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*Progress in Physical Geography* 2009 33: 5
DOI: 10.1177/0309133309105035

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Globalization: a Physical Geography perspective

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Abstract: Although globalization is a term usually restricted to economics and the social sciences, there are aspects of the phenomenon that are intimately linked to the practice and purpose of the physical and environmental sciences and exemplified through Physical Geography. At a fundamental level, Physical Geography has always sought to describe and understand the multiple subsystems of the environment and their connections with human activity: it is global and globalizing at its very roots. Globalization may be seen historically in the global export of western science, including Physical Geography, that underpinned colonial resource exploitation, and which subsequently laid the foundations for the worldwide conservation movement, and for critiques of environment-development relations, such as Political Ecology. Globalization is evident today in the burgeoning productivity and increasing organization of science as well as in the growing accessibility of scientific information. It is also at work in setting contemporary scientific agendas that are focused on larger-scale issues of environment and development and environmental change, particularly in an emergent Earth System Science, and also in Sustainability Science. These global agendas are not simply shared with but also co-produced by the public, politicians and commercial interests, providing both opportunities and challenges for traditional disciplines and traditional disciplinary practices such as Physical Geography.

Key words: conservation, Earth System Science, globalization, Physical Geography, Political Ecology, Sustainability Science.

I Introduction
Globalization is a term most discussed by human geographers, economists and social scientists. Globalization involves ways in which all people and societies in the world are progressively connected, whether through trade, labour and migration, flows of capital and/or technology transfers. For some this marks progressive unification, while for others the process is marked by increasing divisions and extremes as some are ‘included’ and others ‘excluded’ by the phenomenon. At the time of writing this article, globalization is cast in a much more negative light, being associated with the interconnection, and thus collective vulnerability, of failing financial and social systems around the world.

Couched in these terms, Physical Geography seems to have little to say (and little need to say much) about globalization which does not at first seem rather artificial or contrived. Geographers have, however, in
different ways, drawn attention to the way in which globalization is changed and changing in space and time – they are ‘complexifying’ the concept – and it may not, therefore, be inappropriate that some consideration is given to the globalization syndrome from the perspective of environmental science and Physical Geography. This article is an attempt to provide an initial context for associating Physical Geography with the globalization debate, partly through its connections with the wider subject of Geography. It is a starting point for discussion and an introduction to some of the potentially relevant literature. It provides some examples of how globalization has affected and is affecting Physical Geography as a constituent part of the environmental sciences, and it considers Earth System Science and Sustainability Science as, perhaps, the dominant (but very different) rival candidates for the environmental science paradigm of the early twenty-first century. For a fuller discussion on which this article is based, see Clifford (2008).

II Physical Geography as a fundamentally global subject

Physical Geography encompasses the characterization and explanation of geological, hydrological, biological and atmospheric phenomena and their interactions at or near the Earth’s surface. This has often been undertaken in relation to human occupation and activity. Both from the perspective of scholarly and historical completeness and because of concern with the relations between humans and their environment, Physical Geography should not be separated from considerations of Geography as a whole, nor from debates concerning the past, present and future connectedness of environments and human activity. As Gregory (2009) points out, there is no single paradigm of geographical inquiry: geographers have borrowed from across the range of natural, physical and social sciences and Geography’s interconnectedness spans subjects, language traditions, and technologies. Historically, Geography may in this way be seen as a kind of product of an intellectual globalization, which is ongoing. The search is on for new ways to tackle environmental and societal problems and issues which seem themselves to manifest greater interconnectedness between the human and the social and which present at scales from the global to the local. In the face of this new class of globalized environmental and societal problems, new epistemologies are being sought in trans- and multidisciplinary research. These are breaking with old science models of specialism and reductionist methods and drawing on new ideas such as postnormal science and complexity theory. They are also reinventing old subject areas in new ways, such as Earth System Science – thus, representing both challenge and opportunity for Physical Geography as an identifiable and cognate disciplinary activity (see below).

