Nimis P. L., Vignes Lebbe R. (eds.)
Tools for Identifying Biodiversity: Progress and Problems – pp. 423-428.
ISBN 978-88-8303-295-0. EUT, 2010.

# Cost Assessment of the Field Measurement of Biodiversity: a Farm-scale Case Study

Stefano Targetti, Davide Viaggi, David Cuming

**Abstract** — Attention to the effects of agriculture on biodiversity is currently increasing. Yet the measurement of biodiversity is both time-consuming and costly. Considering the limited budgets available for biodiversity conservation, it is timely to focus on the cost analysis of biodiversity indicators in order to ensure the optimization of the scarce funds available. We present the cost analysis of operational data from the fieldwork efforts undertaken in the measurement of biodiversity indicators at farm-scale. Methodological issues are discussed.

**Index Terms** — biodiversity measurement, earthworm indicator, spider indicator, research costs.

## 1 Introduction

The growing societal demand for environmental services provided by agriculture focuses attention on the implementation of sound agro-environmental schemes based on reliable information with respect to the effects of different agricultural practices on biodiversity [1]. The existing gap between need and availability of funds for biodiversity monitoring and assessment highlights the importance of the optimization of resources [2]. The cost analysis of biodiversity measurement, in particular if undertaken by way of a cost-effectiveness analysis, can ensure the optimization of scarce available funds and the selection of the most efficient indicators of biodiversity [3], [4]. Nevertheless, the cost-effectiveness of biodiversity measurement is a practically unstudied issue [5] and only a few examples exist [6] which propose a methodological approach to its analysis.

The assessment of the costs of measuring biodiversity at farm-scale is one of the specific tasks of the BioBio project (Indicators for biodiversity in organic and low-input farming systems -UE-FP7- http://www.biobio-indicator.wur.nl). In this paper we propose a methodology for the cost assessment of biodiversity

*The authors are with the Department of Agricultural Economics and Engineering of the University of Bologna, Italy. E-mail: stefano.targetti@unibo.it, davide.viaggi@unibo.it, david_cuming@hotmail.com.*

measurement, and discuss its practical application to the spider and earthworm indicators measured through the BioBio project protocol.

## 2 Material and methods

The BioBio project involves 12 case studies (CS) throughout Europe concerning organic, or low input, and conventional agricultural systems. Here we present the preliminary results from the French CS (Midi- Pyrénées Region). The cost assessment is related to the field measurement of the spider (SP) and the earthworm (EW) biodiversity indicators carried out in Spring 2010. Data covers 4 arable farms (Tab. 1), where wheat and sunflower are the main crops. Distance from the research centre (driving time in minutes) was similar for each farm (about 1 hour). Survey stratification was performed through habitat mapping in order to cover the different habitat conditions of the surveyed farm sites (see [7] for further details). In the aggregate, 537 samples (345 for SP and 192 for EW) were gathered.

| Farm | Area (ha) | Type | Distance from research centre (minutes) | Number of samples |
|---|---|---|---|---|
| A | 23 | organic | 53 | 113 |
| B | 19 | organic | 57 | 88 |
| C | 27 | conventional | 60 | 111 |
| D | 146 | conventional | 68 | 225 |

Tab. 1 – Main features of the 4 farms studied and number of samples (SP + EW) gathered during the spring fieldwork.

Spider sampling was carried out with the aid of a modified vacuum shredder (Stihl SH 86-D), and 5 suction samples were taken in each plot (each suction had a suction area of approximately 0.1 m² and lasted 30 seconds). The samples were stored separately in a cool-box and transferred to a laboratory. Spiders were sorted out in the laboratory and placed in vials with 70% alcohol [8], [9]. Three survey sessions were scheduled in the project protocol. Here we present data from the first session. The sampling team was composed of 3-4 persons.

Earthworm sampling was carried out by way of two methods: 1) stirring up an allyl-isothiocyanate and ethanol solution into metal frames (30 cm X 30 cm) which were placed in the ground, and collecting the earthworms that came upward during the first 10 minutes; 2) extracting the soil core (20 cm depth) from the sampling site and hand-sorting the earthworms on a plastic sheet. Samples were placed in cold containers with oxygenated water and transferred to refrigerators in the laboratory [10], [11]. The sampling team was composed of 5 persons.

