Environmental Management (2008) 42:603–619
DOI 10.1007/s00267-008-9176-5

RESEARCH

Managing Abandoned Farmland: The Need to Link Biological and Sociological Aspects

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Received: 18 July 2006 / Accepted: 31 May 2008 / Published online: 4 July 2008

Abstract The lack of a particular use associated with abandoned farmland provides real opportunities with respect to the various land-use pressures occurring in productive territories. These environments remain generally poorly known and, because of this, require in-depth studies on the feasibility of management options, on biological as well as social grounds. This study, based on research on the biophysical potential and the perceptions by the owners of abandoned farmlands, analyzes the feasibility of silvicultural management options to improve forestry potential. Using a questionnaire, we surveyed abandoned farmland owners on different aspects of the status of their abandoned farmland in order to determine their willingness toward the management of these private lands. The land owners were also asked to express their interests and their constraints toward various types of interventions, with an emphasis on silvicultural work. The data were analyzed using multivariate methods to establish relationships between the questionnaire data and the characteristics of the land owners (socioeconomic profile and value system toward the environment). The results show that, in general, abandoned farmland is an unwanted space, is generally little used, is poorly known, and has little importance in the plans of its owners. We have found three types of owner profiles; the owners with a farmer's profile are those who are the most interested in managing their abandoned farmland, whether for agriculture or silviculture. The desire to improve abandoned farmland seems less important to owners with an ecocentric profile (high awareness of the environment) and to older owners. Finally, by associating the type of abandoned farmland owned and the characteristics of the owners, it is possible to propose different management options that reconcile the wishes of the owners as well as the biophysical potential of their abandoned farmland.

Keywords Abandoned farmland · Land owners · Management · Perception · Reforestation · Multivariate analysis

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The restructuring of agriculture in North America and Europe has caused agricultural activities to be concentrated on the most productive lands, or at the very least the most amenable to mechanized work, and the abandonment of lands less amenable to these new exploitation methods (Derioz 1994; Houerou 1993; Lasanta and others 2006; MacDonald and others 2000; Tatoni and Roche 1994).

Once a reflection of the damages of epidemics or the result of war (Rouay-Hendrickx 1991), abandoned farmland nowadays reflects profound changes in society (Liou 1991; Poyatos and others 2003; Roura-Pascual and others 2005). In Europe, several warning signs have made abandoned farmland a topic of interest, which has led to a large number of studies on sociological, economic, biological, or ecological aspects of the newly created landscape (Cavailhes and Normandin 1993; CERAMAC 2000;

Dérioz 1991; Laurent 1992). In North America, research was mostly oriented toward the ecological processes involved in the succession of abandoned farmland to forests (de Steven 1991; Li and Wilson 1998; Stover and Marks 1998). Very few North American studies have dealt with the potential use and the improvement of these lands in terms of ecological aspects as well as social aspects. However, abandoned farmlands in productive agricultural areas, such as southern Quebec, are facing strong land-use pressures for residential, commercial, and agricultural uses. These abandoned lands could also serve in the reconstruction and the improvement of private forests, which are generally degraded (Cogliastro and others 1997, 2006). Because of these pressures, landscape planners have become interested in these lands and have tried to define their future use.

It is generally agreed that abandoned farmlands are halfway between agricultural use (tillable land or wine production) and silvicultural use (Charles 1979). For regions such as southern Quebec, management of abandoned farmland should prioritize reforestation or silvicultural treatments. Several reasons support this option. Only 27.3% of this region is forested, and between 1999 and 2002, 3.4% of the forest in this Municipalité régionale de comté was cleared (Soucy-Gonthier and others 2003). Located in the south, in the most productive part of the province, the private forests contain almost all of the large remaining areas of hardwood forests. These forests are young, the tolerant hardwood stands (thus the oldest) are generally degraded, their productivity is low because of management deficiencies, and a low quantity of high-quality stems is observed as a result of past selective harvests (Agence forestière de la Montérégie 2001). It is mainly on plantations that most of the stakeholders involved in the management of abandoned farmlands are focused (Ministère des Ressources naturelles 1996). Afforestation of an intensive agricultural area is also supported by the growing concern of society toward the natural environment (Kassioumis and others 2004) and the fact that agriculture can no longer support the functioning of rural areas. These are indications that new objectives for rural activities will induce some changes in agricultural landscapes (Kristensen and others 2001).

With the objective of improving the quality of private forests located in an intensive agricultural area, questions were asked to determine if these abandoned farmlands could really be used. This objective was supported by a study commission on the management of public forests that recommended that silviculture be promoted on private land, which would thus improve areas of abandoned farmland (Commission d'étude sur la gestion de la forêt publique québécoise 2004). In order to achieve this, the current study proposes an approach capable of taking into account both the social and the ecological aspects of the study subject. The combination of these two aspects, as put forward in landscape ecology (Naveh and Lieberman 1994), allows for the description of an overall portrait of the situation. This study used the behavioral approach, as described by Burton (2004), because we "seek to understand the behavior of individual decision makers," "focus on psychological constructs such as attitudes and values," and use "quantitative methodologies" to analyze our results.

Our Research Objectives Were as Follows

1. Previous research has shown that some abandoned farmland are suitable for silvicultural purposes (Benjamin and others 2007), but are these lands considered available for such use by their owners?
2. If so, can we predict, based on socioeconomic profile and values, the willingness of the owners to allow silvicultural management on their abandoned farmland? Which variables could be the best predictors?
3. Furthermore, based on ecological and sociological data, can we identify the most promising management options that take into account the biological potential of abandoned farmland as well as the wishes of their owners?

Study Area

The study was carried out in the Municipalité régionale de comté (MRC) du Haut-Saint-Laurent, located in the southwest of the province of Quebec (Canada), bounded to the south by the state of New York (United States), and bounded to the north by the St. Lawrence River (Fig. 1). The region is characterized by a number of growing degree-days (the annual sum of positive differences between the mean daily temperature and the base temperature of 5°C) of 2136 (Environnement Canada 2003) and is located in the most productive agricultural zone of Quebec. The geology consists mainly of the Beekmantown Group and of the Potsdam Group (Globensky 1987). Surface deposits are mainly of marine, glacial, littoral, and late-glacial origin (Bariteau 1988). The study area is located in the sugar maple-hickory climax vegetation domain, where mature forests on mesic sites are dominated by *Acer saccharum* Marsh. (sugar maple) accompanied by *Carya cordiformis* Wangenh. (bitternut hickory), *Ostrya virginiana* (Mill.) K. Koch (ironwood), *Tilia americana* L. (basswood), *Fagus grandifolia* Ehrh. (American beech), and *Tsuga canadensis* L. (eastern hemlock) (Bouchard and Brisson 1996). The main anthropic and biophysical factors influencing this landscape are well known since this area has been studied by a multidisciplinary team over the last 25 years (Domon and Bouchard 2007).