A recent view of Geography in this context of emerging challenges and new ways of thinking (Smith, 2005) also holds intriguing possibilities for Physical Geography. Geography is cast:

as an enterprise of relatedness whose vitality is secured by forging connections and crossing intellectual horizons; ... Geography forms a hub for these networks of relatedness ... positioned awkwardly, but productively, as an interface for the social, natural and biological sciences ... both an interstitial subject and an impulse to inter-disciplinarity. It fills the neglected spaces ‘in-between’ human, physical and medical sciences with potential; it is a creative practical exercise; a mode of inventive intelligence, through which the virtual becomes real as the world unfolds. (Smith, 2005: 389–90)

Some of that inventive intelligence to which Smith alludes has been deployed in recent decades in seminal contributions by physical geographers in the fields of environment-development studies and in calls for new kinds of science and scientific engagement, notably Sustainability Science and Earth System Science. All of these can be seen as examples of globalization in operation and
are discussed later. First, however, some aspects of an older kind of globalization and its implications for the development and status of Physical Geography are outlined.

### III Historical antecedents and precedents

1. **The nineteenth century and an older globalization in holism**

One of the foundational statements of mid-nineteenth-century Physical Geography set the context for its scope, scale and nature as a globalizing science:

> Physical geography ... ought to be, not only the description of our Earth, but the physical science of the globe, or the science of the present life of the globe in reference to their connection and their mutual dependence. (Guyot, 1850: 3)

However, as the nineteenth century progressed, more and more became known about the Earth, its environment and its peoples. Also, academic subjects were emerging and organizing on a competitive basis within universities and wider society as a whole (see Livingstone, 1992; Unwin, 1992). Because Physical Geography was a global and globalizing subject which tried to cover so much, it was difficult to preserve its unique role as the integrative science and to maintain its identity as a coherent body of knowledge. By the late nineteenth century, what to some remained a worthy and ambitious subject:

> ... a description of the substance, form, arrangement and changes of all the real things of Nature in their relation to each other, giving prominence to comprehensive principles rather than isolated facts ... [and having] a unique value in mental training, being at once an introduction to all the sciences and summing up of their results (Mill, 1913: 3, 14)

But to others was now an embarrassment:

> ... too often degraded into a sort of scientific curiosity shop, in which there is a vast collection of isolated facts ... without the slightest attempt ... to show how interdependent they are (Skertchly, 1878: 2)

Physical Geography was, then, caught in an early globalization of the academy, which required specialization and focus (depth, rather than breadth) as the hallmark of academic credibility within the universities. This kind of globalization was thus one of coordinating and structuring the academy, rather than one marked by an intellectual project producing new forms of connected knowledge, as most often championed today, and which had been sought since the Enlightenment (see Clifford, 2009, for further discussion).

2. **The twentieth century and globalization through specialization**

One way in which Physical Geography responded to the dilemma of ‘breadth versus depth’ was to tie the physical science of the environment more closely to the human occupancy of the Earth and hence justify Physical Geography as a science of the interconnectedness of human-environment relations (see especially Davis’ tests of causes and consequences, 1899). This worked well while Geography was concerned with larger-scale regional descriptions of the Earth, although Physical Geography remained as a kind of descriptive backdrop to human activity: regional geographies frequently started with physical descriptions of the land surface and, generally, regions were themselves delineated on the basis of landscape. However, this very attribute also functioned to limit Physical Geography’s connectedness with the other physical and environmental sciences, which were becoming more focused and reductionist in their methodologies.

The clearest example of this can be seen in the changing role and relations of geomorphology. From the later nineteenth century, this discipline was typified by larger-scale landform and landscape description, which formed an ideal backdrop to other
regional geographies. In the absence of dating methods, of techniques of palaeo-environmental reconstruction and of detailed geophysical knowledge about endogenic Earth processes, what resulted were elaborate chronologies based essentially on stratigraphic correlations and landform shape – the denudation chronologies. These had no means of ‘independent’ scientific testing and beyond deductive reasoning deployed few other scientific traits which tied them into the contemporary mainstream science. The geomorphological community thus became inward-looking and disconnected from science and was largely focused on a supporting or separate role within Geography.

