The role of Protected Areas in supporting human health: a call to broaden the assessment of conservation outcomes

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Abstract

Ongoing global biodiversity loss has far-reaching consequences for human health and well-being. While Protected Areas (PAs) have become a major policy instrument for biodiversity conservation, their role in supporting human health remains unclear. Here, we synthesize both positive and negative aspects of PAs on different dimensions of human health and provide several theoretical advances to assess the effectiveness of PAs in promoting human health. We finally identify three major research gaps requiring urgent attention. Implementing an interdisciplinary research program remains a priority to better comprehend the linkages between human health, ecosystem services and conservation policies at global scale. We believe this is key to improve the management of PAs and their surrounding areas and foster co-benefits for biodiversity and human health.

Keywords

Conservation; Ebola; Food Security; Human health; Protected Area Effectiveness.

Highlight

- Global biodiversity loss impacts human health and well-being
- The overall health potential of PAs remains under-recognized
- PAs have both positive and negative effects on human health and well-being
- Integrated approaches linking PA management, health and well-being are required
- In view of Aichi Target 11, we need to assess the linkages between PAs and health

Linkages between environmental degradation and human health

Global biodiversity is decreasing at unprecedented rates, as a result of a wide range of anthropogenic activities [1,2,3]. Such planetary-scale transformations erode the ecosystem services on which society relies, posing numerous threats to human health [2,3]. Epidemiological studies have argued that a significant proportion of the global burden of illness is attributable to degraded ecosystems [4]. In this context, several policy instruments have been developed to bridge environmental and health policy agendas. For example, the notion that ecosystem health and human well-being are mutually reinforcing (Box 1) is increasingly being picked up by several international health strategies such as *OneHealth* [5] or *Planetary Health* [6**]. Similarly, the importance of biodiversity for human well-being is a core element of the United Nations Sustainable Development Goals.

Environmental change and biodiversity loss have been shown to affect existing health burdens, increasing food insecurity and annihilating rates of human development [7,8]. As a case in point, the decline in the availability of fish stocks is expected to spell malnutrition in many countries [9]. Furthermore, according to the "biodiversity hypothesis", reduced contact of people with natural environments leads to inadequate stimulation of immunoregulatory circuits. Declining biodiversity in an increasingly urbanized world may thus explain the global rise in the prevalence of allergies and chronic inflammatory diseases [3]. Rapid population growth, land-use change and increasing overlap between human and wildlife populations are also related to the recent spread of zoonotic and vector-borne diseases [10]. Finally, there is increasing evidence that degraded ecosystems also affect mental health [11].

Biodiversity-health linkages have often been explored by looking at ecosystem service flows (e.g., water provision) at multiple scales [4,12**], but rarely taking PAs as a leading analytical unit. Consequently, the health outcomes of PAs have been largely overlooked. Calls for increasing the coverage of PAs have resulted in growing research addressing their performance in halting biodiversity loss and securing ecosystem services, with overall positive (albeit modest) outcomes

[16]. This scholarly work is gradually broadening its analytical scope to link PAs with larger debates on human health and wellbeing [17*]. Yet, a substantial share of the research has focused on examining predominantly the negative impacts of PAs on human health. This is partly because conservation planning is inherently spatial, often segregating people from nature and undermining the well-being of Indigenous Peoples and Local Communities (IPLCs) living close to PAs [13]. Such potential negative impacts of PAs on human well-being were recognized in the Convention on Biological Diversity, asserting that PAs should not harm the well-being of IPLCs [14**]. Along these lines, the Conceptual Framework of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) explicitly incorporates the notion of "good quality of life" in the analysis of institutional arrangements for biodiversity governance [15].

In the following section, we review the contributions of PAs to human health and well-being from a diversity of angles.

Do Protected Areas support human health?

Despite increasing awareness of the inter-linkages between nature and human health (Box 1), the overall health potential of PAs remains under-recognized. The few case-based studies assessing the impacts of PAs on human health have been addressed in different strands of literature, with distinct theoretical and methodological frames. For instance, while some of the works focus on biophysical indicators, most of them rely only on notions of subjective well-being or good quality of life [14**], with few works integrating health and well-being outcomes (Fig. 1).