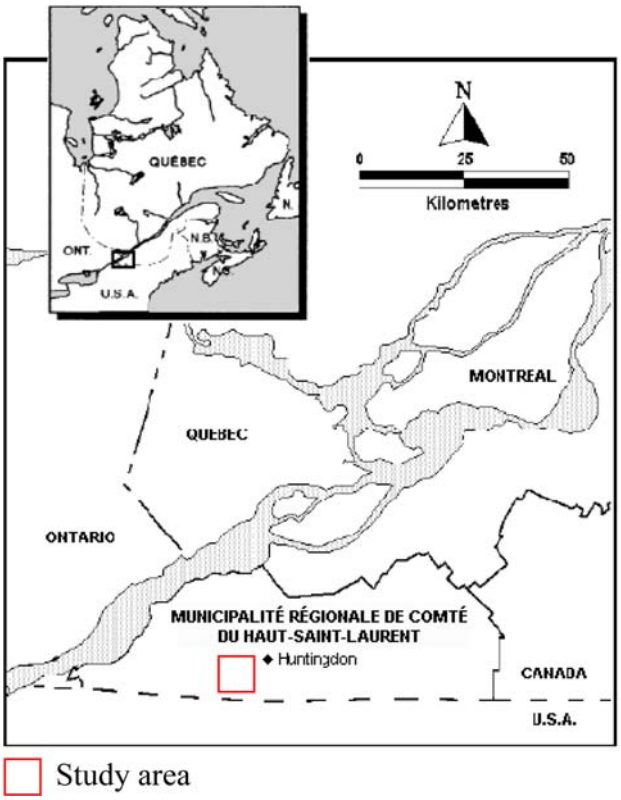

Fig. 1 Study area

The study area occupies 121 km^2 to the west of the city of Huntingdon (Fig. 1) and its exact boundaries correspond to that of an Ikonos satellite image taken in August 2000. The targeted area is composed of two major land-use matrices—one agricultural, the other forested—both intertwined and represented in approximately equal proportions. The major land uses are corn fields (intensive agriculture) and woodlots, with some pastures and hay fields (extensive agriculture), plantations, and abandoned farmland (herb-dominated and shrub-dominated). Based on biological, historical, and spatial dynamics, a previous study (Benjamin and others 2005) of this abandoned farmland revealed two ecological groups. The first group (Type 1) is composed of old pastures on sloping, well-drained, stony soils, abandoned for over 20 years and currently dominated by tall shrub vegetation. These abandoned farmlands have the highest species richness and the most important hardwood regeneration (seedling and saplings). Conversely, the second group (Type 2), composed of 17 of the 36 abandoned farmlands we studied, consists of a herbaceous environment (Type 2b), sometimes with low shrubs (Type 2a), on poorly drained soils, abandoned more recently and with a past agricultural use mostly of cultivation.

We know that abandoned farmlands, herb- or shrub-dominated, are set apart from other land uses because they are assigned, as for intensive agriculture (corn fields), essentially negative perceptions (Benjamin and others 2007). The perception of abandoned farmland at the scale of the property is also negative, because the abandoned parts are often mentioned as the area with the least value (as opposed to corn fields) and the one that is the least appreciated (as opposed to forests).

Methods

Interviews

The research project started in 2000 by analyzing biological, historical, and spatial dynamics of 36 abandoned farmlands. In 2001, we met 33 of the 36 owners whose abandoned farmland had been selected for analysis. The selection of abandoned farmlands had been designed to cover the widest range of context and vegetation composition. Table 1 shows the range of diversity in the owners based on their socioeconomic status variables and on their values indicators. The interviews had three parts: (A) the socioeconomic profile and values of the owner, (B) the perception of abandoned farmland at the landscape and property levels, and (C) management and attitude toward abandoned farmlands. While the first two points were studied previously (Benjamin and others 2007), the current study combines results from the first and third parts of the interviews, and includes findings from the first (Benjamin and others 2005) and second (Benjamin and others 2007) studies conducted, in order to reach our final objective: improving the management of abandoned farmlands.

Socioeconomic Profile and Values

In order to define the types of individuals interviewed, the usual variables such as age, education level, number of children, language spoken, and employment sector were recorded. The primary employment sector is related to the primary transformation of natural resources (i.e., farmers). The secondary sector is related to the transformation of primary goods (i.e., labourers). The tertiary sector is defined as work in the field of services (i.e., school principal). Retired people were in the pensioner category. Being a farmer can influence one's perception of a mixed agricultural and forested landscape (Brush and others 2000; Tahvanainen and others 2002). Therefore variables related to the total area owned and to the value of the land and of the buildings were collected using property registration lists available at the MRC offices. Membership in the Union des Producteurs Agricoles (UPA), the agricultural union to which almost all Quebec farmers belong, was also recorded. Data on the abandoned farmland itself, such as its status (herb-dominated or shrub-dominated) and the time since acquisition

Table 1 Socioeconomic profile and values indicators of the owners

Origin of owner		Age	
Neorural	8	30–40 yr	4
Rural	25	40–50 yr	12
Occupation sector		50–60 yr	9
Primary sector (farming)	13	60–70 yr	3
Secondary sector (laborer)	8	70–80 yr	3
Tertiary sector	6	>80 yr	2
Retirees and pensioners	6	Time since acquisition of abandoned farmland	
Education level		<10 yr	9
Primary	6	10–19 yr	12
Secondary–college	23	20–29 yr	6
University	4	30–39 yr	3
Children		>50 yr	3
0	6	Area owned	
1	1	<100 acres	9
2	11	100–200 acres	10
3	9	200–300 acres	2
4	4	300–400 acres	5
5	1	400–500 acres	3
≥6	1	500–600 acres	3
Language spoken		700–800 acres	1
French	23	Value of land	
English	10	$0–$25,000	4
Stage of abandoned farmland		$25,001–$50,000	11
Shrub dominated	23	$50,001–$75,000	3
Herbaceous	10	$75,001–$100,000	3
Type of property		$100,001–$200,000	3
Farming	21	$200,001–$300,000	3
Nonfarming	7	$300,001–$500,000	4
Decline	5	≥$500,001	2
Mean value[a]		Value of buildings	
Ecocentric	78.5%	$0–$25,000	1
Anthropocentric	73.75%	$25,001–$50,000	10
Apathetic	33.75%	$50,001–$75,000	8
Member of UPA		$75,001–$100,000	2
No	17	$100,001–$200,000	6
Yes	16	$200,001–$300,000	3
		$300,001–$500,000	3

Note: The quantitative variables are presented here in a semiquantitative manner (in classes) for ease of data presentation; these variables were, however, used in their quantitative form in the analyses

[a] These data are not a sample size but the mean of the 33 owners

were also considered. Research recently conducted in similar areas (Paquette and Domon 2003; Roy and others 2005) strongly suggests that a sociodemographic recomposition is now occurring in these areas, making the usual variables (age, education level) inadequate to capture the perceptions of the territory. Three types of complementary variables were thus taken into account in this study. (i) First was the origin of the owner: when an owner mentioned having spent most of his life in an urban environment he was attributed the status of neorural; conversely, if he spent most of his life in the country, we considered him to be of rural origin. (ii) Second, the "domestic landscape trajectories" (Paquette and Domon 2003), or the major patterns in the evolution of the close spatial surroundings of an individual, can contribute in revealing the convictions or values of this individual. Three of the four types of domestic landscape trajectories were encountered during this study: *farming* describes a lifestyle that includes farm buildings in good repair, *decline* is

Table 2 Statements used to define the attitude toward the environment according to three subscales

