**Discussion**

*Opening paragraph*

Global funding for nature conservation is far below what is required (refs, Laufer & Jones 2021). To maximise conservation gains it is necessary to provide conservation managers with insights into the trade-offs between different approaches to long-term investment of limited resources in the context of increasing anthropogenic pressure on natural resources. To our knowledge, no studies have investigated the potential long-term consequences of existing funding mechanisms for conservation projects and organisations. Our results therefore provide crucial quantitative evidence that funders, conservation bodies, and landscape managers can use to develop more effective long-term investment strategies.

*Primary scenarios (scenarios 1 to 3)*

Our results have demonstrated that in a situation where human pressure on a landscape is increasing over time, and assuming managers across all scenarios have access to the same total budget, the most effective funding strategy for a conservation manager is a stable, predictable budget. A constant budget is preferable to an increasing budget that starts too low, even when that budget increases beyond the value of the stable budget halfway through the study period. If a manager’s budget is too low at the start of the study period, initial forest loss is very high. The manager is able to reduce the rate of forest loss as their budget increases over time, but they are not able to make sufficient gains over 50 years to render the strategy better than a stable budget. Likewise, a fluctuating manager budget that reflects predictable grant cycles performs worse over 50 years than a stable budget. During periods of high budget, managers can develop effective policies that reduce forest loss. However, these periods are not sufficiently long, and budgets not sufficiently high, to offset the damage that is done during periods of low funding. Furthermore, the rate of forest loss during periods of low funding increases over time, as community resources increase. If the manager was focussed on the conservation of a wildlife population that exhibited reproduction and thus population growth, the periods of high budget, and therefore more effective protective policies, may be sufficient to maintain a healthy population as there would be periods of recovery. However, we assumed that the loss of primary forest could not be effectively reversed over a period of 50 years (refs). These simulations could be further parameterised to include realistic forest regrowth or regeneration based on a specific landscape or ecosystem, but this would decrease the generality of the results and therefore was not attempted here.

Providing a manager with a stable budget that allows the development and maintenance of policies that minimise deforestation over the long-term is the optimal approach. Stable, predictable budgets in the real world allow conservationists and landscape managers to maintain staffing levels, invest in long-term relationships and partnerships with stakeholders, maintain enforcement levels, and design policies and interventions that are strategic and adaptive over the long-term. Conservation projects that are initially underfunded yet receive increasing resources will still spend many years working to reach the same levels of protection as they would have had, had they been provided an adequate, stable budget at the start. Our results suggest it could be several decades before the deforestation trajectories of the two alternative projects meet, and the increasing budget starts to pay dividends. Projects that repeatedly experience severe funding shortages due to grant cycles will not have the same capacity for long-term investment and strategic planning as projects with stable funding, resulting in greater losses for biodiversity.

*Uncertainty and unpredictability in funding*

Scenarios 4 and 5 highlight two common funding situations for conservation organisations and projects. Scenario 4 represents a situation where the management authority has some level of core funding that ensures the operational budget does not drop below a certain level, despite budget uncertainty over time. This is a common scenario for large, international conservation organisations or statutory authorities, which have long-term support for core operational budgets. They can increase their budgets at any given time through grant applications which can be used to support existing activities, initiate new programmes, bolster enforcement, or extend engagement and collaboration with stakeholders, all of which will have a positive effect on biodiversity conservation on the landscape. Likewise, grant funding will inevitably end within a few years, and there is no guarantee that future bids will be successful, resulting in decreases in overall budgets. However, the maintenance of budgets above a certain level means that core conservation activities do not cease, and the manager is able to minimise forest loss to a level similar to the manager in scenario 1. Conversely, scenario 5 represents a situation where the management authority has no core budget and is therefore entirely reliant on uncertain and unpredictable grant funding over time. This is the reality for many small organisations, grass roots projects, or poorly supported statutory authorities, often in the global south, which rely on the ability of other partner organisations to leverage external funding. In this study, the manager in scenario 5 has the same cumulative total budget over the 50 years as the other scenarios, yet the shape of the budget curve is random. This leads to large and highly unpredictable positive and negative peaks in some cases. Our results show that there is large variability in the overall success of the manager from scenario 5 to minimise forest loss. In some cases, they can maintain a forest loss trajectory similar to scenarios 1 and 4, yet more often the rate of forest loss is worse, regularly leading to extinction.

