Restoring the orangutan in a Whole- or Half-Earth context

Erik Meijaard, Douglas Sheil, Julie Sherman, Liana Chua
Safwanah Ni'matullah, Kerrie Wilson, Marc Ancrenaz
Darmawan Liswanto, Serge A. Wich, Benoit Goossens
Hjalmar S. Kühl, Maria Voigt, Yaya Rayadin, Yuyun Kurniawan
Agus Trianto, Dolly Priatna, Graham L. Banes, Emily Massingham
John Payne and Andrew J. Marshall

Abstract Various global-scale proposals exist to reduce the loss of biological diversity. These include the Half-Earth and Whole-Earth visions that respectively seek to set aside half the planet for wildlife conservation or to diversify conservation practices fundamentally and change the economic systems that determine environmental harm. Here we assess these visions in the specific context of Bornean orangutans *Pongo pygmaeus* and their conservation. Using an expert-led process we explored three scenarios over a 10-year time frame: continuation of Current Conditions, a Half-Earth approach and a Whole-Earth approach. In addition, we examined a 100-year population recovery scenario assuming 0% offtake of Bornean orangutans. Current Conditions were predicted to result in a population c. 73% of its current size by 2032. Half-Earth was judged comparatively easy to achieve and predicted to result in an orangutan population of c. 87% of its current size by 2032. Whole-Earth was anticipated to lead to greater forest loss and ape killing, resulting in a prediction of c. 44% of the current orangutan population for 2032. Finally, under the recovery scenario, populations could be c. 148% of their current size by 2122. Although we acknowledge uncertainties in all of these predictions, we conclude that the Half-Earth and Whole-Earth visions operate along different timelines, with the implementation of Whole-Earth requiring too much time to benefit orangutans. None of the theorized proposals provided a complete solution, so drawing elements from each will be required. We provide recommendations for equitable outcomes.

Erik Meijaard*†‡§ (Corresponding author, orcid.org/0000-0001-8685-3685, emeijaard@borneofutures.org), Safwanah Ni'matullah (orcid.org/0000-0001-5234-0646), Marc Ancrenaz†¶ (orcid.org/0000-0003-2325-2879) Serge A. Wich†** (orcid.org/0000-0003-3954-5174) and Maria Voigt (orcid.org/0000-0002-2894-7031) Borneo Futures, Bandar Seri Begawan, Brunei Darussalam

Douglas Sheil (orcid.org/0000-0002-1166-6591) Forest Ecology and Forest Management Group, Wageningen University and Research, Wageningen, The Netherlands

Julie Sherman (orcid.org/0000-0002-9618-8217) Wildlife Impact, Portland, USA

Liana Chua (orcid.org/0000-0001-7518-8181) Department of Social Anthropology, University of Cambridge, Cambridge, UK

Kerrie Wilson (orcid.org/0000-0002-0092-935X) Queensland University of Technology, Brisbane, Australia

Darmawan Liswanto (orcid.org/0000-0002-7764-7334) Yayasan Titian Lestari, Pontianak, Indonesia, and Yayasan Sintas, Indonesia

Benoit Goossens†† (orcid.org/0000-0003-2360-4643) Organisms and Environment Division, School of Biosciences, Cardiff University, Cardiff, UK

Hjalmar S. Kühl (orcid.org/0000-0002-4440-9161) German Centre for Integrative Biodiversity Research, Halle–Jena–Leipzig, Leipzig, Germany

Yaya Rayadin‡‡ (orcid.org/0000-0001-5492-7723) Forestry Faculty, University of Mulawarman, Samarinda, East Kalimantan, Indonesia

Yuyun Kurniawan, Mulawarman University, Samarinda, Indonesia

Agus Trianto One Forest Project, Ketapang, West Kalimantan, Indonesia

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Dolly Priatna (orcid.org/0000-0002-3787-5965) Graduate School of Environment Management, Pakuan University, Bogor, Indonesia

Graham L. Banes (orcid.org/0000-0003-4382-7684) Wisconsin National Primate Research Center, University of Wisconsin–Madison, Madison, USA

Emily Massingham (orcid.org/0000-0002-9498-2994) Centre for Biodiversity and Conservation Science, The University of Queensland, Brisbane, Australia

John Payne Borneo Rhino Alliance (BORA), Fakulti Sains dan Sumber Alam, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

Andrew J. Marshall§§ (orcid.org/0000-0002-7703-8811) Department of Anthropology, Department of Ecology and Evolutionary Biology, Program in the Environment, School for Environment and Sustainability, University of Michigan, Ann Arbor, USA

*Also at: Great Ape Section of the IUCN/SSC Primate Specialist Group, Ketapang, West Kalimantan, Indonesia
†Also at: IUCN Oil Crops Task Force, Bandar Seri Begawan, Negara, Brunei Darussalam
‡Also at: Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, UK
§Also at: Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic
¶Also at: HUTAN–KOCP, Sandakan, Malaysia
**Also at: School of Biological and Environmental Sciences, Liverpool John Moores University, Liverpool, UK
††Also at: Sabah Wildlife Department, Danau Girang Field Centre, Sabah, Malaysia
‡‡Also at: Ecology and Conservation Center for Tropical Studies, Samarinda, East Kalimantan, Indonesia
§§Also at: Great Ape Section and Small Ape Section of the IUCN/SSC Primate Specialist Group, and One Forest Project, Ketapang, West Kalimantan, Indonesia

