Transition pathways towards a robust ecologization of agriculture and the need for system redesign. Cases from organic farming and IPM

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A B S T R A C T

The growing criticism of intensive agricultural practices that lead to a deterioration of natural resources and a decrease of biodiversity has progressively led to more environmental constraints being put on agricultural activities through an “ecologization” of agricultural policies. The aims of these policies have been to protect environmentally sensitive areas, to improve groundwater quality and, more recently, to develop organic farming and/or reduce pesticide use. However, these efforts are still a far cry from a robust ecologization of agricultural practices. In order to identify the conditions for the implementation of such an ecologization, the changes in practices from conventional agriculture towards organic farming and integrated pest management (IPM) are investigated using a sociological study of farmers’ trajectories, coupled with the ESR (Efficiency-Substitution-Redesign) framework developed by biological and agricultural scientists. This combined approach reveals that a robust ecologization of agricultural practices requires us to take into account the specific and variable tempo of farmers’ trajectories and to redesign not only technical agricultural systems but also interactions within larger agrifood systems.

1. Introduction

The implementation of European legislation as well as various national pesticide action plans and public policies pertaining to organic agriculture, could bring about major changes to agricultural practices within the coming years. In France, at the end of 2007, the government organized a number of public debates over environmental issues, involving various stakeholders from the agricultural sector, as well as NGOs and state institutions. Soon afterward it promised strong growth of organic agriculture (from the current 2%–20% of the agricultural area by 2020) and a reduction in pesticide use by 50% by 2018 “if possible”. This “if possible” became a key word in agricultural profession’s reactions to these announcements. Yet, irrespective of what the final public decisions and regulations are in France, French agriculture, like the rest of European agriculture, will have to comply with European rules that may not drastically change the nature of professional activity and practices in some agricultural sectors, such as extensive livestock farming, in other sectors, such as arable crops or fruits and vegetables, a robust ecologization of agricultural practices requires us to take into account the specific and variable tempo of farmers’ trajectories and to redesign not only technical agricultural systems but also interactions within larger agrifood systems.

Contributing to the conservation of “Environmentally Sensitive Areas” (Reg. 797/85/EEC/Art.19). It was reinforced by the 1992 Common Agricultural Policy (CAP) reform. However, these efforts are still a far cry from a robust ecologization of agricultural practices; in other words, there is a discordance or inconsistency between the changes in macro-structural elements such as policy and in micro-structural elements related to grassroots agency (Burton and Wilson, 2006).

Until recently, the ecologization of agricultural practices was mainly based on voluntary participation of farmers in agri-environmental programmes; it primarily concerned specific areas and extensive agriculture and had little impact on arable cropping systems. In 2003, the CAP started to shift from voluntary to mandatory integration of agri-environmental practices by introducing new principles of cross-compliance and of “good agricultural and environmental conditions”, which could so far concern only a very limited part of a farm’s arable land.

Change will however soon be implemented if the recent political announcements are followed by new regulations regarding pesticide use in France. This time round the regulations will involve substantial changes in practices for all agricultural systems on all the arable land of a given farm. Even though these new constraints and regulations may not drastically change the nature of professional activity and practices in some agricultural sectors, such as extensive livestock farming, in other sectors, such as arable crops or fruits and vegetables, a robust ecologization of agricultural practices requires us to take into account the specific and variable tempo of farmers’ trajectories and to redesign not only technical agricultural systems but also interactions within larger agrifood systems.

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practices will probably require a dramatic adjustment not only in conventional farmers’ practices but also in their conceptions and identity. How will producers adapt, considering that for the majority of them current practices are nowhere near to a 50% pesticide reduction? How will organic agriculture be able to spread from 2 to 20% of the arable land in just 10 years?

In this paper the general premise is that studying past or current transitions towards more sustainable agricultural practices such as organic farming (OF) and integrated pest management (IPM) might help in identifying the conditions for achieving both the changes that most farmers will probably have to make in the future and a more general ecologization of agriculture. I show that identifying the conditions for robust transitions implies the need to analyze farmers’ changes over time and to take into account their relationships to social actors within and outside the agricultural sphere, as well as interdependencies in larger agrifood systems.

I apply a common approach to organic farming and IPM, based on a study of farmers’ trajectories and coupled with the ESR (Efficiency-Substitution-Redesign) framework developed by biological and agricultural scientists (Hill and MacRae, 1995). My two case studies deal with conversion to organic farming in fruit and vegetable production, and transitions towards IPM in arable crops. Despite the significant differences between these two kinds of production, I will show that their comparison enables to identify the conditions for a robust ecologization of practices, either because these conditions appear to be common to both cases (importance of antecedents in farmers’ trajectories) or because they appear symmetrically as a strength in one and a weakness in the other (collective dynamics in the IPM case study vs changes in marketing strategies in OF). This comparison of organic farming and IPM will hopefully allow for theoretical transfers between both types of agriculture, which are rarely considered in parallel.

This paper is organized in four sections. First, I discuss the existing approaches to transitions in agricultural practices and present methods and data. Second, the case of conversion to organic agriculture is presented, and third the case of the transition to integrated pest management is explained. Lastly, I draw on these two cases to discuss the conditions for a sustainable ecologization of agriculture and agrifood systems. I posit just how necessary it is to take into account changes over time, through the study of farmers’ trajectories, as well as relationships and interdependencies in the food chain and with civil society. In the conclusion, I revert to the usefulness of combining a comprehensive study of farmers’ trajectories with the ESR framework in order to analyze transitional pathways towards more ecological forms of agriculture.

2. Analyzing changes in agricultural practices and along producers’ trajectories

The current reliance of the agrifood system on chemical inputs has been analyzed largely as the result of a socio-historical trajectory characterized by effects of “lock-in” and “path dependencies” (Dosi, 1982; Cowan and Gunby, 1996; Possas et al., 1996). The progressive convergence of technological innovations and actors’ strategies has led to a “paradigm of productivism” based on the intensification of agricultural practices, defined as “a commitment to an intensive, industrially driven and expansionist agriculture with state support based primarily on output and increased productivity” (Lowe et al., 1993: 221).

Regarding wheat production, which is central in one of my two case studies, over the last decades technological innovations as well as the dominant actors’ strategies (input and seed companies, big cooperatives and food industries) converged. The result was a progressive change from a curative use of pesticides to a more systematic one with a marked “intensification turn” in the early 1980s as has been assessed in the case of France (Bonneuil and Hochereau, 2008; Lamine et al., 2008).

