



Integrating landscape ecology into landscape practice in Central African Rainforests

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Abstract

Context We describe how large landscape-scale conservation initiatives involving local communities, NGOs and resource managers have engaged with landscape scientists with the goal of achieving landscape sustainability. We focus on two landscapes where local people, practitioners and landscape ecologists have co-produced knowledge to design conservation interventions.

Objective We seek to understand how landscape ecology can engage with practical landscape management to contribute to managing landscapes sustainably.

Methods We focus on two large tropical landscapes: the Sangha Tri-National landscape (Cameroon,

Republic of Congo and the Central African Republic) and the Batéké-Léfini Landscape (Gabon and Republic of Congo). We evaluate (1) a participatory method used in the Sangha Tri-National landscape that embeds interdisciplinary researchers and practitioners within a landscape to apply transdisciplinary learning to landscape conservation and (2) a participatory landscape zoning method where interdisciplinary teams of conservation practitioners analyse local land and resource use in the Batéké-Léfini landscape.

Results We find that landscape ecology's tradition of understanding the historical context of resource use can inform landscape conservation practice and natural resource mapping. We also find that the Sangha Group provides an example for landscape ecology on how to integrate local people and their knowledge to better understand and influence landscape processes.

Conclusions Place-based engagement as well as the uptake of co-produced knowledge by policy makers are key in enabling sustainable landscapes. Success occurs when researchers, local communities and resource managers engage directly with landscape processes.

Keywords Landscape approach · Central Africa · Landscape conservation · Congo Basin · Forest peoples · Landscape sustainability · Sangha Tri National · Batéké Plateaux

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Introduction

The Congo Basin supports a remarkable diversity of wildlife and is home to many different human communities, from hunter-gatherers to farmers. The landscapes are composed of a variety of forest types (Droissart et al. 2018), many of which have been subject to past human influence (Oslisly et al. 2013; Morin-Rivat et al. 2017). Timber harvesting, shifting agriculture, fire and browsing by large mammals, notably elephants, have all contributed to the diversity of the landscapes (Brncic et al. 2007; Blake et al. 2009; Walters et al. 2019). People and wildlife share the forests and meet their needs from mosaics of forest and savanna systems. Landscape ecology can inform decisions on the ways in which different management interventions can affect the flows of goods and services from the forests. Landscape ecology focuses on patterns and processes (Forman and Godron 1986), and can indicate an optimal configuration of the landscape in terms of the location and extent of areas subject to different management interventions and uses. Achieving such an optimal landscape requires influencing the behaviour of multiple actors and reconciling the interests of diverse institutions. In order to achieve sustainable landscapes there is a need to merge the contributions of landscape ecology and landscape governance, the latter of which must address the values of rightsholders and stakeholders pursuing their interests, such as food production or biodiversity conservation (Kozar et al. 2014). We describe two landscapes in the Congo Basin where international conservation agencies in partnership with national governments have used landscape approaches to address the twin goals of alleviating human poverty and maintaining forest biodiversity. The challenge has been to reconcile human institutions and behaviour with the constraints of ecological processes.

Landscape sustainability emerged as a key research priority in 2002 for landscape ecology (Wu and Hobbs 2002) and is defined as “the capacity of a landscape to consistently provide long-term, landscape-specific ecosystem services essential for maintaining and improving human wellbeing in a regional context and despite environmental and sociocultural changes” (Wu 2013a). Landscape ecology has progressively sought to increase linkages to the social sciences and decision-making at different scales (Angelstam et al.

2019); this is particularly evident in landscape ecology’s focus on enhancing natural resource management through an integrated landscape management approach (Risser 1984; Wu 2013b).

Conservation initiatives at large landscape-scales are often adopted with the implicit goal of achieving sustainability (Medley 2004; Freudenberger 2010). The landscape concept emerged in conservation when the complementary functions of components of landscape mosaics was needed to address conservation goals (Noss 1983). Landscape ecology was proposed as a theoretical basis for large scale conservation early on, but largely focussed on species, yet noted that future conservation would have to achieve a balance “between organisms and human-perceived landscapes and scales” (Hansson and Angelstam 1991, p. 192). Since then, approaches have been developed, which broadly seek to create sustainable landscapes through participatory measures involving local people in knowledge production (Angelstam et al. 2019). Attention focussed on landscape approaches (Sayer et al. 2013), participatory mapping (Nackoney et al. 2013), and perception monitoring (Omoding et al. 2020), amongst others. Using research to incite action for sustainability requires co-producing knowledge within landscapes, using transdisciplinary and interdisciplinary processes (Angelstam et al. 2017).

Landscape approaches foster integration of different perspectives and knowledge bases from science to practice (Angelstam et al. 2019, p. 1456). Some of the key components of sustainable landscapes include multi-stakeholder engagement, a shared understanding of sustainability, co-production of knowledge, and sharing experiences (Axelsson et al. 2011; Boedhihartono et al. 2018; Langston et al. 2019). The engagement of stakeholders, including scientists, is seen as a key requirement to improving landscape sustainability (Opdam 2018). Here we focus on two types of landscape-scale approaches that engage conservation practitioners and conservation scientists within large-scale conservation landscapes in the Congo Basin. Through these two landscapes, we explore:

1. a participatory method which embeds interdisciplinary researchers with practitioners within a landscape to apply transdisciplinary learning to landscape conservation in the Sangha Tri-National landscape, and

2. a participatory landscape zoning where interdisciplinary teams of conservation practitioners mapped local land and resource use in the Batéké-Léfini landscape

Using these approaches in each landscape, we ask, “How can landscape ecology be applied to landscape conservation to achieve sustainable landscapes?”

The authors of this paper have collective experience in both landscapes since the early 2000s, with some having worked on large-scale landscape conservation in Central Africa since the late 1980s. We first recount the recent history of Central African landscape-scale conservation and the institutionalisation of 12 conservation landscapes across nine countries. We then present cases from two of these landscapes: the Sangha Tri-National landscape (Cameroon, Central African Republic, and the Republic of Congo) and the Batéké-Léfini landscape (Gabon and Republic of Congo). In each landscape, we focus on place-based methods of knowledge production. We conclude by looking at how conservation practice in these landscapes can draw upon landscape ecology and how landscape ecology can inform conservation practice (Sayer et al. 2007).

Large-scale landscape conservation in Central Africa

The origin of the modern conservation landscapes

Conservationists drew attention to the outstanding wildlife in many parts of Central Africa in the early 1990s (Gartlan 1989; IUCN 1989; Hecketsweiler 1990; Wilks 1990; Cleaver et al. 1992; Sayer et al. 1992). International conservation organizations convened a Congo Basin Forest Summit, patronized by Prince Philipp, the Duke of Edinburgh, in Yaoundé at this time to build support for conservation. The interest in comprehensive regional collaboration and a common vision for sustainable forest management amongst Central African countries increased in the mid-1990s mainly with the organisation of a Conference on Central African Moist Forest Ecosystems (CEFDHAC) in Brazzaville in 1996 (IUCN 1996). The “Brazzaville Process” was supported by the Government of Congo-Brazzaville and the International Union for Conservation of Nature (IUCN). The

initiative received funding from international donor agencies, notably from the Netherlands, the European Union and the United States through a Central African Regional Program for the Environment (CARPE). One of the key decisions of the 10 regional countries (Cameroon, Democratic Republic of Congo, Republic of Congo, Gabon, Chad, Equatorial Guinea, São Tomé and Príncipe, Central African Republic, Burundi and Rwanda) was the official recognition of CEFDHAC (IUCN 1998). The adoption of a Regional Strategic Action Plan for the Environment and Biodiversity Resources committed the countries to collaborate on the conservation of shared and transboundary biodiversity resources in the Congo Basin (IUCN 2001).