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Introduction

Declines in the diversity and abundance of wildlife undermine ecosystem services and threaten human well-being (Cardinale et al., 2012; Vellend, 2017; Díaz et al., 2019). Ambitious, large-scale and top-down proposals have been advanced to reverse these declines. The Half-Earth approach requires setting aside half of the lands and seas on Earth primarily as habitat for other species, free of intensive human economic use (Wilson, 2016; Cafaro et al., 2017; Crist et al., 2021). This proposal has been criticized because of its implications for people already living in remote regions, for being unlikely to meet its conservation objectives and for ignoring biodiversity within the other half set aside for human use (Büscher et al., 2017). A prominent alternative global proposal involves a Whole-Earth (or Sharing the Planet) perspective (Immovilli & Kok, 2020), which advocates the global integration of conservation and other societal goals and a radical change to 'alternative conservation movements that are more democratic, equitable and humane' (Büscher et al., 2017, p. 409). In this latter vision, solutions need to simultaneously engage diverse objectives that include redressing inequalities of power and economics amongst stakeholders.

Here we combine empirical research and predictive models to compare Half-Earth-type and Whole-Earth-type approaches for the conservation of Bornean orangutans *Pongo pygmaeus* and related socio-ecological consequences. Although Half-Earth does not necessarily imply Half-Borneo, our analysis provides insights into the possible effectiveness and feasibility of global theoretical proposals for local conservation contexts. These outcomes could help determine which approach could work best and the time frames over which they can be implemented realistically. We also identify issues that could arise if we operationalize global visions in relation to specific regions such as Borneo and species such as the orangutan. Orangutans are amongst the few species for which a spatio-temporal effectiveness framework is available (Santika et al., 2022), facilitating the evaluation of probable impacts of different land uses and management strategies on conservation outcomes. Furthermore, there are sufficient socio-economic data on the impacts of different land-use strategies to explore some implications of these approaches (Santika et al., 2017b, 2019a).

In 2012 some of the authors wrote that to halt further declines in orangutan populations 'conservationists must think outside the box' (Meijaard et al., 2012, p. 29). The main problem at the time was that whereas 25% of all wild orangutans occurred within protected areas and were relatively safe, there were few effective attempts at protecting any of the remaining 75% of wild orangutans outside protected areas. According to government statistics, the protected area network has expanded by 5.6% and 8.2% during 2010–2020 in Kalimantan (Indonesian Borneo) and Sabah (Malaysian Borneo), respectively, and conservation measures outside these official protected areas have also increased (Meijaard et al., 2020). These include forest management for biodiversity conservation by timber and palm oil companies (Meijaard et al., 2005), rural communities who are given long-term forest management rights (Santika et al., 2019b) and areas managed for carbon sequestration or forest restoration (Budiharta et al., 2014). Furthermore, expansions of industrial-scale plantations and forest loss have both slowed since peaking during 2010–2015 (Gaveau et al., 2019, 2022).

Despite these improvements and an investment of c. USD 1 billion in orangutan conservation during 2000–2019, most orangutan populations have continued to decline (Utami-Atmoko et al., 2019; Santika et al., 2022). One problem is forest loss outside protected areas. This displaces orangutans and forces them into closer proximity with people, where they could cause damage to crops and incite fear. In keeping with widespread local cultural principles, the affected people tend to hold these animals, and sometimes the organizations associated with them, accountable for the damage they cause (Chua et al., 2021). Such orangutans are often either killed or removed ('rescued' or 'translocated') from their natural habitats (Davis et al., 2013; Sherman et al., 2020; Chua et al., 2021). The current losses, estimated at 2–5% above natural mortality rates (Davis et al., 2013), are unsustainable for orangutans, leading to their continuous decline (Marshall et al., 2009). Protecting the unprotected orangutans and reducing losses in all populations remain fundamental conservation challenges (Ancrenaz et al., 2021).

We explore the extent to which a Half-Earth-type approach, here interpreted as a Half-Kalimantan and Half-Sabah approach, could contribute to bolstering and sustaining Bornean orangutan populations (Supplementary Fig. 1). We compare this to the impacts resulting from the continuation of Current Conditions (i.e. the conservation strategies from the 2000–2019 period as described by Santika et al., 2022). We also explore a Whole-Earth approach that envisages deregulating government-led area protection and replacing it with community management of forests as public goods (Supplementary Fig. 1; Büscher et al., 2017). In a fourth scenario, we assess the more ambitious target of orangutan population recovery to indicate what long-term improvement in conservation management could achieve for the species. We explored the first three scenarios over a 10-year time frame, in line

with national orangutan conservation plans in Indonesia and Malaysia, whereas we projected the fourth scenario over a century to assess the potential for long-term recovery (Grace et al., 2019).

Methods

Examination of conservation situations characterized by wicked problems can benefit from the consideration of multiple scenarios (Game et al., 2014). Wicked problems are complex and evolve continuously and thus have no fixed solution. Exploring different scenarios helps us to identify critical factors and uncertainties and provides a useful approach to tackling these complexities. Here we developed scenarios to evaluate the implications of adherence to the Whole-Earth and Half-Earth visions. We acknowledge these visions could be interpreted in different ways by different experts but underline that our focus here is pragmatic and asks how these visions are viewed by conservation professionals (see below and Supplementary Material 1). Thus we consider the outcome for Bornean orangutans under the following scenarios: (1) a Current Conditions approach for the period 2021–2032 that entails continuation of orangutan conservation strategies that typified the period 2000–2019 (Santika et al., 2022) and uses predicted deforestation rates based on historical trends (Voigt et al., 2022); (2) a Half-Earth approach for 2021–2032 (Supplementary Fig. 1a) based on improved protection and sustainable forest management strategies within the Bornean orangutan range; (3) a Whole-Earth approach for 2021–2032 (Supplementary Fig. 1b) focused on the deregulation of existing conservation structures and the amalgamation of conservation and production goals on the same lands; and (4) to explore the recovery potential of the species (Akçakaya et al., 2018; Grace et al., 2019), we test an aspirational 100-year goal estimating the maximum plausible improvement that could be achieved in orangutan occupancy, viability and functionality across Borneo assuming near 0% offtake.

