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Social and ecological factors associated with the use of non-timber forest products by people in rural Borneo

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ABSTRACT

Supply of non-timber Forest Products (NTFPs) is an important provisioning ecosystem service. It is often argued that forest conservation contributes to poverty alleviation through provisioning of NTFPs to the poor. However, implicit assumptions of the argument that NTFPs are more intensively utilized by poor who lack alternative subsistence options, and that NTFP supplies are limited by forest cover, have rarely been critically examined. This study investigated social and environmental factors affecting NTFP uses in rural areas of Borneo, using a land cover map and socio-economic dataset collected from 1596 households in 87 villages. The NTFPs examined were wild boars, sambar deer, wild fruits, firewood, wild vegetables, and wild mushrooms. To explain the variations in NTFP uses among households, four village and nine household characteristics were considered using generalized linear mixed models. We found that forest cover and collection pressure limit the use of some NTFPs, supporting the second assumption. On the other hand, the first assumption was supported only for firewood, and animals and wild fruits were more frequently used by wealthier households, contrary to this assumption. Other factors (education, age and sex of householder and agricultural activities) were also related to the use of one or more NTFPs. This study demonstrates the complexity of the process by which forest cover and other factors affect the ecosystem services people receive. Evaluation of ecosystem services is an important and urgent research subject today, but it is also necessary to pay attention to who receives the benefits, and who does not.

1. Introduction

Ecosystems generate a range of life-supporting services, including provisional, regulating, cultural, and supporting services that underpin long-term socio-economic human wellbeing and continued existence. Landscapes simultaneously produce multiple ecosystem services that interrelate in complex and dynamic ways. Efforts to increase an ecosystem service often result in changes and the decline of other services (Bennett et al., 2009). For example, addition of nutrients can increase agricultural production, a provisional ecosystem service, but reduce water quality, a regulating ecosystem service (Carpenter et al., 1998). Deforestation and development of agricultural fields increase provisional services, but reduce biodiversity and genetic resources (Fitzherbert et al., 2008). Such tradeoff relationships cause the deterioration of some important ecosystem services, and this is regarded as one of the most serious environmental problems today (DeFries et al., 2004; Millennium Ecosystem Assessment and Millennium Ecosystem Assessment, 2003). To make better land-use management and conservation decisions, it is essential to evaluate ecosystem services and to

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understand the mechanisms underlying their dynamic changes by incorporating both ecological and social factors into relevant analyses through interdisciplinary approaches (Carpenter et al., 2009; Daily and Matson, 2008).

Provisioning of non-timber forest products (NTFPs) is one of the most important ecosystem services. NTFPs comprise biological materials (other than timber) of wild plants and animals (for example, fruits, nuts, vegetables, game, medicinal plants, resins, bark, fibers, palms, and grasses, as well as small wood products and firewood) extracted from forests and woodlands (Beer and de Beer and MacDermott, 1996; Shackleton et al., 2011). In many parts of the world, NTFPs provide for a significant part of peoples' daily necessities (Angelsen et al., 2014; Cavendish, 2000). They also provide a complementary or primary source of income. Even if their absolute amount or their contribution to overall household income is small, they may play significant roles in reducing risk and vulnerability of poor households as a safety net and gap filler (López-Feldman and Wilen, 2008); some NTFPs are used to complement and supplement seasonal fluctuations in harvest from agricultural activities, especially in bad years (Arnold and Pérez, 2001; Byron and Arnold, 1999). Scherr et al. (2004) estimated that 1.4–1.6 billion people worldwide make use of NTFPs at least to some degree, while 350 million people depend on NTFPs for their livelihood either as a safety net or as supplementary income.

Changes in ecological environments, such as reduction and degradation of forests or resources, have often been considered a major factor in reducing the use or harvest of NTFPs (Parnwell and Taylor, 1996; Rist et al., 2012; Shackleton et al., 2011). Sustainable management of forest resources and the contribution of NTFPs to forest conservation have been central topics in the study of NTFPs (Arnold and Pérez, 2001; Belcher et al., 2005; Gaoue et al., 2016, 2011; Hernández-Barrios et al., 2015; Shackleton et al., 2011). In tropical and subtropical forests, where people highly depend on NTFPs (Shackleton et al., 2011), extensive deforestation is still ongoing (FAO, 2010). In particular, the deforestation rate in Southeast Asia has been among the highest in the tropics (Achard et al., 2002). Expanding human populations and industrial drivers, such as logging, large-scale agriculture, and exotic-tree plantations, are major causes of forest loss and degradation in this area (Laurance, 2007). In scoring exercises in Indonesian Borneo, people reported that industrial logging had reduced the value of the forest partly because of the decline of NTFP supply (Sheil et al., 2006). Among NTFPs, sago palm *Eugeissona utilis* growing on the ridges is very vulnerable to industrial logging because its habitat is often extensively destroyed to make trails for timber extraction machinery. A more recent study in Cambodia quantitatively examined impacts of deforestation on the use of NTFPs through a social survey in six villages that had experienced different rates of deforestation. It showed that NTFP collections were suppressed in extensively deforested areas (Ehara et al., 2016). Since economically disadvantaged people are considered to depend more strongly than others on NTFPs, the significance of NTFPs for poverty alleviation is often emphasized as a solid ground for tropical forest conservation (e.g., Brosius, 1997; Ros-Tonen and Wiersum, 2005; Shackleton et al., 2011; Sunderlin et al., 2005).