Regional ministerial momentum increased in 1999 when the president of the Republic of Cameroon hosted the first Central African Heads of State Summit for the Sustainable Management of Central African Forest Ecosystems. A key outcome was the linking of sustainable management of Congo Basin forests to ongoing international, regional and national development processes. In order to facilitate the implementation of the Summit’s recommendations, a commission comprised of ministers in charge of forests in Central Africa (COMIFAC) developed a Forest Convergence Plan adopted during a Second Heads of State Summit held in Brazzaville in 2005. The Plan highlighted a common regional intervention strategy for the 10 countries and their international development partners¹ to promote sustainable management of forest ecosystems at the national and regional levels (COMIFAC 2005).

Major efforts to raise funds to address conservation goals in the Congo Basin culminated in an agreement at the Rio plus 10 World Conference on Environment and Development in Johannesburg in 2002. Governments of the Central Africa Region, the USA and other key partners created a Congo Basin Forest Partnership (CBFP). For aid agencies, such as USAID, support of environmental issues in Central Africa represented a departure from their core business of meeting the basic needs of the world’s poorest people. The emergence of this regional collaboration marked recognition of the importance of ecosystem conservation as a basis of long-term improvement of the lives of inhabitants of the Congo Basin. This political commitment culminated in the identification of 12 landscapes (Fig. 1), covering about 80 million hectares and including 37 protected Areas, 68 community zones and 43

extractive zones that were the focus of contributions of 27 partner institutions (Yanggen et al. 2010). Landscape approaches emerged at this time, as the latest of several decades of attempts to integrate conservation and development, a compromise between addressing urgent development needs and conserving globally significant ecosystems (Sayer and Campbell 2004).

These conservation initiatives that begun in the 1980s led to regional collaboration and focussed efforts of governments, scientists, and donors on conservation and sustainability at the landscape scale. The two cases that follow document two contrasting approaches in the Sangha Tri-National and Batéké-Léfini Landscapes. The first focuses on bringing scientists and practitioners together to monitor, learn and adapt actions within their landscape and the second focuses on bringing interdisciplinary teams together to involve local communities in local, spatial planning.

Cases

Sangha Tri-National landscape and the Sangha Group

The Sangha Tri-National landscape (TNS) is an area of 43,936 sq. km of humid tropical forest that straddles the frontiers of Cameroon, the Central African Republic (CAR), and the Republic of Congo. The area is rich in biodiversity and includes three national parks (Lobéké in Cameroon, Dzanga-Ndoki in CAR, and Nouabale-Ndoki in the Republic of Congo), which together cover a total of 7889 sq. km (Sayer et al. 2016). Forest concessions, community hunting zones, commercial hunting concessions, mineral concessions, and agro-forestry zones comprise the rest of the landscape. The three countries have adopted environmental policy reforms putting people at the centre of strategies for biodiversity management and aim to make local people prime beneficiaries of conservation programs.

IUCN launched a major initiative in 2006 named the “Landscapes and Livelihoods Strategy” (LLS). LLS promoted the spatial integration of conservation and development (Sayer et al. 2005). Landscapes

included a variety of forest cover types yielding a range of environmental and developmental goods and services. LLS recognized that people and wildlife were using the same forests and that human needs and ecosystem conservation required integrated measures across the entire landscape (Sayer and Campbell 2003; Sayer et al. 2003). IUCN recognised the challenges of measuring the performance of interventions that addressed trade-offs between conservation and development. LLS chose the Sangha Tri-National Landscape to pilot an integrated assessment methodology based on indicators drawn from the Capital Assets Framework (Endamana et al. 2010), also known as the Sustainable Livelihoods Framework (Endamana et al. 2010).

A consortium of international conservation NGOs, research institutions, local NGOs and community representatives developed a plan for collaboration in the Sangha Tri-National area at a meeting in Kribi, Cameroon in September 2004. The group adopted the name “Sangha Group” after the river that flowed through the landscape where the three countries meet. The Sangha Group is a learning group that brings together conservation and development researchers and practitioners with local Indigenous communities. Its objectives were to apply science to improve the impact of conservation and development interventions in the Congo Basin and to strengthen the scientific basis of conservation and development activities in the three sectors of the TNS. A TNS Foundation was established to mobilize local and international partners of the three TNS country segments and has supported conservation actions including funding the Sangha Group. The Sangha Group continues to contribute to the implementation of a sub-regional political process. The results of the work advance the “Research and development” objective of the COMIFAC convergence plan.

The Sangha Group meets nearly annually and attempts to solicit broad representation of the diverse stakeholders and rightsholders in the landscape at each of its meetings (Table 1). However, the landscape has an area of 43,936 km² and a population of 190,000 people so participation is inevitably selective. World-wide Fund for Nature (WWF), Wildlife Conservation Society (WCS), IUCN, COMIFAC, GIZ and the local staff of the government forestry and conservation agencies meet with community based organisations (CBOs) and representatives of local villagers. Several

¹ https://pfb-cbfp.org/comifac_en2.html.

