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Rationale for measuring and monitoring forest-related indicators for the "Caminos de Liderazgo Program", Osa Region, Costa Rica

Lucia Morales Barquero

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Goal

The ultimate goal of developing an environmental monitoring protocol for the "Caminos de Liderazgo" Program (hereafter referred to as Caminos) is to ensure that there are no negative effects on biodiversity due to activities associated with Caminos (a description of Caminos, can be found at: http://inogo.stanford.edu/programs/leadership-program?language=en; http://www.grupo-rba.com/#!caminosdeosa/c178u). In the case of vegetation monitoring, the efforts should focus on establishing the current state of forests ecosystems found inside the program's "catchment" or "focal" area and on understanding past trends of change of these ecosystems, in order to propose indicators that can inform future management decisions. The term forests ecosystems is used herein to group all vegetation formations such as *matorrales*, tree plantations, *herbazales* etc., because most of the area designated as the Caminos focal area is dominated by forests.

Development of a reference (baseline) condition

For Caminos, it is fundamental to determine a reference state that will serve as a solid baseline for future monitoring, once ecotourism activities are operational. A first step is to identify available data sources. In terms of available remote sensing data, the main source for historical information is Landsat data (1974-2014); for current data with a higher degree of detail, there is also RapidEye data used to establish INOGOMapas (http://inogo.stanford.edu/resources/INOGOMapas?language=en) The main geographical information to establish current reference conditions of the forest ecosystems relevant to Caminos is land use information from INOGOMapas 2012. Analysis of this information serves two purposes: 1) to establish indicators related to the type of vegetation and 2) to establish different types of land cover classes or strata within the Caminos focal area that can be important as proxies for monitoring biodiversity.

Vegetation- related indicators

The selection of indicators is constrained not only by available data but also the timeframe for Caminos interventions and the complexity of measuring and monitoring a certain indicator.

Given these, monitoring based on remote sensing (RS)-derived indicators may be the most practical option at the early stage of Caminos' development.

RS indicators can be divided into two groups, according to the information they provide. The first group provides information on landscape patterns, focusing on the structure and configuration of related ecosystems. The second set provides information on the forest state, using spectral indices.

Indicators based on landscape patterns can be used to evaluate if any changes occur to the *extent and configuration* of related ecosystems; they provide a measure of the degree of fragmentation of forest ecosystems as a result of conversion to other land uses. Also, these indicators can summarize the current state of the different ecosystems in the Caminos focal area that can serve as the reference or baseline condition (i.e., before Caminos interventions).

That is, by analyzing how landscape metrics change over time we can thus determine trends and identify whether Caminos-related interventions are having any effect (negative or positive effect) on the extent and configuration of the forests ecosystems. In general, landscape metrics provide indicators that are credible and can be regularly measured over time (Strand et al. 2007). There are many landscape metrics that can be used as indicators. Table 1 lists some of the "basic" ones that can be used as part of Caminos.

As noted above, monitoring of the *condition* of forests ecosystems can be done using spectral indices. For example, changes in Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Green Normalized Difference Vegetation Index (GNDVI), Optimized Soil Adjusted Vegetation Index (OSAVI) etc., provide information on forest state and can potentially be used as indicators of Caminos-related effects (not cause and effect but potential associations).

In order to use spectral indices, we first need to understand past trends of these indices in order to define thresholds. For instance, one needs to establish a threshold to classify non-disturbed versus disturbed forest areas and assess the magnitude of change of the different indices (Bruggeman et al. 2015). These classes can be used to determine strata for further analysis. Currently, the spectral indices analysis to establish past trends can be done with Landsat data for 4 dates (1979,1998,2003,2014). The 2014 analysis can also serve as a reference condition, before one would anticipate any Caminos-related environmental effects.

A practical option when using indices is to evaluate their average values within different land cover classes both inside and outside the focal area; this will provide a clearer picture of the reference condition. Once Caminos has been implemented, ex-post analysis based on RS data

can be used to evaluate the program's effects. Blackman (2013) provide a series of interesting ex-post methods that can potentially be further adapted to evaluate Caminos in terms of its effects on biodiversity. These methods include matching techniques to create a credible counterfactual that can be used to compare changes in RS indices that can be associated, with high concept validity, to Caminos interventions.

Additionally, it is important to point out that RS data do not represent biodiversity indicators *per se*. While useful, monitoring positive or negative outcomes on biodiversity associated with Caminos interventions can be very technically challenging and costly (Jones 2012). RS data provide at least an indirect approach to evaluating the state of ecosystems that can be used to guide ground-based biodiversity assessments. Ideally, RS should be complemented with ground- based assessments. In the case of Caminos, the analysis of landscape metrics and changes in spectral indices could provide guidance for further monitoring efforts of e.g., the placement of camera traps, the selection of sites to conduct bio-acustic data collection, or rapid biodiversity assessments (e.g. RAPELD) that could be based on the strata determined from the RS analysis. RS indicators, as with any other indicators, rarely tell the whole story (Newton 2007) but, nevertheless, do provide a way to quantify and simplify the information related with program or project intervention implementations on the ground.