Statement	Subscale
I enjoy spending time in natural settings just for the sake of being out in nature.	Ecocentrism
It seems to me that most conservationists are pessimistic and somewhat paranoid.	Environmental apathy
One of the most important reasons to keep rivers and lakes clean is so that people can have a place to relax and to practice some hobbies.	Anthropocentrism
Efforts and money invested in conservation programs are exaggerated.	Environmental apathy
The worst consequence of agricultural modernization is the loss of wetlands.	Ecocentrism
A woodlot has to be managed.	Anthropocentrism
Nature is important because of what it can contribute to the pleasure and welfare of humans.	Anthropocentrism
One of the most important reasons for conservation is to preserve natural areas.	Ecocentrism
The landscapes that I prefer are wild and unmanaged.	Ecocentrism
We have to conserve woodlots in order to ensure a sufficent supply of wood for the next generation.	Anthropocentrism

associated with a property on which buildings are neglected, and *nonfarming* includes a house in good repair that has no link with an agricultural use. (iii) Last was the attitude of owners toward the environment. Kaltenborn and Bjerke (2002) have shown that subtleties can be detected in the general trends in perception of the rural territory when the attitudes of people toward their environment are taken into account. To explore the explanatory potential of the ecocentric, anthropocentric, and apathetic values (Thompson and Barton 1994), we used a subsample of 10 statements (Table 2), inspired by the work of Kaltenborn and Bjerke (2002), showing the same proportion of statements among the three subscales (ecocentric, anthropocentric, and apathetic). The choice of using a subsample is based on the reliability of these subscales, described in previous studies (Bjerke and Kaltenborn 1999; Kaltenborn and Bjerke 2002), during a presurvey done to identify statements adapted to our regional reality, and the necessity of maintaining the attention and concentration of the interviewed owners in order to increase the response rate. The ecocentric attitude is to appreciate nature for its own sake, the anthropocentric attitude is to appreciate nature because it maintains or enhances human quality of life, and the apathetic attitude is indifference toward the environment (Thompson and Barton 1994). This form of description of the owner is used successfully in environmental psychology in order to better describe the perceptions of people or their reactions toward the environment (Casey and Scott 2006; Kortenkamp and Moore 2001; Schultz and Zelezny 1999). All of the criteria used for describing the owners are presented in Table 1. A table with correlations among these variables is included in order to show the links that exist among them (Table 3).

Management and Attitude Toward Abandoned Farmland

The third part of the interview, management and attitude toward abandoned farmland, was divided into four sections: acquisition process, management efforts, management options, and perception of silviculture. Questions related to the first section defined the context of abandoned farmland acquisition and transmission. We asked owners about the status of current abandoned farmland when it was bought. Those who bought their abandoned farmland when it was already abandoned were asked why they purchased it. Then we asked how the abandoned farmland was acquired, the relationship to the previous owner, and the eventual mode of transmission.

The second section, management efforts toward abandoned farmlands, seeks to determine the willingness and the open-mindedness of each of the owners to land-use changes in abandoned farmland. We questioned the owners about the plans they might have for their property in order to determine, indirectly, what status their abandoned farmland had within it. Owners indicated how they perceived the current status of their abandoned farmland: Are they definitely abandoned, maintained, or in waiting for an agricultural or nonagricultural use? These questions allowed us to know whether there is, in the minds of the owners, a possibility of redefining the use of these abandoned farmlands. The reasons for the nonuse of these abandoned farmlands were also recorded in order to determine what kinds of obstacles the owners faced in their development. The use that owners make of their abandoned farmland and the knowledge of the vegetation that they have were also discussed in order to determine the breadth and the type of relationship between owners and their abandoned farmlands. We then wanted to know what interventions the owners had made on their abandoned farmland during the last 5 years, to determine whether the owners had tried to improve their abandoned farmland.

In the third section of the interview, management options for abandoned farmland, owners were asked to comment on different possible types of management, the most plausible for the region. Because afforestation is valued in some

regions (Backlund and others 2004; Behan and others 2006) but raises negative perceptions in more forested areas (Barrué-Pastor and Fournié 1996; Höchtl and others 2005; Karjalainen and Komulainen 1998; Tahvanainen and others 2002), we first sought to determine whether or not owners agreed with the option to use abandoned farmlands for reforestation. We also asked them if they agreed with promotion of the maintenance of abandoned farmland in the landscape. Owners were then asked about their interest in nine possible management options, ranging from return to agriculture to breeding of nontraditional cattle. Then we wanted to know how well the owners knew the structures facilitating reforestation. We asked them if they knew of the Agence forestière de la Montérégie, a nongovernmental organization in charge of managing the funds allocated by the government in support of private forest management. We asked them if they were forest producers, a central condition for receiving grants for forest management, and if they had a forest management plan for their property. We also verified if they were eligible to become forest producers, by owning a woodlot of at least 4 ha in a single piece. This emphasis was influenced by the context under which this region is evolving, which is a sustained demand for quality timber (Cogliastro and others 2001; Commission d'étude sur la gestion de la forêt publique québécoise 2004), the need to reconstruct the forestry potential (Bouchard and Domon 1997), and the climatic and strategic advantages of the region (labor force, road network, proximity to sawmills).

In the last section, perception of silvicultural management, questions about reforestation were asked directly, such as their interest in the five most common types of plantations in the region, the arguments that could encourage them to do some reforestation, or, on the contrary, the arguments that would discourage them from this project. Finally, we asked them from what sources they received their information on forests, in order to determine which ways would be the best for reaching these people.

Statistical Analysis

All data collected with this questionnaire were analyzed jointly with the owners' profiles using multivariate analyzes. This type of cross analysis allowed us to delve deeper into the collected data by illustrating how the socioeconomic profile and values can influence owners' answers. These multivariate analyses allowed us to identify groups of owners sharing the same ideas, thus improving our understanding of the case study. For all semiquantitative data (Table 4), we used redundancy analysis (RDA) in order to associate the answers obtained with the owners' socioeconomic variables and values; with qualitative data we used canonical correspondence analysis (CCA). A CCA was also performed between socioeconomic and values profile and the type of abandoned farmland owned. All of the analyses (CCA and RDA) were done with the Canoco program (ter Braak and Smilauer 2002).

In order to homogenize the data set, and avoid a variable having more importance in the analysis because it varied on a greater scale, the socioeconomic and values variables were all standardized on a scale of 1 to 100, except for the qualitative variables that were used as dummy variables. All of the answers that numbered <3 were removed to reduce noise in the analysis. Also, in cases where an answer was the same for a majority of owners (30 or more of 33), there was no interest in trying to assess relationships between socioeconomic and values variables and this general perception; these answers were therefore removed from the analysis. Moreover, when a trend in the answers was quite obvious, the analysis was done but not shown. Finally, in the case of the use of abandoned farmland, of the reasons for its nonuse, and of the sources of information concerning forests, more than one answer could be recorded for a single owner.

