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Understanding the loss of traditional agricultural systems: A case study of orchard meadows in Germany

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Abstract

Traditional agricultural systems are being lost, along with their associated biodiversity and knowledge. These systems, however, could provide lessons for the development of more sustainable agricultural systems. Orchard meadows are a traditional agricultural system in central Europe that are currently undergoing precipitous decline. They are islands of biodiversity within a densely urbanized landscape and supported the food security of communities for hundreds of years. This study combines the problem-solving–oriented Root Causes Framework with the perspective of agroecology in order to examine the drivers of orchard meadow loss in the state of Baden-Württemberg, Germany. As we found, the loss of orchard meadows and their associated biodiversity is the consequence of a variety of drivers, including government policies and cultural attitudes. Furthermore, the erosion of knowledge about managing orchard meadows has itself become a driver of decline. However, the study also identified several novel market and nonmarket approaches to reversing the decline that actively engage citizens through education and training or offer real economic incentive to growers to cultivate orchard meadows.

Keywords

agroecology, biodiversity, Germany, orchard meadow, root causes, traditional agricultural system

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Introduction

The conservation of traditional agricultural systems is recognized as an important task by the United Nations Food and Agriculture Organization (FAO) through the Globally Important Agricultural Heritage Systems program (FAO, 2007). These heritage systems are landscapes that were shaped and maintained by farmers and herders using locally adapted management practices and building on local knowledge and experience, while hosting domestic and wild biodiversity. Traditional agricultural systems were adapted to local conditions over the course of centuries, providing food, fuel, and fiber to communities before the advent of modern nutrient and energy inputs.

Today, traditional agricultural systems around the world are threatened by rapid changes in technology, population, culture, and economy (FAO, 2007). Nevertheless, these systems can serve as models of highly productive agricultural systems that are not dependent on large nutrient and energy inputs, and thus offer lessons for the development of more sustainable farming systems for the future (FAO, 2007).

One example of a traditional agricultural system undergoing dramatic decline is the European orchard meadow (*Streuobst* in German, figure 1a). Remnants of the system, though often underutilized when compared to the past, are still found in Spain, France, and England in the west to Slovenia and Ukraine in the east. Traditionally, orchard meadows were an agroforestry system of standard-sized fruit and nut trees, diverse species (e.g., apple, pear, cherry, walnut, plum), varieties, sizes, and ages. Below the trees, farmers grew field, forage, and horticultural crops.

Orchard meadows are hot spots for natural and agricultural biodiversity in Central Europe and are regaining political attention (Rotherman, 2008). They provide a wide range of habitats and ecological niches (Zehnder & Weller, 2006) and are therefore among the most biodiverse ecosystems of Central Europe (Baden-Württemberg [BW], 2009). In Germany, estimates of the total number of resident species of flora and fauna in orchard meadows range from 2,391 (Herzog & Oetmann, 2001) to 5,000 (Ministerium für Ernährung und Ländlichen Raum [MELR], 2007). This diversity is dependent on continued maintenance of the fruit trees and underlying fields (BW, 2009), which ensures that the savannah-like structure of the orchard meadows is maintained. In terms of agrobiodiversity, Germany's orchard meadows alone are reported to host about 3,000 varieties of fruits (MELR, 2007).

From the sixteenth century onward, the development of orchard meadows in Germany was supported by the ruling nobility in order to

Figure 1. An Orchard Meadow and Modern, High-density Apple Production in Southwestern Germany

(a) An orchard meadow, with standard-sized fruit trees and a meadow

(b) Modern, high-density apple production, with dwarf, trellised trees improve the food security of the general population and foster economic development through the sale of agricultural products (Rösler, 2003). Orchard meadows were resistant to complete crop failures because they combine various annual and perennial crops (Lucke, Silbereisen, & Herzberger, 1992). Various policy measures protected fruit trees and required citizens to plant and maintain them.

In Germany, both world wars resulted in extensive damage to orchard meadows. Nevertheless, during the difficult post-war years, they were quickly replanted. This revival, however, ended abruptly in the early 1950s. Rösler (2003) suggests that the difficulty of applying modern, chemical plant pesticides and fungicides in the presence of an undercrop was an important factor. Difficulties include both the spatial conflicts between machinery and undercrops and the conflicts between harvesting and consuming the undercrop considering the pesticides used on the trees. In order to carry out modern plant protection, the undercrop was removed, and thus the reason for having standard-sized (rather than dwarf) trees was lost. In addition, Weller, Eberhard, Flinspach, and Hoyler (1986) argue that both the loss of interest in subsistence farming and increasing prosperity, combined with increasing imports, necessitated a restructuring of domestic fruit production in Germany.

In 1952, the state government of Baden-Württemberg (BW) maintained that orchard meadows were a viable agricultural enterprise. Then, in 1953, the federal government decided that henceforth only high-density, trellised, monoculture plantations would be encouraged (Lucke et al., 1992). From 1957 to 1974, federal and state governments subsidized the removal of orchard meadows; 34,595 acres (14,000 ha) were felled in BW alone (Stadler, 1983; as cited in Weller et al., 1986).

The high-density, monoculture plantations with dwarf varieties ("high-density systems," see Figure 1b) are optimized for early cropping, stable high yields, and low labor requirements (Wertheim, 1981). Tree densities range from approximately 500 to 2,000 per acre (1,250 to 5,000 per ha) (Wertheim, 1981), in contrast to orchard meadows, where densities range approximately from 8 to 60 per acre (20 to 150 per hectare) (see Herzog, 1998). High-density production systems make intensive use of pesticides, and their applications are increasing in response to the development of resistance amongst pests (Reyes, Franck, Olivares, Margaritopoulos, Knight, & Sauphanor, 2008). While some of the negative impacts of pesticide use on biodiversity can be mitigated with organic and integrated management, evidence suggests that high-density systems support lower levels of biodiversity than orchard meadow systems, regardless of management type (Rösler, 2003).

Today, estimates of the spatial extent of orchard meadows in BW range from 222,395 to 444,790 acres (90,000 to 180,000 ha) (Landtag BW, 2008b; MELR, 2007). For the same region, Rösler (2003) demonstrates a decline of almost 70 percent from about 36 million to 11 million orchard meadow trees between 1938 and 1990. Zehnder (2006) suggests that, although data is limited, the situation is similar throughout Central Europe, with the system having been reduced to less than half its former distribution, with large regional differences. According to a more recent study, the number of trees in orchard meadows in BW has decreased from 18 million in 1965 to 9.3 million in 2005 (BW, 2009). In addition, 47 percent of all trees were found to be insufficiently or improperly pruned and thus in decline (BW, 2009).

