Practising agroecology: management principles drawn from small farming in Misiones (Argentina)

Girard N.[1], Magda D.[1], Noseda C.[2] and Sarandon S.[3]

[1] *INRA-SAD, UMR AGIR, B.P. 52627 Auzeville, 31326 Castanet Tolosan (France)*

[2] *Ministerio de Agricultura, Subsecretaria de Agricultura Familiar, Buenos Aires (Argentina)*

[3] *Universidad Nacional de La Plata (UNLP) - Facultad de Ciencias Agrarias y Forestales (Argentina)*

Abstract: In face of agricultural sustainability challenges, agronomical research has focused its efforts on the design of new production systems. In parallel, ethnographic-based studies of small farmers' practices in developing countries have shown the sustainability of the so-called traditional production systems and put them forward for the ecologisation of agriculture. Nevertheless, a gap remains between the rules used for agroecological design and the local practices of particular farms. Our objectives are then to draw principles for agroecological management from the in-depth study of farming practices in ecologically-based farms (Altieri, 2000). Our strategy was to study small family farms in Misiones (Argentina). Far from single-crop farming, producers cultivate many different species in the same place at the same time, mainly to save labour and space. They also take into account negative and positive biological interactions between crops, mostly related to shade and light. The location of each crop and the interweaving of crops and livestock is decided at a micro-scale of individual plant or animal. Moreover, organising this diversity within a farm revealed itself as a socio-cognitive activity embedded in social networks of producers. These observed practices can be sumed up in three management principles: i) adjustment and observation instead of control, ii) Variable temporal and spatial units within a flexible management iii) Permanent on-farm experimentation and specification of technical options. We discuss our results regarding the genericity of these principles and discuss the research paths to take these agroecological systems as models for the ecologisation of conventional systems.

Keywords: agroecological management, diversity, practices, empirical knowledge, Argentina, small-scale farming

Closing the gap between agroecological rules and local practices: a challenge for agroecology

In face of agricultural sustainability challenges, agronomical research has largely focused its efforts on defining agroecological rules that new production systems and practices could respect to be more sustainable. To a large extent, these rules are grounded on ecological concepts mainly related to the functional role of biodiversity, thus stating that ecosystem maintenance guarantees the sustainability of productive systems. Nevertheless, agricultural systems and ecological processes may be connected in many different ways, thus contributing to the debate on the diversity of agroecological models. According to the degree of this connection, Wilson (2008) have distinguished weak ecologisation of agriculture to qualify agricultural models which try to reduce negative impacts of agricultural practices on environment from strong ecologization defined as a way to take advantage of ecological processes within the productive process. Horlings and Marsden (2011) enlarged this view to weak ecological modernisation which may decrease environmental effects to a certain extent and strong ecological modernisation including social, cultural, spatial and political aspects.

On the other hand, ethnographic-based studies of small farmers' practices and knowledge in developing countries have shown the sustainability of the so-called “traditional” production systems (e.g. Izquierdo et al, 2003; Abbona et al, 2007) and put them forward as a resource (Gliessman, 1992), as agroecological models (Lopez-Perez et al, 2002) and as an “ingenious agricultural heritage” (Koohafkan and Altieri, 2010) to guide the transition towards more sustainable production systems. As a result, some authors like Altieri and Toledo (2011) consider that "*modern farming systems will necessarily have to be rooted in the ecological rationale of indigenous agriculture and that promising agricultural pathways, modeled after traditional farming systems, can help in the design of a biodiverse, sustainable, resilient and efficient agriculture*". Nevertheless, these authors do not really explicit how such sustainable agriculture can be “*modeled after traditional farming systems*”.

