Making space: Putting landscape-level mitigation into practice in Mongolia

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Abstract
Growing resource demands are driving rapid development to new frontiers in developing countries with important biological diversity. The mitigation hierarchy is a critical tool to manage the impacts of development projects on biodiversity, embedded into numerous government, lender, and corporate policies. However, implementation faces obstacles, in particular deciding when impacts should be avoided. Offset design, the last step, faces difficult questions about location of offsets relative to impacts and how to address uncertainty and conflicts with future development. Planning for conservation and development are typically separate processes, and environmental impact assessments are typically conducted on a project-by-project basis that does not consider the landscape context and cumulative impacts of multiple projects. Here we present a mitigation framework for Mongolia with an example from the Mongolian Gobi Desert, a landscape with globally significant biodiversity facing rapid development. This landscape-level planning approach has been replicated across Mongolia to produce a national level mitigation framework to guide both the government policy commitment to protect 30% of all natural lands and application of the mitigation hierarchy. This has led to protection of 177,000 km² in new national and local protected areas, and development of an offset design mechanism based on the conservation plans.

KEYWORDS
biodiversity offsets, conservation planning, development impacts, environmental impact assessment, landscape scale conservation, landscape scale mitigation, mitigation hierarchy, Mongolia, performance standards, strategic environmental assessment

1 | INTRODUCTION

Halting global biodiversity loss is one of the leading sustainability challenges of the 21st century (Cardinale et al., 2012). Impacts associated with development are the most significant anthropogenic drivers of biodiversity decline (Newbold et al., 2015). Growing resource demands driven by human population and consumption trends are pushing development to new frontiers in developing countries that contain important biological diversity and generally have not seen this level or pace of infrastructure development. An estimated 20% of the world’s remaining natural lands are at
risk of fragmentation from mining, energy, agriculture, and urban expansion (Oakleaf et al., 2015). Arresting further declines will require the implementation of environmental conservation principles that reduce biodiversity losses associated with economic development.

However, a key gap in current environmental policy and practice is the absence of established biodiversity conservation goals, or limits to biodiversity loss, established at a regional- or landscape-level, and approaches to achieve such targets. Unfortunately, environmental impact assessments (EIAs) are typically conducted on a project-by-project basis that does not consider the landscape context, or regional biogeography and cumulative impacts of multiple projects. The impacts from individual developments may be manageable and compatible with conservation goals, but the cumulative impacts of multiple development projects pose the greatest risk to biodiversity and ecosystem services. Effective mitigation will require integrating conservation and development planning at a landscape scale to proactively identify areas at risk of conversion and develop strategic plans to meet and maintain conservation goals in the face of projected cumulative impacts.

Embedded into numerous government, lender, and corporate policies, the mitigation hierarchy is a critical tool to manage the impacts of development projects on biodiversity, requiring proponents of development projects to reduce adverse outcomes first through avoidance, then minimization, then remediation or restoration on-site, and finally by compensating for residual impacts through the use of offsets (Bull, Gordon, Watson, & Maron, 2016; Business and Biodiversity Offsets Programme [BBOP], 2012; Ekstrom, Bennun, & Mitchell, 2015; McKenney & Kiesecker, 2010). However, mitigation efforts often skip the first, critical step in the mitigation hierarchy, avoidance (Clare, Krogman, Foote, & Lempers, 2011; Phalan et al., 2018; Villarroaya, Barros, & Kiesecker, 2014). Although consideration of the landscape context of impacts is a fundamental principle of effective mitigation (BBOP, 2012; Ekstrom et al., 2015; Gardner et al., 2013; Pilgrim & Bennun, 2014), little guidance exists for how to determine when impacts should be avoided and when they can proceed (Kiesecker, Copeland, Pocewicz, & McKenney, 2010; McKenney & Kiesecker, 2010).

If development proceeds and offsets are used to manage residual impacts, there is a tradeoff between locating offsets close to impact and directing offsets to sites that have regional conservation significance (Kiesecker et al., 2009). To maximize benefit or returns, offset siting should consider opportunities that align with regional conservation goals (Gardner et al., 2013) and opportunities for aggregated offsets (Pilgrim & Bennun, 2014). Biodiversity offset investments must also minimize uncertainty and conflicts with future development and other threats to ensure the duration and permanence of offset gains (Bull, Suttle, Gordon, Singh, & Milner-Gulland, 2013; Gardner et al., 2013). These problems may be partially addressed by directing offsets to areas identified as conservation priorities by a stakeholder- and data-driven landscape plan.

In addition, when offsets are used, it is important to ensure that ecological equivalence of impacts and offsets are measured and used to guide offset design. Most policy frameworks require “in-kind” mitigation, but many methods for measuring biodiversity exist and are not applied consistently (Bull et al., 2013; Gardner et al., 2013; McKenney & Kiesecker, 2010; Quétier & Lavorel, 2011) and data requirements vary. Most development frontiers are in developing countries (Oakleaf et al., 2015) that face the combined problem of rapid development and limited biological data to plan effective mitigation.