The results from scenarios 4 and 5 translate logically to the real world; if a conservation project or organisation has no core budget support, it is entirely reliant on the success of fundraising efforts. Winning sufficient funding via short-term grants to support adequate long-term conservation management is neither reliable nor straightforward. When long-term budgets are unpredictable, uncertain, and highly variable, landscape managers are often unable to maintain core activities, guarantee continued support for communities and other stakeholders, plan investments strategically, or target investments at the most relevant drivers of biodiversity loss. In contrast, when core budgets are guaranteed, managers can maintain core activities and investments over the long-term which provides stability and minimises biodiversity loss.

*Key messages*

We have demonstrated that the dominant funding mechanism for conservation in the world today – the short-term grant cycle – is not optimal for conservation investment within social-ecological landscapes where there are competing objectives and increasing anthropogenic pressure on natural resources. In circumstances where project budgets experience negative peaks caused by gaps in grant funding, and where there is no core budget, biodiversity loss is accelerated. In these circumstances, managers are unable to maintain power to affect the system or set policies that benefit nature over the long-term. Increased uncertainty and variability around the shape of fluctuating budget curves inevitably increases uncertainty around the state of biodiversity over the long-term. Brief periods of high budgets in the grant cycle scenarios result in only brief periods of success where rates of forest loss decrease, and in the context of increasing human pressure on the landscape, these are insufficient to mitigate for the periods of low funding. Chronic underfunding, particularly in the early stages of a landscape conservation programme, can lead to serious negative effects on natural resources. Severe forest loss at the start of a project period, with all the associated losses of biodiversity, ecosystem process and services, leads to very poor project success over a 50-year time period. Even when project budgets increase over time, the damage caused during initial periods of underfunding is difficult to remedy.

Simulation studies allow us to investigate possible biodiversity outcomes from a variety of scenarios over time periods much longer than for which we generally have empirical data for. Monitoring data for conservation projects rarely exist over timeframes as long as 50 years, and managers are therefore required to assess conservation actions using monitoring data from significantly shorter periods. This study has demonstrated that this can be misleading. For example, if a manager was provided forest monitoring data for scenario 3 between years two and six, or between years 14 and 18, it would be reasonable to conclude that the existing investment strategy and associated conservation interventions were working, as the rate of forest loss was decreasing. If a manager was given forest monitoring data from any four-year period from scenario 1, they could reasonably conclude that the investment strategy and associated conservation interventions were not working, as the rate of forest loss was increasing. Neither manager could be justifiably criticised for their inference; they are drawing conclusions from the best available data, which is what conservationists around the world must do every day. Nevertheless, our results have demonstrated that these inferences are likely flawed, and that the manager from scenario 1 will have greater success in minimising forest loss over the long-term if they maintain their strategy.

*Conclusions – what can be done?*

The global conservation community requires a huge increase in funding if it is to halt the decline in biodiversity and minimise the worst impacts of climate change (Echols et al., 2019; Larson et al., 2021). We have demonstrated that a funding model that relies on short term grant funding, which is a common mechanism in the conservation sector, is unlikely to be the most effective way of financing landscape conservation. If global funding for conservation is to increase, the mechanisms by which this funding is distributed need to be carefully considered to ensure biodiversity gains per dollar are maximised. Our results suggest that simply increasing the number of short-term grants available within a competitive application framework is unlikely to provide the maximum gains. Alternative funding mechanisms are needed which provide stable and predictable budgets over multi-decadal timeframes thus allowing organisations and authorities to devise and implement strategic, long-term interventions and policies that benefit nature and people.

**Larson et al 2021**

User-pays, public benefits, funding model in USA has funded conservation for 100 years (i.e. hunters and anglers). 60-80% of revenue for state fish and wildlife agencies come from excise taxes from sale of equipment and fishing and hunting licenses.

Land and Water Conservation Fund - funding conservation by utilizing existing revenue from the development of energy and mineral resources on federal lands. Other conservation funding options include general sales taxes, transfer taxes, lottery funds, vehicle license plate sales, nonconsumptive recreation user fees, and outdoor equipment sales taxes.

Majority of college students supported extractive industry contributions, licensing from hunting/fishing, lottery proceeds, outdoor recreational outfitters contribute revenue, excise tax on hunting and fishing equipment, state sales tax, state bonds, fees from other recreational activities.

**Echols 2019**

Ultimately, the conservation community needs to develop additional, creative funding sources. Government funding is static to declining while the need is increasing. Deploying market tools that seek a greater environmental return on investment can be an important innovation for a more effective use of limited funds.

We need to do a much better job of assessing conservation effects and telling the story of how limited financial and human resources are used to deliver conservation outcomes.

Second, we should move to investment models that ask for a greater environmental return‐on‐investment (e‐ROI) instead of spending like entitlement programs. We should shift to a conservation investment system that asks which places and which management actions will produce those outcomes we desire more effectively and do so in a manner that protects land best‐suited for agricultural production.