A first body of literature has examined the effectiveness of PAs in delivering ecosystem services with direct health benefits that would have potentially been eroded had the PAs not been established [18,19]. For example, it has been shown that nearly two-thirds of the global population relies directly on PAs for freshwater provision [20]. Similarly, several studies have demonstrated the role of PAs in providing pollination services for food production [21] or in contributing to air purification and temperature regulation [22]. Many works have also underlined the positive role of PAs in conserving medicinal plants that sustain both local and global pharmacopeias [23], or the numerous recreational services provided by PAs, promoting healthy lifestyles [24].

In contraposition to this literature, some works have focused on examining the health impacts of PAs in the light of ecosystem disservices [25]. Under the idea that “nature sometimes kills us”, this literature argues that IPLCs often carry a disproportionate burden of the health risks derived from living close to PAs [26*]. Some of these ecosystem disservices include the spread of vector-borne diseases [27], animal attacks on humans living close to PAs [28], or lower food security through the destruction of crops by wildlife [29].

Precisely, research on social aspects of conservation has also looked at the impact of some PAs upon nutrition, showing that displacements of IPLCs and restrictions to resource extraction have often resulted in increasing food insecurity and malnutrition [30,31] Although the research on PAs and nutrition is not particularly comprehensive [32], some works have shown that closing off forests to IPLCs through strict regulations generally leads to reduced food supply and nutrition deficits, e.g., anemia [33*,34].

However, other studies have also shown PAs under some circumstances can contribute to alleviate malnutrition, by maintaining stocks of wild food to later be harvested beyond PA boundaries [35,13]. With most evidence confined to marine environments, this literature has shown that strict PAs may enhance local nutrition and health by rebuilding wildlife stocks, improving catch rates outside PAs and helping local people to meet their dietary requirements [36,37]. As for terrestrial ecosystems, some authors have showed that children stunting is lower close to PAs in the Congo Basin [38]. Moreover, it has also been discussed that the establishment of PAs often introduces new livelihoods that can result in positive health effects through PA-related income [13,39]. As a consequence, there is debate on whether the net impact of PAs on local people’s nutrition is positive or negative [14**].

Part of this debate is arguably explained by the distinct health effects of PAs under different management categories [17*]. Moreover, with the establishment of new PAs promoting co-management, agrobiodiversity or sustainable production systems in the PA periphery, the potential of PAs to improve food security should not be under-stated [40,41].

Arguably the most well-researched aspect of the link between PAs and health is their effects on psychological well-being [11,14**]. Research has shown the restorative capacity of PAs and their role in fostering recovery from mental fatigue, reducing stress levels, assisting cognitive functioning, and improving the overall psychological state [32,42]. Interestingly, these psychological benefits have been shown to be higher in areas of greater biodiversity [43,44]. Recent research on nature-based tourism has documented that visiting PAs often results in increased wellbeing [45]. Indeed, there is increasing understanding of the positive health outcomes of PAs, with the Australian program "Healthy Parks, Healthy People" being one of the most paradigmatic examples of this trend [11].

Nevertheless, evidence on the impacts of PAs on the well-being of IPLCs is still contentious. While there are works showing how conservation has improved the health status of many IPLCs near PAs [14**,39], the opposite also holds true. Due to the colonial legacy of conservation (e.g., displacement and exclusion), there are numerous cases in which the establishment of strict PAs has contributed to higher levels of psychological distress and mental illness amongst IPLCs [46,47]. While many IPLCs indeed find spiritual connections with nature as a source of wellbeing [48], the psychological implications of exclusionary PAs are significant.

Finally, an emerging body of literature is trying to assess the role of PAs in relation to Emerging Infectious Diseases (EIDs). PAs shape many socio-ecological factors related to disease prevalence, including land-use, biodiversity, and socioeconomic conditions [49,50]. Hence, PAs may drive disease prevalence by influencing vector and host presence and by controlling human exposure to vector species (Box 2). For instance, it is known that deforestation and hunting in non-protected areas disrupt ecological communities with positive knock-on effects on mosquito populations (e.g., through predation release, improved breeding habitat or increased abundance in dead-end hosts; [10]).

