Experts' perception of potential ecosystem services from agroforestry and other agro-ecological alternatives

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EXPERTS' PERCEPTION OF POTENTIAL ECOSYSTEM SERVICES FROM AGROFORESTRY AND OTHER AGRO-ECOLOGICAL ALTERNATIVES

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Introduction

Although arable landscapes are positively valued by the society, intensified cropping and livestock systems continue to predominate in western EU rural territories. The increase of farm size, conversion/loss of non-crop features and simplification of crop rotations should maintain the trend toward a reduction in landscape diversity associated to an impoverishment of plant and animal communities, a soil and water quality loss due to pollutants transfer, an increase of greenhouse gases and potentially a reduction of the agro-ecosystem's capacity for carbon sequestration (Stoate et al., 2001).

To overcome these issues, in 2012 France decided to set up a strategic programme for the generalisation of "agro-ecology". All farms are proposed to reach economic, social and environmental performances all in one (MAAF, 2016). Innovative cropping/livestock systems are thus expected and special attention is granted to agroforestry which is more than ever widely considered, being even sometimes proposed as the unique solution enable to limit most of the externalities from intensified agriculture.

However, the ecosystem services from agroforestry are not well known. When some are studied, the use of references produced is limited to the sole cropping system, region and tree species of the study area. That is why the appropriation of agroforestry usually remains theoretical (practical use being possible but not without precautions and risks). References on the potential advantages and limits of agroforestry are very frequently expected and questioned within rural territories, by farmers or students. This is particularly the case of water operators which have the duties and the financial capacities to propose to farmers the improvement of the ecological status of their agricultural fields in order to locally contribute to the protection and/or the recovering of the water quality. Very often,

[1] a range of agro-ecological infrastructures such as agricultural parcel (re)forestation (APF), peripheral hedge (PHD), living slope fascine (LSF), mechanical slope fascine (MSF), Grass-covering conversion (GCC), intercalated agroforestry (AGF), short rotation coppice (SRC), in-parcel grass strip (GST), in-parcel slope or ditch (SLO), pond (PON) and

[2] a range of agri-technical alternatives such as no-tillage technics (NOT), direct (undercover) seeding (DIS) or even tillage direction change (TDC)

are proposed to farmers to compensate/replace their intensified practices. But alternatives' adoption remains limited because farmers ignore or are skeptical of such alternatives and the local farm advisory services often lack expertise.

The PREVALTERA project conduced in the Nord - Pas-de-Calais region (Grandgirard *et al*., 2011) aimed to fill the needs of knowledge and expertise. Experts' perception and knowledge about the potential ecosystem services from agro-ecological and agro-technical alternatives have been surveyed and analysed. Objectives are three: (i) to identify the main ecosystem services to be related to the alternatives assessed, (ii) to propose a first cross-ranking of these alternatives and (iii) to identify and rank the ecosystem potentials of the two main agroforestry types questioned in France which are PHD and AGF.

Material

The clarification of experts' perception was undertaken according to IMBE (2015). Experts' panel has been constituted in regards to their technical/scientific specialty and to their local and historical experience of agro-ecosystems functioning. Forty experts were initially contacted and replied to the questionnaire testing their knowledge and expertise. At the end, 23 were selected as being experts. Seven different experts' categories were retained: forestry and wood sector (n=3), agronomy (n=4), agroforestry (n=4), water (n=3), biodiversity (n=3), researchers in agroecology (n=3) and soil (n= 3). Among them, 9 (≈40%) were national experts when 14 (≈60%) were local experts.

The list of the 13 agro-ecological alternatives listed in introduction was then co-decided with the local experts, and the PREVALTERA partners. They mainly deal with farmers and water operators' solutions.
A list of 15 ecosystem services was co-decided by the project partners and the 23 retained experts; it meets the Common International Classification of Ecosystem Services (Haines-Young and Potschin, 2014):
- Provisioning services: Ramial chipped wood production (RCW), Industrial timber production (ITP)
- Regulating services: Erosion limitation (ERO), Nitrate/Pesticide remediation (NPR), Water runoff depth limitation (WRD), Windbreaking (WIB), Carbon sequestration (CSQ), Soil organic content increase (SOC), Soil Water Reserve exhaustion (SWR), Crop nutrients competition (CNP)
- Supporting services: Near-landscape structure diversification (LSD), near-landscape ecological connectivity amelioration (LEC), Crops pests hosting (CPH), Weeds dissemination (WED)
- Cultural services: Negative visual amenity (NVA).

