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INTERNATIONAL FEDERATION OF ORGANIC AGRICULTURE MOVEMENTS

IFOAM Guide to Biodiversity and Landscape Quality in Organic Agriculture

Andreas Bosshard, Berend R. Reinhard, Sheila Taylor (Eds.)

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Please Note :

The opinions expressed in this publication do not necessarily represent an IFOAM approved position

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Preface

The enhancement of biodiversity and its use to promote better livelihoods are essential guiding principles in organic farming. When we develop Organic Agriculture standards, we want to ensure that they embody these principles. When we are engaged in advocacy or policy development we need to have in mind that human beings are the core of any production system and that their contribution towards biodiversity should be acknowledged and fairly rewarded. When we build businesses based on biodiversity we should strive to develop innovative strategies to involve traditional knowledge systems. When we are development workers we need to constantly build bridges with other sectors that have a say in the conservation of biodiversity and with planning at landscape level.

Bosshard, Reinhard and Taylor have edited an extensive selection of examples from around the world, particularly when it comes to improving species diversity on the farm. This book has rightfully been called a guide since it does not cover each subject in detail but provides an outline of key issues that need to be addressed, very often at the local level. Even though the editors have made consistent efforts to address issues related with temperate and tropical areas, readers may identify other topics that should be taken up. If this happens, the purpose of this guide, as well as other IFOAM publications, would be fulfilled: to serve as a stepping stone in the complex process of understanding how biodiversity and organic agriculture are interdependent and developing improved methods to put that understanding into practice for the benefit of our planet and the diverse peoples and cultures that inhabit the Earth.

Loss of diversity and its manifestations in culture, human relationships or production systems is one of the major threats to sustainability. The publication of this guide is an expression of IFOAM's role in promoting the Principles of Organic Agriculture and inspiring positive action by providing real-life examples of how agricultural practices rooted in the Principles can improve both ecosystem health and farm productivity. Developing these practices further is a process of continuous learning and sharing. IFOAM is committed to supporting and facilitating this process, to ensure that Organic Agriculture continues to take the lead in working towards a truly sustainable system of agricultural production.

Roberto Ugás

Vice President of IFOAM

Definition of Organic Agriculture

Organic Agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Principles of Organic Agriculture

Preamble

These Principles are the roots from which organic agriculture grows and develops. They express the contribution that organic agriculture can make to the world, and a vision to improve all agriculture in a global context.

Agriculture is one of humankind's most basic activities because all people need to nourish themselves daily. History, culture and community values are embedded in agriculture. The Principles apply to agriculture in the broadest sense, including the way people tend soils, water, plants and animals in order to produce, prepare and distribute food and other goods. They concern the way people interact with living landscapes, relate to one another and shape the legacy of future generations.

The Principles of Organic Agriculture serve to inspire the organic movement in its full diversity. They guide IFOAM's development of positions, programs and standards. Furthermore, they are presented with a vision of their world-wide adoption.

Organic agriculture is based on:

The principle of health

The principle of ecology

The principle of fairness

The principle of care

Each principle is articulated through a statement followed by an explanation. The principles are to be used as a whole. They are composed as ethical principles to inspire action.

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Principle of health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people.

Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health.

The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

Principle of ecology

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. These cycles are universal but their operation is site-specific. Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.

Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

Principle of fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities

Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties – farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food and other products.

This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behavior and well-being. Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

Principle of care

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken.

This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

IFOAM General Assembly 2005

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Editorial Foreword

The survival of biodiversity and the preservation of the rapidly disappearing individual character of cultivated landscapes is one of the major human challenges of our time. Agriculture as the major human land use activity has a particular responsibility in this context. Agricultural intensification has caused a rapid decline in biodiversity across most taxa worldwide (e.g. Krebs et al. 1999).

Today there exists a broad consciousness that agriculture is far more than food production. The present and future form of agriculture will substantially influence conditions of all life on earth and the sensual qualities of our living environment and landscape.

Consumers show growing interest in the added values and side effects of agriculture. They tend to pay more attention to the context in which food is produced, and demonstrate – to a certain extent – the willingness to pay for food produced locally, fairly and environmentally friendly with a corresponding price. Simultaneously more and more governments, mainly in Europe, develop programs to support farmers financially and methodologically in endeavours to enhance the diversity of life in the agricultural landscape or to preserve ancient cultivated landscapes.

In this general and worldwide trend, in this fundamental change of paradigm concerning the role and task of agriculture, Organic Agriculture (OA) in particular takes a leading role and shows the way with inspiring examples and new ideas to link food production with fostering biodiversity and landscape quality.

The philosophy of Organic Agriculture is based on the principles of health, ecology, fairness and care: "Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water" – this declaration in the Principles of Organic Agriculture summarises this philosophy (see box p. ix). Meanwhile dozens of studies show the beneficial effects of OA on biodiversity (see e.g. Bengtsson et al. 2005).

However, repeatedly scientists and organisations postulate, that OA could and should more effectively foster biodiversity and better develop its inherent potential in this field (Stolton et al. 2003/Bosshard 2003). This criticism was the reason that ELPR Ecology and Landscape Ltd., in co-operation with the biodynamic movement in Switzerland (Section for Agriculture, Goetheanum, CH-Dornach) and the Research Institute for Organic Agriculture (FiBL, CH-Frick), launched a motion towards the IFOAM general assembly that called for concrete endeavours.

The motion was accepted 2002, and in 2003 IFOAM started a process that was accompanied and supported by IUCN (International Union for the Conservation of Nature) and BfN (Bundesamt für Naturschutz / German Agency for Nature Conservation). Part of this process was the aim to develop extension programs, know-how building and motivation toward farmers, advisers and certifiers in the field of biodiversity and landscape quality (Bosshard 2005). Thanks to the financial support of the Software AG Stiftung it was possible to elaborate the present book. It is a valuable mosaic stone within the endeavours to strengthen the contribution of Organic Agriculture towards a holistic sustainability of agricultural land use.

For that purpose this guide:

- compiles, in an easily understandable form, the most important ecological principles and facts in respect to the agricultural role and potential to foster biodiversity and landscape quality
- describes successful examples how to implement these principles with a wide variety of different crops, climates and farm structures,
- shows that biodiversity and landscape measures are not only a burden, but on the contrary may actually increase income and open new market opportunities, hence can have a synergetic effect and strengthen the economic and productive base of a farm.

The guide will support and inspire:

- farmers, who are the key players in realizing biodiversity and landscape values in the cultural landscape. The more they understand the potential benefits of particular endeavours, the more likely they are motivated to develop their own solutions, visions and concepts in the particular context of their farm.
- Consultants ,who support farmers in realizing their biodiversity and landscape quality endeavours.
- certification bodies and member organisations of IFOAM and other organisations, which develop regionally adapted standards and measures to enhance biodiversity and landscape quality in farming systems.
- certifiers, who will need the knowledge to assess, control and monitor the issues addressed by the standards

However, this book is not only addressed to Organic Agriculture and organic farmers. The principles are valid for every form of agriculture, and the respective examples can be implemented on every farm.

A particular challenge for the book was to cover or at least touch upon an extremely wide variety of climatic conditions, conservation priorities, habitats, cultivation methods, traditions and farm structures in different regions of the world. Each landscape and ultimately, every farm needs its own specific measures to conserve its particular biodiversity. Accordingly the present book can only give suggestions that need to be elaborated further, leading to regionally and locally adapted solutions, or that catalyse the elaboration of brochures, courses or particular standards.

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The guide was elaborated within a wide, international network of experienced institutions and authors, with expertise in biodiversity and landscape science, in nature conservation, in extension and education, and in (organic) agriculture. I thank all authors from around the world for their valuable, irreplaceable original contributions. I also thank Software AG Stiftung for its financial support for the preparation of this publication.

Andreas Bosshard, CEO of ELPR Ecology & Landscape Planning & Research Ltd.

Extended Summary

The disastrous extinction of individual species and the rapid disappearance of unique landscapes on our planet are both closely related and linked to agriculture. However, agriculture has the task and potential to nourish the growing human population by not only using but also fostering the incredible richness of life forms and sensual expressions in landscapes on earth.

In Organic Agriculture biodiversity and aesthetic landscape quality is an essential element and guiding principle since the beginning of the organic movement. However, the process that leads from guiding principles to concrete measures and visible effects on the farm and on each field constitutes a permanent challenge – not only for farmers but also for advisers, researchers, politicians and officials.

This present Guide Book is designed to provide substantial support for this process, from the original concept to its realization. It is intended to help farmers overcome the numerous restrictions that exist today whether they be economic, agronomic, or otherwise.

This Guide consists of two components, that enhance each other: The first one is the examples of existing and well working prototypes of innovations worldwide, that are able to substantially enhance biodiversity and sensual landscape quality within the economic and agronomic context. Their intention is to inspire, to motivate and to provide concrete information on how to realize effective measures on a single farm.

If the implementation and adaptation of the innovative examples are to be successful, it is necessary to understand how and why they work. Therefore the outline of prototypes is accompanied by chapters that explain the most important ecological and agricultural principles, facts and ideas in a comprehensive way. This is the second component of the guide.

The book is seen as a first, inevitably unfinished collection of such “prototypes” to be completed in the future. The described examples cover a representative variety of farm types, climatic conditions, cultivation methods, conservation priorities, habitats and farming traditions. Chapters concentrate on pastoral systems, agroforestry and annual cropping systems. There are case studies from different agro-ecological zones from around the world, suggestions and examples of practical demonstrations that are appropriate, and also specialist advice for the conservation of rare species, unique cultural landscapes and some well developed special cropping systems. Particular emphasis is put on whole farm planning approaches and on the aspect of the aesthetic and historical quality of landscape.

The more that farmers and advisers understand the potential benefits and effectiveness of the various possible actions, the more they will be able to develop their own solutions, visions and concepts in the particular context of their own farm or region. Accordingly, this guide is not merely addressed to Organic Agriculture, but can be translated to every form of farm and agriculture.

Levels of diversity

Biodiversity in agriculture incorporates a range of different 'diversities'. There are differences to be seen even between individuals of plant or animal species. These genetic differences form the basis of all diversity. A second level is the diversity between species, and a third level between habitats and ecosystems. Each level is important and has to be respected for its approach that intends to improve the situation of a farm in a holistic way (Chapters 1 and 2, see also box below).

The set of ecotypes, races, breeds, species or ecosystems found on a farm or landscape is dependent on the type of agriculture that is practiced, whether extensive animal rearing or annual or perennial cropping, as well as the natural environment (soil, climate etc.). In all cases the biodiversity on the farm can be optimized by understanding the wild flora and fauna typical of the region, and investigating traditional agricultural systems (discussed in Chapters 1, 2 and 4). Measures to increase biodiversity on the farm vary from one agro-ecological zone and farming system to another, but all share principles of provision of wild habitat by activities such as developing wild margins, leaving natural plants incorporated within the crop areas and reducing mechanical disturbance across the farmed area. (Case studies from around the world are in chapter 3).

Recently published studies show that organic farming increases biodiversity at every level of the food chain (Fuller et al., 2005), and that there are also greater total areas of semi-natural habitat on organic farms (Gibson et al., 2007). However, many, organic farms would have a distinctly higher potential to develop their natural values. Intentional planning for wild species not only increases the range of organisms, but also the range of ecosystems within the farm. Incorporating structural elements that can act as habitat, such as live fences, increases the number of species on the farm, but also contributes to a diversity of different ecosystem types and a distinct landscape character (Chapters 3 and 4).

Combining and managing a diversity of ecosystems on one farm is a strategy that has been practiced worldwide for many hundreds, if not thousands of years. Farmers have learned to optimize use of their land, both in space and time, by choosing different crop combinations and farming practices that are mutually beneficial. The multi cropping seen on many smallholder farms has arisen over years of development, as have very specific 'mutualisms' such as those using duck, fish, or a combination of both in paddy rice (Chapter 4). Ongoing research on optimal conditions and species maximize these types of benefits. Documentation and sharing of traditional practices from around the world can encourage, and provide information for farmers.

Landscape Level Planning

Once diversity is considered at an ecosystem level it is apparent that this can also go beyond the single farm. It may be that a watershed has to be taken as a 'whole', or a group of farms together can increase the benefits to rural communities – perhaps in landscape and cultural terms, and at this level participatory involvement of various stakeholders is desirable (Chapters 4.2.1, 5

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and 7). Natural habitat and the linking of fragments left within a predominantly agricultural landscape setting are most effective at maintaining or enhancing biodiversity. This will often involve different landowners and other users of the relevant ecosystem services. Other landscape issues such as large scale water conservation schemes, flood prevention or pollution control also require extensive collaboration. Both detrimental effects and positive benefits may be felt by a large number of species (chapter 5). A whole ecosystem protection approach to these situations can also benefit rare and keystone species – especially as it is clear that our knowledge of the biological inhabitants of this planet is limited to such an extent that unknown species are becoming extinct or are threatened daily. An alternative protection strategy is to focus on the particular needs of priority species and establish how these can be addressed – often in simple ways that might cause little work or economic change for farmers (Chapter 6).

Aesthetics, culture, history and the spirit of place

Nature as basis for agriculture has, beside its a-biotic and biotic aspects, also a sensual (aesthetic) and cultural component. This component is called here landscape (see box below). The more people live in towns far from nature and primary production, the more the need for intact natural spaces as well as (agri)cultural landscapes becomes essential. The landscape in its cultural and aesthetic aspects is of importance to people as physical and spiritual beings. Indeed the distinctive atmospheres of a particular place, the manifold inspirations of different landscapes not only cause us to judge them as beautiful or ugly, but also contributes, as meanwhile shown by extensive studies, to the well being of those who live and work there or visit them (Chapters 1.3 and 7, and box below). Thus, landscape and its quality and effects has to be incorporated into a holistic concept of agricultural sustainability (Chapter 8). As sensual and cultural values of an (agri)cultural landscape often are closely related with biodiversity values, this Guide covers both aspects.

There remains more to be discovered, e.g. how farming systems, especially in the biological hot-spots of the tropics, can work in harmony with nature before being tempted to follow the route of the so called 'developed' world; or how landscape quality as a clear concept like the conservation of species can be integrated in holistic farm management. Sharing experiences through expanding communication mechanisms as intended with this book can lead to learning and to an ongoing process of further innovation.

The publication of this Guide is an expression of IFOAM's endeavor to promote and further develop the Principles of Organic Agriculture and thus inspire positive actions how agricultural practices can improve both healthy ecosystems and farm productivity.

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Introduction

Biodiversity and landscape quality is essential, particularly for agriculture. For Organic Agriculture, the enhancement of biodiversity and landscape quality is a guiding principle since the beginnings of the organic movement. The principle became of growing importance with worldwide recognition of a disastrous extinction of species – to a wide extent driven by unsustainable agricultural practices (Millennium Ecosystem Assessment, 2005) – as well as of the general disappearance of characteristic, highly structured, cultural landscapes with an intrinsic productivity. The decline has meanwhile taken existential proportions for the survival of mankind and the future of earth.

From principle to action

The way from guiding principles to concrete measures and visible effects on the farm and field is a difficult task and a permanent challenge. The implementation has to deal with many restrictions within the daily farm reality: There are economic constraints, constraints of knowledge, or restrictions of available manpower, and many more. Each single measure taken into account should be sustainable in the sense of bearable and acceptable for the farm in the long run.

A substantial help in this challenging process from principle to action may be provided by existing, well working prototypes of innovations. The promotion of successful examples inspires and motivates and gives concrete hints for actions on the given farm.

The present guide is a first collection of such "prototypes" from all over the world. We have tried to cover a representative variety of farm types, climatic conditions, cultivation methods, conservation priorities, habitats, and farming traditions. Thus for most farm situations there should be found relevant examples.

In addition we tried to select examples that are not only "bearable" for a farmer or a farm, but that might even have clear positive effects in different respects, be it economically, in respect to productivity or to life quality. Win-win situations are much more motivating and have a more general implementation potential than solutions that need particular resources or that decrease income or productivity. This guide intends to show that there exists a wide range of measures enhancing biodiversity and landscape quality that are not a burden, but on the contrary may have manifold positive effects on the farm – e.g. reduce work load or open new market opportunities. Of course, many actions demand a long breath, while success is uncertain, some examples also do not provide win-win results at all, but might be just for the pleasure or "intrinsic" life quality of the farmers livelihood – such as keeping beautiful old breeds or cultivating flower strips.

When designing the guide we were aware that the description of examples alone is not sufficient. In order to transform the "prototypes" into the particular situations of single farms and regions an understanding of why and how the examples work is essential. Therefore the given examples are accompanied by chapters that explain the most important ecological and agricultural principles, facts and thoughts in an easily understandable form. The more farmers

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and advisers understand the potential benefits of particular endeavours, the more they will be able to develop their own solutions, visions and concepts in the particular context of their own farm. Accordingly, this guide is not only addressed to Organic Agriculture, but can be translated to every kind of farm and agriculture.

Agriculture is biodiversity and landscape management

A close relation between biodiversity and landscape quality on one side and agricultural practices on the other is particularly given for Organic Agriculture. Two different aspects within this interrelation should be distinguished.

First, biodiversity touches the functionality of the farming system in its fundaments: All agricultural activities and all farming outputs are widely dependent on organisms, of which the composition and diversity of wild and domesticated species forms the key component. More than other production systems Organic Agriculture is focused on a cooperation rather than a "control" approach and therefore has an intrinsic interest in a healthy, diverse and stable environment with an "enhanced" biodiversity. The presence or absence of particular – wild and domesticated – species decides to a large extent what can be produced on a farm. Species can be helpful as well as harmful. And species and their characteristics (within and between species) are responsible for and origin of for the most important ecosystem services. As the unforeseen repercussions of ecosystem destruction have become evident and also economically relevant, research is now demonstrating the benefits to be gained of this approach (Harpinder et al, 2008; Ash and Jenkins, 2007).

Second, to a wide extent also the opposite is true: biodiversity and landscape quality is essentially dependent on farming activities wherever a place is used for primary production. Agriculture may harm, but also foster biodiversity and landscape quality to a wide extent (Millennium Ecosystem Assessment, 2005). It is important to state that in temperate zones particularly the agricultural use of the ecosystems and landscapes raised structural and species diversity as well as the sensual landscape qualities during centuries. In some regions far more than half of the "wild" species depend directly or indirectly on agricultural practices (BDM 2008). Thus the so called "traditional cultural landscapes" i.e. in Mid-Europe or in many parts of Asia can be much richer and more differentiated than the "natural" or original one.

