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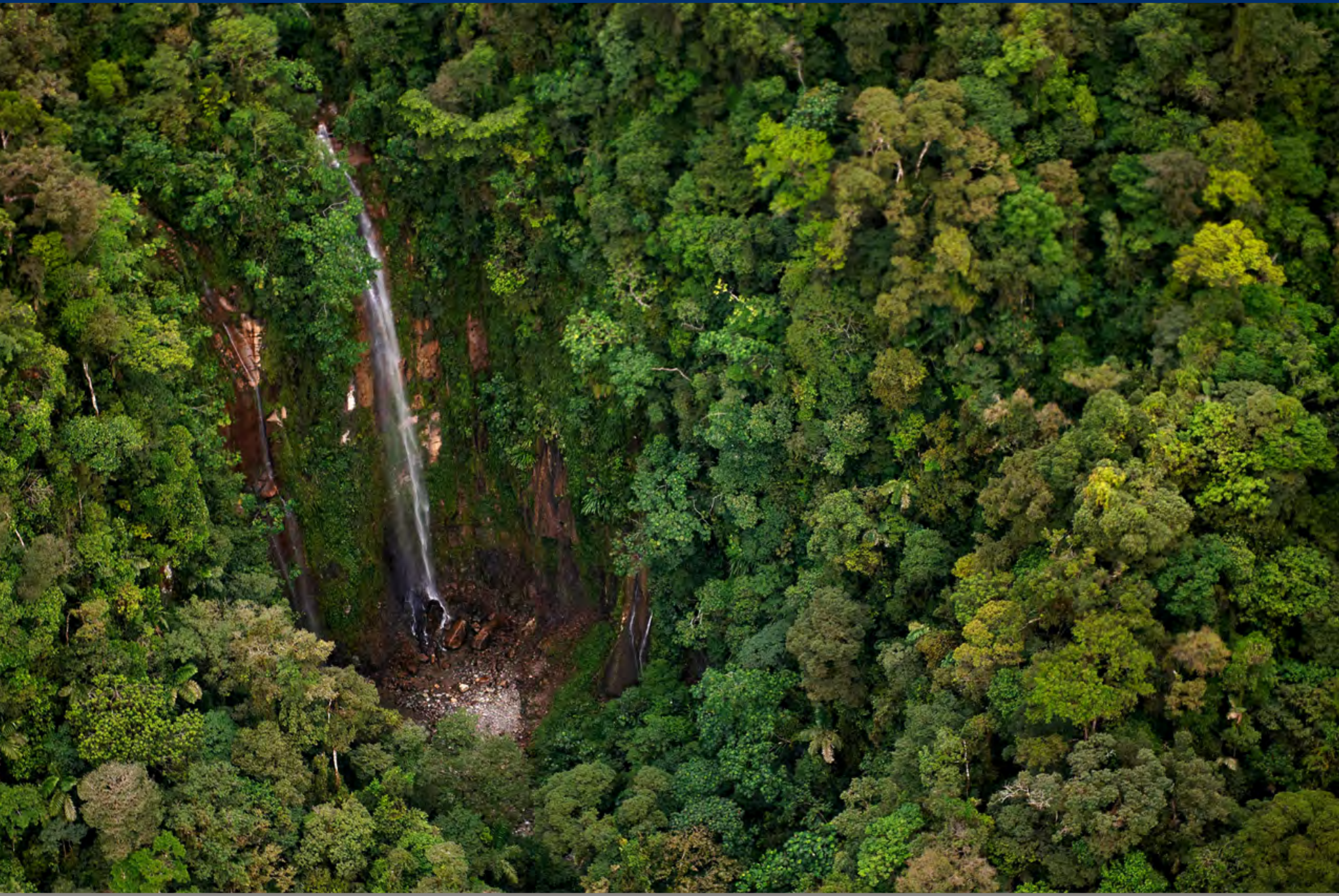
Biodiversity Case Example

INCORPORATING GEOSPATIAL ANALYSIS INTO USAID BIODIVERSITY PROGRAM DESIGN



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MEASURING IMPACT

CONTRACT INFORMATION

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Front Cover: El Sira Communal Reserve, Peru. Photo credit: Thomas J. Muller
Back Cover: Ucayali, Peru. Photo credit: Thomas J. Muller

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ACRONYMS & ABBREVIATIONS

ACA	Amazon Conservation Association
GIS	Geographic Information System
GPS	Global Positioning System
E3	Office of Forestry and Biodiversity
FAB	Bureau for Economic Growth, Education, and Environment
LAC	Latin America and the Caribbean
MINAM	Ministry of Mines and Energy
MINEM	Ministry of the Environment
NGO	Non-governmental organization
SRTM	Shuttle Radar Topography Mission
USAID	United States Agency for International Development

1. INTRODUCTION

The United States Agency for International Development's (USAID) Biodiversity Policy calls for taking a systematic approach to biodiversity programming.[1] In particular, the Policy calls for "an adaptive management approach that integrates program design, management, and monitoring to test assumptions, adapt actions, and learn." To this end, USAID's Bureau for Economic Growth, Education, and Environment (E3) Office of Forestry and Biodiversity (FAB), through Measuring Impact, provides technical assistance and is developing guidance to help Missions that program biodiversity funds use better adaptive management in the context of USAID's Program Cycle.[2] This approach is designed to help Missions develop a conceptual understanding of the program context or problem; the theory of change behind programmatic interventions; and the outcomes and indicators needed for adaptive management by going iteratively through a series of steps in the biodiversity program design process. Each of these elements of the program design process can be respresented graphically to help teams collaborate, share, and implement: the program context or problem is represented by a situation model; the theory of change is represented by a results chain; and the outomes and indicators can be mapped onto the results chain and tracked through implementation of the theory of change.

As biodiversity programming takes place at increasingly larger spatial scales, however, it becomes problematic to treat design in a purely conceptual manner. Programs take place in spatially diverse environments. As a result, it becomes imperative to incorporate geospatial analysis into all of the steps in the biodiversity program design process. This analysis aims to:

- Demonstrate how geospatial analyses can improve key steps in the biodiversity program design process
- Document the geospatial data needs, types of analyses, and key issues for each step in this process
- Demonstrate how geospatial data were applied to project design by USAID/Peru
- Provide recommendations for further incorporation of geospatial data and analysis into biodiversity program design processes

PERUVIAN AMAZON EXAMPLE

USAID/Peru used geospatial data and analyses to design their Sustainable Landscapes and Biodiversity Project with technical support from E3/FAB, Latin America and the Caribbean (LAC) Bureau, Measuring Impact, and the GeoCenter at the USAID Global Development Lab.[3] This example will be profiled in blue text throughout this document, demonstrating how one team used geospatial data during design of their project.

[1] For the purposes of this document, the terms "program" or "programming" are used as general terms to encompass USAID project and activity levels.

[2] E3/FAB, through Measuring Impact, has developed three Biodiversity How-To Guides to assist USAID staff in implementing the Biodiversity Policy as they program biodiversity funds: 1) *Developing Situation Models in USAID Biodiversity Programming*; 2) *Using Results Chains to Depict Theories of Change in USAID Biodiversity Programming*; and 3) *Defining Outcomes and Indicators for Monitoring, Evaluation, and Learning in Biodiversity Programming*. These how-to guides are based on requirements of the USAID Program Cycle, Program Cycle Operational Policy (ADS 201) revisions of 2016, and concepts from The Open Standards for the Practice of Conservation, a set of best practices for adaptive management developed by the Conservation Measures Partnership (of which USAID is a member) and widely used in the conservation community.

[3] The GeoCenter, located in the USAID Global Development Lab, is the Agency's geospatial data and analysis unit and provides services to both Missions and USAID/Washington Bureaus and Offices in support of all stages of the USAID Program Cycle. These services include data acquisition and generation, geospatial analysis, and the delivery of high-resolution satellite data to USAID offices and partners.

2. DEFINING PROGRAM SCOPE USING GEOSPATIAL INFORMATION

The biodiversity program design process involves analyzing the development context and clarifying the outcomes or impacts that USAID plans to achieve through its programming. This design process is described more fully in three USAID *Biodiversity How-To Guides*. In the context of biodiversity programs, the program design process starts with identifying the biodiversity program scope, which is defined as "the broad parameters or rough boundaries (geographic or thematic) on which a program will focus." Geographic and thematic scopes encompass a program's biodiversity focal interests, which are defined as "elements of biodiversity, within the defined scope, on which a team has chosen to focus." In particular, a geographic program scope can be defined by a natural boundary (ecosystem, ecoregion, landscape,[4] watershed), a political boundary (state, province, region), a management boundary (national park, network of wildlife reserves), or some combination of these different types of boundaries.