The graphs of the RDA and CCA analyses (Figs. 2–6) show the significant explanatory variables (socioeconomic and values; boldface black type) at $p \leq 0.100$ and the response variables (black italic type). To these, supplementary variables are added (gray italic type) which are the complement of explanatory variables determined to be statistically significant. For example, if working in the primary sector is significant, the three other employment sectors will appear as supplementary variables. These variables, although shown in the figures, have a p-value that is too high to be considered significant and they were not included in the calculations of the analysis shown; they are only illustrated in the graph. The significance level of this model is tested for the first canonical axis, as well as for all the canonical axes. For all of the RDA and CCA graphs, the vectors representing the explanatory variables, the response variables, and the supplementary variables can be extended in the opposite direction for the same length in order to show the opposite response or trend (i.e., old owners versus young owners). For the sake of clarity, only the increasing direction of socioeconomic and values variables is illustrated in the graphs. The owners are represented by dots. In some graphs there are not 33 dots for owners, because some answers were omitted or because the dots for several owners overlap; the different shades of gray of the dots indicate the number of owners represented by each dot. The dummy variables, or qualitative variables (i.e., neorural and rural; primary, secondary, or tertiary sector; pensioners; etc.), are represented in the graphs at the centroid of the position of the owners showing this trait. In the case of binary variables, the opposite criterion (i.e., rural or neorural, shrub-dominated or herb-dominated) was inserted in the graphs at the corresponding centroid; the centroids, contrary to the vectors, are not located exactly opposite of each other in the graphs. Analysis of this type of result can sometimes be

Table 3 Correlations among the socioeconomic variables of the owners

	Age	Secondary–college	University	Primary	Children	French	Primary sector	Secondary sector	Tertiary sector	Pensioners	Area	Value of land
Age	1.0000											
Secondary–college	−0.4609*	1.0000										
University	−0.0022	−0.5632*	1.0000									
Primary	0.5510*	−0.7149*	−0.1751	1.0000								
Children	0.5810*	−0.3971*	−0.0026	0.4753*	1.0000							
French	−0.0678	−0.0043	0.0429	−0.0311	−0.0262	1.0000						
Primary sector	−0.0710	0.1268	0.0806	−0.2193	0.0379	−0.1431	1.0000					
Secondary sector	−0.2761	0.0653	−0.2101	0.1000	−0.2029	0.0653	−0.4561*	1.0000				
Tertiary sector	−0.2535	−0.0311	0.3064	−0.2222	−0.2243	−0.0311	−0.3801*	−0.2667	1.0000			
Pensioners	0.6502*	−0.2020	−0.1751	0.3889*	0.4017*	0.1399	−0.3801*	−0.2667	−0.2222	1.0000		
Area	−0.2551	0.1224	0.1103	−0.2392	0.0066	0.0812	0.7642*	−0.2337	−0.3169	−0.3915*	1.0000	
Value of land	−0.2044	0.1821	−0.0464	−0.1777	0.0709	0.1096	0.7257*	−0.2900	−0.2954	−0.3018	0.9285*	1.0000
Value of buildings	−0.2149	0.1581	0.0016	−0.1897	0.0571	0.1490	0.7259*	−0.3125	−0.2887	−0.2836	0.7884*	0.8253*
Total value	−0.2177	0.1805	−0.0291	−0.1904	0.0684	0.1303	0.7578*	−0.3119	−0.3058	−0.3078	0.9130*	0.9737*
UPA	−0.2183	0.1119	0.1970	−0.3001	−0.0353	−0.0200	0.8310*	−0.2658	−0.3001	−0.4573*	0.7425*	0.6491*
Shrub	0.3096	−0.1865	0.0657	0.1667	0.4117*	0.0933	−0.0877	0.1000	−0.1667	0.1667	0.1806	0.1498
Acquisition	0.8693*	−0.3783*	0.0082	0.4437*	0.6106*	−0.2172	0.0590	−0.3329	−0.2254	0.5205*	−0.0744	−0.0711
Neorural	−0.3455*	0.0653	0.2232	−0.2667	−0.3354	0.2191	−0.3114	−0.1550	0.4667*	0.1000	−0.3014	−0.2916
Farming	−0.0420	0.1431	0.1094	−0.2631	0.2528	−0.2617	0.3962*	−0.1228	−0.2631	−0.1023	0.5342*	0.4419*
Nonfarming	−0.2612	−0.0886	0.0066	0.1000	−0.3023	0.2191	−0.4561*	0.1750	0.4667*	−0.0833	−0.4426*	−0.3867*
Decline	0.3695*	−0.0892	−0.1569	0.2390	0.0168	0.0947	0.0052	−0.0418	−0.1992	0.2390	−0.1991	−0.1400
Ecocentric	0.1984	−0.0158	−0.0483	0.0598	0.0483	−0.0739	−0.1117	−0.1047	0.1636	0.0944	−0.3046	−0.1928
Anthropocentric	0.1449	−0.1147	−0.0631	0.1901	0.2170	−0.0161	0.0995	0.0308	−0.2563	0.0961	0.1584	0.0798
Apathetic	0.2265	−0.1897	−0.0792	0.2931	0.2992	−0.0639	0.4716*	−0.1881	−0.3067	−0.0818	0.4244*	0.3986*

Table 3 continued

	Value of buildings	Total value	UPA	Shrub	Acquisition	Neorural	Farming	Nonfarming	Decline	Ecocentric	Anthropocentric	Apathetic
Age												
Secondary–college												
University												
Primary												
Children												
French												
Primary sector												
Secondary sector												
Tertiary sector												
Pensioners												
Area												
Value of land												
Value of buildings	1.0000											
Total value	0.9323*	1.0000										
UPA	0.5717*	0.6465*	1.0000									
Shrub	0.1406	0.1527	−0.0857	1.0000								
Acquisition	−0.0389	−0.0612	−0.1097	0.2468	1.0000							
Neorural	−0.2798	−0.2997	−0.1243	−0.3500*	−0.4415*	1.0000						
Farming	0.3944*	0.4422*	0.5340*	0.2193	0.1661	−0.2675	1.0000					
Nonfarming	−0.2721	−0.3575*	−0.5488*	−0.2000	−0.3231	0.3400	−0.7016*	1.0000				
Decline	−0.2122	−0.1753	−0.0717	−0.0598	0.1598	−0.0418	−0.5241*	−0.2390	1.0000			
Ecocentric	−0.1503	−0.1841	−0.2864	0.0849	0.1078	−0.1670	−0.2706	0.1444	0.1962	1.0000		
Anthropocentric	0.1132	0.0968	0.1616	0.1538	0.2708	−0.2865	0.4013*	0.0096	−0.5584*	−0.3142	1.0000	
Apathetic	0.3520*	0.3974*	0.4874*	0.2045	0.2985	−0.3568*	0.1201	−0.2556	0.1417	0.0029	0.3337	1.0000

* $p < 0.05$

Table 4 Questions asked in the third part of the questionnaire, management and attitude toward abandoned farmland, and the type of answers (qualitative or semiquantitative)

Questions asked	Type of data
Acquisition process of abandoned farmland	
Status of abandoned farmland at time of purchase	Qualitative
Why was a piece of abandoned farmland purchased?	Qualitative
Type of acquisition	Qualitative
Relationship to previous owner	Qualitative
Who should be the next owner?	Qualitative
Management efforts toward abandoned farmland	
What are your projects for your property in the next 5 years?	Qualitative
Current status of this part of your property	Qualitative
For what reasons is this abandoned farmland unused?	Qualitative
What use do you make of your abandoned farmland?	Qualitative
What plants are growing on your abandoned farmland?	Qualitative
Change in the abandoned farmland during the last 5 years?	Qualitative
Management options for abandoned farmland	
Some managers believe that unused land should be reforested. Are you in favor or not?	Semiquantitative
We should try to maintain unused land in the landscape. Are you in favor or not?	Semiquantitative
Would you be interested in the following management practices for your abandoned farmland?	Semiquantitative
Favoring the growth of the young trees already there, let nature take its course, tree plantation, transform it into cultivable land, traditional cattle breeding, untraditional cattle breeding, untraditional culture, establishing trails for recreational purposes, interventions for favoring the fauna	
Do you have a forested area of at least 4 ha in a single block? (yes/no)	Qualitative
Did the Quebec government give you the status of forest producer? (yes/no)	Qualitative
Do you have a forest management plan certified by a forest engineer? (yes/no)	Qualitative
Do you know of the Agence Forestière de la Montérégie (yes/no)?	Qualitative
Perception of sylvicultural improvement	
Would you be interested in...	Semiquantitative
softwood, hardwood, hybrid hardwood (walnut, poplar), *a mix of softwood and hardwood, a mix of hybrid and hardwood*	
Would the following arguments incite you to reforest?	Semiquantitative
A rise in the price of wood, the availability of technical advice, the availability of financial advice, the availability of competent contractors, the assurance that fauna would be protected, the assurance that the landscape would be protected, the assurance that the environment would be protected, a better knowledge of forestry, availability of financial help, 85% land tax refund on reforested plots	
Would the following arguments stop you from reforesting?	Semiquantitative
Timber conflict, seeing profit from the forestry work only after 40 years, rectilinear aspect of a tree plantation, sensitivity of trees to disease, maintenance, soil physical constraints	
Sources of information on forests	Qualitative