Regarding fruit and vegetable production, which is central in my other case study, this convergence of innovations and strategies can also be demonstrated, even though an alternative path has clearly been opened, particularly with biological control. While part of it has been integrated into the dominant system through business-to-business certification schemes, the rest has been marginalized.

In both agricultural sectors (and others), this trajectory has been reinforced by a looping back phenomenon, including increased pest attacks due to resistance to pesticides and a decreasing number of natural predators, which in turn prompts farmers to increase their use of pesticides. It has also been reinforced by the continued specialization of farms from the 1960s to the 1990s (Walford, 2003), as well as the simplification of work organization due to the continual process of downward labor adjustment (Evans, 2009). These lock-in effects and interdependencies or path dependencies have impeded the development of alternative techniques and strategies such as the adoption of resistant varieties combined with low-input crop management strategies, in the case both of wheat and of fruit and vegetable production (Vanloqueren and Baret, 2008).

Even though this development turned out to be the most compelling one of several possible trajectories, it was by no means consensual. Firstly, this development, and more generally the modernization of European agriculture, left the majority of farmers by the wayside. Their living conditions worsened to the extent that they eventually had to give up farming for other professional sectors1. Secondly, criticism and controversies increased over the consequences of intensive agriculture on the environment. Rachel Carson in her book “Silent Spring” (1962) was one of the first people to call attention to the side-effects associated with pesticides in the western world, while some alerts had been expressed in the medical world about the effects of pesticides on farmers’ health from the early twentieth century (Jas, 2007). Thirdly, there were and continue to be minor trends in this larger trend of intensification of agricultural practices.

Some authors have argued that modern agricultural regimes have moved in the recent period from productivism to post-productivism or multifunctionality, even though this is matter of controversy (see Burton and Wilson, 2006). What seems less disputable however is that a variety of agricultural models which challenge the productivist paradigm and claim to be more ecological, including organic farming and integrated pest management on which I focus here, have expanded although to various degrees.

Organic agriculture is certainly the most institutionalized of these alternative models. It has been conceptualized and practised for nearly a century2 but was not regulated on a national scale until 1980 in France, and not until the early 1990s at European level (Reg. 2092/91/EEC). This institutionalization has generated a boom in research and publications in various scientific disciplines, including the social sciences. Most sociological research on “alternative” models focuses either on organic agriculture or on agri-environmental schemes (Morris and Potter, 1995; Winter, 2000), at the expense of other types of practices such as IPM. This can be explained by the fact that strongly institutionalized forms of agriculture are more easily grasped by sociological approaches, especially as research often takes place within programmes launched by public agencies and institutions to evaluate public policies.

1 In France, the total number of farms decreased from 1.6 million in 1970 to 500,000 in 2007, and the total number of agricultural jobs from 3.8 million persons to 1.1 million.
2 R. Steiner’s Spiritual Foundations for the Renewal of Agriculture dates back to 1924 and An Agricultural Testament by A. Howard, to 1940.
Whereas organic agriculture has been codified into rules, labels and organizations, IPM (integrated pest management) has somewhat unstable and variable definitions, and encompasses a large variety of practices— even though the International Organization for Biological Control of Noxious Animals and Plants (IOBC), founded in 1956 by Swiss and French entomologists, has published rules for an alternative technical model (El Titi et al., 1993). This lack of codification and institutionalization might be a reason why IPM has not really tempted social scientists, with a few exceptions concerning more fruit or wine production (Warner, 2007) than arable crops (Morris and Winter, 1999) and more southern countries and participatory programmes (e.g. Norton et al., 1999) than developed countries.

Many sociological studies have emphasized the driving social and relational factors and motivations behind transitions towards more ecological practices, especially organic farming. The approaches vary: some are based on quantitative analyses of farmers’ motivations or attitudes, others on qualitative approaches to farmers’ practices and conceptions. Several authors have compared organic with conventional farmers’ attitudes, and “potential converters” with organic farmers or, recently, with more experienced converters (Koesling et al., 2005; Lockie and Halpin, 2005; Best, 2008). Such studies might lead to a sometimes simplistic opposition between market-oriented farmers and value-oriented ones, or pragmatic organic farmers and committed ones—the former being able to revert to conventional farming if price premiums were to diminish (Fairweather, 1999; Darnhofer et al., 2005). Few authors have chosen to follow organic farmers’ trajectories and to study the changes in their conceptions and practices over time (Guthman, 2000), even though such approaches were at the core of some pioneering studies on organic farming in the 1970s and 1980s (Harris et al., 1979; Barrès et al., 1985; Le Pape and Remy, 1988). In general, most studies in both the social and the agricultural sciences minimize the importance of transitional and long-term aspects within trajectories, and rarely approach conversion as a longer process than its legal duration (Lamine and Bellon, 2009).

The notions of agricultural transitions and transition pathways have been used and discussed far more within debates on multi-functionality and post-productivism. Even though this literature does not usually refer to the actual agricultural models that farmers and public policies are likely to implement, my own research partly echoes its description of agricultural transitions as temporally non-linear and characterized by “pivotal points” as well as “system memory” (Wilson, 2008). Beyond the case of agriculture, transition theories have also pointed out the necessity to take into account the different elements of the socio-technical regime as a whole (Geels and Schot, 2007).

The impact of food chain interdependencies on agricultural changes (or non changes) is indeed an aspect which has not received due attention. Some authors have pointed out the need to rethink production-consumption links (e.g. Goodman, 2000; Guthman, 2002), which has led to research on farmer/consumer interactions and possible negotiations around farming practices in the case of short food-supply chains like local markets or box schemes (Renting et al., 2003; Griffin and Frongillo, 2003; Kirwan, 2004; Lamine, 2005). For example, CSA (Community-Supported Agriculture) systems give farmers a guarantee of income and support from consumers, which might help them to change their technical practices towards organic or low-input agriculture. Studies on such changes in the context of corporate systems are scarce, however, and once again tend to concern the case of fruit production (Toubon et al., 2000; McKenna and Campbell, 2002) rather than cereal production (Wiskerke, 2003).

Even scarcer are studies which consider possible theoretical and methodological transfers between organic agriculture and other forms of sustainable agriculture. One of the reasons for this might be that in some way researchers are reluctant to challenge most of the conceptions of the “actors themselves”, according to which organic farming (OF) is based on such different principles that mutual learning processes with other “intermediary” forms of sustainable agriculture are virtually impossible.