The present study examines the root causes of orchard meadow loss in BW. Popular opinion regards orchard meadow decline as somehow inevitable in the face of progress. However, less abstract mechanisms and drivers must be involved. The purpose of searching for these drivers and thus root causes is that only conservation efforts that actually address root causes, rather than symptoms, can be successful and sustainable in reversing the loss. We present a framework for analyzing orchard meadow decline that consists of the Root Causes Framework of socio-economic drivers of biodiversity change, augmented by the perspective of agroecology.

Methods

The Root Causes Framework (RCF) provides a method with which to examine the socio-economic drivers of orchard meadow loss. Emanating from political ecology, RCF is an interdisciplinary approach to understand the socio-economic factors that constrain and shape local actions of individuals and communities that directly cause biodiversity loss (Stedman-Edwards, 2000). The emphasis is on linking scales, from the local to the global, in order to create a conceptual model of the causes of biodiversity loss for a particular site (Stedman-Edwards, 2000).

The method has been applied to assess the causes of biodiversity loss in several developing countries, in areas ranging from forestry, fishing, wetland and floodplain management, nature reserves, and highlands (Wood, Stedman-Edwards, & Mang, 2000). The resultant conceptual model is intended to become an input for policy development and action (Stedman-Edwards, 2000).

For topics as complex as the drivers of biodiversity loss, it can be difficult to focus on those factors that are relevant. The RCF suggests critical factors for biodiversity loss using five categories (Stedman-Edwards 2000; see table 1): (1) demographic change, (2) poverty and inequality, (3) public policies, markets, and politics, (4) macroeconomic policies and structures, and (5) social change and development bias.

One challenge of the methodology identified by Stedman-Edwards (2000) is the difficulty of setting limits to the analysis of root causes. Therefore, Stedman-Edwards suggests that a root cause be defined as a point at which successful intervention is feasible. This is in contrast to contextual factors, which are defined as historical or physical facts that cannot be altered. For example, in the case of the contemporary decline of orchard meadows, the subsidies paid to farmers for removing orchard meadows in the past would be seen as historical context, rather than a root cause.

In the case of orchard meadows, an agroecological perspective is also helpful for understanding the loss of biodiversity. Agroecology is "the integrative study of the ecology of the entire food system, encompassing ecological, economic, and social dimensions" (Francis et al., 2003, p. 2). Such an agroecological perspective helps us place the biodiversity of the orchard meadows within the context of the food system in which it is embedded.

For the purpose of this study, the concepts of agroecology and the RCF were combined to understand the root causes driving the loss of biodiversity through the loss of orchard meadows. In other words, in order to arrest the loss of biodiversity through the loss of orchard meadows, we must understand why our food system discourages farmers and landowners from maintaining their orchard meadows.

The analytical framework used in this study is depicted in figure 2. On the left, the five categories of socio-economic drivers of biodiversity loss described by Stedman-Edwards (2000) shape the food system in which orchard meadows are embedded. The orchard meadow food chain is

Table 1. Socio-economic Factors Driving the Loss of Biodiversity, from Stedman-Edwards 2000

Socio-economic Factor	Description
Demographic Change	Population growth, displacement and migration
Inequality and Poverty	Inequality of resource distribution, poverty, wealth, consumption
Public Policies, Markets, Politics	National laws, economic and political institutions, government policies, governance, and market structures
Macroeconomic Policies and Structures	National and international markets and related government policies, trade agreements
Social Change and Development Bias	Understandings of development, favoring of urban over rural and industry over agriculture

Based on Stedman-Edwards, 2000.

embedded within this broader food system. Individual socio-economic drivers impact the orchard meadow food chain at various stages: consumption, marketing, processing, and production. Furthermore, impacts at one stage ripple through the food chain via the flow of materials and energy (Francis et al., 2003, p. 4), as well as information and values. Thus, the socio-economic drivers, directly and indirectly, shape the production system. Finally, the actual physical state of orchard meadows impacts changes in biodiversity.

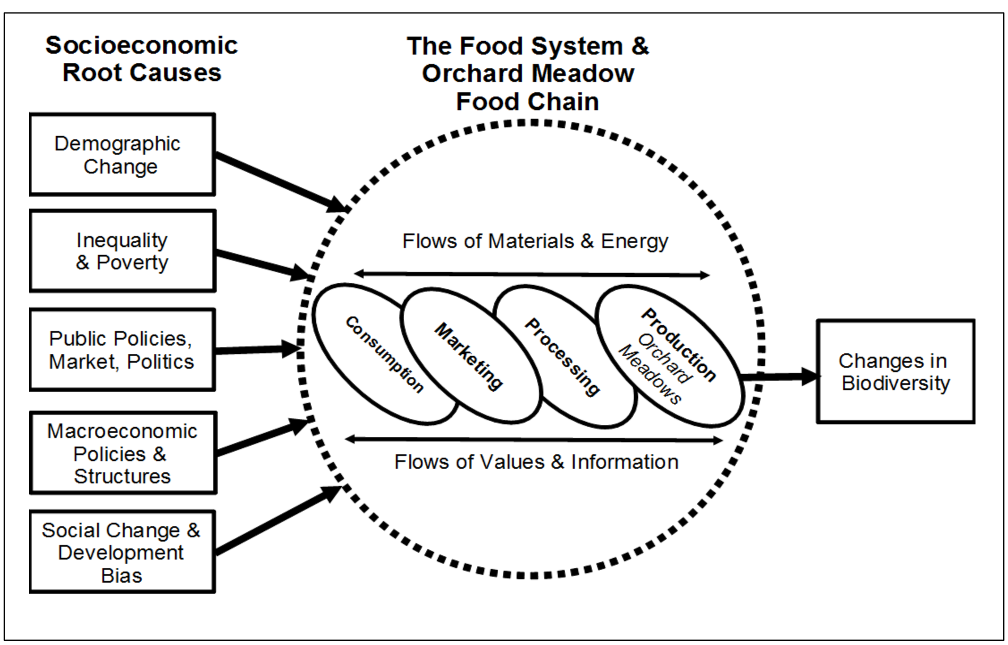
The Root Causes Framework involves four steps (Stedman-Edwards, 2000):

1. **Literature review:** The literature review should be focused on the local situation while taking into consideration the national context and generally recognized causes of biodiversity loss. It should produce a set of hypotheses about the root causes of local biodiversity loss that identify possible drivers at the local, national and international scales.
2. **Initial iteration of the conceptual model:** This step involves taking the hypothesis developed in step one and asking the questions who, what, how, and why, for each step along the chain of explanation and using the hypotheses found in the literature review to answer these questions.
3. **Data collection:** Data gaps are filled through local data-gathering and research.
4. **Revise the conceptual model:** The initial model is revised, based on the information gathered in step three. The aim is to produce a model that will provide information about the causes of biodiversity loss, which is needed to develop strategies and policies to counter this loss.