As a result, a gap remains between the general rules used for agroecological design and these specific sustainable systems. Several authors have pointed out the necessity to bridge the design of sustainable systems from agroecological rules and the analysis of “traditional systems” showing a very low degree of artificialization (Altieri, 2009; Malézieux, 2012; Toledo et al, 2003). In such studies, these “ecologically-based farming systems” (Altieri et al, 1983) are used as good examples of sustainable systems respecting agroecological rules, but no lessons are really drawn from their situated functioning. While agroecology severely questions the applicability of scientific knowledge assumed to be universal across local situations and calls for a relocalisation process of knowledge production (Warner, 2008), the question remains on how produce generic knowledge from agroecological practices and knowledge emerging in particular action situations (Lyon et al, 2011). Agroecology is now facing "*a greater conundrum of how to relate the general knowledge of science to the place-specific, experience-based knowledge of [...] farmers*" (Lyon et al, 2011).

Our objectives was then to draw principles for agroecological management from the in-depth study of farming practices and knowledge in the case of agricultural systems showing exemplary features of ecologically-based systems. Beyond the observed practices which may appear very idiosyncrasic or context-dependent, we argue that they exemplify management principles which are more generic.

Material and methods

Our strategy was then to describe farming practices and knowledge within small family farms considered as typically organized on ecological basis, that is with a high level of agrobiodiversity and no chemical inputs. Within a joint Argentinian-French cooperation program, our study was undertaken in the Misiones region (located in the northeastern corner of Argentina) which shows a subtropical climate and an ecosystem characterized by hot summer and without dry season, which makes Misiones one of the most humid provinces in Argentina (average annual precipitations from 1600 to 2000 mm). The natural vegetation is the original and typical "Selva Misionera", the ecosystem of greatest biodiversity and ecological complexity of the country. Its topography is strongly undulating with altitudes reaching up to the 800 mts, with red and clay soils, fragile and very eroded. Part of this forest has been transformed to implant ranching and cultures such as yerba mate, tea, citrus, tobacco and sugar cane. Misiones' region shows nowadays a very polarized productive matrix with on one hand an economy based on small-scale farming producing a wide range of vegetals and animal products for family needs and for local markets and on the other hand large estates with mainly forestry industry.

The study used a case-based method (Mitchell, 1983), in which we selected a sample of 6 family farms according to structural criteria such as the farmland size (from 2 up to 42 ha), the family composition (from a couple up to a complex family with 3 generations living in the same house), their level of capitalization (farmers who do not own the land up to farmers investing in new lands)... These farms also show a high diversity of products (see Table 1), and as a consequence a high number of different crops, associated with livestock units. Such a diversity can first be explained by the aim, shared among all producers, to produce a weathly and diverse food for the family while selling the excess of food when there is some. Feeding the animals is also a need which they integrate in their food balance. Nevertheless, some producers also cultivate to make an income, in order to pay the school for children or land taxes.

Data were collected in 2012 and 2013 with a comprehensive procedure. Data collection was based on at least two semi-structured interviews (along with walking around farm fields) entering the following topics: farm history and family, objectives, products (diversity and use), technical practices, knowledge sources and networks. All interviews were recorded, transcribed and structured in a database using NVivo computer-aided qualitative data analysis software. This information was then coded and inductively analyzed using a strategy close to the "grounded theory". Farming practices were first analyzed with a within-case approach (Miles and Huberman, 1994) to abstract the "realized strategy" of each farmer, i.e. the combination of practices he implements (Mintzberg and Waters, 1985; Girard and Hubert, 1997). In a second step, we compared the practices with a cross-farm analysis (Miles and Huberman, op.cit.): within an inductive approach and an abstraction process that is deeply rooted in what farmers currently do, and not in a priori literature-driven categories, we thus characterize management principles which were common among all studied farms.

Results

Practising agroecology by managing diversity in time and space

Which species diversity?

These farming systems show a high diversity given by their food need and their autonomy objective as well as their permanent adaptive attitude taking advantage of opportunities emerging on the way. As a result, all farms show a high **diversity in cultivated species** (from 25 to 45 different species and up to 5 varieties by species), going with a diversity of use of each product. There are crops that are grown in all the farms such as maize, manioc, pumpkin, vegetables, citrus fruits, banana, although in variable area for each. Other crops can be found only in some farms according to the preferences of each family as well as the local market demands. The main difference found among the studied farms was the part of the forestry component (natural or planted) since only two of the farms plant trees to obtain wood for commercial purpose. It can be explained by the available space, their attitude towards long term and tenure security. All producers told us that as far as they can remember, there has always been diversity on their farms, as a permanent feature strongly linked to their way of life.