Organic Agriculture has, from its roots, a particular ethical concern about biodiversity and landscape and the effects of agricultural practices towards it. The organic movement regards man as a part of nature with a clear responsibility for the well-being of the planet with all its species and beauty. Interestingly – unexpectedly for many economists – this ethical aspect has become market-relevant. Particularly in industrial countries agriculture is increasingly regarded as far more than merely a branch that provides food in the most "efficient" and profitable way. Consumers show growing interest in the added values and the positive (and negative) side effects of agriculture. And they are even willing to pay a corresponding price for it. Simultaneously more

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and more governments, mainly in Europe, developed programs to support farmers financially and methodologically in endeavours to enhance the diversity of life in the agricultural landscape or to preserve ancient cultivated landscapes.

Thus, endeavours to foster biodiversity and landscape quality by adapted agricultural measures and a holistic planning as proposed in this Guide, are not only an ethical commitment, but promise to bring agriculture forward in a functional and economic respect.

The origin of the innovations

Many farmers around the world, often with the help of scientists and advisers, and many scientists and advisers, normally with the help of farmers, are developing and testing techniques that enhance and protect biodiversity and at the same time improve livelihoods and even increase farm production levels and profit. These – sometimes simple – measures are exactly the type of innovations needed for implementing the principles of organic farming and developing the multifunctional agricultural systems which provide healthy food and fiber and income for farming communities, recreational and aesthetic values as well as the maintenance of biodiversity. However, since many of these innovations are often not communicated beyond the regional scope or reduced to generalized global management guidelines, potential integration, modification and further development by other farmers in other regions of the world as well as support for very promising innovative solutions is limited. Collecting, communicating and elucidating concrete and practical innovations as this Guide proposes is therefore, an obvious first step into the right direction.

How to use the Guide

The Guide contains an astounding number and range of innovations from around the globe which should inspire us all to take local action! However, after preparing yourself with the General Principles (Chapter 1) you might choose to go directly to the examples detailed in Chapter 2, 3 and 4 that are most relevant to you. They are divided by agricultural system: pastoral, annual cropping, perennial farming, and then within each one examples are given from different climatic zones. There you can read of innovations described by authors who live and work in, and are familiar with the particular systems described. Examples of trials, the impact upon biodiversity and the farm economy, lessons learned in practice on the ground, suggestions for practical activities to consider and references and websites, should launch you into some creative thinking for your own situation. A good look at ideas from other places and situations can also be stimulating, so then go back and read the rest!

The manual is primarily addressed to fervent (organic) farmers and enthusiastic environmental advisers (in the wider context it is also aimed at scientists, policymakers and students) who are looking for inspiration to adopt, modify and develop innovations which will contribute towards the organic and multifunctional agriculture of the future.

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The guide is thought to be a starting point for a book that has to be continued – with all the successful experiences not documented here, and all the experiences, solutions and further developments that were inspired by this starting point.

Developing these practices further is a process of continuous learning and sharing. IFOAM is committed to supporting and facilitating this process, to ensure that Organic Agriculture continues to take the lead in working towards a truly sustainable system of agricultural production.

BOX / Definitions

What is Biodiversity?

Biodiversity reflects the number, variety and variability of living organisms. It includes diversity within species, between species, and among ecosystems. The concept also covers how this diversity changes from one location to another and over time. Indicators such as the number of species in a given area can help in monitoring certain aspects of biodiversity. (Millennium Ecosystem Assessment, 2005).

What is Landscape Quality?

Aesthetics, culture, history and the spirit of place

We distinguish three aspects of nature: an a-biotic, a biotic and a spiritual or immaterial one. If the spiritual aspect does matter for nature, is not at stake at this point, but undoubtedly it is highly relevant for man as it is both – a natural and a spiritual being. The spiritual aspect of nature has many facets. In the context of agriculture a most important element can be called landscape in the sense of the meaning that man creates a particular surrounding. The landscape as "meaning", also called "athmosphere" or sprit or genius of a place, consists of the interaction between the sensual perception of "things" by man (aesthetics) and the notion that is given to those perceptions. The notion depends at the same time on the perceivable "things" and the cultural and individual mental background of the perceiver (according to Petrarca Foundation, Bosshard 2000, and European Landscape Convention 2000). As a consequence, landscapes can have healthy or also hurtful effects on the people (Abraham et al. 2007).

1. General principles

1.1. Biodiversity in an agricultural context – from genes, species, and ecosystems to whole landscapes

From Pollinators to Predators

On this planet, there are organic farms surrounded by terrain so wild that large predators occasionally visit, and yet there are other farms encircled by lands so sterile that a bee has a hard time finding sustenance. Farmers on the wilder side are learning to leave safe passages for large predators because they value this biodiversity that exerts a top-down regulatory influence on ecosystems. Take out these large carnivores, and the mid-sized predators and large grazing animals become overabundant, depleting smaller animals like birds that eat pest insects, and overgrazing vegetation that holds soil in place, respectively. Even the organic farmers situated in ecological wastelands of huge monocultures are bringing biodiversity to their lands by planting native flowering plants supportive of pollinators and predatory insects.

Biodiversity – What It Is and Isn't

Biological Diversity (biodiversity) is the variety of life. Not only does it include exotic mushrooms and heritage turkeys grown on the farm, but also the wilder elements of the landscape. From bacteria and fungi to grasses, ferns, trees, insects, and mammals, biodiversity includes all life forms and ecosystem types on Earth. It encompasses the diversity found at all levels of organization, from genetic diversity (i.e. diversity within species), species diversity (i.e. the number and variety of species) and ecosystem diversity (total number of ecosystem types). Biodiversity also includes the full range of natural processes upon which life depends, such as nutrient cycling, carbon and nitrogen fixation, predation, symbiosis, and natural succession.

It has been estimated that there are somewhere between 30 and 100 million species on Earth. For the last 250 years, biodiversity has been catalogued using the system first developed by Swedish naturalist Carl von Linne (Linnaeus in Latin). Each organism is assigned a double scientific name in Latin. For example, the wildcat of Europe, Asia, and Africa is known as ***Felis silvestris***. The first name Felis is the genus and the second silvestris is the species. People innately classified things long before Linnaeus however. Aboriginal societies have used the same kind of nested system, typically recognizing the same entities as species. Today's classification system has become more exact, taking into account not just the structural similarities first identified by Linnaeus, but also genetic analysis to show how closely related species are to one another and to their common ancestors.

Misunderstanding of the term biodiversity has perhaps occurred on some fronts in agriculture. Conservationists originally coined the term, and later farm groups defined it anthropomorphically. While biodiversity includes diverse soil micro-organisms, rare varieties and breeds (agricultural or farm biodiversity), it also encompasses the plants, animals and ecosystems (wild biodiversity) existing on and flowing through the farm. Industrialized agribusiness has clearly shown us the

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need to preserve both our farm heritage and natural systems along with the essential functions they provide in our farmscapes. As the farm perspective realigns with the conservation definition of biodiversity, farms and the wild will more thoroughly benefit from each other.

Gene Flow and Conservation

Diversity at the genetic level matters. Just as the nuances of genes give us production characteristics that can make for healthy livestock, so they determine the fitness of wild plants and animals. Within cattle for example, genes can express traits for efficient grazing; in crops, genes can provide resistance to pathogens. For native plants and animals, the flow and mix of the genes from one population to another keeps species from losing the full array of chromosomes that helps them function at their best. Farms can ensure that wild nature is sustained by conserving and restoring areas where native species are best suited, and by providing corridors that help connect gene flow through the landscape.

Conserving local and traditional animal breeds and crop varieties fosters optimum genetic diversity of farmed species. Locally adapted species do not use excessive water in dry climates, do not wilt or freeze as easily as those from other areas, nor do they require undue amounts of pest abatement. Traditional breeds are better suited to feed themselves in bio-diverse pastures of grasses and forbs instead of grazing a narrower selection of forage containing high levels of protein. Additionally, they do not require as much supplemental feeding, which can lead to excessive accumulation of manure in one place with resulting pollution.

All Species Are Not Equal

Not all species should be given equal weight when deciding which biodiversity to conserve and promote on the farm, and what changes to the land make the most sense. For example, the gain of a common pigeon or a hayfield does not offset the loss of an eagle or a wetland. Some native plants and animals are quite common in fragmented, simplified, human-dominated environments, and their numbers may even increase through agricultural activities. It is the well-being of the uncommon and priority species that should receive more consideration in organic farming. Priority species are composed of “rare species” that are in danger of becoming extinct within the foreseeable future, and of “keystone species” that are vital to maintaining their ecosystem, whose loss or reduction would lead to the decline of many species.

Generally, the conservation of native predators carries more weight than the conservation of their prey. Raptors and large carnivores take precedence over rabbits and mice (unless they themselves are priority species). In the same way, some species, such as reptiles and amphibians, are more likely to be harmed by farming activities than squirrels or blackbirds, and organic farm plans should include strategies to avoid or mitigate such losses. Native plant species should be used in farm restoration whenever possible; they have evolved in specific areas and have complex interactions with their ecosystems that are hard to duplicate. Additionally, native plants are well-adapted to local rainfall patterns, temperature fluctuations, soil conditions and native pests, and thus do not require excessive water or pampering. Local wildlife evolved with

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native plants and some of it is always able to utilize their resources, unlike with non-native plants, and these natives often attract beneficial organisms to the farm. At the same time, changing conditions such as climate change have to be taken into account. These may call for faster adaptation than would naturally happen – in this case, careful decisions for integrating other species have to be made.

Invasive plants and animals displace native species, significantly decreasing biodiversity in the landscape. Every farm has weedy plant species – those invading natural areas are of most concern. Once established they are hard to remove, so the best strategy is to learn about the potential invasives near the farm and remove them immediately they are found.

Ecosystem Libraries and Networks

Many primary ecosystems are becoming scarce due to human activity and will continue to decline significantly from their historic ranges as our population grows, unless we choose differently. They supply human and wild communities with 'ecosystem services', such as clean water and carbon sequestration. And like libraries of knowledge, intact ecosystems inform us how to conduct restoration that can benefit the farm.

A conservation network of connections linking farms and primary ecosystems, including protected areas, supports biodiversity. Farms frequently have unused pieces of land that may be too rocky, steep, or wet to work, and these patches whether big or small can serve as the backbone of a farm's corridor. As a rule of thumb, a continuous connection is better than a fragmented one, corridors are better wide than narrow, and two or more linkages between fragmented wildlands are better than one.

Whole Landscapes in Context

Landscape scale biodiversity conservation generally takes place over areas much larger than an individual farm or a single ecosystem. The measure of success is not simply the number of species, natural communities, biological processes, or even ecosystems in a given area. It is whether the landscape as a whole achieves conditions able to support viable populations of native species, particularly those most adversely affected by human disturbance.

1.2 Interrelations and synergies between agriculture and biodiversity

Farmers' Ability to Rectify the Biodiversity Crisis

About half of the earth's land is in farming and ranching. That large footprint has replaced natural habitat and is the major reason for the world's biodiversity crisis. Rather than being spread around evenly, this loss predominantly affects flatter lands – the area most accessible to people. With respect to different ecosystems, forests have been hit the hardest. Habitat loss from

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agriculture has caused the listing of about 89% of all threatened birds, 83% of all threatened mammals, and 91% of all threatened plants (IUCN). As stewards of the land, farmers have a unique ability to help turn this around.

Depending on the diversity of the farm and the health of its watershed, agricultural lands can support large populations of plants and animals and can considerably affect the overall level of biodiversity. Daily decisions made by farmers have significance. Their simple actions might conserve clean spawning gravels for rare fish or safe passage for large predators. Wildlife needs quality habitat in order to survive the vagaries of weather and the inconsistencies of food, shelter and water supplies. Native plants' presence indicates the soil and water conditions and disturbance regimes necessary for their livelihood. They are resilient, but only under the right conditions. Farmers' actions can support the health of these native species, helping them to prosper, or can compromise it, forcing them to relocate or die.

Fragmentation and Agricultural Connections

Protected areas amount to about 10% of the global landscape. Without connections, these habitats become fragmented "islands" within altered lands, and the movement and gene flow between native populations is severely diminished. Isolation eventually leads to the loss of many original species, and the dynamic between the remaining numbers of species changes as well, shifting for some to become unnaturally abundant and others much less so. Agriculture can serve as networks of functional habitats that link fragmented populations of native species and ecosystems.

The most obvious wildlife connections between farms and neighboring lands are often along waterways where riparian vegetation offers cover. However, linkages do occur wherever patches of woodlands, grasslands, and other wildness have been conserved. In places where wildlife has left its telltale tracks, the paths can be augmented with native vegetation. Working with adjoining landowners helps to establish and maintain ecosystem connections and makes an even greater contribution to biodiversity conservation. By establishing these links, farmers reap nature's ecosystem services, including pollination, insect pest control, advantageous fire, predation, and natural erosion control.

Nature's Gifts to Agriculture

Farms function within and interact with the surrounding ecosystem on multiple levels. Bacteria and fungi feed on organic matter giving the soil tilth and fertility. Native vegetation in riparian areas holds soil in place while filtering out sediments and excessive nutrients. Unique combinations of wet and dry soils have the ability to break down many types of pollutants, thereby yielding cleaner water. Native plants can also complement livestock forage in pastures. A diversity of plants supports native grassland birds and increased soil biota, and yields a diet more appropriate to traditional breeds of livestock.

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Native pollinators contribute billions of dollars to crops, pastures and wildlands, ensuring food for the next generation. Some crops, such as alfalfa, blueberries, cranberries, and tomatoes, produce higher yields and income with native pollinators than with non-native bees. Pest outbreaks can be averted by attracting predatory and parasitic insects. These beneficial insect services are more abundant on farms that provide sequentially flowering native habitat in hedgerows, windbreaks, or riverside plantings. Similarly, farms located close to wildlands providing a diversity of flowering vegetation and cover also reap pollination and pest control services.

Birds do their part in keeping insect populations down, having evolved to search out pests that frequent pastures crops, and orchards. Most songbirds feed on insects and while some do eat fruit, even they raise their young on a diet containing insects. Insectivorous bats will consume more than their body weight in invertebrates. Raptors such as the barn owl, will capture a dozen rodents per night when raising their young. Farms providing nesting and roosting habitat or near natural areas that do, garner the most support from these free-flying pest services.

Mid-sized predators, taking advantage of wildlife movement corridors on farms, will help to keep rodents in check. Larger, top-down predators are the widest-ranging, and their rarer presence keeps healthy populations of mid-sized predators from overly impacting the birds, snakes, fish, and other wild vertebrates. A conservation network of farms linked to wildlands results in a bio-diverse landscape full of native bees, migratory birds and top food chain predators.

When habitat is restored for one reason, a cascade of other benefits may result. Native fish can thrive in areas that make soil conservation a priority. Hedgerows and windbreaks installed to attract beneficial insects and moderate the climate can support amphibians, birds and bats. Land values can increase with the presence of aesthetically pleasing restored areas. Although benefits abound, incorporating conservation practices may come with certain risks. Unwanted pests could be attracted and sensitive ecosystems may be harmed. Care should be taken to monitor new practices and actions, so that for example, native plants don't harbor crop diseases, or a manipulated wetland does not become less viable for rare species.

Implementing the many organic farming practices that benefit native species and ecosystems also benefits the larger community. Farmers become good neighbors and appreciated members of their society. Maintaining habitat can be enduring and cost effective; an organic farmer's standard of living is measured not only by yields, but also by the quality and biodiversity of life.

Interactive pest management – A short history of mutual benefits

In conventional or chemical agriculture, synthetic pesticides are used to control unwanted organisms. This has caused many problems such as food and environmental pollution and poses risks to animals, human and other organisms. The so-called 'pesticide' is a chemical used to control, to repel, to attract or to kill pests, such as insects, weeds, birds, mammals, or microbes that are considered a nuisance. Pesticides are usually highly poisonous, causing injury, illness or death of living organisms, and chemical engineers are continually developing new pesticides to enhance existing products.

DDT is one example of a once heavily used insecticide that is also toxic to birds and mammals. It was banned in the 1970s in a wide range of countries, but the adverse effects are apparent even now, for example, affecting babies through milk containing DDT that was deposited in the mother's body several decades ago. Many of the newer generations of pesticides also present dangers to humans when used to control weeds or insects on food crops. Fruits and vegetables may contain residual pesticides even after being washed or peeled and yet still meet government limits. Besides human health risks, pesticides also pose dangers to the environment. Non-target organisms can be severely impacted. Therefore, alternative methods of pest management must be utilized for any form of natural farming or organic crop production.

Integrated pest management (IPM) was introduced as a concept in the United States in the late 1950s and developed to harmonize chemical control and biological control. The early concept was based on the premise that pesticides should have a minimum impact on the natural enemies. The idea of "Economic threshold" was introduced at the same time, based on the knowledge that pest populations fluctuate naturally. Control measures should only be used to prevent an increasing pest population from reaching the economic injury level. This "economic injury level" was defined as the lowest density that will cause economic damage. These concepts remained the major theme of IPM throughout the 1970s though there are in fact 64 definitions of integrated pest control or integrated pest management (IPM) that have been made since the early 1930s! In simple terms, IPM can be a procedure to manage pest populations by harmonizing control methods such as natural enemies, pesticides and cultural practices, for the purpose of minimizing economic damage and harmful environmental side-effects by managing pest populations instead of eradicating or removing the pest.

The theory and principles of IPM have been developed over the last 40 years. Prior to World War II, pest control was accomplished primarily through cultivation practices such as tillage and rotation as well as mechanical removal of pests. After World War II, DDT and other synthetic insecticides came into use world-wide to control insect pests. The regular use of pesticides started in industrialized countries in the early 1950s. By the 1970s, farmers in industrialized countries had come to rely heavily on pesticides without considering other methods. However, pests adapted to the chemicals and there was a general loss of efficacy. This at first led to increases in dosage, and eventually caused a shift to non-pesticide tactics in the 1980s with expanded use of cultural and biological controls and introduction of resistant crop cultivars for economic reasons. In the 1990s, extension techniques and policy have strongly emphasized the development of IPM. This trend within conventional farming has increased the amount of research on IPM, enabling organic and natural farmers to access a large amount of new information. Practices of the alternative type of 'interactive pest management' are encouraged and embedded into organic farming. The aim of managing pest species or keeping a balance in the agro-ecosystem reduces collateral damage to the environment and the wider biodiversity.