Geographic program scopes are inherently spatial in nature, but in many cases program scopes are determined without spatial data by using existing political divisions or by simply naming a commonly known area. This, however, may result in the omission of key biodiversity interests, a lack of shared understanding between stakeholders of the area of interest, the establishment of an unmanageably large and complex scope, and challenges in communicating the scope of the program to outside parties. Using geospatial data and analyses allows design team members to precisely and reproducibly define the program scope and to ensure that all stakeholders have a common understanding of the program's focal geographic area. Geospatial data can also help teams meet the requirement of the USAID Biodiversity Policy that "site-based programs must have the intent to positively impact biodiversity in biologically significant areas."[5]

At its simplest, a geographic program scope is an outline on a paper or digital map showing the outer boundary of the program area (see Figure 1 on page 6). A first pass at a program scope can thus be made by roughly drawing the boundary or by appropriating an existing map feature. If, however, the scope is defined by multiple types of boundaries – such as ecological, political, and administrative boundaries – then several spatial datasets may be used in a geospatial analysis to precisely define it. For example, the scope of a marine conservation program may be bounded by biological features such as key habitat or spawning grounds; political or economic divisions such as administrative areas or fishing grounds; and marine protected areas.

To use geospatial analysis to help define the scope of a biodiversity program, design teams should first identify the spatial datasets that are relevant for the biodiversity programming. These may include, for example, boundaries of different ecosystems, administrative or political units, or existing protected areas. Once these datasets have been identified and gathered, they may be visualized in a Geographic Information System (GIS) and analyzed to help identify the key dataset or combination of datasets to define the final scope. The analysis must be documented and reproduced should new spatial data become available.

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[4] USAID defines landscape or seascape as areas that include multiple land/sea use types and whose boundaries define a level of connectivity for ecological processes, species, or biological community assemblages. Protected areas (government, community, or private) may be a large component of a site but should not be the only land or sea use type.

[5] The Biodiversity Policy goes on to note that while "a country or region may possess relatively high overall biological diversity…this does not mean that all areas within the country or region are equally significant for biodiversity. Many areas are already widely recognized as biologically significant based on existing analyses and priority-setting exercises conducted by governments (such as National Biodiversity Strategy and Action Plans…, (and work of) research organizations, conservation NGOs, and…IUCN."

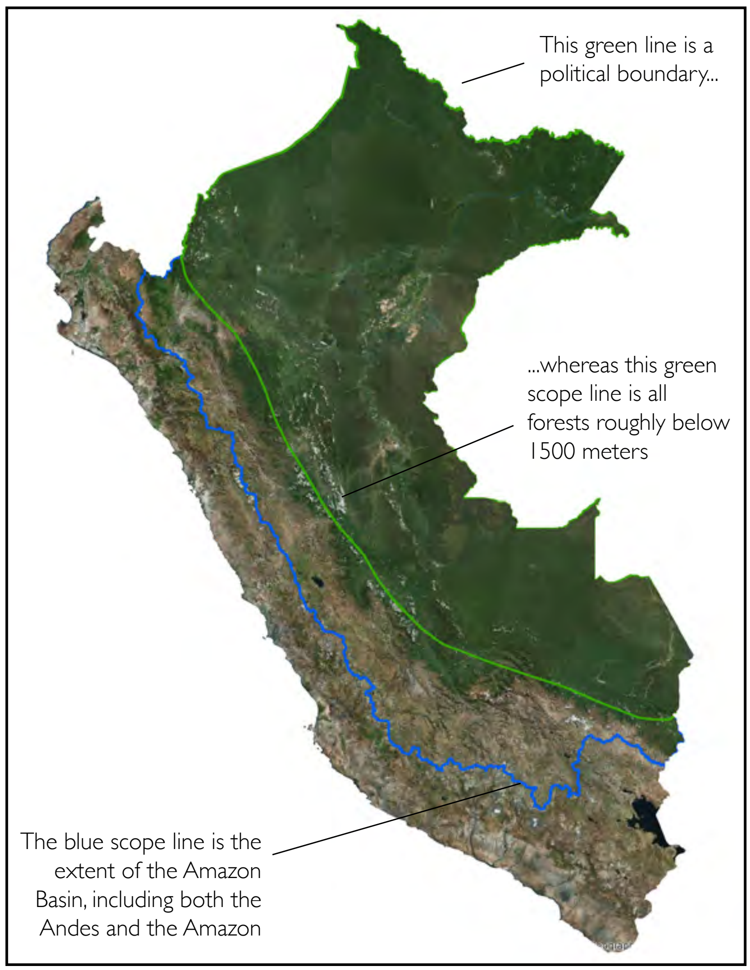
PERUVIAN AMAZON EXAMPLE

Peru contains approximately 16% of the Amazon Basin and has been recognized as a Tier 1 country under the USAID Biodiversity Policy due to the global significance of these forests. Although the geographic program scope of biodiversity programming in Peru may seem clear as "Peruvian Amazonian Rainforest," defining this area properly is critical to good programming.

To define this scope, the design team started with the area drained by the Amazon River and its tributaries, also known as the Amazon Basin, and trimmed it to the area of Peru (Figure 1). The Amazon Basin is a commonly used definition of Amazonia, is calculated easily from global elevation datasets, and is available from multiple sources. Due to its massive size, however, the Amazon Basin features many different ecosystems across its range: lowland rainforest at its center, scrubland and savannah in its south, and the mountainous Andes in its west. This is especially true for Peru, whose Amazonian tributaries drain landscapes ranging from lowland rainforest at 200 meters to Andean mountains at over 6,000 meters. In this instance, the design team decided to restrict the scope of the program to lowland Amazonian ecosystems.

The design team thus used a second screen to identify all land below 1,500 meters as a threshold to identify "lowland Amazonia," based on the free NASA global elevation dataset from the Shuttle Radar Topography Mission (SRTM). Although it was possible to calculate this area precisely based on the SRTM data, the team decided that digitizing this threshold by eye from the elevation data would provide a smoother and more useful product (Figure 1). This new threshold ran approximately parallel to that defined by the outline of the Amazon Basin, but substantially lower and more eastward, and it no longer followed watershed outlines. Based on these data and analyses, the team was able to narrow the project scope to lowland Peruvian Amazonian ecosystems and define a discrete area within which to identify priority biodiversity focal interests.

***Figure 1. Peruvian Amazon Example: Narrowing geographic program scope for Peru,** using a combination of topographic and political features. In this figure, all land to the east of the blue line falls in the Amazon Basin, defined as all land draining to the Amazon River. This includes the Andean highlands in the west and Amazonian lowland in the east. The green line narrows the scope further, to all forests roughly below 1,500 meters on the eastern side of the Andes. The scope on the northern and eastern side is defined by a political boundary – the Peruvian national border.*



3. SELECTING BIODIVERSITY FOCAL INTERESTS USING GEOSPATIAL INFORMATION

The second step in the process of designing a situation model to support biodiversity programming is the selection of biodiversity focal interests within the program's geographic scope. Biodiversity focal interests are the "the elements of biodiversity (species, habitats, and/or ecosystems), within the defined scope, on which a program has chosen to focus," where habitats can include both critical ecosystems and priority biodiversity landscapes and seascapes. In all cases, biodiversity focal interests should be selected to represent the full suite of biodiversity to be conserved and managed within the program scope, and are later used both to identify critical threats to biodiversity and to measure the ultimate success of a program's conservation strategic approaches.[6]

As with the program scope, this step can be completed in the absence of geospatial data by simply making a list of the priority species, habitats, and/or ecological communities in the program area. However, using geospatial data for this process carries several clear advantages. First, program areas, especially those with a large scope, are often spatially heterogeneous. Having a spatially explicit map of the biodiversity focal interests within the program scope can ensure that the right set of biodiversity focal interests is selected to truly represent the biodiversity of the area, helping standardize a process that is as much art as it is science. Furthermore, this spatially explicit map enables planners to determine where the most important sites for each focal interest are located and to direct design efforts accordingly. Later in the design process, this spatial data for focal interests can be overlaid with information on other factors that influence the status of the biodiversity focal interests, such as location of roads and communities, planned changes in land use, and other factors, as discussed in more detail in Section 4 on page 10.[7] Finally, as with the program scope, this map enables all stakeholders to have a common understanding of what the program is working to conserve, at what scale, and where those biodiversity focal interests are located.

Biodiversity focal interests can be depicted by points, lines, or polygons (two dimensional areas), depending on the type of feature and available information for each feature. For example, landscapes or habitats are typically depicted by polygons showing their extents, although points or a raster area of pixels may also be used if locations are only approximately known. Stream and river networks, in contrast, are typically represented by lines. Focal species can be represented by polygons depicting their ranges if range maps are available, or by points indicating known observations of those species during critical phases of their lifecycle.