I believe that, on the contrary, comparing the cases of OF and IPM might contribute to the identification of general conditions for a robust ecologization of agricultural practices, whether this ecologization is translated into conversion to OF or transition to IPM or to other forms of sustainable agriculture. This approach required me to adopt a common grid for describing the processes of transition and characterizing the changes in practices. This is why I have coupled a sociological approach to producers’ trajectories and to changes in practices and conceptions, with the ESR (Efficiency-Substitution-Redesign) model developed by biological and agricultural scientists to analyze transitions in crop protection practices. I have borrowed principles from two theoretical sources. The first source is the sociology of controversies (Chateauraynaud and Torny, 1999), which seems appropriate to study “emerging” practices and conceptions with a low degree of stabilization and a high degree of diversity. From this source I retain two principles, also shared by the actor-network theory: (i) to consider public issues over a long period of time and look for antecedents and signs of changes often occurring well before the institutionalization of these issues in regulations, public policies or organizations, and (ii) to study the complex network of social actors involved in these public issues and debates and analyze their interactions. I applied these general principles to an ethnographic study of farmers’ trajectories over time, taking into account their insertion in social networks and relationships within and outside the agricultural sphere.4

The second source of theoretical inspiration is a framework proposed by agricultural scientists who have suggested a distinction between three approaches for the changes in crop protection practices, to deal with environmental problems caused by industrial agriculture: Efficiency (making the best choice and use of pesticides in order to reduce their overall use), Substitution (replacing chemical pesticides with biological ones) and Redesign (reorganizing production systems according to ecological principles) (Hill and MacRae, 1995). We will see that this grid has to be complexified, especially since trajectories and changes are by no means linear and cannot be described as a mere sequence of these 3 approaches which often overlap in a given trajectory (Hill et al., 1999). Through this combined approach, my analysis is also intended to be a contribution to the theories of agricultural transitions.

On the subject of conversion to organic farming, comprehensive interviews with 12 fruit and vegetable growers from the Provence region of France were held in 2005 and 2006.5 Farmers with diverse profiles in terms of age, career, length of experience in organic farming, production choices and marketing modes were chosen to

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3 Moreover, there is some semantic confusion between IPM, ICM (Integrated Crop Management), IFS (Integrated Farming Systems) and integrated production despite they share the same basic principles.

4 This is complementary to an analysis of public debates over agri-environmental issues and particularly over pesticides on a larger scale, based on the analysis of a press corpus and interviews (Haynes et al., 2009).

take into account the diversity of organic farming. This was completed by a longer-term study of short food-supply chains (box schemes) involving organic farmers or farmers considering conversion to OF. For this purpose 20 meetings, bringing together farmers, consumers and civil society organizations, were attended from 2002 to 2008.

On the subject of IPM, 27 comprehensive interviews with arable crop farmers (some of them also growing vegetables or breeding animals) as well as 10 interviews with advisors, researchers, and food chain actors were held in 2007 and 2008 in Normandy and Picardie (Northern France). Most of these farmers belonged to “IPM groups”, i.e., groups of farmers who apply the principles of integrated protection (cf. infra) to varying degrees, at least for their winter wheat. However, farmers who had tried but given up on IPM, as well as conventional farmers, were also interviewed in order to provide a wider range of positions. 8 meetings of these farmers’ groups were also analyzed.3

In both case studies, comprehensive interviews were carried out with the objective of tracing life stories in order to identify what the determining factors in farmers’ trajectories (antecedents, shifts and triggering events) were, both before conversion to organic farming or adoption of IPM practices and afterward. Farmers’ trajectories are depicted as temporal stages with successive phases whose boundaries are specific events, decisions or changes regarding technical and managerial dimensions, marketing, learning processes, and interactions with diverse networks. The ESR framework is then applied to each individual case in order to identify the presence of the above three paradigms of Efficiency, Substitution and Redesign along the trajectory.

3. Giving up pesticides: conversion to organic agriculture

The application of the ESR (Efficiency-Substitution-Redesign) framework (Hill and MacRae, 1995) to organic farming can lead to a distinction between an “input substitution” paradigm and a “system redesign” paradigm (Altieri and Rosset, 1996). The input substitution paradigm defines organic farming as the replacement of synthetic inputs by alternative methods to fight pests and diseases, which actually fits with the official European definition of organic farming (Reg. 834/2007/EC). The system redesign paradigm defines organic farming in a more holistic way and refers to the construction of diversified production systems, in which interactions between components of the “agro-eco-system” enhance natural regulation processes and therefore help guarantee fertility, productivity and resilience. It fits with the core principles put forward by OF social movements such as IFOAM. The third paradigm of efficiency of the ESR grid might seem less relevant in the case of organic farming (as it usually describes a reduction in the use of chemical inputs, whereas organic producers have to give up their use completely); however, we will see that it might also be present along producers’ trajectories.

In my field data it is possible to find evidence of the two paradigms of “input substitution” and “system redesign” both in practices and in conceptions. Some farmers replaced banned inputs by authorized ones but maintained the aim of fighting pests and diseases: as one of them said, “We do not use the same products, but we do the same treatments”. Others would redefine things more holistically, considering “that a new ecosystem can rapidly appear as there is no chemical intervention” and aiming more at coping with pests than fighting them. This “system redesign” would often go beyond technical practices and involve other aspects such as marketing modes and insertion in professional and social networks. Moreover, looked at in more detail, none of the 12 case studies under consideration can be strictly and entirely related to a single paradigm. When studying changes over the long time span of farmers’ trajectories, situations appear much more complex and subject to change. Some changes began long before conversion, while the farmer was still practising conventional farming, and continued after conversion to OF. Rather than setting the farmers’ activity under one paradigm or the other, this approach makes it possible to see the succession and frequent overlapping of these two paradigms along their trajectories.

This approach led to the identification of antecedents and steps along farmers’ trajectories, which enabled me to define two main types of trajectory. In the first type, conversion to organic farming tended to be direct: farmers decided to convert quite suddenly (one to three years between the first time organic farming was considered and actual conversion), for example following a health-related incident or economic difficulties. In the second type, conversion was more progressive: a break with conventional agriculture had occurred long before conversion to organic farming was considered. In some cases, there were up to twenty years between the first experience of pesticide reduction or the first experiment in organic farming and the actual technical and administrative conversion7, with accelerations and decelerations or even giving up. This shows that such transitions are not only progressive but also non-linear. Can these characteristics of more direct or more progressive trajectories be related to the above two paradigms? Can we infer that progressive trajectories are more likely to lead to the system redesign paradigm which calls for overhauling the system, and that more direct trajectories would rather reflect the input substitution paradigm?