Within individual countries, eliminating expensive and environmentally damaging subsisides can reduce environmental damage plus reduce government expenditure, which theoretically can be redirected towards conservation (see the creation of the Conservation Title in the US).

Ecosystem Service Markets have the potential to be a significant new funding source for conservation investments. One of the impediments has been the reluctance of consumers of ecosystem services to pay for something they may get for free.

A potential emerging innovation for funding focused on imperilled species, is the Recovering America’s Wildlife Act. Similar to the LWCF, this legislation proposes to draw a dedicated fund from the extraction of energy and mineral resources from federal lands. The proposal seeks to direct US$1.3 billion annually to improve the management of species in significant decline through partnerships with state wildlife agencies guided by State Wildlife Action Plans. The legislation is designed to provide a regular and secure source of funding for management of species prior to listing under the 1973 Endangered Species Act.

**Laufer & Jones 2021**

Three major streams of funding for marine – government, private foundations, public charities. Lack of cohesion, coordination, and transparency (se also Blasiak et al 2019). Many of the processes within funding organizations are hidden (Blasiak et al., 2019), making financial planning a guessing game. Notably, these findings suggest that strategically framing a proposal through priorities, moral foundations, and characters may increase the likelihood of acceptance.

Other surveyed funders shared frustration with past marine funding for failing to “address the need for long-term thinking”, and believe that “too much short-term thinking has harmed the ocean”.

**Gruby et al 2021**

We are living in the ‘new Gilded Age’: an era of mega-wealth and big philanthropy [1]. As Skocpol [2, p.433] has observed, “In the current period of sharp accumulations of wealth at the very top, philanthropic giving is booming with many societal reverberations.” Mirroring upward trends in philanthropy generally, marine conservation philanthropy (hereafter: ocean philanthropy) is reported to have more than doubled in the past decade [3].

Akin to keystone species in ecosystems, we suggest that private foundations may be examples of “keystone actors” in marine social-ecological systems [6,7], with a profound and disproportionate influence on conservation agendas, research, organizations, networks, policy, and the local societies affected by these interventions.

Social scientists have described organized philanthropy as a “black box” and “vast research frontier” deserving urgent attention in light of the increasing influence of foundations in governance and public policy in sectors like education, health, civil rights, immigration, and the environment [8,9].

First to emerge in the U.S., private foundations are tax-subsidized non-profit organizations that support “charitable activities” primarily by making grants [19].

The significance of foundations can be understood within the shift from government to governance in the environmental sector, whereby non-state actors are playing increasingly important roles in governance processes, structures, and institutions [31]. For a review of environmental philanthropy scholarship relevant to this paper, we direct readers to our work in [35], where we synthesize the literature to outline a research agenda on foundations as agents of environmental governance.

Foundations are not required to disclose information about their funding allocations – a problem of transparency well recognized by scholars [12,38] and the media [61].

**Betsill et al 2021**

Today’s mega-rich direct significant portions of their wealth through philanthropic foundations (Kolbert 2018). Increasingly, foundations play a prominent role in environmental arenas as funders of projects, organizations, policy initiatives, and research activities across a range of issue areas.

Compared to cities, civil society organizations, businesses, and scientific networks, foundations are largely absent from environmental governance research, despite providing substantial funding and other support for many initiatives that have been the subject of scholarship.

Studies of foundations as *funders* emphasize their significant financial assets, while scholars who analyze foundations as *field- builders* consider how foundations deploy non-material or social resources alongside financial resources to advance agendas in environmental arenas.

Disbursing grants for specific activities is seen as the primary mechanism through which foundations exercise agency in environmental governance (Delfin and Tang 2007, Bakker *et al*. 2010, Brulle 2014, Nisbet 2018). For example, in the US, foundations are an increasingly significant funding source for conservation science considering declining federal support, thereby performing the role of knowledge production.

Critical scholars argue that foundations direct resources to well-established NGOs supportive of market-based solutions, which enables foundations to co-opt NGO agendas and leadership to advance a capitalist agenda. From this perspective, channeling allows foundations to act as gatekeepers and marginalize organizations supporting more radical or structural change.