For the literature review, publications from a variety of sources (science, government, and nongovernmental organizations) were reviewed and the pertinent information of each source entered into a table, sorted by author. Subsequently, this data was categorized in two ways. First, the causes were classified according to the five groups of socio-economic root causes described by Stedman-Edwards (2000). Second, the causes were classified according to their roles in production, processing, marketing, and consumption, using an agroecological approach (Francis et al., 2003). Finally, an initial model of biodiversity loss was developed using the chains of explanation method described by Stedman-Edwards (2000) and Robbins (2007).

In this study, the method chosen for step 3 (data collection) was key informant interviews. Candidates were

Figure 2. Schematic Diagram of the Analytical Framework Used in This Study



selected based on their work related to orchard meadows. In order to gain a broad perspective, candidates were chosen from a variety of sectors (research and education, government, nongovernmental organizations, political organizations, private enterprise, and landowners) and fields (agriculture, landscape studies, horticulture, sociology, and food processing). Scientists working on topics related to orchard meadows were identified by searching the websites of BW universities and colleges. The institutions' websites were used to find schools and/or departments related to agriculture and ecology. The profiles of teaching and research staff were examined to determine if any individuals were carrying out or had recently carried out research related to orchard meadows.

We reviewed the website of the Ministry for Food/Nutrition and Rural Areas to identify relevant government employees. We also reviewed nongovernmental organizations working on the subject and chose candidates based on their current and past work. Finally, we looked for businesses related to orchard meadows. A total of 20 interview candidates were contacted in April 2008 to request their participation in the study.

The interview was structured as follows: As an introduction, four questions related to the informant were posed: (1) their field of expertise, (2) their age, (3) their family's past orchard meadow ownership, and (4) their present orchard meadow ownership. The informant was then presented with five cue cards depicting different types of orchard meadows, based primarily on their location: (1) along roads, (2) on steep slopes, (3) individual trees, (4) village belts, and (5) in fields and meadows. The informant was asked whether such a categorization was reasonable as a basis for discussion. The categorization was based on previous research, which had suggested that different mechanisms were at work for different types of orchard meadows (Rösler, 1996).

Subsequently, the informants were asked to identify the presence or absence of activities that were resulting in the loss of the individual orchard meadow types. These were noted by the interviewer on cue cards and placed on a large piece of kraft paper next to the relevant orchard meadow types. Next, the interviewer returned to each activity and asked the informant "why is this happening?" The informant's response was noted on cue cards and placed next to the respective activity. Finally, the informant was asked to identify important relationships and feedbacks among the activities and their drivers. The entire "model" was taped to the kraft paper and retained by the researcher, along with notes.

The "model" and notes from each interview were reviewed and a table was made of the activities, which orchard meadow types they applied to, and what drivers the informant identified. Key relationships and feedback identified by the informant were captured in simple causal diagrams (Doyle & Ford, 1998). Subsequently, a flow diagram was created for each interview to capture the chains of explanation (Robbins, 2007).

Once all the interviews were completed, a flow chart was created for each orchard meadow type, which consolidated all the activities and drivers described for that type. This produced six flow charts, one for each type of orchard meadow and one that dealt with those factors affecting all types.

The causes were then classified according to the five categories of socio-economic factors described by the RCF (Stedman-Edwards, 2000) and using an agroecological perspective (Francis et al., 2003). Finally, based on the flow charts, feedback and interactions classified by the experts, the initial conceptual model of biodiversity loss through orchard meadow decline was revised (Stedman-Edwards, 2000). This model was then shared with the experts via e-mail or postal mail in order to gain their feedback, and revisions were made as needed.

Results

Review of Literature

The literature review showed that a range of socio-economic factors are driving the decline of orchard meadows. In terms of demographic change, the government of BW states that a decline in the farming population and in farm family sizes has resulted in a decline in demand for the subsistence uses of orchard meadows (MELR, 2007).

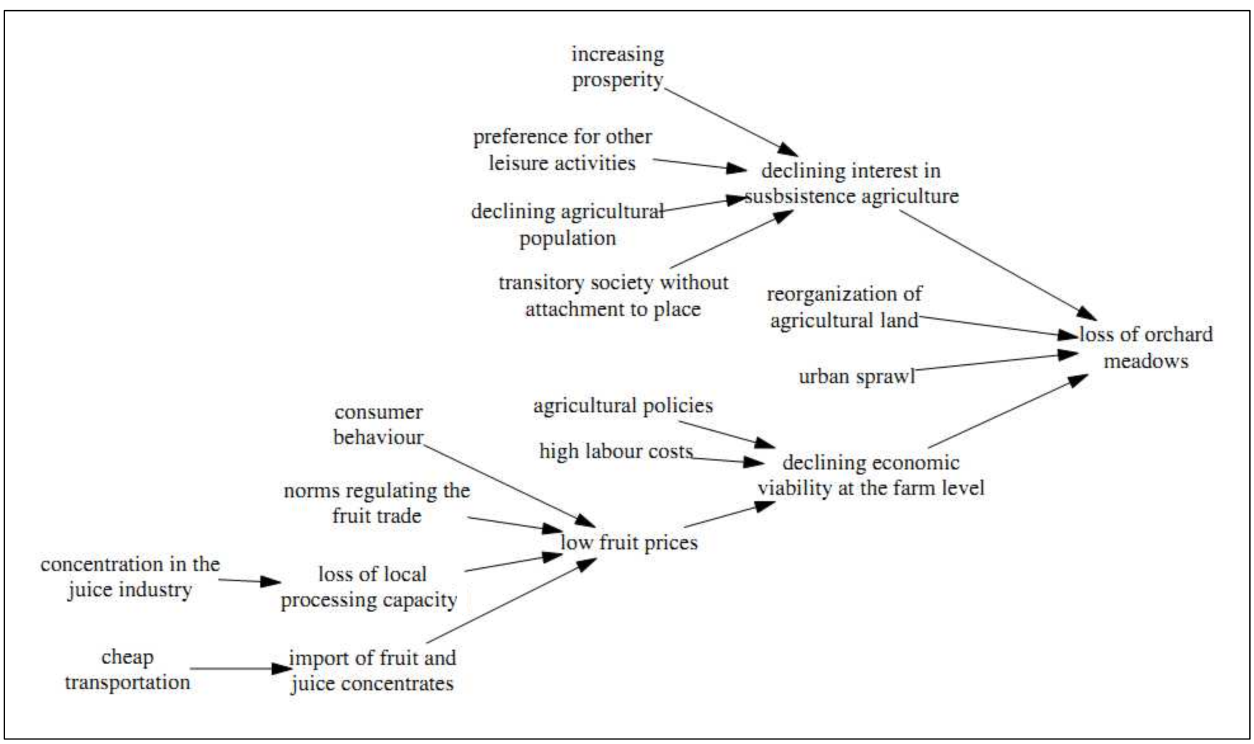
Prosperity rather than poverty appears to be another driver of loss. Increasing prosperity is responsible for declining interest in subsistence agricultural traditions, according to several authors (Lott, 1993; Rösler, 1996; Weller et al., 1986; Zehnder & Weller, 2006). Simultaneously, rising labor costs associated with increasing prosperity are problematic for a labor-intensive production system (Zehnder & Weller, 2006). Finally, several authors argue that the increasing mobility allowed by prosperity is to blame for a lack of attachment to and care for place (Lott, 1993; Rösler, 1996).

