabling the first quantification of Wild Land Areas for the Scottish government **[3]**.

The US National Park Service (NPS) required methods to map wilderness character using their inter-agency "Keeping It Wild" model. This opportunity led to adaptations of the Scottish model by Carver and collaborators from the Aldo Leopold Wilderness Research Institute, USA, to map and assess elements of wilderness character described by the US Wilderness Act (1964) for the first time **[4]**. Following the European Parliament resolution on wilderness (2009), methodological advances were commissioned, leading to research with colleagues from Alterra and PanParks to develop a European Wilderness Register and Index which was used to identify opportunities for rewilding **[5]**. This led to subsequent applications of the model in France, Iceland and China **[6]**. This research enhanced understanding of the importance of scale in relation to data quality and availability, recognising the cultural setting in which mapping projects sit and how this affects the purpose and outcomes of mapping work.

This body of research has provided robust and repeatable quantification of strategic and policy-relevant concepts of landscape, wildness and wilderness quality. This is being used to support strategic thinking about these aspects of landscape for international governance and conservation policies and agendas, as well as providing detailed spatial information in support of management objectives.

3. References to the research (indicative maximum of six references)

[1] **Carver, S**., **Comber, A.,** McMorran, R. and Nutter, S. 2012. A GIS model for mapping spatial patterns and distribution of wild land in Scotland. *Landscape and Urban Planning* 104(3-4): 395-409.

[2] **Comber, A., Carver, S**., Fritz, S., McMorran, R., Washtell, J. and Fisher, P. 2010. Different methods, different wilds: Evaluating alternative mappings of wildness using fuzzy MCE and Dempster-Shafer MCE. *Computers, Environment and Urban Systems* 34(2): 142-152.

[3] McVittie, A., Bryce, R., Glass, J., Woolvin, A., **Carver, S**., Fisher, M., McMorran, R. & Sedee, C. 2017. *A review of the social, economic and environmental benefits of wild land in Scotland*. Scottish Natural Heritage Commissioned Report No. 919.

[4] **Carver, S**., Tricker, J. and Landres, P. 2013. Keeping it wild: Mapping wilderness character in the United States. *Journal of Environmental Management* 131: 239-255.

[5] Kuiters, A.T., van Eupen, M., **Carver, S**., Fisher, M., Kun, Z. & Vancura, V. 2013. *Wilderness register and indicator for Europe*. Final report October 2013. Contract No: 07.0307/2011/610387/SER/B.3

[6] Cao, Y., **Carver, S.** and Yang, R. 2019. Mapping wilderness in China: Comparing and integrating Boolean and WLC approaches. *Landscape and Urban Planning* 192: 103636.

4. Details of the impact (indicative maximum 750 words)

Adaptations of methods developed initially in Scotland have been used to map wilderness character and cumulative visual impact, and influence policy change amongst governments, government agencies and NGOs around the world.

The president of the WILD Foundation explained how the vital decision-support **research for wildland areas underpinned the implementation of US Interagency policy**: "*Your work with US National Parks and colleagues in the Aldo Leopold Wilderness Research Institute provided the quantitative basis for mapping and monitoring under the long-standing principle of "Keeping It Wild" in US National Parks*" **[A]**. Five national parks selected by the US government have been mapped to date using our techniques, providing key information for protection of wilderness character and guiding park management plans. Two of these (Denali, Death Valley) are in the top five largest US national parks, and across the five parks our work has so far informed the management of an area in excess of 40,000 km^2.

Research which developed detailed wilderness mapping appropriate to large heterogeneous areas across China has been used to underpin **the Chinese Ministry of Natural Resources' expansion of China's national parks and plans for a Wilderness Preservation System** similar to that in the USA. The Deputy Director of Land Consolidation and Rehabilitation Centre,

Ministry of Natural Resources, People's Republic of China, explained that **[B]**: "*your map and data has already been applied in a regional landscape planning project in the Three-Parallel-River region* [17,000km^2) *in Yunnan province... a global biodiversity hotspot and also World Heritage Site, which have global significance. The data is also being applied in another ongoing ecological restoration planning project and related policy advice in Chong Qing province, mainly focus* [sic] *on ecological restoration land consolidation*". The corroboration goes on to explain how the Land Consolidation and Rehabilitation Centre wrote "*a report on wilderness conservation and rewilding and passed it to the Minister of Natural Resources. The recommendations … have been accepted and highly approved and supported by the minister. Our minister has already asked the agencies charging for ecological restoration and spatial planning to further explore the concept*" thus informing national plans to protect biodiversity and wilderness in China.