The diversity of cultivated varieties can also be seen as the result of an opportunist strategy in seed origins. Even if the basic principle is to keep home-produced seeds, allowing producers to choose the variety they like without purchasing them, most of them take advantage of free exchanges to enlarge their panel of cultivated varieties and to test new ones. Purchasing seeds from the local store is generally seen as the last solution, whereas, on the contrary, some of the producers even take advantage of spontaneous seedlings, with specific management practices (e.g. replanting spontaneous seedlings in more favourable places). In some farms, this system goes with a timing of planting/harvest dates so as to have the greatest diversity of products to be sold on the local market at each moment of the year or to have a large harvesting period.

Cultivating different species in the same place at the same time

Far from specialised agricultural systems relying on single-crop farming, all producers cultivate many different species in the same place at the same time. Table 1 illustrates the species combinations practised by one producer, each specie being in interaction with up to 14 species.

Table 1: Example of combinations of species ("X") carried out by a producer in Misiones

	Cedar	Lemon	Corn	Manioc	Pineappple	Watermelon	Pumpkin	Banana	Bean	Stevia (sweetleaf)	Sugar cane	Cucumber	Melon	Native trees	Onion	Lemon verbena	Number of combinations in which the specie participates
Lemon	X		X	X	X	X	X	X	X	X	X			X	X	X	14
Cedar		X	x	X	X	X	X	X	X		X			x	X	X	12
Watermelon	X	X	X	X	X		X		X			X	X	X	X		11
Manioc	X	X	X		X	X	X		X	X				X	X		10
Corn	X	X		X	X	X	X	X						X		X	9
Pineapple	X	X	X	X		X	X		X	X				X			9
Native trees	X	X	X	X	X	X		X									7
Pumpkin	X	X	X	X	X	X			X								7
Bean	X	X		X	X	X	X										6
Onion	X	X		X		X		X									5
Banana	X	X	X											X	X		5
Stevia (sweet-leaf)		X		X	X												3
Lemon verbena	X	X	X														3
Sugar cane	X	X															2
Cucumber						X							X				2
Melon						X						X					2

Producers justify this practice of mixing crops by different arguments.The main argument is the maximum use of space in their relatively small farmland, which incites them to plant for example pumpkin on the edge of plot of corn to save space. Another organisational argument is limiting the work load by taking advantage of a synergy between two technical operations. For example, one of the producers take advantage of the uprooting of garlic to plant his peanut in the resulting clean area. Nevertheless, some arguments put forward by producers are related to ecological processes. In particular, some of them rely on a specific knowledge of soils, using their experience of the results obtained in the previous years and thus putting a specific crop in a specific place regarding to "what is of use the soil". In this case, the combination of crops in the same place is only the consequence of a 'precision' reasoning process on the individual location of each crop.