We explored which parts of the orangutan range are protected currently or could be protected given the priorities and assumptions of the scenarios. We focused the analysis on Sabah (Malaysia) and Kalimantan (Indonesia), where we mapped the orangutan range based on up-to-date forest cover and species presence data (Supplementary Material 1). We did not include the Malaysian State of Sarawak because the orangutan range is restricted to a small part of that state and the conservation context is different from that of Sabah and Kalimantan (Santika et al., 2022). We determined the current land use across the range of the species and what future land use would be given the assumptions of the scenarios. We used expert assessments to estimate current annual offtake rates and population sizes and asked experts to predict these for the future using our scenario descriptions. We used this approach because we have confidence in the ability of experts to predict orangutan distribution and density. Orangutan populations occur under conditions that are known sufficiently to permit meaningful inferences and predictions. Nevertheless, there are unknowns. Most studies take place in areas with above-average orangutan densities. Other areas are often suitable ecologically but populations have been reduced by past hunting (Marshall et al., 2006; Meijaard et al., 2010, 2021). Furthermore, although assessing and modelling habitat suitability is straightforward, the assessment and modelling of past, current and future killing rates is more difficult. Asking experts to evaluate well-delineated scenarios helps to identify plausible outcomes.

To represent the Half-Earth scenario, we added areas under different management strategies to the current network of protected areas to estimate the effect of having at least 50% of the regions in which orangutans occur managed as protected areas or sustainably managed forests by 2032 (Supplementary Material 1). In the scenario description provided to the experts we assumed that better forest protection would reduce forest loss, reduce displacement of orangutans from their home ranges and reduce crop conflict and conflict-related harm to orangutans. The Whole-Earth scenario built on the suggested 'increase of the amount of land in which people can live and work, but which is off limits to resource extraction and drastic land use change' (Büscher et al., 2017, p. 408). For this scenario we selected those land uses that under current laws allow people to live and work on the land whilst preventing major land-use change. We excluded lands with high rural community-use needs for products such as timber and mining. We recognized in the scenario description that many types of land-use changes following Whole-Earth objectives are not legally possible at present and that radical legal and economic changes would be required (Büscher et al., 2017). We captured this legal change in the scenario description by referring to the regulatory vacuum following the fall of President Soeharto and his government in Indonesia. We provided information about these events and asked experts to judge whether such dynamics could occur again (Supplementary Materials 1).

We contacted 63 people with expertise in estimating the size and distribution of orangutan populations. We identified experts with extensive experience in estimating orangutan densities and threats, focusing generally on scientific experts who had first-authored scientific publications on these topics or had contributed significantly to the data collections or analyses in such publications. We sent these experts, independently and confidentially, a questionnaire (Supplementary Material 2) that delineated clearly the parameters and assumptions of each scenario. We asked the experts to review the background information about the scenarios. We next asked them to estimate the current

