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Insight, part of a Special Feature on Why does hunting in tropical regions matter?

Managing hunting under uncertainty: from one-off ecological indicators to resilience approaches in assessing the sustainability of bushmeat hunting

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ABSTRACT. Despite the fact that sustainability of bushmeat hunting in tropical areas is of major concern for conservation and development practitioners, we still know very little about how to measure sustainability and how to put in place sustainable bushmeat hunting systems. We review the current limits of traditional methods used to investigate sustainability of bushmeat hunting, discuss the need to incorporate the characteristics of complex systems into sustainability assessments, and suggest how resilience theories could assist in understanding bushmeat sustainability and more effective conservation of wildlife in tropical areas. Traditional methods used to assess the sustainability of bushmeat hunting include demographic models of population growth, one-off biological indicators, population trend methods, harvest-based indicators, and comparisons of demographic parameters between sites. These traditional biological sustainability indices have proved inadequate for measuring the impact of bushmeat hunting because sustainability is treated as a static, binary (yes or no) question, thus ignoring stochastic processes, the inherent variability of natural systems, and the complexity of hunting systems. We suggest that bushmeat hunting systems in tropical areas should be regarded as social-ecological systems in which the impacts of hunting on prey populations are not the only focus. Instead, the analysis of resilience aims at understanding the complex and dynamic relationships between the hunting ground, its resources, the stakeholders, and the different exogenous drivers of change that affect the components of the system at different scales. The main implication of using the resilience theory in the context of bushmeat hunting is the shift from the need to assess stocks with imprecise measures to the incorporation of the uncertainty and stochasticity inherent to complex systems in participatory and adaptive management processes. As such, the resilience analysis provides an unprecedented opportunity for the sustainable use of bushmeat and allows the identification of strategies to strengthen resilience when the system is found to be close to a given threshold, instead of reinforcing fortress conservation.

Key Words: *bushmeat; hunting; resilience analysis; social-ecological systems; sustainability; tropical areas*

INTRODUCTION

Bushmeat consumption, defined as the use of any nondomesticated terrestrial mammals, birds, reptiles, and amphibians harvested for food (Nasi et al. 2008), is a reality in many tropical forest areas. Using data from the end of the 1990s, Fa and Peres (2001) and Fa et al. (2002) suggest that more than 5 million tons of meat feed millions in the Amazon (0.15 million tons) and the Congo Basin (4.9 million tons) forests annually. Bushmeat is a crucial source of food and income in Central Africa, where the population is also among the poorest in the world, with a mean annual income of US$583 for 104 million people (UNESCO 2006). Although bushmeat consumption appears less important in South America (Rushton et al. 2005), it is of particular cultural importance for indigenous people as well as a key element along with fish in protein diversification (Sirén et al. 2013).

Bushmeat has been in the spotlight because of the generally agreed-upon assumption that hunting in tropical forest regions is unsustainable and that overhunting leads to "empty forests" (Redford 1992). Therefore, bushmeat hunting has been compared with domestic meat a symbol of anachronism, backwardness, and inefficiency, just as slash-and-burn agriculture is perceived in comparison with permanent modern agriculture (Mertz 2009). Research in the past three decades has seen a substantial increase of peer-reviewed papers addressing hunting sustainability (Swamy and Pinedo-Vasquez 2014). Often, a "chronicle of a death foretold" is regularly expressed, based on hunter-prey indicators that ultimately predict that game populations are destined to disappear under current levels of hunting. However, just like the bumblebee,[1] most hunted species continue to survive despite scientific predictions announcing their extinction since the late 1990s. Similarly the demise of bushmeat use did not take place, despite regulations and pressure from western civil society, even where alternatives exist. In fact, a plethora of bushmeat hunting sustainability measurements in tropical areas have been published (around 628), of which only one third suggests unsustainable harvesting rates (Weinbaum et al. 2013).

However, Milner-Gulland and Akçakaya (2001:686) observed that indicators most commonly used to evaluate the sustainability of wildlife hunting "do not perform well under realistic conditions." More specifically, Weinbaum et al. (2013), in a systematic review of empirical sustainability assessments, highlighted both the uncertainty and lack of uniformity in sustainability science. However, since the early 2000s, several authors have referred to the need to consider factors such as spatial and temporal variability, multispecies systems, social and governance drivers, and multiple-scale processes in assessing hunting sustainability. However, because these innovations have arisen separately, there is an important need to bring all these ideas together to estimate the sustainability of bushmeat hunting with the complexity of those social-ecological systems taken into account. The global extent of bushmeat hunting, the role of wildlife underpinning human food security in many tropical areas, and current defaunation threats to bushmeat species, which are not necessarily attributed to hunting alone, highlight the need for appropriate sustainability approaches to monitor conditions for sustainable harvest and trends of harvested bushmeat species.