The research developed by Carver and colleagues has led the way across Europe, forming the basis for a **European-wide wild land definition and mapping programme**. This work addressed the European Parliament resolution on Wilderness in Europe (2008/2210(INI)) and subsequent refinements at the EU Presidency conference on Wilderness and Large Natural Areas in Europe (Prague, 2009). The co-ordinator of the Wild Europe initiative noted that research on the "*characterisation and mapping of wilderness and its attributes was crucial in providing credibility among policy makers*" **[C]**. Upscaling has provided the necessary analysis of wilderness quality across the EU and its relationship with protected area boundaries [Fig 1a], enabling the EU to identify 113,000km^2 of legally designated wilderness and compare these to 22,000km^2 of wilderness areas that remain without protection. **The EU now recognises wilderness areas as vital for achieving EU Habitats and Birds Directive's objectives, and those of the wider EU 2020 Biodiversity Strategy and the new European Green Deal.** Carver's research was used in the preparation of new guidance on how best to ensure the conservation of wilderness areas within the Natura 2000 Network (covering >18% of EU land and marine areas) as further noted by **[C]**: "*the Wildland Research Institute* [at Leeds]*…has been centrally involved in large-scale ecosystem conservation that we have promoted, under contract to the European Commission. Among these have been Guidelines for the Management of Wilderness and Wild Areas in the Natura 2000 network, and the EC European Wilderness Register*".

The impact also extends to the **International Union for Conservation of Nature (IUCN) global policy-making**, as corroborated by the Chair of the IUCN World Commission on Protected Areas (WCPA) Beyond the Aichi Targets Task Force, and Co-Founder and Strategic Advisor of the Yellowstone to Yukon Conservation Initiative: "*it has helped to inform the ideas that led to our Task Force developing a new framework that we have proposed for the Convention on Biological Diversity Conservation's Post-2020 Strategic Plan called the Three Global Conditions for Biodiversity and Sustainable Use*" **[D]**.

Carver was **commissioned directly by IUCN France to map 'haute naturalité'** in France, thus developing a bespoke method for quantifying degrees of naturalness across the country and providing the spatial data that underpins President Macron's promise for stronger nature protection ("protection forte"). Phase II has been developed and successfully tested with Phase III ongoing for the remainder of the country. The wild land mapping research base has enabled **Icelandic NGOs to map and protect Icelandic wilderness from inappropriate energy development**, and realise wilder landscape values by quantifying the patterns of impact and loss of wilderness values if permission were to be granted. The Chair of ÓFEIG Náttúruvernd corroborated this impact **[E]**: "*Your experience and expertise has helped us accurately map the threat from hydropower plants and accompanying dams in the area* [Westfjords of Iceland; 22,271km^2]. *This area is part of one of the largest wilderness areas outside the highlands in central Iceland, which without the mapping would prove difficult to protect. We are confident that your mapping work has been an important and influential factor in the decision of developers in 2020 to put the Hvalárvirkjun power plant development on hold. The mapping and report you presented in Reykjavík (26/11/19) gained huge attention and put the potential impacts the plant would have firmly in the spotlight, not least within government agencies…your work has*

influenced a Bill of Law proposed by the government, leading to amendments to the Icelandic Nature Conservation Act No 60/2013 making the mapping of wilderness mandatory".

Modelling of wild land indices enabled Scottish Natural Heritage (SNH) to deliver recommendations made in their 2002 policy statement. Specifically, **the Scottish Government has now accurately mapped wildness across the country** based on the research [Fig 1b], with significant impetus from work by the Cairngorms National Park Authority (CNPA). Research by Carver played "*a significant part in the development of national park policy and indeed influenced the Scotland wide approach to wildland mapping. It has established wildness as one of our most significant Special Landscape Qualities. We have gone on to work with SNH on developing a rigorous appraisal methodology that is now used in a wide range of applications for example; Windfarms, hill tracks, widening of the A9 and woodland planting in the uplands. As a tool for conserving the wildness of the national park it will have an effect on every visitor, in the region of 1.5m per annum",* as noted by the Heritage Manager at the Cairngorms National Park Authority **[F]**.

The research provided the intellectual and methodological basis for **Scottish Government policy change in 2014 to better protect wild land areas [G]**, with related campaigns by NGOs such as the John Muir Trust drawing heavily on Carver's work **[H]**. The Policy and Advice Manager for Scottish Natural Heritage corroborated these changes **[G]**: "*Critical to the feasibility of mapping wildness at a national level was the use of the voxel viewshed software developed at Leeds University. The national map of wildness provided the foundation for our identification of 42 Wild Land Areas (c.19% of Scotland) in 2014. These were given formal policy recognition in the Scottish Government's Third National Planning Framework and Scottish Planning Policy as being of national interest. The wildness mapping and Wild Land Areas have become established as important tools in guiding development and informing planning decisions, particularly on renewable energy schemes. We continue to advise planning authorities and Scottish Ministers on the impact of various proposals on wild land areas, and have successfully defended our position in a number of cases at public local inquiries, drawing on the information and approach taken by the mapping work".*