To discuss these points I consider the case of a particular farmer’s progressive trajectory that paradoxically appears as a rather radical (and sudden) conversion, as this farmer used to be specialized in a very intensive form of agriculture, i.e., greenhouse tomato production, and converted to organic farming, diversified production and a community-supported agriculture box-type scheme in less than 2 years. However, when we consider it over a long time span it appears that the presence of determining antecedents in this farmer’s conventional period reveals the progressiveness of his trajectory.

At the time of my study this farmer was 48 years old and had taken over the farm 25 years earlier. At that stage he removed the last apple trees of what used to be a semi-diversified farm (field vegetables, orchards, and greenhouses built by his father in the mid-1980s) and decided to invest in high-tech greenhouses and to specialize in tomato production. He became heavily involved in the local producers’ organization and in the technical development of this production, both in terms of “hard” technological innovations (such as climate regulation in the greenhouses) and in terms of improving crop protection strategies (e.g., use of thresholds and observation in order to reduce pesticide use). He and his father were among the pioneers of the introduction of biological control in this area in the 1980s, with the help of a few scientists from the INRA (French National Institute for Agronomic Research) with whom they shared experiments. Due to various sanitary crises and increasing competition with other production areas such as the

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6 This fieldwork was undertaken within 3 research projects: the Tracks project on conversion to organic farming (2005–2006), the Cedupic project devoted to Integrated Pest Management, under the “Programme Agriculture et Développement Durable” supported by the ANR, the French National Research Agency (2007–2009), and the Endure European Network of Excellence centered on crop protection issues (2007–2010).

7 In some cases where farmers refused to subscribe to any label or scheme, the technical conversion was not followed by an administrative one.
Netherlands and southern Spain, the group of producers he was part of from 1997 entered business-to-business certification schemes in order to keep their position in the market and respond to the retailers’ increasing demand for traceability. He soon became one of the leaders of this producers’ group and of this development. The reduction of pesticide use through the use of thresholds and biological control were part of the guidelines which the producers had to follow. These guidelines were for the implementation of IPM principles for greenhouse tomato production — which points to a likely transition effect from IPM to organic practices in the cases of farmers who turn to OF after having been involved in IPM schemes and groups, even though we should note that the majority of IPM farmers would never turn to OF.

However, within a few years market operators largely imposed such “good agricultural practices” guidelines, in a movement which this farmer described as a “retailers ‘harnessing’ farmers’ work”. Indeed, most retailers’ guidelines, which act as private certification schemes, mainly deal with the traceability of practices and products and are not particularly demanding in terms of pesticide reduction and alternative methods. Some criteria might refer to IPM or biological control but they would be “minor” criteria in the schemes, which means that they are not compulsory. In fact these guidelines are far more commercial tools for producers to guarantee their “access to the market”, and for retailers to influence the perception of food products as safe and healthy, than tools for the support of a different agriculture (Jarosz and Qazi, 2000; Morris, 2000). This is why the development of guidelines for good agricultural practices, particularly common in fruit and vegetable production, can be described as a “greenwashing” process rather than a real ecologization of practices and products. However, these certification schemes can de facto be a factor of change because they might lead some producers, like this one, to go further in their IPM and mainly their biological control strategies, thanks to their collective organization in producers groups. These groups often use the services of advisors who are independent from the input suppliers. Some groups have their own technicians, who go from farm to farm and help farmers with surveillance tasks and the use of thresholds. In that sense, the impact of such guidelines would probably not depend so much on the tool itself as on the way it is implemented locally.

With this development of retailers’ guidelines, this farmer stated that “things got out of our control” and that he felt he was “losing the core identity” of his profession. He also became increasingly sensitive to environmental issues as well as to consumers’ demands: “we burn gas to heat the greenhouses, and people say tomatoes are not tasty”. Like many other growers in his area, he ended up losing his competitive edge and went bankrupt in the early 2000s. Soon afterward he read a newspaper article about a new weekly box scheme created in his area with a farmer he happened to know. Very quickly he obtained information about this system and within a year started to grow various vegetables for heating them. The greenhouses allowed for enhancing biological regulations, which helped in redesigning the farming system even though biological control products were still used for some problems, while the box scheme was a way to adjust marketing strategies to the reality of product irregularities due to conversion to organic (see Section 4). Both aspects can be related to the paradigm of “system redesign”. This development also allowed him to stabilize the number of farm workers and their working contracts.

Although this shift might seem radical, and appeared as such to his former colleagues of the tomato group as well as to his new ones, i.e., organic producers involved in box schemes, the analysis of this trajectory actually reveals continuity with some antecedents in this farmer’s former activity, such as his early and keen interest in biological control and the fact that he increasingly questioned energy use and product quality. There is also continuity in the role he played as an individual within the professional collective. He used to be a leader in his specialized tomato producers’ group and encouraged the organization of clubs de progrès (“progress clubs”) led by producers, which would meet regularly to discuss technical issues. After his conversion, he suggested the same type of organization to his new colleagues, and together they organized regular meetings on technical and commercial issues such as the diversification and planning of their production.

The use of the ESR framework coupled with the trajectory approach, affords a more subtle understanding than would be offered by the mere application of this ESR framework to current practices. In this case, as in others where trajectories were progressive (7 out of the 12 farmers’ trajectories under study), antecedents in conventional agriculture determined the way in which the conversion to OF was carried out. It was possible to identify three main phases along these progressive trajectories, as in the case described above:

1. a phase of input reduction or efficiency (E) while still in conventional agriculture, often characterized by the use of thresholds and observation;
2. a phase of substitution (S) where some chemical inputs are replaced by biological ones or by biological control, which often starts while the farmers are still in conventional agriculture and reaches a complete elimination of chemical inputs when they go organic, and
3. a phase of system redesign (R) when the farmers gain experience in organic farming and become more involved in organic networks.