However, most producers also take into account potential biological interactions between crops when trying to avoid negative combinations: they cultivate together only species which he/she knows that "do no harm to each other", arguing that some species combinations are negative and thus prohibited. Producers have various explanations for these negative combinations. For pumpkin or cucumber with corn, they related it to spatial extension of these species: looking at the way these *Cucurbitaceae* spread out on the ground, producers consider that they can be cultivated on the edge of an area of corn, but not in the middle. As a result, some species such as cucumber or melon can be cultivated only apart, whereas other ones can be combined with more than 10 other species without problem (table 1). For some other negative combinations, they only notice the negative effects of combining two species such as that they do not give fruits or that they do not have roots. When investigating their underlying spontaneous theories of these negative combinations, we found that most of them relate them to issues of shade and light and qualify crops and their relations according to the pair of "caliente-frio"[237] opposites, whereas with very different meanings. For some producers, this qualification concerns one crop and its relation to others: this is the case of a producer who considers that corn is "caliente" (hot) and cannot be cultivated with anything other species. As a result, she cultivates corn at a low density, referring to the positive effect of wind refreshing the crop between the rows. For other producers, the opposite "caliente/frio" qualify the relation itself, and not the species. For example, the producer whose practices are described in table 1 qualifies manioc as "caliente" for other plants (watermelon, bean), as well as watermelon is qualified as "frio" (cold) for manioc. For him, it may be different according to the variety, with the example of large leaves of a manioc variety creating more shade. One then explains that the distance between rows has to be calibrated to provide the mixed crops (in his case corn, watermelon and bean) the right balance between light and shade according to the different stages of crops. He even identifies a sensitive stage when seedlings should not be too much in the shade of the corn. Another producer sums up that "*shade is good and bad*" to put forward the necessary balance between them. This light-shade opposite is often related by producers to the issue of humidity (or in contrast to drought) produced by a crop: shade is related to terms like maintain, and its opposite "light" with expressions such as "*drinks the water*", "*dries the soil*", "*burns the fruits*". As a consequence, the spatial combination of species has to be organised in time, to take into account the development stages of each crop. Avoiding a negative combination may thus be solved by "planting in time". For example, garlic and peanuts planted together is possible at a stage (garlic "*which has a head*") which triggers the planting of peanuts because at this point, one is not detrimental to the other.

Beside these positive species interactions referring to trophic resources (light, water), the only biological regulation of crop pests explicitly expressed by producers is about bean and tobacco: one producer cultivates tobacco in the middle of beans which plays, according to this producer, the role of repellent for a pest of tobacco.

Combining crop and livestock at the plant and animal scale

There is a strong relation between animal feeding and crops since most of the animal food is produced on the farm (specific crops or by-products of crops for family food), at least for local breeds. As a result, all parts of cultivated plants (leaves, stems...) are used to feed the animals within a more general philosophy of "nothing is lost when there is animals", especially with unsold products. Taken as a whole, producers' practices take the most of the diversity of resources produced on farm for animal feeding: their use is decided on the way according the crop state, the current yield of other crops, the family needs, thus giving the system a great temporal flexibility. In this totally intentional interweaving of crops and livestock, they favour a micro-level reasoning, at the plant and animal scale. For example, they give permanently a dual-purpose to corn (food/grain), with a practice of planting 4-5 seeds per hole for maize. With the classical agronomic viewpoint, such practice can be seen as a source of competition between plants detrimental to crop yield. In doing so, if more than one come out, producers obtain clumps of 4-5 feet of corn. The smallest plants will be thinned out gradually when there is a need of them to feed the pigs or kept as stockpiled food for later uses, within a strategy of animal food insurance *"for periods of lack of fodder".* This multiple seedling practice is described as traditional by the producers themselves and seems to come from the former generation of producers.

Diversity as a result of a socio-cognitive activity

Far from the idea of an isolated practice, organising the diversity within a farm revealed itself as a socio-cognitive activity which is largerly embedded in social networks of producers. For exam-

[237] Hot/cold

ple, the high diversity in cultivated varieties results from exchanges of seeds or plants with family members, neighbours, local advisors and other producers met at seed festivals, as well as the national extension project on vegetable gardens. As a consequence, seeds used may not only be "local", but are surely the outcome of local exchanges between producers and their acquaintances.

Facing such a diversity of varieties and crops, all producers put forward their need of technical knowledge[238] to organise and steer their production. For all producers who were born on farms (i.e. all producers of our sample except one), they acquired this knowledge since childhood with their parents and transmitted it to their children, thus giving to their practices the legitimacy of an inheritance as well as permanency. Their very frequent use of "always" highlights the validity of their practices, reifying them in a "style of planting" which has never failed and leaving useless any question about why doing so. The one who was not born on a farm learned from her husband, observing him, but also following technical training courses and participating in producers groups, thus placing her activity in many networks. This search for new knowledge within networks of producers is common to all the producers studied, whether they are born or not on a farm. The most cited source of knowledge refers to exchanges between producers and the experience that each producer can take to his/her farm, some of them becoming themselves a source of knowledge for others by their activist involvement in extension groups. Nevertheless, the "local nature" of small producers' knowledge seems to be more a myth than a reality since most of them rely on many different sources of knowledge to perform their activity, even remote ones such as the Paraguayan TV. One producer refers also to the bible to explain his way of cultivating, as the higher principle which guides his life, and in particular his relationship to nature. Others draw from their knowledge of a previous work experience (e.g. in a company of citrus to make grafts).