By the mid-twentieth century, this large-scale landform denudation chronology approach had probably reached its limits in the provision of new knowledge. With the quantitative revolution in Geography and a move away from the regional geography paradigm, denudation chronology was effectively redundant (and redundancy of old practice is, of course, a consequence of globalization). Geomorphology’s response was twofold: on the one hand, particularly far-sighted practitioners, notably R.J. Chorley (Chorley, 1971), realized both the potential and the necessity to redefine and reconnect geomorphology, Physical Geography and Geography as a whole and to connect Geography into a new and more enduring scientific framework. In effect, this was an effort to recapture an older form of globalized and globalizing knowledge and methodology. The vehicle for this was to be General System Theory (von Bertalanffy et al., 1951) but in some ways this was ahead of its time and is more appropriate today as a response to global environmental problems (see below on Earth System Science). A second response was to focus on more traditional physical science and its reductionist methodologies. This stressed the investigation of surface landform processes which could be monitored at the smaller scale. At the same time, enormous advances were made in various forms of environmental dating, palaeo-environmental reconstruction and large-scale (but fine detail) Earth observation. All of these were well represented in Physical Geography, but they developed more or less independently within the subject. Today, the consequence is that none of them are well connected to rapidly developing strands of geophysics that have remained outside Geography (Summerfield, 2005). Moreover, none of them are well placed to exploit opportunities offered by integrative science or to respond to challenges demanded by the awareness of global-scale environmental dynamics – that is, by the new period of scientific globalization (see below).

The important lesson of this history is that academic subjects change in character and popularity through time and that a globalizing subject requires particular circumstances to thrive. The post-Enlightenment period to the mid-nineteenth century was one such period as ‘new’ knowledge developed across a very broad range and required organization and classification: this was an early period of scientific globalization. As this was accomplished, more focused study requiring distinctive methodologies had greater credibility. Judged against this set of new requirements, Physical Geography in the nineteenth century lacked both a focus for its study and a distinct epistemology for the disclosure of the new knowledge which it might claim to provide. Its response (denudation chronology) gave it uniqueness, but isolated it from other environmental and Earth sciences. This situation persisted until the mid-twentieth century when a re-tooling of Physical Geography, marked by increasing specialization, reliance on technical methodologies and smaller-scale laboratory-like studies, brought it closer to other physical sciences and science methodology. This was despite strong advocacy of General System Theory (really, an alternative way to reconnect the many strands of Geography and science, using an older, holistic view). It was not until the end of the twentieth
century, however, that the stage was set for the re-emergence of the subject cast in a General System manner and recovering some of its much older heritage (Clifford, 2009). The key players on this emergent stage were new classes of environmental issues, the development of ideas in science such as complexity theory, debates favouring increasing inter- and transdisciplinary studies and new technologies capable of global-scale environmental monitoring with fine-scale local detail. In a globalizing world, globalization has, in some respects, thus created the conditions for the re-emergence of a more ambitious Physical Geography as a force in Earth Systems Science.

IV Physical Geography and the new globalization of science: some examples
Beyond historical experiences, there are at least three indicators of the ways in which science (and thus, Physical Geography) can be said to be part of the globalization syndrome today. First is the enormous growth in scientific output and the rapid (but still differential) electronic ‘remote’ access to this. Second is the increasingly global agenda of science. Third is the changing academic foci and character of the environmental sciences. Each of these is examined in a little more detail in the sections which follow.

I The globalization of scientific output
The enormous growth in scientific output and the ease of access to this is seen in the number and range of scientific journals and in the power of web-based search engines such as Google Scholar and the ISI Web of Knowledge. At the time of writing, for example, Google Scholar (http://scholar.google.co.uk/intl/en/scholar/about.html), which promises to ‘Search diverse sources from one convenient place; find papers, abstracts and citations; locate the complete paper through your library or on the web’, was able to provide 1.37 million references under the key word ‘Geography’ and 588 000 under the key word ‘Physical Geography’, all in around one tenth of a second! What this powerful search engine provides is now unremarkable, but it would hardly have been imaginable a generation ago. It is clear testimony to the globalization of knowledge technology – provided, of course, that individuals have access to it. Access (whether to information, wealth or life chances) is a key contested issue in the globalization debate. Some exponents argue for the benefits of global knowledge spread while others caution against its monopolizing and homogenizing tendencies. People in places also produce knowledge, which is not always fed into the global network. People may thus be empowered or disempowered by the growth of science and technology and by access to it, in common with other aspects of the globalization syndrome.