The sequence is then E-S-R, with the shift from S to R usually being progressive and starting either at the time of conversion to organic farming or later on. The second phase of substitution usually involves ongoing efficiency practices, partly because biological control is not available or efficient for all pests and diseases. The third phase of redefinition often involves ongoing substitution practices (E-S-R+S). For instance, once he had converted to organic farming, the above producer did not immediately redefine his production practices; he went on substituting non-chemical crop protection products for chemical ones, for some pests and diseases. In some cases the third phase also involves a further reduction in biological inputs themselves, i.e., E-S-R+1-E(o). This is why we should talk more of an overlapping rather than a linear succession of the three paradigms of the ESR grid.

Farmers whose trajectories have been more direct (5 out of 12) have current practices which can be characterized by the notion of substitution of conventional inputs by biological ones. This substitution phase might have been preceded by an efficiency phase while in conventional agriculture, and the sequence in terms of paradigms is then E-S. This does not mean that they would not enter a phase of redefinition later in their trajectory, but simply that at the time of the study they had not yet done so.

From this analysis of farmers’ trajectories and its comparison with the ESR grid, I could define two main types of trajectory among these organic fruit and vegetable growers: direct conversion, which is closer to the input substitution paradigm, and progressive conversion, which is closer to the redefinition paradigm (cf. Table 1). However, we can wonder whether the recent boom in French organic agriculture (2008–2010) would also involve more direct transitions to system redesign.
As shown in Table 1, not only crop protection and technical practices, but also the degree of specialization or diversification and the modes of marketing can be interpreted in terms of the distinction between an input substitution and a system redesign paradigm. Most of the producers who directly converted and are currently in a phase of input substitution have a higher degree of specialization, i.e., a limited range of vegetable and/or fruit varieties, while those who realigned their system have diversified more in terms of products and/or varieties. Regarding marketing modes, the former mostly replaced previous conventional customers by similar organic ones (either for long food chains such as cooperatives and wholesalers or short food chains such as farm sales or farmers’ markets), whereas the latter have radically changed their marketing modes, shifting for example from corporate buyers to short food chains such as box schemes. This challenges some assumptions regarding the limited changes linked to conversion to organic farming in terms of farm business strategies (Evans, 2009). These changes depend not only on farm adjustment strategies but also on opportunities offered in the specific areas where farmers operate and in the professional and social networks to which they have access. This highlights the strong links between production and marketing choices and the grasp that producers have of these aspects in some sectors like fruit and vegetable production, as opposed to others like arable crops where the marketing possibilities are more limited.

### 4. Reducing pesticides: transition to integrated pest management

In the case of IPM, the three paradigms of the ESR framework could theoretically be found, although in my fieldwork centered on arable crops and especially wheat production, the “input substitution” paradigm would usually be characterized by the introduction of biological pesticides or biological control was not present because such innovations are still scarce. Therefore, the relevant distinction here is between an “efficiency” paradigm and a “system redesign” paradigm, with a clear opposition between farmers who mainly talked of reducing inputs in order to reduce costs (mostly through the use of precision agriculture methods such as decision support systems), and those who held a more systemic view. Considering not only what they said but also their actual practices, this could be assessed through the degree of application of the set of principles which defines IPM in the two groups studied. These principles were as follows for winter wheat, which was the core crop in these regions:

- a choice of wheat varieties which are resistant to diseases and lodging;
- crop management practices which limit pest attacks and diseases, i.e., later sowing, less density and less fertilizer;
- longer crop rotations, as diversifying the crops helps to limit weeds and resistances; and
- good conditions for ecological regulations, by limiting plot size and creating hedges and buffer zones.

Farmers who implemented all or most of these principles could be said to be undertaking a systemic change in their practices and could therefore be characterized by the system redesign paradigm, while those who adopted only one or very few of these principles, particularly if they did not change their crop rotations, were closer to the efficiency paradigm. Situations changed over time though, and as in the case of conversion to organic farming, it is necessary to look at farmers’ trajectories over a longer time span. In this perspective, some farmers might have adopted a systemic view even though they may have been at the beginning of this process at the time of the interview and may have implemented only some of the above principles. The transition towards IPM can be expected to be more reversible than the conversion to organic agriculture because it is neither codified by the process of certification nor reinforced by specific professional and marketing networks or by a high degree of acknowledgment in civil society. For example, due to the context of high prices (after a long period of low prices) and bad conditions in terms of diseases in 2007 and 2008, some farmers reversed their IPM practices and used more pesticides.

In the case of IPM, the relevant categorization involves this potential reversibility of the transitions, and three types of trajectory have been identified among the 27 farmers interviewed:

- progressive and robust conversion (17 farmers): these farmers turned progressively to IPM for various intricate reasons, including economic and environmental ones, as well as health; they adopted most of the above principles and would not consider returning to conventional agriculture;
- opportunistic and reversible conversions (4 farmers): these farmers turned rather rapidly to IPM mainly for economic reasons in a period of low prices, and did or could possibly return to conventional practices;
- conventional farmers (6 farmers): among farmers who did not adopt IPM, some are interested but remain hesitant while others are clearly reluctant.

Here we can raise a question similar to the one suggested in the case of organic farming: is there a link between progressive and robust transitions and system redesign paradigm on the one hand, and between direct and reversible transitions and the efficiency paradigm on the other?

Consider the case of the progressive and robust conversion of an arable crop grower. Since he started farming (1994) this farmer had been aiming for economic optimization in order to obtain two wages from the farm, one for his father (before his retirement) and one for himself. As the farm was initially composed of diverse plots with contrasting potential yields, he decided to apply adequate strategies so as to minimize the costs of the plots which had the worst potential yields. This first change, based mainly on economic motivations, took place in a context of CAP reform and low prices (1992–2006). He described his practices at the time as “lightened conventional farming”: meaning that he had already started to reduce pesticide and fertilizer use, but without changing the general framework.

In 2004, several events triggered a conversion to IPM. This farmer encountered huge problems with weeds and experienced a feeling of incoherence of his strategies. For example, he had reduced the use of mineral fertilizers and fungicides for his wheat crop without changing anything in the rest of his techniques (i.e.,

<table>
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<th>Table 1</th>
<th>Transitions towards organic farming and ESR paradigms.</th>
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<td><strong>Progressiveness of the trajectory</strong></td>
<td><strong>Crop protection strategy</strong></td>
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<td>Direct (transition lasts less than 3 years) (5 cases)</td>
<td>Use of biological inputs in the same framework as in conventional agriculture</td>
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<td>System redesign (7 cases)</td>
<td>Combination of partial effects through acting on coordinated agronomic levels and enhancing biological regulations</td>
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<td>Progressive (transition lasts 3–20 years, with antecedents such as use of biological control while in conventional)</td>
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date and density of sowing). At that time of increasing questioning, he heard of a local advisor who was specialized in IPM and had brought together a group of farmers interested in IPM — although situated at different levels in terms of the application of the above principles — and he joined this group. That was actually when, with the help of the advisor and of the group, he started to interpret his intuitive feeling of incoherence in terms of interdependency between techniques. His growing overall awareness of agriculture's environmental consequences, along with the discussions he had with the other members of this IPM group, led him to progressively merge his economic motivations with more environmental ones. The fact that in the past he had led a farmers' group working on the reduction of fertilizers for water quality issues had also been a determining antecedent in terms of environmental awareness.

