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A combination of methods needed to assess the actual use of provisioning ecosystem services

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ABSTRACT

Failure to recognize that potential provisioning ecosystem services are not necessarily collected and used by people may have important consequences for management of land and resources. Accounting for people's actual use of ecosystem services in decision making processes requires a robust methodological approach that goes beyond mapping the presence of ecosystem services. But no such universally accepted method exists, and there are several shortcomings of existing methods such as the application of land use/cover as a proxy for provisioning ecosystem service availability and surveys based on respondents' recall to assess people's collection of e.g. wild food. By combining four complementary methods and applying these to the shifting cultivation systems of Laos, we show how people's actual use of ecosystem services from agricultural fields differs from ecosystem service availability. Our study is the first in Southeast Asia to combine plot monitoring, collection diaries, repeat interviews, and participant observation. By applying these multiple methods borrowed from anthropology and botany among other research domains, the study illustrates that no single method is sufficient on its own. It is of key importance for scientists to adopt methods that can account for both availability of various services and actual use of those services.

1. Introduction

The importance of the concept 'ecosystem services' was elevated by the publication of the Millennium Ecosystem Assessment (MA) in 2005, a work involving over 1300 scientists. One of the outcomes of the MA was a call for research on measuring, modeling and mapping ecosystem services, and assessing changes in their delivery with respect to human wellbeing (Carpenter et al., 2006; Millennium Ecosystem Assessment, 2005; Sachs and Reid, 2006). Yet, the MA did not prescribe *how* to use the concept of ecosystem services (Seppelt et al., 2011). Since the completion of the MA, the number of scientific articles addressing ecosystems services has augmented exponentially (Fisher et al., 2009), and this ongoing research has revealed new challenges in the basic science needed to assess ecosystem services (Carpenter et al., 2009). The lack of consensus on methods that can be consistently applied makes it difficult for scientists to assist policy makers with robust recommendations on ecosystem service governance. Action is therefore needed to develop rigorous and practical approaches.

A wide spectrum of methods has been proposed to assess the availability and use of provisioning ecosystem services. These include site-scale and landscape-scale modeling, biophysical observations and economic studies (see Bagstad et al., 2013a for a review of 17 ecosystem service tools). But there are challenges to such studies. Too often, ecological and economic studies have been carried out separately from each other (Carpenter et al., 2006) and this has led to results that are difficult or impossible to use for decision-makers. Another challenge in existing approaches is that ecosystem services can be difficult to measure directly. The application of land cover/land use as a proxy for ecosystem service availability has accordingly been widespread (Bennett et al., 2009; Naidoo et al., 2008). Yet, the relationship between land use/land cover, ecosystem service availability and people's actual use of

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services remains untested in many regions of the world (Nelson et al., 2009). As the land use/land cover does not necessarily reveal which specific ecosystem services the landscape provides and whether people actually use those services, simple land use/land cover proxies might not adequately capture crucial information needed (Bennett et al., 2009). Rather, we need integrated social-ecological approaches that can differentiate between ecosystem conditions, availability of ecosystem services, and people's actual use of ecosystem services (Guerry et al., 2015).

In the present paper, we show how people's actual use of provisioning ecosystem services can be systematically examined through complementary methods that take both social and ecological factors into account. We focus on provisioning ecosystem services in shifting cultivation systems, and we pay special attention to people's use of services from agricultural fields. Such focus is particularly important as previous research on agricultural fields as sources of ecosystem services other than the main food crops has been limited (Schulp et al., 2014). This is remarkable as Scoones et al. (1992) already two decades ago called for a focus on the 'hidden harvest' from agricultural fields, especially wild food sources including both plants and animals. The concept of a hidden harvest refers to the fact that along with the major crops planted by the farmer, a range of plant material and animals can be found in agricultural fields that represent important sources of potential food, and in Borneo agricultural communities consume as many as 700 different wild and semi-wild plan species of which many come from fields and fallows (Christensen, 2002). In addition to being food sources, many wild plants also have medicinal and animal feed purposes (Cruz Garcia and Price, 2012). Some animals present in the arable lands are likewise essential food sources, especially with regards to proteins (Fiedler, 1994) although they often are deemed pests. Despite the obvious importance of these wild food sources, decades of official food security policies worldwide have tended to overlook their importance. The underestimation results from the lack of monetization of wild food as well as the lack of formal markets, and hence they are not captured in national level accounting (Dovie et al., 2007).