To use geospatial data to identify and map biodiversity focal interests, program design teams need to compile available spatially explicit location information for each candidate focal interest. Spatial data on species and ecosystems can be obtained from government agencies, conservation non-governmental organizations (NGOs), museums, or academia, and can include both published data, data available in the grey literature, and data provided directly by partners, experts, and stakeholders. These data can then be used to develop initial polygons, lines, or points to represent each of the candidate focal interests. Analysis and discussion of these candidate biodiversity focal interests can then be used to refine the list of biodiversity focal interests, and potentially the overall program scope. If desired and if data are available, the design team can also use viability analysis to determine the status of each biodiversity focal interest, or even the relative status of the biodiversity focal interest, such as sub-populations of an endangered species.[8]

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[6] See forthcoming *Biodiversity Supplemental Guide 1: Defining Scope and Biodiversity Focal Interests in USAID Biodiversity Programming*

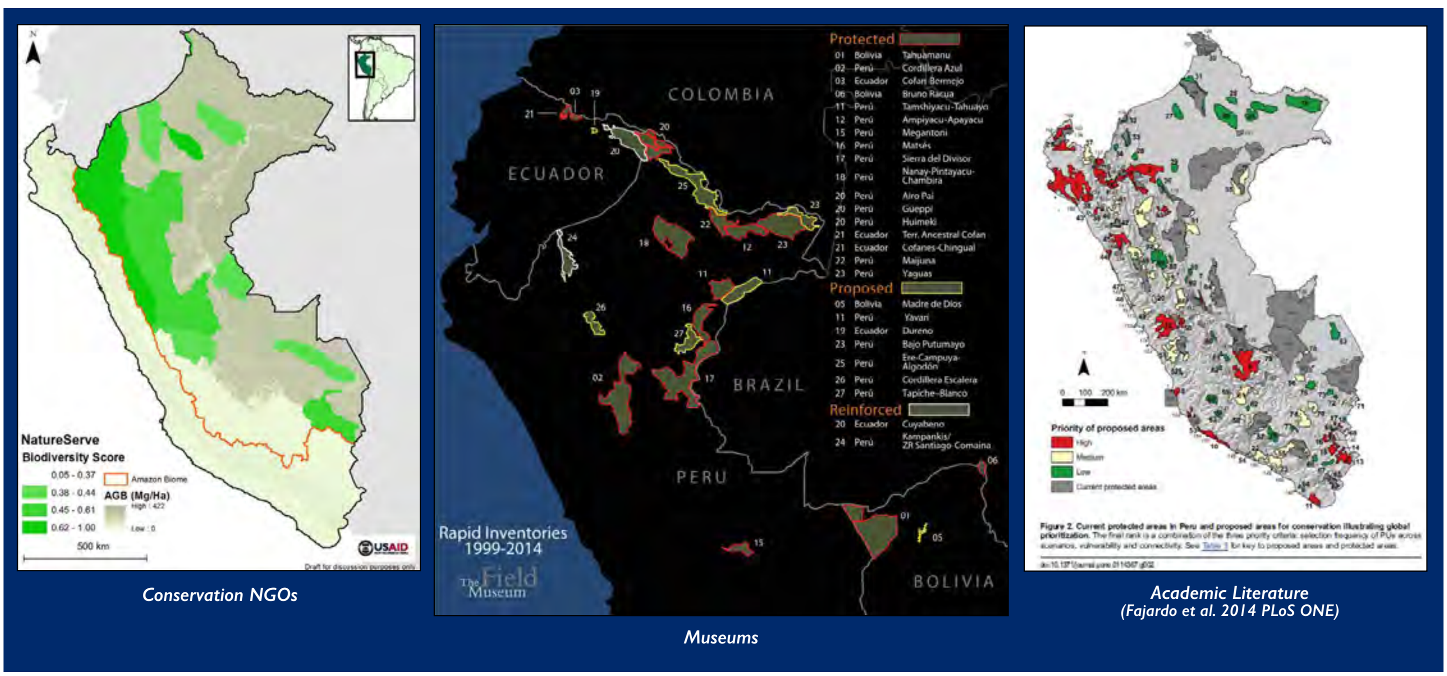
[7] See forthcoming *Biodiversity Supplemental Guide 2: Rating Direct Threats in USAID Biodiversity Programming*

[8] For more details about viability analysis, see Foundations of Success. 2009. Conceptualizing and Planning Conservation Projects and Programs: A Training Manual, pp. 44-54. Foundations of Success, Bethesda, Maryland, USA.

PERUVIAN AMAZON EXAMPLE

After the USAID/Peru design team identified the project scope as lowland Peruvian Amazonia, they set about identifying the priority biodiversity focal interests within this area. This task was particularly important given the large project area – almost 40% of Peru. The design team made two initial decisions to narrow the set of biodiversity focal interests. First, the design team decided not to use individual species or ecosystems, as the available prioritization data focused on larger landscape-scale units such as watersheds that included multiple species and ecosystems; this is largely due to the lack of spatially explicit information regarding the Amazonia ecosystem and species distributions. As such, in order to remain consistent with the scale of best available data, the design team decided to use landscapes as their biodiversity focal interests.[9] Second, the team applied spatially explicit data on existing biodiversity conservation priorites to create a narrowed set of candidate biodiversity focal interests to use as the starting point for the remainder of the selection process.

Figure 2. Peruvian Amazon Example: Using multiple data sources of spatial data on conservation priorities to identify and refine biodiversity focal interests. *The left panel shows conservation priorities generated by NatureServe, a conservation NGO, in collaboration with researchers across Europe, the United States, and Latin America (Josse et al. 2013) where darker shades of green indicate higher priority values on the basis of using watersheds as the unit of analysis. The center panel shows conservation priorities identified by Chicago's Field Museum of Natural History based on Field Rapid Inventories, where red outlines indicate priority existing protected areas, yellow outlines indicate priority proposed protected areas, and white outlines indicate protected areas needing reinforcement. The right panel shows conservation priorities published in the peer-reviewed literature (Fajardo et al. 2014) in which the colored polygons represent proposed protected areas in order of priority from green to yellow to red (indicating highest priority).*



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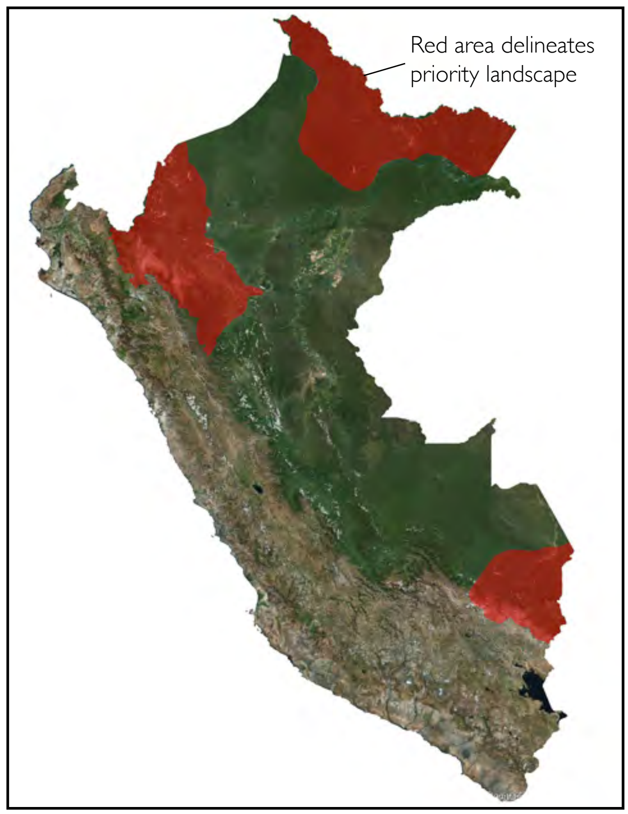
[9] See *Biodiversity How-To Guide 1: Developing Situation Models in USAID Biodiversity Programming* and the forthcoming *Biodiversity Supplemental Guide 1: Defining Scope and Biodiversity Focal Interests in USAID Biodiversity Programming*. Many design teams apply a "coarse filter" and "fine filter" approach. Coarse filter interests are those key ecosystems that, when conserved, also conserve the majority of species within the program scope. The fine filter is used to identify species and communities that are not well captured by coarse filter interests and, thus, require individual attention. The USAID/Peru project design team elected to use only the coarse filter due to a lack of information about individual species and ecosystems. This approach can be used when, as in the case of the Peruvian Amazon, data are lacking and the scope is very large and complex.

To refine their suite of biodiversity focal interests to a set of priority landscapes within the scope of lowland Amazonian forests, the design team collected available data on conservation priorities for Peruvian Amazonia (Figure 2). Conservation priorities in geospatial format were ultimately available from conservation NGOs (World Wildlife Fund and NatureServe), museums and research institutions (The Field Museum of Chicago, Woods Hole Research Center), the academic literature (Josse et al. 2013, Jenkins et al. 2013, Fajardo et al. 2014), and the Government of Peru (National Institute of Natural Resources, Rodriguez 1996).

Next the design team used these data to identify priorities. This was a complex and iterative process that combined diverse analyses with expert knowledge and other considerations. In analyzing multiple data sources, it was important for the design team to understand the basis of each of the data sets used: each anaylsis defined geographic conservation priorities based on different criteria, underlying data, and analyses. Thus, their recommendations were not directly comparable, but needed to be considered and discussed in various combinations to help the team identify priority landscapes. The data and analyses were supplemented by expert knowledge within the team about the priority areas identified in each analysis, the criteria used to select those priorities, overall context including existing conservation efforts, and priorities that were not represented by the data. Based on this iterative and consultative process, the design team ultimately identified seven custom landscapes as their biodiversity focal interests. These were digitized manually from the existing map data and iteratively reviewed and edited by the team.

***Figure 3. Peruvian Amazon Example: Three priority landscapes,** as developed using available conservation priority data, expert knowledge, and institutional considerations.*



At this point, the team had identified a set of seven candidate biodiversity focal interests in the form of priority landscapes. After completing a high-level threat assessment (described in the next section), they evaluated each of these seven landscapes in the context of these threats and other institutional criteria, ultimately selecting the final set of three landscapes that served as the focal interests (Figure 3). These three landscapes were then put into a more detailed threats analysis that is described in Section 4 on page 10.