The application of the ESR framework puts this case into the system redesign paradigm if we consider this farmer's current practices and the general trend of the changes that he was implementing. He and other farmers whose transitions towards IPM can be described as progressive and robust (first type of trajectory above) had also adopted or were adopting quite a fairly extensive definition of IPM. Regarding wheat production, this means a large part of the set of IPM principles presented above: not only resistant varieties and lower doses of pesticides, but also later sowing, a lower density, less fertilizer, no growth regulator, longer rotations, and sometimes reduction of plot size and creation of hedges and buffer zones. These farmers turned to IPM for various inter-related reasons (economic motivations, ecological ones, health, organization of work, and anticipation of future changes in regulations), usually quite slowly and step-by-step. My analysis shows that the complexity and diversity of motivations tend to favor a robustness of transitions, whereas opportunistic and reversible transitions are mostly linked to economic-centered motivations.

IPM farmers who can be described as having robust trajectories (first type of trajectory above) often present antecedents, as in the case of the above farmer and the first category of organic growers. All of them had already experienced the reduction of their pesticide use. Some had done so for economic reasons on plots with less potential, as in the case above where the farmer went through an “Efficiency” phase before turning to a broader redesign of his system; others did so within agro-environmental schemes or CTE (contrat territorial d’exploitation).8 In these former experiences, some were confronted with technical problems and felt a lack of coherence in their strategies, which led them to seek advice and progressively to change their techniques in a more systemic way. Certain limits in their “efficiency” strategies then led them to the “system redesign” paradigm. Their trajectory can be described in terms of an E-S sequence.

Farmers who can be described as having a reversible trajectory (second type of trajectory above) usually did not implement the whole set of IPM principles. They might have chosen resistant varieties — largely the case today even among intensive farmers — and reduced pesticide doses, but they would not have changed their crop rotation: the length of their crop rotations is 3 (classical wheat-oilseed rape-barley succession) to 4 years (for example when they grow potatoes), as opposed to an average of 6 years for the first category of farmers (see Table 2). We can consider that these farmers correspond to the Efficiency paradigm. In terms of crop protection strategies, they use thresholds and decision support systems. They turned to IPM mainly for economic reasons in a period of low prices (up to 2006), but then the context of high prices and the poor conditions — in terms of diseases — of the 2007 and 2008 seasons led them to use more pesticides (and/or treat more frequently), while in the same context farmers from the first category did not revert to conventional practices. Some decided to apply one more treatment for diseases, and increased the doses. Some even stopped listening to the IPM advisors and turned back to more conventional advice. The reversibility of their trajectories confirms this persistence of productivist attitudes that has been shown by various studies of farmers’ decision-making processes (Walford, 2003; Burton and Wilson, 2006). However, it would theoretically be easier for these farmers to turn to IPM once again and significantly reduce their use of pesticides if the regulations were to change or if significant incentives were to be launched, because they would already have experience of it.

Finally, some farmers remain hesitant or reluctant with regard to integrated production (third type of trajectory above), mostly because they know little about it and are afraid of failing and losing their crops. In terms of crop protection strategies, they apply planned treatments. Some are not convinced of the positive effects of IPM techniques in terms of net margins and technical results. They might also be reluctant because they feel there is no urgency, and would turn towards IPM if the pressure from the government and from the market were to intensify. Skeptical farmers are usually not close to colleagues who have turned to IPM, and might also lack a concrete access to IPM growers’ experiences. Finally, they are likely to be in contact with advisors from the input suppliers and cooperatives, as in the second category of reversible trajectories, rather than with advisors from the “Chamber of Agriculture” system — which is operated independently of the suppliers —, as in the first category.

Table 2 presents these three types of trajectory and their characterization in terms of progressingness of the trajectory, crop protection strategies, degree of application of IPM recommended principles, average length of crop rotations (an indication of the degree of specialization/diversification that was also assessed in the case of organic farming), type of advisor, and TFI (Treatment Frequency Index, i.e., number of applications of pesticides with standard approved dosages on a given plot).

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8 A scheme which was implemented from 1999 to 2003 and gave farmers strong incentives to make their practices more environmentally friendly.
Other characteristics such as level of education and age do not appear very significant in these case studies, contrary to most theories on the diffusion of innovation (Mante and Gerowitt, 2007). However, the data show that very young farmers are less likely to convert to IPM because they are less likely to take risks, for financial reasons (as assessed in other studies: see Burton and Wilson, 2006) or because they lack skills and experience or may not be independent from the former generation who is still on the farm. The cohabitation of two generations often hinders changes in practices.

Aspects linked to professional networks are of major importance. In the two regions under study, the IPM farmers who were interviewed belonged to an IPM group and met every month with their local advisor who had specialized in IPM. Belonging to this group helped them to overcome technical problems by collectively finding solutions adapted to their situations.

The effects of collective dynamics and networks on learning and technical change have been studied extensively. In professional groups and networks, whether local or not, farmers can advise one another on technical aspects and give one another moral support (Darré, 1994; Norton et al., 1999; Collet and Mormont, 2003; Compagnone, 2004; Léger et al., 2006; Warner, 2007). In this case, it also helped them to build a collective identity in a professional world that is largely skeptical. Actually, the main reference when farmers compare themselves to others remains yields. This is the basis of the classical definition of the “good farmer”, although the regularity and neatness of their fields are also important factors in this definition (Burton, 2004). Turning to IPM requires farmers to change their conception of what a good job and a beautiful wheat field mean, as they have to accept the fact that their yield will probably be lower (but their gross margin comparable or better, depending on circumstances) and that their wheat fields are going to be more irregular at the beginning.