Here we present an example of a landscape-level mitigation framework that addresses these challenges in the Mongolian Gobi Desert region, a data-scarce landscape with globally significant biodiversity values facing rapid development. This framework serves as a mechanism to apply the mitigation hierarchy to meet the government goal of protecting 30% of all natural habitats (Parliament of Mongolia, 1998, 2014) in a manner that maximizes biodiversity conservation. The framework is based on a stakeholder-driven, landscape-level conservation plan developed following systematic conservation planning methods (Groves et al., 2002; Margules & Pressey, 2000) adapted for landscape-level mitigation (Kiesecker et al., 2010). The Gobi plan is the second of four conservation plans replicated across Mongolia between 2009 and 2017 that combined produce a national mitigation framework.

1.1 | Study area

The study area is the Mongolian portion of the Central Asian Gobi Desert ecoregion, spanning 510,000 km² or the southern third (32%) of the country, as delineated by Chimed-Ochir et al. (2010) and Dash (2007). This area is a cold desert with a continental climate and long, cold winters. Mean annual precipitation ranges from less than 40 mm in extreme arid areas to over 200 mm in the Gobi-Altai mountains (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005) and varies greatly interannually (Vandandorj, Gantsetseg, & Boldgiv, 2015).

The Mongolian Gobi Desert (Figure 1) is part of the largest steppe ecosystem in the world that supports its historic wildlife assemblage, including long distance wildlife migrations (Butsaikhan et al., 2014), as well as traditional nomadic pastoralism. Globally, temperate grasslands such as those found in Mongolia are the most converted and least protected biome on the planet (Hoekstra, Boucher, Ricketts, & Roberts, 2005). Parts of the Mongolian Gobi Desert region
have been identified as among the world's largest and most intact (least converted) remaining wild areas (Allan, Venter, & Watson, 2017; Kennedy, Oakleaf, Theobald, Baruch-Mordo, & Kiesecker, 2019). The region currently supports 34 animals listed as nationally threatened or endangered (Clark et al., 2006; Gombobaatar et al., 2011; Terbish et al., 2006), including the world's largest remaining populations of Asiatic wild ass (Equus hemionus), Goitered gazelle (Gazella subgutturosa), wild Bactrian camel (Camelus ferus), Siberian ibex (Capra sibirica), Gobi bear (Ursus arctos gobiensis), and Mongolian gazelle (Procapra gutturosa) (Clark et al., 2006; Kaczensky, Lkhagvasuren, Pereladova, Hemami, & Bouskila, 2015; Mallon, 2008a, 2008b).

However, the wildlife and pastoral livelihoods of this area are threatened by rapid growth of mining and related infrastructure (Batsaikhan et al., 2014; Suzuki, 2013). In 2012, 14% of Mongolia's surface area and 24% of the Gobi study area was leased for mineral extraction or exploration (Ministry of Mineral Resources and Energy of Mongolia, 2012). In 1998, in anticipation of growth in the mining sector, the Mongolian government established a goal of designating 30% of the country's land as national and local protected areas (Parliament of Mongolia, 1998; 2014). As of 2008, Mongolia had designated 74 national protected areas covering about 217,000 km² or 14% of the country (MNET, 2008), and within the Gobi study area 21 national protected areas covered about 109,000 km² or 21% of the study area.

2 | METHODS

Our methods are based on systematic conservation planning standards described by Groves (2003) and adapted for landscape-level mitigation planning (Kiesecker et al., 2010) to guide avoidance and offset implementation (Figure 2). Systematic conservation planning is a transparent, data-driven process for identifying a set of places or areas that, together, represent the majority of native species habitats, natural communities, and ecological systems found within the study area. To be effective, conservation efforts should consider distributions of habitats, threats, and impacts at a regional- or landscape-level across biogeographic regions (Groves, 2003; Groves et al., 2002). A conservation portfolio of priority sites, the product of conservation planning, contains a set of areas selected to represent the full distribution and diversity of native species and ecosystems (e.g., Cameron, Cohen, & Morrison, 2012; Goldstein et al., 2017).