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1.3 Landscape quality and function – an important product of agricultural land use

Agriculture is responsible for the largest component of human impact on the landscape

Landscape and agriculture are strongly interrelated because agriculture has the most far ranging effect on the inhabitable surface of earth of all human activities. More than half of the terrestrial area is directly shaped by agriculture, i.e., five billion hectares are under agricultural use.

What is Landscape?

In the US, Australia and other countries mainly in the new world, landscape is associated primarily or only with the functional aspect, i.e. landscape as a fundamental substrate of physical processes. On the other hand, particularly in Europe, but also in eastern Asian countries the qualitative or aesthetic approach is predominant. This different understanding of landscape often aggravates communication. Therefore we first need a clarification of the term "landscape".

Landscape quality

In this book we refer to the aesthetic approach, while the physical aspect of landscape is included in the chapters concerning ecology and biodiversity enhancement. In qualitative terms landscape can be defined as the sum of sensory impressions of a location and ist meanings: we can speak of the holistic character of a landscape, the genius loci, the atmosphere, or the place's essential nature. In the same way that a human being first touches us by their character, or charisma, each location possesses its particular character - be it a "power place" (a sacred or holy place), a wheat field, a farm, a doleful margin or a highway. The fact that we are not normally aware of this particular character of each location does not mean that it is irrelevant. Rather the aesthetic quality of a landscape is a fundamental part of human quality of life, and of our mental and physical health. There is no question that we compose our living and working environments – including landscapes – according to our own aesthetic visions and needs. Some old cultural landscapes are among the most attractive landscapes in the world and are visited each year by millions of tourists. The cultural landscape of Switzerland alone is estimated to generate economic revenue of more than one billion dollars per year through tourism. These are impressive numbers and examples that show the potential - in this case economic - value of the qualitative aspect of landscapes. For farmers there are normally other aspects of landscape quality that are more important. The following are three examples that show why landscape quality on a farm really matters:

- *Landscape quality affects the health and welfare of the farming family:*

  The landscape is their main living and working space, and its atmosphere, which includes all aspects of health: physical, mental and psychic, impact directly on the well being of the farmer day by day. When working in a field that lies along a road with permanent car traffic, negative impacts are obvious and measurable. Nobody denies that it could harm a farmer's health if they are exposed to the noise and the exhausts of the highway over a long time. Less "physical" and accordingly less obvious is the difference between a bare landscape and highly structured landscape: we may feel completely different, in the two landscapes and it is possible that the genius loci of these two landscapes, during a longer period of time, affects our welfare in completely different ways. Several studies investigated this phenomenon: the attractiveness of a landscape, for example, can be expressed by the price index of comparable houses – as more traditional and structured the landscape, as higher prices are payed. Normally, the more structured a landscape is the more its particular character becomes expressed and the higher its potential as a recognized beautiful place becomes.

- *Landscape quality may affect the quality and yield of the agricultural products:*

  There is a positive relationship between some physical or sensual landscape quality aspects and the product quality - e.g. air quality as fundamental sensual aspect of a landscape affects the pollutant contamination of e.g. legumes.

- *Landscape quality and character can be used as an effective marketing instrument:*

  Many landscapes have the potential or status of real brands due to their typical, unique characters. Many examples illustrate these brands as an important marketing tool. Such branding can lead to remarkably high product prices compared with brand-less products - at least if combined with a particular product quality. One example is the "DO certified Dehesa de Extremadura hams", that originate from particular pork breeds which live only in the typical vast open oak forests in central and south-western Spain and feed on acorns. Many examples are also known from Italy, where the 'lentils of Castellucio' is one of the most impressive: the lentils are cultivated with traditional methods on just a few hectares in one particular place, a high, outstandingly beautiful plateau at 1400 m a.s.l. in Umbria. On the spot they are sold for 13 US $ a kilo, in other places for even more. The large difference in price with a 'conventional' kilo of lentils which costs less than 3US $, illustrates how landscape quality contributes to added value.

The most important question in relation to landscape quality is how to define or measure it. What makes the beauty of a landscape? What are the elements that create the spirit of a power place? What are the ingredients that make a landscape healthy? Unfortunately these questions are not as simple to answer as questions concerning the yield of a wheat field or the nutritional content of its grains. Landscape quality is of a more subtle and ethereal kind. Bockemühl, a landscape philosopher, once said that the values of a landscape depend on "the between" (between the visible, physical "things") (Bockemühl J. 1992 - Awakening to Landscape. Verlag am Goetheanum). However, as landscape philosophy and qualitative landscape theory is beyond the scope of this guide, it is sufficient to point to the aesthetic aspect of landscape and to call on people to pay more attention to its particular character and to the effect different landscapes have on us. If this kind of attention and sensibility is developed, then the above questions on "what is landscape quality?" can more easily be explained, and accordingly, increasingly clear answers can be found for each single case (for more details and further reading see links and sources). Some examples on how to improve the health of a landscape are given in the following chapters.

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Landscape functionality

Whereas landscape quality can be viewed as the more subtle aspect of landscape, landscape in terms of functionality refers to the physical aspects of landscape. From this functional viewpoint, a landscape can be seen as a complex system that consists of various ecosystems containing different habitats, structures, species, ecotypes, genes, and abiotic conditions. All these elements are interrelated and are responsible for the 'output', i.e., the performance and health of the system. Thus a landscape provides fundamental functional services - called landscape or ecosystem services, such as clean water, pest control by beneficial organisms, good soils etc. Consequently, agricultural systems, which disregard natural system services, produce inefficiently and expensively. Conventional agriculture nevertheless tends to replace many of the natural services by artificial inputs, e.g. pesticides and non-renewable energy. On the other hand, organic agriculture attempts to co-operate with the functionality of the landscape as far as possible by supporting and at the same time by using those services in an intelligent way. This sustainable approach is one of the fundamentals of organic agriculture. Because conventional agriculture depends heavily on artificial inputs, conventional agriculture becomes less competitive and attractive with increasing prices for energy and row materials like fertilizers.

Structure and biodiversity are two crucial elements within the network of a landscape and thus decisive for many of the ecosystem services provided. For example, research shows a close relationship between species diversity and yield in meadows. It is also well documented that pest investation in species rich landscapes is lower than that in structurally poor monoculture landscapes. In the following chapters, examples of intelligent, synergetic use of landscape services are given.

2. Maintaining genetic diversity of crops and breeds

2.1. General Introduction

The term "biodiversity" does not only refer to wild flora and fauna, but also includes the once rich variety of agricultural breeds and seeds, and whole ecological systems, which have been traditionally used for human nutrition (agricultural biodiversity). This diversity has been significantly decreased by replacing old domestic breeds and varieties by the high performance breeds favored by industrialized agricultural processes. The breeds that did not reach the new desired standards such as more meat and milk for cattle or higher yielding strains of corn, lost their value and disappeared both from the market and the farm. Some breeds and varieties are already extinct, and for others only a few individuals remain. Even though the old breeds and varieties bring unsatisfactory yields when compared to modern standards, they possess important qualities like high fertility, robustness, and are resistant to harsh climates as well as against some diseases. These factors could regain importance in changing future economic or climatic conditions. The traditional breeds and seeds have been adapted over generations to the needs of man as well as to the special conditions of their local environment. Thus, they are not only genetically interesting, but are also a valuable cultural heritage worthy of conservation.

As far as rare breeds of farm animals are concerned:

These breeds have proven their usefulness in the past and even today their unique characteristics can be 'put to work', albeit it in different and novel ways. Each breed has its own specific characteristics that mark it out from others and make it worthy of conservation. These animals are often known for their hardiness, longevity, climatic tolerance, ease of reproduction and for their disease resistance. Additionally, the products made from the milk or meat are of good flavor. Alternative uses for these breeds can be developed or revitalized that allow conservation to occur whilst bringing benefits to farmers. For example, horses can be used for forestry work, pigs to cultivate land, sheep and cattle for grazing areas that are difficult to mow. There are many facets of the old breeds of farm animals that make them ideal for low input farming and nature reserve management.

These breeds constitute a pool of valuable genetic resources that were useful in the past and might become valuable in the future in the light of food security for growing populations, especially in poorer countries. New genetic combinations may well be required for the changing global climate. The combining of the genetic attributes found in old breeds can give rise to new crossbreeds that can cope with harsher climates, more frugal fodder and a rise in disease. Many modern breeds will not be able to survive drastically changed conditions.

As far as varieties of cultivated plants are concerned:

Traditionally, cultivated plants grow and thrive in symbiosis with surrounding species. They evolved over thousands of years in a dynamic interaction between nature and farmers' careful selection and breeding. Local varieties of wheat, corn, fruit and vegetables have assured millions of people an adequate diet. Traditional plants have provided fodder for domestic animals, fiber, clothing, shelter, and energy as well as multiple other products and services, and will continue to combine local resources with local needs in an optimal way. Old and traditional cultivated plants may be adapted to a particular type of soil, climate and growing season. Their genes may endow them with particular traits needed by farmers: disease resistance, cold or heat tolerance, special flavor or nutritional qualities. These qualities provide farmers and plant breeders with raw materials to improve their cultivated plants and adapt them to changing environmental conditions and should, therefore, be preserved.

In general, traditional breeds and cultivated plants reflect historical and cultural values, as they are the result of centuries of caring, nurturing and selecting by our forefathers and deserve our respect. They have largely contributed to our present standard of living (textiles, nutrition, and leisure) and earn our gratitude; they are an integral part of some local landscapes and environment and thus, merit our protection.

When farmland is largely traditionally managed, it can carry a massive diversity of wild plants and animals. Thus, agro-biodiversity can be seen as an essential part of biodiversity conservation. This conclusion is reflected in the international agreement of the "Convention on Biological Diversity" signed in 1992 in Rio de Janeiro (CBD, Art. 2, ff). Not only are wild animals and plants worthy of protection and conservation, their domesticated relatives are equally worthy. With sustainable use of the natural surroundings, biologically valuable traditional agro-ecosystems have developed within each regional ecosystem. A traditional agro-ecosystem is characterized by a regional blend of wild and domesticated plants and animals. It is not only the animals and plants on the farm that are included in these systems, but also the wildlife, wild plants, forests and waterways close to the farmstead as well as more remote external factors such as the Alpine meadows used in summer in Europe. Today these areas of high diversity belong to the most endangered ecosystems. Yield increases, industrialization and over-use for agricultural production have led to destruction of ecosystems and biodiversity through the changing production methods and expectations of agriculture. Relicts of once extensive regional ecosystems need to be conserved long-term in both sustainable and economically viable ways. Principles of organic farming offer many fruitful synergies between nature conservation and agro-biodiversity: it is only with good management practice that a regional ecosystem can be conserved in its full diversity. Old livestock breeds and cultivated plants adapted to the locality, can offer a low-cost alternative to elaborate technical solutions. These alternatives can provide an extra income source for farmers, as niche products can be created or rediscovered that make use of the new on farm diversity.

Some examples of low cost alternatives:

- Grazing with old livestock breeds: robust and bred for sparse conditions, they are content with rough grazing and usually need no more than a shelter.

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- Conserving old fruit trees: robust orchards and traditional hedgerows with fruit bushes are elements of the landscape enjoyed by wildlife and humans alike.
- Cultivation of regionally typical grain and vegetable varieties can be used as a sustainable and environmentally compatible pesticide free farming method in delicate natural areas.
- Traditional agro-ecosystems, in which specifically adapted livestock and cultivated plants are used, conserve the functioning of ecological systems promoting soil fertility, regulation of pests and diseases and increase pollination.

2.1.1. Examples for improving animal breed diversity and genetic diversity within breeds

Introduction

Marginal grassland and pastures, terraced landscapes, ravines, and meadows on very steep slopes are all elements of farm landscapes that developed through necessity and whose conservation requires creativity. In extensive and inaccessible areas particularly, good maintenance and economically efficient use and management are often impossible. The expense of cutting and removing hay may be too cost intensive to be of interest to a farmer. Fallow development, vegetation encroachment and thus undesirable decrease of species diversity are the result. This trend can be turned around through the use of traditional breeds.

Traditional management of the farm ecosystem allows a wider range of animals to be kept on the farm. In order to manage the traditional livestock breeds effectively, it is recommended that farmers do their homework well before embarking on the adventure of keeping these livestock. In this they can be supported by their local or national associations for the conservation of agro-biodiversity (see: www.agrobiodiversity.net) who often provide guidance on how the breed can be kept and also on how to maintain genetic diversity within it. A further source of information is other farmers who keep traditional livestock breeds (see: www.arca-net.info)

Generally it is very important to start the project of introducing old livestock breeds to the farm by researching local traditions. Over centuries animals have been selected and bred to endure and survive the climatic and vegetative conditions of the area. Thus, any animals chosen should ideally be animals that have been traditionally found there. Talking to members of the older generation to gain traditional knowledge is important. National or local organizations concerned with promoting and conserving agro-biodiversity will be able to aid in decision making. Sometimes, however, local livestock breeds may have become extinct, in which case it is suggested that a replacement breed that comes from a similar environment as is found on the farm in question should be used. Occasionally, animals are used in landscapes where they have never occurred before (such as Scottish Highland Cattle in Southern Europe). These attempts are doomed to failure from the start as the animal species or breed is not adapted to the environment, thus causing numerous husbandry problems. Modern performance breeds for example can cause devastating trampling damage to farmland at sensitive sites.

Another important point is to choose which type of animal to keep. To do this one must decide where it should be kept and what infrastructure and knowledge is already to hand on the farm. For example, a farm that already keeps sheep will have very little extra costs or infrastructure needs should the decision be made to keep a traditional breed of sheep as an additional flock. A traditional sheep breed has an advantage in that it can be kept on land that may not be ideal for modern breeds; it requires only a shelter and can withstand harsh weather conditions. Also, a-seasonal lambing patterns, high fertility and few birthing problems can bring extra income to the farm through sales of meat.

Innovation

Old and traditional breeds that can be put to use on land that cannot be farmed efficiently by modern methods.

Innovation 1

Using old breeds to manage marginal land on the farm.

Biodiversity (++)	Economy (+)
Keeping down scrub growth, promoting biodiversity rich meadows, utilising land that would otherwise be unusable.	Benefits of "free" mowing or "tidying" of difficult areas as well as low maintenance animals.

Implementation:

Many examples of using old breeds to manage marginal farmland already exist:

- Turopolje pigs keep the swamp areas of the Sava Plains in Croatia open. Many bird species, insects and small mammals benefit from their activities.
- Podgorska Red Cattle are well adapted to the mat-grass (*Nardus stricta*) of the Polish Beskids. Grazing with this breed helps to maintain this rare type of cultural landscape.
- Water buffalo at Lake Prespa (and at other sites) in Greece act as natural lawnmowers in swamp areas and keep the shore vegetation open for wild animals.
- The small and agile Prespa cattle prevent the area at Lake Prespa from the vegetation encroachment, dreaded in many nature protection areas.
- Karachan sheep conserve the open park landscape in the Bulgarian Rhodopen.
- Karachan horses are 'ecological' draught animals in Rila National Park in Bulgaria.
- Rhoen sheep conserve pastures at higher altitudes and semi-dry grassland with unique plant communities in German low mountain ranges.

- Original Pinzgau cattle have been nominated as the breed of the Austrian National Park "Hohe Tauern". Their 'work' can be admired at many sites of the park and the meat is offered in restaurants.

Impact on biodiversity

Extensive pasture landscapes, as examples of primary natural ecosystems, have become subject to nature conservancy protection. Many of these areas in Europe are now densely wooded as they were not grazed so that they lost their original wood-pasture character. The "New Forest" in Southern England (Hampshire) is often mentioned as 'mother' of this grazing practice. For more than a thousand years, continuous grazing with different livestock species has been practiced here. Today it is the largest area in the whole of Western Europe where heathland, swamp and wood-pasture habitats coexist in a functioning ecosystem. The application of traditional techniques such as grazing forest pastures is very important for the conservation of these landscapes. In most traditional husbandry systems, different animal species are managed together on a relatively large area: on alpine pastures, cattle and goats grazed together. Pigs were fed with whey from cheese production, but also grazed or, in the case of the New Forest, were released to forage for 'pannage' usually in the form of acorns. In South-West Europe it is common in many remote areas to graze animals together. Park ¬like landscapes including a mosaic of different habitats develop in this way thus increasing biodiversity.

Impact on farm economy

Using animals to graze rough pastures and inaccessible areas of the farm has the advantage of reducing the mowing required to keep these areas clear of scrub. The man-hours and machinery used in this mowing is no longer necessary, instead the farm benefits from the services and the produce (meat, wool) provided by the traditional breeds. Other services provided by traditional breeds can be seen in the land clearance performed by pigs, goats and chickens who all clear scrub land well, fertilizing as they go. Pigs have been traditionally used to clear windfall fruit in orchards and fruit-tree meadows both before the main harvest begins and after the main crop has been harvested. Allowing pigs to forage in orchards shortly before slaughter leads to a fine flavored meat that can be sold for a premium price.

Examples

It is important to use the breeds traditional to the locality as these often have the following advantages:

- They are adapted to the regional climate and protected by their coats, subcutaneous tissue or fat from effects of the weather.
- Hooves and claws are adapted to local conditions: hard hooves in stony mountain regions, resistance against foot rot or scald in humid areas or swamps
- They are smaller and lighter than modern performance breeds. Trampling damage is seldom, animals are exceptionally agile.

- They are frugal as regards feed supply, use rushes and poor grasses as they have been adapted to regional sites for centuries
- They give birth easily, but reach maturity late
- They are generally robust and tough as the sum of above listed characteristics
- Being kept outside throughout the whole year, they only need rough shelter.
- The quality of their meat often exceeds that of performance breeds as regards taste and aroma, because slow growth produces fibrous meat.

Lessons learned

- Expensive land maintenance of marginal sites can be accomplished with less man-hours and no machines through the deployment of traditional breeds of domestic livestock.

Fig. 2.3(1).The booted goat (Stiefelgeiss) is a robust and hardy goat, ideal for hilly or mountainous areas. It is a good meat animal and also produces a good quantity of milk. It is known for its fertility and generally produces twins. Photo by Béla Bartha.