Agroecological management principles

From these practices in ecologically-based farming systems, we have extracted three agroecological management principles. The expression "management principle" refers to the common coherence of the spatial and temporal organization of the practices carried out and their underlying logic, following Mintzberg and Waters (1985) and Girard and Hubert (1997).

Adjustment and observation instead of control

The first one is to **favour an adaptive management** relying on frequent observations of crops state and dynamic, with few intentions of prediction, planning and rigorous control of productive processes. Contrasting with the classical planification and prediction paradigm which guides the management of crops in the industrialised agriculture, these producers clearly show a preference for adjustment: as external interviewers, we found it very difficult to formalize the calendar of cropping activities, as if each action is decided on the way. Beyond this apparent improvisation, what seems to be a management principle for them is the idea of taking advantage of circumstances, as shown by the many occurences of the word "aprovechar" in the interviews. It goes with a certain position regarding risks, as shown again by the practice of planting 4-5 seeds per hole for maize. Far from the classical agronomical strategy of risk reduction by processes control, such multiple-seeds planting practice plays in fact the role of a risk insurance policy for the maize production, since producers explicitly hope that at least one will come out. At the individual scale, these adjustments strongly rely on observation and remembering skills, as shown by a producer who go back frequently to past results and observation to justify a decision. This producer seems to have a really good memory of past years and is able to reconstruct crop sequences on her farm for many years. Observation is thus incorporated into daily routines for many producers

[238] "Technical knowledge" refers here to the knowledge and know-how regarding the production process (and not to standardised knowledge which can be brought by technical advisors)

for whom walking around in their farmland and observing what is going on is seen as a daily and enjoyable activity. By contrast with the importance of observation in their management, their knowledge may seem approximate since they cultivate many varieties which they do not know the name. More than the scientific identification of a variety or a population, what is important to them is the cropping or cooking properties of these varietes: as a consequence, they have very precise expectations about each of them regarding their role in the cropping, farming or even family system.

Variable temporal and spatial units within a flexible management

In the same line, **the second principle is to organize production in time and space in a very flexible way**. Their "taking advantage of circumstances" strategy brings to give up with the *ex ante* planning of stable temporal and spatial objects: their management relies on various spatial units which additionally vary over time, then giving flexibility to their management style. In particular, with the high degree of diversity and the complex combination of various crops in the same area (see 3.1.2.), agronomical plots do not exist anymore in these farms. On the contrary, their practices open the continual (re)-definition of situated boundaries of cultivated units, whether it be "patch", "line" or even "plant". In the same way, the classical agronomic concept of "planned crop sequence" is of limited use in their management since they do not seek for high prediction of cropping yields, showing a somewhat fatalistic attitude towards hazards related to their religious beliefs. As a consequence, at each moment of the year, there are very few fixed boundaries or deadlines to conform with. Many decision possibilities stay open all along the year in terms of planting, thinning out and harvesting.

Permanent on-farm experimentation and specification of technical options

A third principle is to **permanently experiment to check and specify** technical options regarding their specific farmland, putting learning-by-doing processes at the heart of their knowledge system whereas generic knowledge is often largely mistrusted. Whatever its origin, the knowledge which is used is almost always tested to see if it works "at home". They perform many on-farm experiments, which practice appears frequently and spontaneously in their discourse, with a high frequence of words such as "testing", "searching" or "studying", just as if they were researchers! The (quasi) mandatory nature of this on-farm validation can be linked to the mistrust that the producers express regarding general rules which are considered as not necessarily valid. Most producers insisted repeatedly that practicing and observing what is really happening on the farm are the only ways to learn. For example, a producer's wife explained that one time, they were expecting good results for pineapple because the soil was "new" (general rule) and that has not been the case. She carried on her example by saying that on the contrary, when they tried to grow pineapple on a place looking like a pasture with a hard soil, they had good results. They concluded that it was worth not following the general rule and trying to plant, enabling them to identify the favourable context (here the degree of sunlight) for a specific crop. Some of them are conscious that the knowledge they produce can be controversial regarding legitimated technical knowledge, but they strongly affirm the value of their own experience. Experiments can also be performed at the collective scale, i.e. during exchanges between producers, which highlight the diversity of their worldviews. These exchanges mix discussions between producers and collective real tests of practices to see what works.

