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Quantifying impact reduction due to avoidance, minimization and restoration for a natural gas pipeline in the Peruvian Andes

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ABSTRACT

We present monitoring methods and quantitative biodiversity data to document components of the mitigation hierarchy. We estimated avoidance, minimization, restoration and impact reduction in quality hectares for the 25 m wide right of way of a 408 km natural gas buried pipeline that crosses 14 Ecological Landscape Units (ELUs) in the tropical Andes of Peru. We found that applying the mitigation hierarchy as part of a comprehensive biodiversity action plan substantially reduced impacts on biodiversity in all habitats studied. Avoidance and right of way minimization contributed to significant impact reduction. We quantified impact reduction during construction and operation on the right of way of the pipeline over a five-year period and found that restoration was the greatest contributor to reducing impacts. We documented that most ELUs have a positive restoration trajectory. We also documented how monitoring over large scale spatial scales, in combination with site-specific monitoring, generated data for management to determine restoration priorities and impact mitigation. A biodiversity action plan that incorporated the mitigation hierarchy and a science-based biodiversity monitoring and assessment program contributed to biodiversity management of the project and played an important role in minimizing and managing impacts.

1. Introduction

As infrastructure and development projects continue to be implemented worldwide (Battacharya et al. 2012), biodiversity rich areas are increasingly at risk of experiencing negative impacts on biodiversity and ecosystems services (Benchimol and Peres 2015, Finer et al. 2008, Winemiller et al. 2016). Reducing impacts due to project design and construction is a critical component of conservation and development, and entails participation and investment in funds and expertise by the public, private, and non-profit sectors (Business and Biodiversity Offsets Programme 2012, Saenz et al. 2013) as well as "mainstreaming" biodiversity conservation and management outside of protected areas (Redford et al. 2015).

Several strategies have been proposed to implement best-practices and mitigate project impacts to safeguard biodiversity and attain "no net loss" (Business and Biodiversity Offsets Programme 2012, Villarroya et al. 2014). In addition to the Environmental and Social Impact Assessments (ESIA) as a tool to determine the potential impacts on biodiversity (Energy and Biodiversity Initiative 2003), the project-lending sector is providing standards for biodiversity and ecosystem services standards and implementation of the mitigation hierarchy (International Finance Corporation 2012, World Resources Institute 2008).

The mitigation hierarchy framework is a best-practice approach for development projects that manages risks and potential impacts to biodiversity and ecosystem services (Cross Sector Biodiversity Initiative, 2015). It encompasses four components that can contribute to reduce, manage and offset project impacts: avoidance of sensitive habitat, minimization of impacts, restoration of habitat, and offsetting project impacts if necessary. Avoidance measures are taken to prevent impacts from the planning and beginning of a project and may include modifications in spatial or temporal placement of elements of the infrastructure to minimize impacts. Minimization includes measures taken to reduce the duration, intensity and/or extent of impacts that cannot be avoided. Restoration measures are those taken to restore impacted ecosystems following exposure to impacts not avoided or minimized

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and are a response variable to avoidance, minimization and adaptive management efforts. Finally, offsets as a last resource, are measures taken to compensate for any residual, significant, adverse impacts that cannot be avoided, minimized and/or restored/rehabilitated, in order to achieve no net loss or a net gain in biodiversity (Business and Biodiversity Offsets Programme 2012).

Although a stated condition for offsets is that the mitigation hierarchy be applied first (International Finance Corporation 2012), and offsets be utilized as a last result, little qualitative and quantitative information exists on the application of the mitigation hierarchy prior to offset design (Kiesecker et al. 2010). The application of offset measures has received a lot of attention with regard to the mitigation hierarchy (Gardner et al. 2013, The Biodiversity Consultancy and Fauna and Flora International, 2012a, b, Villarroya et al. 2014), yet application of offsets is still controversial (Bull et al. 2013, Maron et al. 2012, Quetier et al. 2014), and few studies exist that show their long-term efficacy or sustainability (Curran et al. 2014, Moreno-Mateos et al. 2015). For example, habitat restoration offsets may lead to a net loss of biodiversity (Curran et al. 2014) while a number of theoretical and practical issues ranging from use of appropriate currencies, determining habitat equivalencies, longevity, uncertainty and others (Bull et al. 2013) make designing offsets a challenge. Moreno-Mateos et al. (2015) make the claim that multiple ecological, regulatory and ethical losses can occur when evaluating offsets and argue for greater transparency in documenting biodiversity losses. Because application of avoidance, minimization, and restoration/rehabilitation are critical components of a biodiversity strategy or action plan, and may influence offset planning as well as landscape level land-use planning (Saenz et al. 2013), careful implementation and quantification of the mitigation hierarchy is crucial for biodiversity conservation in the area of influence of a project. Furthermore, quantifying the effects of impacts on species, habitats, and ecological processes becomes indispensable for quantifying residual impacts of a project.