However, there is debate on the pathways through which PAs shape the distribution of infectious diseases (e.g., malaria). While some authors have discussed that PAs could reduce malaria risk by decreasing human exposure to anopheline breeding habitats [51], others have argued that PAs actually favor higher exposure to malaria [52]. At the same time, other works have emphasized that PAs could reduce malaria prevalence through improved socio-economic conditions [53]. Such contradictory findings are partly explained by different methods and datasets at various spatio-temporal scales, with certain confounding factors largely unaddressed. As a result, evidence on the role of PAs in shaping EIDs dynamics remains inconclusive. Moreover, and although positive cases of co-benefits between biodiversity conservation and disease control exist, it is noteworthy that the complex effects of PAs on EIDs vary with disease ecology, PA management categories and landscape attributes at various spatio-temporal scales [51,54].

Need for systematic integrative approaches

With progress to achieve Aichi Target 11 of protecting at least 17% of terrestrial and 10% of marine areas globally by 2020, assessing the role of PAs in supporting human health remains paramount. Yet, such role cannot be directly extrapolated from studies on the health benefits of nature, given that PAs, as organizational units embedded within certain socio-political contexts, inevitably alter human-nature interactions [55]. Responding to recent calls to improve our knowledge of the role between PAs and human health and well-being [14**], we integrate developments from different research fronts with the aim of bringing forward the discussion and stimulate new analytical approaches.

Assessments of the social impacts of PAs should acknowledge different dimensions of human health and well-being (Box 1). The evidence to date on positive and negative aspects of PAs derives from an heterogeneous sample of studies addressing very specific aspects of health, which have been often conducted opportunistically and mostly lacking robust study designs and/or baseline measures [14**], thus not allowing to guide policy actions. Yet baseline data exists for a number of health indicators globally, and different long-term health monitoring schemes are being promoted in the vicinity of many PAs. Examples include USAID's Health Survey Data, the World Bank's Living Standards or the database of the Poverty Environment Network [14**,56], all of which could potentially be analyzed from a PA perspective. Similarly, in countries such as Canada or Australia large amounts of indigenous health data exist [57], some of which have been collected near PAs. There are also numerous PAs with health monitoring programs in neighboring local communities. Such datasets could serve a purpose in furthering our understanding of the linkages between PAs and health. Yet, the establishment of monitoring networks that include simultaneous measures of both aspects of PA effectiveness (ecosystem and human health) should be a priority.

PA impacts on health may be direct or indirect, *in situ* or *ex situ* (Figure 2, Panel A). Given that the core areas of PAs are generally uninhabited, most health impacts are expected at the PA periphery. Yet, some of them take place at larger scales. For instance, the rising numbers of tourists visiting PAs challenge the assessment of health impacts only at the local level, but also raise important questions on "whose health" is being evaluated. Research on the links between PAs and health should ideally account for both local and non-local impacts, avoiding biased samples (only surveying tourists) that serve certain political or economic agendas. Moreover, it is also important to evaluate the role of PAs in supporting future health. For instance, many PAs conserve plants underpinning the future provisioning of medicines for both local and prospective global uses [58]. Assessments of the linkages between PAs and health should thus find a balance between the health prospects of both present and future generations.

Along these lines, it is crucial to recognize that health is also dependent on the socio-economic context. Socio-economic factors are known to affect the conservation effectiveness of PAs [59]; yet, they are rarely considered when evaluating PA impacts on health or well-being. Aspects such as PA permeability have been also argued to impact health [54]. For example, strict PAs (IUCN Category I) will have different impacts than PAs with sustainable use of natural resources (Category VI). PA size and isolation will also play an important role. Panel B in Figure 2 illustrates a few alternative settings of PAs varying in governance type, size and isolation, particularly due to land-use changes at the PA periphery. Here we deliberate on the potential health consequences of such scenarios, while stressing that empirical evidence is largely lacking and that analytical approaches accounting for PA attributes are urgently needed.

