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OPAL: An open-source software tool for integrating biodiversity and ecosystem services into impact assessment and mitigation decisions

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ABSTRACT

Governments and financial institutions increasingly require that environmental impact assessment and mitigation account for consequences to both biodiversity and ecosystem services. Here we present a new software tool, OPAL (Offset Portfolio Analyzer and Locator), which maps and quantifies the impacts of development on habitat and ecosystem services, and facilitates the selection of mitigation activities to offset losses. We demonstrate its application with an oil and gas extraction facility in Colombia. OPAL is the first tool to provide direct consideration of the distribution of ecosystem service benefits among people in a mitigation context. Previous biodiversity-focused efforts led to redistribution or loss of ecosystem services with environmental justice implications. Joint consideration of biodiversity and ecosystem services enables targeting of offsets to benefit both nature and society. OPAL reduces the time and technical expertise required for these analyses and has the flexibility to be used across a range of geographic and policy contexts.

Software availability

Name of software: OPAL (Offset Portfolio Analyzer and Locator)
Developers: James Douglass, Richard P. Sharp and Douglas Denu
Contact address: Natural Capital Project, Stanford University, 371 Serra Mall, Stanford, CA 94303, USA
Email: jdouglass@stanford.edu
Year first available: 2014
Software required: Microsoft Windows 7 or later; GIS software recommended for preparing inputs and visualizing results
Program language: Python 2.7
Program size: 193 MB
Availability: Free download with user guidance available at http://www.naturalcapitalproject.org/software/#opal
Source code available at: https://bitbucket.org/natcap/opal

1. Introduction

With the rapid growth in infrastructure development expected in coming decades (Dobbs et al., 2013; Dulac, 2013), balancing anticipated economic benefits against environmental and social risks is critical to ensure that development activities result in net benefits to society. Nearly all countries have environmental licensing processes which require completion of an Environmental Impact Assessment (EIA) before a development project is permitted to proceed (Morgan, 2012). The EIA process is designed to minimize environmental and social losses from development. In accordance with the mitigation hierarchy, when environmental losses cannot be avoided or restored through on-site activities, compensatory mitigation actions outside the project area may be required (BBOP, 2012).

According to recent estimates, 56 countries worldwide have or are developing policies regarding offsets, with 45 compensatory mitigation programs in existence as of 2011, and 27 more programs in development (Madsen et al., 2011; The Biodiversity Consultancy, 2013). Within the private sector, as of 2011, 32 companies had public environmental no net loss or net positive impact goals (Rainey et al., 2015). In the United States alone, spending on

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compensatory mitigation by the public and private sectors is estimated to exceed $4 billion per year (BenDor et al., 2015). If spent effectively, these funds provide an opportunity to contribute substantially to conservation and provide benefits to both nature and people.

Compensatory mitigation policies and programs were often created with social objectives in mind (Tallis et al., 2015). In practice, however, impacts and associated offsets have been evaluated based on the area affected, or on metrics of biodiversity or ecosystem function, without explicitly linking these properties to human well-being (Quétier and Lavorel, 2011; Robertson et al., 2014). This narrowly focused implementation has led to unintentional redistribution of ecosystem services (ES) — the benefits nature provides to people — creating social inequalities in direct contradiction to the intent of many such laws (e.g., King and Herbert, 1997; Ruhl and Salzman, 2006; Sun et al., 2012; Tallis et al., 2015). Recognizing this oversight in implementation, there has been growing interest in and requirements to explicitly incorporate ES into mitigation processes, including impact assessment and offsets. As of 2012, the International Finance Corporation's performance standards require IFC-financed projects to evaluate and mitigate impacts to ecosystem services (IFC, 2012). These performance standards have been adopted by the 80 Equator Principles Financial Institutions (Equator Principles, 2013). In 2013, the African Development Bank introduced new safeguards procedures that similarly require assessment and mitigation of impacts to ecosystem services (AfDB, 2013). Governments, including many in Latin America and Europe, are adopting mitigation policies that require or enable consideration of ES (The Biodiversity Consultancy, 2013; Villarroya et al., 2014).