Fig. 2.3(2). Turopolje pigs keep the swamp areas of the Sava plains in Croatia open. Photo by Christian Windhofer

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Fig. 2.3 (3). Karakachan Sheep: They are resistant to cold and wet weather and are exceedingly fertile and healthy. Photo by Srdjan Stojanovic

Fig 2.3(4).Grazing at the Bojana Buna Delta. Dwarf Cattle are light footed, hardy, satisfied with meagre grazing. They are ideal for extensive grazing in fragile areas. Photo by Borut Stumberger.

Recommended reading

- The State of the World's Animal Genetic Resources for Food and Agriculture, FAO Commission on Genetic Resources for Food and Agriculture, Rome, 2007.
- "Conservation and Sustainable Use of Agricultural Biodiversity" A Sourcebook. CIP-UPWARD – International Potato Centre, Philippines, 2003
- Gauchan., D and Smale., M (2007) the Value of Rice Landraces in Nepal. In Jarvis, D.I., Padoch, C. and Cooper, H.D. (eds) Managing Biodiversity in Agricultural Ecosystems. Bioversity International, Columbia University Press, Chichester, West Sussex

Recommended websites

- Organizations involved in the conservation of Agro-biodiversity: http://www.agrobiodiversity.net/
- Domestic Animal Diversity Information System: http://dad.fao.org/
- Global Facilitation Unit for Underutilized Species: http://www.underutilized-species.org
- Rare Breeds International: http://www.rbi.it/

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3. Improving species diversity on the farm

3.1. General Introduction

In many regions of the world, agriculture has shaped impressive cultural landscapes that have been ecologically stable for centuries. Studies indicate that traditional agriculture was capable of raising the agricultural productivity of those landscapes without depleting the natural resources, and that an increase in productivity and a permanent increase of biodiversity are not mutually exclusive (Fig. 3.1.(1)). In some regions of Central Europe, direct or indirect effects of agriculture contribute to more than half of the diversity of plants and of several other organism groups. This impressive example of sustainability point to the potential of agriculture to produce food in co-operation with nature and even to enhance biodiversity and landscape quality.

In the last decades, the role of agriculture has turned from enriching to depleting the landscapes. Agriculture today is the largest factor of all human activities that contributes to the loss of biodiversity. There are many reasons for this tragic development. However, more important than a retrospective analysis is the fact that modern farming, and particularly organic farming, is able to reverse the dramatic decline of biodiversity in the cultural landscape if distinct efforts are made, and measures are developed that balance the support for nature with the requirements of a farm.

Biological diversity / biodiversity on a farm can be categorized into three major elements:

- genetic diversity of crop and livestock varieties on the one hand and of wild biota on the other (genetic level of biodiversity, subject of chapter 2.)
- the diversity of species on fields, plots and in specific cropping systems (species level of biodiversity, chapter 1).
- the diversity of vegetation communities, habitats or crop types including the interactions of these in the whole farm (ecosystem level of biodiversity, chapter 4).

This chapter focuses (1) on the species level of biodiversity on farmland, and (2) on the natural or semi-natural part of the species diversity. The latter represents the richness of species that are not deliberately planted, seeded or fed on a farm.

The chapter gives examples that show how improving biodiversity can bring about economic and social benefits: biodiversity can be directly beneficial to the farmer in terms of enhancing productivity, supporting product quality or securing food production if agricultural practices are built on aspects of a sound landscape management..

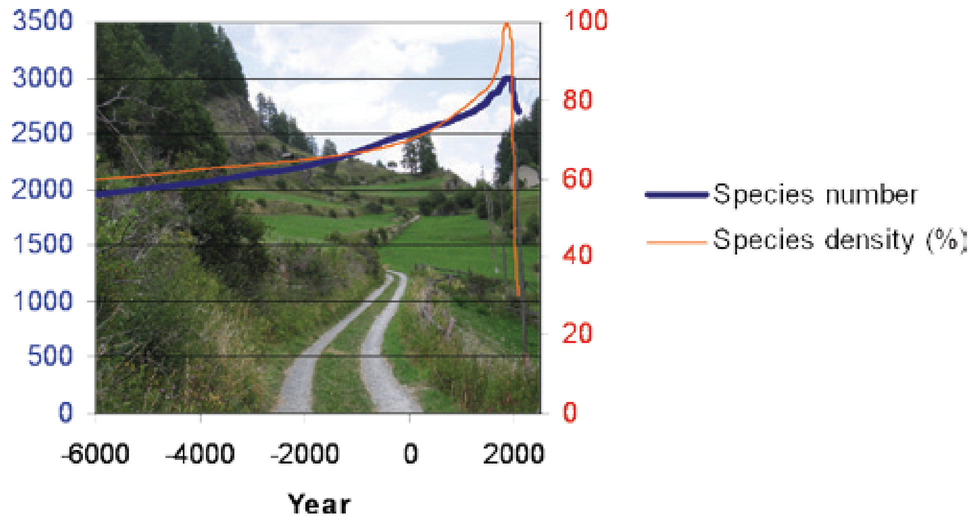

Fig. 3.1(1). Development of plant biodiversity in Switzerland during the last 8000 years. Source: Landolt 1991, the red list of higher plants in Switzerland (blue line), Bosshard, publ. in prep. (red line – referring to an average farm of 20 ha in the Swiss plateau).

3.2. Meadows and pastoral systems

3.2.1. Examples from pastoral systems in temperate zones

Introduction

Meadows and pastures are grassland ecosystems that are influenced by the way they have been used. In Europe, both semi-natural and extensively utilized grasslands are part of the most species-rich ecosystems. Also, species-diverse meadows and pastures make up the largest percentage of the so called 'High Nature Value Farmlands'. Their importance goes much further than just the maintenance of biodiversity of plants and animals as they fulfill many other functions within the natural environment (e.g. function of quality for agricultural products such as cheese, meat; filter and buffer functionality for ground and surface water; habitat for pollinators; recreation; identity and cultural function).

In grassland systems in boreal and temperate zones, mowing is a fundamental human interference with natural processes. Over centuries man has turned many woodland areas into grassland, which today are not only the habitat of many different species but also part of our cultural heritage. However, today's widely practiced mowing techniques; modern machinery, the commonly adopted mowing regimes, fertilization, and the constant grazing pressure of livestock pose major threats to many of the existing meadow species and their beneficiaries. Also, the mowing of large areas in short intervals as well as the preparation of silage instead of hay causes problems to the fauna of grasslands. Two examples will be used to describe innovations that could be adopted by organic farmers in order to contribute towards the protection of biodiversity in grassland systems without incurring a major economic loss.

Innovations

1. Use appropriate mowing techniques/equipment for species rich grassland.

2. Use biodiversity friendly grassland management regime on pastures and meadows.

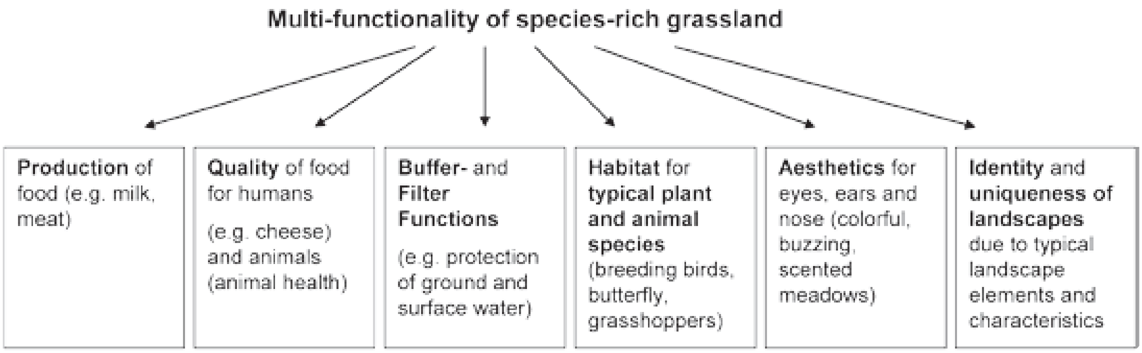

Fig. 3.2.1(1): Species-rich grassland is a model for multi-functionality within agriculture. These functions consist of functions of production, ecological functions as well as socio-economic and health functions.

Fig. 3.2.1(2): A flower-rich meadow reflects the habitat quality also for animals, e.g. butterflies, grasshoppers and many other insects as well as insectivore birds (left). The whinchat (*saxicola rubetra*) depends on insect-rich meadows and pastures as breeding habitat (right).

Innovation 1

Use appropriate mowing techniques/equipment.

Biodiversity (++)	Economy (-)
Substantial reduction of damage to fauna.	Not always practical and time-consuming.

Implementation

This first innovation is a technical one. A number of different investigations have shown that mowing can cause substantial losses of grassland fauna, depending on the machines and techniques used (Fig. 3.2.1(5)). Therefore, only moderate mowing equipment should be applied as carefully as possible on current or potential species rich grassland.

In order to implement this innovation the following measures are adopted by many farmers in central Europe:

- Horizontal blade mowers are used instead of rotary mowers or mulching mowers and mower conditioners are not used on species rich grassland.
- The minimum mowing level is kept more than 10 cm above the ground and grassland areas are mown from the centre to the edge (see transparency 3.2.1(5)) or in striped patterns.

Impact on biodiversity

Blade mower systems cause the least damage to fauna since they operate with a comparatively small danger zone and without pull and/or centrifugal forces. They cause 2 to 3 times (and maybe up to 10 times) less damage to vertebrates like amphibians, and invertebrates, if compared to rotary mowers and mulching mowers, respectively. Mower conditioners, however, additionally increase the damage to fauna. The damage to bees for example has been recorded to be sevenfold higher if compared to mowers without this conditioning equipment. Keeping the mowing level more than 10 cm above the ground will allow a big proportion of the ground dwellers such as spiders, beetles, amphibians and reptiles to escape damage caused by the blades. For birds and other vertebrates mowing from the centre to the edge allows them to escape from mowing machines. Leaving out strips from mowing generates another advantageous effect as they provide temporary shelter, cover and nourishment for some animals.

Impact on farm economy

Provided that the equipment is already available the only economic burden associated with choosing a horizontal blade mower instead of any other mowing equipment is a potential increase in mowing time. This is usually due to slower driving of the machines (sensitivity of the equipment) and because the blades need to be changed more frequently. The mowing equipment (modern horizontal blade mowers) itself is not more expensive than modern rotary mowers. Mowing with horizontal blade mowers needs less energy and fuel: the mowing equipment is less heavy and requires less operating power. Not using a mower conditioner involves an extension of the drying or wilting time of the grass cut, which can be a disadvantage in critical weather situations. Unfortunately, some mowing machines are designed in a manner that the mowing conditioner cannot be switched off (since many modern mowing machines are built with integrated conditioners). Adapting the mowing level is easily implemented and does not lead to a substantial loss in the amount of hay or silage harvested. Also, mowing from the centre to the edges as well as leaving out marginal stripes is normally done without any problems.

Lessons learned

- Mowing species rich grassland, the horizontal blade mower is the most biodiversity friendly equipment.
- For the protection of biodiversity, mower conditioners and mulching mowers should not be used on species rich grassland.
- Mow grassland areas from the centre to the edge or in stripe patterns and leave some later mown strips.

Fig. 3.2.1(3): High losses of fauna occur especially with the usage of rotary mowers.

Fig. 3.2.1(4). In comparison, blade mowers are the most gentle mowing machines. This figure shows a modern "butterfly-mowing-machine" (with a front-mower and 2 rear-mowers) with 9m working-width. (Right) and a blade mower which exists for front and rear extension and for working-widths of up to 9m (left).

Case study

The study of Classen et al. (1996) shows the effect of different mowing techniques on the biodiversity. Figure 3.2.1 (5) highlights the findings of the study.

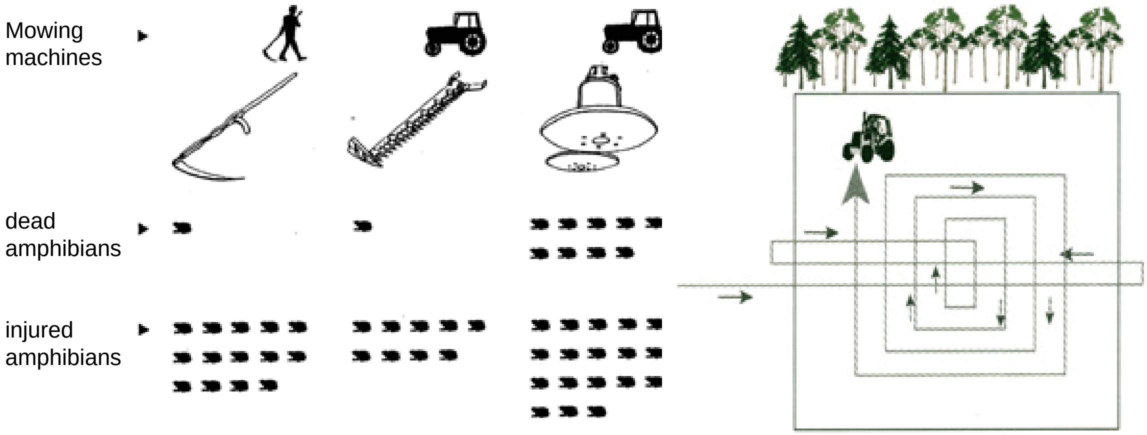

Fig 3.2.1(5): (Left) every frog represents 1% of the inhabiting population killed or injured in respect to the mowing equipment. Note that the rates of damage of dead and injured animals vary enormously according to the different mowing equipment (Classen et al. 1996). (Right) nature-friendly mowing technique means mowing from the centre to the edges, hence, animals can escape from within the area.

Activity/Practical Demonstration

Organize a group of farmers to meet on a farm on which species rich grassland is about to be mown, and ensure that a horizontal blade mower and a rotary mower with a mowing conditioner are present. On the areas that have to be cut, place or attach filled rice bags and/or small balloons of an approximate size of 5 x 3 x 3 cm – they represent simple animal dummies, e.g. amphibians. Now cut strips of 20 – 50 m length with the different mowing machines and examine the cut animals in regard to their level of damage and also in regard to insects that are damaged or dead. Discuss the findings within the group.

Recommended reading

- Classen, A., A. Hirler & A. Oppermann 1996: Auswirkungen unterschiedlicher Mähgeräte und die Wiesenfauna in Nordost-Polen; untersucht am Beispiel von Amphibien und Weißstorch. – Naturschutz und Landschaftsplanung 28, (5): 139-144
- Fluri, P., R. Frick and A. Jaun (2000). Bienenverluste beim Mähen mit Rotationsmähwerken. Zentrum für Bienenforschung, FAM, Liebefeld.
- LBL - LANDWIRTSCHAFTLICHE BERATUNGSZENTRALE LINDAU (2003): Mähtechnik und Arten-vielfalt. – Merkblatt. UFA-Revue (CH-8401 Winterthur) 4/2003, 6 S.
- Oppermann, R. and A. Krismann (2003): Schonende Bewirtschaftungstechnik für artenreiches Grünland. in: OPPERMANN, R. AND H. GUJER (2003): Artenreiches Grünland bewerten und fördern MEKA und ÖQV in der Praxis. Stuttgart (Ulmer), 199 S., S. 110-116.

Innovation 2

Use biodiversity friendly mowing regime on pasture and meadows.

Biodiversity (++)	Economy (-)
Maintain food chains involving hundreds of species.	A relatively small loss in low quality hay.

Implementation

On many pastures and meadows a maximized yield of fodder is expected to be harvested from the point of view of farm economy. For this reason the first cut is early in the season and grassland is often mown and fertilized right to the edges of the field. Meadows are portioned in a way that optimal grazing is guaranteed (no under or overgrazing). However this is contrary to biodiversity goals. Temporarily unused or under-used areas, as well as the intersections of differently used areas are of importance to biodiversity. The conscious creation of such places in grasslands and meadows, and their integration into the area management is also significant.

Farmers in central Europe who use this innovation apply the following measures:

- Approximately 10% (range 5 - 20%) of the surface is left unmown during the first cut or for a time period of at least three weeks; i.e. marginal strips along ditches, edges of forests, or even smaller areas or strips amid large meadows (in contrast to the 'habit of accuracy').
- Integrate undergrazed areas - this is also relevant for pastures where the grazing is managed in such a way that some undergrazed areas remain (10 - 30 %). In addition to undergrazed areas (which could or should alternate annually), approximately 5% of permanent structures like hedges, bushes and trees, dead wood areas, stone cairns etc. are integrated on pastures (they are very useful and serve as sun shades for the cattle).
- Determine optimal cutting time - this depends on the growth of the meadows; there are regional season specific natural indicators to time the cut in Central Europe (e.g. first mature seeds of the ox-eye daisy, *Chrysanthemun leucanthemum*).

Fig. 3.2.1(6):. A mosaic of areas that are mown at different times and with unmown areas serve as refuge for many animal species and therefore gives them the chance to survive.

Impact on biodiversity

It is scientifically proven that later mown meadows, undergrazed parts and meadow fringes function as 'hideaways' for animal species that lose a large part of their habitat during cutting or grazing periods. Also, these areas are important with regard to biotope networks within a landscape.

Natural indicators highlight the period during which the vegetation is in a certain growth stage, and since the dates of this period can vary significantly between years and locations, natural indicators are better than predetermined dates for mowing. For example, in Switzerland, by the time the seeds of the ox-eye daisy are mature many important flowering grassland plants have already reproduced. Cutting the species rich grassland at that stage will therefore not deplete the seed bank and ensure sustainable management. However, specific indicators will have to be identified for different regions. Once the mowing season starts, mosaic and strip mowing ensures that some vital food and cover will remain for the meadow fauna. Patches of grassland that are not mown and left to stay until the following year are particularly valuable since they provide essential cover for fauna, especially during the winter period.

Impact on farm economy

Leaving uncut or later cut strips and undergrazed areas on pastures of the above mentioned size results in economic losses of approximately 5-10%. This is a minor loss compared to the area of surface (10-20% of unmown/undergrazed areas), because on the one hand, only areas with little vegetation cover or prevailing cultivation difficulties are chosen for marginal strips (edges of forests or ditches, steep slopes), and on the other hand, fodder that is gained from later mowing can partly be used as structural fodder components within the total fodder for cattle.

Case study

In Switzerland a biodiversity program motivates farmers to practice "strip mowing". In species rich meadows strips of max. 10 m width are left uncut over around of 5-10% of the whole meadow. With each cut the strip is moved. As farmers normally use forest edges and small slopes for uncut strips, mowing time is substantially reduced, while the decrease of fodder is negligible as species rich meadows provide only small fodder yields. Hence, the program is popular.