PAs of Type A (i.e., small size, strict protection and highly degraded periphery) have often induced exclusion of IPLCs (through restrictions on resource use), undermining food security and well-being [35,60**]. Malnutrition increases immunity deficiency and susceptibility to infection. IPLCs living in degraded PA peripheries are thus potentially more vulnerable to zoonotic and vector-borne diseases, following changes in the distribution of vector species. Potential benefits associated to Type A would be contingent on infrastructure development and poverty alleviation initiatives, which should be rarer for small areas of strict protection compared to Types B and C. Such developments could bring about improvements in healthcare delivery; yet, these are unlikely to counterbalance most health costs.

Types B and C may instead lead to more co-benefits for both health and biodiversity. Increased PA size associated to sustainable resource extraction either within Type B or within the buffer zone of Type C would decrease health costs associated to alienation and malnutrition, while incomes from tourism could bring livelihood diversification and poverty alleviation in the periphery (Type B, Fig. 1). From the perspective of EIDs, the evidence is still inconclusive, and outcomes may well be disease-dependent as well as context-specific (Box 2). Yet, we expect that large core areas of strict protection surrounded by sustainable-use peripheries (Type C), would decrease the probability of EIDs expansion, while best conserving species and habitats. In this case, a well-managed buffer zone would hold a significant portion of semi-natural habitats allowing for sustainable use by IPLCs, with benefits in terms of livelihoods, nutrition and well-being.

Future research directions

While research on the linkages between human and ecosystem health grows, this review stresses an urgent need to address specifically the role of PAs in supporting human health. In this review, we have identified important research gaps that preclude us from developing a clear picture of the overall health effects of PAs. These include among others: i) integration and comparison of the heterogeneous set of health dimensions, ii) a comprehensive overview of different human population targets for health assessments (i.e. whose health is being evaluated; within and beyond PAs), and iii) a context-dependent analytical framework incorporating spatial, environmental and socio-economic factors (including PA management types). Additionally, while studies on the effectiveness of PAs in safeguarding biodiversity are becoming ever more common, we are not aware of any single study linking effectiveness of biodiversity conservation with health outcomes. Research at all these fronts will shed light into many ongoing debates, and be able to clarify why some PAs may promote health while others not.

In order to tackle the abovementioned gaps, we highlight that tools and datasets are already available to support substantial advances, while others need yet to be implemented. For instance, many of the health monitoring databases mentioned above could be used to develop a more integrated overview of the health impacts of PAs. Similarly, diverse large-scale environmental, geographical and socio-political datasets can already be linked to disentangle the effects of particular health indicators in different contexts. Research systematically comparing the health outcomes of PAs under different management categories is particularly called upon and a straightforward step given the available data.

At finer scales, emphasis should be placed on buffer zones around PAs in order to disentangle the complex linkages between land-use change, natural resource use and socio-economic conditions and understand how they influence different aspects of health, for instance linking nutrition and emerging infectious disease impacts. Replicated and standardized studies of this type in multiple contexts are very much in order.

All things considered, however, we view as paramount the need to strategically develop and implement, integrated, large scale co-monitoring schemes in order to assess synergies and trade-offs between biodiversity conservation and human health. Monitoring biodiversity responses to human disturbance inside PAs, as well as in the PA periphery and buffer zones, and understanding how this in turn affects different dimensions of human health across different types of PAs is an urgent priority.

We end with a note of warning regarding reports of negative impacts of PAs on human health. While empirical research on the reality of health risks is desirable, caution is needed when communicating research outcomes to wider audiences in order to avoid misinformed and unsupported health concerns undermining long-term conservation efforts [61].

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Boxes and Figures

Box 1. Human Health, Well-Being and Ecosystem Health

Numerous frameworks exist for conceptualizing health and well-being, ranging in focus from the individual to the nation, and hailing from such diverse disciplines as anthropology, economics or epidemiology [62,63]. Such frameworks have used a wide array of indicators to measure the health, ranging from mortality (e.g., child mortality), morbidity (e.g., prevalence, incidence), health status (e.g., high blood pressure), nutritional (e.g., children stuntness), social health (e.g., substance abuse), or health-system (e.g., healthcare delivery) indicators.