The cost assessment methodology was organised in such a way as to allow for an analytical assessment of actual costs, as well as the subsequent simulation of costs with standardised costs. For this reason, both physical units of resources used and related prices were collected on a regular basis. Data collection was performed through the collection of records related to staff time, distance and transport time, consumables and equipment. Time spent (and costs) for fieldwork organisation and preparation and taxonomy identification is not included. Field staff filled-in a weekly cost-form which was entered into a relational data-base. Data collection was organised in order to retrace the costs related to each single farm and each single indicator. Each record contained: date, farm site, staff qualification, time spent per field-worker and was linked to different tables indicating the salary band of the staff, the distance of the farm site from the research centre, transport time, equipment and consumable costs, and the type of work (fieldwork, laboratory, etc.). The cost of the indicator measurement was composed of three resource categories: 1) equipment and consumables, 2) labour time investment (fieldwork, laboratory-work and transport), 3) worker categories (permanent, temporary).

Equipment and consumables included all the materials used during the fieldwork as well as the field lunches for the staff. The cost of the vacuum shredder was calculated as: cost per suction = cost of the vacuum new / number of suctions over its lifetime. This was approximated to 0.038€ per suction. The gross salary of the staff was approximated to 36€ per hour for permanent workers and 13.8€ per hour for temporary workers. Vehicle costs were charged at 0.32€ per km and included fuel, car insurance and vehicle depreciation. All the costs are related to 2010.

## 3 Results

The composition of the costs for the field measurement of the two biodiversity indicators in the four farms studied are presented in Tab. 2. The cost per sample of the earthworm indicator was 3.5 times higher than the spider indicator. EW costs per hectare were only 2 times higher than SP because of the lower number of samples gathered for the EW indicator. Although the spider indicator required a higher permanent work effort (1 hour of permanent work for every 2.6 hours of temporary work for SP vs. 1 hour of permanent work for every 4 hours of temporary work for EW), the labour load was higher for the EW indicator (the labour cost was 83% of total cost for EW vs. 57% for SP). The portion of the other costs were always lower (max. 10% of total costs), except for lab work and preparation of samples which constituted an important component of costs for the spider indicator (23% of total costs).

The cost of transportation (vehicle, highway tolls and work time for transfer of fieldworkers from the research centre) was a consistent portion of costs for the measurement of biodiversity (Tab. 3). This cost was about 30% of total costs. Accordingly, the cost of the measurement of the indicators was strongly tied to the organisation of the fieldwork (number of sessions, distance of farms from research centre, etc.). The portion of transportation + transfer of fieldworkers with respect to the total costs was higher for SP than for EW (34% vs. 28%) because the research unit was equipped with only one vacuum tool. As a result only one sampling team could be organised for fieldwork each day. The EW measurement was more flexible as several sampling teams per day could be arranged. Thus, the differences in costs between the two indicators were more evident when considering the effective costs of fieldwork (resources spent in field measurement after transport costs): 13.3€ $ha^{-1}$ for SP vs. 28.1€ $ha^{-1}$ for EW (ratio 1:2.1).

| Biodiversity indicator | Spiders | Earthworms |
|---|---|---|
| Cost per sample | 12,6 | 44,3 |
| Cost per ha | 20,2 | 39,6 |
| Labour | 618 | 1756 |
| Permanent / Temporary ratio | 1: 2,6 | 1: 4 |
| Consumables and equipment | 110 | 187 |
| Labwork | 253 | 35 |
| Vehicle and tolls | 105 | 148 |
| Sum of costs | **1086** | **2126** |

Tab. 2 – Composition of costs (mean values per farm) for the field measurement of biodiversity indicators (values in €) and permanent vs. temporary work effort ratio.

| Biodiversity indicator | Transport costs (vehicle + displacement of fieldworkers, €) | Percentage of total costs (%) | Effective cost per sample (€) | Effective cost per ha (€) |
|---|---|---|---|---|
| Spiders | 369 | 34 | 8,3 | 13,3 |
| Earthworms | 618 | 28 | 31,4 | 28,1 |

Tab. 3 – Analysis of costs of the field measurement of biodiversity. Share of transportation and transfer of fieldworkers with respect to total costs (mean values per farm) and effective costs of fieldwork (effective costs are: total costs – transport and transfer of fieldworker costs).

The comparison of effective costs of biodiversity measurement between organic and conventional farms pointed out a consistent higher effort of field sampling for the organic farms (Tab. 4). Even if the mean number of samples was higher in the conventional farms (84 vs. 50), sampling effort in organic farms was 1,5 times higher concerning the cost per hectare and 2,4 times higher considering the days $person^{-1}$ $ha^{-1}$. This is probably related to a higher variability of habitats for the organic farms which required a more intense sampling than the conventional farms.

| | Samples | Effective cost $ha^{-1}$ | Effective days per person $ha^{-1}$ |
|---|---|---|---|
| Organic | 50 | 41,6 | 0,62 |
| Conventional | 84 | 27,5 | 0,26 |

Tab. 4 – Comparison of costs of field sampling in organic and conventional farms. Number of samples, effective cost $ha^{-1}$ and effective days $person^{-1}$ $ha^{-1}$ of effort required (mean values of Sp + EW sampling per farm, effective cost is: total cost – transport and transfer of fieldworker costs).