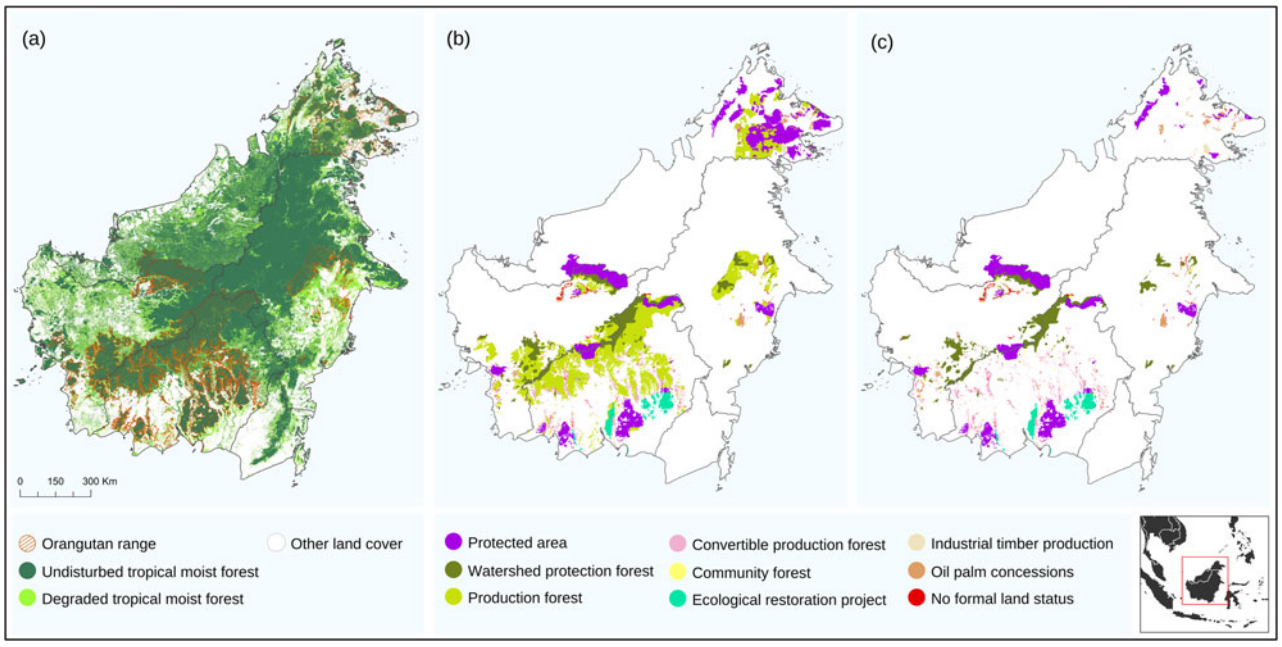

FIG. 1 (a) Current (2021) Bornean orangutan distribution range, with a 2019 forest-cover map (Vancutsem et al., 2021). (b) The allocation of different land uses under the Half-Earth scenario. (c) The allocation of different land uses under the Whole-Earth scenario.

orangutan population size of Sabah and Kalimantan and the annual orangutan offtake rate. Recent (not current) population sizes have been approximated by several studies (Santika et al., 2017a; Voigt et al., 2018; Utami-Atmoko et al., 2019) but none of these provide clear overall population estimates for all major and minor (e.g. small forest fragment) orangutan populations. The experts therefore had to rely on their general understanding of the drivers of decline (e.g. past and current killing rates), habitat-specific densities and recent changes in habitat availability. Similarly, although several estimates for annual killing rates exist (Meijaard et al., 2011; Davis et al., 2013), considerable uncertainties persist, and some experts have distinct views on such values. We then asked the experts to estimate population sizes and annual offtake rates for the Current Conditions, Half-Earth and Whole-Earth scenarios and to provide their best estimate for the total population of Borneo orangutans in 2122 given the potential recovery of populations if offtake rates were near zero.

The use of expert estimates acknowledges uncertainties. In theory, all experts can access most of the same information and science, but there is variation in this evidence and its interpretations because of differences in methods, analytical approaches, perceptions and emphasis (e.g. estimates of total population size and annual offtake rates; Santika et al., 2017a; Voigt et al., 2018; Utami-Atmoko et al., 2019). To make predictions, experts combine their personal views on the literature, field observations and information gleaned from others. Synthesizing the predictions of such knowledgeable experts under delineated scenarios provides a novel perspective on the future of orangutan conservation. To focus discussion on the relative effects of the proposed scenarios rather than absolute population size or offtake rate estimates, we report changes predicted by experts relative to their own estimates of current population sizes and offtake rates. Despite variation amongst predictions and estimates, particularly regarding current population size and offtake, there was broad consensus on the distinct implications of each scenario. To help interpret the predictions from ecological experts regarding the socio-political contexts of the scenarios, we asked social and political scientists with experience in Bornean conservation dynamics to review the population predictions and draw conclusions. We analysed the expert estimates in *R 4.1.3* (R Core Development Team, 2022; Supplementary Material 1). All data (anonymized expert responses) and code necessary to duplicate our results and data figures are provided by Marshall (2021).

Results

Present-day land use across the orangutan range

Our spatial analysis indicates that the total area of orangutan presence in Sabah and Kalimantan (see Supplementary Material 1 for the reason Sarawak was not included) is c. 13,706,060 ha (Fig. 1a), of which 26.1% is within protected areas, 12.8% is within watershed protection forests, 52.3% is within production forests and restoration concessions, 0.6% is within community forests and 7.1% is within forest

areas in agricultural landscapes or conversion forest areas (Supplementary Table 1). An additional 188,906 ha is outside the State Forest without an association with the above land uses (i.e. it is 'unmanaged'). There is some overlap between the land-use classes, with, for example, 53,971 ha of the community forest areas located within watershed protection forest or 308,912 ha of oil palm plantations overlapping with conversion forest, but this does not significantly affect the relative allocation of orangutan habitat to different land uses (Supplementary Table 1).

Expert views on relative population changes under different scenarios

Of the 63 orangutan experts contacted, 24 returned a fully completed questionnaire, 14 declined participation (mostly because their knowledge of distributions, densities and population trends was restricted to a specific location) and 25 did not respond to either the initial e-mail and questionnaire or subsequent reminders.

Overall estimates of population sizes and offtake rates differed substantially amongst experts, but estimates of the relative effects of different scenarios were consistent. For example, experts estimated that under the Current Conditions scenario the total population would decline to a median of 73.2% of its current size by 2032 (range = 0–100%; 25th percentile = 61.4%; 75th percentile = 80.1%; Fig. 2b). They estimated a median annual offtake rate of 2.5% of the total population under Current Conditions (range 0.02–8.00%; 25th percentile = 1.4%; 75th percentile = 3.8%; Fig. 3b, Supplementary Fig. 2). Despite the variation between experts, the direction and relative magnitude of changes within individual experts were broadly consistent relative to their estimates of baseline population and offtake rates (Supplementary Fig. 2).