It should be noted that in many cases, this analysis of biodiversity focal interests would have been conducted with specific species or ecosystems, instead of landscape units. Species and ecosystems have the benefits of being easier to define, identify, and measure success against. Examples might include individual lobster species in fisheries management or specific tropical dry forest types in the case of fuelwood driven deforestation. In the case of the Peruvian Amazon, however, the design team was working at an extremely large scale with ecosystems that are insufficiently well known and overly species-rich for the design team to identify discrete species or ecosystems for conservation recommendations, resulting in the landscape-based approach noted here. The intent of the design team, however, was to refine these elements during the design of specific research and implementation activities and eventually identify specific species or ecosystems to target and use as measures of conservation success.

4. IDENTIFYING AND RATING THREATS USING GEOSPATIAL INFORMATION

The next step in the process of developing a situation model to support biodiversity programming is the identification and rating of direct threats to the biodiversity focal interests. A direct threat is defined as "a human action or unsustainable use that immediately degrades one or more biodiversity focal interests," and this step initially concentrates on these threats rather than the ultimate drivers of these threats. Teams can better understand which threats to address by prioritizing the scope, severity, and irreversibility of each threat on each biodiversity focal interest. Through these analyses each threat is assigned a status rating: Very High, High, Medium, or Low, for each biodiversity focal interest they affect and across the program as a whole.[10]

Using geospatial analysis to identify and rate threats has a number of clear advantages. First, if the locations of biodiversity focal interests are known, simply overlaying threat data will immediately reveal which threats affect which biodiversity focal interests. A threat map thus makes it clear to all stakeholders and partners which threats are most important to consider. A good threat map also enables a program team to analyze how threats have changed over time and to make predictions as to where threats will occur in the future. Finally, geospatial analyses can help determine the degree to which each threat affects each biodiversity focal interest. Specifically, maps can help calculate the scope of each threat on each biodiversity focal interest, as well as help visualize variation in the severity of each threat on each biodiversity focal interest.

Direct threats to biodiversity focal interests fall into two classes: those with a clear spatial footprint and those without a footprint but clearly associated with existing map features. With regard to the first, many threats have an obvious spatial footprint and can be represented on a map as polygons or lines. For example, agricultural expansion or clearcut logging can be represented as one overall polygon or a series of sub-polygons on a map layer showing where these human activities are taking place. Similarly, road or pipeline networks can be represented as lines on a map. Since, by definition, a direct threat is a human action or unsustainable use that immediately degrades one or more biodiversity focal interests, a threat polygon is not necessarily the entire area of the human activity, but rather the intersection of the human activity with the footprint of one or more biodiversity focal interests across the overall program area. As shown in Figure 4 on page 11, agricultural expansion and roads are threats to the forest focal interest, but not where they are taking place in degraded agricultural lands. In addition, threats may already exist on the landscape or can be future threats that are predicted to occur in the coming years. It may be helpful to denote current threat features as different from predicted future threats or even to show the year in which each threat sub-polygon occurred or is predicted to occur as a way of representing temporal trends and better predicting future problems.

The second set of threats has a less obvious spatial footprint, but can still be associated with existing map features such as a biodiversity focal interest or a political boundary. For example, the design team could draw a polygon representing a subsistence hunting threat as either contiguous with a forest-wide focal interest or, as shown in Figure 4 on page 11, as buffer areas around the road that represent the likely distance that hunters will travel to hunt. The actual distance could be estimated or it could be measured through observation (e.g.,

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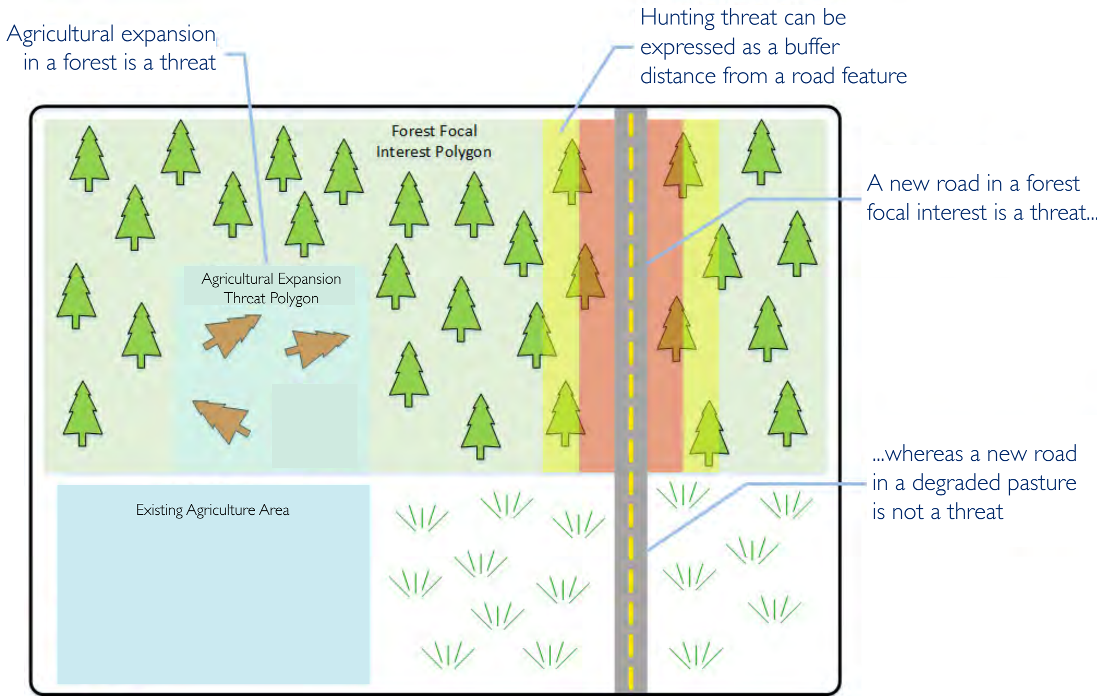
[10] See *Biodiversity How-To Guide 1: Developing Situation Models for USAID Biodiversity Programming* for information about threat identification and a forthcoming *Biodiversity Supplemental Guide 2: Rating Direct Threats in USAID Biodiversity Programming*, including definition of these terms. There are several techniques available for doing threat ratings. See:

Foundations of Success. 2009. Conceptualizing and Planning Conservation Projects and Programs: A Training Manual, pp. 44-54. Foundations of Success, Bethesda, Maryland, USA.

The Nature Conservancy, 2007. Guidance for Step 4: Identify Critical Threats. In *Conservation Action Planning Handbook: Developing Strategies, Taking Action and Measuring Success at Any Scale*. The Nature Conservancy, Arlington, Virginia, USA.

Figure 4. Threat polygons at the intersection of human activities and forest focal interests



mapping locations of snares encountered by patrols in relation to distance to the road). In a similar fashion, the design team could assign a threat status of future oil exploration or production taking place to a given political district to the political district polygon itself based on a combination of geological features and an assessment of the degree of support of district officials to new oil drilling activities.

To use geospatial data in threat analyses, design teams must first identify all possible direct threats and then narrow this list down to a subset for which spatial data are available or that can be represented in spatial formats. Data on deforestation and land use are consistently important for biodiversity programming, and some countries produce their own annual or decadal deforestation and land use maps in digital formats. USAID partners including academic institutions and NGOs can also be excellent sources of threat data.

Design teams next need to overlay the threat data on the previously identified biodiversity focal interests. This can be as simple as displaying both threats and interests simultaneously in a GIS, but can also include more complex analysis with the data, such as buffering roads to identify the zone of influence of poachers, loggers, or other human activities. In addition, as threat data are often available in best and worst-case scenarios, these analyses can be repeated to identify the range of possible threats to biodiversity focal interests over the life of the program and beyond.

At this point in the development of the situation model, design teams have sufficient information to rate threats to their biodiversity focal interests. Three factors are used to rate the threats: scope, severity, and irreversibility.[11] Geospatial information can be used to understand and depict the scope of the threat, that is, the amount of the biodiversity focal interest impacted by the threat. Although geospatial data can be used to delineate the threat scope in a rigorous manner, it is often easier and sufficiently accurate to "eyeball" threat scope from map data.