We highlight the limits of classical methods used to assess bushmeat hunting sustainability, discuss the need to incorporate characteristics of complex systems into sustainability assessments, and suggest how resilience theory could help us

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understand bushmeat sustainability in tropical areas. We then discuss implications of this theoretical shift for research and more efficient conservation in practice.

LIMITS OF APPROACHES CLASSICALLY USED TO MEASURE THE SUSTAINABILITY OF HUNTING

Methods classically used over the last decades to assess hunting sustainability are demographic models of population growth, one-off biological indicators, population trend methods, harvest-based or market-based indicators, and comparisons of demographic parameters between sites (Weinbaum et al. 2013). In tropical areas, a diversity of methods has been used to assess hunting sustainability (Weinbaum et al. 2013). Authors have used (1) comparisons of hunting offtake over time (Hill et al. 2003, Baker et al. 2004, Fa et al. 2005, Kümpel et al. 2010); (2) comparisons of prey abundance and age structure between hunted and nonhunted sites (Cullen et al. 2000, Hart 2000, Hill and Padwe 2000, Mena et al. 2000, Noss 2000, Peres 2000, Lahm 2001); or (3) trends in species composition of the catch at village or market level (Cowlishaw et al. 2005, Albrechtsen et al. 2007, van Vliet et al. 2012, Coad et al. 2013). Most of these anachronic studies are based on the comparison of two, or at best three, points in time, which is likely insufficient to diagnose unsustainability, and available synchronic studies have limitations given the difficulties in controlling for other influencing factors such as habitat type, landscape context, and social-economic characteristics. Others have used one-off biological indices: Robinson and Redford's model (1991), the Unified Harvest Model (Bodmer et al. 1994), and the Stock Recruitment Model (Milner-Gulland and Akçakaya 2001). The most commonly used of these indicators in tropical hunting systems is the one proposed by Robinson and Redford (1991). This indicator uses literature- or field-based values of a target species' carrying capacity and intrinsic population growth rate to calculate a maximum annual production, a fraction of which is then taken to be the species' maximum sustainable yield (MSY), with the fraction being dependent on the life span of a typical individual (Levi et al. 2011). The harvest model of Robinson and Bodmer (1999) follows a similar approach, using empirical estimates of local game species densities and calculating a sustainable offtake from the expected annual fecundity. In Central Africa, out of 17 publications dealing with estimations of hunting sustainability for duikers (*Philantomba* and *Cephalophus* spp.), 13 used the Robinson and Redford model (van Vliet and Nasi 2008). Key to the use of these indicators is our capacity to estimate offtakes, prey stocks, and the relevant biological parameters (e.g., age at first/last reproduction, fecundity rates), which will together determine productivity.

Although this approach is based on quick and simple algorithms that provide estimates of sustainability, there is now widespread agreement that this model is plagued with different levels of errors (Milner-Gulland and Akçakaya 2001, van Vliet and Nasi 2008, Weinbaum et al. 2013). In addition, the indices are applied under the assumption that exploited populations are isolated and, in most instances, that the prey base consists of a number of different species (Rowcliffe et al. 2003). Such sustainability indicators have been shown to be inadequate for measuring the impact of hunting because sustainability is treated as a static, binary (yes or no) question, with the result being sensitive to the arbitrary choice of the size of the catchment area (Levi et al. 2009). In a sustainable system, half of a random sample of sustainability indicator evaluations would indicate unsustainability because of stochastic processes (Ling and Milner-Gulland 2006). Milner-Gulland and Akçakaya (2001) and van Vliet and Nasi (2008) showed that the major problems related to the use of simple biological indicators are paucity of available biological data even for the most common species and the difficulty of collecting data needed for a full sustainability assessment. Several authors have suggested that models for calculating sustainable harvest may produce conservative estimates (Alvard et al. 1997, Robinson and Bodmer 1999, Noss 2000, Novaro et al. 2000) and report levels of harvest above sustainable values, yet these levels have been maintained or increased over time with no sign of population depletion (Salas and Kim 2002). Moreover, the use of one-off sustainability indicators requires extensive fieldwork that must be repeated for each new study site if quantitative measures of game offtake or animal stocks are to be obtained (Robinson and Bodmer 1999, Sirén et al. 2004, Ohl-Schacherer et al. 2007, Smith 2008). Even ignoring these caveats, sustainability assessment via simple biological indicators based on the MSY assumption cannot be used to project the impact of hunting into the future, nor to visualize or quantify the distribution of hunting impact over space.