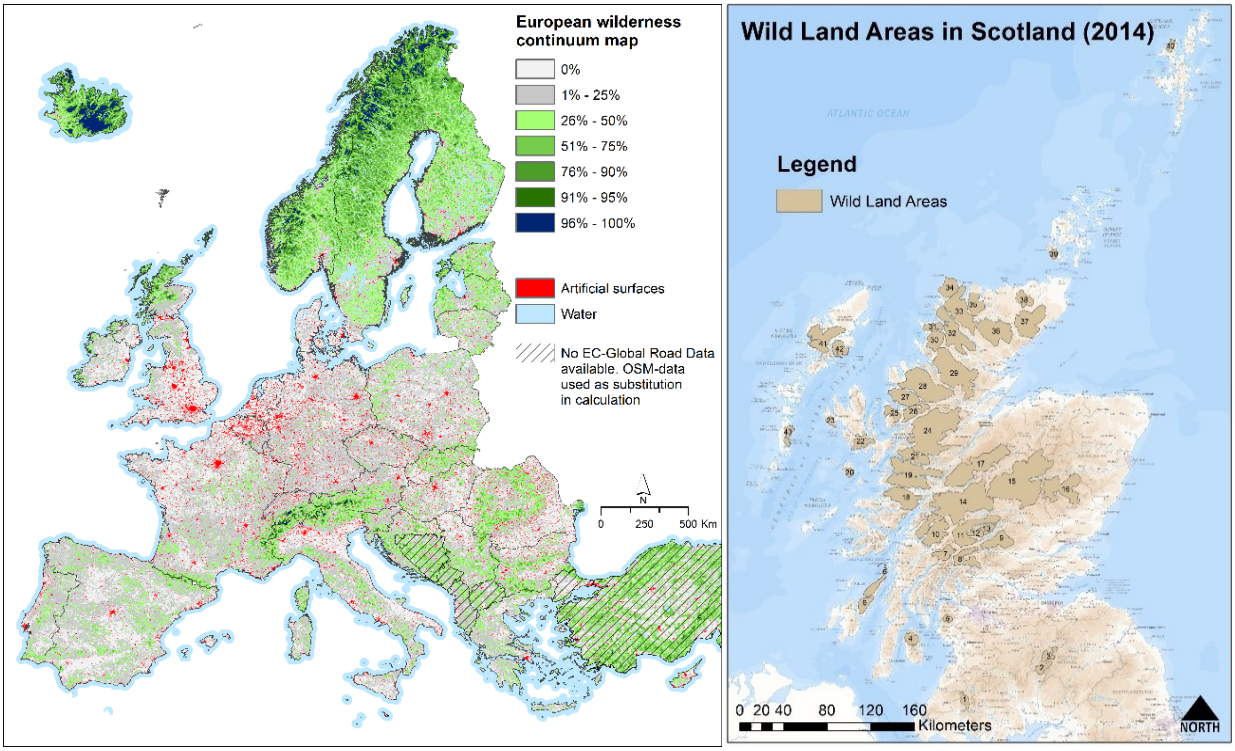

Figure 1. (a) EU Wilderness Index and (b) Scotland 2014 Wild Land Areas

5. Sources to corroborate the impact (indicative maximum of 10 references)

[A] Letter from the President of the WILD Foundation, Boulder, Colorado, USA, explaining the research impacts in Europe and the USA.
[B] Deputy Director of Land Consolidation and Rehabilitation Centre, Ministry of Natural Resources, on the use of the research in the People's Republic of China.
[C] Letter from the Coordinator of the Wild Europe Initiative, summarising the research uptake in European wildland policy.
[D] Chair of Nature Needs Half, and International Union for the Conservation of Nature task force leader, explaining in a letter the use of the research informing IUCN WCPA policy for a new framework for the Convention on Biological Diversity Post-2020 Strategic Plan
[E] Chair of the ÓFEIG Náttúruvernd NGO, describing in a letter the way the research shaped the NGO's campaigning work on changes in government policy.
[F] Letter from the Heritage Manager, Cairngorms National Park Authority, corroborating impacts of work undertaken for the CNPA leading to policy changes by the Scottish Government.
[G] Letter from the Policy and Advice Manager, Scottish Natural Heritage, further corroborating impacts of the research on Scotland's wildland management policy.
[H] Head of Policy, John Muir Trust, explaining in a letter the role of the research in influencing the organisation's land management activities and campaigning work to protect wild land.