We identified a portfolio of sites that support native biodiversity and ecological processes representative of the Mongolian Gobi Desert, based on four criteria from systematic conservation planning principles (Groves, 2003; Groves et al., 2002; Margules & Pressey, 2000)—representation, ecological condition, efficiency, and connectivity. To meet the representation criterion, the portfolio composition must meet the 30% protection goal for all biodiversity elements, defined here as terrestrial ecosystems. To optimize for ecological condition, selected areas contain biodiversity elements that have the highest ecological integrity relative to the study area, as measured by an index of disturbance from cumulative anthropogenic impacts. To maximize efficiency, the portfolio contains the least area necessary to meet biodiversity goals, with some redundancy to withstand current and future threats. To maximize connectivity, where possible, portfolio sites are selected as large, contiguous areas, following the general principle that a nature reserve network consisting of fewer, larger contiguous sites is preferable to
one consisting of many, smaller sites (Crooks et al., 2017; Haddad et al., 2015).

We designed the portfolio following four steps described below. We chose and developed these methods to address the scope and scale of conservation planning across the study area with available data. Because the process depends on existing data that is coarse and incomplete, expert review was an essential component throughout the process.

Step 1: Assemble a working group. We convened experts and stakeholders to advise and review the planning process. This advisory group consisted of biologists and geographers from academia, government agencies, and conservation NGOs with expert knowledge of the study area and available data as well as officers in national and provincial (aimag) government agencies with knowledge and expertise in law, policy, and implementation strategy (see Supporting Information Section 1). The advisory group reviewed all components and products of the assessment.

Step 2: Identify existing priority conservation areas. We identified a set of existing priority conservation areas that are either (a) current national protected areas, that is, strictly protected areas, national parks, national monuments, and nature reserves; (b) the Tost and Toson Bumba Local Protected Area that was proposed as a national protected area; or (c) Important Bird Areas (Nyambayar & Tseveenmyadag, 2009) that were identified through a systematic selection process and are the Mongolian component of the world database of Key Biodiversity Areas (BirdLife International, 2019). These areas form the foundation or starting point for portfolio design and cover 110,000 km², or 21% of the study area.

Step 3: Site selection for ecosystem representation. We identified a set of areas that, in combination with National-level PAs and existing priority areas, meets representation goals for biodiversity elements in a configuration that optimizes for ecological condition, efficiency, and connectivity (spatial contagion). This analysis involved selecting a set of representative biodiversity elements and mapping their distribution, developing a spatial metric of ecological condition, and site selection analysis.

To define biodiversity elements and map their distribution, we developed a terrestrial ecosystems classification and spatial model organized as a hierarchy of regional biogeographic zones (Dash, 2007), ecosystem types based on vegetation structure and geomorphology, and landforms (Heiner et al., 2015). This approach to ecosystem classification for conservation planning has been applied widely in regional conservation plans across terrestrial, freshwater, and marine realms (Groves, 2003; Groves et al., 2002). We set representation goals as 30% of the distribution of each ecosystem type across the study area, based on the national protection goal. To assess the distribution of threatened species, we identified 34 nationally listed rare and endangered animals: 19 mammals, 8 birds, and 7 herptiles (Clark et al., 2006; Gombobaatar et al., 2011; Terbish et al., 2006) listed in Supporting Information Section 3; developed spatial models
of potential habitat based on range maps, literature, and existing survey data; and measured representation in the portfolio post-hoc (see Heiner et al., 2013).

To guide site selection, we calculated a metric of ecological condition derived from spatial data representing sources of anthropogenic impacts that include population centers, roads and railways, mines and supporting infrastructure, and livestock grazing (see Supporting Information Section 2). The result is an index of disturbance from cumulative impacts that functions as a generalized measure of ecological condition and competing economic values such as high livestock use. In site selection, this index directs selection to sites with least degradation and conversion from historic natural conditions and has the effect of excluding highly converted areas such as population centers and active mine leases. Three of this region's wide-ranging and threatened species, Asiatic wild ass (or Mongolian khulan), Goitered gazelle, and Mongolian gazelle, have been found to avoid human activities as modeled by this disturbance index (Buuveibaatar et al., 2016; Nandintsetseg et al., 2019).

To conduct site selection analysis, we used MARXAN (Ball, Possingham, & Watts, 2009), a software package developed for spatial conservation planning that conducts site selection to meet user-defined representation goals for biodiversity elements while minimizing user-defined planning unit cost. In this case, planning unit cost was derived from the disturbance index so the more disturbed planning units had higher cost values. The MARXAN cost function includes a connectivity component that provides a cost savings for sites that share a boundary. We constructed a spatial analysis framework that divides the study area into ~10,550 planning units or cells of uniform shape (hexagons) and size (50 km²). We then populated this framework to identify existing priority conservation areas (Step 2 above), and for each cell calculated composition (area) of ecosystem types and the mean disturbance index value. We set MARXAN parameters following a sensitivity analysis as recommended by Game and Grantham (2008). The initial site selection consisted of 50 sites covering 195,000 km² or 37% of the study area.