## 4 Conclusion

The first important result concerns the relevance of costs that were in the thousands of Euros per farm.

The *ex-post* assessment of costs of the field measurement of biodiversity is of significant importance both for the organisation of the sampling sessions as well as for the cost-effectiveness analysis. The cost assessment could be a valid tool for the optimisation of the use of available resources. This evidence is of great importance considering the gap between the need and the availability of funds for biodiversity. It is our opinion that the increased availability of cost data could be of great assistance in the advancement of the effectiveness of biodiversity assessments.

The share of transportation costs (vehicle and transfer time of staff) suggests that a careful organisation of fieldwork should be considered essential for the optimisation of available resources.

Our preliminary analysis clearly identified lower costs, coupled with a higher number of samples (thanks to the vacuum tool), for the spider indicator. However, this information is incomplete without an assessment of the effectiveness of the measurement. Moreover, the cost of SP will be much higher considering the other two survey sessions which are scheduled in the BioBio project protocol.

### Acknowledgement

This work was supported by a grant from EU-FP7, BioBio - Indicators for biodiversity in organic and low-input farming systems. The authors wish to thank J.P. Sarthou, J.P. Choisis, C. Pelosi and S. Ledoux for their cost data gathering.

## References

[1] OECD, “OECD Expert Meeting on Agri-biodiversity Indicators”, Zurich, 5-8 November 2001, http://www.oecd.org/dataoecd/16/56/40339943.pdf, 2010.

[2] T. B. Gardner, J. Barlow, I. S. Araujo, T. C. Avila-Pires, A.B. Bonaldo, J. E. Costa, M. C. Esposito, L. V. Ferreira, J. Hawes, M. I. M. Hernandez, M. S. Hoogmoed, R. N. Leite, N. F. Lo-Man-Hung, J. R. Malcolm, M. B. Martinus, L. A. M. Mestre, R. Miranda-Santos, W. L. Overal, L. Parry, S. L. Peters, M. A. Ribeiro-Junior, M. N. F. Da Silva, C. Da Silva Motta and C. A. Peres, “The Cost-Effectiveness of Biodiversity Surveys in Tropical Forests”, *Ecology Letters,* vol. 11, pp. 139-150, 2008.

[3] P. J. Ferraro and S. K. Pattanayak, “Money for Nothing? A Call for Empirical Evaluation of Biodiversity Conservation Investments“ *Plos Biology,* vol. 4, pp. 482-488, April 2006, http://

www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.0040105, 2010.

[4] B. S. Halpern, C. R. Pyke, H. E. Fox, J. C. Haney, M. A. Schlaepfer and P. Zaradic, “Gaps and Mismatches Between Global Conservation Priorities and Spending” *Conservation Biology,* vol. 134, pp. 96-105, 2007.

[5] A. Juutinen and M. Mönkkönen, “Testing Alternative Indicators for Biodiversity Conservation in Old-Growth Boreal Forests: Ecology and Economics”, *Ecological Economics* vol. 50, pp. 35-48, 2004.

[6] A. Qi, J. N. Perry, J. D. Pidgeon, L. A. Haylock and D. R. Brooks, “Cost-efficacy in Measuring Farmland Biodiversity – Lessons from the Farm Scale Evaluations of Genetically Modified Herbicide-tolerant Crops“ *Annals of Applied Biology,* vol. 152, pp. 93-101, 2008.

[7] R. Jongman and R. G. H. Bunce, *Farmland Features in the European Union. A Description and Pilot Inventory of their Distribution*, Alterra report 1936, ALTERRA, Wageningen UR, 2009.

[8] M. H. Schmidt-Entling and J. Dobeli, “Sown wildflower areas to enhance spiders in arable fields”, *Agriculture Ecosystems & Environment,* vol. 133, pp.19-22, 2009.

[9] M. H. Schmidt and D. T. Tscharntke, “The Role of Perennial Habitats for Central European Farmland Spiders” *Agriculture Ecosystems & Environment,* vol. 105, pp. 235-242, 2005.

[10] E. R. Zaborski, “Allyl isothiocyanate: an alternative chemical expellant for sampling earthworms”, *Applied Soil Ecology,* vol. 22, pp. 87-95, 2003.

[11] C. Pelosi, M. Bertrand, Y. Capowiez, H. Boizard and J. Roger-Estrade, “Earthworm collection from agricultural fields: Comparisons of selected expellants in presence/absence of hand-sorting”, *European Journal of Soil Biology,* vol. 45, pp. 176-183, 2009.