Lessons learned

- For a period of approximately at least three weeks, 10% (5-20%) of the meadows should be left unmown during the first cut.
- On pastures, additionally to the undergrazed areas approximately another 5% of coppice, deadwood areas, and stone cairn structures should be integrated.

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Recommended reading

- Boller E. F., F. Häni and H-M. Poehling.2004. Ecological Infrastructures. Idea book on Functional Biodiversity at the farm level. IOBC wprs Commission on integrated Production Guidelines and Endorsement.
- Oppermann, R. & Luick, R. (1999): Extensive Beweidung und Naturschutz-Charakterisierung einer dynamischen und naturverträglichen Landnutzung.- Natur und Landschaft 74, 411-419.
- Oppermann, R. & Gujer, H. (2003): Artenreiches Grünland bewerten und fördern -MEKA und ÖQV in der Praxis. Stuttgart (Ulmer), 199 S.

Fig 3.2.1(7).With a nature-friendly extensive cultivation there will always be structures (e.g. trees, hedges) and undergrazed areas on the pastures.

3.2.2. Examples from pastoral systems in arid and semi arid Savannahs

Introduction

Dominating the continent of Africa, savannahs are also found in India, Australia and the northern part of South America. Typical savannah environments are characterized by high temperatures and seasonal water availability with most rainfall confined to one season of the year. Their communities are formed by widely spaced, scattered trees (although in many savannah communities tree densities can be even higher and trees more regularly spaced than in forest communities) and a herbaceous layer, which makes them attractive for a large and diverse range of wild and domesticated grazing animals. Today, however, due to continuous clearance of savannah woodland, frequent burning and constant overgrazing by domesticated animals such as sheep, goats and cattle, or feral goats, donkeys, and camels, much of the world's savannahs have undergone substantial change and degradation. This ranges from changes in pasture composition, to woody weed encroachment or severe soil erosion, which is ultimately the leading problem of desertification.

In some savannahs, particularly those in Africa, distinct land tenure rights such as open access farming add to the pressure on the savannah systems as they are often related to unsustainable pastoral management systems.

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Although the diversity and composition of pastoral systems is determined primarily by soil and climate, it is also heavily influenced by the form of tenure rights and their associated rangeland management system. Two biodiversity enhancing innovations are described here that focus on management systems used by farming authorities in Namibia aiming to restore ecological functionality on rangeland in order to achieve a sustainable livelihood. Similar systems could be adopted and developed by organic rangeland farmers in other savannah habitats.

The first innovation originates from the experiences of farmers, who, when working towards sustainable land management often find conventional methods of monitoring veldt conditions, determining fodder availability and estimating carrying capacity complex and time consuming. The commonly used techniques also require special skills and experience to provide usable data and information. However, in this example from Namibia, Napcod/DRFN2 has developed a robust and simple Local Level Monitoring (LLM) system that is easily applicable by farmers, enabling them to improve their decision making when used on quantitative data from these previously identified indicators.

The second innovation originates from the principle of HRM (Holistic rangeland management) which is based on the management of rangeland as an ecological whole and mimics the role of wild African herbivore herds in the ecology of savannah grasslands. HRM aims to restore patterns of interaction closer to those that were present during the millions of years over which grasses and their herbivore predators co-evolved.

HRM guidelines for grazing rely on rotational management in which rangeland is divided into grazing camps or zones. These are then intensively grazed with high stocking densities for a relatively short period only to ensure thorough grazing of edible forage, followed by livestock exclusion for periods long enough to permit plants to recover the energy lost to grazing. Increasing the number of camps results in each camp being more evenly and fully grazed which in turn improves the ratio of recovery to grazing period and enhances the likelihood that repetitive grazing with adequate intervening recovery will be possible. However, temporary fences and full-time herd supervision are often necessary. Dividing the farm into permanent grazing camps to control rangeland grazing is commonly used on farms where the grazing rights and therefore the beneficiary of the costly investment into resource intensive camp infrastructure is clearly defined.

Innovations

1. Develop a Local level monitoring (LLM) System

2. Apply a Holistic Range Management (HRM) approach in open access farming systems

Footnotes

[1]Generally three major forms of pastoral land tenure right systems can be distinguished: 1) Nomadic pastoralism, where small traditional tribes live in reserves practicing a nomadic lifestyle (e.g. the Himbas in north-western Namibia). 2) Open or shared access farming, where there exist no or limited individual tenure rights for livestock owners. 3) Commercial farming, where individual land owners/tenants have distinct resource user rights over rangeland areas.

[2]Napcod (Namibia's Program to Combat Desertification) and DRFN (Desert Research Foundation of Namibia), have developed a model for integrated resource management at local level.

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Fig. 3.2.2(1). The herbaceous layer of savannahs generally provides good food on rangeland for livestock and game alike. Under an unsustainable management system, however, the rangeland can lose its palatable herbaceous layer within a short time, leading to soil erosion and ultimately to desertification.
Photo by Berend Reinhard

Innovation 1

Develop a Local Level Monitoring system.

Biodiversity (++)	Economy (-)
Appropriate management based on real information restores ecological functionality.	time-consuming and resource intensive.

Implementation

To develop a Local Level Monitoring (LLM) system, the following was done by Napcot/DRFN in Northern Namibia:

- With the help of advisers (rangeland ecologists), farmers identified indicators that reflect or predict the condition of the rangeland. These indicators included: livestock condition, rangeland condition/bush density, various biodiversity indicators, rainfall trends and carrying capacity.
- The advisor then helped to develop a standardized methodology that could be applied to obtain quantitative data from these previously identified indicators.

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- The methodology was presented in a simple field guide that included color photos, graphics, color-coded information sheets and other simple reference material that specifically focused on monitoring methods as well as on analyzing and interpreting the collected data.
- Based on the field guide, farmers assessed which indicators they found most relevant to monitor.
- Decisions on rangeland management are then based on the collected data. Here it was initially important that farmers were assisted by advisers concerning the evaluation and interpretation of the data collected.
- Farmers from an area came together and made joint decisions, applying a broader ecosystem approach to management of rangeland and pastoral systems.
- The indicators and monitoring methodologies needed to be continuously tested and further developed and adapted.
- The responsibility for monitoring rangelands and promoting sustainable development now rests within the communities involved.

Impact on biodiversity

In savannah ecosystems the variability of productivity can be great, and therefore there is a need to “track” the available resource base in order to avoid over use. Under the LLM approach the herbaceous vegetation can be utilized more sustainably since decisions can be based on the natural environment at the time. Therefore the LLM approach can maintain/restore ecological functionality of rangelands with benefit to both the farmer and biodiversity. For example, changes in species diversity (e.g. grasses) can be detected at an early stage if continued monitoring is applied and relevant management interventions can be geared towards recovering desirable, rare, or declining species.

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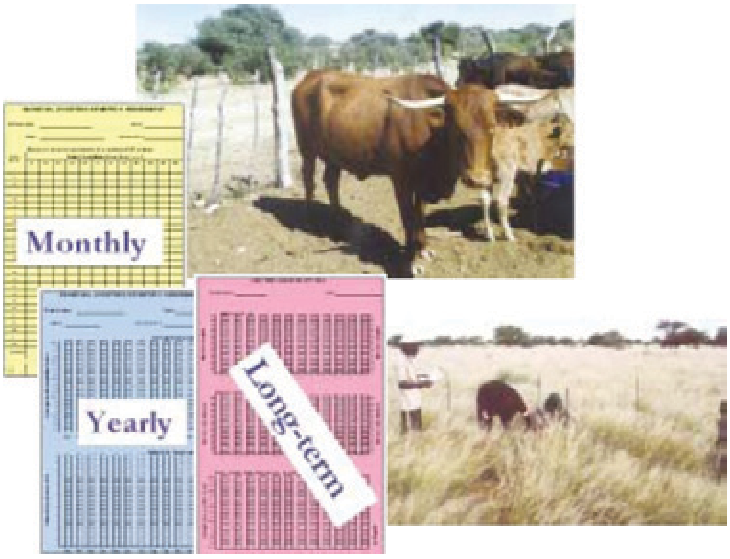

Fig. 3.2.2(2). Communities themselves identify information needs and in close cooperation with technical advisors develop relevant indicators of rangeland conditions for monitoring purposes. To date indicators like livestock condition, rangeland condition/bush density, rainfall and carrying capacity have been identified and are being monitored. However, the list of indicators may expand as skills, needs and faith in the programme grow. A field guide on how to conduct regular monitoring, comprises colour photos, graphics, colour coded information sheets and includes charts as well as guidelines for use by the farmers. Photo by Desert Research Foundation Of Namibia (DRFN).

Impact on farm economy

There is little direct economic burden associated with the LLM approach, once it is well adopted. However, the development and identifications of the indicators and the constant monitoring are time consuming. To create an LLM system for an area, however, capacity building investments at the introduction level and the initial development of appropriate methodologies are resource intensive. However, examples show that the benefits derived from promoting LLM as a decision-support tool for adaptive management, outweigh the initial investment costs.

Case study

To date Local Level Monitoring is used in several rangeland areas throughout Namibia. One example is the #Khoadi //Hoas[3] conservancy in Grootberg, northwest Namibia. This was organized by the farmers union from that area. The initial phases of the implementation included the identification of indicators and the collection and interpretation of data. Monitoring is carried out repeatedly by the community and results are widely shared, ensuring sound management decisions. Rangeland conditions have improved throughout the years.

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Fig. 3.2.2(3). Collection of data on rangeland condition during the llm approach.
Photo by BRinK (Biological Research in Kuzikus).

Lessons learned

- Collecting information on the rangeland aids decision-making at the local level.
- The LLM approach allows farmers at the local level to monitor and obtain information in efficient and effective manner.
- Healthy rangeland conditions can be maintained if decisions are based on the LLM approach.
- Joint decisions should be made for shared natural resources.

Activity/Practical Demonstration

Arrange a meeting on a farm for farmers as well as other stakeholders in the region. Ask the participants to identify rangeland condition indicators that best suit their area and needs. Notes should be taken and data sheets should then be formulated for the purpose of monitoring these indicators. Once the data sheets are roughly designed take the farmers around the farm, test and discuss the indicators with them. Then explain the advantages of monitoring the indicators and introduce the LLM approach.

Recommended reading

- "Biodiversity conservation – an organic farmers' guide". (See: http://wildfarmalliance.org/resources/)
- Desert Research Foundation of Namibia (DRFN). 2003. Local Level Monitoring for enhanced decision making. A booklet commissioned by Napcod, a project of DRFN. Windhoek, Namibia.
- Desert Research Foundation of Namibia (DRFN). 2003. The Forum for Integrated Resource Management (FIRM). A booklet commissioned by Southern African Development Commission (SADC), Desert Research Foundation Namibia (DRFN) and Desertification Interaction (SDDI), a project by DRFN. Windhoek, Namibia.

- Zeidler, J. 2000. Communities take the lead. Monitoring and management of natural resources in communal farming areas: case study from Namibia. In: B. Gemmill (ed.), People 4. managing resources, ELCI, Nairobi, Kenya, p. 27-29
- Zeidler, J. 2001. Communities take the lead. Monitoring and management of natural resources in communal farming areas: case study from Namibia. (http://www.monitorinternational.org/namibia.htm)

Recommended websites

- www.drfn.org.na

FOOTNOTE

[3]Conservancies are community-based organizations initially established to facilitate the common and management of natural resources in communal farming areas: coordinated management of wildlife in communal areas, traditionally considered to be "open access". In recent years the institutional set-up has been furthered in its functions to manage other "common goods" such as grazing.

Innovation 2

Apply a Holistic resource management (HRM) approach on open access farms.

Biodiversity (++)	Economy (-)
Reduced erosion and increased species diversity	Increased grass productivity but also increased workload. Fencing is expensive.

Implementation

On open access farmland, where resources are often scarce and less clearly defined property rights concerning the 'common grazing lands' prevail, successful adaptation of the HRM approach has been demonstrated in Namibia (see case study below) based on the following key principles:

- Water sources are mobile: e.g. in the form of a water tank using a trailer to drive water to grazing areas without water in order to avoid unnecessary migration and severe trampling and overgrazing at single waterpoints.
- Herding is done from existing homesteads or from new boreholes where homesteads have been established close together, making it easier to bring the animals into one herd.
- Daily grazing camps are made, using fences (game capture nets or other alternatives), which are moved daily. Grazing periods are planned based on desired and recommended recovery time of the rangeland communities (recovery time may vary from season to season as a result of variable rainfall).

Impact on biodiversity

Rotational management and sticking to grazing periods ensures that the grazing pressure is not too high, and enhances the growing condition for the vegetation. It improves the species biodiversity as moderate grazing pressure is generally associated with high species diversity.

Impact on farm economy

The economic burden associated with the HRM approach is the putting up of fences as well as the intensive management. This should not be discouraging, as the overall performance of the farm will improve with time. The HRM approach improves the health of the livestock and livestock production, which in turn can increase farm revenues.

Fig. 3.2.2(4). Overgrazing around a water point. Photo by Desert Research Foundation of Namibia (DRFN).

Lessons learned:

- Movement of livestock from one camp to the other increases vegetation/grass productivity.
- Using grazing camps in rotation helps to control grazing pressure and prevents overgrazing
- Multiple mobile water points ease the grazing pressure around the main water source.

Case studies

HRM has mainly been practiced on commercial farmland (see case study A). However, more recently HRM principles have been applied in the context of community-based natural resource management projects in communal areas e.g. in north-western Namibia (case study B).

A) Agro Rust of Sonnleiten Ranch, southern Namibia, has managed his farm successfully through the HRM approach. When Rust implemented the HRM approach, he improved the range conditions, his herd enlarged, and his ranch started to make profits (Voigts, 2002). Rust divided his land into smaller camps and rotated his herd every two to three days to avoid overgrazing, to achieve even manuring and to eliminate parasite problems. The herd was kept together to ensure breeding throughout the year. Rust achieved impressive results: his cattle herd increased; the concentrated hoof action improved soil structure, water infiltration and seed germination; vegetation cover increased; carrying capacity improved and net farm income increased (Voigts, 2002).

B) Selected conservancies in the Kunene region of Namibia have been divided up into livestock grazing areas (co-managed with game), to serve as the equivalent to "camps" in freehold areas. Specific land use plans and grazing management plans were then developed by the farmers. Herders were appointed, and planned "rotational grazing" is practiced. Additional boreholes have been drilled to give added flexibility and increase access to new grazing areas. A precondition for becoming a part of this 'joint management program' at a conservancy, however, is that all livestock owners combine their herds into one herd that must be herded daily - ensuring planned grazing.

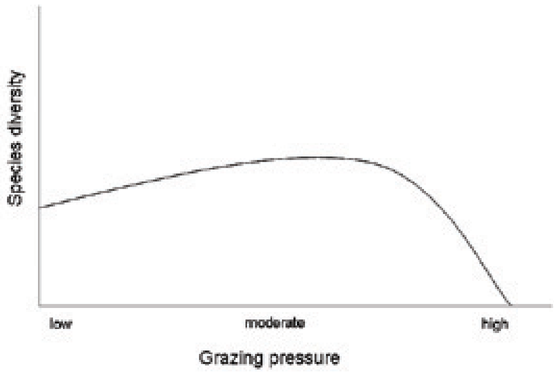

Fig. 3.2.2 (5) Grazing can reduce the competitive exclusion of dominant grasses, allowing a much higher diversity of plant life to exist in the area. Because of this competitive exclusion, there are levels of grazing that would enhance species diversity. At the same time, few plant species are specialised to cope with extreme disturbance levels, so there is a point at which grazing causes an abrupt collapse in diversity. Low stocking density is therefore the safest farming strategy to ensure the maintenance of diversity.

Activity/Practical Demonstration

Organize a farm day where farmers come to a farm that practices the HRM approach. Point the different camps out to the farmers and discuss the rangeland condition in the camps and around water points where the grazing pressure is very high. Discuss the condition of the livestock. Stimulate the exchange between communal and commercial farmers so that they learn about the peculiar circumstances of management in systems of different tenure. Highlight the importance of creativity and innovation to problem solving.

Recommended reading

- Nott, C. (unknown). Going Beyond Sustainable Management of Wildlife. Available from: http://www.irdnc.org.na/download/going_beyond.pdf
- Savory, A. (1988). Holistic Resource Management. Island Press, Washington, D.C., U.S.A.

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- Swift, J. (1988). Major issues in pastoral development with special emphasis on selected African countries. Rome: FAO.
- Voigts, U. (2002) Dryland Ranching Made Sustainable. In: Migongo-Bake, E. (Ed.) Success Stories in the Struggle Against Desertification. A publication for UNEP.

Recommended websites

- Integrated Rural Development and Nature Conservation (IRDNC), http://www.irdnc.org.na/hrm.htm

3.2.3. Examples from pastoral systems in tropical zones

Introduction

In Central America, which was a once continuously forested landscape, nearly 40% of the total land mass is currently now pasture. More than 50% of these pastures are estimated to be degraded or are in the process of degradation (Szott et al. 2000). Forests have been transformed into pastures with no to low tree density and high chemical inputs. This has generated numerous environmental problems including rampant deforestation, increased soil erosion and loss of soil nutrients, desertification, pasture degradation and biodiversity loss (Kaimowitz 1996; Ibrahim et al. 2000). These unsustainable management practices eventually lead to reduced production levels, and pasture degradation driven by overgrazing and ecological collapse. In order to conserve the Mesoamerican flora and wildlife, conservationists and organic farmers must now work together to create habitat and connectivity for wild biodiversity within this pasture dominated matrix.

Recently, silvo-pastoral systems, or the incorporation and integration of trees into the production system is starting to be used in many parts of South America as a strategy to increase productivity, conservation value, and sustainability of these pasture production systems. Silvo-pastoral systems integrate multipurpose trees and shrubs with pasture and cattle or other livestock and render an alternative land use type that reduces deforestation, increases livestock productivity, and generates environmental services (e.g. biodiversity conservation and carbon sequestration) (see table 3.2.3(1)).