Step 4: Redesign to minimize conflict with planned mineral development. The initial site selection included ~31,000 km² (16% portfolio area) that were leased for mineral exploration. Recognizing that in the Mongolian Gobi Desert there are a range of options to meet representation goals and that most stakeholders did not want to retire or convert existing exploration leases, we redesigned the initial portfolio to minimize conflict with exploration leases. Within the set of conflict areas, we identified cells with critical conservation significance based on three criteria—optimacity, rarity, and high quality habitat for Mongolian khulan (Asiatic wild ass), as described below—and designated these as areas where development should be avoided. We replaced the remaining conflict areas with sites of similar composition and condition outside existing leases. The result is a redesigned portfolio that avoids mining leases except in areas of critical conservation significance. Existing national protected areas were unaffected by this redesign because national protected areas prohibit mining exploration and mining leases.

Optimacity (Wilhere, Goering, & Wang, 2008) is a measure of the relative contribution of each cell to an optimal MARXAN solution independent of the representation goals. The rarity metric calculation is a modification of the Relative Biodiversity Index (Schill & Raber, 2009) that removes the influence of cell size and standardizes the distribution and range of values. A rarity value is calculated for each ecosystem type within each cell as the area of the ecosystem type relative to its total area across the study area, and the cell rarity metric is the maximum rarity value in the cell. In general, the cells with the highest rarity metric contained rare wetland ecosystems including water bodies, oases, and wet depressions. To identify areas of potential khulan habitat, we adapted a habitat model published by Kaczensky et al. (2011). The advisory group chose to prioritize suitable khulan habitat because it is regionally endangered (Clark et al., 2006) and 75% of the world's population is in the Mongolian Gobi Desert, where it is currently threatened by habitat loss and fragmentation due to linear infrastructure expansion to support mining operations (Kaczensky et al., 2015).

To redesign portfolio conflict areas, we identified areas of critical conservation significance as cells either with the sum of the optimacity and maximum rarity values (rescaled from 0 to 1) in the upper 30th percentile or containing high-quality khulan habitat. We designated cells meeting either of these criteria (19,850 km² or 64% of the conflict areas) as areas where development should be avoided. We replaced the remaining cells (11,100 km², or 36% of the conflict areas) with sites of similar composition and condition outside existing leases.

3 | RESULTS

The final conservation portfolio covers 195,000 km² in 50 sites, or 37% of the study area, with current National Protected Areas covering 110,000 km², or 56% of this portfolio area. The redesigned portfolio contains at least 30% of all ecosystem types and at least 30% of potential suitable habitat for 32 of the 34 focal species (see Supporting Information Section 3). By redesigning the initial portfolio to avoid conflicts with development, conflicts with 11,100 km² of development leases were avoided, with no change to the total area of the portfolio. After completion of the Gobi Desert regional planning framework in 2013, 68,800 km² of new protected areas were designated based on the portfolio.
With the establishment of these new protected areas, 160 exploration and application leases have been retired (MMRE, 2012; Mineral Resource and Petroleum Authority of Mongolia [MRPAM], 2019).

The Gobi Desert plan is the second of four regional conservation plans that have been replicated across Mongolia and have directed designation of new national and local protected areas based on the portfolio. The first, completed in 2011 for the Eastern Mongolian Grasslands (Heiner et al., 2011), led to designation of 39 new protected areas covering 60,200 km², including 21 National Protected Areas (19,300 km²). Planning for the remaining regions of western (Mongol Altai Mountains and Northern Altai Gobi) and northern (Khovsgol and Khangai) Mongolia was completed in 2017 (Heiner, Galbadrakh, Batsaikhan, et al., 2017; Heiner, Galbadrakh, Bayarjargal, et al., 2017), and led to protection of an additional 48,500 km² of new protected areas. In total, ~177,700 km² of new protected areas have been established based on the national conservation portfolio and planning process (see Figure 3).

4 | DISCUSSION

Transformation of the natural world for infrastructure development and resource extraction remains one of the greatest threats to species persistence and functioning ecosystems (Maxwell, Fuller, Brooks, & Watson, 2016). There is general consensus among researchers and practitioners that mitigation should be more comprehensive, considering whole systems, anticipating impacts, and recommending effective actions to keep our natural systems healthy (Ekstrom et al., 2015; Hayes, 2014; Kiesecker et al., 2010). To effectively mitigate impacts, development planning must follow the mitigation hierarchy and function at the landscape-level, considering regional biogeography and cumulative impacts of multiple projects, and therefore requires proactive regional planning. However, historically, mitigation has been a reactive process occurring at small spatial scales on a site-by-site basis.

The landscape mitigation framework for Mongolia that we describe here is designed to guide site level mitigation decisions with a landscape scale information system that moves beyond a reactive, project-by-project approach to a proactive, regional vision for development that is consistent with broader conservation goals. This framework provides a foundation to guide both development decisions and conservation investments. Here we discuss how to use the framework to determine when development objectives are consistent with conservation goals, and design effective offsets in terms of location relative to impacts, long-term security, and ecological equivalence with losses.