Monitoring programs for indicator species and habitats during all phases of a project is a useful approach to quantify residual impacts and guide restoration decisions (Alonso et al. 2013, Lindenmayer 1999). Habitats and biodiversity can be restored more effectively if project managers utilize monitoring programs within an adaptive management framework, especially when the mitigation hierarchy is applied. When impacts can be reduced and restoration activities are informed by appropriate monitoring techniques that suit the scale of the project, measure appropriate indicators, and assess aspects or proxies of ecosystem functionality, then impact reduction targets and positive restoration trajectories may be attained.

Over a five-year period, we quantified systematic impact reduction during construction and operation of a 408 km long 34″ wide natural gas pipeline in the tropical Andes. The pipeline extends from the eastern Ayacucho Region, traverses the Andes through the Departments of Ayacucho and Huancavelica, and goes into the Pacific slope through the desert of the Departments of Ica and Lima, where a 4.4 million metric tons per annum natural gas liquefaction facility (LNG plant) is located (Fig. 1). Prior to the pipeline construction, 14 Ecological Landscape Units (ELUs) that correspond to mountain systems, drainage basins, and functional attributes and commonalities were assigned to landscapes along the pipeline (Langstroth et al. 2013). Major habitat types ranged from Andean wetlands, grasslands, montane forest, dry forest, scrublands, desert scrub and desert, and altitude ranged from sea level to 4900 m. Avoidance and Right of Way (RoW, the stretch of land to be used for construction and operation of the pipeline) width minimization were quantified for the entire RoW and vegetation restoration was monitored annually for the first 241 km of the pipeline, which corresponded to ELU's 1–11. Site - and species-specific research and monitoring activities were conducted throughout the pipeline (ELU's 1–12) via a partnership between PERU LNG and the Center for Conservation and Sustainability, Smithsonian Institution via their Biodiversity Monitoring and Assessment Program (BMAP).

Herein, we present quantitative data on the mitigation hierarchy. We estimated post-hoc avoidance data due to micro-routing of the final track, and width minimization measures for 408 km of the 25 m wide pipeline RoW as specified in contractor management plans. We also present quantitative restoration estimates that compare plant abundance and diversity of the RoW to control areas. While monitoring restoration, we also assessed effectiveness of impact minimization measures (such as topsoil management, erosion control, etc.). Based on these estimates, we calculated residual project impacts for 241 km of the RoW after five years of pipeline operation. We also present one example of a site-specific monitoring study that examined impacts on small rodent diversity and ecological processes such as seed dispersal and habitat connectivity in addition to vegetation restoration. We illustrate how this data was utilized to inform restoration progress or lack thereof. Data gathered via assessments and monitoring at various spatial scales demonstrated to the company the benefits to avoid and minimize impacts implemented prior to project construction, and how to reduce impacts and to achieve a positive restoration trend for the RoW after construction.

2. Background

The company responsible for the construction and operation of the pipeline is PERU LNG, a consortium formed by Hunt Oil (50%), Shell (20%), SK (20%) and Marubeni (10%). A consortium of lenders that included the Inter-American Development Bank, International Finance Corporation (IFC), Export-Import Bank of the United States of America, and others, funded the project. The aforementioned banks apply environmental and social best practices to their projects. These include policies related to biodiversity protection, especially those pertaining to IFC Performance Standard 6 (PS6), which includes specific guidelines to minimize threats to biodiversity through the application of a mitigation hierarchy (International Finance Corporation 2012). The current PERU LNG project was conceived and designed adhering IFC performance standards as defined in 2006.

In order to more effectively implement the mitigation hierarchy to reduce biodiversity associated risk with pipeline construction, PERU LNG developed a Biodiversity Action Plan (BAP), based on guidelines developed by IPIECA (International Petroleum Industry Environmental Conservation Association 2005). The BAP was designed to incorporate the mitigation hierarchy into planning, construction, and post-construction phases and provide specific implementable actions for the protection and conservation of biodiversity during construction and operation of the pipeline (PERU LNG 2007a). The BAP included evaluation of alternative pipeline routes, implementation of the ESIA (Walsh Peru 2005), detailed and smaller scale Ecological Field Surveys (Domus Consultoria Ambiental 2007) and an Ecological Management Plan for each ELU (Environmental Resources Management 2008). These and specific Ecological Action Plans were implemented at the time of the construction of the pipeline. Contractor management plans were written with specific instructions for operating contractors during the construction phase. The BAP was written to follow Peru's legal environmental and social policies, as well as the IFC PS6 version 2006 (Taborga and Casaretto 2013, Dallmeier et al. 2013). The BAP served as an umbrella document that described the framework on how to apply the mitigation hierarchy to reduce and manage biodiversity risks (Maguire et al. 2010). It also provided a framework for the development and implementation of a comprehensive biodiversity monitoring program (the BMAP) and refined the implementation of a restoration plan. The BMAP was used for impact quantification and monitoring to track restoration. BAP activities taken during the various phases of the PERU LNG project were qualitatively summarized by Taborga and Casaretto (2013) and are illustrated in Fig. 2. While area and habitats avoided during construction of the final pipeline route to due micro-routing and width minimization were not quantified until the present study, quantitative data on restoration were collected immediately after