Note: Semiquantitative data on a 5-point scale

complex, because it does not allow binary interpretations. For example, it is not because option A is the most popular with young owners of abandoned farmland that option B will be the most popular with older owners.

Multivariate analyses seek instead to show how a set of data is structured in relation to several explanatory variables, and they allow the representation of a complex reality from which trends can be identified.

Results

The Acquisition Process of Abandoned Farmland

At the time of purchase of the property, 25 of the 33 abandoned farmlands studied were already unused; the 8 others were cultivated lands that were abandoned after the purchase. Among these 25 owners, 24 said that they had

acquired the abandoned farmland because it was part of the property they wanted to buy. The acquisitions occurred entirely by purchase; none of the 33 owners interviewed had acquired his property through inheritance. We must, however, note that 14 of the 33 owners said that they bought their property from a family member, perhaps implying a preferential sale price. The owners who purchased from a family member are essentially people who own high-value buildings, people whose purchase dates back many years and who have a rural origin (Fig. 2); this profile corresponds with farmers long settled in the region. On the other hand, those owners who purchased from a stranger (18) are composed of neorurals and the most recent owners. The transmission of the property will be, for a majority of owners (23), to one of their children.

Management Efforts Toward Abandoned Farmlands

The answers show that the abandoned farmland does not figure prominently in the projects of the owners, since only 5 of the 12 owners who had plans of an agricultural nature mentioned these lands in their plans. However, when owners were asked what, according to them, is the status of their abandoned farmland, 15 said that it was awaiting future agricultural use, 10 said that it was abandoned permanently, and the other 8 were split between light maintenance and future nonagricultural use. As expected, multivariate analysis showed that large land owners and members of the UPA tended to answer that this land was awaiting agricultural use (Fig. 3). These results also show that permanently abandoned farmlands were not owned by UPA members or those with an ecocentric profile.

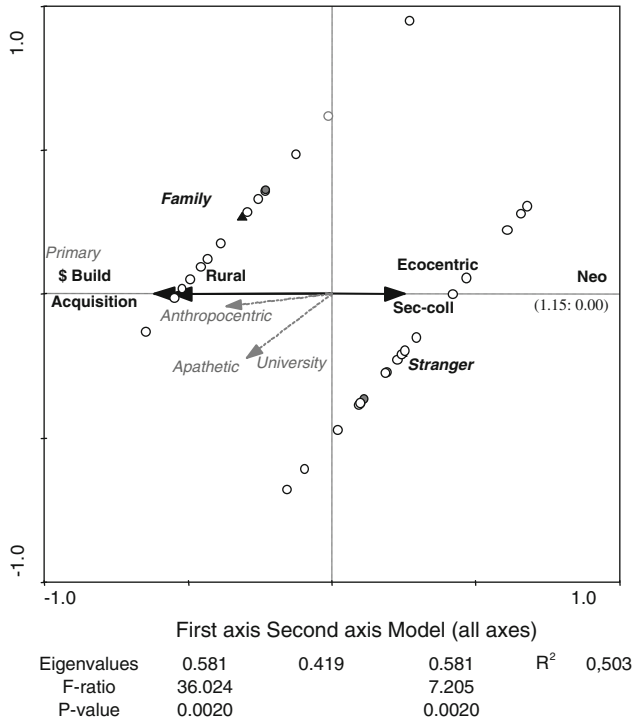

Fig. 2 Canonical correspondance analysis (CCA) of the relationship to previous owner

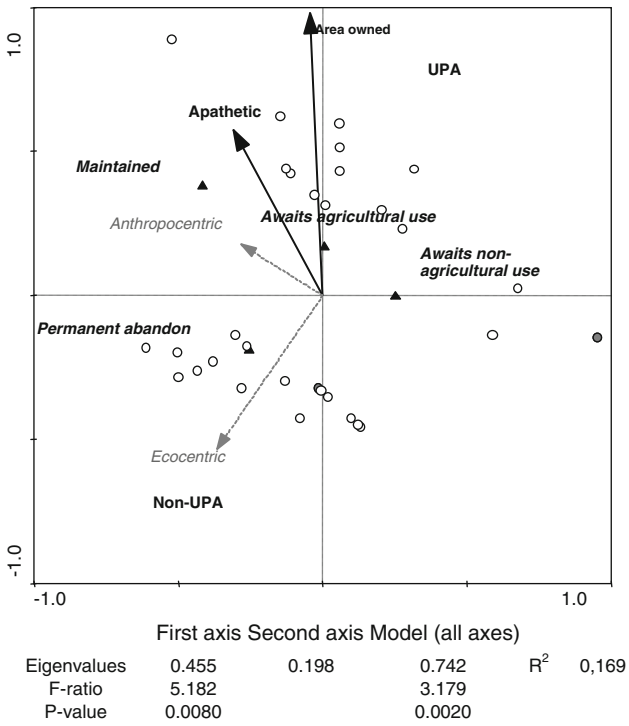

Fig. 3 Canonical correspondance analysis (CCA) of the current status of the abandoned farmland

In order to understand the major obstacles standing in the way of managing abandoned farmland, owners were asked to talk about the main reasons why these lands were unused. A large number of reasons (14) were listed; cost, time, and "keep it as it is" were the most common. This array of socioeconomic reasons shows that there is not a single general trend to farmland abandonment in this area; each case is particular.

Unwanted, abandoned farmlands are also slightly used; 18 of 33 owners said that they made no use of these lands, while the others mentioned one or more uses, for activities such as hunting and walking. Abandoned farmlands are also poorly known by their owners. Individuals who were able to identify fewer than five plant species or used general terms, such as hay and grass, represented 21 owners of 33. Finally, our results indicate that 24 of 33 owners had not makde any changes to their abandoned farmland in the last 5 years.

Management Options for Abandoned Farmlands

It is interesting to note that 19 of 33 owners consider that abandoned farmland should be reforested, and that a large

number of them, by owning buildings of high value, owning a large property, and having apathetic and anthropocentric values, correspond to the farmer profile (Fig. 4a and Table 3). Also, owners who assert that certain abandoned farmlands should be maintained in the landscape are numerous (23) and seem to have more pronounced ecocentric values, which corroborates data obtained previously (Benjamin and others 2007).