Although a full review of these frameworks is beyond the scope of this paper, it is important to note that despite their theoretical differences, most of these works share a general vision of linking human and ecosystem health [18,64]. Frameworks in this vein resonate with indigenous peoples' philosophical concepts of living in harmony with nature (e.g., Andean notion of Mother Earth), identifying kinship between people and nature as a determinant of human well-being [15]. Overall, these ever-more holistic definitions of human health (reflecting the origin of the word, derived from the Greek '*hal*' or 'whole') are providing new opportunities for conservation managers to play a greater role in supporting human health than in the past [32]. As a result, there have been recurrent calls for a shift from purely biophysical measures of health to broader well-being indicators, targeting life satisfaction, good quality of life, or happiness, to cite just a few [62,65]. Many of these indicators have also started to gain prominence in environmental discourses (e.g., *Sumak Kawsay* in Ecuador; Gross National Happiness in Bhutan).

Box 2. Protected Areas or their periphery as hotspots of infectious disease emergence?

Up to two-thirds of known human infectious pathogens have emerged from animals [66]. This transmission from other species to humans fits with pathogen ecology and evolution, but the opportunities for animal-to-human pathogen spillover are higher with increasing human encroachment in natural habitats, particularly in the tropics [67]. Major disease hotspots appear to be at the interface between natural and degraded ecosystems, such as at the periphery of PAs. However, few studies have taken PAs as a leading analytical unit in epidemiological studies [53].

A topical case is that of Ebolaviruses, extremely contagious pathogens causing lethal hemorrhagic fever disease in humans and animals with high fatality rates. They have been repeatedly reemerging across the African equatorial belt since 1976 [68]. Despite the multiple Ebola outbreaks, we still have limited understanding of the reservoir host species and the environmental contexts favoring animal-to-human transmissions [69]. For instance, RNA of the Zaire Ebola virus (EBOV) has been detected in multiple wildlife species such as three species of bats, duikers (*Cephalophus* species), gorillas (*Gorilla gorilla*), chimpanzees (*Pan troglodytes*) and various rodents, remaining debatable which are the natural reservoirs [70,71].

Ebola outbreaks have indeed been linked to contacts with wildlife. The cases in Gabon and DRC, in proximity to Odzala Kokoua National Park in 2001-2003 (Fig. 2), started when locals found and manipulated carcasses of infected mammals at the PA periphery [72]. Hunting pressure is high in North-eastern Gabon and affects large-scale animal communities [73], highlighting the role of bushmeat familial consumption as a high-risk behavior in these local communities. Yet outbreaks have also been linked to environmental change in Central and West Africa, with index cases in humans occurring in hotspots of forest fragmentation [74*]. The maps below (Fig. 2) illustrate how Ebola emergence locations (marked A, B and C) correspond to areas of recent deforestation, in the periphery of the Odzala Kokoua National Park. This suggests an interaction between land-use change and bushmeat hunting enhancing zoonotic disease outbreaks. While the role of PAs in the spatial dynamics of EVD outbreaks has not been investigated, caution is needed when interpreting spatial patterns. Although PAs are sometimes portrayed as EIDs hotspots because of the species they protect within [52], EIDs emergence might instead be attributable to the processes of fast land degradation happening beyond their borders.

Given that EIDs are responsible for over one billion human cases per year, we urge research to investigate i) how the interaction of deforestation and bushmeat consumption affect wildlife communities and particularly the host species around PAs; ii) how this resonates into spatial dynamics of EID emergence taking into account variation in livelihoods, human malnutrition and variation in PA governance and law enforcement; iii) the feasibility of an international protected area network of wildlife and human health monitoring combined with public education about zoonotic diseases particularly at PA periphery [75].