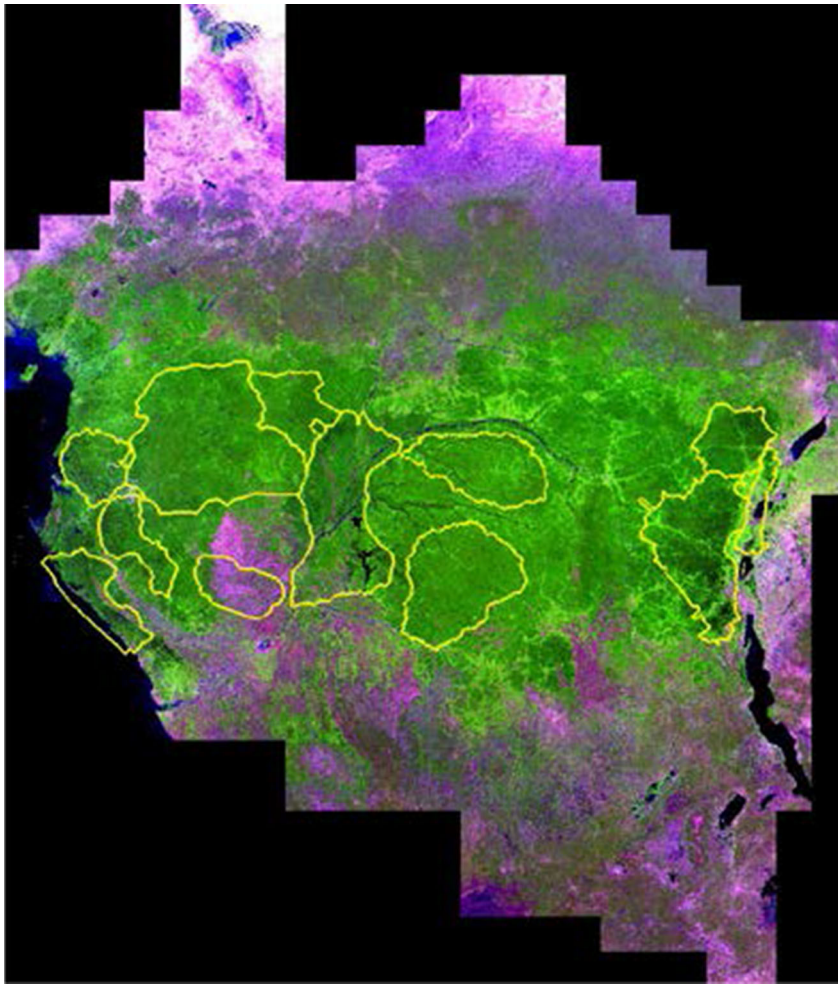


Fig. 1 The 12 Congo Basin Forest Landscapes outlined in yellow, overlaid on 2016 LandSat composite imagery, based on (Potapov et al. 2012)

forestry companies send representatives to Sangha Group meetings and representatives of the USAID CARPE program attend. Meetings average around 20–30 participants. International facilitators have come from IUCN, the Center for International Forestry Research, the Autonomous University of Madrid, Spain and James Cook University in Australia. The functioning of the group is described in more detail in accounts of its scientific work (Sandker et al. 2009, 2012; Endamana et al. 2010; Boedhihartono et al. 2015). Participation in the Sangha Group meetings evolved over time. Key local members of the staff of organisations moved on; the interest of local people varied and logistical and security considerations sometimes limited participation. Continuity in

the work of the group was provided by staff from WWF, WCS, CIFOR and IUCN, who benefited from knowledge of scientists from universities in the region and beyond. Specialised expertise in landscape modelling and other data analysis tools was provided by these universities. Varying participation led to a lack of continuity in monitoring; however, it also meant that a wide diversity of people were involved over the years. Each meeting submitted reports and recommendations to decision makers in regional governments and NGOs. The Sangha Group does not have full time dedicated support staff although IUCN provided an institutional host and organized each meeting.

Table 1 Date, place and thematic focus of each Sangha Group meeting

Year	Place	Countries	Main activities
2004	Kribi	Cameroon	Exchange workshop and reflection on theoretical approaches to modelling the landscape—choice of the STELLA model for the TNS
2005	Bayanga	CAR	Development of the first set of change indicators in the TNS and test in Moussapoula and Bayanga (CAR)
2006	Mambele	Cameroon	Collection of baseline data, revision of indicators, first visualization
2007	Bomassa	Republic of Congo	Monitoring and reflection
2008	Bayanga	CAR	Monitoring and reflection
2009	Djembe	Cameroon	Monitoring and reflection
2010	Lomie	Cameroon	Monitoring and reflection
2011	Djembe	Cameroon	SWOT analysis of participatory monitoring system—Monitoring and reflection
2012	Libongo	Cameroon	Revision of indicators for CIFOR Sentinel Landscape approach—Monitoring and reflection
2013	Kabo	Republic of Congo	Monitoring and reflection
2015	Libongo	Cameroon	Monitoring and reflection
2016	Bayanga	CAR	Monitoring and reflection
2018	Bomassa	Republic of Congo	Monitoring and reflection

The Sangha Group was innovative in placing responsibility for the selection and measurement of indicators in the hands of local people, using a participatory approach to assess the dynamics of change in the TNS landscape. Simple simulation modelling techniques and a set of indicators were used to track changes in the landscape, to provide an integrated assessment of landscape performance in delivering conservation and development benefits (Sandker et al. 2009, 2010, 2012). Local people led the process of defining the indicators that related to their livelihoods. The initiative allowed a broad range of stakeholders to assess changes in local peoples' livelihoods and the environment.

The large number and diversity of stakeholders and rightsholders occupying this vast forest landscape and a shortage of skilled enumerators meant that indicator values were difficult to measure consistently. However, the existence of the models and indicator framework did enrich the discussions amongst the stakeholders and helped them to understand the main drivers of change in the landscape. It was found that interventions of aid agencies and conservation organisations had little long-term impact on local peoples' livelihoods. External impacts, notably the global financial crisis in 2008 and the civil strife in the

CAR sector beginning in 2011 caused a serious deterioration in indicators of both livelihoods and the environment in the landscape (Sayer et al. 2012, 2016; Sandker et al. 2012). The Sangha Group used visual techniques to enable local people to express their preferences on the future of the landscape (Boedhihartono et al. 2015). All of these techniques treated the landscape as an integrated system where biodiversity and livelihood benefits flowed from the entire landscape and not from segregated components of the landscape. The overall aim was to achieve an optimal balance between competing land uses. In 2009, the Sangha Group became the scientific committee for the TNS following a decision of ministers from the three countries.

IUCN work in the Sangha Tri-National had an impact on concepts under-pinning integrated landscape approaches worldwide (Sayer et al. 2013). The Sangha Tri-National landscape demonstrated that industrial logging and local agricultural development could be compatible with the conservation of wildlife; based on the monitoring indicators, it became clear that the international financial crisis not only disrupted logging concession activities, but caused an upsurge in poaching, as those who lost their jobs remained in the villages and some turned to hunting. The TNS

landscape remains an icon of international conservation even though outside pressures have intensified in recent years. Organized poaching gangs with modern military weapons have entered the area to hunt elephants. Outside investments in mining, estate crops and the infrastructure to enable such developments are under discussion (Weng et al. 2013, 2017). The monitoring framework established by the Sangha Group has enriched the discussions of these development initiatives and influenced the policies of national governments and outside investors. The work of the Sangha Group led to a coherent narrative on the urgent need to achieve a balance between improving the condition of some of the world's poorest people and the need to conserve globally significant forest ecosystems. The Sangha Group has continued to function for almost 20 years and has guided this narrative on reconciling the trade-offs between conservation and development in the landscape (Sayer et al. 2016).

Batéké-Léfini landscape and CARPE's macro and micro-zoning

In many Congo Basin landscapes, CARPE aimed to develop spatial plans to segregate conservation and development areas, fostering landscape sustainability. CARPE's landscape approach made extensive use of formal Land Use Planning based on the experience of the United States Forest Service. CARPE saw landscapes as being composed of discrete parts and relied upon land-use plans, macro-zone plans and annual work plans that combined to form a management framework (Beck 2010; United States Forest Service s.d.). These landscape plans focused on habitats, scientific research, socio-cultural features, education, community participation, income generation, ecotourism, and ecosystem services. The planning process was participatory, and focused on the present state of the landscape and how natural resources could provide future benefits. Landscape plans are developed on the basis of the landscape's historical background, recognising community lands and traditional natural resource governance and management practices (United States Forest Service s.d., pp. 17, 19). The micro-zones are smaller areas within the macro-zone managed for different objectives, such as fishing, hunting or agriculture. Communities played a central role in mapping micro-zones. One of the critical steps is

recognising boundaries where "local residents have developed a tradition of resource partition" (United States Forest Service s.d., p. 20).