In a more general context, forest remnants, forest fallows, pastures with high density of trees and live fences can serve as a refuge for wildlife by increasing connectivity in pasture dominated landscapes and by providing additional habitat. Conservation efforts within pasture dominated landscapes however are strongly reliant on a clear understanding of land use dynamics and the impact of farmer management strategies on conservation. Although the presence of a diversified vegetation complex in silvo-pastoral systems is clearly beneficial from a conservation view point, integrating these conservation measures within a production context remains challenging. Increasing tree cover is often associated with decreased pasture productivity according to farmers. Additionally, farmers may not consider conservation to be one of their management objectives; rather, they may consider biodiversity conservation as being detrimental to production through productive land lost to conservation, or to the introduction of species that reduce crop production. These perceptions though, are not correct, as several novel and promising studies have demonstrated that biodiversity makes significant contributions to ecosystem functions of importance to producers at both the farm and landscape scale, such as pollination, disease and pest control, increased productivity, and stability of grasslands.

1. Integrate trees into the production system to create a silvopastoral system

Fig.3.2.3(1). The adoption and implementation of silvopastoral system minimizes man's environmental impact. Photo: M.L. Enriquez-GEF-SPS Project.

Innovation 1

Integrate trees into the production system to create a silvopastoral system.

Biodiversity (++)	Economy (++)
Maintain habitat integrity.	Additional products of economic value.

Implementation

In Central America typical tropical silvo-pastoral systems contain the following aspects:

- Pasture systems include dispersed trees within pastures and live fences (hedgerows).
- Trees in the pastures are typically remnants from when the forest was cleared; these arise from natural regeneration or increasingly, are planted by farmers
- The farmer makes active decisions as to which trees to remove or to retain.
- When planning and designing silvo-pastoral systems for pasture dominated systems, this should include a mixture of species capable of providing multiple benefits such as timber, firewood, fruit and forage from which farmers can increase farm productivity while increasing the habitat quantity and quality found on the farm. (See table 3.2.2(2))
- The role of silvo-pastoral systems in biodiversity conservation can be enhanced through careful design and management, increasing the floristic and structural diversity of tree cover. Currently, agricultural landscapes and land uses types are extremely variable with significant differences in structure, tree composition, management intensity (high stocking

rates and heavy grazing regimens) as well as the spatial distribution of trees. All of these variables affect the conservation values of the farm and landscape (see figure 3.2.3(3)).

Impact on biodiversity

From a conservation perspective, trees provide structure, habitat and resources that can facilitate the presence and movement of some species of plants and animals within agricultural landscapes.

Impact on farm economy

Trees can provide farmers with additional products such as timber, fence posts (for both traditional fences and live fences), fuel wood, fruit and fodder for livestock. This diversification can serve as a means to minimize risk through diversifying the farm's economic production.

Lessons learned

- Silvopastoral systems with a high tree density and multiple strata can contain significant numbers of tree species in fragmented landscape compared to degraded pastures.
- Silvopastoral systems can provide conservation for a variety of species of organisms, and play a critical role in enhancing connectivity.
- At the regional level, silvopastoral systems may play a pivotal role as is exemplified by the establishment of the Mesoamerican Biological Corridor. Here it is expected that these corridors will provide adequate habitat for wildlife while facilitating seed dispersal and the regeneration of native vegetation (Saunders et al., 1991).

Fig. 3.2.3(2). Dispersed trees in pastures and life fences can help to increase the structural connectivity in agricultural landscape. Photo: C. Villanueva.

Case studies

Recently silvo-pastoral systems have generated much interest as an important tool for conservation, with increasing numbers of studies demonstrating their capacity to contribute to biodiversity conservation at farm and landscape scales and enhance farm productivity. The two case studies that are presented here inventoried biodiversity in silvo-pastoral systems, demonstrating their contribution in particular to the conservation of particular species of concern in agricultural landscapes. The studies were conducted by researchers from CATIE's Livestock and Environmental Management Group in Central America and Colombia.

A) Integrated management practices can increase the sustainable production and conservation value of cattle farms.

Dispersed trees in pastures and live fences are common silvo-pastoral systems of Central American cattle farms. Live fences are used to delineate fields, pastures, and farm boundaries. They form intricate networks of tree cover that criss-cross the landscapes. In contrast, dispersed trees in pasture generally occur in small patches or the trees can be randomly scattered throughout a field. The tree species composition of these silvo-pastoral systems is greatly influenced by farmer choice and is often made up of quite a limited number of species (Muñoz et al. 2003).

Several projects have inventoried and characterized the tree component of pasturelands (Souza de Abreu et al. 2000, Viera and Barrios 1998, Harvey and Haber 1999; Casasola et al., 2001; Morales and Kleinn 2000, Esquivel et al.,2003). In a study on remnant trees in pastures of dairy farms in the Monteverde region of Costa Rica, Harvey and Haber (1999) found 190 tree species amongst 5,583 individuals plants counted. From these species, 37% were classified as timber species whereas Souza de Abreu et al. (2000) reported between 73% and 88 % of silvo-pastoral tree species in San Carlos, Costa Rica as having timber value. In Mexican farms, Guevara et al. (1998) found 98 tree species of which 76 species (77.5%) correspond to primary forest species. Similarly, in the northern region of Costa Rica, Van Leeuwen and Hofslede (1995) found that 96% of the 79 tree species identified correspond to primary forest species. These studies show that tree cover varies with respect to density, species composition and percentage of area covered. Tree species found in these studies include timber trees, fruit trees and multipurpose tree species. Of the multiple uses of these tree species, their capacity to provide shade, shelter and forage for cattle are particularly valued by farmers (Table 1).

Cattle farmers of Esparza Costa Rica have stated that they prefer retaining multi-purpose tree species that provide benefits such as timber, fruits and forage for the dry season. In Esparza, a total of 68 species were found in pasture, 60% of which came from natural regeneration, 35% were forest remnants and 5% were planted by farmers. From those species 61.8% were timber species, 16.2% forage and 27% fruits (Villanueva et al. 2007). That result was similar to a study in Cañas, Costa Rica, where Esquivel et al. 2003 found 99 tree species. From these species 50% were wood species, 27% forage species and 27% fruits. The composition, distribution and abundance of tree species in the paddock is thus associated with the preferences and needs of the farmers (Table 2).

The number of tree individuals within pastures presented a mean tree density of < 30 trees per ha, and crown cover ranged from 0 to 30%. (Esquivel et al., 2003). Though species richness in these pastures can be quite high, they predominantly consist of few species. For example, in Costa Rica (Esparza and Cañas) and Nicaragua (Matiguas) more than 60% of all individual trees registered were of only nine species (Esquivel et al. 2003, Villanueva et al 2003a, Villanueva et al. 2007). However in some cases, pastures included threatened and endangered species, though in low densities such as ***Swietenia macrophylla*** (Caoba) and ***Dalbergia retusa*** (Cocobolo). Efforts need to be made to work with farmers to increase tree diversity in cattle farms and particularly to favor rare and endangered species native to the sites. The results of the Esparza study, where conditions are similar to those in Cañas, show that the number of individual trees and species is higher in pastures where manual weed control is practiced compared to pastures in which herbicides are applied (Camargo et al. 2000; Villanueva et al. 2003a). Tree seedling damage caused by cattle trampling, defoliation and breaking of young trees is another important factor that affects tree species composition, richness and abundance in pastures. Intensively managed pastures (high stocking rates and heavy grazing regimens) typically have lower tree density and species richness as well (Villacis et al. 2003).

B) The contribution of dispersed trees in pastures and live fences to biodiversity conservation in agricultural landscapes

Recent studies have shown that the presence of forest and tree cover within agricultural landscapes contributes to the conservation of biodiversity at large spatial scales (Harvey et al. 2006). In Monteverde, 94% of the tree species found in pastures provide fruits for birds, bats and other animals and contribute significantly to the conservation of biodiversity within agricultural landscapes (Harvey and Haber 1999; Saad and Petit, 1992; Estrada et al., 1993a; 1993b; Petit and Petit 2003, Tobar et al. 2007, Saenz et al 2007).

Food availability for wild animals is greater in these tree dominated systems, and the complex structure of the vegetation provides nesting sites and may provide increased protection against predators compared to treeless agro-ecosystems. It has been pointed out that isolated trees within pastures and forest fragments play a critical role in the conservation of biodiversity by serving as stepping stones or corridors for animal movement. These trees are also critical to the regeneration of new tree individuals through a seed rain effect where seeds often fall directly beneath the parent tree, or originate from perched birds passing tree seeds though their guts (Guevara et al., 1992, 1998; Guevara and Laborde, 1993; Harvey and Haber, 1999; Harvey et al 2006). In Esparza, Costa Rica, birds and butterflies were monitored to measure the impact of a 'payment for ecosystem services' scheme designed to encourage farmers to increase tree cover in pasture dominated landscapes. Birds and butterflies were selected for their capacity to serve as indicators of land use change, and to evaluate the conservation value of silvo-pastoral systems. Although the species richness of birds and butterflies responds differently to various land uses, both taxonomic groups had greater species richness in those land uses where tree cover was greatest. Forest areas, pasture with high density and multi-strata live fences (plants with different canopy height) had the greatest species richness for both birds and butterflies while degraded pasture consistently had the lowest species richness (see fig. 3.2.3(3)).

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Table 3.2.3(1). Benefits of tree cover in pasture dominated landscapes.

Farm benefit	*Conservation benefit*
• Cattle fodder (forage & fruit) production of nutritious native trees and shrubs for feeding cattle, especially during the dry season • Shade • Wood product (firewood, timber) • Increased natural capital. • Provisioning of fence posts.	• Enhance landscape connectivity and biological corridors • Increased provisioning of environmental services • Increased watershed protection • Additional habitat for biodiversity • Increased soil conservation

Table 3.2.3(2). Summary of abundant and principal uses of tree species (dbh > 10 cm) found dispersed in pastures and life fence of cattle farms in different landscapes of Central America. * Principals species use in life fence. Source: Esquivel et al 2003, Villanueva et al. 2003A, 2003b, 2007, and GEF-SPP-Project.

Species	*Pacific Region, Costa Rica*			
	Shadow	**Wood**	**Fruit**	**Forage**
Acrocomia aculeate (Coyol)			X	
Andira inermis (Almendro de montaña)		X		
Bursera simaruba (Jinocuabe)*		X		X
Cordia alliodora (Laurel)		X		
Enterolobium cyclocarpum (Guanacaste)	X		X	
Gliricidia sepium (Madero negro)*		X		X
Guazuma ulmifolia (Guacimo)				X
Mangifera indica (Mango)		X	X	
Pachira quinata (Pochote)*		X		
Psidium guajava (Guayaba)			X	
Samanea saman (Cenízaro)	X	X		X
Swietenia macrophylla(Caoba)				
Tabebuia rosea (Roble)		X		
Species	*Central Region, Nicaragua*			
	Shadow	**Wood**	**Fruit**	**Forage**
Acrocomia aculeate (Coyol)				
Andira inermis (Almendro de montaña)				
Bursera simaruba (Jinocuabe)*		X		X
Cordia alliodora (Laurel)		X		
Enterolobium cyclocarpum (Guanacaste)				
Gliricidia sepium (Madero negro)*		X		X
Guazuma ulmifolia (Guacimo)	X		X	X
Mangifera indica (Mango)				
Pachira quinata (Pochote)*		X		
Psidium guajava (Guayaba)				
Samanea saman (Cenízaro)	X	X		
Swietenia macrophylla(Caoba)		X		
Tabebuia rosea (Roble)				

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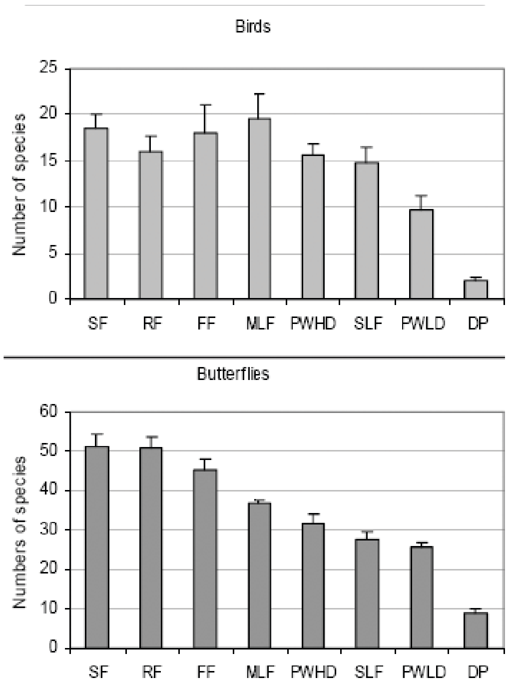

Fig. 3.2.3(3). Mean bird and butterfly species richness for land uses in a pastoral landscape of esparza, Costa Rica, 2004 -2006. *Sf*: secondary forest, rf: riparian forest, ff: forest fallow, mlf: mulistrata life fence, slf: simple life fences, pwhd: pastures with high density, pwlh: pasture with low density, dp: degraded pasture. Source: Saenz et al 2007, Tobar et al. 2007.

Recommended websites

Center for Research and Education in Tropical Agriculture (CATIE): www.catie.ac.cr

3.3. Annual cropping systems

3.3.1. Examples from annual cropping systems in temperate zones

Introduction

In recent decades, particularly in the temperate zones, the habitats of many plant and animal species have been lost due to an increase in high-input agriculture, intensive management, simplified crop rotations with winter crops, and reduction of fallow land. Late season flowering plants and those that depend on high light intensity or cannot compete on nutrient enriched soil, suffer the most from the expansion of industrial crop fields. Additionally, associated fauna suffers from a loss of host plants, habitat fragmentation and the monotony that large intensively managed crop fields bring along. Simple measures that encourage wild plant and animal life in annual cropping systems therefore go a long way in terms of enhancing biodiversity. Here some innovations are described that can be integrated into actual management practices of farmland, whether arable or pasture.

Innovations

1. Maintain grassy field margins around the edge of arable fields or permanent pasture

2. Practice biodiversity friendly management of hedgerows around arable fields

Innovation 1

Simple biodiversity friendly management of field and field margins

Biodiversity (++)	Economy (-)
Secure food/cover for farmland fauna throughout the year while providing a buffer zone to ecological infrastructures	Minor loss of potentially productive land

Implementation

In order to promote species-rich wildlife communities on and around arable fields the following measures are practiced on many organic farms:

- Combining several arable fields into a single unit is avoided, and existing large fields are divided into smaller units.
- The field is not cultivated right to the edge but a margin of about 3-5m is left uncultivated not fertilized or sprayed. The margin could consist of spontaneous (if rarer wildflowers exist in the surroundings) or sown flora.
- Grass strips/field margins are located adjacent to hedgerows or water courses.
- The margin is managed so that temporally alternating flowering species are present.
- Stinging nettles are not removed if they are present in the margins.
- A small proportion (20%) of the field margin is left uncut for 2 to 3 years.
- On parts of the field margin with high soil nutrient level, for successive years the first cut is applied as late as possible and the cut vegetation is removed.
- Up to 60% bare ground across some margins is created. For scarification a power harrow (in March/April for Europe) to a depth of 2.5cm is often used.

For maximum benefit to biodiversity, different measures should be practiced on different fields/ margins.

Impact on biodiversity

Marginal structures (road edge, grass strips or hedges) often form valuable habitats for many threatened species of plants and animals in the landscapes. Therefore increasing the amount of marginal structures is beneficial to biodiversity; however field margins smaller than 3m are unlikely to provide the desired buffering effect for sensitive habitats (hedgerows, watercourses) from fertilizer and spray drift. A mix of temporally alternating flowering species in the field margin will provide invertebrates with food over a period of 5-6 month and a good hunting ground for birds and prey (barn owls, kestrel). Stinging nettles (*Urtica dioica*) harbor a rich and ecologically beneficial fauna. Old uncut grass stands in the margin are an ideal over-wintering habitat for crop pest predators (hoverflies, spiders) and many other insect species. They also provide cover and nesting sites for ground nesting birds (Yellowhammer ***Emberiza citrinella***, various pheasants) and are a refuge for small mammals (Common shrew ***Sorex araneus***, field vole ***Microtus agrestis***), while cutting grass strips only late on in the season ensures that the seed bank is not depleted. Subsequent removal of the cut vegetation accelerates nutrient depletion, which could in the long term, also lead to increased species richness. In the aim to reduce competitive grasses, bare ground should be increased to improve the value of margins for biodiversity. Removal techniques, such as scarification improve different aspects of biodiversity if compared to conventionally mown margins of 15cm height in March/April.


Figure 3.3.1(1) Left: Unmown strips in a mid intensive meadow as habitat for insects, birds and small mammals. Right:Unplouwed strips bring structure and habitat into crop dominated landscape. Photos by Andreas Bosshard

Lessons learned

Grassy field margins provide an important habitat particularly for the ground dwelling fauna, they protect ecological infrastructure such as watercourses and hedgerows and they provide a barrier for weeds and pests.

Activity/Practical Demonstration

Ask farmers to walk along a grassy field margin, counting the number of grasshoppers and flowers present in it. Subsequently, ask them to repeat exercise on an adjacent fertilized pasture or arable field. This should be done before and after a cut or harvest. Encourage the farmers to interpret their results and indicate the importance of the field margin as a habitat, especially during times after the cutting/harvesting of productive fields.

Recommended reading

- Edwards C., G. Dodgson & Patrick Goldsworthy. 2007. Enhancing arable biodiversity. Sustainable Arable LINK program.
- Ernst F. Boller, Fritz Häni & Hans-Michael Poehling (Eds.) 2004: Ecological Infrastructures: Ideabook on Functional Biodiversity at the Farm Level. LBL, Eschikon 28, CH-8315 Lindau, Switzerland.

- von Arx, G., A. Bosshard & H. Dietz 2002: Land-use intensity and border structures as determinants of vegetation diversity in an agricultural area. Bulletin of the Geobotanical Institute ETH 68, 3-15. www.geobot.umnw.ethz.ch/publications/periodicals/download/68_03_vonArx.pdf.
- Bosshard A. & F. Klötzli 2003: Restoration Ecology. In: Bastian O. & U. Steinhardt (Hrsg.): Development and Perspectives in Landscape Ecology: conceptions, methods, application. Kluwer. ISBN 1-4020-0919-4.