Table 1 Some proposed indicators based on landscape metrics to assess spatial characteristics of forest landscapes (Jung 2012)

Indicator	**Description**
Number of patches	Total number of patches of each individual land cover class or ecosystem. The higher the number, the more fragmented.
Mean patch size	Average size of all patches of each individual land cover class or ecosystem. The bigger the number, the less fragmented
Mean Nearest Neighbor	Measure of patch isolation. The nearest neighbor distance of an individual patch is the shortest distance to a similar patch (edge to edge)
Number of Core Areas/Core Area Density	Area of interior habitat patches defined by specified edge buffer width defined by the user
Total Edge/Edge density	Length of patch edges

Other considerations:

- **Mixed Method Approach:** the RS component of monitoring should be complemented with socio-economic data collection. Collecting data on how the communities are using the forests ecosystems resources, through relatively simple surveys and/or participatory mapping exercises is therefore highly recommended as it would provide a more complete picture of how actions may be affecting biodiversity/ecosystems [i.e., what, where and how are people using the project area and what were the uses in the past (at least in recent times)]. Ideally, such data collection would be geo-referenced to an area such as the interviewee property or to a community, making it possible to associate activities to what is observed in the field and in RS images. Some example of basic questions to include in a community assessment could be: What types of vegetation can you identify in the area? What do you use the forest for? What products do you get from the forests?
- **Adaptive monitoring**: measuring outcomes of projects or programs such as Caminos is a challenging task. Monitoring protocols likely will need to be adapted as more information becomes available and/ or Caminos evolves. As activities and interventions as well as their intensity are often not fully defined a priori, an adaptive monitoring approach should be part of the "toolbox". Sooner rather than later, Caminos outcomes need to be clearly linked to outputs, as well as the link between outcomes and what monitoring is being proposed.
- **Project Area:** before starting any spatial analysis, the area of influence should be clearly agreed upon. The area to be analyzed might go beyond the specific area of activity e.g. of Caminos interventions. For various reasons it might be necessary to include other areas in the reference area. For example: the comparison of spectral indicators should be done against a benchmark that can be areas subjected to less human presence (e.g. parts of Corcovado National Park) that have similar environmental conditions.
- **Community boundaries and project area:** the area to be monitored for vegetation should be large enough to include both community boundaries and the area of influence of Caminos. Vegetation monitoring should adapt to the official definition of community (e.g., what the Comite de Desarollo establishes) and /or to what is established by communities in terms of on how they use the area.
- **Project Zones:** A clear definition of zones and activities is also needed meaning, which activities are allowed or will be performed in which geographic areas and by which actors. This is essential to be able to consider how any observed change in the state of biodiversity relates to Caminos activities.
- **Community Monitoring:** the involvement of local stakeholders in the monitoring of the Caminos focal area should be sought as it is key to understanding local knowledge,

values, and perceptions of importance as it relates to the use of forests ecosystems resources. Communities could participate in future monitoring efforts involving field data collection for biodiversity assessment of both trees and wildlife. Furthermore, incorporating local people into the selection and prioritization of indicators encourages a more transparent decision-making process and might improve data quality (Lawrence 2010).

- Effects should be detectable at the landscape level
- Other geospatial information collected on other aspects of Caminos can be combined with the forests ecosystems spatial data. It would be useful to have a common geospatial database for the Caminos monitoring.

References

Blackman, A., 2013. Evaluating forest conservation policies in developing countriesusing remote sensing data: an introduction and practical guide. For. Policy Econ.34, 1–16.

Ferraro, Paul J, and Subhrendu K Pattanayak. 2006. "Money for Nothing? A Call for Empirical Evaluation of Biodiversity Conservation Investments." Edited by Georgina Mace. *PLoS Biology* 4 (4) (April): e105. doi:10.1371/journal.pbio.0040105.

Bruggeman, Derek, Patrick Meyfroidt, and Eric F. Lambin. 2015. "Production Forests as a Conservation Tool: Effectiveness of Cameroon's Land Use Zoning Policy." *Land Use Policy* 42 (January): 151–164. doi:10.1016/j.landusepol.2014.07.012.

Jones, J. P. G. 2012. "Getting What You Pay for: The Challenge of Measuring Success in Conservation." *Animal Conservation* 15 (3) (June 6): 227–228. doi:10.1111/j.1469-1795.2012.00554.x.

Lawrence, A. (2010) Introduction: learning from experiences of participatory biodiversity assessment. Taking Stock of Nature. Participatory Biodiversity Assessment for Policy, Planning and Practice (ed A.Lawrence), pp. 1–29. Cambridge University Press, Cambridge.

Martin Jung (2012) LecoS - A QGIS plugin to conduct landscape ecology statistics, http://plugins.qgis.org/plugins/LecoS

Newton, Adrian. 2007. *Forest Ecology and Conservation: A Handbook of Techniques (Techniques in Ecology & Conservation)*. Oxford University Press, USA.

Strand, H., R. Höft, J. Strittholt, L. Miles, N. Horning, E. Fosnight, and W. Turner (eds). 2007. *Sourcebook on Remote Sensing and Biodiversity Indicators*. Technical Series N32.Montreal: Secretariat of the Convention on Biological Diversity.