The Half-Earth scenario, interpreted as Half-Borneo, indicates that these commitments can be achieved on paper relatively easily within the regions in which orangutans occur (Fig. 1b, Supplementary Table 1). The current government goals in Sabah (Sabah Forestry Department, 2020) provide potential permanent forest protection for c. 93.7% of the remaining orangutan habitat (but see below for a discussion of the planned tree plantation expansion). There are c. 181,811 ha of additional orangutan habitat (Supplementary Table 1) that are not captured currently in these protected forests, mostly in forest fragments within agricultural areas. Kalimantan is already formally protecting c. 33.2% of the remaining orangutan habitat in national parks, nature reserves, wildlife reserves and watershed protection forest (c. 3,616,840 ha). By additionally committing to the permanent protection of production forest, restoration concessions and community forest areas, another 58.1% (6,325,526 ha) of the remaining orangutan habitat could be protected. We have argued elsewhere that such forests with low-intensity human use retain high ecological and biodiversity values (Meijaard & Sheil, 2008b; Runting et al., 2019; Santika et al., 2019b). This leaves 791,760 ha of habitat, mostly in agricultural areas (*Areal Penggunaan Lain*) and conversion forests (*Hutan Produksi Konversi*). Experts estimated that implementing the Half-Earth scenario in Borneo would result in an orangutan population decline by 2032 to a median of 87.1% of its current size (range = 39.9–120.0%), but all but one of the 24 experts predicted this decline to be less than under the Current Conditions scenario (Fig. 2b,c). Experts estimated a median annual offtake rate under Half-Earth of 0.85% of the total orangutan population (range = 0.01–4.00%; Fig. 3a), which is lower than the 2.5% predicted under Current Conditions (Fig. 3b, Supplementary Fig. 2).

Under the Whole-Earth scenario 32.9% of the Bornean orangutan range would have some habitat protection through existing laws and support from nearby communities (Fig. 1c). A further 7.1% would be in existing agricultural areas and plantations, where, similarly to the Half-Earth scenario, new protective regulations would be needed to formally protect the remaining orangutan habitat in, for example, Essential Ecosystem Areas, which can grant legal protection to forests outside State Forest land (Sahide et al., 2020). Finally, orangutan habitat in degazetted production forests, national parks, watershed protection forests and nature and wildlife reserves would be legally unprotected and thus would require new management structures under community management, such as through social forestry licenses (8,221,058 ha or 60.0% of the total area). The experts estimated an orangutan population decline by 2032 to a median of 43.9% of its current estimated size (range = 0–89.6%; Fig. 2a). Experts estimated a median annual offtake rate of 4.1% of the total population (range = 0.007–16.0%; Fig. 3a), which is greater than that predicted under other scenarios (Fig. 3b, Supplementary Fig. 2).

The fourth scenario envisages an aspirational future in which orangutans naturally repopulate areas in Borneo where they occurred previously (Spehar et al., 2018) over a 100-year time frame and without hunting or persecution. The experts estimated a median increase to 148.5% of their estimate of the current population (range 20–500%; Fig. 2d). Given the longer time involved and the neglecting of climate change impacts in our scenarios (see Supplementary Material 1), we note additional uncertainty in this final scenario.

Discussion

Our analysis of the scenarios developed from Half- and Whole-Earth proposals indicates that these play out over different time frames. Although many of the Half-Earth requirements have already been implemented, the Whole-Earth scenario would require decades more. Whole-Earth

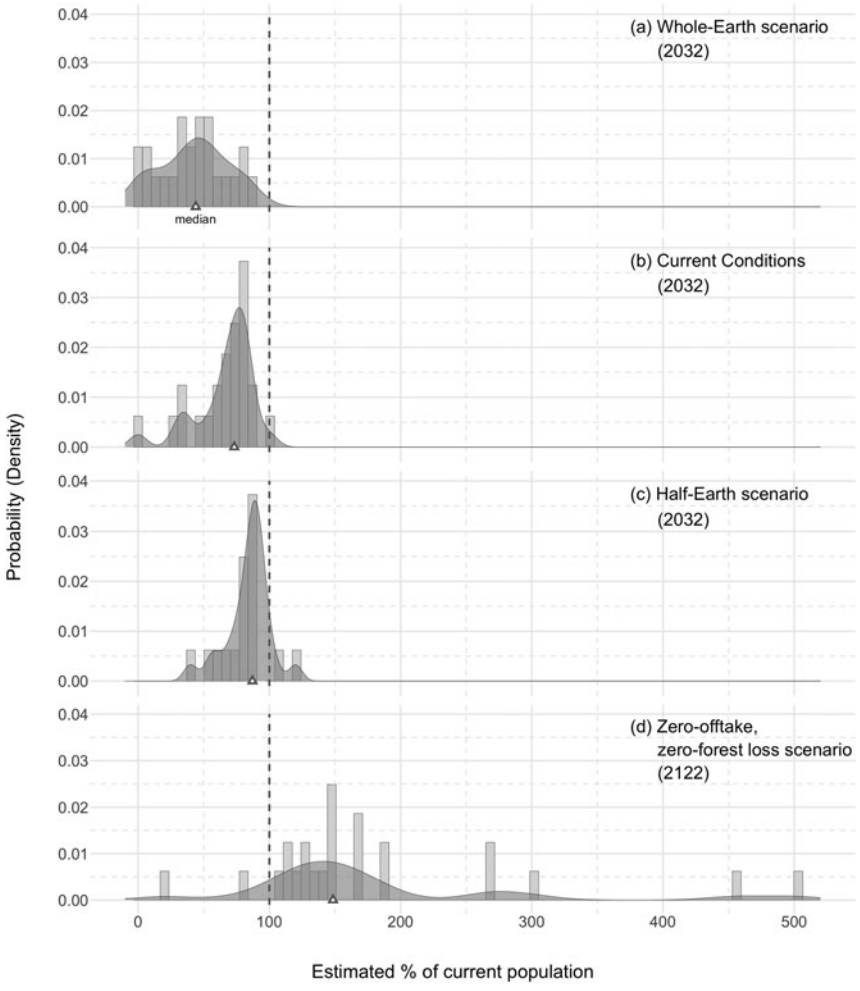

FIG. 2 Expert predictions of the impacts of the (a) Whole-Earth, (b) Current Conditions, (c) Half-Earth and (d) zero-offtake, zero-forest loss scenarios on Bornean orangutan populations relative to estimates of the current population size (vertical dashed lines). Grey bars indicate expert responses, shaded probability density curves show the distributions of estimates and triangles indicate the median estimates for each scenario.