Modern conservation history of the landscape

The Batéké-Léfini landscape is an ancient forest-savannah mosaic that lies astride the border of Gabon and the Republic of Congo (Schwartz and Lanfranchi 1991; Haddon 2000). It occupies an area of more than 35,000 km² and contains the Léfini Faunal Reserve in Republic of Congo, a colonial era reserve dating from the 1950s, and the Plateaux de Batéké National Park in Gabon, established in 2003. The area is known for western lowland gorillas (Le Flohic et al. 2015), cuckoo migration (Hewson et al. 2016), the reintroduction of lions (Henschel 2006), as well as a diverse savanna (Walters et al. 2012) and forest flora (Walters et al. 2011).

This landscape received external support from several conservation partners, including the Aspinall Foundation for Gorilla reintroduction, and Panthera for lion reintroduction. The Wildlife Conservation Society was active in the Gabon portion of this landscape from 2003 to 2012, but ceased activities in 2012 after CARPE withdrew its funding.

Micro-zoning was applied to the Batéké-Léfini Landscape in 2009. Typically interdisciplinary teams were formed including a socio-economist, biologist, forester, agronomist, conflict resolution specialist, jurist, mapping expert, and tourism specialist (Wildlife Conservation Society 2009a). Here, we focus on the micro-zoning carried out in the Ekouyi-Mbouma area, south of Léconi, Gabon, a case previously undescribed (Minlol and Ndikumagenge 2010). Over two visits lasting a total of seven days, the Wildlife Conservation Society team, comprised in this case, largely of social scientists, met with local authorities and community members to discuss natural resource use in their macro-zone. During the second four-day meeting, the team identified micro-zones for agriculture, hunting, fishing, forestry, ecotourism and sacred areas. Hunting micro-zones were noted to be located in "the four corners of the territory" (Nse Esseng 2009). Analysis by WCS indicated that the communities did not clearly define their macro-zones, however, the communities were noted to have an interest in environmental and conservation questions and desire to protect their territories from illegal hunters. The

resulting report recognised the heritage sites and cultural values of the Batéké people, and the report noted the need to engage with Batéké history.

A later report from the same process noted the existence of a traditional management systems where “the land owners are responsible for a part of the land, bequeathed to them by their ancestors” (Wildlife Conservation Society 2009b). The report further recognised that the people in the villages use most of their land for agriculture and hunting, have established boundaries and users do not typically traverse these limits. However, despite this recognition of cultural zoning, the report gave little detail on how the traditional management system worked. Furthermore, this report did not engage with existing work by Gabonese scholars on the area’s customary management systems, nor anthropological work that was carried out just prior to the micro zoning exercise, and which had been done collaboratively with WCS, and whose results had been partially presented at CARPE meetings in the landscape. This lack of engagement with these specialists and the related literature can be seen as a lost opportunity to clarify many aspects of the traditional management system that the micro-zoning attempted to map and understand.

By contrast, the anthropological study, sought to understand changes in customary natural resource governance in the conservation landscape. Over a period of 18 months, researchers used participant observation and interviews with hunters within their hunting territories. A local historian had described how the Batéké people of this macro-zone had historically organised their lands into lineage-based hunting territories called *ntsie* which were originally further grouped into supra-territories called *essi* (Ebouli 2001), with each level having a chief (Vansina 1990). Anthropological work with local hunters and chiefs mapped the rivers and ridges that demarcated these zones. Related historical research showed that Batéké management of their territories has been repeatedly challenged by French colonial interests (Coquery-Vidrovitch 1972). A resettlement program moved the Batéké from their territories to their current areas along roads in the 1950s (Sautter 1966; Pourtier 1989). Batéké customary lands, vacated during the colonial resettlement period, became part of the Plateaux de Batéké National Park in 2003 (Quammen 2003). Hunting practices within the area had been organised for more than a century, despite having

changed after independence from France in 1960 (Walters et al. 2014; Walters 2015), with these changes impacting savanna vegetation structure (Walters 2012). The limits of the lineage-based territories have been maintained (Walters et al. 2015). Today, in the current territory, the Batéké have become participants in conservation activities that aim to create sustainable landscapes.

The CARPE micro-zoning approaches described above did not benefit from a transdisciplinary team, working across research disciplines and practice that could have brought anthropological and historical perspectives to the micro-zoning exercise, through engagement with scientists knowledgeable about the place and people. Although the micro-zoning did recognise the existence of traditional natural resource governance systems, when zoning was carried out over a very short period, the maps produced did not correspond to the traditional boundaries recognised by the Batéké people. In comparison to lineage-based mapping of the same area, which occurred over 18 months, and which detailed extensive use of the area for hunting (Walters 2010; Walters et al. 2015), the micro-zoning underestimated the size of the hunting areas, and potentially misrepresented the extent of customary rule over extensive areas (see Wildlife Conservation Society 2009c).

After landscape level planning was completed, country team meeting meetings held by CARPE in each country and by COMIFAC at the regional level adopted large-scale land use plans for all 12 Congo Basin landscapes. However, the process did not lead to any formal adoption of the plans at the regional level, although they were widely used in some landscapes. This means that in some cases, the land use plans did not directly inform national level land use planning when it came to formalising them into law. This appears to be the case for Gabon. The Government of Gabon has taken a series of steps to formalise their land use planning starting in 2011, with a national strategy for development (République Gabonaise 2011). Until then, Gabon did not have a national policy on land tenure, and retained a system dating from the colonial era (Ovono Edzang 2019). The most notable effort is the Plan National d’Affectation des Terres, governed by an inter-ministerial sub commission which brings together information and consults with local communities (La République Gabonaise 2015). Ovono Edzang (2019) reported that rural

populations, including fishing and forest communities with customary usage, are the most precarious, and lack legal title to land.

The Batéké-Léfini case shows that participatory micro-zoning methods using an interdisciplinary team of practitioners, which engage well with the local populations, may still lack the competence to understand the conservation aspects of the traditional governance systems, especially when not engaging with researchers knowledgeable in the area. Furthermore, the zoning maps did not inform policy adoption in Gabon, perhaps in part because of the discontinuation of CARPE work in that part of the landscape. Nonetheless, significant lessons from the CARPE land use planning exercises can inform current government efforts. Notably, CARPE land use planning elsewhere in the Central African landscapes notes that such zoning should focus on supporting communities to meet their needs from their sustainably managed resources rather than just as lands to buffer a protected area (Beck 2010). Concerning micro zoning itself, participatory planning is only one factor amongst many that influences landscape sustainability (Minlol and Ndikumenge 2010).