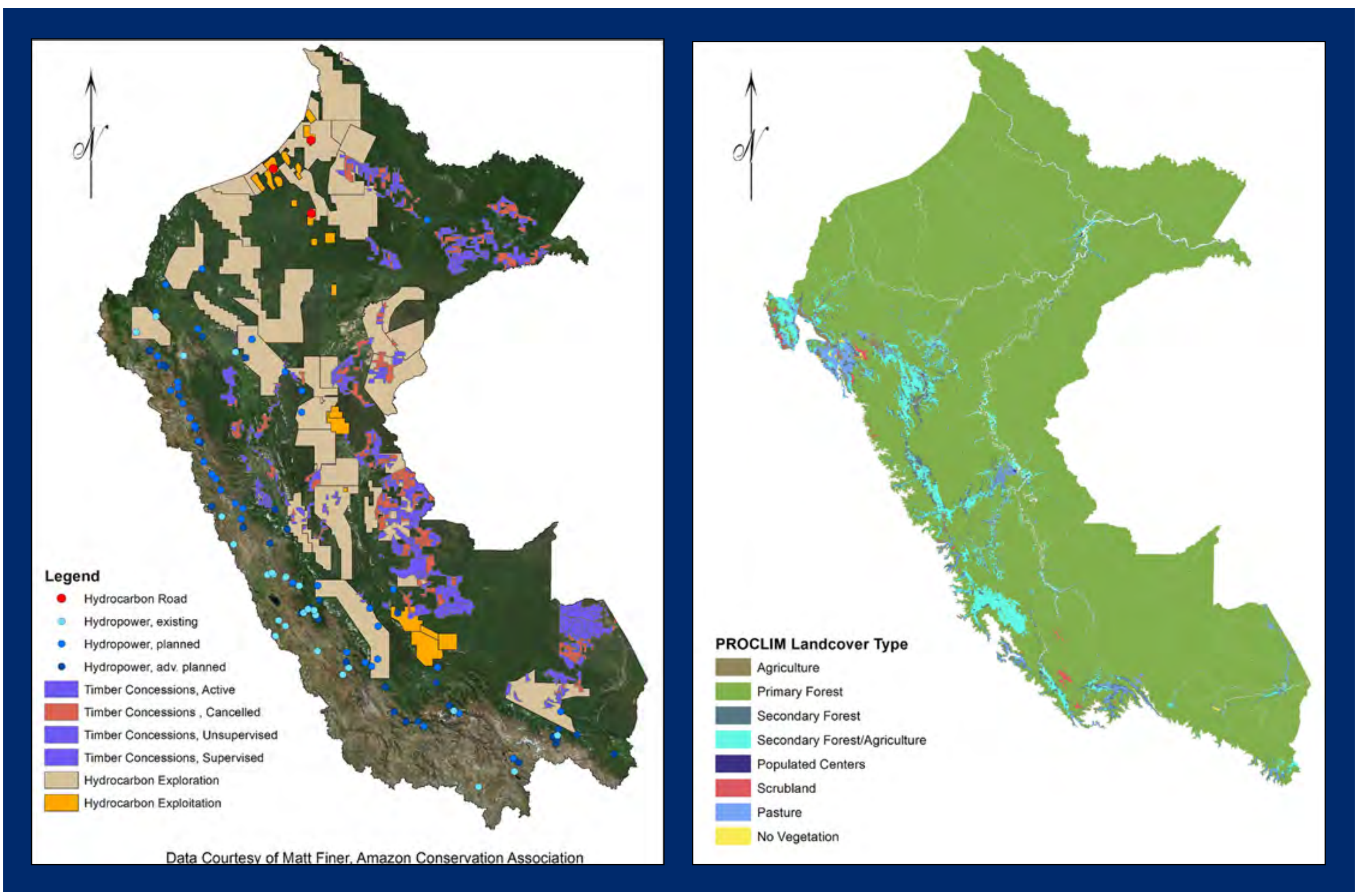
[11] See forthcoming *Biodiversity Supplemental Guide 2: Rating Direct Threats in USAID Biodiversity Programming* for definition of these terms and more details.

PERUVIAN AMAZON EXAMPLE

Once USAID/Peru had identified its three priority landscapes as their biodiversity focal interests, the team's next task was to identify the threats to these landscapes and rank those threats. As noted above, the ecosystems of the Peruvian Amazon are impacted by multiple threats, such as illegal logging, small- and large-scale agriculture, illegal mining, oil and gas concessions, and roads, among others. The program design team needed to identify which of these threats directly intersected with the prioritized landscapes and determine the extent of threat impact in each.

For this purpose, the design team gathered data on threats from a partner (the Amazon Conservation Association (ACA)) with 15 years of published data on threats to the Peruvian Amazon. This partnership yielded abundant data on all of the threats described above, with the added value that most data had also been documented in peer-reviewed academic journals (Figure 5). The design team additionally gathered decadal land-cover data (PROCLIM) from the Peruvian Ministry of Mines and Energy (MINEM), and deforestation data from the Peruvian Ministry of the Environment (MINAM), including forest loss, forest conversion to agriculture, and forest conversion to urban areas (Figure

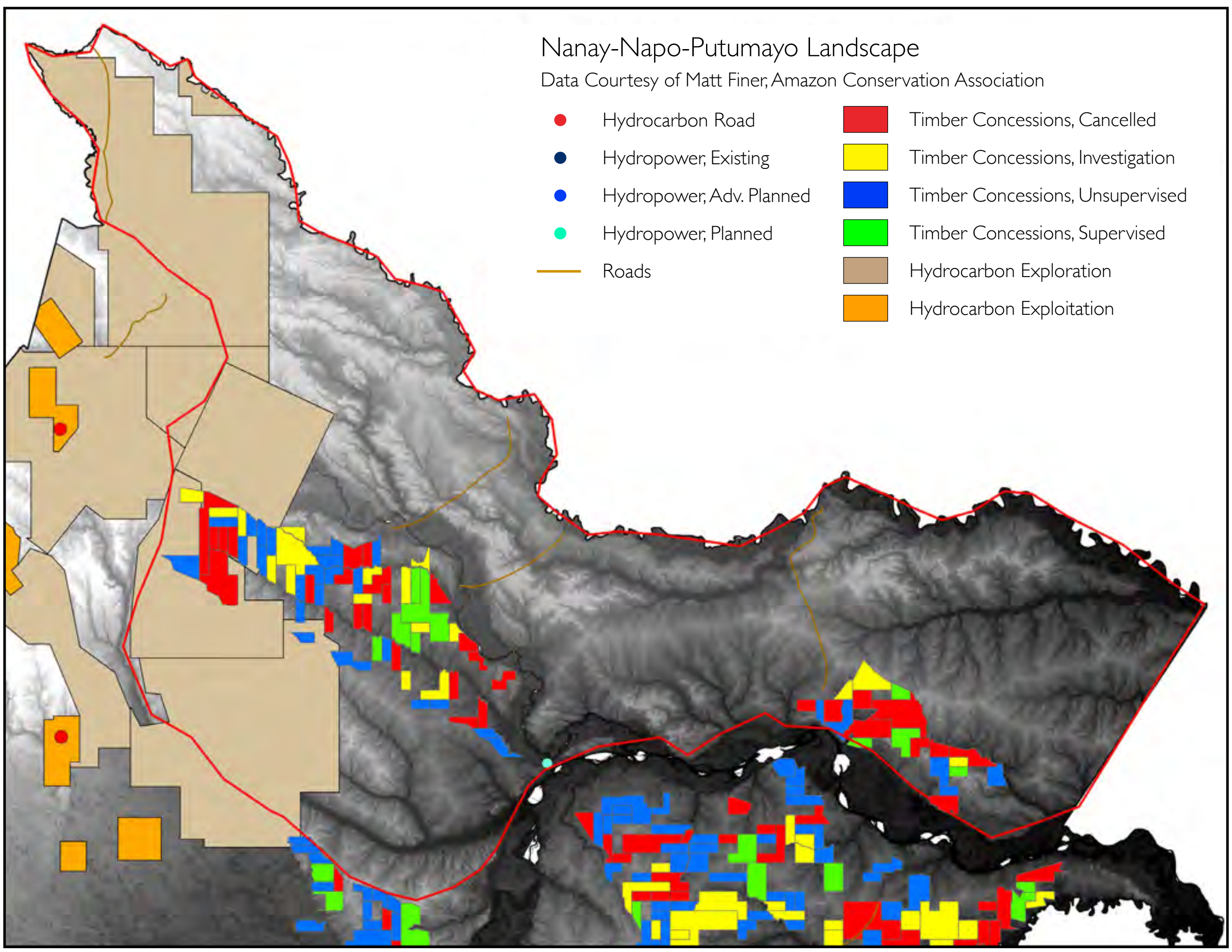
***Figure 5. Peruvian Amazon Example: Samples of threat data** collected from both a partner (ACA, left) and a government agency (MINEM, right). In the left panel, orange and brown areas indicate oil concessions that are active or open for bid, respectively; blue and red areas indicate forest concessions that are active or have been cancelled due to illegal activity; blue dots indicate existing, planned, or advance planned hydropower facilities; and red dots indicate existing hydrocarbon access roads. The right panel shows landuse types as mapped by the Government of Peru PROCLIM program including agriculture (light blue), primary forest (green), secondary forest (dark blue), populated areas (dark purple), scrubland (red), pasture (light purple), and no vegetation (yellow).*



6). While this is not a comprehensive body of threat data available for the Peruvian Amazon, together, these datasets provided a clear picture of forest cover change in lowland Amazonian Peru over the previous 10 years.

The team then overlaid these threats on the three biodiversity focal interest landscapes and identified those that required additional analysis. To do this, the design team displayed each of the landscapes with the threat data superimposed on it and identified the relevant threats; due to the large amount of threat data, this was conducted in several stages for each landscape (Figure 6). As these threats were assessed for each priority landscape, the design team simultaneously estimated the scope, severity, and irrevesibility of the threats relative to the landscapes. All estimates were entered into an Excel spreadsheet and ranked, and threats that would be considered for further analysis and design of interventions were selected.[12] Priority threats identified by the design team included illegal logging and mining, and oil and gas exploration/exploitation, both widespread across the Peruvian Amazon and threatening all landscapes.