appears better at addressing societal concerns, including access to resources, but Half-Earth would be more effective at reducing orangutan losses. Expert estimates indicate that the rate at which orangutans and their habitats are declining requires rapid action, necessitating the immediate improved protection envisaged under Half-Earth. Concurrently, a gradual transition to Whole-Earth offers a seemingly viable and ethically just development model that also meets protection goals. Strategically combining these two scenarios could create an essential 'middle ground' through which to address concerns about both conservation and social justice (Immovilli & Kok, 2020). A similar conclusion was drawn in a recent review: 'Half Earth is inevitably a Whole Earth project' (Ellis & Mehrabi, 2019, p. 28).

What Half-Earth can do for orangutans

The concern from Whole-Earth proponents that 'the [global] removal of land from non-conservation use will impact most on those communities that are poorest and least responsible for our current environmental predicament' requires serious attention (Büscher et al., 2017, p. 408). However, protecting half of Borneo would not remove land from non-conservation uses. With 67.1% of the land mass of Kalimantan designated as State Forest, Indonesia already exceeds the Half-Earth goal of locking in 50% of land, although we recognize that the protection offered by State Forests has been imperfect and that not all of this State Forest land is currently forested. In 2011 the Indonesian government instituted a nationwide moratorium on developing new plantations on peatlands and primary forests, and this moratorium was extended indefinitely in 2019, contributing to reduced forest loss (Gaveau et al., 2019, 2022). If the current prohibition on the conversion of natural forests to plantations in production forest areas became permanent this would benefit orangutans. Sabah has also exceeded the Half-Earth goal. According to the 2020 Annual Report of the Sabah Forestry Department, 65% of Sabah remains forested; 24% of the state (1.8 million ha) is gazetted as forest reserves (production forests) and 28% is gazetted as totally protected areas (2.0 million ha), including national parks, wildlife sanctuaries and three categories of forest reserves (protection purposes) (Sabah Forestry Department, 2020). Its government, however, still aims to expand industrial

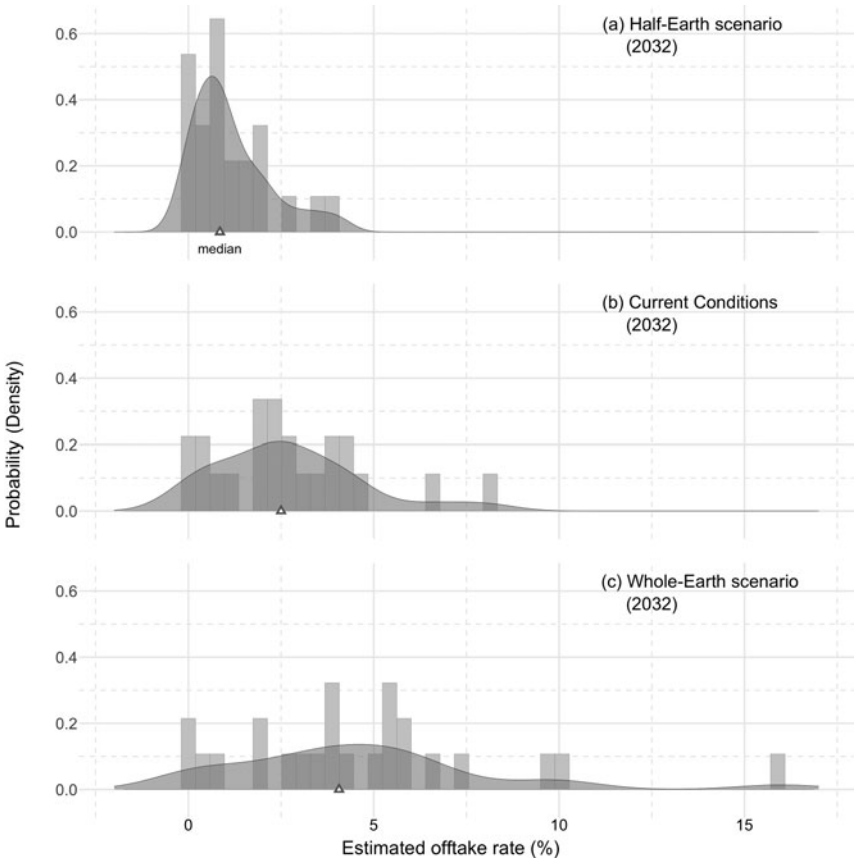

FIG. 3 Expert predictions of Bornean orangutan offtake rates under the (a) Half-Earth, (b) Current Conditions and (c) Whole-Earth scenarios. Grey bars indicate expert responses, shaded probability density curves show the distribution of estimates, and triangles indicate the median estimate for each scenario.

tree plantations by 400,000 ha in Class II Forest Reserves (Malay Mail, 2022), which could lead to further loss of orangutan habitat.