However, the use of NTFPs can also change depending on various social factors and services, and on the characteristics of the services' recipients. Even if NTFPs are available in peoples' environment, their use may dwindle when people either become more involved in the production of food or commercial crops, or when people become more integrated into the market economy and become more dependent on purchasing goods as their income rises (Arnold and Pérez, 2001; Byron and Arnold, 1999). Extreme examples of this include abandoned ecosystems that were formerly intensively used in developed countries. “Satoyama” is an area of secondary woodlands and grasslands near human settlements in Japan, and such areas have traditionally been maintained and used for fuel, fertilizer, and fodder collection. These areas have been abandoned in the wake of the appearance of alternative resources and the decrease in the number of people and increase in the average age of people living in rural areas (Takeuchi, 2010). The use of NTFPs may also be depressed if markets for the NTFPs are not available or accessible, or if knowledge or skills regarding how to use them are lost.

This study investigates factors associated with variations in the use of NTFPs among people in rural areas of Sarawak, Borneo. In particular we focus on the relationships between poverty alleviation and forest conservation through NTFP uses. Two implicit assumptions about the synergistic relationships between poverty alleviation and forest conservation are that (1) NTFPs are more utilized by poorer than by wealthier people, and that (2) the use of NTFPs is limited by forest cover. We examined the veracity of these assumptions using a unique dataset collected from 1596 households in 87 villages. In this region, people have traditionally conducted either swidden or wet rice cultivation as their major source of livelihood (Ichikawa, 2007). In addition, most people collect forest products for daily consumption and trade, or for medicinal and ritual uses (Christensen, 2002; Ichikawa, 2004). During the past few decades, this region experienced drastic land cover changes mainly due to industrial logging and expansion of oil-palm plantations (Stibig et al., 2014). Simultaneously, social transformations (rapid urbanization and penetration of monetary economy) have been expanding quickly. Many people, especially those in the younger generation, leave rural villages to work in towns (Ichikawa, 2011; Soda, 2001, 2000). For most households, paid work has been a more important source of income than forest resources (see Methods). Cash crops for the international market have also been cultivated since the 19th century (Cramb, 2007). Rubber and oil palm are the most important cash crops today (Hansen and Mertz, 2006; Ichikawa, 2007; Soda et al., 2015).

Here, we focus on six categories of NTFPs that are popularly collected by means of hunting and gathering by people mostly for their own and local consumptions: These were wild boars, sambar deer, wild fruits, firewood, wild vegetables, and wild mushrooms. Many studies have documented NTFPs in Sarawak with very high market values collected mainly for external trade, including *gaharu* or fragrant wood, edible bird's nest created by cave-dwelling swiftlets, and *damar* or resins from dipterocarp trees (Hose et al., 1912; Metcalf, 2010; Ooi, 1997). We did not include such high-market-value NTFPs, however, because this study focused on NTFPs that are potentially available for most people in the rural areas of Sarawak. According to the literature and our preliminary field surveys, collections of such expensive NTFPs have become very local or rare today, although there are some people who still rely heavily on these NTFPs for their lives (Chin, 1985; Lim et al., 2002; Ooi, 1997). We address the following questions: (1) What are the relationships between the use of NTFPs and economic status of the households? We hypothesized that if the NTFPs are more intensively used by economically weaker people, the NTFPs may contribute to improvement of the standard of living of these people, and thus to poverty alleviation. (2) Do other subsistence activities such as paid work or rice or cash crop cultivation have a tradeoff relationship with the use of NTFPs? Other subsistence activities are expected to have a negative association with NTFPs when they provide sufficient resources and services to complement NTFPs, and/or when both activities are so time-consuming that one can not increase one activity without decreasing the other. (3) How do other factors affect the use of the NTFPs? If the local forest cover is positively associated with intensity of the use of the NTFPs, deforestation may directly reduce availability of the NTFPs. Since availability of NTFPs may also depend on the density of people who want to use them, we also included the number of households in the village as an index of local population density, and also remoteness as an index of population density of wider areas, since villages tend to aggregate around a city. We also considered other potential factors, such as distance from the market and education, as well as a few household characteristics. Some NTFPs are more intensively collected around a city due to high demand in the city and low cost of transport (e.g., Brashares et al., 2011; Shackleton et al., 2011). Exposure to modern information through communication and schooling are considered to

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