Figure 6. Peruvian Amazon Example: Threat data overlaid on the northeastern Nanay-Napo-Putumayo Landscape. *The red outline indicates the extent of the landscape; the orange and brown areas indicate oil concessions that are active or open for bid, respectively; the blue, green, yellow, and red areas indicate forest concessions that are active and unsupervised, active and supervised, under investigation, or cancelled due to illegal activity; blue dots indicate hydropower facilities; and the brown lines indicate roads. The background map shows topogaphy, where light tones indicate higher elevations and dark tones indicate lower elevations.*



[11] Threat rating summaries can also be developed using Miradi software, which includes a threat rating algorithm. See Miradi User Guide I: Develop a Situation Model.

5. PRIORITIZING STRATEGIC APPROACHES USING GEOSPATIAL INFORMATION

Once the situation model is completed, the next phase in the biodiversity program design process involves using the situation model to brainstorm and prioritize potential strategic approaches for taking conservation action. A strategic approach is defined as "a set of actions with a common focus that work together to achieve a series of results in a results chain." In the USAID context, using geospatial tools to depict strategic approaches has three functions: first, USAID staff can use geospatial tools to understand where individual strategic approaches need to be implemented – helping design teams ensure that the most effective actions are taken to address critical threats to biodiversity focal interests. Second, geospatial tools can help USAID track implementation activities, thereby increasing efficiency and reducing redundancy. Finally, USAID can use geospatial tools to monitor implementation and determine where course corrections or additional support is needed.

Given that biodiversity focal interests and threats tend to occur in patches across a landscape or seascape, the application of a given strategic approach may be more important in some locations than others. There may even be tactical advantages to implementing certain approaches in certain places, for example, setting up protected areas in critical habitat areas that are also likely to face looming development pressures or to block roads that might open up sensitive habitat. Maps can also be used to show where approaches being implemented by different organizations or funders are taking place, thus revealing gaps and avoiding unnecessary duplication.

As with previous factors, strategic approaches can be depicted by points, lines, or polygons, depending on the type of feature and available information for each feature. Similar to threats, strategic approaches fall into two classes: those with a clear spatial footprint, and those without a footprint but clearly associated with existing geospatial features. Examples of the former include setting up a protected area or implementing on-the-ground enforcement programs. Examples of the latter include improving policy in a political district or providing training in better management practices to farmers which can then be mapped on a farm-by-farm basis.

Using geospatial data to identify and map strategic approaches first involves determining the range of different strategic approach types being implemented within the program area. If possible, each strategic approach should then be mapped, noting the type of strategic approach, the geographic area of influence of the approach, who is implementing it, the current implementation status, and (if available) the cost of the strategic approach being implemented. Design teams can use this map to determine which strategic approaches they need to implement and where. The map can also be used to track the progress of implementation of these strategic approaches by partners and to determine where progress is satisfactory and where additional attention is needed.

PERUVIAN AMAZON EXAMPLE

After USAID/Peru identified its biodiversity focal interests and prioritized threats, the design team began to identify potential strategic approaches. To deal with the threats of forest loss in oil and gas extraction sites, the design team proposed the promotion and implementation of best practices, including roadless access for infrastructure development, minimum-width road and pipeline right-of-ways, and directional drilling to concentrate wellheads in single locations. The design team would then be able to use maps to show where these practices were being implemented.

6. MEASURING EFFECTIVENESS AND ADAPTING USING GEOSPATIAL INFORMATION

USAID biodiversity program design teams are required by the Biodiversity Policy and the Automated Directive System (ADS) to articulate the theory of change underlying their program design. The Biodiversity Policy requires a set of indicators associated with that theory of change.[13] This helps USAID and its implementing partners measure the effectiveness of biodiversity programming and adapt as new information becomes available. These outcome statements and indicators are important components of the program's Monitoring, Evaluation, and Learning framework. For example, if a marine biodiversity program chooses training in low-impact fishing methods as a strategic approach, the design team might develop an outcome statement of "20% of fishers able to identify eight new fishing practices by year 2," and might select as an indicator "percentage of fishers able to identify eight new fishing practices." These indicators can then be monitored to track the success of individual actions and their combination to generate an effective program.[14]

Geospatial analysis adds value to this process in two ways. First, many biodiversity indicators are inherently spatial (e.g., forest loss, grazing intensity) and desertification, and could be easily measured using geospatial data, specifically remote sensing (e.g., satellite) data. Although it might be possible to measure these indicators by sending teams to collect measurements in the field, in many cases using remotely sensed data can facilitate and improve the measurement of these indicators in remote locations and can be a more efficient use of limited monitoring resources. Remotely sensed data is also often available for multiple time periods, facilitating analysis of 'baseline' conditions before implementation has started and comparison over time with comparable areas where USAID activities were not implemented. Second, although many biodiversity indicators may not be inherently geospatial (i.e., "the number of fishers able to identify eight new fishing practices"), analysis of the information provided by these indicators may still benefit from the collection of spatial data and spatial analysis. The effectiveness of programs may vary substantially from place to place, and collecting spatial data for these indicators can allow more powerful assessment of progress in achieving results and more informed evaluations. Spatial data also facilitates comparison with other variables to identify the reasons for differing effectiveness. For example, by overlaying the uptake of new fishing practices upon political, cultural, or economic factors, it might be discovered that program success is strongly controlled by poverty, cultural background, or other variables. Even though it might be possible to tabulate such statistics using existing administrative divisions, this can sacrifice much power in both monitoring and evaluation versus using explicitly geospatial analysis.

Two types of geospatial data are available for biodiversity indicators, corresponding to the two types of indicators described above (inherently spatial or not inherently spatial but benefitting from spatial analysis). For indicators that can be monitored from remotely sensed data (e.g., forest loss), the data itself will usually consist of grids of pixels, where each pixel measures the condition of the land or sea surface (e.g., forest loss, algal bloom, or coral bleaching). For indicators that are not inherently spatial in nature, the individual observations used to calculate the indicator can be geolocated so that further spatial analyses are possible. In this case, the data are represented by individual points for each observation generated by the monitoring program. For example, questionnaires regarding fishing practices could include Global Positioning System (GPS) coordinates, such that the response for each community is represented by a point, and the variation in these results through

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[13] See USAID Biodiversity Policy for requirements and *USAID Biodiversity How-To Guide 2: Using Results Chains to Depict Theories of Change in USAID Biodiversity Programming* for guidance.

[14] See *Biodiversity How-To Guide 3: Defining Outcomes and Indicators for Monitoring, Evaluation, and Learning in Biodiversity Programming*.

space can be displayed. These patterns can then be analyzed to identify spatial patterns in program success, and possible correlates with success, and this information can then be used to adapt programming.

To use geospatial data to inform monitoring and adapting, teams should identify which of their indicators are inherently spatial or might benefit from spatial data collection. Indicators that are inherently spatial may be clear from their associated outcome statements, such as the number of hectares of primary forest converted to agriculture. Indicators that can benefit from geolocation are those that are collected across a land or seascape and associated with biodiversity outcomes, such as the number of personnel trained in different communities or the number of violations of timber codes observed in different political districts. When designing illustrative indicators to include in program descriptions or scopes of work, program design teams should draw on the analyses and data (such as those discussed above) used for setting biodiversity focal interests and identifying threats. To ensure that appropriate data are collected, the design team should also carefully consider what types of baseline and monitoring data are needed in order to conduct analyses that will accurately measure progress towards preserving biodiversity focal interests and reducing threats, as detailed in the program's theory of change.

Program managers should then ensure that geospatial data are included in post-award Monitoring, Evaluation, and Learning Plans so that they are collected for these chosen indicators and provided to USAID. For inherently geospatial data, this means ensuring that the source data (such as forest loss datasets) are preserved in addition to summary statistics. For non-spatial data, this means that monitoring observations are systematically geolocated using, for example, a GPS device.

Program managers and implementing partners will then be positioned to analyze collected data, identify locations where activities may not be performing as expected, and use this information to adapt. The analysis of geospatial monitoring data can be as simple as asking where indicator values are positive, where they are unchanged, and what the reasons for those differences might be. Alternately, these analyses might be as complex as spatial regressions of indicator values against other spatial data (e.g., poverty, education, or governance indicators) to precisely identify the cause or causes of this variation. In both cases, these results can be used to identify the conditions underlying effective programs, to inform course corrections, and to adapt programming as needed.