By contrast, a large body of prior research has focused on forest areas as providers of ecosystem services such as wild food, pharmaceuticals and a range of other non-timber forest products (NTFPs) (de Groot et al., 2010; Delang, 2006b; Heubach et al., 2011). A recent special issue of *World Development* included both global-comparative studies and case studies that assessed the environmental incomes local people gain from forest also referred to as forest-extractive incomes (Wunder et al., 2014). The popularization of the concept of ecosystem services has widened the attention of research to include land use types other than those deemed most important for the conservation of biodiversity, to consider the landscape scale and include a greater diversity of land use types including agricultural fields (de Groot et al., 2010; O'Farrell and Anderson, 2010). Failure to fully recognize the importance of agricultural fields in assessments of people's use of ecosystem services has potentially important consequences for management of land and resources. While recent studies have focused on the change towards more intensive collection among local people of the fewer species of economic value (Belcher et al., 2005; Kusters et al., 2006; Nanthavong et al., 2011), we concentrate on methods to assess the broad range of provisioning ecosystem services local people utilize from the agricultural fields. Our attention is devoted to four categories of provisioning ecosystem services: wild vegetables, wild meat, fodder, and medicinal plants.

The shifting cultivation systems of Southeast Asia provide a unique experimental area to test methods for assessing how people derive provisioning services from the fields. These landscapes deliver a broad variety of ecosystem services of which many have been exploited by local people to gain part of their subsistence. But current land use transitions from subsistence to commercial agriculture are likely to have profound impacts. As our attention is devoted to local people's use of services at the village level, ecosystems and their 'beneficiaries' are co-located. We define 'shifting cultivation' in line with Mertz et al. (2009): "*a land use system that employs a natural or improved fallow phase, which is longer than the cultivation phase of annual crops, sufficiently long to be dominated by woody vegetation, and cleared by means of fire*". We note that fallows should not be considered abandoned (Brookfield and Padoch, 1994; Mertz et al., 2009) as farmers will return not only for later cultivation, but also use the area to collect numerous provisioning ecosystem services such as wild food (Fox et al., 2000).

By using three villages in Laos as case studies, the paper illustrates advantages as well as pitfalls of four different methods. The selected complementary methods are (1) Monitoring of agricultural field plots to identify which provisioning services people derive from their fields during a growing season from field preparation to harvest, (2) Collection diaries used to estimate the amount and variety of provisioning services households collect from various land use types, (3) Semi-structured interviews with selected household members to validate and provide additional information on the observed collection of provisioning ecosystem services, and (4) Participant observation to witness the collection. We show that if the methods are applied on their own, they fall short of estimating local people's actual use of the ecosystem services. In contrast, when the methods are used in concert, they provide attractive means for scientists for obtaining a robust understanding of, not only, the presence and availability of ecosystem services, but also whether these services are used as goods. The findings illustrate the inadequacies of using land use/land cover as a proxy for ecosystem service use. When the methods are used in concert, the results can inform decision makers about which ecosystem services are deemed important and actually used by local people.

2. Literature review on common methodologies to assess actual use of provisioning ecosystem services in Southeast Asia

As there is no single methodology recommended to assess people's use of provisioning ecosystem services, we look into methods applied within the field of ethnoecology, which describes local people's interaction with the natural environment, including both plants and animals. Ethnoecology operates at the interface of several disciplines and methods are mainly drawn from anthropology, botany, ecology, and environmental economics. These methods include: (1) ecological surveys such as plot monitoring to understand the diversity and occurrence of various plants and animals as well as the harvesting quantities, (2) quantitative methods such as questionnaires or collection diaries to obtain data on e.g. people's actual use of various plants and animals, (3) qualitative methods such as semi-structured interviews or group interviews to acquire an in-depth understanding of human behavior related to the use of resources, and (4) participant observation such as landscape walks conducted in the research area (Albuquerque et al., 2014; Martin, 1995).

Since research on availability and use of provisioning ecosystem services in many ways resemble ethnoecological work, we propose that ecosystem service assessments would benefit from drawing on ethnoecological methodologies. Yet, a main argument brought forward already in the mid-1990s was that ethnoecologists should combine different methods and techniques borrowed from the various disciplines included in ethnoecology in order to