Recommended websites

- www.safie.info
- www.agroecl.co.uk/fieldmargnet.html
- www.ecology.ch/en/fieldmargins.php

Impact on farm economy

Mowing parts of grass field margin only once every two to three years saves time and work. Grass strips at field margins reduce the spread of undesirable weeds into the crop edge, while over wintering crop pest predators in field margins prevent spread of pests and therefore can increase the productivity. Some figures adapted from SAFFIE (2007) conducted in the UK calculated the cost of mowing margins: £12.50/ha, scarification: £14.50/ha and applying graminicide: £17.50/ha

Case study

In the UK farmland birds are generally used as an important measure of the health of the countryside. However, populations and ranges of many familiar species have halved since 1970. Changes in farm practice, especially increased winter cropping and loss of hedgerows, have been identified as the main reasons for these declines. From 2001 to 2006, the Sustainable Arable Farming for an Improved Environment (SAFFIE) project aimed to develop and assess new ways to enhance biodiversity in winter cereals. These crops account for nearly half of UK arable land. The aim was to improve biodiversity and wildlife access within both field margins and crop. Novel management approaches were tested to improve food and habitat for a range of species important to UK farmland biodiversity. Farmland birds were monitored in wheat fields of at least 5ha on 26farms. The impact of the techniques on farmland bird numbers was calculated from field data. The most relevant technique with regard to economically viable enhancement of biodiversity included skylark plots and scarification of plots in wild flower and grass margins. No additional costs arose from skylark plots in wheat fields or scarified wild flower/grass margins.

Innovation 2

Adopt a biodiversity friendly management of hedgerows

Biodiversity (++)	Economy (++)
Reduces soil erosion, enhances ecosystem services and conserves soil biodiversity	Reduced cost of farm input, reduced labour and increased crop yields

Implementation

For 'biodiversity friendly' management of hedgerows the following measures are generally practiced in temperate zones:

- Slow growing hedgerows are cut every other year with the aim of creating a layered structure (strata of different height).
- A grassy base or an adjacent grass field margin is established.
- On larger hedge surfaces, in central Europe, shrubs and trees are normally trimmed down to 10cm above ground every 7 to 15 years. Also consider selective trimming of plants with strong growth at intervals of every few years.
- Hedges are not trimmed down to ground level along their entire length but sector-wise trimming is practiced. Also a few slow growing plant species are spared from trimming.
- Hedgerows are trimmed during the winter months (January to February) and if possible 'set-aside rotations' are used to gain winter access.
- Crushing and burning of the trimmings is avoided.

Impact on biodiversity

In general, well maintained hedges provide shelter for stock and crops in terms of windbreaks, protection against erosion, retention capacity for water, regulation of soil moisture content and a filtering effect for polluted air close to roads. They also provide an important habitat for many rare plants and animals by providing food, shelter and nest sites for farmland birds if they are managed accordingly. They are essential wildlife corridors across the farm (e.g. for Gatekeeper butterfly, dormouse) (also see chapter 5) and their layered structure ensures botanical diversity while the grassy base or adjacent grass field margins further increases their value for wildlife. Selective trimming of hedges is important so that slow growing plants (e.g. blackthorn *Prunus spinosa*) are provided with more light and space while sector-wise trimming ensures that animal inhabitants of hedges find essential refuges. Trimming hedges in winter when most trees are dormant is important in order not to interfere with their growth and energy balance. Not burning the trimmings protects a range of fauna, and cutting plants with a blade instead of crushing them increases the plants chance of survival after trimming.

Impact on farm economy

The 'biodiversity friendly' management of hedgerows might be a little more time consuming than the conventional management of the hedgerow, but it can have the benefit of regulating plant disease and insect pests which sometimes develop in hedgerows and may be detrimental to crops, reducing the yields.

Lessons learned

A biodiversity friendly management of hedgerows enhances habitat for fauna and flora while it can also lead to an increased crop yield.

Recommended reading

- Elizabeth Agate 2002: Hedging. 125 pp. ISBN 0 946752 17 6

Recommended websites

- Peoples Trust for Endangered Species: Hedgerows - a guide to wildlife and management. Hedgerow Group, London.
  www.ptes.org/files/310_hedgerow_guide_web_version.pdf

Figure 3.3.1(2) Rigth: Stone and branch heaps improve the habitat and aesthetic quality of a hedgerow substantially. Left: Differentiated cutting of a hedgerow. Photos by Andreas Bosshard

3.3.2. Examples from annual cropping systems in tropical zones

Introduction

The tropical areas (23°N to 23°S) are characterized by warm climates marked by distinct wet and dry seasons. Annual crops grown in these areas are the main source of food for people and livestock. The crops are often grown in dense stands and predominantly on small-scale rather than large-scale farms. Also they are highly diverse and vary depending on climatic conditions, soil and preferences by individual farmers. The main annual crops grown in tropical areas include cereals, pulses, oilseed crops, root crops and vegetables.

In many tropical areas the challenge of balancing agricultural production with biodiversity conservation and landscape quality is increasingly complex as difficult socio-economic factors often prevail. With this in mind the innovations proposed here suggest measures that can sustain and maintain livelihoods and improved productivity while having the beneficial side effect of reducing environmental degradation and hence protect biodiversity.

As soil erosion is one of the biggest problems faced by small scale farmers in the tropics today sustainable soil conservation measures must be found within all production methods, to ensure current production levels can be maintained.

Soil conservation management refers to a strategy in which the new crops are established in the previous crop's residues, with no or minimal tillage being applied. In this way the soil is allowed to develop a stratified layer, with a vegetative soil layer and a relatively high infiltration rate, making it is less prone to erosion, high in biodiversity and ensuring continuous productivity. This strategy is particularly recommended for production systems of small-grained cereal crops and agriculture on eroding soils of smallholder farmers with limited resources.

Many small scale farmers in tropical regions also apply slash and burn agriculture to free up productive land for the cultivation of annual crops. However, this newly cleared land loses its fertility after continuous cycles of slash and burn which often contain only short recovery periods. Soil erosion can occur and dependence on mineral fertilizer and pesticides is often seen as the last resort in order to counterbalance the associated loss in productivity. After a couple of rotations, loss in soil productivity may force the farmer to abandon annual crop cultivation and to practice slash and burn on new or other re-established parts of the available forest. With an increasing population and multiple uses of forests, the proportion of land available for cultivation becomes limited, and slash and burn agriculture becomes unsustainable as field rotation is no longer an option. Therefore alternatives to slash and burn agriculture should be encouraged in order to make agriculture in the tropics more sustainable and environmentally friendly.

Based on the principles of natural succession, it is possible to establish more sustainable systems for cultivating annual crops in the tropics. The major problem with common slash and burn agriculture is that burning frees the energy of the biomass which would otherwise be used by soil micro-organisms to perform their beneficial function of supporting soil fertility. The innovative successive agro forestry system described here does not involve burning and builds upon the recycling of organic matter, mimicking nature. Experiments show that yield in these systems is higher and labor necessary for weeding is reduced. This innovation is particularly useful for small scale farms that often only have a small amount of forest left on their land.

Innovations

1. Apply soil conservation management with minimum to no tillage.

2. Substitute slash and burn systems with successive agro forestry systems

Innovation 1

Soil conservation management with minimum or no tillage

Biodiversity (++)	Economy (++)
Reduces soil erosion, enhances ecosystem services and conserves soil biodiversity	Reduced cost of farm input, reduced labour and increased crop yields

Implementation

The following is practiced by organic farmers in Kenya:

- The organic matter from the previous crop is left on the field, covering the ground.
- On evenly sloped fields, livestock is allowed to feed on the crop stubble to enrich the soil with their droppings before the next planting season (as is done in many agro-pastoral systems elsewhere in Africa).
- At the onset of the rains, seeds are planted in relatively shallow holes or on fallow strips which are created by a hand-driven mould board plough or by an ox-plough.

Impact on biodiversity

Minimum tillage and remaining plant cover moderate soil temperature which adds to the accumulation of organic matter and subsequently to the preservation of the soil biodiversity.

Impact on farm economy

Waste seeds from the previous crop germinate and provided an early crop that can be harvested for human and livestock consumption. Any dependency on inorganic fertilizer is reduced as the new crop benefits from the organic matter, livestock manure and the conserved soil moisture, thus reducing the need for and costs of inputs. The time and labor that is required to prepare the field for planting is reduced and the farmer remains flexible in timing field operations. Additionally, reduced run off erosion through improved water infiltration rates and constant plant cover improves the soil structure and elevates the water conservation capacities of the soil, increasing fertility and rendering the option for multiple cropping.

Case study

On some farms of sub-Sahara Africa, farmers have adopted minimum tillage as a viable and cost effective strategy of increasing crop yields. This practice has been shown to increase crop yields by two and half times during second year (IIRR 2002).

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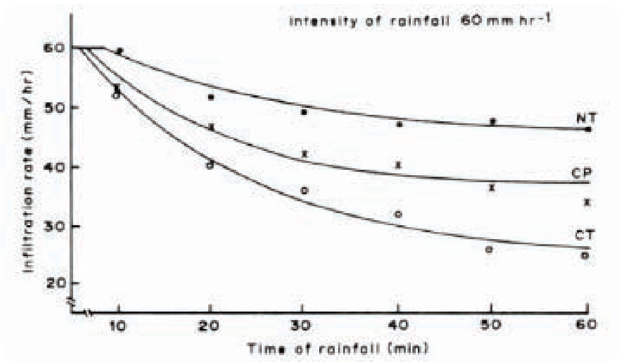

Fig. 3.3.2(1). Infiltration rate over duration (time) of rainfall. Effects of no-till (nt), plough till (cp) and ploughing with motorised farm operations (ct). Adapted from Da Silva et al. 1981.

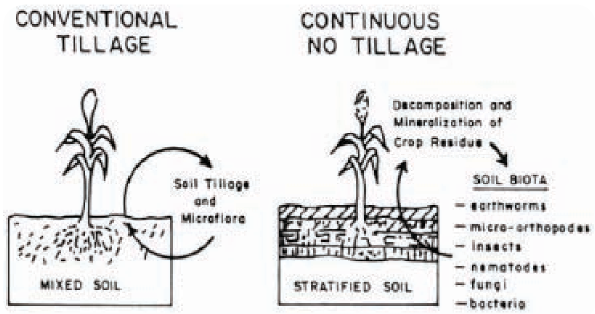

Fig. 3.3.2(2). Structural profile of a no-till soil. The soil is rich in soil biota such as earthworms, micro-arthropods, insects, nematodes, fungi and bacteria. Adapted from House and Parmelee, 1985.

Lessons learned

- Reduced soil disturbance ensures rainwater retention and less soil wash off during torrential rainfall
- Reduced soil disturbance allows for a structured soil high in biodiversity.
- Soil conservation management greatly reduces the land area to be cultivated and thus spares time and energy, which is especially important on farms where labor is done manually.

Recommended reading

- African Conservation Tillage Network: Information Series No. 2 pp4

- House G.J, and R.W. Parmelee (1985) Comparison of soil arthropods and earthworms from conventional and no-tillage agro-ecosystems. Soil and Tillage Research [SOIL TILLAGE RES.]Vol. 5 (4) pp. 351-360.
- IIRR and ACT (2005). Conservation agriculture: A manual for farmers and extension workers in Africa. Published by International Institute of Rural Reconstruction, Nairobi and Africa Conservation Tillage Network, Harare. Pp. 251
- International Institute for Rural Reconstruction (IIRR). (2002). Managing Dryland Resources. English Press Ltd: Nairobi. Pp. 214
- Kurt Steiner (2002). Conservation tillage: Gateway to food security and sustainable rural development, the economics of conservation tillage. African Conservation Tillage Network: Information Series No. 2 pp4.

Recommended websites

- http://www.atnesa.org/

Innovation 2

Use successive agro forestry systems as an alternative to slash and burn.

Biodiversity (++)	**Economy (++)**
Reduced pressure on primary forest	Increased productivity

Implementation

Although precise details for establishing annual crops without previous burning have to be assessed case by case and primarily depend on the type and age of the forest cover, it is possible to introduce the fundamental principles, by taking dry land rice cultivation in Bolivia as an example. Corn, (maize) rice and beans are the main sources of food and an integral part of family livelihood in many tropical regions particularly in central and South America. Fundamental measures to establish sustainable dry rice cultivation without burning are as follows:

- Firstly, shrubs are trimmed to make light available. Then the lower vegetation is manually cleared without burning. Trees are left as they are.
- Corn is sown together with jack bean (*Canavalia ensiformis*), pigeon pea (*Cajanus cajan*), annatto (*Bixa orellana*) and *Inga ssp*. or other tree or shrub species. It is important to note that dry rice cannot be sown on a field directly after the lower forest cover is cleared since the amount of fresh biomass on the ground inhibits the germination of the rice. Therefore in the first instance corn is sown together with the other species mentioned.
- The trees are cut only after seeding of the corn and the other species specified above is finished.

- The tree trunks are hacked into little pieces which are then evenly distributed across the field under cultivation. In the region of Alto Beni (Bolivia) this work is normally done at the end of the main rainy season, in March/April. Although many farmers doubt that corn, rice and beans are able to grow through a strong mulch layer of organic material, practical experiments in Bolivia (conducted by ECOTOP) have shown that there is no negative effect of a 30 cm mulch layer on the germination or seedling establishment and growth of corn and beans. Even dry rice is able to grow under a mulch layer of 10-15 cm.
- After germination of the corn and the other sown species, weeds are controlled manually and selectively. All naturally growing trees and shrubs do not count as weeds and are not cut. Only grasses and climbers are removed. The jack bean will cover the ground very quickly so that no further weeds can grow and no further intervention is needed until the corn is harvested.
- In the beginning of the rainy season (in Alto Beni in beginning of November) after the corn is harvested and before the rice is sown, the jack bean is harvested and cut, the pigeon pea and all remaining species are cut down to a height of about 20-30 cm.
- The biomass from the cut trees which was generated during the initial preparation of the field will have decomposed during the corn cultivation period and now rice is sown.
- Rice is sown in a mixture with the ratio of 1 kg *Bixa orellana* seeds to 9 kg of rice. 4 weeks later *Cajanus* is planted at 0.5 x 0.5 m spacing in the 'rice field'. Heavily growing species are cut back once more since the young rice does not tolerate shade.
- • After harvesting the rice (in Alto Beni in March of the following year) the rice stubble is cut and the rest is left as it is in order to harvest *Cajanus* and *Bixa* at little later. An alternative would be to cut back *Cajanus* and *Bixa* to a height of about 60-80 cm and to sow winter crops such as beans or *Canavalia* in combination with corn. In this case the supporting flora needs to be trimmed frequently until the corn stands above it.

Impact on biodiversity

The described system enables the cultivation of annual crops over many years on the same piece of land without losing soil fertility of that land. The support of the natural succession and the cessation of slash and burn agriculture reduces the pressure on the remaining forest patches, therefore making an invaluable contribution towards biodiversity.

Impact on farm economy

Dry rice is particularly important in the economy of small settlements in tropical forests which are created either spontaneously or due to government programs, since their livelihood needs to be sustained in the short term. For farmers of these communities especially, the application of successive agro forestry principles would make the cultivation of dry rice and other annual crops economically attractive. The cultivation does not need any external production material such as fertilizer. Additionally, the system also significantly reduces the risk of yield failure due to drought or very early rain (in which case fields that are managed with burning sometimes do not burn properly), as well as disease outbreak.

Case study

For successful cultivation of dry rice, older secondary forest (5 years or older) or primary forest is usually "slashed and burned". Slash and burn of young forest sites for rice cultivation is not practiced since quick weed encroachment in these areas makes them economically unattractive.

Action against further destruction of forest ecosystems due to slash and burn and subsequent rotation after the soil loses its fertility, or heavy weed encroachment (often only a couple of cropping cycles) is needed. Small scale farmers in Bolivia now also have a shortage of sufficient forest areas left in which to cultivate dry rice since they have already slashed and burnt most of their land. For these reasons an innovative Farmer working with ECOTOP, a consulting company in Bolivia, approached the problem of how dry rice could be cultivated without a previous slash and burn technique. A 3 year experiment in Alto Beni, Bolivia, showed that it is possible to cultivate dry rice and to sustain the yield on the same piece of land (not needing rotation). After this experiment, plantations were established in cooperation with 18 small scale farmers. As well as establishing plantations without previous burning of biomass, other plantations were also established on fields that had only been burned once before. The harvested yield is illustrated in Figure 3.3.2(1). Another successful experiment was conducted on a 7000m^2 (1 Manzana) field in Honduras. Even after one rotation period, the agro-forestry cultivation system reduced labor time necessary for weed control by 70 %, reduced nitrogen fertilizer by 50% and increase productivity by 65% compared to monocultures. See table 3.3.2 (1).

Lessons learned

Incorporating successive agro forestry principles into annual cropping systems in tropical areas indicate an opportunity for sustainable production systems which improve productivity and biodiversity.

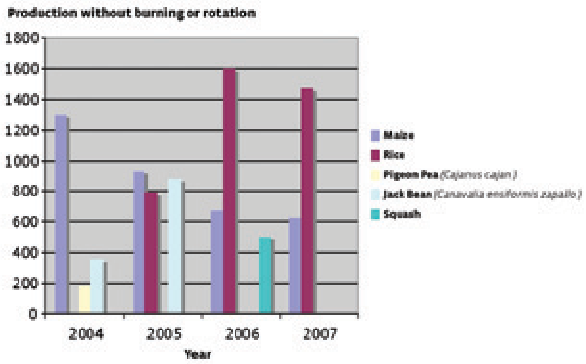

Fig. 3.3.2 (3). Yield from a single field of a successive agroforesty system between 2004 and 2007 is shown in kg/ha. In 2005 winter corn was destroyed by wild boars. 2005 and 2006 an extreme drought hit the area. The average yield of peeled dry rice produced on a field of a 5 to 7 year old "secondary successive forest system" in the region of Alto Beni lies at about 1000 kg/ha. yield for cajanus and canavalia for the winter 2007 were not yet available. Unpublihed, study by Ecotop.

Table 3.3.2 (1).Comparison between corn monoculture system and a system based on the principles of successive agro forestry systems at san nicolás in Honduras. The reduced labour needed to prepare the field for the following cultivation period is not incorporated. Unpublished study by Ecotop.

Labour and yield in regard to 1 manzana (700m²)	*monoculture*	*successive agro forestry system*
Manual weed control measured in daily salary	64	26
Corn yield (kg)	1104	1840
Canavalia (kg)	/	64
Straucherbse (kg)	/	128
Fertiliser (kg)	276	138

Fig. 3.3.2(4). Second cultivation period after trimming back the supporting (accompanying) flora.

Fig. 3.3.2(5). Dry rice with bixa orellana.