INCORPORATING COMPLEXITY IN SUSTAINABILITY ASSESSMENTS OF BUSHMEAT HUNTING

Besides the uncertainty caused by inherent variability of natural systems and arising from our methodological shortfalls in measuring the relevant parameters, there is an additional level of uncertainty that reflects our ignorance of the complexity of natural systems (Milner-Gulland and Akçakaya 2001). Theories of complex systems portray them not as deterministic, predictable, and mechanistic, but as process-dependent organic ones with feedbacks at multiple scales (Holland 1995, Levin 1999). Bushmeat hunting needs to be considered as a complex social-ecological system.

Dynamic systems: the importance of spatial and temporal heterogeneity

One difficult issue to address with simple biological indicators, but one that is increasingly recognized as crucial for the sustainability of bushmeat hunting, is the influence of spatial and temporal heterogeneity. The emergence of geographic information systems has allowed spatial effects in natural resource management to be taken into account. Studies on sustainable hunting using spatially explicit individual-based models (Novaro et al. 2000, Salas and Kim 2002, van Vliet et al. 2010) have tested the role of landscape structure and dispersal characteristics that might influence the sustainability of hunting. Salas and Kim (2002) suggest that spatial factors, e.g., the shape of the hunted area and the size of the population in surrounding areas, are important in determining the harvest sustainability. Novaro et al. (2000) found that dispersal has a key role in rebuilding animal populations depleted by hunting. Thus, variables such as spatial distribution and size of areas with or without hunting, population size in source areas, and social behavior must be considered when evaluating sustainability of bushmeat hunting in heterogeneous areas with spatially and temporally variable hunting pressure (Novaro et al. 2000). Ling and Milner-Gulland (2006) and Bousquet et al. (2001) consider the animal-hunter couple as a dynamic system governed by the responses of hunters as well as the population dynamics of prey. van Viet et al. (2010) show that the impact of hunting on prey populations depends on the spatial heterogeneity of hunting and the biological parameters of prey species, e.g., dispersal rate and territory size, which determine prey distribution at small scales within a hunting area. As such, detailed knowledge of species ecology and behavior, and of hunting practices, is crucial to understanding the distribution of potential sinks and sources in space and time. Levi et al. (2011) developed a method that can project the spatial human foraging model in a dynamic way according to prey availability, profitability, and presence of alternative sources of protein or income.

Hunting systems are necessarily connected to society

The only social parameter taken into account in simple biological models is the level of hunting offtakes. The sustainability of hunting depends not only on the stocks available and their dynamic, but also on the social component of the system, which goes beyond hunting offtake levels. Indeed, the levels of hunting and hunting patterns are highly influenced by a range of social drivers that influence hunter decision making. The sustainability of bushmeat hunting is closely related to the spatial and temporal variation of offtakes, mostly determined by cultural drivers, cash needs, and the combination with other economic activities (as shown by van Vliet et al. 2010), bushmeat markets and prices (Damania et al. 2005, Ling and Milner-Gulland 2006), habitat changes and deforestation in hunting grounds (Iwaruma et al. 2013), demographic changes and changing livelihood opportunities (Coad et al. 2013), and household size and time spent at the village (Nuno et al. 2013).

Hunters' behavior is highly influenced by motivations for hunting. Recent efforts have been made to understand the multiple functions of hunting (Fisher et al. 2013) and the multiple connections of bushmeat hunting with social, cultural, and economic aspects (Nasi et al. 2008). Hunting is an important component of peoples' livelihoods in rural areas (Brown 2003, van Vliet and Nasi 2008, Coad et al. 2010) and contributes to local economies through active bushmeat markets at national (Fa et al. 2000, van Vliet et al. 2012) and international (Chaber et al. 2010, Bair-Blake et al. 2014) levels and through the sport hunting business (Lindsey et al. 2007). Bushmeat is also important for people's nutrition and food security (Wilkie and Godoy 2001, Wilkie et al. 2005, Kümpel 2006, Sirén and Machoa 2008, Fa et al. 2009, Golden et al. 2011) and contributes to enhanced cultural identity (van Vliet and Mbazza 2011, Sirén 2012, Walters et al. 2014). However, this knowledge is not yet properly taken into account in sustainability analyses.