Substantial theoretical advances have been made in how to incorporate ES into environmental impact assessment and mitigation (Geneletti, 2011; Tallis et al., 2015). This has been accompanied by a growing body of guidance aimed at practitioners (e.g., Landsberg et al., 2013; Olander et al., 2015). A few case studies have demonstrated these approaches in practice (Mandle et al., 2015b; Tallis et al., 2012), but their application is limited within the realm of project-level impact assessment. Rosa and Sánchez (2015) reviewed five of the first Environmental and Social Impact Assessments (ESIA) to incorporate ES as part of the recent IFC performance standards. They found that none of the five assessments predicted impacts, nor did they map or measure ES supply and demand, in contrast with established best practices. Quantifying ES supply, developing indicators for impact prediction, and characterizing beneficiaries remained key challenges limiting integration of ES into project-level impact assessments (Rosa and Sánchez, 2015). The expertise and time needed to complete such analyses remains a barrier to widespread uptake by licensing agencies and development funders (Baker et al., 2013; Tallis et al., 2015).

While a number of tools exist for quantifying and mapping ES (see tool reviews by, e.g., Bagstad et al., 2013; Waage and Kester, 2015), they are not sufficient for overcoming these barriers. Many tools exist for general ES assessment, providing great flexibility and power (e.g., Jackson et al., 2013; Frank et al., 2015; and many others). However, they carry a concomitant burden in necessary expertise and time to adapt these tools to the context of project-level environmental impact assessment and mitigation. This burden often makes the use of these tools impractical for impact assessment professionals given project timelines and resources. We know of no tools tailored to this decision context that account for ES supply and provision to beneficiaries in a quantitative, spatially explicit manner.

To meet the need for a practical tool directed towards incorporating ES and biodiversity information into project-level impact assessment and mitigation decisions, we developed OPAL (Offset Portfolio Analyzer and Locator), a free, open-source software tool. OPAL allows evaluation of development project impacts and facilitates selection of mitigation options within a single software tool. It accounts for both supply and delivery of ES benefits to beneficiary groups (such as low-income groups, minority populations, indigenous groups), as well as impacts to terrestrial ecosystems (in terms of area impacted and quality) as a proxy for biodiversity. OPAL allows for rapid, repeated analysis of projects, and has the flexibility to be adapted to different mitigation contexts based on local policies and practices.

Here we introduce OPAL and provide a case study of its application for designing offsets for an oil and gas extraction site in Colombia. Colombia's National Biodiversity and Ecosystem Services Policy calls for incorporating biodiversity and ES into planning and development decisions (Ministerio de Ambiente y Desarrollo Sostenible, 2012a). With Resolution 1517 of 2012, Colombia adopted a policy requiring developers to offset losses of natural vegetation by protecting a greater area of comparable vegetation (Ministerio de Ambiente y Desarrollo Sostenible, 2012b) and is now in the process of adding similar requirements specifically to offset ecosystem service losses. We show how the OPAL tool can help identify mitigation options for development projects in line with Colombia's national policies, while considering the equity of ES benefit flows associated with mitigation.

2. The OPAL software tool

2.1. Tool purpose

OPAL was designed to support project-level environmental impact assessment and mitigation decisions, accounting for both impacts to terrestrial ecosystems (as a proxy for terrestrial biodiversity) and to ecosystem services — sediment and nutrient retention for surface water quality regulation, and carbon storage for climate regulation as defaults, with the option to include additional services. With OPAL, users can estimate the impacts of development activities, such as mines or roads, on terrestrial ecosystems and on a subset of the services they provide, and then efficiently select offsets to mitigate losses. OPAL tracks how the environmental impacts of development and mitigation activities affect people through their effects on ES provision. In doing this, OPAL helps make the consequences of development more transparent and enables design of mitigation portfolios in a way that maintains or restores environmental benefits in a more socially equitable manner. OPAL users are expected to have familiarity with project-level environmental impact assessment and mitigation processes. Basic skills in GIS and processing of spatial data are needed to prepare the initial tool inputs, but once those inputs have been prepared for an area of interest, GIS expertise is not required to run OPAL or to interpret the results.

2.2. Tool structure and function

Using OPAL involves four main steps (Fig. 1). First, the user inputs spatial data, including the biophysical properties of the area of analysis, information related to the beneficiaries potentially impacted by development, and any priorities or preferences to be used in selecting mitigation options (see *Data required* section below for more details and Fig. 2). Next, based on these inputs, OPAL quantifies estimated impacts to ecosystems and to ES. OPAL then filters offset sites based on these impacts and the user-provided priorities and preferences, screening out sites that do not meet specified requirements. Finally, OPAL outputs an interactive results report (Appendix A: Example output report). The results report includes a summary of impacts, an interactive list of