Underlying the technology of knowledge dissemination is, of course, scientific output – the reporting and publication of research. There has been an exponential growth of academic and other journals over the course of the twentieth century, characterized by an average compound annual growth rate of 3.3% (Mabe and Amin, 2001), but there are also other intriguing aspects (marked in the differing growth rates for refereed scientific journals in particular historical periods) which tie academic and scientific output and activity to deeper definitions and ramifications of the globalization syndrome. Broadly, three periods are suggested:

1900–1914, where there was little funding for science from government and growth was driven by the collective behaviour of disciplines themselves, with journals almost entirely in the hands of scientific societies. This is called a time of small-scale, ‘innocent’ science.

1944–1978, a period of ‘Big Science’ where advances in science and technology were largely supported by governments. These were driven by concerns for international security following WW2 and through the Cold War, and later by the ‘space race’. This was a period of maximum growth in academic output, with publication now mixed between academic societies and commercial publishers.
The most recent phase, from the late 1970s, is associated with lower growth rates and a pervasive disappointment or questioning of an overly ambitious science. Issues such as the oil crisis of the 1970s, potential ecological disaster and concerns about nuclear technologies have seen a relative decline in government-funded science and concomitant growth in commercial funding. Growth in the number of journals has slowed (but journal numbers are still increasing) and academic library subscriptions have fallen back more than ever before. This has been termed a period of ‘scape-goat’ science. (Mabe and Amin, 2001: 157–58)

Based upon this analysis, it is impossible to separate the growth of academic journals (and science as a whole) from wider issues of funding, from the agendas of government and larger-scale business and from public perceptions of the role and value of science. Discipline-specific behaviours are the source of further debate (in Geography, there is discussion of how publication behaviour varies between physical and human geographers; see Ferguson, 2003, for example). What is clear, however, is that scientific publication (and, through this, all scientific activity underpinning it) is part of the globalization syndrome. During the twentieth century, science has increasingly left the control of scientists and scientific organizations and been more and more reliant on commercial organizations and the changing economic and political agendas of the time.

Globalization of science is not just about the scale of scientific output and access to it. Globalization also relates to the way in which science is focused on particular global issues in a context set by changing global views and needs. Physical Geography and environmental science offer several examples of this. In the sections below, the historical and more recent involvement of Geography with the worldwide conservation movement, with Political Ecology and, most recently, with Sustainability Science and Earth Systems Science, are presented as illustrations of the globalization syndrome and its effects on these various forms of environmental practice.

2 The globalization of science agendas – worldwide conservation

The connection between people and the environment, built and natural, is the crux of both geography and conservation. Geographers study and conservationists worry about the environment over the same breadth of space and time … Only geographers among the academics who interface with conservation, claim to offer the tools from both natural science and social enquiry that conservationists are constantly calling for. (Warren, 1987: 322–23)

Warren’s statement reflects a common sentiment that Geography, environment and conservation are necessarily and deeply connected, both as intellectual and as practical projects. Geography and geographers can lay some strong claims to have provided both paradigmatic or seminal works in the field; they are well-known chroniclers and popularizers of the conservation/development ‘message’; and they are members of international aid and environment agencies (see Butzer, 2002, for discussion).

Historically, conservation and Geography have been seen as inseparable from commercial exploration and exploitation of new territories, largely by the European powers (and the European companies) of tropical islands and continents. Grove (1992; 1995) details how western environmentalism and conservation were recognizable and prominent from the seventeenth century and developed rapidly over the succeeding century as new lands were first explored, subjected to scientific evaluation, then colonized and commercially exploited. The first waves of settlement led to unbridled deforestation and were quickly followed by soil and water resource depletion. Early (academic) conservation efforts were championed principally by naturalists or polymaths, accompanying voyages of discovery financed by private capital. Their academic background was normally that of medicine and increasingly botany and geology. Significantly, conservation ideas rested on the concepts of linkage between
elements in an environmental system and Grove places the roots of environmentalism in the work of Alexander von Humboldt. In ways strikingly reminiscent of the critique of globalization today, there was early recognition that European rule and, with this, unfettered capitalism could be environmentally destructive – first, to local landscapes, lifestyles and people; second, to continued resource availability; and subsequently to the local and perhaps global operation and sustainability of climate and the environment.