**Aseres & Sira 2020**

An increasing number of protected areas (PAs) are being established in many countries to conserve and preserve the wildlife species and to maintain earth's ecological balance, but in emerging economies such as Ethiopia, PAs are currently confronted with inadequate conservation funding that makes it tough to protect the remaining biodiversity. PAs, therefore try to use other financial means such as ecotourism to subsidize their financial shortage and nourishes the nexus between conservation and development. Estimation of visitors' willingness to pay (WTP) would be useful to craft strategies to strengthen the self-financing capability of PAs and hence realizing environmental and livelihood goals. In this study, the visitors' WTP for the proposed conservation fund in the context of Bale Mountains National Park (BMNP) was estimated using a contingent valuation method. The finding indicated that 75% of visitors were willing to pay a conservation fee. The mean WTP was estimated to be US$7.40 for foreign visitors and US$1.00 for domestic visitors. The finding suggests that the implementation of conservation fee in addition to the existing entry fee helps to improve the long-term sustainable financing of PAs

**Evans et al 2020**

As economies contract in response to the fight against Covid-19, all areas of expenditure by individuals, industry and government will be squeezed. Previous investments in conservation are unlikely to be maintained, and there seem to be vanishingly small prospects of substantial increases in investment to the levels required to meet globally agreed conservation targets.

**Clark et al 2018**

In order to meet these challenges, we are facing uncharted territory that requires taking unprecedented action to recalibrate globally towards a low-carbon economy. Unlocking private finance is regularly regarded as a solution to achieving such change (African Development Bank et al., 2015), however the enabling political, regulatory and economic conditions that would stimulate redirecting the bulk of private sector investment towards meeting these goals remain unchanged (Parker et al., 2012; Almassy et al., 2015).

However, in recent years, there is a growing discourse claiming the availability of trillions of dollars to finance the global environmental agenda, simply waiting to be “unlocked” (World Bank, 2015).

It has previously been noted that disconnects may exist between global commitments and the human and technological capacity to implement (Murcia et al., 2016; Holl, 2017). We agree with this assertion and further speculate that a similar disconnect exists between global ambitions and financial realities and that the mechanisms by which such commitments can be fulfilled will likely require transformations across scales of geographies, policies, and economies.

Financing options to support conservation, climate action, and sustainable development have been expanding in recent years and vary across different scales, types and time horizons—all of which are largely dictated by funding sources. Funds such as the World Bank BioCarbon Fund, the Clean Development Mechanism, the Global Environment Facility and the Green Climate Fund have emerged to support the global agenda. Capital can also be obtained from local, federal and international sources as well as disparate sources encompassing regional governments, conventional financial institutions such as banks and private equity firms, development finance institutions, private sector investment, high net worth individuals and others, although philanthropic and government sources dominate this space (Shames et al., 2014). This is problematic, since these sources can only fulfill a small fraction of the overall finance required to meet the sustainable development and climate agendas. As such, new funding structures and innovative collaborative partnerships represent important shifts in the financial markets to develop solutions.

As such, new funding structures and innovative collaborative partnerships represent important shifts in the financial markets to develop solutions. Calls for the up-scaling of finance have been directed at all levels of government and international funding agencies, accompanied by a recent focus on the private sector (Schuyt 2005; Stein et al., 2010).

It is crucial to have reliable, integrated information regarding the current status of financial flows across various domains, sectors and efforts such as climate change and sustainable development In order to properly assess the current state of financing and inform clearly articulated strategies and financial decisions to address gaps and allocate limited resources in the most efficient way possible.

Various sources have recognized a disconnect between investors seeking projects and projects seeking funding due to a perceived lack of opportunity as well as challenges sourcing a viable pipeline of bankable projects. We identify a paucity of comprehensive research providing empirical evidence supporting the current state of green finance being spent across the various sectors and forecast needs for the near future.

Governments also play pivotal roles in incentivizing private investment through policies, subsidies, grants, concessional loans and risk mitigation mechanisms including insurance and government guarantees. The importance of conservation finance as part of wider global efforts addressing climate change and sustainable development is undeniable, yet inadequate funding remains a persistent challenge.

Approximately USD52 billion annually, primarily from philanthropic and public funds, currently flows to conservation projects (Huwyler et al., 2014); however, it is estimated that an additional annual investment of USD200–300 billion is required for ecosystem preservation globally across land and oceans (Huwyler et al., 2016).

Sachs et al 2019

Freeling & Connell 2020

Lennox et al 2016

**McFarland 2018**

There are numerous financial and strategic solutions to conserve the world’s remaining forests. Essentially what is needed going into the future is mitigation of global climate change; conservation of large tracts of land; investable, scalable projects for the private sector; development of new financing structures; public funds used to leverage private financing; education and reduced public apathy; a new economic system that values natural capital; respect for local communities, Indigenous Peoples, and human rights; and policy matters.

Examples of such mechanisms? Trusts? Commitments from international bodies, financial institutions, and statutory agencies?