4.1 | Guide avoidance decisions

Most guidance recommends avoiding impacts to “difficult-to-replace” and “high significance” resources, however, this first and most important step in the mitigation hierarchy is most often ignored (Clare et al., 2011; Phalan et al., 2018;
Villarroya et al., 2014). Most guidance also gives wide discretion to regulatory authorities about when to avoid, minimize, or offset (McKenney & Kiesecker, 2010). This problem is compounded by the fact that most landscape-level conservation planning exercises do not result in tangible conservation actions (Knight et al., 2008; Prendergast, Quinn, & Lawton, 1999). A root cause of these gaps in practice is that development and conservation planning are typically independent, isolated processes (Kiesecker & Naugle, 2017).

Therefore, with our analysis, we sought to direct avoidance decisions at the landscape-level by identifying a portfolio of sites that meets policy goals for habitat protection and minimizes conflict with future mineral development. After redesigning the initial Gobi Desert portfolio to avoid conflicts with development, conflicts with 11,100 km² of development leases were avoided, and the total area was unchanged. Current legislation prohibits mining in national and local protected areas, and therefore local protected area designation by provincial (aimag) governments functions as a mechanism to implement avoidance (Parliament of Mongolia, 2016). With the establishment of new protected areas based on the Gobi Desert portfolio, 160 exploration and application leases have been retired (MMRE, 2012; MRPAM, 2019).

The planning process was formally approved by the Mongolian Academy of Sciences in 2014, establishing it as the basis for landscape-level conservation planning (MAS, 2014) and the national framework for implementing both the government protected area commitment and the mitigation hierarchy, specifically to determine areas to avoid development. Nationally, ~177,000 km² of new protected areas have been established based on the national conservation portfolio and planning process (see Figure 3). We attribute this success largely to stakeholder consultation throughout the planning process with a broadly defined set of stakeholders (see Supporting Information Section 1).

Local protected areas are designated by provincial (aimag) governments and approved by the local khural, the government body that represents the interests of rural communities and pastoralists. Pastoralists are not excluded from local protected areas, national nature reserves, or national monuments, and national strictly protected areas and national conservation parks include limited use zones that allow traditional grazing and subsistence use (e.g., medicinal plant collection). Protected areas administrations often engage local pastoralists in site planning. The widespread adoption of the portfolio as local protected areas is evidence of the acceptance of protected areas by rural communities and pastoralists.

The conservation portfolio can also be basis for designating critical habitat to implement lender performance standards. The European Bank for Reconstruction and Development (EBRD), a major source of financing for mining development in Mongolia, follows the International Finance Corporation’s (IFC) Performance Standard 6 that requires their financed projects to adhere to the mitigation hierarchy (EBRD, 2008; IFC, 2012). Core to these standards is the definition of three categories of habitat—critical, natural, and modified—and general mitigation requirements for each category. Impacts in areas designated as critical habitats require measures to achieve net gains of biodiversity values. Critical habitat definitions include criteria that are the basis for portfolio design, specifically highly threatened or unique ecosystems identified through systematic national or regional assessments and key evolutionary processes based on physical ecological surrogates. Critical habitat guidance calls for consideration of the distribution of ecosystems and species across an ecologically appropriate analysis area, with methods considering the breadth of ecosystems and forms of habitat, and areas with multiple values (IFC, 2018). Therefore, the portfolio could be considered critical habitat, thus requiring either avoidance or offsets to achieve net gains in biodiversity values. Other areas of critical habitat meeting other criteria may occur outside the portfolio. Remaining areas with land cover in natural vegetation cover would be considered natural habitat, with residual impacts offset to achieve no-net-loss. Modified habitat can be identified as the most disturbed or converted remainder of the landscape, according to the disturbance index, and allow development following best management practices without offset requirements. For critical habitat definitions to drive avoidance, they must be practical and operational, and ideally link to a national policy goal, based on principles of conservation planning, with the objective of ensuring long-term viability of native species and ecosystems. In Mongolia, the definitions above are tied to an explicit government commitment to habitat protection and regulatory structure that has been implemented.

4.2 | Guide offset design and implementation

Offsets are intended as the last option for addressing environmental impacts of development following measures to minimize and remediate impacts on-site to ensure that negative environmental impacts of development are balanced by environmental gains, with the overall aim of achieving a net neutral or positive outcome (Bull et al., 2016; Maron et al., 2018; McKenney & Kiesecker, 2010). Though much of the recent literature on biodiversity offsets has focused on offset accounting with respect to no-net-loss goals, biodiversity offset design must overcome several other methodological obstacles including where to locate offsets relative to impacts; how to minimize threats, uncertainty, and conflicts with future development; and how to ensure that offsets are ecological equivalent in terms of the ecological systems.
and/or species impacted (Bull et al., 2013; Kiesecker et al., 2009; Sochi & Kiesecker, 2016).