The survey package consisted of (i) a visual presentation describing structurally/physically (but not functionally) each one of the alternatives and (ii) a questionnaire combined with the user guide. To avoid possible effects of the order to which "alternatives*ecosystem services" combination was assessed, 3 differently questionnaires were used and randomly sent to experts. Experts used a 7 (from 5 to -1) point scale to evaluate each potential "alternatives*ecosystem services" combination.
To identify consensual perception of agro-ecologial alternatives, Generalized Procrustes Analysis (GPA) was conducted. It was preferred since it solves problems typically encountered with preference analysis such as variation among panelists and allows for optimal comparability to obtain consensual judgment. Survey provided 23 configurations of the 13 alternatives* 15 ecosystem services combination. Mean and median values for each combination were used respectively to rank alternatives and identify their potential class of effectiveness.

Results
In order to avoid indirect learning and biased judgment from experts, no training period was carried out before sharing the questionnaire. Consequently, variation observed among experts was high: the highest residue was obtained for LSF (186.8), the lowest for GCC (67.8) and a residue of 143.4 for AGF (result not shown). Concerning experts, residues were between 90.6 and 38.9 but neither experts' categories nor experts' local and historical contextual experience had effect on judgment (result not shown). In addition to this analysis, test of Rc consensus indicated that the consensual configuration represents 74.1% of the original variance and that it is not acquired by chance, authorizing interpretation of the consensual configuration.

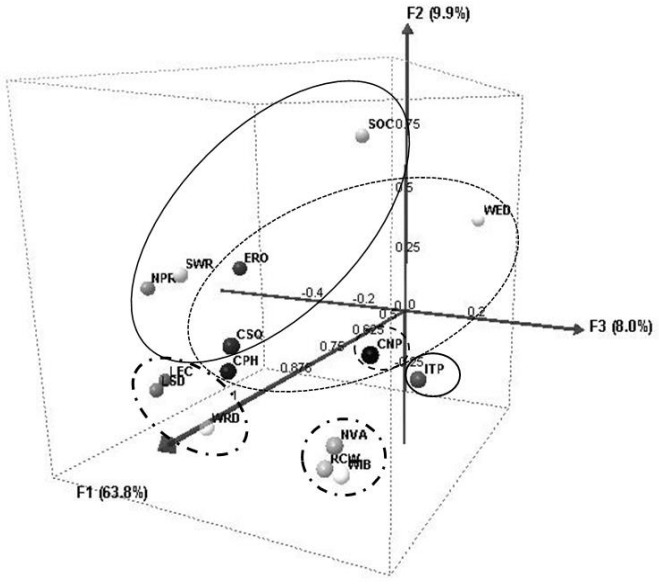

Figure 1: ecosystem services projection according to the first 3 principal components of the GPA scatter

From the consensual configuration, the first 3 principal components of the GPA explained 81.7% of the variability, with 68.8% explained by the sole first axis (Figure 1). A following Hierarching Ascending Classification allowed for grouping the ecosystem services into 6 different clusters respectively related to (a) **soil** functioning (CSQ, SOC, SWR, NPR), (b) **pest** risks (WED, CPH), (c) ecological **connectivity** (LEC, LSD), (d) **shade** impacts (WIB, NVA), (e) system **productivity** (ITP) and (f) **crop yield** interaction (CNP). By using the same methodology, the alternatives were grouped into 3 different clusters (Figure 2): Cluster A for alternatives with complete or partial surface **conversion** of the parcel (APF, SRC, GCC), Cluster B for peripheral and/or internal **linear** alternatives such as PHD, LSF, SLO and AGF, cluster C for **agri-technical** solutions (DIS, TDC, NOT) and non-living alternatives (PON, MSF).

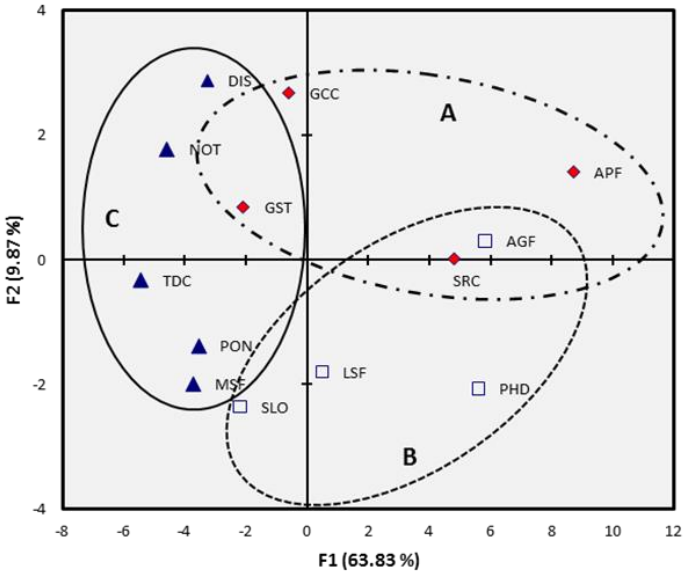

Figure 2: The 3 alternatives clusters distribution resulting from the GPA consensual configuration