Historical and contemporary agricultural and trade policies in general, and fruit production policies in particular, are considered important causes of the decline by many (Eichhorn et al., 2006; Herzog & Oetmann, 2001; Lott, 1993; Lucke, Silbereisen, & Herzberger, 1992; Rösler, 1996; Weller et al., 1986). Rösler (1996) also notes the role of the lobbying work of high-density, monoculture fruit growers in shaping such policies. Another set of problems relates to the concentration of the fruit-processing industry and the loss of seasonal processing capacities (Rösler, 1996), the effects of international trade in juice concentrates and fresh fruits (Lott, 1993; Lucke et al., 1992; MELR, 2007; Rösler, 1996;Weller et al., 1986; Zehnder & Weller, 2006), and the norms regulating the fruit trade (Lott, 1993). Together, these factors result in it being increasingly difficult for producers to find local processors and markets for their juice fruits, low prices, and the exclusion of many orchard meadow products from the conventional grocery trade.

In terms of land use planning, the reorganization and consolidation of agricultural land (Lott, 1993; Weller et al., 1986; Zehnder & Weller, 2006), road construction (Landtag BW, 2008a; Lott, 1993; Weller et al., 1986; Zehnder & Weller, 2006), and urban sprawl (Landtag BW, 2008a; Lott, 1993) continue to result in the destruction of orchard meadows.

Consumer behavior has also changed. Alcohol and cider consumption have decreased — the latter dramatically as rising prosperity means that individuals can afford to buy beer instead (Rösler, 1996). Consumers have also become accustomed to the year-round availability of fresh fruits, including

Figure 3. The Initial Conceptual Model of Orchard Meadow Decline, Based on the Literature Review



tropical and subtropical varieties (Lott, 1993; MELR, 2007; Rösler, 1996).

A Preliminary Model of Decline

Based on the literature review, we developed a preliminary model of the decline of orchard meadows (figure 3). Four factors appeared to be the primary drivers of orchard meadow loss: declining interest in subsistence, declining economic viability at the farm level, the reorganization of agricultural land, and urban sprawl. These drivers are a combination of local, state, federal, and international factors. Land reorganization and land use planning occur at the local and state level. Agricultural policy is developed at the state, federal, and European Union (EU) levels. The social changes, cultural preferences, and economic prosperity that also play a role are phenomena throughout Germany, with regional and state variations.

It is important to note that many of these factors reinforce each other. For example, while a decline in farming population results in a decreased demand for traditional subsistence uses of the orchard meadows, increasing prosperity and trade mean that other products are available and affordable. Moreover, increasing labor costs, another product of widespread prosperity, make it increasingly difficult to maintain the labor-intensive orchard meadows. In addition, the concentration and consolidation in the fruit processing industry mean that it is difficult for producers to either sell their product to a local processor or have their fruits processed for home consumption.

Additional Data: Key Informant Interviews

A total of fifteen individuals were interviewed as key informants. Five individuals declined or were not available. When the informants were asked whether the categorization of orchard meadows used in this study was reasonable as a basis for discussion, some hesitated with orchard meadow type (3) individual trees. However, these trees were seen as important elements of the landscape and are usually the same species and varieties that are found in orchard meadows. Therefore, the experts accepted their inclusion in the study.

The informants identified five primary mechanisms of decline for orchard meadows: Fruit trees are (1) removed, (2) die, or (3) are not replanted, and the meadows are either (4) lost to succession (abandoned) or (5) become dominated by grasses, rather than herbs, resulting in a different plant (and animal) community because of intensified mowing and fertilization (see table 2). Not all mechanisms apply to all types.

Characterizing Orchard Meadow Decline and Renewal

Root causes framework

Diverse socio-economic drivers were identified by the informants as contributing to the decline of orchard meadows. These ranged from international trade, through housing and transportation policies, to consumers' perception of their own culinary heritage (table 3).

Table 2. Orchard Meadow Types and the Primary Mechanisms of Decline

		Trees			Meadow	
		Removal	Death	No replanting	Succession	Conversion to grass
A	Along roads	X	X	X		
B	On steep slopes		X	X	X	
C	Single trees		X	X		
D	Village belts	X	X	X	X	X
E	On fields and meadows	X	X	X	X	X

An agroecological framework

Applying an agroecological perspective reveals that there are important problems in the marketing portion of the value chain. These include trade, import, and price issues, as well as marketing regulations and a lack of development in the marketing and image of orchard meadow products. However, through the lens of agroecology, the majority of problems causing the decline of orchard meadows appear to be related to production (see table 4).

Neglect, marginal sites, and negative environmental conditions (drought, pollution, diseases, climate change, etc.), in addition to the advanced age of many orchards, result in production that is far below the actual yield potential. Research in BW has shown that the production of fruit trees in some orchard meadows is only 30 to 40 percent of expected yields.

Many informants expressed concern about the

Table 3. The Decline of Orchard Meadows as Described by the Key Informants, Classified According to the Five Categories of Socio-economic Drivers Described by Stedman-Edwards (2000)

Type of Factor	Factor	Consequence
Demographic Change	• Decline in rural and agricultural population	• Less labor available to cultivate orchard meadows results in neglect, removal of trees, and lack of replanting
Inequality and Poverty/Wealth	• Widespread prosperity results in a decline in need for and interest in subsistence agriculture • Widespread prosperity results in mass use of the car as a means of transportation	• Less labor available to cultivate orchard meadows results in neglect, removal of trees, and lack of replanting • More car traffic fosters more and wider roads, which results in the removal of orchard meadows
Public Policies, Markets, Politics	• Housing and transportation policies support urban sprawl and car-dependent development • Agricultural policy supports intensive and specialized agriculture through subsidies, research, education, training, and extension • Concentration and consolidation in the fruit juice industry	• More car traffic fosters more and wider roads which results in the removal of orchard meadows. Urban sprawl results in the removal of orchard meadows • Agriculture is intensified and specialized, which results in conflicts with the diversified orchard meadows and eventually their removal from prime agricultural sites or their neglect on marginal sites • Fewer processors have greater power in the market place, resulting in lower prices for growers • Low prices eventually result in removal, neglect, and lack of renewal
Macroeconomic Politics and Strategies	• International trade in agricultural products • Lack of country of origin labeling	• Cheaper imports are substituted for domestic products, resulting in low prices for domestic fruits • Consumers are unaware of the origin of their food and cannot choose local products. Producers and processors are unable to differentiate their product in the marketplace based on origin
Social Change and Development Biases	• Negative bias toward physical labor • Peasant agricultural heritage is not valued • Consumers are concerned primarily with the cheapness of food	• Nonfarmer owners neglect their orchard meadows • Agricultural and culinary traditions are neglected. The products of traditional systems are not valued, which fosters poor prices • Poor prices for producers