Analysis and discussion

How can landscape ecology contribute to landscape conservation practice?

The work of the Sangha Group illustrates how scientists can move beyond providing information and engage with practitioners in landscape knowledge co-production with the objective of influencing decisions on the ground. The experience in the TNS shows how landscape ecologists can engage both with local actors and with other disciplines and become more “holistic and humanistic” (Opdam et al. 2018, p. 6). Landscape ecologists may fail to appreciate the complexity of the power and interests of local stakeholders and rightsholders with solutions based upon theoretical landscape ecology potentially failing to achieve traction amongst local actors. Long-term engagement on the ground between scientists and local people may be the only way to find solutions that can influence the behaviour of key actors (Boedihartono et al. 2018; Margules et al. 2020).

A key aspect of the Sangha Group was the engagement by scientists within the landscape itself, across a variety of disciplines, using an “embedded science” approach (Langston et al. 2019). This approach, rather than separating researcher and subject, brings the two together. Embedded science has similarities to the action research widely employed in agriculture where scientists and farmers work in close collaboration. There is a need for landscape ecologists to practice action research with the people whose decisions determine the future of a landscape. Unfortunately, the reward systems of academia rarely permit landscape ecologists, or any researcher, to have the luxury of such long-term, in depth engagement with decision-making processes in their landscapes.

The Sangha Group was also key in supporting South-South and North-South Cooperation amongst universities and conservation programs. Over a decade, the group mobilised nearly 2000 person-days of work. The landscapes provided a field laboratory for scientists from Northern Universities in pursuit of their mission to conserve ecosystems of global biodiversity value. Scientists contributed by building capacity of actors from government, conservation organisations and civil society, in particular around long term landscape monitoring. The Sangha Group supported dialogues between international and national economic actors, while also boosting cooperation between the three countries. The different users of the space, with differing interests, have dialogued and come to agree on a common vision for the sustainable management of the landscape. Finally, the Sangha Group has contributed to the international visibility of the TNS landscape, a rare example of a successful tri-national conservation partnership.

Landscape ecology draws on historical change to offer a perspective on how to understand landscape change processes over time and in an interdisciplinary way (Bürgi et al. 2017; Li et al. 2017). Landscape ecology also demonstrates how to use the past to look forward to the future, valuing the role that people have in creating and sustaining landscapes (Palang et al. 2019). There is potential for landscape ecologists to collaborate on large-scale landscape conservation initiatives, bringing an important dimension to not only understanding landscapes, but also to planning for their sustainability. Large landscape conservation programs like CARPE, could draw from the historical tradition of landscape ecology, where historical

processes are recognised for the role they play in shaping the landscapes that are the objects of conservation today (Rhemtulla and Mladenoff 2007). Furthermore, historical processes can be used to find future opportunities (van der Leeuw et al. 2011), in this case, in working with traditional natural resource governance at the local level.

Landscape ecology also calls for an integration of culture into landscape planning (Wu 2010). To understand the cultural context of a landscape, as called for by the CARPE micro-zoning guidance, requires in-depth engagement with communities and collaboration between social and biological conservation scientists and practitioners (West and Brockington 2006). Although in CARPE much effort is spent conducting participatory mapping exercises and many lessons have been learned (Yanggen et al. 2010), most projects employ rapid assessments with communities, resulting in a shallow and incomplete picture of community resource governance, such as the one described here. Although the CARPE guide stresses the need to understand the historical usage of resources, and the importance of an interdisciplinary team to achieve this, implementation in the field is highly variable and requires long periods of fieldwork.

Inaccurate maps of micro-zoning of community natural resource use, such as those produced in the Batéké case, can imply that much land is not used or claimed by local people. In many places, governments consider unoccupied land to be vacant (Jaffré 2003), especially when land is subject to less visible uses such as hunting, fishing, and cultural ceremonies. The lack of historical and cultural understanding of resource usage, including the extent to which communities use their lands, and a lack of full recognition of the traditional management systems in place will undervalue local interests in the landscape.

Landscape sustainability: connections and disconnections

In this paper, we present two very different initiatives to knowledge co-production: the Sangha Group in the TNS and participatory micro-zoning the Batéké-Léfini Landscape. Both approaches attempt to understand resource use and imagine a more sustainable landscape, however the processes used are drastically different, and with very different outcomes for policy. Here we can speak of connections and disconnections:

landscape approaches that connect people, places, policy, and those which may not.

Working on landscape sustainability requires knowledge across disciplines (Wiek et al. 2011; Freeman et al. 2015). The Sangha Group served to connect researchers from several disciplines and practitioners and communities working in the landscape, and it connected these people to a place, both through the group's work directly in the TNS (rather than in a distant location) and in linking the work to understanding local resource use. Likewise, the work in the Batéké-Léfini landscape also connected practitioners from several disciplines to each other and to communities, in the place of engagement, however it did not connect to researchers working in the same landscape, and so fell short of fully benefiting from the knowledge about natural resource governance that could have enhanced the micro-zoning effort.

Working on landscape sustainability takes time, and requires researchers and practitioners to substantially engage with the landscape where they work. The Batéké micro-zoning exercise described here, over a period of 7 days, stands in stark contrast to the detail of work from an 18-month anthropological research in the same landscape. One might say that conservationists cannot spend such time in the field, however, CARPE micro-zoning carried out in the Lac Tele area in the Republic of Congo tells a different story. There, a Wildlife Conservation Society team worked with customary leaders, at the lineage level, to understand customary natural resource governance laws, traditional zoning and the history over a period of four years (Rainey and Twagirashyaka 2010). Effective micro-zoning was possible due to several team members spending up to half of each year in the field, allowing for verification of maps with communities.

The Sangha Group also required researchers and practitioners to spend time in the TNS landscape, but in this case, repeatedly, over a period of nearly 20 years and 2000 person-days of work. This intense and long-term engagement with the TNS permitted researcher and practitioner alike to substantially engage with the landscape and contribute to both research and policy.

A challenge in landscape sustainability is to make the connections between the knowledge produced and the pathways to policy uptake. In the case of the TNS, a clear pathway to using scientific and practical knowledge in policy was made through the Sangha

Group being formally recognised as a cross-border Scientific Committee. By contrast, there was a disconnection in the Batéké-Léfini landscape micro-zoning and the Gabonese Government not adopting the zoning plans produced. However, there are potential lessons from the CARPE exercise in the current Gabonese initiative on land use planning, especially concerning engagement with local communities and understanding their histories. This will be especially important as the government intends to extend the national park in that landscape into community lands.

These pathways from landscape knowledge to policy are important for landscape sustainability. Landscape studies ensure that decisions are based on evidence from a variety of sources, from research to practice to communities. The CBF landscapes have moved from being recognised by a single donor to becoming recognised throughout the Congo Basin countries by all governments and most donors. However, the institutionalisation of scientific bodies, like the Sangha Group, is also important, providing a unique platform for knowledge production to inform policy.