The conservation portfolio and the supporting spatial datasets provide a mechanism to address these challenges. Directing offset investments to portfolio sites maximizes biodiversity conservation benefits in terms of ecosystem representation and optimal ecological condition. It can also improve long-term security (certainty and permanence) of offset investments by directing offsets to portfolio sites that can become protected areas. Designating these sites as protected areas will minimize threat from future development, maximize the security of these offset investments, and provide a mechanism to direct offset funds to restoration and management as protected areas.

In 2012, the Mongolian Parliament amended the EIA law to require biodiversity offsets for all mining and oil development projects (Parliament of Mongolia, 2012). The law allows developers to comply either through a permittee responsible process or in lieu fee program, and requires companies to calculate a minimum offset cost following specifications published by the Ministry of Environment, Green Development, and Tourism (MEGDT) that are based on the conservation portfolio and supporting datasets (MEGDT, 2014). The specifications define a method for calculating compensation according to impacts measured in terms of area, magnitude, duration, and four landscape conservation factors based on ecosystem composition, ecological condition, critical habitat designation, and proximity to portfolio sites. The impact area of a proposed development project is calculated according to the spatial extent of infrastructure and related impacts and delineates three zones of impact magnitude based on infrastructure type. The four landscape conservation factors are designed to require higher compensation for impacts to rare and highly productive ecosystems, areas in good ecological condition, and/or near the portfolio sites, with the goal of steering development away from these areas. The methods for delineating the impact area, deriving the landscape factors, and calculating offset cost are described in Supporting Information Section 4.

Given limited capacity, Mongolian government agencies are unlikely to assess the offset accounting of every mine project. To support transparent and replicable implementation of this regulation, in 2016, the MEGDT developed a Mitigation Design GIS Toolset to apply these specifications to calculate the minimum offset cost (MEGDT, 2014; TNC, 2016). The toolset includes an offset siting function that identifies potential offset sites by comparing ecosystem composition of the development footprint with portfolio sites to identify those with similar ecosystem composition and within several possible spatial extents defined by political units (districts/soums, provinces/aimags) within the biogeographic study areas (Figure 4). This is intended to direct offsets to sites within the same biogeographic study area based on the ecosystems, representation goals, and portfolio developed for the biogeographic study area (biogeographic study areas are shown in Figures 1 and 3). Though this is not intended for exchanges between the biogeographic study areas, we chose and developed datasets and methods that could be replicated to form a consistent national framework.

Because the Mongolian offset regulation is new, existing capacity is limited, and the initial implementation framework must be operational, it does not include a commitment to no-net-loss. Instead, the EIA law amendment and offset regulations specify calculation of an in lieu fee that is proportional to the potential impacts on biodiversity. This can steer development away from rare and productive ecosystems and regional conservation priorities, thereby minimizing losses to habitat and biodiversity. A survey of 165 mining EIAs submitted between 2014 and 2017 found that 91 companies or 55% of those surveyed include an offset plan, and 20 or 22% of those offset designs consider biodiversity conservation following the offset regulations and guidance (unpublished survey by TNC-Mongolia program).

In lieu payments are offset compensation paid by developers to a third party to implement conservation interventions (Benabou, 2014; OECD, 2016). In Mongolia, third party implementers can be any institution that is responsible for management of a given site. This could include co-management committees made up of the protected area administration and local stakeholders. Two examples are the Toson Khulstai Nature Reserve in eastern Mongolia and the newly established Tost and Toson Bumba Nature Reserve in the Gobi Desert that are considering implementing biodiversity offsets for nearby mines.

An advantage of in lieu payments over developer-responsible offsets is that the offset activities are implemented by groups with a conservation focus who will aim to maximize the conservation benefits (Agarwal, 2001), often pooling funds to create economies of scale (Benabou, 2014; Calvet, Napoléone, & Salles, 2015). In contrast, separate developer-led offsets may result in piecemeal conservation efforts with a lower overall benefit. Other studies also suggest it is cheaper for developers to pay others to implement effective offsets (Ando & Shah, 2016). However, in lieu fee offsets face some obstacles, including the question of whether the funds and actions are sufficient to ensure a “no-net-loss,” as well as issues around measurement of ecological equivalence (Boisvert, Méral, & Froger, 2013). Although the Mongolia offset program is not intended to support no-net-loss accounting, it does not preclude a company or government agency from conducting a more detailed offset design that seeks to achieve no-net-loss (e.g., The Biodiversity Consultancy & Flora and Fauna International, 2012). As the Mongolian offset program grows, it can be adapted to incorporate more
complex assessments of impact and offset values generated, and develop monitoring systems to ensure compliance, legal accountability, and long-term conservation benefits.