Because sustainable bushmeat hunting needs to address the multiple needs and desires of societies without jeopardizing the options for future generations to benefit from the full range of goods and services provided by tropical forests, sustainability needs to be understood within its three main pillars: economic, ecological, and social sustainability (Gibson et al. 2006). Sustainability hinges on the feedbacks and balances between social and ecological systems, and should be investigated within a holistic framework (Ostrom 2007). Simplistic efforts that only measure sustainability with an ecological lens, ignoring important determinants of human behavior (Peterson 2000), will generate management recommendations that are inadequate or open to misuse (Ludwig et al. 1993, Gunderson 1999).

Drivers of change: the bushmeat hunting system nested in a wider context

The hunting system cannot be considered in isolation, because it is influenced by a variety of drivers that impact on hunter and prey behavior and population dynamics. These drivers vary according to locations and contexts, and include governance drivers (e.g., conflicts, institutional change), economic drivers (e.g., availability of other sources of income and food, infrastructure investments increasing access to markets), social drivers (e.g., migration, urbanization, displacement), and ecological drivers (e.g., climate change, climatic hazards, habitat degradation, land cover change). Lindsey et al. (2012) have listed the drivers of bushmeat hunting in savanna areas as follows: (1) increasing demand for bushmeat; (2) lack of clear rights regarding land and wildlife; (3) inadequate legal protection for wildlife, and inadequate enforcement and penal systems; (4) poverty and food insecurity; and (5) political instability. Further, the emergence of market-based economies and the commercialization of bushmeat in urban centers have increased demand for bushmeat through commodification and exportation (Brashares et al. 2011). Other drivers include disease control, wildfires, weather, crop scarcity, cultural preferences, lack of environment education, and crop destruction (Nyaki et al. 2014). Some of these drivers operate at a local scale, but other operate at national, regional, and even international scales. Unfortunately, current approaches do not take the diversity of drivers and their interrelated links into account to assess the sustainability of hunting.

RESILIENCE ANALYSIS THEORIES TO UNDERSTAND THE SUSTAINABILITY OF HUNTING

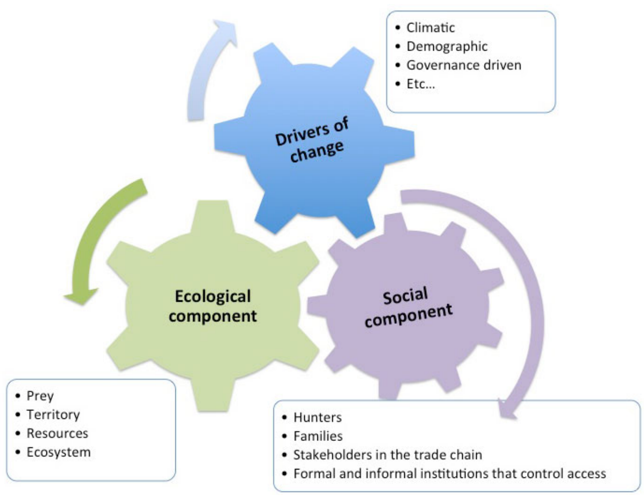
The hunting system considered as a social-ecological system

Hunting systems may be understood as social-ecological systems as defined by Gallopin et al. (1989). The concept of a social-ecological system reflects the idea that human action and social structures are integral to nature and hence any distinction between social and natural systems is arbitrary (Berkes and Folke 1998). Natural systems refer to biological and biophysical processes, whereas social systems are made up of rules and institutions that mediate human use of resources as well as systems of knowledge and ethics that interpret natural systems from a human perspective (Berkes and Folke 1998). In the context of hunting, the ecological system includes prey species, the ecosystems that support them, and the ecological processes and interactions between prey, their territories and resources, and the different components of the ecosystems in which they live (Fig. 1). The social component of the hunting system corresponds to the hunters, their behavior and choices in relation to their families, the rest of the trade chain and the formal or traditional institutions that regulate their activities, and different interactions and feedback loops between those stakeholders.