A more personal account echoes many of Grove’s points and brings the historical account to life through the compelling vignette of the African mountain gorilla. Against extinction (Adams, 2004) is a history of conservation and nature which is also a pointer to the need for and basis of a changed conservation paradigm. Taking the theme of conservation as essentially a twentieth-century ‘western’ movement inspired by nineteenth-century ideals, Adams charts the changing scope and fortunes of conservation and of ‘nature’ since initial encounters with the gorilla by German colonial administrators operating between Rwanda and Uganda (as now). These encounters were initially motivated by ‘discovery and capture’ – animals hitherto subject to local, indigenous encounters through millennia were now shot, stuffed and exhibited.

Subsequent encounters were for capture of a different kind: the live exhibition in zoos where animals were first exhibited as spectacles in cages and later in enclosures (fragments themselves of a captured nature). Later still, zoos became ‘nature’s saviours’, through captive breeding of rare species in ex situ conservation. Zoos became centres not of entertainment but of conservation, education and science, and, to some extent, proselytizations of habitat loss and threat of extinction. In a bizarre paradox it was freedom which thus came to justify captivity, or wilderness to legitimize domestication (Anderson, 1997). Different worlds were actually being appropriated and brought together by such captivation, and recreated and symbolically represented to others – another very distinct kind of globalization.

Alongside the zoo, Adams situates the nature and game reserves, sanctuaries and national parks as the big idea of twentieth-century conservation. Again, the mountain gorilla provides a very strong symbol of this. The first African national park was declared to protect the animals, and the gorilla became an icon for the scientific study of threatened species, through Dian Fossey’s (1983) Gorillas in the Mist and the subsequent film biopic. While parks were primarily justified on scientific grounds (to protect both landscape and animals) there were important early geopolitical considerations. There were, for example, ideas to link parks transnationally and thus form bridges between competing colonial powers. Now the parks are truly part of a global phenomenon, governed by international conventions and emblematic of a kind of international corporatism. One way or another, they signify conservation moving from a minority to a majority concern, increasingly linked with a web of connections around the globe, with pressing questions of the degree of acceptable human occupation and use of the park resources by local people (and by outside commercial concerns). The national parks have always wrestled with the question of ‘naturalness’ and ‘community’ versus conservation: now, there is gorilla tourism and a need to habituate gorilla groups to human presence. There is also the need to manage the financial gains and disturbance of growing tourist numbers.

Finally, Adams asks a basic question that, with so much local and global effort in conservation over a century and with so much global emphasis on development, why is there still so little global conservation success and so much local and regional poverty? He suggests that:

Natural science is just one among several ways of understanding nature ... Conservationists
need to recognize that concepts like ‘biodiversity’ shut out other ideas about nature just as effectively as rooms full of Western-salaried conservation scientists mapping hotspots shut out other people. (Adams, 2004: 233–34)

Effectively, this is a plea for a pluralist conception of nature, but also of people – what Adams calls nature’s neighbours – and a focus on the characterization and restoration of relationships between the two in the context of the globalization debate. Writing like this resonates well with the economic and political critiques of globalization, as people and place are brought into a global whole, where lives are affected by globalizing processes, but where people do not necessarily benefit as a consequence and become disempowered to shape their own agendas. Within the environment-development arena, such relations between local and global and between empowerment and disempowerment have also been championed by those with a strong Physical Geography training, that is, in the field of Political Ecology.

3 The globalization of science agendas – Political Ecology

Political Ecology deals with investigations of resource use and abuse, land degradation and marginalization and the environment as overexploited and undervalued. This line of inquiry began in the 1970s and is most clearly articulated in Blaikie’s (1985) Political economy of soil erosion and in Blaikie and Brookfield’s (1987) Land degradation and society. These are part of a wider set of geographical contributions to the identification and characterization of uneven development (Smith, 1984; 1996). The key theme is that environmental problems and issues are manifestations of an ‘ideology of nature’. This ideology masks social inequality arising from the inequitable distribution and exploitation of resources, while claiming a scientific (ie, neutral) knowledge of problems arising from human impacts.