The TNS landscape has a high level of support from the three governments, enjoying a tri-lateral agreement signed in 2000 by Cameroon, Central African Republic and the Republic of Congo. The TNS has been able to secure high levels of conservation funding, notably through the TNS Foundation established in 2007 to support long-term conservation work. By contrast, little institutionalisation of landscape-level bodies has occurred in the Batéké-Léfini landscape. Nonetheless, the Gabonese and Congolese governments continue to explore cross-border protected areas. In Gabon and Republic of Congo, separate conservation initiatives are funded by a diversity of donors, but potentially without the same level of cross-border cohesion experienced in the TNS.

Conclusion

Landscape sustainability foresees the maintenance of landscape level ecosystem services (Wu 2013a), while also engaging with stakeholders through co-production of knowledge (Axelsson et al. 2011; Opdam et al. 2018). In this paper, we examine initiatives in two Central African landscapes that demonstrate the

strengths and weaknesses of different conservation approaches to landscape sustainability through place-based knowledge co-production.

Many conservation landscape initiatives are still developed by people who have little understanding of local realities (Boedihartono et al. 2018). In depth understanding of the landscape context is essential to achieve conservation outcomes; conservation programs need to involve the local communities and interested stakeholders and rightsholders in the sustainability of the landscape, and in understanding their perspectives in light of natural resource use history (Bluwstein 2019; Omoding et al. 2020). Landscape ecology can contribute to this in-depth understanding through research, but researchers must, in turn, actively engage in the landscapes where they work. Long periods of fieldwork where researchers and practitioners experience the daily lives of the population can sensitize researchers to the realities of local actors and can help achieve a long-term understanding of landscape trends and changes, such as demonstrated in the long-term engagement in the TNS and in the Batéké Plateaux. We use the term inductive research to describe this process of investigating local contexts—long periods of inductive research are needed to fully comprehend the complexity of landscape processes (Margules et al. 2020).

In order to translate landscape theory into practice, researchers must learn to engage with the people on the ground. Collaboration and negotiation with local communities and decision-makers is fundamental to conducting and applying research, anything less will result in a loss, both for conservation and for sustainability. Landscapes are subject to continual change and landscape ecologists must make long-term commitments if they are to influence those changes (Margules et al. 2020). Plans can be useful but external drivers are difficult to predict and we prefer to consider landscape change as a continuing process in which landscape ecologists and conservation practitioners must engage (Langston et al. 2019). External attempts to influence landscape change through plans developed by teams of experts who fly in and fly out are unlikely to deliver desirable outcomes (Boedihartono et al. 2018). There is a need for action research at landscape scales where scientists have a seat at the table where landscape decisions are made. The incentive systems and funding mechanisms for development assistance and research rarely allow for such

long-term engagement but our experience in the Congo Basin is that such long-term engagement will be essential if the livelihoods or people in tropical forests can be improved and the ecosystem values of these forests conserved.

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References

- Angelstam P, Barnes G, Elbakidze M, Marais C, Marsh A, Polonsky S, Richardson DM, Rivers N, Shackleton RT, Stafford W (2017) Collaborative learning to unlock investments for functional ecological infrastructure: bridging barriers in social-ecological systems in South Africa. *Ecosyst Serv* 27:291–304
- Angelstam P, Munoz-Rojas J, Pinto-Correia T (2019) Landscape concepts and approaches foster learning about ecosystem services. *Landscape Ecol* 34:1445–1460
- Axelsson R, Angelstam P, Elbakidze M, Stryamets N, Johansson KE (2011) Sustainable development and sustainability: landscape approach as a practical interpretation of principles and implementation concepts. *J Landsc Ecol* 4:5–30
- Beck J (2010) Landscape land use planning: lessons learned from the CARPE Program. In: Yanggen D, Angu Angu K, Tchamou N (eds) *Landscape-scale conservation in the Congo Basin: lessons learned from the Central Africa Regional Program for the Environment (CARPE)*. International Union for Conservation of Nature & USAID, Gland, pp 13–22
- Blake S, Deem SL, Mossimbo E, Maisels F, Walsh P (2009) Forest elephants: tree planters of the Congo: forest elephants, seed dispersal, and trees. *Biotropica* 41:459–468
- Bluwstein J (2019) Resisting legibility: state and conservation boundaries, pastoralism, and the risk of dispossession through geospatial surveys in Tanzania. *Rural Landsc* 6:1
- Boedhihartono AK, Endamana D, Ruiz-Perez M, Sayer J (2015) Landscape scenarios visualized by Baka and Aka Pygmies in the Congo Basin. *Int J Sust Dev World* 22:279–291
- Boedhihartono AK, Bongers F, Boot RGA, van Dijk J, Jeans H, van Kuijk M, Koster H, Reed J, Sayer J, Sunderland T, Turnhout E (2018) Conservation science and practice must engage with the realities of complex tropical landscapes. *Trop Conserv Sci* 11:194008291877957
- Brcic TM, Willis KJ, Harris DJ, Washington R (2007) Culture or climate? The relative influences of past processes on the composition of the lowland Congo rainforest. *Philos Trans R Soc Lond Ser B* 362(1478):229–242
- Bürgi M, Östlund L, Mladenoff DJ (2017) Legacy effects of human land use: ecosystems as time-lagged systems. *Ecosystems* 20:94–103
- Cleaver K, Munasinghe M, Dyson M, Egli N, Peuker A, Wencelius F (1992) *Conservation of West and Central African Rainforests*. World Bank, Washington
- COMIFAC (2005) *Plan de convergence: pour la conservation et la gestion durable des écosystèmes forestiers d'Afrique Centrale*
- Coquery-Vidrovitch C (1972) *Le Congo au temps des grandes compagnies concessionnaires 1898–1930*. Mouton & Co., Paris
- Droissart V, Dauby G, Hardy OJ, Deblauwe V, Harris DJ, Janssens S, Mackinder BA, Blach-Overgaard A, Sonké B, Sosef MS, Stévant T (2018) Beyond trees: biogeographical regionalization of tropical Africa. *J Biogeogr* 45:1153–1167
- Ebouli JM (2001) Les structures de type féodal en Afrique Centrale le cas des Téké: étude des relations de dépendance personnelle et des rapports de production entre “A mfumu” et “Elogo dja Mfumu” (des origines à 1880). Université Omar Bongo
- Endamana D, Boedhihartono A, Bokoto B, Defo L, Eyebe A, Ndikumagenge C, Nzooh Z, Ruiz-Perez M, Sayer JA (2010) A framework for assessing conservation and development in a Congo Basin Forest Landscape. *Trop Conserv Sci* 3:262–281
- Forman RTT, Godron M (1986) *Landscape ecology*. Wiley, New York
- Freeman O, Duguma L, Minang P (2015) Operationalizing the integrated landscape approach in practice. *Ecol Soc* 20:24
- Freudenberger K (2010) *Paradise lost? Lessons from 25 years of USAID Environment Program in Madagascar*. International Resources Group, Washington