The next questions were about the interest of owners in a selection of possible management options. Interventions to improve the growth of tree seedlings already in place and plantations are the two management options that are the most interesting according to the owners (Fig. 4b). Animal rearing, whether it is traditional (cattle) or nontraditional (ostriches), a return to conventional (cereal crops) or nonconventional (medicinal plants) agriculture, and the establishment of walking trails are management options that generate the least interest but seem to be almost exclusively concentrated in owners with a farmer profile (Fig. 4b). In fact, members of the UPA and those owning large areas seem to be the most interested, generally, in managing their abandoned farmland, since most of the proposed management options are associated with these two vectors. Furthermore, "Let nature run its course" is preferred by pensioners and those who purchased their land a long time ago; these results show a certain disinterest in proactive management. Owners employed in the secondary sector could, just like the members of the UPA, have a certain tendency to want to transform their abandoned farmland into agricultural land or breed traditional cattle, which demonstrates a certain amount of initiative and willingness for management by people whose work does not involve agriculture.

In order to promote reforestation in the region, we wanted to know if the administrative structures were adequate for abandoned farmland owners who would like to do such management. Of the 33 owners interviewed, 30 met the main requirement to be considered a forest producer, which is to own a wooded area of at least 4 ha in a single piece. However, only eight of these owners were already forest producers, and seven had a forest management plan drawn up by a forest engineer. There were seven owners who knew of the Agence forestière de la Montérégie without necessarily being forest producers.

Perception of Silvicultural Management

When abandoned farmland owners were asked to express their interest in each of the five types of plantations, hardwood plantations stood out for the amount of interest they generate; opinions were divided for the other types of plantations. This interest forin hardwoods may be

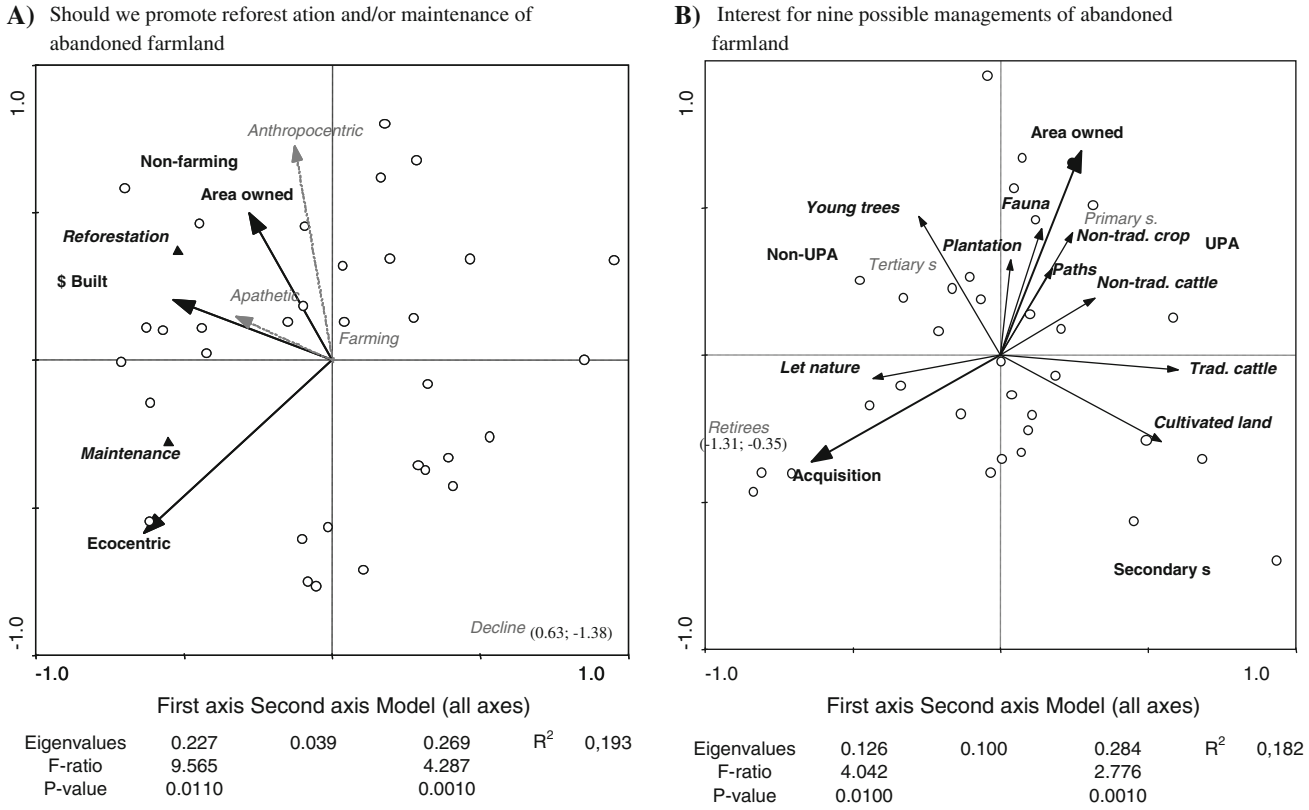

Fig. 4 Redundancy analysis (RDA) of perception and interest in possible management options for abandoned farmlands

motivated in part by the possibility of planting sugar maple, a species which, at maturity, is exploited in the region for producing maple syrup. Interest in re-creating a hardwood forest could also come from the fact that this type of forest is the only one known in the region; it is also the type of forest that can be exploited for firewood production, a business that is widespread among owners of woodlots (Agence forestière de la Montérégie 2001).

To complete the picture of the feasibility of reforestation in the region, owners were asked to comment on the incentives and the constraints of plantations. The desire to preserve the environment, the wildlife, and the landscape and, also, fiscal incentives seemed to be the best reasons for the establishment of a plantation (Fig. 5a). An increase in the price of wood and the possibility of obtaining financial and technical advice did not seem to be good means to use for promoting reforestation. We noticed again that older owners seem uninterested in land improvement.

Furthermore, the constraints associated with reforestation seemed to affect few people. Here again, the constraints associated with profitability, such as the recent softwood lumber conflict between Canada and the United States, and the fact that profits from plantations can occur only after 40 years, seemed of little concern to the owners (Fig. 5b). Farmers and owners with the highest ecocentric values weare the most concerned by these constraints, whereas older owners were the least concerned.

Finally, in order to know how to properly inform and increase awareness about reforestation, the last part of the questionnaire sought to find out where people got their information on forests. Among 33 owners, 15 reported having never sought information on forests; magazines, Internet, and forest engineers were the most common information sources for the remaining 18 owners.