4.3 | Aggregated offsets

This framework can also support offset designs that address cumulative impacts arising from more than one development project through aggregated offsets (e.g., Kiesecker et al., 2010; Pilgrim & Bennun, 2014; Thorne, Huber, Girvetz, Quinn, & McCoy, 2009). Aggregated offsets may provide better mitigation at lower cost with a higher probability of success, reduce costly delays due to protracted environmental review (Cameron, Crane, Parker, & Randall, 2017; Ekstrom et al., 2015), and lead to a better ecological outcomes (Kennedy et al., 2016). For example, an aggregated offset plan for one province (aimag) could be designed by first measuring the approximate footprint of all active mines within the aimag, and then identifying ecologically similar portfolio sites within the aimag. This aggregated offset approach has been adopted by Omnogovi aimag, the largest province in the study area (Omnogovi Province Parliament, 2015).

4.4 | Directing offsets to protected areas

In guiding offset design, our objectives were to locate offsets sites based on a landscape-level vision and direct funding to areas that are currently or could soon be part of the protected areas network. This will provide the greatest contribution to regional conservation goals and provide the most security for investments by minimizing threats and conflicts with future development and land use changes. Because portfolio sites were selected to optimize for ecological condition, offsets in portfolio sites would be less dependent on restoration actions that have uncertain likelihood of success (Maron et al., 2012).

There has been considerable debate whether protected areas are suitable as offset sites (Maron et al., 2016; Maron, Gordon, Mackey, Possingham, & Watson, 2015; Pilgrim & Bennun, 2014). One risk of channeling offset funds toward
protected areas is that these new funds displace—rather than supplement—current or future funding committed to protected areas management. In such cases, compensation would not be additional—instead of reducing overall impacts of development, offsets would facilitate a continuing decline in biodiversity (Pilgrim & Bennun, 2014). For example, a country could cap or cut funds to protected areas in anticipation that offset funding will fill the gap.

However, this debate is focused on the typical case, in which mitigation planning and conservation planning occur separately, while the framework for Mongolia integrates the two. The conservation portfolio identifies areas to avoid development, and offset design is an integral part of the process, based on the same datasets, to ensure offsets enforce and support the vision of the protected areas network. This type of joint planning for development and conservation is rare but could provide a mechanism to both design a conservation vision and generate funding to implement that conversation vision in proportion to impacts from development.

The case of Mongolia is also unique because Mongolia has already protected a relatively large portion of its land area, with 20% in national protected areas (MEGDT, 2019). As Pilgrim and Bennun (2014) have suggested, offsets in protected areas would be viable once a country has achieved the 17% protection target defined by the Aichi targets in the Convention on Biological Diversity. The Aichi targets commit signatories to create an ecologically representative and well-connected protected area system containing at least 17% of their land area. Mongolia has already met this target and seeks a more ambitious target of 30%.

Without adequate funding for management of protected areas, biodiversity values will likely continue to decline. An assessment of over 8,000 protected areas across the world found that about 40% showed major deficiencies in management effectiveness (Leverington, Costa, Pavese, Lisle, & Hockings, 2010). In Mongolia, national government funding covers only operational costs for strictly protected area and national conservation parks that make up approximately half of all national protected areas and 85% of the total area. Support for the remaining national protected areas (monuments and nature reserves) and all local protected areas is the responsibility of local (province/aimag and county/soum) governments. So while steering funding toward protected areas management may not meet the additionality principle from a policy perspective, it can certainly add value in terms of protecting biodiversity.

4.5 Limitations of this study and outstanding issues

In a landscape that remains largely unfragmented but faces rapid changes from mineral and energy development and climate change, planning must be flexible and regularly reviewed and revised to allow managers to adapt to new threats and changes in land use, and incorporate new information (Wilson, Westphal, Possingham, & Elith, 2005). The results of spatial conservation planning are sensitive to the choice of biodiversity elements, goals, and measures of ecological condition and to the accuracy of the source data. Also, spatial planning conducted at regional and local spatial scales may produce varying results (Huber, Greco, & Thorne, 2010). Therefore, local adoption and implementation of the conservation portfolio should include local review and revision of site boundaries based on local knowledge and surveys.

Data and information regarding the distributions, status, and ecology of species and biodiversity in the Gobi Desert region is limited, and there is an urgent need for basic research and surveys to inform conservation, mitigation, and monitoring (Clark et al., 2006). Therefore, we developed an approach that relies on biophysical surrogates for biodiversity. All biodiversity surrogates have limited and variable power (Grantham, Pressey, Wells, & Beattie, 2010) but remain a key component of systematic conservation planning (Margules & Pressey, 2000; Rodrigues & Brooks, 2007). As knowledge and datasets in this region improve, the data used to represent biodiversity in the region must be updated.