- Gartlan S (1989) La conservation des écosystèmes forestiers du Cameroun. UICN, l'Alliance mondiale pour la nature: Commission des Communautés Européennes, Gland, Suisse
- Haddon IG (2000) Kalahari group sediments in the Cenozoic in southern Africa. Oxford monographs on Geology and Geophysics, Oxford
- Hansson L, Angelstam P (1991) Landscape ecology as a theoretical basis for nature conservation. *Landsc Ecol* 5:191–201
- Hecketsweiler P (1990) La conservation des écosystèmes forestiers du Congo. IUCN, Gland
- Henschel P (2006) The lion in Gabon: historical records and notes on current status. *Cat News* 44:10–13
- Hewson CM, Thorup K, Pearce-Higgins JW, Atkinson PW (2016) Population decline is linked to migration route in the Common Cuckoo. *Nat Commun* 7:12296
- IUCN (1989) La conservation des écosystèmes forestiers d'Afrique centrale: un plan d'action pour la République-unie du Cameroun, la République Centrafricaine, la République populaire du Congo, la République Gabonaise, la République de Guinée Equatoriale, la République Démocratique de Sao Tomé-et-Principe, la République du Zaïre. IUCN, Gland
- IUCN (1996) Actes de la 1ère CEFDHAC: Conférence sur les écosystèmes de forêts denses et humides d'Afrique centrale. Yaoundé, Cameroon
- IUCN (1998) Actes de la 2ème CEFDHAC: Conférence sur les écosystèmes de forêts denses et humides d'Afrique centrale. Republic of Congo, Brazzaville
- IUCN (2001) Regional strategic action plan for the environment and biodiversity resources of the Congo basin ecosystems. Yaoundé, Cameroon
- Jaffré R (2003) La mise en valeur de la forêt. In: Christy P, Jaffré R, Ntougou O, Wilks C (eds) *La forêt et la filière bois au Gabon*. Multipress-Gabon, Libreville, pp 203–274
- Kozar R, Buck LE, Barrow E, Sunderland TC, Catacutan DE, Planicka C, Hart AK, Willemer L (2014) *Toward Viable Landscape Governance Systems: What Works*. EcoAgri-culture Partners, Washington
- La République Gabonaise (2015) *Plan Opérationnel Gabon Vert Horizon 2025: Donner à l'Émergence une trajectoire durable*
- Langston JD, Riggs RA, Kastanya A, Sayer J, Margules C, Boedhihartono AK (2019) Science embedded in local forest landscape management improves benefit flows to society. *Front For Glob Change* 2:3
- Le Flohic G, Motsch P, DeNys H, Childs S, Courage A, King T (2015) Behavioural ecology and group cohesion of Juvenile Western lowland Gorillas (*Gorilla g. gorilla*) during rehabilitation in the Batéké Plateaux National Park, Gabon. *PLoS ONE* 10:e0119609
- Li L, Fassnacht FE, Storch I, Bürgi M (2017) Land-use regime shift triggered the recent degradation of alpine pastures in Nyanpo Yutse of the eastern Qinghai-Tibetan Plateau. *Landsc Ecol* 32:2187–2203
- Margules C, Boedhihartono AK, Langston JD, Riggs RA, Sari DA, Sarkar S, Sayer JA, Supriatna J, Winarni NL (2020) Transdisciplinary science for improved conservation outcomes. *Environ Conserv* 47:224–233
- Medley KE (2004) Measuring performance under a landscape approach to biodiversity conservation: the case of USAID/Madagascar. *Prog Dev Stud* 4:319–341
- Minloll A, Ndikumagenge C (2010) Community based natural resource management land use planning: lessons learned from the CARPE program. In: Yanggen D, Angu Angu K, Tchamou N (eds) *Landscape-Scale Conservation in the Congo Basin: lessons learned from the Central Africa Regional Program for the Environment (CARPE)*. International Union for Conservation of Nature and USAID, Gland
- Morin-Rivat J, Fayolle A, Favier C, Bremond L, Gourlet-Fleury S, Bayol N, Lejeune P, Beeckman H, Doucet JL (2017) Present-day central African forest is a legacy of the 19th century human history. *Elife* 6:e20343
- Nackoney J, Rybock D, Dupain J, Facheux C (2013) Coupling participatory mapping and GIS to inform village-level agricultural zoning in the Democratic Republic of the Congo. *Landsc Urban Plan* 110:164–174
- Noss RF (1983) A regional landscape approach to maintain diversity. *Bioscience* 33:700–706
- Nse Esseng CS (2009) Cartographie participative des zones communautaires riveraines au Parc National des Plateaux Batéké: phase préliminaire paysage Léconi-Batéké-Lefini. Wildlife Conservation Society
- Omoding J, Walters G, Andama R, Carvalho S, Colomer J, Cracco M, Eilu G, Kiyangi G, Kumar C, Langoya CD, Nakangu Bugembe B (2020) Analysing stakeholder perceptions to improve protected area governance in Ugandan conservation landscapes. *Land* 9:207–231
- Opdam P (2018) Exploring the role of science in sustainable landscape management. An Introduction to the special issue. *Sustainability* 10:331
- Opdam P, Luque S, Nassauer J, Verburg PH, Wu J (2018) How can landscape ecology contribute to sustainability science? *Landsc Ecol* 33(1–7):7
- Oslisly R, White L, Bentaleb I, Favier C, Fontugne M, Gillet JF, Sebag D (2013) Climatic and cultural changes in the west Congo Basin forests over the past 5000 years. *Philos Trans R Soc B* 368:20120304–20120304
- Ovono Edzang N (2019) Processus d'amélioration de la gouvernance foncière au Gabon et impact des actions entreprises. *Annales de l'Université de Bangui* 10
- Palang H, Külvik M, Printsmann A, Storie JT (2019) Revisiting futures: integrating culture, care and time in landscapes. *Landsc Ecol* 34:1807–1823
- Potapov PV, Turubanova SA, Hansen MC, Adusei B, Broich M, Altstatt A, Mane L, Justice CO (2012) Quantifying forest cover loss in Democratic Republic of the Congo, 2000–2010, with Landsat ETM+ data. *Remote Sens Environ* 122:106–116
- Pourtier R (1989) *Le Gabon: Tome 1: Espace, histoire, société*. Harmattan, Paris
- Quammen D (2003) Saving Africa's Eden. *Natl Geogr* 203:50–74
- Rainey HJ, Twagirashyaka F (2010) Community-based natural resource management land use planning: lessons learned from the Lac Télé Community Reserve. In: Yanggen D, Angu Angu K, Tchamou N (eds) *Landscape-scale conservation in the Congo basin: lessons learned from the*