The Table 1 shows that ranking and level of effectiveness of each alternative*ecosystem service combination seems to not correspond fully to the alternatives tested. For weed dissemination (WED), Crop pests hosting (CPH) and Crop nutrient competition (CNP), the level of effectiveness does not exceed 3/5, while it reaches 5/5 for all other services. Both agroforestry types considered (intercalated AGF and peripheral PHD) present a relatively good level of effectiveness and as element of the "linear alternative B cluster", they just tailgate the three alternatives considered consensually as the best alternatives for addressing water quality problems: APF, SRC and GCC.

Table 1- Ranking of the 13 agro-ecological alternatives for each ecosystem service retained

		Alternatives' ranking												
		From the higher potential						*to*						*the worst potential*
GPA dimensions i.e. ecosystemic services		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Erosion limitation	**(ERO)**	APF	GCC	SRC	PHD	LSF	AGF	DIS	GST	MSF	SLO	NOT	TDC	PON
Soil Organic Content increase	**(SOC)**	APF	GCC	AGF	DIS	SRC	PHD	NOT	GST	LSF	SLO	MSF	TDC	PON
Near-landscape structure diversification	**(LSD)**	APF	PHD	AGF	SRC	GCC	GST	SLO	LSF	PON	MSF	DIS	NOT	TDC
Near-landscape ecological connectivity	**(LEC)**	PHD	APF	AGF	GCC	GST	SRC	LSF	PON	SLO	MSF	DIS	NOT	TDC
Negative visual amenity	**(NVA)**	APF	AGF	SRC	PHD	LSF	SLO	MSF	GCC	PON	GST	DIS	TDC	~~NOT~~
Nitrate/Pesticide remediation	**(NPR)**	APF	SRC	GCC	AGF	PHD	GST	LSF	PON	DIS	SLO	NOT	MSF	TDC
Soil Water Reserve exhaustion	**(SWR)**	APF	SRC	AGF	PHD	GCC	GST	LSF	PON	DIS	SLO	NOT	TDC	MSF
Water runoff depth limitation	**(WRD)**	APF	PHD	SRC	SRC	LSF	AGF	SLO	MSF	GST	PON	DIS	NOT	TDC
Crop pests hosting	**(CPH)**	APF	SRC	PHD	AGF	LSF	SLO	GST	GCC	DIS	NOT	PON	MSF	TDC
Weeds dissemination	**(WED)**	NOT	DIS	GST	AGF	APF	PHD	SRC	LSF	SLO	GCC	TDC	PON	MSF
Crop nutrients competition	**(CNP)**	AGF	APF	SRC	PHD	LSF	DIS	GST	GCC	NOT	SLO	MSF	TDC	PON
Windbreaking	**(WIB)**	PHD	APF	AGF	SRC	LSF	SLO	MSF	DIS	GCC	PON	NOT	TDC	GST
Ramial chipped wood production	**(RCW)**	APF	PHD	SRC	AGF	LSF	SLO	MSF	GCC	TDC	NOT	GST	PON	DIS
Carbon sequestration	**(CSQ)**	APF	AGF	SRC	PHD	GCC	LSF	GST	SLO	DIS	NOT	MSF	PON	TDC
Industrial timber production	**(ITP)**	APF	AGF	PHD	SLO	LSF	SRC	GCC	MSF	GST	DIS	NOT	~~TDC~~	~~PON~~
Cells' colour significations	*xxx*	*=5*	*xxx*	***=4***	*xxx*	*=3*	*xxx*	*=2*	*xxx*	*=1*	*xxx*	*=0*	~~*xxx*~~	*<0*

Discussion

These results confirmed the potential interests of agroforestry for most of the ecosystem challenges to be addressed. Firstly, it was pointed out that agroforestry is perceived as an intermediary alternative for partial agricultural parcel improvement but not for its conversion and land use change. Secondly, it was showed that despite the loss of production, alternatives advocating agricultural parcel conversion are perceived as the best alternatives for addressing water quality problems. Thirdly, results indicated that experts are (unconsciously) reducing alternatives to a limited number of dimensions to be assessed which are questions that R&D should tackle to ease agro-ecological alternatives and agroforestry adoption. They are also expertise currently lacking in advisory boards and could have to be developed within dedicated training cursus. Finally, high residues initially observed from experts and alternatives configurations suggested that current knowledge regarding agroforestry services remains insufficient. Consequently, these results participated to a first round and are asking for complementary studies.

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