Linking Sociological and Biological Data

A canonical correspondence analysis between the characteristics of the owners and the type of abandoned farmland owned allowed us, first, to determine that important criteria, such as membership in the UPA, the area owned, and the age of owners, are also correlated with the type of abandoned farmland owned. We know that owners who seem the most interested in reforestation are those who are currently members of the UPA and who possess a large property. Owners with this profile own a large proportion of Type 2a abandoned farmlands (Fig. 6), which are poorly drained lands often dominated by shrub species such as willows (*Salix*) and *Spiraea alba*. Owners with the same profile also owned a large part of Type 1 abandoned farmland, which are old pastures on stony soils and are

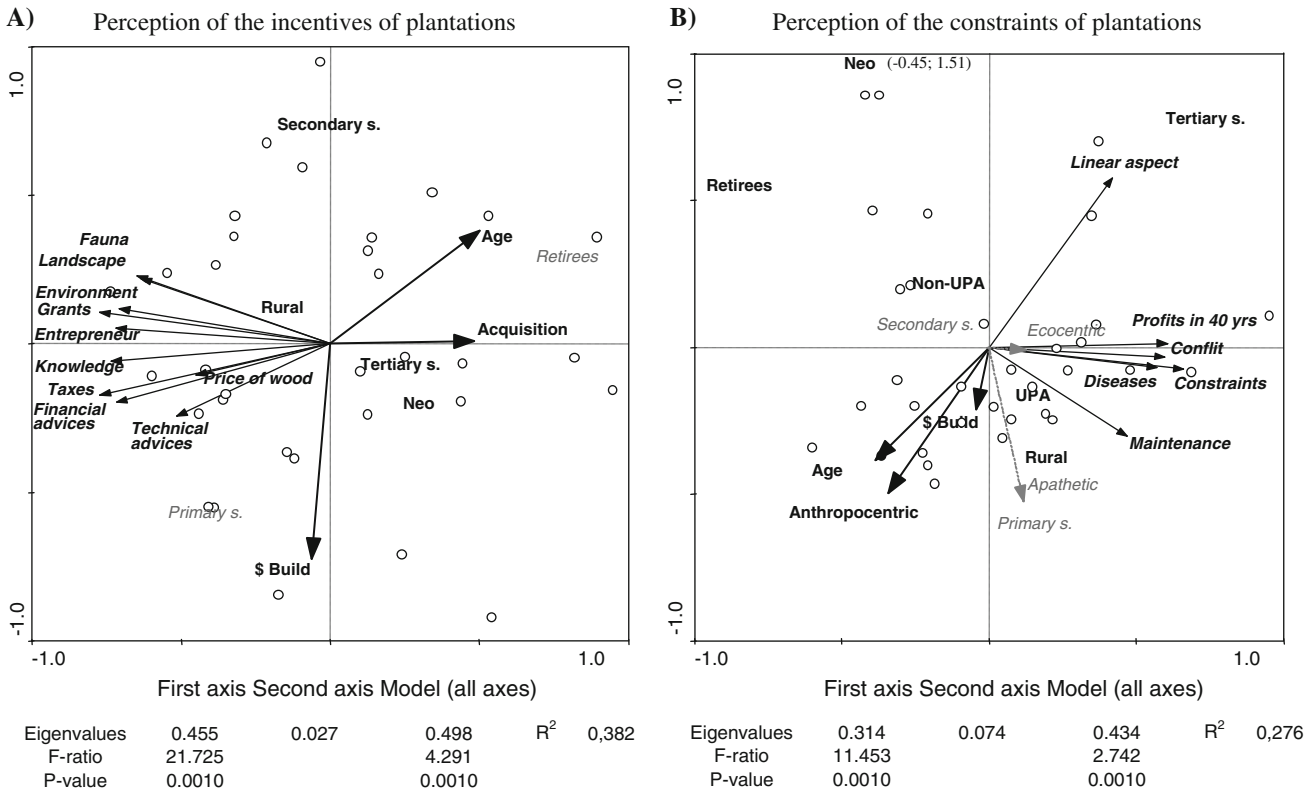

Fig. 5 Redundancy analysis (RDA) of perception of the incentives and the constraints of plantations

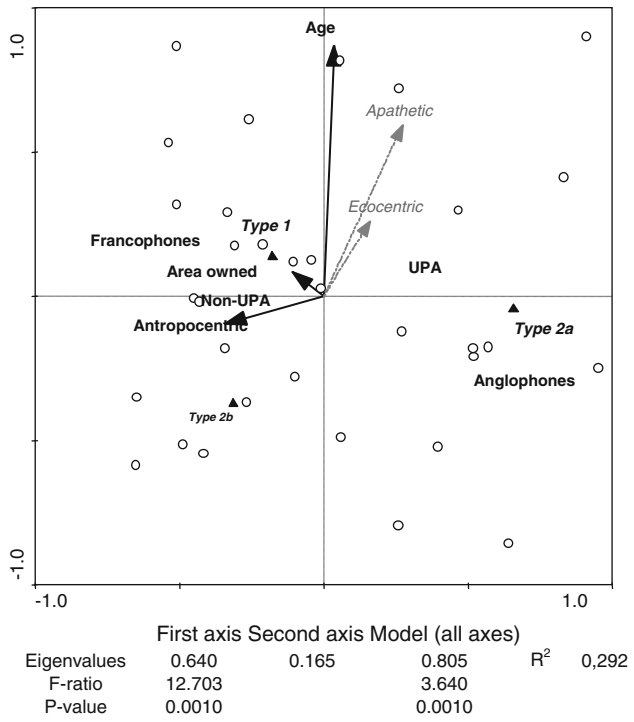

Fig. 6 Redundancy analysis (RDA) of the profiles of owners of different types of abandoned farmland

currently shrub-dominated (Benjamin and others 2005). The analysis shows that older people, less interested in improvements, also possess this type of abandoned farmland.

Discussion

Abandoned Farmlands can be Improved

All the data collected during the interviews seem to indicate a weak link between the owner and his abandoned farmland, making these lands available for improvement. There does not seem to be a strong and general wish to retain abandoned farmland within properties. These unused lands do not hold any particular attraction to the buyer of a property, because the purchase of an abandoned farmland was made because owners did not have the choice; it was a part of the property they wanted to buy. We already knew that abandoned farmlands were rather poorly perceived (Benjamin and others 2007), and these new results tend to confirm that there are no strong attachments, in general, between owners and their abandoned farmland. Few use it, few know what grows on it, and a large number of them would like to transform it into cultivated land.

However, reconversion to agricultural use would lead to a loss of biodiversity (Billeter and others 2008) and crop production is already responsible for landscape standardization. Many studies show that the biodiversity decline in agricultural landscapes is related to changes in farming practices and intensification (Donald and others 2001; MacDonald and others 2007). That is why this study aims to promote reforestation as an alternative to the reconversion of abandoned farmlands into agricultural lands. Managed forests or plantations can contribute to increase biodiversity in an agricultural environment. One study showed that, although old forests differ from managed forests in their structure, the species richness in managed forests is the same as in old forests (Crow and others 2002). Besides, Aubin and others (2008) came to the conclusion that deciduous plantations are prime candidates for restoration of natural vegetation assemblages since their understory structure and abiotic environment are similar to those of natural stands.

Predicting the Willingness to Improve Abandoned Farmlands Using Socioeconomic Criteria and Values

In the study area, two broad options for development can be expected for abandoned farmland. The first is a return to agricultural use, and this modification is likely to occur with owners who are farmers. The second broad option for improving abandoned farmland in the study area is reforestation. The choice of this option may be motivated by the wishes of the owner to devote part of his property to the reconstruction of the forestry potential of the region, or to return it to profitability.

Our results tend to suggest three types of owners that are not necessarily mutually exclusive: farmers, older people, and those with an ecocentric profile. For owners with an ecocentric profile, we can surmise that they accept the idea of having abandoned farmland on their property, particularly since the ecocentric profile is associated with the most positive perception of abandoned farmland encountered in these owners in a previous study (Wilson 1992). Also, when talking about constraints with these owners, we noticed that they are the most concerned. These results are consistent with our findings since ecocentric owners are those who, more than any other owners, want to keep abandoned farmland as it is.