Turning to low-input practices might hurt the bases of farmers’ professional identity and the image of professional excellence, even though these farmers often said that they were also re-discovering the core identity of their profession and that they liked the experimental and technical sides of such changes. The fact that belonging to these groups helped them to overcome the apprehension linked to profound changes in their practices indicates that risk aversion is as much collective as individual — contrary to prevailing economic interpretations. These farmers do not only practice integrated pest management, they are also well integrated themselves in the sense that they all belong to various networks. Indeed, they are far from being isolated.

5. Some conditions for a robust ecologization of agriculture and agrifood systems

Studying transitions towards organic farming and IPM through an approach combining a sociological analysis of farmers’ trajectories and the ESR framework allows us to identify two main types of transition: progressive and robust transitions on the one hand, and more direct and reversible transitions on the other. A progressive and robust transition usually leads to the implementation of a system redesign paradigm, through a complex, long and often non-linear process. This process goes through one or both of the other two paradigms: through the efficiency paradigm, in the case of IPM (or while in conventional agriculture for those who converted to organic farming), and/or through the input substitution paradigm, in the case of organic farming or IPM (introduction of biological control in fruit and vegetable production, for example). The advocates of a systemic vision of agriculture would consider the system redesign paradigm as the basis of a real ecologization of agriculture allowing for real environmental and even social benefits, while they would consider the paradigms of efficiency or input substitution as mere “greenwashing”, where nothing changes fundamentally. Actually, it is likely to be far more complicated than that, for two main reasons. First, a farmer’s position in a paradigm describes a stage in a longer trajectory and is subject to change and also to overlapping, as demonstrated by the trajectory analysis. Second, the actual impact on the environment of the agricultural practices related to each paradigm is different to what is expressed in the farmers’ conceptions and practices, analyzed in this paper from a sociological point of view. In this regard, input substitution practices in organic farming would still have a general positive impact on the environment when compared to conventional practices. Moreover, OF environmental impact is very complex to evaluate as some inputs which are eligible in organic farming such as copper are considered by some experts as dangerous for the environment. Regarding IPM, the Treatment Frequency Index appeared to be much lower in situations which could be related to the system redesign paradigm (2.8, see Table 2) than for practices dealing more with the efficiency paradigm, even though the latter have a better ratio (4.9) than conventional practices in the same area (6.1).

However, over a longer time period “efficiency” and “substitution” practices might prove rather unsustainable in agronomical and environmental terms (because of long-term impacts on soil quality, for example) as well as in social terms. When the paradigm of substitution also characterizes the marketing modes and when organic farmers substitute organic long supply chains for conventional ones, they are likely to remain dependent on corporate actors and not to change much in their working and living conditions or those of their workers. This has been discussed in the debate over the conventionalization of organic production (Guthman, 2004; Smith and Marsden, 2004). In some cases though, it appears that “efficiency” and “substitution” practices might be more sustainable in economic and social terms, for example in the case of middle-sized organic farms whose entire conversion to diversified production (and direct marketing modes) would mean unbearable workloads and a diversity of skills that is not easily imaginable in farming of that scale. In such cases, collective dynamics and complementarities between neighboring farmers might make it possible to reach a stage of system redesign which would then probably qualify a small territory consisting of a group of farms rather than a single farm. This point would need to be explored in further research.

With these nuances, this study enables us to identify the conditions for sustainable changes in practices, whether in conversion to organic farming or in transition towards IPM. Three main sets of conditions appear to be present in both cases and therefore allow for theoretical transfers and continuities between organic farming and IPM: antecedents along farmers’ trajectories, insertion in networks and collective dynamics, as well as inclusion of food distribution and consumption practices in the conception of transitions.

The first type of condition, antecedents along farmers’ trajectories, appears to be a determining factor in transitions towards both organic farming and IPM. Regarding organic farming, four main kinds of antecedents while the farmer was still involved in conventional farming can be identified: a reduction in pesticide use with or without any technical support; an introduction of alternative crop protection methods such as biological control; organic trials on limited plots; and an incentive to implement environmentally friendly practices in the framework of agri-environmental schemes (or, in France, CTE, with financial and technical support).

9 It is important to note that the TFI is an indicator of pesticide use whose link to the potential environmental impact of practices is subject to controversy.
This concerns farmers converting to organic farming from conventional agriculture, and we may wonder if this notion of antecedents is also relevant to farmers who start directly with organic farming. In the few cases of newly-established organic farmers, some antecedents were also found, although they primarily concerned former professional activities or hobbies which expressed farmers’ sensitivity to environmental issues, for instance a longstanding practice of private gardening according to biodynamic principles or an experience as an advisor in organic production or as a park ranger.

Regarding IPM, similar antecedents were found and most farmers had already experienced input reduction and/or taken part in an agri-environmental scheme or a CTE (the case of 8 out of 17 of all “robust” IPM transitions compared to 1 out of 10 for “reversible” transitions and conventional farmers in the set of 27 arable crop farmers). These prior experiences provide a practical basis for a progressive change in conceptions and in turn allow the adjustments necessary in farmers’ occupational identity. For example, they help farmers to move from a conception of excellence that is mainly based on yields towards one that would aim more at technical and environmental achievements.

The second type of condition concerns collective dynamics and networks. Farmers are in no way isolated rational economic actors, and in both organic farming and IPM their insertion in professional and social networks is a determining factor in their transitions. These networks appear to be quite different in the two cases. Although most organic farmers talked of important contacts and networks in their conversion (through specialized advisors, trainings, neighbors, sometimes consumers), very few belonged to a regular and formal farmers’ group. They reported that they exchanged a lot of information with other organic farmers in informal local networks and were often involved in regional and/or national organic networks. Moreover, as some of them marketed their products directly, they were also involved in non-agricultural networks with consumers and sometimes local civil society organizations. This further helped to increase their sensitivity to environmental issues and civil society expectations. These differences in terms of types of collective and modes of learning between IPM and organic farming would warrant further research.

In contrast, this is a specific difficulty of IPM as opposed to organic farming, and of cereals as opposed to fruit and vegetables. As there are no specific label or marketing networks, or even a stabilized image of IPM for the consumers of these products, and as cereal products are not consumed directly and are rarely marketed through direct schemes, farmers are unlikely to feel reassured by consumers about their transitions. They are also unlikely to feel supported by civil society in general, as IPM lacks legitimacy: for example, local authority support programmes for agriculture rarely mention IPM or low-input agriculture and mainly target organic farming. However, this might change due to the consequences of the application of future regulations regarding water quality and pesticide use. In this general perspective, we can expect IPM farmers to feel more concerned and to become more involved in environmental debates at local level, especially around issues of groundwater quality and biodiversity. However, this would imply, conversely, that local stakeholders are more willing to consider not only organic farming but other alternatives as well.