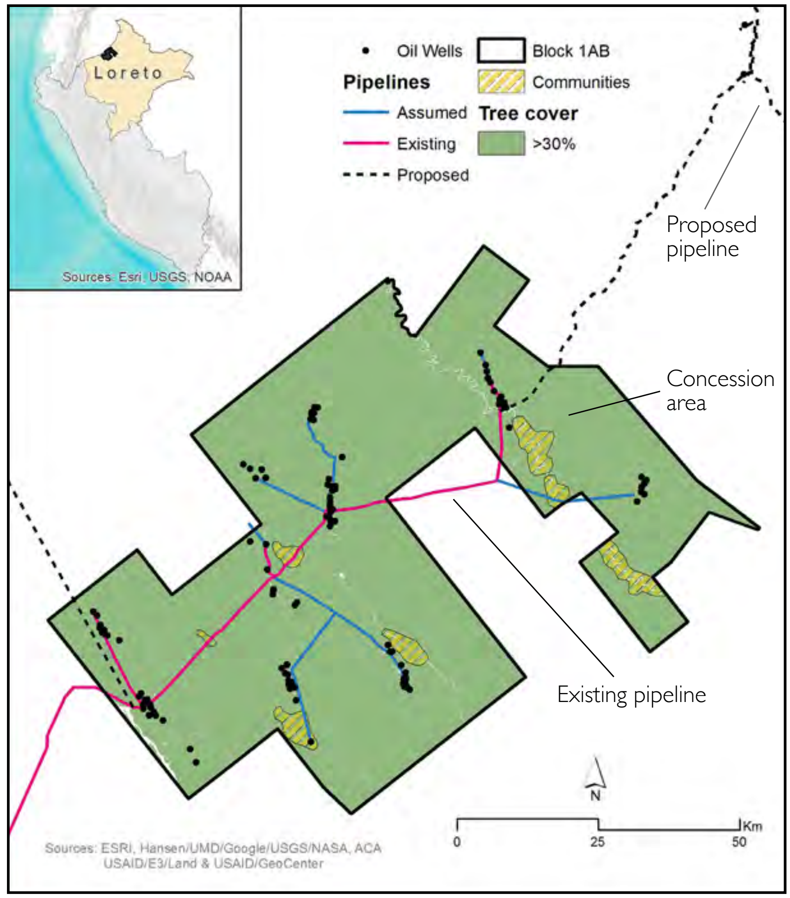
PERUVIAN AMAZON EXAMPLE

The USAID/Peru design team identified illustrative indicators that might be monitored using geospatial data. To test the usefulness of these indicators, the design team examined a hypothetical example of how this data might be used and how it could benefit future programming.

For this hypothetical example, the design team used the strategic approach of supporting best practices for oil and gas extraction in Amazonian forests. This strategic approach seeks to reduce forest loss at oil and gas extraction sites through the promotion and implementation of multiple best practices, including roadless access, minimum-width road and pipeline right-of-ways, and directional drilling to concentrate wellheads in single locations. Although an overall indicator for this outcome was the percent reduction in forest loss from oil and gas extraction, the design team wanted to disaggregate this indicator into this forest loss from roads, from pipelines, and from facilities. In addition, due to the presence of indigenous peoples in the oil and gas concession, they also wanted to monitor forest loss in these communities. This disaggregation would allow them to identify the effectiveness of individual best practices and allow adaptation as implementation progressed.

The design team chose an existing oil concession in northern Peru for the hypothetical test case to examine how these indicators might be measured and what information they might provide for adaptive management. Although this concession is not actually implementing best practices, this well-known concession offered a good opportunity to test geospatial indicators. To measure forest loss, the team used the USAID-funded University of Maryland Global Forest Loss dataset developed by Dr. Matt Hansen and colleagues. This dataset provided global forest loss data at 30-meter resolution in annual time steps from 2000 to 2014, and was ideal for any application requiring forest cover monitoring. To disaggregate forest loss by facilities and pipelines the team used geospatial data provided by ACA depicting these features (Figure 7). Last, to monitor loss in indigenous communities, the team digitized the outline of these communities (Figure 7). Forest loss was calculated for pipeline, facilities, and indigenous communities for the period between 2000 and 2014.

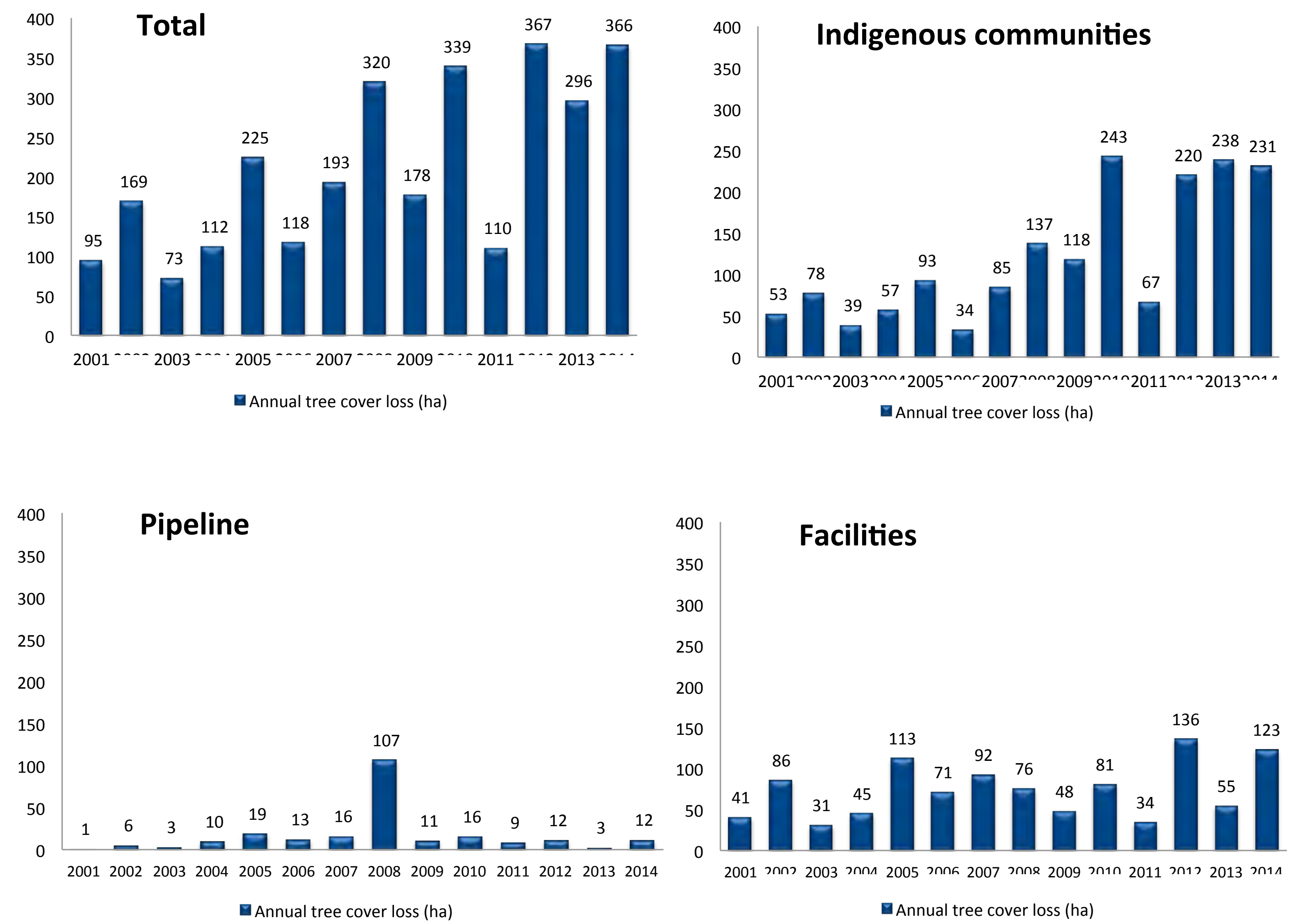
Figure 7. Peruvian Amazon Example: Overview of Lote 1AB oil concession in northern Peru, *used as a test case to identify useful geospatial indicators and analyses. The black outline indicates the concession area; the blue and pink lines indicate pipelines, and the black dots indicate oil wells. In addition, the yellow patches indicate indigenous communities mapped from satellite imagery.*



The results of this analysis were clear and interesting (Figure 8 on page 18). Forest loss in the concession showed a strong and steady upward trend over the 14 years of monitoring, indicating continuous forest loss in the concession. Despite this trend, forest loss due to oil company facilities and pipelines showed no trend during this period, accounting for only 43% of the total forest loss in the concession. Instead, the majority of forest loss (53%) in the concession occurred in indigenous communities, apparently driven by population increase through birth or settlement. Based on expert knowledge on the design team regarding the concession, they concluded that economic benefits to the communities from oil company presence, such as a market for locally grown fruits and vegetables, electrification, and gasoline donations, were encouraging population growth in these communities.

In the hypothetical case the concession is using best practices, and the design team learned through the exercise of monitoring these indicators that even best practices along pipelines, facilities, and roads are not sufficient to reduce deforestation there. Information generated from monitoring these indicators suggests an adaptation that might be needed for this hypothetical program to be successful: new practices on interactions with indigenous communities in concessions such as limiting trade or developing other incentives for settlement. This hypothetical example demostrates the use of a spatially explicit program design to identify useful indicators and data sources, the feasibility of monitoring these indicators using geospatial data, and their utility in informing consideration of program adaptations to increase effectiveness.

*Figure 8. Peruvian Amazon Example: **Forest loss in Lote 1AB concession,** including total forest loss and forest loss due to pipeline, facilities, and indigenous communities.*



7. CONCLUSIONS AND RECOMMENDATIONS

ADVANTAGES OF USING GEOSPATIAL ANALYSES

There are a number of advantages to incorporating geospatial analysis into biodiversity program design.