Under the Half-Earth scenario the largest area of orangutan habitat that would be protected permanently consists of normal and limited production forests and restoration concessions in Kalimantan and the commercial forest reserves in Sabah (total 7,165,580 ha; Supplementary Table 1). Forest loss in these production forest areas is normally $< 1\%$ per year, mostly from small-scale clearing or fire (Santika et al., 2015), although land use in these areas can be changed legally from natural forest to silvicultural plantations, which results in the loss of orangutan habitat. Half-Earth investments should prevent such further losses. Improving legislation and strengthening business propositions for sustainable forest management to prevent forest conversion are key, although we recognize that these remain challenging for multiple reasons (Runting et al., 2019). Strengthening the protection of watershed protection forests (1,751,056 ha), which receive little active management currently, is another important component of Half-Earth. These forests on steep slopes and deep peats had forest loss rates of 0.5% per year during 2000–2012 (Santika et al., 2015), but this rate was lower in subsequent years (Gaveau et al., 2019), and with timber harvest prohibited these forests are relatively safe, except from fires. Preventing fires and agricultural activities in these protection forests is therefore a key goal under Half-Earth. With forest loss reduced, displacement of orangutans would decrease, probably resulting in less crop conflict and conflict-related harm to orangutans because of such land-cover change (Abram et al., 2015).

The increasing number of forest areas under formal community management, especially in Indonesia, would strengthen forest management under the Half-Earth scenario. In Indonesia, one form of such community protected forests, Village Forests (*Hutan Desa*), reduced the likelihood and severity of deforestation (Santika et al., 2017b). Our expectation is that in the current phase of slowing deforestation rates across Borneo, greater government commitment to protecting remaining forests, improved management, effective engagement of private companies and a transition of community oversight would result in a stabilizing landscape under the Half-Earth scenario.

Under Half-Earth, governance would focus on enforcing existing laws on State Forest land and providing additional protection for other currently unprotected forest. The designation of land as State Forest has historically harmed traditional communities by denying their claims over the forest in favour of state control (Peluso & Vandergeest, 2001; Lynch & Harwell, 2002). The 2012 ruling by the Constitutional Court of Indonesia emphasized that customary forest lands (*Hutan Adat*) cannot also be State Forests,

making the governmental claims over many forests potentially invalid (Butt, 2014). The government continues to find ways to operationalize this returning of oversight to communities. Whatever the long-term nature and designation of these forest lands, the process should involve local communities and acknowledge their rights (Sheil & Lawrence, 2004; Sheil & Boissière, 2006). Effective partnerships between private companies, local communities and governments are also needed to improve management of forests and land. Such solutions can be implemented in areas where the main land-use objective could be either conservation or production. Other opportunities lie in the new Essential Ecosystem Area policy in Indonesia and in High Conservation Value forests managed in certified oil palm areas.

What Whole-Earth can do for orangutans

The focus of Whole-Earth on community rights probably would result in greater local buy-in, but such positive changes are unlikely to happen rapidly in Borneo other than in a few locations. We estimate that under Whole-Earth, areas requiring new management structures overlap with 997 villages within the orangutan range where community forest management would need to be formalized. Changing legal land status in Indonesia remains difficult and time-consuming. Even if such village-by-village legal changes can be avoided, bringing 997 village land areas under effective community management would take several decades following current government requirements. This reflects the need to build management capacity, to set up forest management and governance structures, to develop plans and to obtain government approval, which is currently happening at a rate of c. 200,000 ha per year in Kalimantan (Meijaard et al., 2020). At this current pace, by 2032 some 25% of the deregulated nature and wildlife reserves and commercial timber concessions could be under effective community management, whereas the remaining 75% would be without formal management.

Whole-Earth is riskier than Half-Earth. The regulatory vacuum resulting from the rapid implementation of Whole-Earth could mirror the situation that existed in Indonesia following the fall of President Soeharto in 1998 when decentralization and devolution of powers resulted in increased deforestation rates (Ardiansyah & Jotzo, 2013) related to unclear and contested responsibilities and divisions of power (Arnold, 2008). Thousands of local logging and mining licenses were issued and widespread illegal logging occurred, including in protected areas (Casson & Obidzinski, 2002; Ravenel, 2004). With reduced government income from forestry and other extractive industries under Whole-Earth, there would be less funding available to finance conservation, and other forms of funding would need to be found.

Complementarities and shared concerns

Whatever strategy is selected needs to address the killing of orangutans, estimated currently at an offtake rate of c. 2.5% of the population per year (Fig. 3; Meijaard et al., 2011; Davis et al., 2013). To date, conservation investments have had little lasting impact (Santika et al., 2022). More effective law enforcement could help reduce killings but risks alienating local people (Freund et al., 2017). The focus of current conservation on prioritizing and protecting orangutans has in some places removed orangutans from local accountability (Chua et al., 2021). Local people do not get compensation or assistance if orangutans damage their crops or property, but if they take actions that could harm orangutans they risk punishment. This generates a perception that conservationists care more about animals than people, which causes resentment of and alienation from conservation programmes (Meijaard & Sheil, 2008a; Howson, 2018). We favour a more sensitive approach that better aligns with local perceptions and needs and goes beyond education and punishment, such as through the provision of benefits to communities in return for their protective services.