The theory of resilience in the context of bushmeat hunting systems

When considering the bushmeat hunting system as a social-ecological system, the focus is no longer on the impacts of hunting on prey populations, but rather on the resilience of the whole system, which means the capacity of the system to adapt to changes and continue to develop on the current pathway or transform into new pathways. The analysis of resilience aims at understanding the complex and dynamic relationships between the hunting ground, its resources, the stakeholders in play, and the different exogenous drivers of change that affect the components of the system. The main implication of using the resilience theory in the context of bushmeat hunting sustainability assessments is the shift from the need to assess stocks with imprecise measures of variables to the incorporation of the uncertainty and stochasticity inherent to complex systems. Another important shift is the recognition that systems evolve over time, adapt, and transform. In other words, the possibility that a hunted system can be different from an unhunted one is acknowledged and does not produce any emotional conclusions as long as the system is able to develop, adapt, and transform without losing its main functions.

Fig. 1. Theoretical representation of the social-ecological hunting system.



IMPLICATIONS FOR RESEARCH AND PRACTICE

Implications for research and bushmeat hunting sustainability assessments

The main implication of changing the theoretical understanding of hunting systems is that one-off biological indicators are no longer useful for the estimation of sustainability. Other methodologies that integrate complexity need to be sought. These include theoretical models that integrate complexity such as agent-based models, companion modeling approaches, fuzzy cognitive mapping, and resilience analysis tools, among others.

Spatially explicit multiagent-based models are particularly adapted to the understanding of bushmeat hunting sustainability (Bousquet et al. 2001, van Vliet et al. 2010, Iwaruma et al. 2013). Agent-based models are a class of computational models for simulating the actions and interactions of autonomous agents, both individual and collective entities such as organizations or groups, with a view to assessing their effects on the system as a whole. These models combine elements of game theory, complex systems, emergence, computational sociology, multiagent systems, and evolutionary programming (Grimm et al. 2005). Most agent-based models are composed of (1) numerous agents specified at various scales, (2) decision-making heuristics, (3) learning rules or adaptive processes, (4) an interaction topology, (5) a spatial environment, and (6) scenario building.

To support collective decision-making processes in complex situations, participatory models for decision making such as the companion modeling approaches may be particularly useful (Barreteau et al. 2014). The approach facilitates collective decision-making processes by making more explicit the various points of view and subjective criteria to which the different stakeholders refer implicitly. Indeed, as demonstrated in past research (Mermet 1992, Weber and Reveret 1993, Ostrom et al. 1994, Funtowicz et al. 1998), when a complex situation exists, the decision-making process is evolving, iterative, and continuous. This process always produces imperfect "decision acts," but following each iteration they are less imperfect and more shared. In other words, the question is not the quality of the choice, but the quality of the process leading to it. Participatory scenario planning allows the description of how the future might unfold on the basis of coherent assumptions about the relations among drivers of change and key aspects of the system. The method also allows the participation of a great diversity of stakeholders.

Fuzzy-logic cognitive mapping (FCM) is a simple and easy form of graphical stock-and-flow modeling that allows groups to share and negotiate knowledge collaboratively and build semiquantitative conceptual models. FCM facilitates the explicit representation of group assumptions about a system being modeled through parameterized cognitive mapping (Gray et al. 2014). Specifically, FCM allows cognitive maps to be constructed by defining the most relevant variables that constitute a system, the dynamic relationships between these variables, and the degree of influence, either positive or negative, that one variable can have on another. In group settings, FCM models are constructed based on combining group beliefs in a similar format as individuals share their experiences and understanding (Gray et al. 2014). The strength of using FCM in this context is the ability to extract, combine, and represent group knowledge in a sensitive situation for comparison between or among groups. Nyaki et al. (2014) used FCM to understand the drivers of bushmeat trade in four Tanzanian villages bordering Serengeti National Park.

The resilience assessment workbook (Resilience Alliance 2010) may also be useful to provide insight into developing strategies for buffering both known and unexpected change in hunting systems. The workbook was developed by Resilience Alliance to apply resilience thinking (Walker et al. 2002). It is the only social-ecological research initiative that operationalizes resilience for practitioners, and following its first release in 2007 it has been applied in multiple contexts around the world (Resilience Alliance 2013). It has been primarily applied in natural resource management contexts (Peterson et al. 2003, Bennett et al. 2005, Biggs et al. 2012) and more recently in urban planning (Sellberg et al. 2015), but it has never been used in the context of bushmeat hunting. The resilience assessment workbook guides researchers and practitioners in identifying the focal social-ecological system, describing threats and the impacts of those threats, and identifying the current and new strategies to strengthen the resilience of the system. The resilience assessment framework also guides the identification of potential thresholds that represent a breakpoint between two alternative system states and helps reveal what is contributing to or eroding system resilience.