lack of regard for quality among processors and producers; poor quality fruits are often processed, resulting in a poor quality final product. In part, it was felt that this is a rational economic response to the poor prices paid for the fruits and processed goods. The informants familiar with hard cider also emphasized the difficulty of producing a well-balanced hard cider today. A good hard cider is generally the product of a blend of varieties, each of which contributes important elements to the cider, such as aroma, acidity, sweetness, and tannins. The varieties necessary to do this are increasingly hard to find due to the decline of the orchard meadows. Even for sweet cider, the fruit juice industry has recently voiced concern about the loss of particular orchard meadow varieties, which are valued for improving the taste of apple juices made from dessert apples grown in high-density systems.

While the informants identified an array of drivers of loss, they repeatedly highlighted the erosion of knowledge, low prices, and decline in system productivity as interacting drivers of orchard decline.

Drivers of renewal

Despite the very bleak overall situation of orchard meadows described by the informants, several informants also described what they see as drivers of renewal of orchard meadows. Five examples include (1) the *Brennrecht* and price premium paid by the Federal Monopoly Administration for Spirits, (2) *Aufpreisinitiativen*, (3) Manufaktur Jörg Geiger, (4) the *fachwart* training program, and (5) bag-in-box technology.

Brennrecht and price premium by the Federal Monopoly Administration for Spirits

Before World War II, southern Germany was home to 50,000 small distilleries that produced liquor from orchard meadow fruits. These distilleries took advantage of the traditional right of

Table 4. The Decline of Orchard Meadows, Classified Using an Agroecological Perspective (Francis et al., 2003)

Production	• In comparison to high-density systems that use dwarf monocultures, orchard meadows have:
	  o longer period between orchard establishment and first harvest
	  o lower plant density
	  o increased biennial bearing
	  o more dangerous labor conditions (pruning)
	  o higher labor intensity
	• Often small parcel sizes
	• Often located on steep slopes
	• Marginal production due to marginal location
	• Loss of knowledge and training programs
	• New diseases (e.g., fireblight)

Processing	• Loss of particular varieties makes it difficult to produce quality products • Loss of small processors • Low quality standards
Marketing	• Limited interest and/or ability of producers to engage in direct marketing • Limited interest and/or ability of consumers to purchase directly from producers • Low prices for juice fruits due to imports of concentrates • Norms for dessert apples limit marketability of orchard meadow products • Poor image of hard cider
Consumption	• Consumers are accustomed to year-round availability of fruits, including tropical and subtropical types, which lowers appreciation for domestic and seasonally available fruits • Declining interest in subsistence agricultural practices • Low levels of consumption of hard cider • Lack of appropriate storage spaces and tools needed for preservation (fresh fruits, cider, juice, dried fruits) in modern households

farmers to distill the equivalent of 13.2 U.S. gallons (50 liters) of pure alcohol annually, or up to 79.25 U.S. gallons (300 liters) if they owned orchard meadows, known colloquially as *Brennrecht* (legally *Brandtweinrecht).* With structural change in agriculture after World War II and the resultant neglect of orchard meadows, the number of distilleries fell. Nevertheless, approximately 2,400 distilleries remain in BW (BW, 2009). To support orchard meadows, the Federal Monopoly Administration for Spirits of Germany maintains this right and offers the distilleries a premium price for industrial alcohol, resulting in higher fruit prices. Consequently, a total of 121,254 U.S. tons (110,000 tonnes) of fruits (or 25 percent of the total harvest from orchard meadows) are fermented and distilled annually in BW (BW, 2009). This subsidy requires an exemption from European Union agricultural policy and its continued existence is therefore uncertain.

Informants believe that the fact that any orchard meadows remain at all can be attributed to this law. However, due to the very low quality requirements of this marketing venue and its low profit margin, it provides farmers with little incentive to maintain or improve their orchards.

Aufpreisinitiativen *place-based marketing*

In response to the decline of orchard meadows and the ecological values associated with them, particularly biodiversity, a unique form of place-based marketing emerged in Germany in the late 1980s. These *Aufpreisinitiativen* (bonus price initiatives) were created by coalitions of environmental nongovernmental organizations, fruit processors, and municipal governments in an effort to contribute to the conservation of orchard meadows. The initiatives pay a higher-than-market price to the growers in return for their adherence to a set of production guidelines aimed at conserving the orchard meadows (Herzog & Oetmann, 2001). The resulting products are marketed regionally at a premium price.

The effectiveness of this approach in conserving orchard meadows and their associated biodiversity is unclear. According to many of the informants, the financial incentives provided by the initiatives are insufficient. At best, the incentives encourage growers to undertake the minimum of maintenance of their orchard meadows, but they are insufficient to revive orchard meadows. The initiatives also appear to have underestimated the importance of production and processing knowledge in the conservation and renewal of orchard meadows. In recent years, the initiatives have expanded their scope of work to include a supraregional marketing campaign, product branding, lobbying, and product exhibitions (BW, 2009).

Manufaktur Jörg Geiger

This private enterprise is revitalizing orchard meadow culinary traditions. The family-owned company produces a line of quality hard and sweet ciders and brandy. The company not only uses apples but also a wide variety of the other fruits found in orchard meadows. These products command premium prices. To obtain certain varieties at consistent quality, the company pays about USD110 for 220 lbs. (80€ for 100 kg) of fruit. In comparison, the average price paid for orchard meadow fruits by the conventional juice industry over the past 20 years has been just USD10.50 for 220 lbs. (7.50€ for 100 kg) (Landtag, 2008a). The prices paid by Geiger are so high that the seemingly unimaginable is happening: farmers are planting new orchard meadows! In addition to the financial motivation, the company is helping farmers to access relevant knowledge on establishing and maintaining orchard meadows.

The fachwart *training program*

The *fachwart* program builds on historical schools at state universities. These schools trained individuals in the care of orchard meadows, with a focus on tree pruning, and awarded them with the title of tree warden (*Baumwart*). Proper pruning ensures both the quality and quantity of the fruit harvest, while also providing firewood. Historically, such programs ensured that each community had an individual trained in the art and science of tree pruning and cultivation. Through the program, the government actively supported the dissemination of technical skills and knowledge among growers.