The focal species habitat models represent working hypotheses regarding the distribution and habitat selection of these species and are significant improvements over range maps. Range maps have been found to grossly overestimate actual distribution of species and habitat in comparison to spatially explicit habitat suitability models (Di Marco, Watson, Possingham, & Venter, 2017; Ocampo-Peñuela, Jenkins, Vijay, Li, & Pimm, 2016). The spatial models of ecosystems and species habitat developed for this conservation plan can guide surveys to collect data that can in turn improve the spatial models.

Mongolia has been warming since the 1950s (Batima, Natsagdorj, Gombluudev, & Erdenetseng, 2005; Chen et al., 2009) with observed declines in surface- and ground-water sources and stream flows (Fassnacht et al., 2011; MNET, 2009), predicted declines rangeland productivity (Angerer, Han, Fujisaki, & Havstad, 2008), and serious implications for wildlife, pastoralists, and economic development. Climate change will likely drive range shifts and changes in habitat use and compound the threat of habitat loss, fragmentation, and movement barriers (Singh & Milner-Gulland, 2011). To address the uncertain impacts of climate change, conservation planning guidance emphasizes biophysical representation while maintaining landscape connectivity (Anderson & Ferree, 2010; Brost & Beier, 2012; Hunter, Jacobson, & Webb, 1988). Although the conservation portfolio is static, biophysical representation and site configuration are designed to accommodate dynamic environmental conditions. The biophysical ecosystem classification ensures that the portfolio represents a range
environmental settings distributed across biophysical gradients and contains redundant examples distributed across multiple sites. Site selection criteria also include a preference for large, contiguous sites.

Transportation infrastructure and traffic supporting mining operations create barriers to wildlife movement that are an urgent threat to the viability of wide ranging mammals including this region's iconic plains ungulates, Asiatic wild ass or Mongolian khulan, Mongolian gazelle, and Saiga Antelope (Batsaikhan et al., 2014; Ito, Lhagvasuren, Tsunekawa, Shinoda, & Takatsuki, 2013; Kaczensky et al., 2011). Protected areas alone cannot effectively conserve the current populations of wide ranging mammals (Runge, Martin, Possingham, Willis, & Fuller, 2014), and movements of wide ranging species fall outside Mongolia's protected area model that was the focus of this study. Transportation and other linear infrastructure require mitigation measures, including avoidance of critical habitat resources and minimization of barrier effects with design and operation that includes passage structures and traffic curfews. Mitigation measures for transportation are summarized by van der Rhee, Smith, and Grilo (2015) and the focus of conservation efforts in Mongolia (Lhagvasuren, Chimedorj, & Sanjmyatav, 2011; Olson, 2012; Wingard, Zahler, Victurine, Bayasgalan, & Buuveibaatar, 2014).

5 | CONCLUSION

A landscape-level vision for biodiversity conservation is essential because it ensures that biologically and ecologically important features remain the core conservation elements over time. Without this, we lose sight of the overarching conservation goals, establishing priorities becomes difficult or irrelevant, and we waste scarce resources. Determining stakeholder- and data-driven conservation priorities and developing a shared conservation vision is a challenging exercise, but the real challenge is finding funding mechanisms to implement that vision. The framework outlined here not only balances development with conservation goals, it provides a structure to fund conservation commensurate with impacts from development.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

Data development and analysis: all authors; project management including stakeholder engagement: D.G., Y.B., and B.T.; manuscript writing: M.H., D.G., J.O., and J.K.; manuscript review and editing: all authors.

DATA AVAILABILITY STATEMENT

All source datasets are cited in the paper or supplemental materials. The spatial datasets produced by all four assessments are publicly available online in a national spatial data archive that includes the portfolio sites, biophysical ecosystem classifications and components, and the disturbance indexes and components. This national spatial data archive and the mitigation design GIS toolset were made publicly available as part of a national capacity building project directed by the MEGDT and funded by the EBRD through Contract No: C30074/EBSF-2012-08-107, “Capacity building for Mongolian Ministry of Environment Green Development, and Tourism (MEGDT) in relation to biodiversity and conservation in the southern Gobi Desert” with reports available online at https://www.conservationgateway.org/ConservationByGeography/AsiaPacific/mongolia/Pages/southerngobi-ebrd.aspx. The national spatial data archive is available online at https://tnc.app.box.com/s/zpdlhezvqrijpq9c3towsrzwoc88mke.

ETHICS STATEMENT

The authors are not aware of any ethical issues related to this study.

TARGET AUDIENCE

The target audience for this is conservation scientists and practitioners involved in mitigation planning, and specifically those in governments of developing countries facing rapid development and in companies and financial institutions seeking to implement performance standards.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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