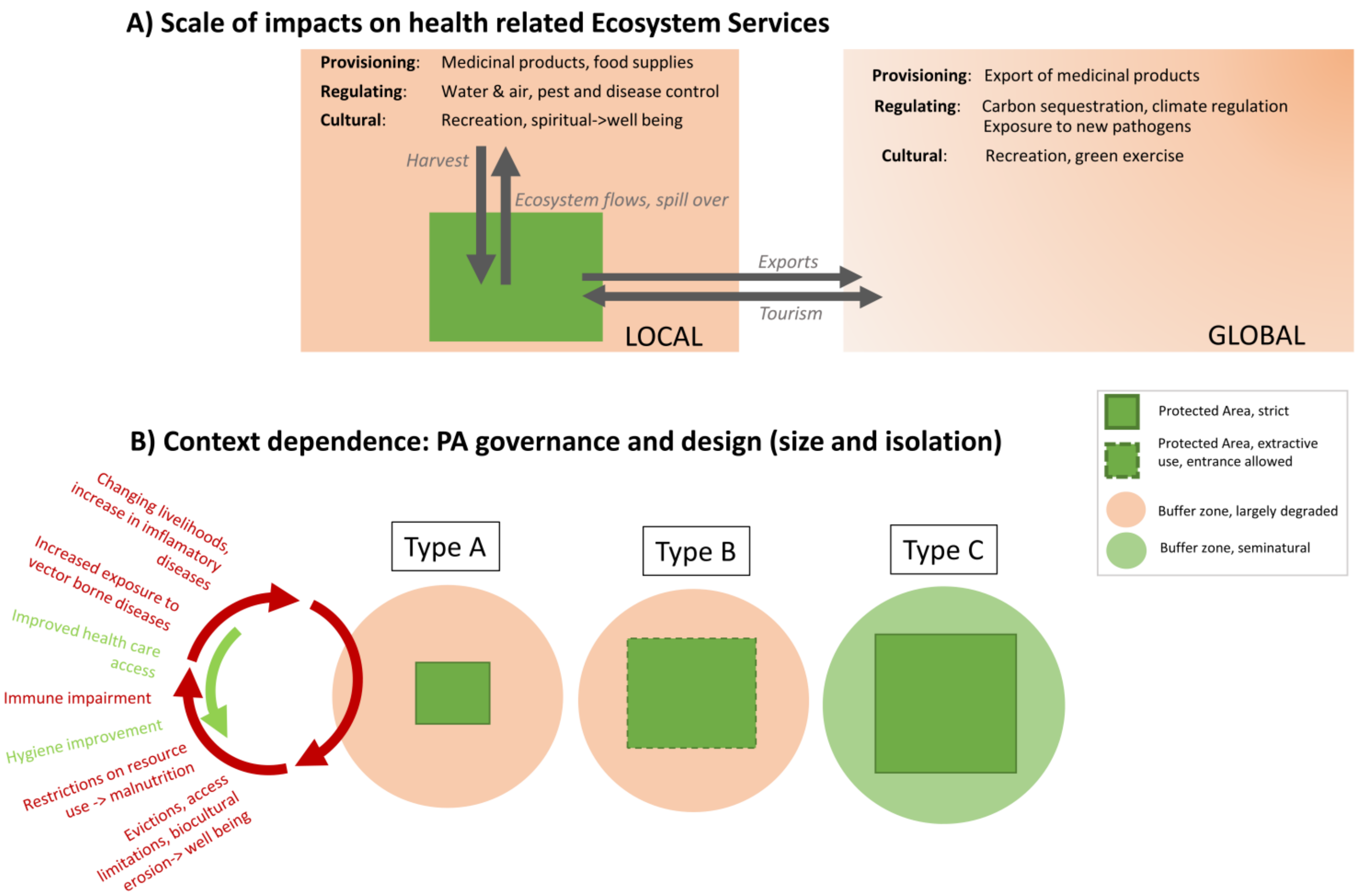
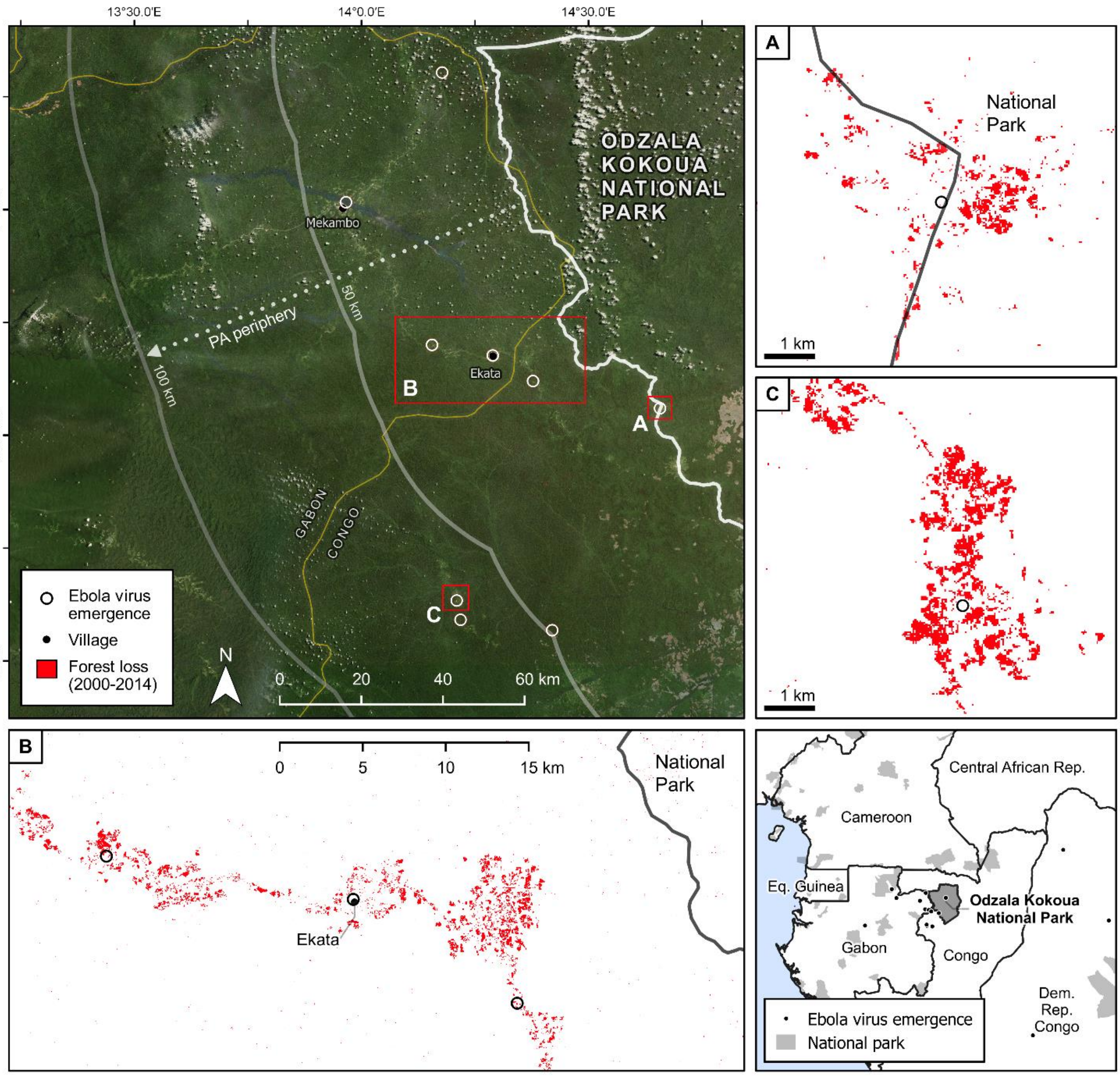


Figure 1. Linkages between human health, ecosystem services and PA management. Panel A. Scale of impacts on health through different ecosystem services. Impacts can be local or global, within or outside the PA. Processes marked in cursive. Panel B illustrates different PA settings. Protected areas can have different restrictive uses, from complete exclusion of human actions to sustainable extractive uses of different types. In addition, they vary in their spatial design, with aspects of shape, size and isolation affecting both biodiversity as well as health impacts.



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542 **Figure 2. Ebola virus emergence in the periphery of Odzala Kokoua National Park in relation**

543 **to forest loss patterns** (Congo – Gabon).

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