Since 1998 the nonprofit association for orchard meadows, gardens, and landscapes, LOGL

(Landesverband für Obstbau, Garten und Landschaft Baden-Württemberg e.V.), offers the modern *fachwart* training course, which was developed with and is recognized by the state government. The course is geared toward nonfarmers who have an interest in orchard meadows, perhaps having inherited an orchard from parents or grandparents. Training is provided through workshops, which take place over the course of a year, on evenings and weekends. Participants acquire the knowledge and skills needed to maintain and make use of orchard meadows.

Informants highlighted the positive effects of this program: The condition of orchard meadows has improved where the program is offered, the evidence being that more trees are correctly pruned and meadows are mown appropriately. Today, the program is offered in 25 counties of BW, and similar programs have been initiated in other states.

Bag-in-box technology

New, small-scale technologies ranging from harvest machinery to processing technologies were also described by informants as drivers of orchard meadow renewal. A prominent example is the "bag-in-box" method of storing juice. A small, mobile press processes the fruit, pasteurizes the juice, and then seals it into 1.3 or 2.6 gallon (5 or 10 liter) bags. These bags are placed into cardboard boxes, making them easy to transport and store. The small size of these stackable containers, in contrast to traditional 26 gallon (100 liter) juice and cider barrels, is far more compatible with modern families' houses and apartments. Unopened, the juice can be stored for many months, and once opened it can be stored for several weeks without spoiling. This technology allows families to make use of their orchards in a simple and cost-effective manner.

A Revised Conceptual Model of Decline and Renewal

Based on the information gathered from the experts, the preliminary model of decline (figure 3) was revised (figure 6). The new model defines dynamic variables and their influences on each other. Using the symbol convention of system dynamics, a positive influence (+) means that more of one variable causes an increase in the other variable. A negative influence (-) means that more of one variable causes a decrease in another. A positive feedback loop is a self-enforcing cycle, while negative feedbacks are self-attenuating.

The revised conceptual model contrasts starkly with the initial model. The literature review identified a broad range of socio-economic drivers as being relevant to orchard meadows. However, as was noted earlier, there was a significant lack of knowledge of the actual mechanisms involved. The mechanisms by which the socio-economic context shapes the physical state of orchard meadows (and thus changes in biodiversity) became clearer through the interviews as the informants described the decision-making process of orchard meadow owners. The revised model is therefore actor-centered, because this approach better captures the mechanisms through which orchard meadows change over time.

The core of the model (see figure 4) is the basic economic model of price, supply, and demand. The model core contains two negative feedback loops: First, increased supply will decrease prices, while decreasing prices will decrease supply. Thus as supply increase, prices will decrease, which will result in a decrease in supply. This feedback is self-attenuating. Second, decreasing prices will increase demand, and increasing demand will increase prices. Both feedback loops are of the form (+-). As prices decrease, demand increases, which results in higher

Figure 4. The Supply, Price, and Demand Feedback Cycle, with Price as the Motivation for Producers

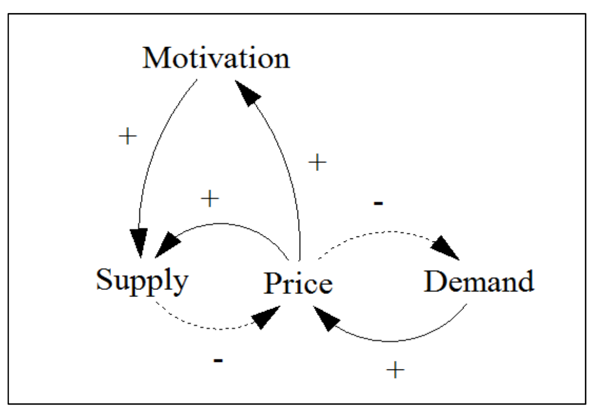
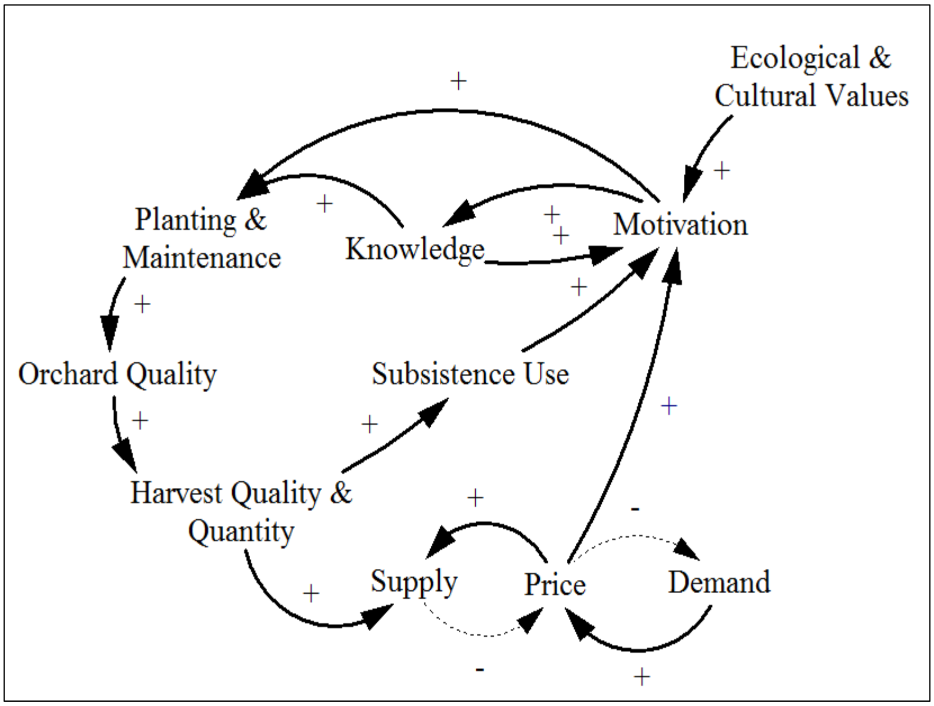


Figure 5. Market and Nonmarket Variables that Impact Producer Motivation To Plant and Maintain Orchard Meadows



processors via a market loop, and processors are linked to customers via a second market loop. Both producers and processors are motivated by market prices and by other factors as discussed for figure 5.

A self-enforcing (or positive) feedback of decline is currently active with regard to orchard meadows. Apple harvests that are of low quality lead to low-quality processed products and subsequently to a poor public image. Consequently, the demand for processed orchard meadow products drops, along with the price that processors can obtain. Without this market incentive, processing and thus the demand for raw products decline. With the decline of demand in apples and other raw products, prices for fruits collapse, demotivating producers to maintain their orchard meadows. Due to this negligence, over the course of decades, the condition of orchard meadows degrades. This reduces harvest quality and quantity, degrades the product quality and thus image, and reduces consumer demand for orchard meadow products further. Over time, knowledge of orchard meadow maintenance and the production of quality products are largely lost. At the same time, increasing prosperity and the availability of other products has resulted in the collapse of the subsistence use of the system: Even though many people still gather fruit from orchard meadows, there is currently no perceived motivation (need) to maintain or plant orchards expressly to serve subsistence needs.