In the case of IPM, the lack of direct interactions with consumers and civil society makes collective dynamics between farmers all the more important. My fieldwork provides evidence that belonging to a group affords access to positive feedback in a professional world which tends to be skeptical.

The third condition for sustainable transitions concerns the inclusion of food distribution and consumption practices in the conception of these transitions. IPM, when applied in an essentially systemic manner, and organic farming have one point in common: the difficulty of producing products which respect the standards imposed by the market, such as visual aspect and size of fruits and vegetables, and technical criteria such as protein content for wheat (given that a high protein content is achieved by a high level of input, especially fertilizer). Developing OF and even IPM practices in a system of quality rules and codification that is driven by product aspect and standardization is nearly impossible, as the reduction of pesticide use usually has an impact on these criteria. This is an example of lock-in effects within the agrifood system. From the point of view of retailers and marketers, it is not possible to change much, due to the “consumer demand” for perfect and regular products. However, market sociologists have shown that such criteria result from a construction of quality that is aimed at managing products’ transport and marketing, and not at satisfying consumers’ spontaneous “social demand”, which is also socially-constructed (Dubuisson-Quellier, 2003). Therefore, changing agricultural practices is not enough, and changes should also encompass food systems, as the theoreticians of agro-ecology, among others, argue (Gliessman, 2007).

In contrast, in some alternative systems such as the French Associations pour le Maintien d’une Agriculture Paysanne (AMAP) and other Community-Supported Agriculture-type box schemes, one of the main principles of the partnerships defined jointly by producers and consumers is that these consumers accept irregularities in both production (the content of the box) and products (their aspect and size). This is facilitated by the direct interactions between the two during the weekly deliveries, and by specific meetings and leaflets (Lamine, 2005). These systems also guarantee farmers a regular income, which enables them to take certain technical risks, especially regarding crop protection strategies and, in most cases, including a conversion to organic farming. The case of these systems shows not only that farmers may have to adjust their identity and conceptions, but also that such an adjustment involves consumers or market intermediaries in terms of acceptance of products’ irregularities and/or even of involvement in production tasks in some cases. However, these alternative systems remain limited to certain types of consumers, namely those with a high level of education, though often not a high income, and to certain types of producers, usually small farms and almost no arable crop farmers. Two crucial questions for future research thus emerge. First, how can general principles of mutual commitments of producers and consumers towards more ecological practices be extended to more consumers and producers? Education or, more generally, public sector food procurement is certainly one of the possible ways. Second, how might traditional market actors such as retailers favor more ecological practices by relaxing strict criteria in terms of visual quality, while maintaining or improving sanitary, nutritional and gustative quality?

6. Conclusion

In this paper I have drawn on the cases of conversion to organic farming and transition towards IPM in order to analyze the processes and conditions for a robust ecologization of agricultural practices.

For my analysis of the complexity of the processes of change that farmers experience when turning to more ecological practices, I have adopted an approach combining a sociological analysis of farmers’ trajectories and insertion in networks, with the ESR framework developed by the biological and agricultural sciences. Based on the study of farmers’ life histories, I have analyzed the intricate changes they experiment in their agricultural practices and, more largely, in the different aspects of their professional and social activities. Based on the ESR framework, I have characterized
the degree and nature of the changes in technical practices, according to three paradigms: (input) Efficiency, (input) Substitution, or (system) Redesign.

This combined approach has enabled me to identify two main types of trajectory towards organic farming or IPM, according to their degrees of progressiveness and redefinition of technical practices: progressive and rather robust transitions leading to a redesign of farming systems, and more direct and sometimes more reversible transitions where technical practices can be related to the input substitution or the efficiency paradigms. This comprehensive analysis, based on qualitative and ethnographic methods, allowed to show that the three paradigms of the ESR grid can be used to characterize changes not only in technical practices but also in the diversity of farm productions and activities, in marketing modes and in interactions with advisors or, more generally, insertion in social networks.

This study also led to the identification of three main conditions for robust transitions towards organic farming or IPM. The first one concerns the progressiveness of transitions and the presence of antecedents in farmers’ trajectories. One of the possible practical applications of this result is that, for extensionists who are involved in driving changes, it would be helpful to identify and build on these antecedents. The second important condition concerns collective dynamics among farmers at local level where they can meet and share their difficulties, solutions and doubts, especially in the case of IPM where, unlike organic farming, institutionalized or militant professional networks are scarce. It is therefore important for extension services and public policies to initiate or support such collective dynamics. The last condition concerns the inclusion of food distribution and consumption practices and, more generally, the interactions with the non-agricultural sphere. The legitimation of organic farming in civil society in environmental and health terms is one of the reasons for the recent increase in organic consumption, while the lack of legitimation in the institutional and professional world is probably a reason for the slow development of organic production in France. It is even worse for IPM which is neither legitimated nor codified by laws and regulations.

This comparison of organic and IPM farmers in France has provided a more generic understanding of the processes of transitions towards more ecological modes of production and the possible transfers between these two kinds of agriculture, despite all their differences. The case of organic farming is rarely confronted with other forms of ecological agriculture although such comparison can further our understanding of the conditions of transition for producers who often do not switch directly from conventional (intensive) to organic farming. In this perspective, the application of the ESR grid to the two case studies has also shown that transitions are not linear. Efficiency, Substitution and Redesign correspond less to successive stages than to overlapping, lasting periods in farmers’ trajectories. It means that the complexity and overlapping of the stages of these transitions have to be acknowledged in order to analyze them or, in terms of possible practical applications, to accompany them efficiently.

Finally, this grid and these paradigms do not have to be seen in a normative way. Studies on agricultural transitions often rely on the assumption that the end of the spectrum (redefinition here, strong multifunctionality in studies of transitional pathways towards multifunctionality, see Wilson, 2008) is the best and the most moral type of agriculture. Even though this is often the way citizens, policy makers or farmers themselves see it, this study also suggests that “intermediary” stages or paradigms such as efficiency or substitution may be more viable in social and economic terms for some farmers, and certainly much better than their former conventional practices, or those of their neighbors, in environmental terms. Further research should investigate this point which requires a combination of ecological, social and economic assessment and of quantitative and qualitative approaches.

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References