Blaikie’s original and central example is the African rangeland landscape and the problem of overstocking and degradation: at different times and to different degrees, the colonial administrations viewed and constructed nature and natives in value-laden terms, leading to often coercive and resisted environmental conservation and management policies, most persuasively seen in soil erosion control measures. ‘Western’ science, from the 1930s on, adopted a model of erosion based upon field experiments from the USA. These emphasized slope gradient and slope length as primary variables in erosion loss and implicated native tillage practices as an exacerbating factor. The solution was to adopt terracing and to change land-use and land-holding practices – at enormous political cost – with a generally paternalistic and modernizing attitude. However, in the ensuing decades, the model of erosion was questioned, leading to an emphasis on rainfall intensity (not controlled by terracing) and to the revaluing of local knowledges as an alternative source of conservation technique. In this reconceptualization of the problem, erosion was controlled by traditional methods of ground cover, less intensive tillage and intercropping.

This key issue of erosion thus reflected a deeper and wider embeddedness of science within policy-making and bureaucracy, stretching from colonial and postcolonial administrations to world aid organizations. Blaikie (2001: 136) goes on to argue that approaches to nature reflect less about disclosure and adoption of ‘truths’ and more about understanding political narratives. In the sense that such narrative analyses necessitate a globalization perspective, but also a critique of this, then placing ‘facts’ within a social and political context frequently uncovers new dimensions to environment, conservation and reconstruction problems and to their solutions or responses. It also prompts a political agenda of enabling change through improved representation and explanation.
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(Bryant, 2001) and is something of an antidote to other aspects of globalization.

4 The globalization of science agendas – Earth System Science

Earth Systems Science (ESS) is a label which has been variously employed to create structure and coherence to an array of disciplines concerned with aspects of the Earth’s physical and biological systems (Clifford and Richards, 2005; Richards and Clifford, 2008). ESS was promulgated by NASA in the 1980s for structuring its Earth observation activities, but has since broadened to encompass much of the historical territory of Physical Geography and much of what might be termed ‘integrated geography’ – that is, consideration of both physical environmental and human-social phenomena as linked systems. ESS is now a term widely used in universities, research funding bodies, environmental agencies and scientific publishing. Its three defining characteristics are: its emphasis on interactions between component systems of the natural world; its emphasis on systems, which encompass and link both natural and social subsystems; and its global scale.

It is clear that ESS has been deliberately configured not just as a ‘new’ intellectual enterprise (originally and allegedly distinct because of its scope, scale and technological underpinnings) but also as a new unifying theme for the scientific community. In some writings (Schellnhuber, 1999; Pitman, 2005) there is an explicit agenda for the globalization of science: its purpose, practice and products. In some guises, consideration of the opportunities (and, perhaps, necessities?) of improving links between the various Earth and environmental sciences is both timely and balanced (Paola et al., 2006). In other guises, ESS represents what might be termed an aggressive project. It has grand and totalizing ambitions: ESS is now prominent, for example, in all US Geography programmes, in some cases replacing the title Physical Geography.

Clifford and Richards (2005) and Richards and Clifford (2008) provide introductory critiques of ESS and draw attention to a more negative aspect of the ESS which is particularly relevant to the globalization debate. A key consideration is that, unlike much physical science and applied physical science where outcomes are predictable, environmental science is often characterized by a lack of certainty and predictability. Add to this that the ‘new’ science is highly politicized and environmental, then all sorts of warning signals regarding power, manipulation of agendas and access to solutions are sounded. Perhaps unwittingly, ESS may represent one more way in which power relations (between scientists, politicians and public) are recast and reinforced in the guise of greater inclusivity, but with a new technocratic method and an expert language drawing on General System Theory, GIS and the newer fields collectively known as complexity science. Frequently, the appeal to ESS is based on very emotive language concerning climate change, global warming, sea-level rise and other impending ecological disasters. It is also an example, then, of how the relations between scientists and the public are being reworked. Science agendas are changing so as to shape (but also as a response to) journalistic and public interest in the environment in what has been called the democratization or socialization of knowledge (Gibbons et al., 1994). Science must be ‘socially robust’ (that is accepted in society and co-produced) as it is ‘scientifically reliable’ (Nowotny et al., 2001). The degree to which ESS is used in a ‘top-down’ manner and is hence a kind of perpetuation of an older order, remains to be seen, but the potential is clearly there. In all of these respects, ESS provides another microcosm of the globalization syndrome. It may be contrasted with the other new and ‘big’ or global agenda – that of Sustainability Science – which also has a strong presence of Physical Geography and physical geographers.
5 The globalization of science agendas – Sustainability Science