The degradation and loss of orchard meadow impacts biodiversity negatively because alternative land uses offer less diverse ecological niches. Thus the loss of biodiversity is a side effect (externality)

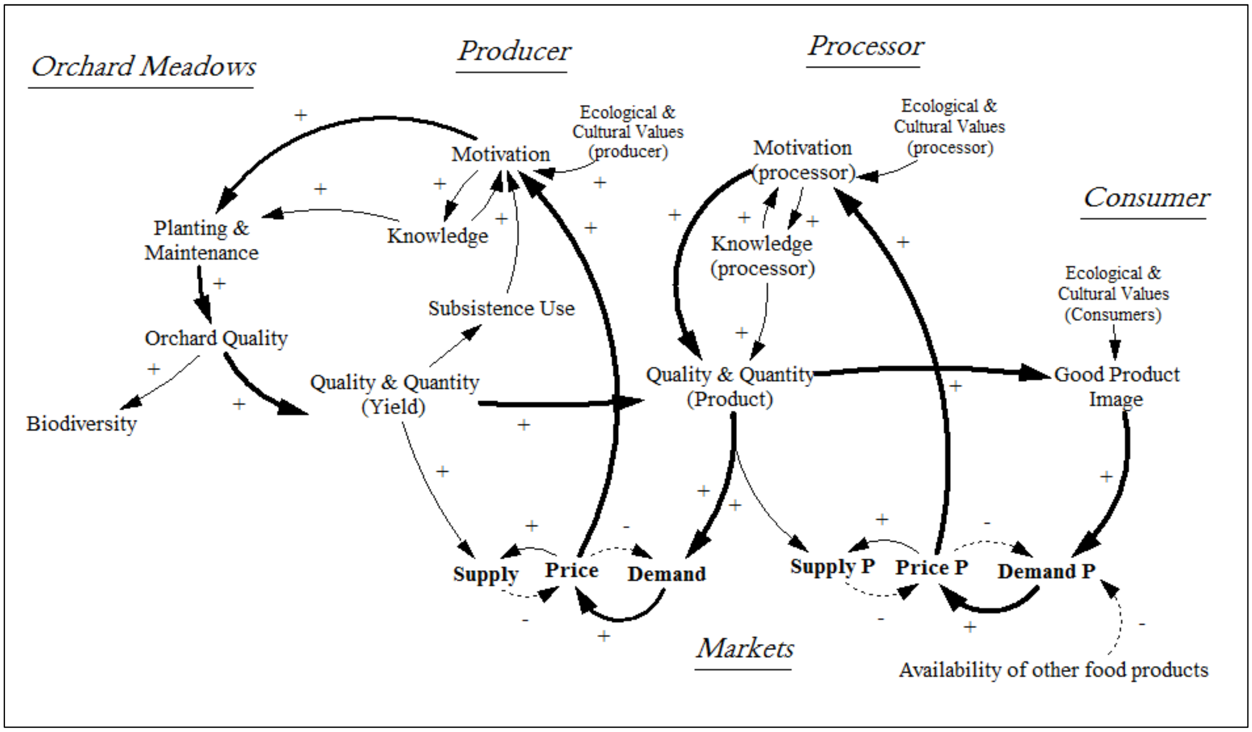
prices. Again the feedback is self-attenuating.

The informants' emphasis on the loss of knowledge and the drivers of renewal suggest that additional feedback mechanisms exist that motivate producers to maintain their orchard meadows. Knowledge is one important precondition for proper planting and maintenance of orchard meadows. The ecological and cultural values of orchard meadows also appear to motivate some landowners to maintain orchard meadows. Other landowners are motivated to maintain orchard meadows in order to be able to make use of the harvested products themselves — in essence modern subsistence use. Therefore, the economic motivation model of figure 4 was extended to recognize the role of knowledge and nonmarket motivations (figure 5).

The full model of orchard meadow decline includes four main components: the orchard meadow itself as a natural system, the owners who harvest products (fruits, nuts, etc.), the processers who package and/or transform these products into marketable goods, and the consumers (figures 6 and 7, left to right). Producers are linked to

Figure 6. A Conceptual Model of the Decline of Orchard Meadows in Baden-Württemberg, Combining an Actor-Based Agroecological Perspective with the Root Causes Framework

The quality and quantity of production declines with the degradation of the orchard, the loss of motivation of producers, and the erosion of knowledge. This feeds back on the quality of processed goods and the product image. Thus a self-attenuating cycle of decline emerges (bold arrows).



of the decline of orchard meadows.

Historically, the development of the orchard meadow system in BW was driven by government policy at multiple leverage points (Lucke et al., 1992). These government activities are understood as a root cause of the establishment of orchard meadows (figure 7). For example, publicly funded research, development, and extension services disseminated knowledge and technologies and provided varieties that were adapted to local growing conditions and specific purposes (e.g., storability, hard cider, table fruits).

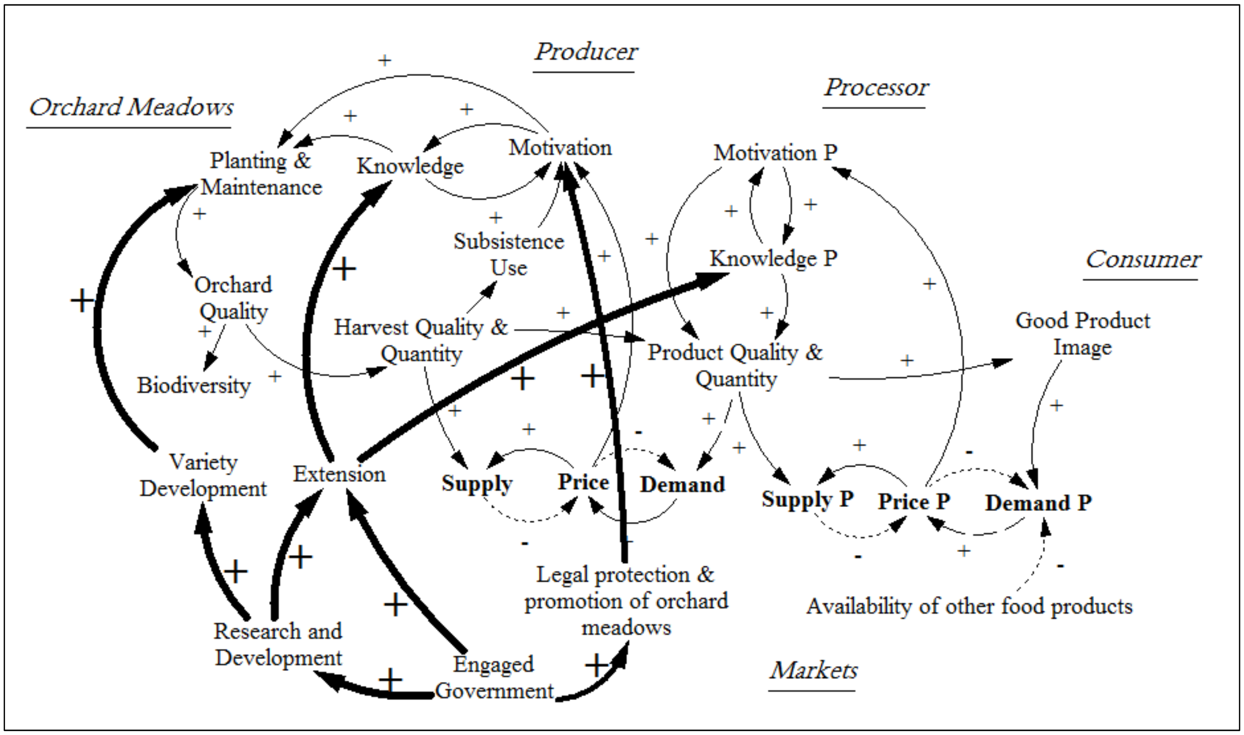
In the past, the feedback loop of the conceptual model operated in a manner that supported the development of orchard meadows. The root cause of this was a varied support strategy pursued by various levels of government. The turning point in 1953, when government decided to discontinue the support of orchard meadows and instead support high-density monocultures, is marked by a shift in policies that supported producers (research, development, extension), rather than in direct market interference.