Implications for sustainable bushmeat use in practice

One of the major practical implications of shifting the theoretical focus toward resilience analysis when assessing the sustainability of bushmeat hunting is that it explicitly allows for sustainable use options. Traditional one-off biological models, based on a binary yes/no question, did not allow for understanding how to bring the system back to sustainability in case the answer was no. When the answer was no, the response was to ban hunting, reinforcing the "fences and fines" approach, or fortress conservation, which seeks to protect wildlife by prohibiting its use through legal prohibitions on use across the landscape. In contrast, the resilience theoretical focus provides the opportunity for sustainable use and allows the identification of strategies to strengthen resilience when the system is found to be close to a given threshold. The resilience approach recognizes the benefits that bushmeat use generates for people, particularly those indigenous and local people who live with wildlife, bear any associated costs (e.g., danger to life, damage to crops, restrictions on land use), and often play a de jure or de facto stewardship role (Cooney and Abensperg-Traun 2013).

The resilience approach to sustainability also highlights the importance of participatory processes in assessing the current status of the system and in finding the strategies to strengthen the resilience of the system. In contrast to the command-and-control approach, resilience thinking incorporates the diverse views of stakeholders, their different value systems, and different knowledge sources (e.g., experimental or scientific knowledge, experiential or local ecological knowledge) to govern complex adaptive systems. To achieve its goal, the process needs to foster the engagement of stakeholders in real participatory processes, enhancing communication among decision makers, managers, and bushmeat users. As a result, resilience approaches recognize the presence of multiple objectives, design mechanisms for incorporating them, weigh trade-offs, and establish conflict resolution mechanisms that are fair to all parties. Identifying areas of agreement and disagreement between actors helps in understanding and overcoming obstacles between them. The resilience approach provides insights about the perceived probability of particular outcomes from ongoing and potential interventions and people's willingness to accept these outcomes (Biggs et al. 2011).

Last but not least, the resilience approach introduces the need to adopt an adaptive management process, which embraces uncertainties. In more classic forms of management, precautionary principles were put forward, interpreting precaution as the need to avoid impacts until bushmeat stocks are estimated with precision and risks are measured. These interpretations can place high and unnecessary short-term costs on society. Many lessons can be learnt from the fisheries, where the practical challenge of giving advice when evidence is uncertain was solved by moving toward a better quantification of uncertainty, rather than trying to quantify stocks of dynamic and dispersing species (Getz and Bergh 1988). Recent experiences of adaptive management in temperate hunting systems can also provide inspiration for the sustainable use of bushmeat in tropical areas (Fiorini et al. 2011, Hunt 2013, Carter et al. 2014, Brown et al. 2015). Weinbaum et al. (2013) suggest that learning how to manage under uncertainty is fundamental to achieving sustainable bushmeat hunting and requires putting in place efficient monitoring processes. The creation of participatory monitoring systems often triggers a process of collective action, which can be included in any strategic action aimed at managing bushmeat resources (Garcia and Lescuyer 2008). The hypothesis stating that the information generated by the system is inserted into the decision-making process so as to approach sustainability is only possible when resource management is completely decentralized and when a direct link is established between the monitoring results and the management decisions taken (Garcia and Lescuyer 2008).

CONCLUSIONS

We believe the hunting system should be considered as a complex social-ecological system in which the sustainability of bushmeat hunting is understood as the capacity to address the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by bushmeat and tropical forests as a whole. For sustainability assessments, the implications of the interpretation we present include changing the focus from seeking optimal states and the determinants of MSY (the MSY paradigm) to resilience analysis, adaptive resource management, and participatory governance (Walker et al. 2004). The resilience perspective shifts policies from those that aspire to control change in systems assumed to be stable to managing the capacity of social-ecological systems to adapt to and shape change (Berkes et al. 2003, Smit and Wandel 2006). Such an approach allows movement toward an understanding of conservation that recognizes the fundamental convergence of wildlife conservation and human well-being through a more sophisticated framework that embraces uncertainty and is sensitive to value pluralism and complexity in social-ecological systems. The approach also requires a full appreciation of trade-offs and consideration of biological, social, and cultural values.

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[1]"Recent studies have shown that, with the aerodynamics of the bumblebee it is impossible for him to fly, given the relationship between the area of its wing and its corporal mass. But the bumblebee doesn't know it and keeps flying"—Igor Ivanovitch Sikorski.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7669

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