Monitoring biodiversity conservation outcomes in complex agricultural mosaic landscapes

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Problem Statement

Conservation of wild biodiversity is a central goal of ecoagriculture and of other related approaches to integrated landscape management. Conceptually, it is simple to evaluate and monitor the contribution of managed landscapes to wild biodiversity conservation: one need only to quantify the diversity, abundance, and distribution of organisms and habitats on the landscape. Operationally, however, such monitoring has proven extremely difficult, especially in the agricultural mosaic landscapes that characterize smallholder agriculture throughout major portions of the developing world. Practitioners face several important challenges:

> **Challenge 1:** The fine-grained nature of agricultural mosaic landscapes means that it is difficult to generalize from one location to the next, or to establish a valid sampling system from which to draw conclusions about the landscape as a whole.
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> **Challenge 2:** Agricultural mosaics, especially in a smallholder context, tend to be quite dynamic due to shifting human management regimes. As a result, these landscapes may be in a state of permanent ecological disequilibrium whereby species assemblages are not fully characteristic of their habitat or ecological context, and where historical legacies exert strong influences.
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> **Challenge 3:** Landscape context is likely to have a high, but variable, influence on species distribution, so site-scale characteristics may not be a good predictor of plant and animal assemblages.
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> **Challenge 4:** Data availability and access are often quite limited. Fragmented parcel ownership in smallholder landscapes means that field data collection requires coordination with numerous private landowners. In developing countries, baseline data are typically absent, GIS databases are sparse or nonexistent, and large areas may be physically inaccessible for field work.

Response to Problem

In light of these challenges, an initiative was developed to identify pragmatic approaches to biodiversity monitoring in mosaic landscapes by evaluating the accuracy and cost-effectiveness of several potential methods, both established and novel. First, we are investigating the validity of various proxies for biodiversity conservation outcomes that could be used to garner conservation data for large areas and to integrate across disparate landscape patch types (Challenge 1). Second, we are working to determine the most appropriate scale or scales at which to monitor conservation outcomes (Challenge 3). Finally, we are evaluating the tradeoffs between data accuracy and the cost of data acquisition to identify the “minimum data set” necessary for valid conservation outcomes assessment, and to determine how additional monitoring resources can be used most strategically to improve data quality (Challenge 4).

Conceptually, different approaches to biodiversity monitoring can be arrayed along a continuum from the most accurate (but most expensive) techniques to those that are the most affordable (but least accurate). Figure 1 shows the approximate location along this spectrum of the five approaches that are included in this project. All of these techniques have been used in the context of agricultural mosaic landscapes, and some have been evaluated for accuracy. However, no prior studies have explicitly compared all of these approaches to assess their relative accuracy or cost-effectiveness in particular locations.

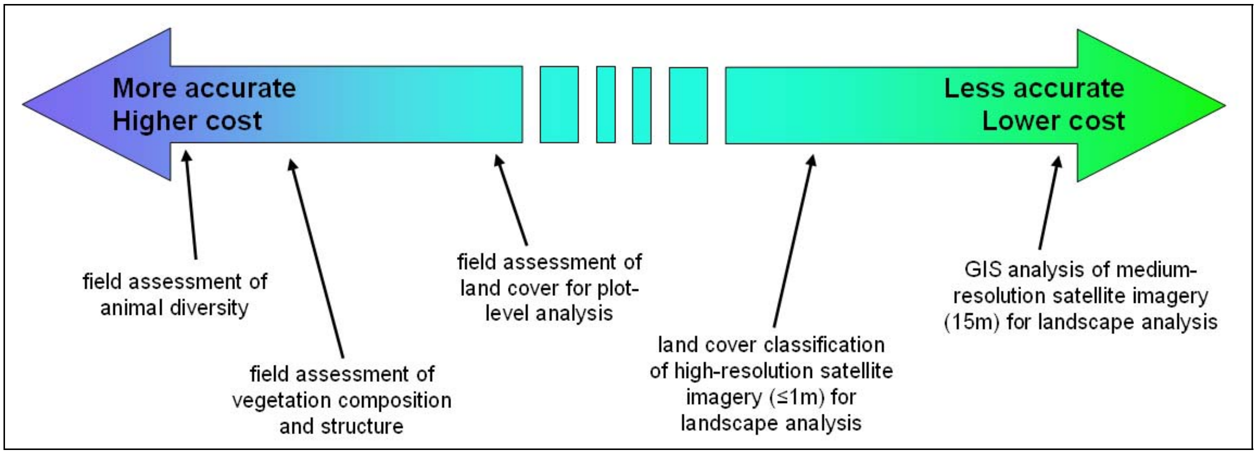

Figure 1. Different approaches to biodiversity monitoring in agricultural mosaic landscapes being investigated in this project.

In addition, almost all prior studies on biodiversity assessment in agricultural mosaics have been limited to individual landscapes. Such studies can elucidate relationships between agricultural management and conservation outcomes in specific contexts (particular bioclimatic zones, cropping systems, and so forth) but cannot determine whether there are consistent relationships that hold true more generally. Establishing the consistency of these relationships is the *sine qua non* for identifying reliable proxies that can be used in new landscapes where detailed scientific studies have not yet been completed.

To assess the consistency of the relationships among the species composition, site-scale, and landscape-scale indicators shown in Figure 1, this project is working in four silvopastoral landscapes in northern Latin America (Table 1). Silvopasture is an agroforestry technique that integrates livestock production with forest patches, tree cover, and small cropped areas in a fine-grained mosaic. It is a dominant land use practice throughout Mesoamerica, supporting many smallholder farmers and believed to be critical for sustaining biodiversity outside of protected areas. If consistent relationships and reliable proxies are identified across the four landscapes, these may be applied to other silvopastoral systems throughout the region.

Table 1. Location and characteristics of project landscapes.

Landscape	Landscape Size (km^2)	Bioclimatic zone	Dominant Land Uses
Esparza, Costa Rica	432	Tropical dry forest (Pacific slope)	Cattle pasture, pasture with trees, forest fragments, urban areas
Matiguas, Nicaragua	353	Transition from tropical dry forest to humid forest	Cattle pasture, pasture with trees, small areas of agricultural crops
Copan, Honduras	800	Tropical wet forest (Atlantic slope)	Cattle pasture, pasture with trees, oak/pine forest, coffee
Cuenca Rio la Vieja, Colombia	583	Tropical humid premontane forest	Cattle pasture, pasture with trees, broadleaf forest, coffee

For descriptions of the five approaches to biodiversity monitoring that are being explored, with illustrations of data sources, see www.landscapemeasures.org (Case Studies, Latin America, Costa Rica).

Applications

One of the key outcomes of this effort will be to identify a range of cost-effective biodiversity monitoring approaches for agricultural landscapes. At one end of the spectrum, we will propose a "gold standard" approach that combines field surveys and remote sensing. This approach may be suitable for scientific research efforts or learning-based pilot projects sponsored by national governments, NGOs, or multi-lateral organizations. At the other end of the spectrum, we hope to be able to recommend one or more low-cost techniques to track changes in the biodiversity conservation outcomes of agricultural landscapes. These are likely to rely heavily on remote sensing data, including the very low cost ASTER imagery. There are numerous possible applications for low-cost techniques, including in conservation and rural development projects, for monitoring conservation benefits in payment for ecosystem services programs, and for guiding community-based conservation efforts, such as those now ongoing in the Copan and Matiguas landscapes.

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