The model also consistently explains the examples of contemporary drivers of renewal described by the informants. Three examples use the market and price incentive as the primary motivation for producers, at different scales and with varying degrees of success: the *Brennrecht, Aufpreisinitiativen* (the bonus price initiatives), and the Manufaktur Jörg Geiger, which pays prices that allow for farm-level economic viability. The private enterprise makes use of additional support mechanisms by educating producers (knowledge), improving processing technology, and marketing products as valuable culture artifacts (product image). To a lesser extent, the bonus price initiatives also pursue these support mechanisms.

In contrast, the *fachwart* program was initiated by individuals with strong ecological and cultural

Figure 7. The Role Government Support Played in the Establishment and Maintenance of Orchard Meadows in Baden-Württemberg from the 16th to the Mid-20th Century

The same drivers and relationships were involved in the rise of orchard meadows as are today involved in its decline; the basic conceptual model does not change. However, in the past the involvement of government through research & development, extension, and laws drove the feedback cycles of the system such that orchard meadows flourished.



values, and targeted private landowners (producers) who share these values. From the perspective of the model, the *fachwart* program provides knowledge, which supports participants in engaging with orchard meadows and reinforces their initial values-based motivations. By enabling landowners to make use of their orchard meadows, the program also offers participants another motivation: modern subsistence use. Similarly, bag-in-box technology provides a simple technology that enables owners of orchard meadows (or their friends and neighbors) to make use of their orchard meadows.

In summary, the conceptual model can explain the historic development of orchard meadows, their ongoing decline since the 1950s, and contemporary drivers of renewal that make use of a variety of market and nonmarket mechanisms to maintain orchard meadows. In all cases, changes in biodiversity are an externality of the socio-economic and cultural orchard meadow system.

Discussion

This study has shown that the decline of orchard meadows is not inevitable, contrary to popular and academic belief. By applying the RCF and the food systems perspective of agroecology, this study has traced the root causes of orchard meadow decline and shown the decline to be the consequence of multiple interacting drivers. Many of these can be traced back to the removal of the multipronged government support for the system that existed until the 1950s. Prior to this, support for the system had been motivated by multiple objectives, including food security and rural economic development. The decision to remove the supports was based on socio-economic and technological developments at the time, including a narrow focus on the farm-level economic aspects of the production system.

In subsequent decades, the unintended consequences of that decision have become apparent, especially the impacts on biodiversity. Today, new decisions can be made, based on economic, ecological, and social criteria. If the government decides to support orchard meadows again, then there is a range of leverage points for policy intervention that do not require market interference.

The methodology employed in this study combined the RCF (Stedman-Edwards, 2000) and the agroecology concept of the "ecology of the food system" (Francis et al., 2003). While the RCF provides an overall framework for examining the socio-economic root causes of changes in biodiversity, the food system approach focuses the research on specific actors involved in the system: producers, processors, and consumers. This actors-based approach bridges the broad socio-economic patterns identified with the RCF, and with changes in the physical landscape, by describing the options available to actors and their motivations. This approach not only helps us understand what is happening in the system and why, but also offers insight into potential points of intervention.

The methodology could be improved by supplementing the initial individual interviews with key informants with a subsequent group session. The initial interviews allow each informant to contribute his or her understanding of the system without being drowned out by other perspectives, as might happen in a group session involving individuals from diverse fields and education levels. However, after the conceptual model has been developed based on these interviews, a group session would be helpful to "validate" the results. Sharing the conceptual model with the informants and asking for feedback via mail or e-mail is inadequate, because it does not allow the researcher to explain the model and tell its story, nor is it easy for the informants to give critical feedback.

The conceptual model may be challenging initially to readers unfamiliar with such methods. However, such a visual representation of a system can be a powerful tool for understanding it in a holistic way. In the case of orchard meadows, a relatively simple conceptual model represents the same mechanisms that favored the development of orchard meadows during preceding centuries, the decline of orchard meadows during the past half century, and contemporary drivers of renewal. Such a holistic understanding helps us understand the social and cultural aspects of biodiversity loss and may help to focus intervention for reversing this loss. Once the initial hurdle of familiarizing oneself with this method is overcome, conceptual modeling provides a powerful tool for developing action.

In the future, quantitative research into the various market and nonmarket points of intervention would be valuable. In particular, it would be helpful to understand how market and nonmarket interventions complement each other. For example, do purchasing habits of those who participate in the *fachwart* program change with regard to orchard meadow products? Does the availability and an improving public image of high-quality orchard meadow products motivate individuals to maintain their own orchard meadows? Furthermore, comparative studies between orchard meadows and modern, high-density monoculture systems (both organic and conventional), which quantify costs, benefits, and externalities using a triple bottom line (economic, ecological, and social), would also be valuable.

Conclusions

This study has examined the root causes of biodiversity loss resulting from the decline of orchard meadows in Baden-Württemberg, Germany. It has shown that the decline of orchard meadows is the result of several factors interacting with each other. However, the study has also shown the existence of several cases of orchard meadow renewal. Drivers of both renewal and decline operate through the same mechanisms, by transmitting values and resources through the orchard meadow food chain and thus shaping the range of options available to producers and landowners, who ultimately maintain, remove, or neglect their orchard meadows. The conceptual model that captures these mechanisms, highlights that there are multiple points of intervention available to individuals and policy-makers for reversing the decline of orchard meadows and the associated loss of biodiversity.

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