

## FORECOST



### The provision of forest ecosystem services: A dual cost approach

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**Context** — Forests provide ecosystem services (ES) for the benefit of society. Beside timber production, most of ES are non-marketed goods and services but with high values for the society. These ES (e.g., carbon sequestration, protection of water bodies, landscape, and recreation) have become increasingly important in recent forest economics literature as a result of their multifaceted relevance for the society coupled with their support for biodiversity conservation and climate change protection. Most ES are thus public or common goods, so that their social benefits are under-estimated. This specificity and the existence of markets for timber often involve the under-provision of ES and the overexploitation of ecosystems. The joint costs of provision of these public goods and timber production are poorly understood. Yet, they give important information on trade-off and synergies between these different ES, which is crucial for the forest owners and their management modes, as well as the design of public policies to conserve biodiversity.

**Objectives** — We study the joint production of timber and non-market goods and services related to the use of forest land, considering the relationship between the costs of forest management and the level of provision of those goods and services.

A first objective in a first paper was to analyse the interactions between ES in terms of cost (cost complementarity vs. substitutability) from a survey of private forest owners in the Hoa Binh Province in Vietnam.

A second objective in a second paper was to study the effects of some management modes (including setting aside a part of the forest) to conserve biodiversity on costs and ES provision. This econometric study is based on a survey of NIPF owners in Denmark.

**Approach** — Our approach consists in modelling and estimating cost functions of forest management. In a first study from data obtained through a field survey on private forest owners in Vietnam, we estimated the cost of provision of market goods (wood and non-timber forest products - NTFPs) and non-marketed ones (carbon and dead wood as an indicator biodiversity). The econometric analysis was carried out applying a dual cost function approach to analyse the trade-off between forestry costs and ecological performance. This is, to our knowledge, the first time such an approach has been applied to estimate the production relationship between marketed outputs and non-marketed ES in the forest sector. This approach appears to be appropriate for handling the multiple joint outputs of forest production. It allows us to estimate marginal costs and other cost measures such as cost complementarities in the production of multiple ES.

In a second study from online survey data on Danish non-industrial private forest owners, we studied management decisions of their forest property and their impact on costs, timber production and biodiversity. This paper specifically focuses on the decision to set aside forest land. It raises the more general question of the efficiency of multiple-use vs. specialized management of forest lands. We propose an econometric analysis to identify factors of the set-aside choice and to measure the impact of this decision on forest management costs. A flexible cost function is modeled and estimated for both types of management. The percentages of old/mature deciduous and old/mature coniferous forests are used as biodiversity and carbon indicators.

### **Key results** —

First paper (Are ecosystem services complementary or competitive in Vietnam?)

- Our results indicate that there is complementarity in the provision of timber and carbon sequestration.
- We also found that keeping deadwood (favouring biodiversity) had no significant cost and was complementary with NTFP (also an indicator of biodiversity in our study).
- In the same time, a certain quantity of deadwood in the forest could increase the marginal cost of producing timber.

Second paper (Modeling the choice between and the costs of multiple-use vs. specialized forest management. Denmark. Results show that the set-aside choice depends on the landowners' income and on their socio-economic characteristics.

- The set-aside decision has a significant and positive impact on the management costs, but has no impact on the marginal cost of timber harvesting.
- However, the marginal cost of timber production is increasing in old deciduous forests. This result seems to reject the hypothesis of the complementarity of costs between timber production and biodiversity conservation

### **Main conclusions including key points of discussion** —

- Policies that enhance carbon sequestration in private forests in Vietnam can be implemented without additional costs for the forest owner.
- Biodiversity can be enhanced without additional costs on the condition that the quantity of deadwood does not increase too much.
- We observed that the percentages of old deciduous and coniferous forests have no effect on the set-aside decision and concluded that forests with high potential for biodiversity and carbon sequestration are not the target of forest owners.
- The Danish experience of specialized management is found to be a more costly solution than multiple-use forestry. This implies that the additional private and public benefits achieved from specialized as opposed to multiple-use management should exceed this cost premium.
- Our results also clearly show a more intensive timber harvesting in the case of specialized management and that is quite independent of price levels.

**Future perspectives** — Knowledge of the cost structure, as well as the relationships between ES, offer the basis for setting efficient targets for provision of externalities and for cost-effective management strategies to meet such targets. The design of appropriate policy instruments, including market-based ones, relies on an understanding of the factors that have an impact on the costs of provision (Robert and Stenger, 2013). Yet too few empirical studies have investigated the cost of provision of FES as of this time.

However, one must be cautious when dealing with multi-output cost functions and production sets, together with “particular goods” such as ES. Examples can be found in species population dynamics in the standard predator–prey framework in which non-convexities appear in harvest production functions (Tschirhart, 2012). Furthermore, non-convexities in the production possibility set can arise from positive forest externalities along with a timber production function. Also, fixed logging costs and administrative constraints on logging regulations can create non-convexities in production sets.

The first problem is thus to find functional forms of cost functions or transformation functions, and econometric methods that do not require convexity assumptions, in order to well estimate and identify relationships between ES. In our papers, we partly addressed these issues by estimating a flexible translog cost function. However, such cost functions have good local estimation properties since it is a second-order approximation, but make the tests depend on the point of approximation. The second problem is caused by non-convexities in production sets. As highlighted by Tschirhart (2012), in economics, convexity is convenient because efficient allocation mechanisms are obtainable using a price system. However, when production sets are non-convex, as is likely in the context of FES, economic tools (such as taxes, subsidies or PES) might produce non-optimal results since models show the possibilities of multi-equilibria or even optima that are minimum (Brown et al., 2011).

This is will be the topic of our new proposal in the framework of innovative projects and the request of financing for a PhD student research.

## **Valorisation —**

### **Submitted Papers**

Kombat Lambini C., Thanh Nguyen T., Abildtrup J., Dien Pham V., Tenhunen J., Garcia S. (2016). Are ecosystem services complementary or competitive? An econometric analysis of cost functions from private forests in Vietnam, September, mimeo. Second revision in *Ecological Economics* Facteur d'impact (2 ans) : 3.227 (Social Science). Facteur d'impact (5 ans) : 4.227 (Social Science). Notoriété à 2 ans : Exceptionnelle (ECONOMICS). Notoriété à 5 ans : Exceptionnelle (ECONOMICS). Web of science® Times Cited : 3. (HCERES : A ; CoNRS : 1).

Petucco C., Garcia S. (2016). Multiple-use or specialized management for biodiversity conservation and carbon sequestration: Evidence from a survey on NIPF owners in Denmark, September, mimeo. Submitted to *American Journal of Agricultural Economics*.

### **Conference**

Lambini C., Nguyen T., Abildtrup J., Pham V.D., Tenhunen J., Garcia S. (2016). Are ecosystem services complementary or competitive? An econometric analysis of cost functions of private forests in Vietnam. Presented at the Annual Conference of the French Association of Environmental and Resource Economists (FAERE), Bordeaux, FRA (2016-09-08 - 2016-09-09)

Garcia S., Petucco C., Thorsen B., Vedel S. (2017). Modelling the choice between and the costs of multiple-use vs. specialized forest management. Presented at the Annual Conference of the European Association of Environmental and Resource Economists (EAERE), Athens, GRE (2017-06-28 - 2015- 07-01), Annual Conference of the French Association of Environmental and Resource Economists (FAERE), Bordeaux, FRA (2016-09-08 - 2016-09-09).