Better design and priority setting. Taking a spatial perspective can help inform key steps in the biodiversity program design process, including defining program scope, selecting biodiversity focal interests, identifying and rating threats, brainstorming and prioritizing the strategic approaches of the program's theory of change, measuring implementation effectiveness, and informing adaptive management based on results. Spatial analyses complement analyses and assessments that USAID teams normally conduct during program design and help teams to focus their efforts and ensure that they are identifying and addressing the most critical factors in the right places.

Manage spatial heterogeneity, especially at larger scales. Taking a spatial perspective is particularly important when working at larger, or over multiple, spatial scales in which biodiversity focal interests, threats, and even strategic approaches are not homogeneously distributed. For example, if the biodiversity focal interest is a forest, then it may occur across a landscape in patches, each with a different viability. Furthermore, an agricultural expansion threat may be affecting the forest in the eastern part of the project area, but not in the western. As a result, it may be necessary to intervene only in high value forest patches that are under imminent threat, rather than trying to work everywhere.

Inform tactical interventions. Building on the previous point, in some cases using spatial analysis may allow for more efficient deployment of biodiversity resources. Just as army generals looking at a map may order their troops to defend a specific river crossing to prevent the enemy from advancing into territory beyond it, in a similar fashion a biodiversity team might choose to set up wildlife trade checkpoints at key locations along a road. Likewise, they might invest in alternative livelihood approaches in a specific community at the mouth of a watershed to prevent loggers or illegal agriculturalists from moving into less impacted portions of the watershed.

Enhance sharing of information among stakeholders. Spatial analyses and maps often provide a powerful tool to share information across a wide range of stakeholders. For example, if a design team identifies a forest as its biodiversity focal interest or an agricultural expansion threat in a logframe table or a conceptual model, then these factors really only "exist" in the context of that design team's documents. However, if the design team represents these factors as points, lines, or polygons on a map and then makes the map publicly available, then all interested stakeholders can know they are referencing the same forest or agricultural area and can readily share information about these factors. Online and interactive mapping tools are increasingly powerful and effective for this kind of collaboration.

Effectively communicate findings to decision makers. Spatial analyses and maps are also powerful tools to share information with decision makers, including government officials, other donors, and community stakeholders. Maps are more readily understood and visually compelling than a logframe table or long document. Audiences will generally be able to look at a map (e.g., a map showing the viability status of different forest patches or the locations of the agricultural expansion frontier) and know how to interpret what the map is telling them.

ADDRESSING COMMON CHALLENGES IN USING GEOSPATIAL ANALYSES

There are several considerations when undertaking geospatial analyses.

Find the available data. This will depend both on the strength of spatial analysis in national institutions, as well as international institutions and NGOs in that country. Peru is a good example of a country with both active national institutions and a strong domestic and international NGO sector, and, as a result, geospatial data are relatively abundant. This can be very different in countries with fewer data resources provided by the public sector. In all cases, however, the tactics for identifying geospatial data are similar. First, it is useful to search for maps and data layers produced by national agencies, identify those produced with digital data (usually clear from inspection), and obtain underlying geospatial data if possible from those agencies. This often requires one or more in-person visits to those agencies, but can yield valuable data. Then, identify domestic or international NGOs or researchers that have published data for the country of interest who are willing to share their data. Global data sets can also be useful in many cases to supplement national data sets.

Be transparent about permissions and rights. As data can often be proprietary, especially in the case of research groups and published data, it is often useful to explain that the data will not be distributed without permission from the authors and that it will only be used for the purposes of the current work. It is also useful to agree in advance on the products that might be produced from the data (e.g., maps in JPG or PDF format). Given the interest of NGOs and researchers in seeing their work put to good use, however, it is usually possible to secure agreement. The examples presented in this report are largely based on both government and NGO data.

Assess the quality of the available data and correctly document its shortcomings. Modern GIS tools have the benefit of producing polished maps and analyses while requiring relatively little user effort or experience. The clean appearance of these products, however, can hide serious shortcomings in the starting data or analyses; as the saying goes, "garbage in, garbage out." As such, it is strongly recommended that users understand the methodologies to create the data in the analyses and the impacts of data weaknesses on those analyses. The weaknesses of the starting data and analyses can then be documented with the results of the design. Although the results of a design process can be sufficiently robust that even weak or partial data will give the appropriate answers, it is important that those weaknesses be understood and documented.

Incorporate institutional priorities into key planning steps and analyses as appropriate. These can include priorities of the host government or U.S. Embassy, locations of previous or ongoing USAID work, or any other variables not included in the initial datasets. These can also include priorities both for biodiversity focal interests (e.g., specific landscapes, ecosystems, or species) or threats (e.g., illegal gold mining or wildlife trafficking). It is important that these priorities are identified at the beginning of the process, so that they may be incorporated at the right time without distorting technical analyses. For example, only technical criteria should be used during a threat rating exercise.[15] After the threat rating is completed, then institutional criteria can be considered in a separate but complementary process to help inform which threats to address.

Adjudicate between differing datasets, particularly when selecting biodiversity focal interests. Biodiversity can be measured in many ways (species richness, endemism, rarity, or the irreplaceability of certain ecosystems), and priorities from NGOs or government partners will reflect a specific index or combination of indices. Therefore, adjudicating between these differing priorities is more art than science and requires a good understanding of the different priorities, ample time for consideration of their relative merits, and documentation of decisions.

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[15] See forthcoming *Biodiversity Supplemental Guide 2: Rating Direct Threats in USAID Biodiversity Programming*.

Match the precision of the analysis to the decision being made. Many teams spend scarce resources to try to create overly precise maps. For example, a team does not have to know the precise location of every illegal gold mine in a conservation area if their strategic approach will be to try to stop access of gold miners to the entire area. However, if the strategic approach will be to shut down each individual mine, then having a more precise map will be necessary.

RESOURCES AVAILABLE AT USAID TO ASSIST WITH GEOSPATIAL ANALYSES

The analyses presented here were conducted by USAID staff, and are good examples of the resources available at USAID for program design support. In USAID/Washington, two groups are available for assistance on geospatial analyses work related to biodiversity program design: GIS specialists in the E3/Land Tenure and Sustainable Urbanization Office and GIS specialists in the GeoCenter at USAID's Global Development Lab. Under a memorandum of understanding between the two offices, the E3/Land Tenure and Sustainable Urbanization Office is the first point of contact for all USAID GIS work related to environmental and natural resource topics. Depending on the topic and previous experience, however, this work may also be shared with the GeoCenter.

The second, and perhaps more important, resource for GIS expertise are the GIS specialists in USAID's Missions. When available, these specialists are the first resource for geospatial work and can be supported by USAID/Washington staff, as needed. The availability of GIS specialists in USAID's Missions has increased substantially with increased demand for geospatial products. The GeoCenter can provide support for GIS specialist hiring through standard procurement language and direct support to Missions. In addition, these specialists receive support as members of USAID's global geospatial community of practice, which is facilitated by the GeoCenter and convened annually in two-week trainings. Missions with recurring needs for GIS specialists should consider adding them to their staff, as the results are often immediate and substantially faster than relying on USAID/Washington offices.

This resource offers four challenges to the design process: 1) It can be difficult to procure GIS work for design processes unless it is available under a pre-existing contract; 2) Many firms may not want to bid on procurement-sensitive design work because it will preclude them from bidding on the program of work; 3) It can be difficult to recover the data used by outside contractors; and 4) It can be challenging to document and reproduce outside GIS analyses that use multiple datasets and occasionally complex analytical methods. This can make it difficult to revisit the prioritization process if new data are encountered. It can also be a challenge during future design rounds.

However, contractors are very valuable resources in the use of geospatial data for monitoring and evaluation during implementation. During implementation it is unlikely that Mission or USAID/Washington staff will have the capacity to implement geospatial data collection or indicator monitoring. To maximize the potential value of geospatial analyses it is recommended that procurement and award language refer to needed requirements and resources for the collection and use of geospatial data. This can also apply to Monitoring, Evaluation, and Learning Plans. Together, they offer value for award implementation, reporting, and adaptive management.

It is important to note that provision of underlying geospatial data – not just the maps and analyses created from such data – should be required of implementing partners. Since the 2014 USAID Open Data Policy, USAID has worked to implement the policy's mandate to "ensure that USAID-funded data is centrally cataloged and made available to the public by default." This policy is based on the recognition that development outcomes will be improved when data on development activities are broadly shared. Standard contract language[16] should thus be updated to specify that geospatial data in appropriate formats (e.g., shapefiles, rasters, geodatabases, etc.), and including standard metadata, are provided to USAID in addition to the maps and analyses that these data are used to create. The central USAID Development Data Library created in response to the Open Data Policy, is a resource and repository to make such data available to the public, as well as for internal USAID use.

In summary, geospatial analysis offers USAID staff who program biodiversity funds a powerful and nimble set of tools to enhance the quality and efficiency of design, monitoring, evaluation, and learning. USAID has internal and external resources available to guide these processes. The example from the Peruvian Amazon demonstrates how design of a project at a very large spatial scale was enhanced by using geospatial information and analyses. Specifically, the design team in Peru refined the project scope, focal interests, threats, and strategic approaches using spatial information. They also incorporated spatial considerations into the development of the project Monitoring, Evaluation, and Learning Plan by considering which information needs could be met using spatial data and analyses.

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[16] The USAID GeoCenter has developed such language to insert into contracts.

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