Discussion and conclusion

Whereas ecologically-based agricultural systems have been mainly described as alternatives to the conventional ones, leading some authors like Lyon *et* al (2011) to call them "*farming without a recipe*", our results provide positive insights by scaling up ecologically-based practices in three management principles. Drawn from idiosyncrasic practices of small producers in Misiones, their genericity has to be questioned. At a first level, some of the practices of Misiones farms can be found elsewhere in the world. Multi-species cropping, such as the “milpa” model is very common in South America, as well as the complexity of spatial management units and crop combinations (Toledo et al, 2003). Moreover, avoiding negative combinations of crops is a practice which has been reported in Africa by Séhouéto (2006) and the opposite “caliente-frio” as the conceptual basis for reasoning crop combinations seems also to be classical all over South America (Cerdan et al, 2012). Close to our European systems, the farmers' attitudes facing hazards in Misiones is not so far from the attitude called “diversifying to mitigate the effects of hazards” described by Girard and Hubert (1997) in sheep farming systems of southern France. On a second level, the flexibility of decision making in Misiones with possibilities staying opened all along the year in terms of cropping operations can be seen as specific to subtropical climate context where light, heat and humidity are not constraining ecophysiological processes. Nevertheless, such a flexible and complex management has already been described for market-gardens in France (Salmona, 1994). While some agroecological principles may be inappropriate in new ecological settings (Abbona et al, 2007), they could perhaps be generalized in terms of the nature of uncertainties (Voß et al, 2007) that are facing farmers all over the world, more or less independantly with their climate context. At a third level, what remains to be investigated is the relevance of our management principles for other farming systems with various functional relationships between production and ecological processes, including more intensive farming.

By describing the management principles underneath the high biodiversity of these systems, we have also contributed “*to turn the ‘problem’ of diversity and context dependency of agricultural practices into a real ecological and social virtue*” (Harlings and Marsden, 2011). Moreover, far from taking local knowledge as the panacea for sustainable systems or as a green alternative to scientific knowledge (Murdoch and Clark, 1994), our results put forward the need for further research on the link between action and knowledge processes and the possibility to generate technology “*as a demand-driven process and spatially sensitive*” (Harlings and Marsden, 2011). Nevertheless, we did not analyse directly the process of ecologisation, its driving forces and dynamic. Taking these agroecological principles as tools for the ecologisation of conventional systems brings about at the same time the Re-design of these systems (in the line of Ricci et al, 2011) and the change of management paradigms implemented by farmers. An opened research question remains on how to guide such a paradigm change within the transition process.

Acknowledgements:
This research was made possible by a grant from the Agence nationale de la recherche as part of the SYSTERRA Programme INTERRA ANR-09-STRA-04.

References

Abbona, E.A., Sarandon, S.J., Marasas, M.E., Astier, M. (2007). Ecological sustainability evaluation of traditional management in different vineyard systems in Berisso, Argentina. Agriculture, Ecosystems and Environment 119:335–345.

Altieri, M.A., Martin, P. B., Lewis, W.J. (1983). A Quest for Ecologically Based Pest Management Systems. Environmental Management 7(1):91-100.

Altieri, M.A. (2000). Multifunctional dimensions of ecologically-based agriculture in Latin America. International Journal of Sustainable Development & World Ecology 7(1):62-75.

Altieri, M.A. (2002). Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment 93,1–24.

Altieri, M.A. (2009). The ecological role of biodiversity in agroecosystem Agricultures, Ecosystems and Environnement 74:19-31.