Sustainability Science has emerged recently as a formal response to ideas and issues of sustainability developed in the 1980s and 1990s, which examined the connections between environment, development and society at global and regional scales (Clark and Dickson, 2003). These debates emphasized a divide between the North and South not simply in terms of wealth, but also in terms of lifestyle and development priorities, and with respect to their nature-society-environment relations (see above in the context of Political Ecology). Sustainability Science is about stating and shaping an agenda that tackles environmental and development issues at a world and world-changing scale and it is also the clearest example of how environmental science and Physical Geography are necessary and fundamental parts of the globalization syndrome.

Some of the core questions of this new science may be summarized as follows:

- How can the dynamic interactions between nature and society be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development and sustainability?
- How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?
- What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of ecosystems and human livelihoods?
- How can today’s operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?

These questions provoke a renewed ethical engagement with the world for (Physical) Geography and reflect deeper thinking of the ways in which globalization acts on people and place and is itself formed and changed by and in them, too. Kates et al. (2001) are clear that sustainability demands a new form of science: one that is regionally and locally sensitive and which does not apply science or science policy simply from the ‘top down’. In this way, they implicitly distance themselves from what might be termed ‘globalization as McDonaldization’ and come close to the more complex conceptions of scale and its meanings discussed in Marston et al. (2005). Here, the overarching concept is that of a ‘flat ontology’ which breaks with hierarchical views of large-scale/small-scale and place/region/globe. To Marston et al., space and place are more like networks and nodes for human-environment interaction, which engender a wide range of political opportunities to engage with environment and society. Whereas hierarchical conceptions of space and place (and of globalization within this context) tend to lead to ideas of people and places as passive recipients of globalization, the flat ontology view admits a view of people and place as agents in its (i.e., globalization’s) change and representation. Sustainability Science, then, is one more way in which physical and human geographers, environmental and social scientists are, through new representations of nature-society-development relations, challenging and complicating globalization as a concept, as well as themselves being agents of change in the process of globalization!

V Conclusion

Globalization, as normally applied in the economic and social sciences, refers to the increasing connectedness or unification of societies through economic, social and cultural transformations. This is often in association with new technologies for the transfer of capital and information. It is
not a term which has commonly been applied in the physical and environmental sciences, despite increasing understanding of the connectedness, multiple scales and complexity of many environmental problems and of the essential relatedness of these to human activity, economic development and sustainability.

Geography (and Physical Geography within this) is a natural subject to examine such complexities and relationships. It is both a vehicle for, and a critical contributor to, the globalization of science, environmental and development policy. Geography and geographers have played key roles in raising awareness of the global scale of human impact on Earth surface systems and in providing basic scientific knowledge and developing tools for understanding and managing these impacts. They have also helped to shape and change debates and research agendas associated with globalization in a variety of guises, from esoteric academic critiques, through strategic policies in government and NGOs, to more popular agenda-setting activities.

Historically, both the structure and content of Geography, as well as the practices of geographers, were governed by the export of western capital around the globe and in response to nineteenth-century organizational changes in science and academic institutions, all of which can be seen as early forms of globalization. From a contemporary perspective, Geography and Physical Geography are still part of a wider scientific and academic community which is restructuring and changing in the process of globalization, marked now by the growth in information technologies and by what might be called the democratization of the environment. Neither Physical Geography nor physical geographers can, nor should, be immune to such globalization, since there is as much potential to change and shape the globalization process as there is to simply enact a globalizing agenda.

Acknowledgements
This article is a shortened and revised version of ‘Globalization: science, (physical) geography and environment’ (Clifford, 2008).

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