- Central Africa Regional Program for the Environment (CARPE). USAID, Washington, pp 142–150
- République Gabonaise (2011) Plan stratégique Gabon Emergent: Vision 2025 et orientations stratégiques 2011–2016 Déclinaison en Programmes et Actions du Projet de Société de son Excellence Ali BONGO ONDIMBA, Président de la République: «'Avenir en confiance». Libreville, Gabon
- Rhemtulla JM, Mladenoff DJ (2007) Why history matters in landscape ecology. *Landscape Ecol* 22:1–3
- Risser PG (1984) Landscape ecology: directions and approaches. Illinois Natural History Survey, Champaign
- Sandker M, Campbell BM, Nzoo Z, Sunderland T, Amougou V, Defo L, Sayer J (2009) Exploring the effectiveness of integrated conservation and development interventions in a Central African forest landscape. *Biodivers Conserv* 18:2875–2892
- Sandker M, Campbell B, Ruiz-Pérez M, Sayer JA, Cowling R, Kassa H, Knight AT (2010) The role of participatory modeling in landscape approaches to reconcile conservation and development. *Ecol Soc* 15:13
- Sandker M, Ruiz-Perez M, Campbell BM (2012) Trade-Offs Between Biodiversity Conservation and Economic Development in Five Tropical Forest Landscapes. *Environ Manage* 50:633–644
- Sautter G (1966) De l'Atlantique au fleuve Congo, une géographie du sous-peuplement. République du Congo, République du Gabon Editions du Centre National de la Recherche Scientifique, Paris
- Sayer JA, Campbell B (2003) Research to integrate productivity enhancement, environmental protection, and human development. IUCN
- Sayer J, Campbell BM (2004) The science of sustainable development: local livelihoods and the global environment. Cambridge University Press, Cambridge, U.K, New York
- Sayer JA, Harcourt CS, Collins NM (1992) Conservation atlas of tropical forests. Macmillan, London
- Sayer JA, Elliott C, Maginnis S (2003) Protect, manage and restore. Conserving forests in multi-functional landscapes, Québec
- Sayer JA, Maginnis S, Laurie M (2005) Forests in landscapes: ecosystem approaches to sustainability. The World Conservation Union, Cambridge
- Sayer J, Campbell B, Petheram L, Aldrich M, Perez MR, Endamana D, Dongmo ZL, Defo L, Mariki S, Doggart N, Burgess N (2007) Assessing environment and development outcomes in conservation landscapes. *Biodivers Conserv* 16(9):2677–2694
- Sayer JA, Endamana D, Ruiz-Perez M, Boedhihartono AK, Nzoo Z, Eyebe A, Awono A, Usongo L (2012) Global financial crisis impacts forest conservation in Cameroon. *Int For Rev* 14:90–98
- Sayer JA, Sunderland TCH, Ghazoul J, Pfund JL, Sheil D, Meijaard E, Venter M, Boedhihartono AK, Day M, Garcia C, Van Oosten C (2013) Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proc Natl Acad Sci* 110:8349–8356
- Sayer J, Endamana D, Boedhihartono AK, Ruiz-Perez M, Breuer T (2016) Learning from change in the Sangha Tri-National landscape. *Int For Rev* 18:130–139
- Schwartz D, Lanfranchi R (1991) Les paysages de l'Afrique Centrale pendant le quaternaire. In: Lanfranchi R, Clist B (eds) Aux origines de l'Afrique Centrale. Centre Culturel Français d'Afrique Centrale; Centre International des Civilisations Bantu, Libreville, pp 41–45
- United States Forest Service (s.d.) Integrated landscape land use planning in Central Africa: A U.S. Forest Service Guide Version 3.0. Washington
- van der Leeuw S, Costanza R, Aulenbach S, Brewer S, Burek M, Cornell S, Crumley C, Dearing JA, Downy C, Graumlich LJ, Heckbert S (2011) Toward an integrated history to guide the future. *Ecol Soc* 16:art2
- Vansina J (1990) Paths in the Rainforest: toward a history of political tradition in Equatorial Africa. James Currey, London
- Walters G (2010) The Land Chief's embers: ethnobotany of Bateke fire regimes, savanna vegetation and resource use in Gabon. University College of London, London
- Walters G (2012) Changing customary fire regimes and vegetation structure in Gabon's Bateke Plateaux. *Hum Ecol* 40:943–955
- Walters G (2015) Changing fire governance in Gabon's Plateaux Bateke savanna landscape. *Conserv Soc* 13:275–286
- Walters G, Dauby G, Stevart T, Lachenaud O (2011) Novitates Gabonensis 80: new additions to the Gabon Flora. *Edinb J Bot* 68:423–442
- Walters G, Parmentier I, Stévar T (2012) Diversity and conservation value of Gabon's savanna and inselberg open vegetation. *Plant Ecol Evol* 145:46–54
- Walters G, Touladjan S, Makouka L (2014) Integrating cultural and conservation contexts of hunting: the case of the Plateaux Bateke savannas of Gabon. *African Study Monographs* 35:99–128
- Walters G, Schleicher J, Hymas O, Coad L (2015) Evolving hunting practices in Gabon: lessons for community-based conservation interventions. *Ecol Soc* 20:31
- Walters G, Fraser JA, Picard N, Hymas O, Fairhead J (2019) Deciphering Anthropocene African tropical forest dynamics: how social and historical sciences can elucidate forest cover change and inform forest management. *Anthropocene* 27:1–7
- Weng L, Boedhihartono AK, Dirks PHGM, Dixon J, Lubis MI, Sayer JA (2013) Mineral industries, growth corridors and agricultural development in Africa. *Glob Food Sec* 2:195–202
- Weng L, Sayer JA, Xue L (2017) Will China redefine development patterns in Africa? Evidence from Cameroon. *Extr Ind Soc* 4:506–512
- West P, Brockington D (2006) An anthropological perspective on some unexpected consequences of protected areas. *Conserv Biol* 20:609–616
- Wiek A, Withycombe L, Redman CL (2011) Key competencies in sustainability: a reference framework for academic program development. *Sustain Sci* 6:203–218
- Wildlife Conservation Society (2009a) Document Stratégique pour l'Elaboration du Plan d'Aménagement et de Gestion Simplifié de la Macrozone CBNRM Plateaux. Paysage Léconi-Batéké-Léfini. Wildlife Conservation Society, Franceville

- Wildlife Conservation Society (2009b) Plan d'Aménagement et de Gestion Simplifié de la Macrozone CBNRM plateaux: Paysage Léconi-Batéké-Léfini
- Wildlife Conservation Society (2009c) Implication des Communautés de Base dans la Mise en Œuvre des Activités du Processus de Gestion des Ressources Naturelles à Base Communautaire des Macrozones CBNRM Ogooué Létili et Plateaux: Paysage Léconi-Batéké-Léfini. Wildlife Conservation Society, Franceville
- Wilks C (1990) La conservation des écosystèmes forestiers du Gabon. IUCN, Gland
- Wu J (2010) Landscape of culture and culture of landscape: does landscape ecology need culture? *Landsc Ecol* 25:1147–1150
- Wu J (2013a) Landscape sustainability science: ecosystem services and human well-being in changing landscapes. *Landsc Ecol* 28:999–1023
- Wu J (2013b) Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop. *Landsc Ecol* 28:1–11
- Wu J, Hobbs R (2002) Key issues and research priorities in landscape ecology: an idiosyncratic synthesis. *Landsc Ecol* 17:355–365
- Yanggen D, Angu Angu K, Tchamou N (2010) Landscape-scale conservation in the Congo Basin: lessons learned from the Central African Regional Program for the Environment (CARPE). International Union for the Conservation of Nature, Gland

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