Conservation programmes under either Half- or Whole-Earth scenarios should address underlying drivers of orangutan population decline. What can communities gain from participating in conservation programmes? It might be better, for example, to focus on species that also matter to communities such as fish or bearded pigs *Sus barbatus*, for which declining populations require similar interventions as orangutans (e.g. forest protection, reduction in killing rates, species monitoring; Chua et al., 2020). In addition, it would be helpful to transition from the current mostly donor-driven, short-term projects with patchy local presence and limited lasting impacts towards more low-key, constant and long-term conservation presence that provides organizations with the opportunity to build trust. Such sustained presence of conservationists and regular, trust-based, reciprocal interactions between conservationists and villagers, combined with the provision of tangible benefits to the community, have been shown to work well, resulting in reduced threats of forest loss and wildlife killing (Ancrenaz et al., 2007; Webb et al., 2018). Engaging communities in conservation planning alongside broader village development planning could ensure that conservation objectives become integral to these broader plans (Wollenberg et al., 2009). Processes such as structured decision-making, which is used in situations with high degrees of controversy between stakeholders, could help in reaching a consensus between various village objectives (Johansson et al., 2018). This could overcome the current problem that provisions for orangutan conservation are often written by people who have little connection to or understanding of the livelihood strategies and patterns of Indigenous communities. Indigenous communities in

Borneo have long been opportunistic and entrepreneurial, identifying and adapting to new opportunities as they emerge (Wollenberg et al., 2009; Chua et al., 2021). Irrespective of either the Half- of Whole-Earth context, it is thus important that any solution permits flexibility and development rather than trapping people in any fixed lifestyle. Similarly, it is vital that such communities' own forms of stewardship and sustainable land use are acknowledged, engaged with and supported by conservationists rather than pigeonholed as local knowledge or local wisdom (Sheil et al., 2015).

Both the Half- and Whole-Earth scenarios would require increased levels of conservation funding. Although nominal investments in orangutan conservation have risen threefold during 2000–2019 (Santika et al., 2022), this funding has not prevented orangutan declines. Under Half-Earth, funding increases would be possible through increased donor funding and investments from companies operating in timber production, mining, energy and agriculture. In the Whole-Earth scenario, deregulation of commercial logging and mining could reduce tax revenues but encourage private investment in conservation, including innovative approaches. These could include, for example, blockchain payments from conservation donors tied to digital twins of individual orangutans (Ledgard & Meijaard, 2021), expansion of payments for ecosystem services such as forest carbon in community forest areas (Intarini et al., 2014) or initiatives such as that of the Lowering Emissions by Accelerating Forest Finance Coalition, which aims to finance forest protection.

Conclusion

Our evaluations of scenarios have implications for the global debate regarding the future of nature conservation (Soulé, 2013; Kareiva, 2014; Wilson, 2016; Büscher & Fletcher, 2019). They indicate that the local consequences of large-scale, top-down conservation proposals will vary with differing socio-ecological contexts and that these one-size-fits-all visions will have unintended consequences. Better nature conservation will not be achieved by grand designs but rather requires locally specific interventions that make the best of a situation: 'muddling through', as it has been termed (Sayer et al., 2008). Nevertheless, these grand designs have value, and relevant lessons can be learnt. The reality is that orangutan conservation in the next 10 years is going to unfold under a capitalist model. Although Whole-Earth advocates wholesale change, ultimately the idea will have to play out in the real world. Here we have attempted to describe how different plans could unfold in the context of Borneo. Our finding that a Half-Earth proposal is feasible on Borneo, could reduce declines in orangutan populations and would not require major governance changes indicates that in this context the vision is less drastic than has been suggested (Büscher et al., 2017; Büscher & Fletcher, 2019). The infeasibility of Half-Earth and its 'dangerous and counter-effective consequences if implemented' (Büscher et al., 2017, p. 408) are not evident in Borneo. Because global conservation priorities are distributed unequally across the planet, we realize that Half-Earth (i.e. setting aside half of the planet for conservation) need not imply Half-Borneo. Nevertheless, the situation in Borneo is probably representative of many tropical forest regions where it might be relatively straightforward to meet similarly determined Half-Earth goals. The top 10 countries in the world for forest cover as a percentage of total land area are all tropical (FAO, 2020). Half-Earth approaches do not require new governance arrangements, and although the governance conditions and concomitant social and environmental outcomes can be improved, the land-use systems under Half-Earth retain considerable conservation values. Away from the tropics, however, an equitable Half-Earth (i.e. 50% conservation goals for all countries) brings different opportunities and challenges, with major restoration and rewilding of ecologically degraded areas (Meijaard & Sheil, 2011; Strassburg et al., 2020). With Indonesia and Malaysia effectively already committed to Half-Earth, we call on the Global North and the wealthy nations in particular to match and support these commitments.

Ongoing debates that distinguish between Half-Earth and Whole-Earth or between mainstream, new and convivial conservation approaches suggest a belief in universal solutions to global environmental and social challenges (Tallis & Lubchenco, 2014; Büscher & Fletcher, 2019). In reality, none of these proposals provide an optimal approach in all conditions. The desire for finding and implementing any uniform, top-down approach must leave space so as not to conflict with and exclude the rich diversity of local schemes and innovations (Scott, 2008) that must also be part of any living and evolving system of democratic, equitable and humane conservation. Specific contexts require specific analysis, where assessments of local needs, values and aspirations along with many other cultural, political and biophysical factors inform which approaches might be best over what time frames. Here we are not disparaging either Half-Earth or Whole-Earth. Bold visions have their value. But perhaps the bigger challenge is enacting these approaches together in practice. Improved orangutan conservation requires that we move beyond theory and grand rhetoric and also focus on addressing immediate needs and actions.

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