Cerdán, C.R., Rebolledo, M.C., Soto, G., Rapidel, B., Sinclair, F.L. (2012). Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems. Agricultural Systems110:119–130.

Girard, N., Hubert, B. (1997). A conceptual framework to identify a diversity of farmers' strategies and responses to uncertainty in sheep farming systems of southern France. Proceedings of the 4nd International Symposium on Livestock Farming Systems, Foulum (Denmark), 22–23 Aug. 1996, EAAP Publication no.89, Wageningen Pers (Wageningen): 60–66.

Gladwin, C.H. (1989). Indigenous Knowledge Systems, The Cognitive Revolution, and Agricultural Decision Making. Agriculture and Human Values 6(3):32-41.

Gliessman, S.R. (1992). Agroecology in the Tropics: Achieving a Balance Between Land Use and Preservation. Environmental Management 16(6):681-689.

Horlings, L.G., Marsden, T.K. (2011). Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'. Global Environmental Change 21:441–452.

Izquierdo, I., Caravaca, F., Alguacil, M.M., Roldán, A. (2003). Changes in physical and biological soil quality indicators in a tropical crop system (Havana, Cuba) in response to different agroecological management practices. Environmental Management 32(5):639-645.

Koohafkhan, P., Altieri, M.A., Gimenez, E.H. (2011). Green Agriculture: foundations for biodiverse, resilient and productive agricultural systems. International Journal of Agricultural Sustainability 10(1):61-75.

Lopez-Perez, J.A., Bello, A., Garcia-Alvarez, A., Arias, M. (2002). Mediterranean agrosystems as an agroecological model for nematode management. In proceedings 4th International Nematology (Tenerife, SPAIN), Eds Cook, RC; Hunt, DJ. 2:71-84.

Lyon, A., Bell, M.M., Gratton, C., Jackson, R. (2011). Farming without a recipe: Wisconsin graziers and new directions for agricultural science. Journal of Rural Studies 27:384-393.

Malézieux, E. (2012). Designing cropping systems from nature. Agronomy for Sustainable Development 32:15–29.

McCorkle, C.M. (1989). Toward A Knowledge of Local Knowledge and Its Importance for Agricultural RD&E. Agriculture and Human Values 6(3):4-12.

Miles, M.B., Huberman, A.M. (1994). Qualitative Data Analysis: An Expanded Sourcebook. London, Sage Publications..

Mintzberg, H., Waters, J.A. (1985). Of strategies, deliberate and emergent. Strategic Management Journal 6:257-272.

Mitchell, J.C. (1983). Case and situation analysis. The sociological Review 31(2):187-211.

Murdoch, J., Clark, J. (1994). Sustainable knowledge. Geoforum 25(2):115-132.

Ricci, P., Bui, S., & Lamine, C. (2011). Repenser la protection des cultures: innovations et transitions. QUAE Editions.

Salmona, M. (1994). Les paysans français. Le travail, les métiers, la transmission des savoirs. Editions L'Harmattan.

Séhouéto, L. (2006). Savoirs agricoles localisés et production vivrière en Afrique subsaharienne. Revue internationale des sciences sociales 187:127-134.

Toledo, V.M., Ortiz-Espejel, B., Cortés, L., Moguel, P., de Jesús Ordoñez, M. (2003). The Multiple Use of Tropical Forests by Indigenous Peoples in Mexico: a Case of Adaptive Management. Conservation Ecology 7(3):9.

Voß,J.-P., J.Newig, B.Kastens, J.Monstadt, Nölting, B. (2007). Steering for Sustainable Development - A typology of empirical contexts and theories based on ambivalence, uncertainty and distributed power. Journal of Environmental Policy & Planning 9:193-212.

Warner, K.D. (2008). Agroecology as Participatory Science: Emerging Alternatives to Technology Transfer Extension Practice. Science, Technology & Human Values 33(6):754-777.

Wilson, G.A. (2008). From 'weak' to 'strong' multifunctionality: Conceptualising farm-level multifunctional transitional pathways. Journal of Rural Studies 24:367–383.