Farmers want to make their whole property profitable. This is particularly true in the current context within the study area, where the search for new lands for agriculture is always a concern. The pattern of property transfer in these owners can also create a notion of family heritage that will be favorable to property improvements and could lead to long-term management (Primdahl 1999). Our results indicate that owners with a farmer profile are expected to carry out transformations of their abandoned farmlands over the next few years. To these people interested to a certain extent in silvicultural management, and aware of their

constraints, we should promote the advantages of reforestation and the added value that it would contribute to the property, in order to encourage them to opt for this alternative instead of agricultural reconversion.

Older people do not seem to be a promising target for promoting sustained forestry work such as silviculture; however, underplanting or seedling release could be a possibility. The answers older people gave about their interest in the nine management options, and the incentives and constraints of plantations, show an overall drift away from improving their abandoned farmland. This observation allowed us to say that former farmers tend to give up or neglect their land upon their retirement. Unable to find farmers to rent their land, and without changing their views, these older owners witness the slow afforestation of their whole life's work. This result supports previous studies by Wilson (1992) and Kristensen and others (2004), who showed that landscape changes in agricultural areas are linked to farmers' age.

The popularity of hardwoods among landowners is promising information for the study area and reflects a positive perception of afforestation. In the region, the most common type of plantation is that of conifers, whereas in its natural state the region is the territory with the highest diversity of deciduous hardwoods in the province (Bouchard and Brisson 1996). The reasons conifers are planted are the ease with which their seedlings can be obtained through the reforestation aid program, as well as their resistance to competition. Hardwood plantations are much less common. They require more maintenance to eliminate competing vegetation during the first growing seasons (Cogliastro and others 1990), and hardwoods are generally more vulnerable to diseases. Thus, the group of owners to target for promoting reforestation, the farmers, seem to prefer hardwood plantations, which is good news for a region that needs to rebuild its hardwood forests. Farmers, through their interest in hardwood species and their capability to make their properties profitable, may thus participate in the reconstruction of the region's forestry potential.

In a general way, we can say that those who will choose reforestation will do so with a certain awareness of its advantages and inconveniences, while being governed by reasons that appear to be other than monetary. In an area of intensive agriculture like our study area, owners who could decide to have a plantation on part of their property consider that part of their land a living place rather than a production area (Primdahl 1999). These findings are supported by the work of Gluck (2000), who demonstrated that the decisions made by owners reflected economic values, perceived public and personal amenity, and environmental consideration. Also, it is clear that conditions that owners must meet in order to receive reforestation grants are not an obstacle to this type of management. We suggest instead that poor knowledge of the available options facilitating reforestation (like the Agence forestière de la Montérégie and the forest producer status) already in place is the factor currently limiting reforestation. This could reflect landowners' low interest in reforestation, but we suspect that it is more likely the lack of active forest managers to inform them. This lack of knowledge was also reported by Kassioumis and others (2004), while Gluck and Humphreys (2002) identified availability of information as a key component to involving landowners in projects. Therefore, in order to reach people who could be interested in plantations, but who are generally poorly aware of the possibilities that are offered to them, there should be a more important and direct awareness campaign about the available options.

Management Options for Abandoned Farmlands According to Biological and Sociological Data

The last part of our analysis matches biological and sociological data to understand which type of owner owns which type of abandoned farmland, in order to determine which combinations of owners/abandoned farmland are the most promising in this region for promoting hardwood reforestation. We saw that the most promising owners for silvicultural management are farmers. Some of them have abandoned farmland dominated by low shrub vegetation. These abandoned farmlands could be converted into short-rotation plantations for biomass production using willows (Labrecque and Teodorescu 2003; Messier and others 2003). The entrepreneurial attitude of the members of the UPA, as well as the possibility of exploiting their property in a manner other than with traditional agriculture, could be attractive to these people. Another group of farmers has abandoned farmland composed of spiny shrub vegetation. It would be very appropriate to focus on these people to promote the plantation of hardwood tree species and thus supplement natural regeneration. Reforestation in such abandoned farmlands, where the shrubby vegetation is used as an ally against strong winds and excessive light, appears promising (Cogliastro and others 2006). Since these types of abandoned farmland are also owned by older people, it would be equally appropriate to let these environments evolve naturally, as they possess the highest degree of tree regeneration, which suggests that they have the potential to produce a regenerated forest that is interesting for forestry. Finally, Type 2b abandoned farmlands, with mostly herbaceous plant cover, would certainly be easy to use for reforestation, because of the relatively minor effort needed to make them suitable for reforestation. However, these abandoned farmlands are also habitats that are becoming increasingly rare in the region because of extensive

wetland drainage for ever-expanding agricultural use. As mentioned by Rouay-Hendrickx (1991), a process aimed at eliminating all of the abandoned farmland could lead to landscape and social aberrations.

Our results show that it is not necessary, nor is it desirable, to manage all of the abandoned farmlands; these environments are of course created by human actions, but they still have their place in the landscape as valuable habitats, and they contribute to landscape diversity, which is the key to biodiversity conservation (Benton and others 2003). It has been shown that set-aside land could have positive impacts on wildlife (MacDonald and others 2007). It would therefore seem opportune to target the most abundant type of abandoned farmlands, mostly Type 1, for improvements aimed at recreating a forest cover, as this is evidently what they are naturally evolving toward.

Conclusion

The possibility of managing abandoned farmland, based on the wishes of their owners and on the biophysical potential of these farmlands, was studied from the perspective of associating biology and sociology. The first part of the study tends to show that there is not an obvious attachment, or strong relationship, between the owner and the abandoned farmland that could hinder an improvement aid program. Our results show that abandoned farmlands are environments that were not sought, but were acquired by default along with the rest of a desired property. Abandoned farmlands are also areas of the property that are little used and poorly known. It also seems that the people most interested in improving their abandoned farmland, whether for silvicultural or agricultural use, are the farmers; optimal use of their property, often their main source of income, seems well established in this group. Conversely, neorural inhabitants seem to want, in a certain way, to conserve their abandoned farmland in its current state and thus encourage a return to the "natural environment."

From the perspective of improvement of the forestry potential, where abandoned farmland represents an important potential, the farmers seem to be the people worth targeting. Their preference for hardwood plantations bodes well for a region where hardwood forests are generally degraded. To these people, we should promote the advantages of a plantation in order to encourage them to opt for this alternative instead of opting for reconversion to agriculture. At this state of our understanding, it would be appropriate to reflect on the results of plantations established on these abandoned farmlands. Would the hardwood plantations that seem attractive to the farmers be established for maple syrup production, firewood production, or improvement of the hardwood forest of the region? Would short-rotation-time plantations, such as those using willows that could be established on more humid lands, constitute an additional intensive exploitation of the region, or would they enrich the landscape with the diversity they would bring? These possibilities of silvicultural management on abandoned farmland open the door to future studies addressing whether an increase in the number of trees in the region necessarily implies better landscapes and better forests.

Acknowledgments This study was conducted with the support of a Fond québéçois de la recherche sur la nature et les technologies (FQRNT) team research grant to A. Bouchard, A. Cogliastro, G. Domon, and D. Marceau, an NSERC individual grant to A. Bouchard, an SSHRC grant to G. Domon, and a FCAR graduate scholarship to K. Benjamin. We are grateful to P. Legendre and S. Daigle for their advice on statistical analyses. We wish to thank all of the owners of abandoned farmlands who participated in this study. We also thank the four reviewers of this paper for their constructive comments on the manuscript.

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