Fig 3.3.2(6). Dry rice with growing supporting flora.

Fig 3.3.2(7). Stand of cajanus cajan in the 2. Year of cultivation. Cajanus cajan will have to be trimmed back again in order to seed dry rice and corn again.

Activity/Practical Demonstration

Organize a farmer visit to an Innovation site: one of the biggest problems concerning forest conservation in the wet tropics is slash and burn for the purpose of cultivating annual crops. Here a practical innovative alternative where dry rice is cultivated without slash and burn has been suggested. However, many farmers are still very reserved concerning this system since its implementation requires good botanical knowledge in order to manage the system successfully. Visiting existing pilot cultivations substantially increases the trust of the farmer in this innovative system. During a visit it is easier to explain and to point out the exact management

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methods required by the innovation. However, farmers should be supported and guided by technicians or consultants particularly during their first year of applying this cultivation system in order to prevent mistakes in the installation as each mistake will eventually cost more labor.

Create a pilot cultivation: establish plots of 20 m x 20 m if possible on the same farm on which rice and corn is also conventionally grown using the slash and burn technique. Through having both plots on the same farm, the visiting farmers will be able to compare the two systems in terms of management and yield produced.

Recommended websites

- www.ecotop-consult.de

3.4. Perennial cropping systems

3.4.1. Examples from vineyards

Introduction

Vineyard establishment amid wild lands imperils biodiversity composition, structure, and function (Noss 1990). To begin with, new vineyards sometimes replace native vegetation including grassland, chaparral, woodlands, and forested communities (Fig. 1). The composition of these complexes varies with location. Native plant species sustain animals that are evolutionarily adapted to feed on them or pollinate them, and in turn provide important food for other wildlife. Vineyard development that necessitates removal of native plants and other important habitat features can impact native animal populations. Also, when vineyards replace other farming systems, the former may provide less favorable conditions for foraging by some native birds, as has been shown in northern California for Swainson's hawks (Buteo swainsoni), which preferentially forage in alfalfa fields and in grasslands (Swolgaard et al., 2008).

Vineyard development often leads to fragmentation of wild lands (Fig. 2) that can disrupt animal movements (Hilty and Merenlender 2004, Hilty et al. 2006), predator–prey relationships, plant pollination, and surface and groundwater dynamics. In addition, vineyard requirements for irrigation and frost protection lead to competition for scarce water resources and may thereby imperil native biota (Merenlender et al. 2008).

Organic farming practices, such as cover cropping and applying composts and other soil amendments are beneficial measures for biodiversity, but there are also other measures that may mitigate the net loss of biodiversity that occurs through "vineyardization" of landscapes. We will address three kinds of measures in detail: (1) Use of a spontaneous green cover ("resident vegetation" in Californian usage) or seeded cover crops in alleys (="middles" in Californian usage); (2) Designing wildlife-friendly fencing; and (3) Management of ponds and other water features to favor native biota (Zanini et al. 2008). Other practices that we will only mention in brief here with key resources cited include the use of hedgerows (Earnshaw 2004), bird boxes (Heaton et al. 2008), and collaborative management of vineyard irrigation needs to reduce impact on groundwater and surface waters (Merenlender 2000, Merenlender et al. 2008).

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Innovation 1

Implement biodiversity friendly infrastructures in the vineyards

Biodiversity (++)	Economy (-)
Allows wildlife to move through the landscape.	Erosion control. Neutral with respect to yield but increased costs due to increased fencing material and increased labour.

Implementation

To enhance biodiversity in vineyards the following measures are taken by farmers in parts of Europe, Australia, South America, and the USA:

- A permanent spontaneous green cover is established on the entire vineyard if the annual precipitation is above 600-700mm. In regions with less rainfall a temporary (= seasonal) green cover is established in the alleyways.

- Design and manage irrigation reservoirs and other vineyard water features to conserve and restore native plants and animals. In vineyards in California, the following considerations apply, and may be adapted for other regions:
  - Reservoir design should include a section that is at least 1.2 m deep, with adjoining emergent vegetation such as bulrushes or tules (*Scirpus* spp.) or cat-tails (*Typha* spp.) to provide refuge from heat and from predators.
  - Design should include a shallow end that is bare or has low-growing plants to permit basking.
  - Add native emergent and riparian vegetation to edges.
  - Include adjoining groves of riparian plants with moist, marshy sections (via dripline).
  - Remove and subsequently exclude non-native Centrarchidae (bass and sunfish) and mosquito fish (*Gambusia affinis*)-- Drain pond every two years to reduce use by non-native North American bullfrog (*Rana catesbaiana* [=*Lithobates catesbeianus*]).
  - Shoot out North American bullfrog and remove bullfrog eggmasses in summer.
  - Use Sacramento perch (*Archoplites interruptus*), three-spined stickleback (*Gasterosteus aculeatus*), or other native fish, or rely on native insects (Hemiptera and Odonata) for mosquito control.
  - High mowing and reduced tillage of green cover will make the vineyard understory more hospitable to amphibians and reptiles.
  - Many amphibians and reptiles use rodent burrows for shelter, enabling aestivation or hibernation. However, rodents, such as voles, pocket gophers and ground squirrels, can make for a difficult balancing act. The use of PVC pipes as artificial burrows has been successfully used to enhance Japanese tree frog (*Hyla japonica*) explored in Japanese rice fields (Hirai 2006). Analogous artificial burrows should be assessed for conserving other amphibians and reptiles.

- If fencing is necessary, wildlife-friendly techniques are used. On farms in California this involves the following considerations:
  - Deer and other wildlife are excluded from the vineyard because they can over-graze the

available vegetation and damage the vines.

- Fencing across or along creeks is avoided because riparian zones are particularly attractive to wildlife and are major corridors for transit. However, when riparian zones have been degraded due to human disturbance, fencing, may be needed to restore native trees that otherwise will be suppressed and stunted by continual browsing by native and introduced animals (e.g., deer, wild pigs, cattle). An efficient way of accomplishing this is by curtain fencing, which uses remaining trees as posts,
- Do not fence in deer and other wildlife. Wildlife can over-graze the available vegetation and should not be isolated from the surrounding populations.
- In North America, the currently accepted wildlife-friendly fence standards are: three strands of smooth wire with the bottom strand at least 16" above the ground, the second strand at 24", the third wire at 32", and a pole on top at 40". The top pole provides an important visual barrier that wildlife can detect and prevents them from getting tangled in a top wire.
- Generally the more visible the materials the better; therefore, wood, recycled plastic, or PVC are used instead of wire.
- A staggered picket of 1.50m (5ft) height is better than a 1.80m – 2.40m (6-8 ft) high woven wire fence that extends all the way to the ground.

Impacts On Biodiversity:

Green Cover

Cover crops are widely used in vineyards for erosion control and nitrogen fixation. Cover crop mixtures are important, because having multiple species provides functional redundancies and complementarities. For example, functional redundancy occurs when multiple legumes are used in a mix: if one species grows poorly, another may compensate, providing back-up. Functional complementarities can be obtained by seeding grasses and legumes together, grasses are often more efficient at scavenging soil nitrate, whereas legumes fix atmospheric nitrogen. These cases highlight key aspects of functional biodiversity.

Some but not all studies on the subject suggest that green cover can enhance biological control of arthropod pests of vineyards.

For at least part of the year, many wine-grape growers use a spontaneous green cover (=resident vegetation by Californian usage). In North Coast counties of California, winter-annual resident vegetation is used to protect the vineyard soil from erosion during the most intense winter rains.

Ponds and Other Water Features

Farm ponds, canals, ditches, drip-irrigation system backflush zones, ornamental fountains that adorn wineries and wine-tasting rooms, and other agricultural water features have major potential to help conserve and restore sensitive species. Farm ponds, specifically, are increasingly seen and managed as important habitats for sensitive species (Knutson et al. 2004, Davies et

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al. 2008a, Davies et al. 2008b). Studies conducted in Europe (Céréghino et al. 2008, Ruggiero et al. 2008) suggest that farm ponds can play major roles in conservation of aquatic insect species, including charismatic species, such as dragonflies (Odonata).

Irrigation reservoirs and other vineyard water features can be designed or retrofitted and managed to conserve and restore sensitive species. Areas that receive backflush from irrigation systems can be adapted and enhanced as small ponds or wetlands.

Wildlife-Friendly Fencing

Fences can act as an effective barrier to both target and non-target animals. Fences are effective at keeping deer from feeding on grapevines. However, they also affect the movement of non-pest species, forcing them to take paths that may lead to their deaths by predation, or collisions with motor vehicles. Though fences may be needed, we can limit the fence placement to the vineyard, rather than fencing the entire property. Designing the fence into "blocks" with corridors between the blocks is another approach. In both cases, the aim is to increase "permeability" and access by wildlife to water, food, cover, and to other tracts of wildland. Using wildlife-friendly fencing wherever possible minimizes the habitat fragmentation that results from fencing.

Impact on Farm Economy

A spontaneous green cover may assist with soil organic matter enhancement, and with fixation of atmospheric nitrogen, and with reducing erosion and nutrient leaching problems. Nectariferous plants used by natural enemies of pests include extrafloral sources like bell bean and common vetch, and floral sources like Persian clover, buckwheat, and common chickweed, Vineyard managers typically manage nectariferous plants with overlapping bloom periods to provide season-long habitat for natural enemies of pests. In this way, some studies suggest that it is possible to build up the number of natural enemies in the system early in the growing season, which helps to keep the pest populations at acceptable levels. However, managing the green cover will lead to an increased work load.

The aim in fence design is to exclude damaging wildlife such as deer but not restrict movement by non-target wildlife. The mentioned methods are neutral with respect to yield, but may result in increased costs that attend fencing multiple vineyard blocks while retaining inventing corridors.

Managing farm water features to conserve and restore native biota may require increased expenditures to rework the depth profiles, remove invasive exotic species, reintroduce native organisms, and maintain a dynamic that favors the latter.

Recommended Websites.

- LEISA Journal: http://www.leisa.info
- Lodi-Woodbridge Winegrape Commission: http://lodiwine.com/lodirules_home1.shtml

- Low Input Viticulture and Enology (LIVE): http://www.liveinc.org/
- Napa Valley Grape Growers: http://www.napagrowers.org/programs.html
- Napa Sustainable Winegrowing Group: http://www.nswg.org/
- University of California Sustainable Agriculture Research and Education Program, Cover Crop Resource Page: http://www.sarep.ucdavis.edu/ccrop/
- Victoria, Australia Department of Primary Industries http://www.dpi.vic.gov.au/DPI/nrenfa.nsf/FID/-9D5D0AFF7C8D9661CA256CBC00042B34?OpenDocument

Innovation 2

Biodiversity friendly management of green cover or cover crops

Biodiversity	Economy (-)
Provide a stable and relatively undisturbed habitat for fauna	Increased labour for management

Implementation

The following measures are taken into account in organic vineyards in California:

Green cover management is focusing on developing regimes that reduce mowing and tillage, especially during the breeding season (early spring) when ground-nesting birds are likely to be selecting their nesting sites.

Impact On Biodiversity

Mowing and tillage lead to the “attractive sink” scenario, whereby birds such as western meadowlark or red-winged blackbird in California are attracted to nest in a standing cover crop, that is later mowed, thereby destroying the nests and nestlings. Mowing in late February or March to keep cover crops low and unattractive during the nest-selection period is part of the solution, but may not be seen as practical. Cover crops are grazed or their seeds fed upon by herbivores, including insects and other arthropods; these herbivores in turn serve as prey for predators. Several winter-annual cover crops harbor higher densities of aphids, plant bugs, and associated predators than the natural vegetation, although no formal comparisons have been published. Bean aphid, cowpea aphid, and pea aphid occur on winter annual legumes, oat-bird cherry aphid infests cereals, and cabbage aphid and mustard aphid occur on mustards. Tarnished plant bug (*Lygus* sp.) and Norwegian plant bug (*Calocoris norvegicus*) occur on vetches, burr medic, and clovers, except for subterranean clovers. Black grass bugs (*Labops* spp.) occur on some grasses, especially on the North Coast. Most arthropods on these cover crops are abundant from late March to early May, coinciding with bloom period, and they may be important as food for birds and predatory insects.

Since species-rich herbaceous plant complexes in vineyards often degrade into grass-dominated stands after about 4 years, periodic re-seeding with forbs may be needed. A typical aim is, overall, to have the green cover include at least 4 differently aged complexes of plants. This will provide better functional biodiversity than pure grass stands (See Boller et al. 2004).

Impact On Farm Economy

Cover cropping entails costs for seed purchase, inoculation, site preparation, seeding, irrigation, mowing, and tillage. It can result in unforeseen competition with vines, or lead to excessive vine vigor, depending on the site conditions, rootstock, scionwood, cover crop selection, and management. It can affect nitrogen supply, serving either as a source or sink. Assessment of these issues and the resulting economic balance must be on a case-by-case basis.
Key points:

- The green cover between the vines consists of a spontaneous local flora.
- The green cover is managed so that a high proportion of perennial herbs are present.
- Sown cover crops include a diverse flora with species that flower early and continue to flower throughout the season.
- A desirable botanical diversity can be maintained by tilling every second alleyway every 4 years.

Lessons learned

- The ecological value of spontaneous or seeded green cover in vineyard alleyways can be enhanced by simple but effective management
- Alternating spading of adjacent alleys is an excellent measure to increase botanical diversity in vineyards.

Recommended reading

Bugg et al. 1996, Ingels et al. 1998, Boller et al. 2004, Ingels et al. 2005, McGourty et al. 2008.

3.4.2. Examples from orchards in temperate zones

Introduction

Because semi-permanent and relatively undisturbed systems have become rare, orchards have a huge potential to be a valuable habitat for a wide range of species, including fungi, lichens and plants, insects and other invertebrates as well as birds and mammals. The diversity of species is especially large if herbicides have not been used for a long time. In order to develop and to take full advantage of the potential of orchards for biodiversity, the implementation of simple biodiversity friendly management practices that consider the farm economy is proposed here.

Because the ecological potential of fruit orchards depends on the fruit type and the regional and local conditions, localized versions of the proposed management practices should be developed for each farm.

Innovations

1. Maintain and improve ecological infrastructures inside the orchard.

2. Enhancing species diversity on the farm

Innovation 1

Maintain and improve ecological infrastructures inside the orchard

Biodiversity	Economy
Secure food/cover for beneficial antagonists and enhance diversity	Potential biological pest control Increased labour

Implementation

Biodiversity in commercial orchards can be improved by adopting biodiversity enhancing management practices on available land areas. The following measures are taken on some organic farms in Switzerland:

- Grass dominated alleyways are managed for maximum floral diversity. If alleyways contain a high number of broad-leaf plants, floral diversity can be improved by extending the mowing intervals or by managing the alleyway vegetation according to the innovations mentioned in 3.2.1 (Temperate pastures)
- Inter-tree strips are not kept clear throughout the whole year: a green winter cover is allowed to grow up in the plantations.
- Wild flower strips are created on marginal land around the orchard.
- Disturbance in the rough edges and other ruderal habitats within the orchard is maintained by passing over periodically with a vehicle or by mowing every two years. Disturbance levels are managed to promote pioneer plant communities and to avoid the establishment of shrubs.
- High stem orchards are planted on pastures or in annual crop fields.

Impact on biodiversity

In order to increase the success of biological pest control, adequate habitats that support the necessary beneficial fauna need be maintained close enough to the target orchard. Generally, the efficiency of biological control increases with a decreasing distance between the orchard and the habitats for the beneficial fauna. Habitat requirements and management of the habitats depend on the specific ecology of the different beneficial species. For instance, botanically rich alleyways and wild flower strips provide food and shelter for the flower-visiting beneficial

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fauna. Landscape elements that serve as corridors or as stepping stones for the migration of the beneficial flora should be promoted. Such elements can for instance be green cover during the winter period, low intensity grasslands, wild flower strips or extensively (in the sense of low input) managed grassland in proximity to the orchards. Moreover, ruderal elements can provide habitats for pioneer species that are normally not found in the orchard alleyways.

Impact on farm economy

An orchard rich in structural elements brings about many economic advantages. For instance, wild flower strips can reduce vole damage because voles prefer these strips to the orchards. As mentioned above, wild flower strips and florally diverse alleyways provide habitat for beneficial fauna. Antagonists can play an important role in fruit production strategies that operate with high ecological quality standards, although the beneficial fauna alone is often not enough to reduce key pests below economically relevant thresholds. An economic drawback is, however, that maintaining and managing the alleyways and surrounding ecological infrastructure can be labor intensive and time consuming. Therefore, each farm should consider the positive and negative aspects of the proposed management practices separately to evaluate the individual impact on its economy.

Case studies

In a Quebec apple orchard, ***Tanacetum vulgare, Chrysanthemum maximum***, ***Aster tongolensis*** and ***Achillea millefolium*** were planted to attract and retain predacious and parasitoid arthropods. The plants covered one-third of the surface of the experimental block and provided nectar, pollen and refuge for beneficial arthropods. The parasitoid fauna increased several-fold during the study period. The most important result of this study for pest management was that in the fifth study year 90.8% fruits at harvest were clean (fruit quality). Such a high percentage of clean fruits is a success, but the result also implies that it takes several years to build up a beneficial arthropod population large enough for effective biological control. Such a long transition phase between conventional and biological control of pests may commercially be unacceptable because of too large losses of yield during this period when pesticides can no longer be applied and the beneficial fauna is not yet established. Therefore, the biological pest control technique used in this study cannot be readily adopted into orchards that are in full production. Nevertheless, this example indicates the power of ecological functionality of orchards and suggests that habitat management that favors the fauna for biological control of orchard pests can serve as a basis for additional bio-control techniques to further increase the quality of the yield at harvest (Bostanian et al. 2004).

Lessons learned

Ecological features implemented and maintained inside the fruit orchard do not always suffice to achieve an efficient biological pest control but are nevertheless a relatively simple contribution enhancing the biodiversity value of orchards.

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Recommended reading

- Bostanian N. J., H. Goulet, J. O'Hara, L. Masner, G. Racette .2004.Towards Insecticide Free Apple Orchards: Flowering Plants to Attract Beneficial Arthropods. Biocontrol Science and Technology 14(1): 25-37.
- Häsli, A., F. Weibel, H. Brunner, W. Müller. Biologischer Obstbau auf Hochstämme. Forschungsinstitut für biologischen Landbau (FiBL).

3.4.3. Examples from crop tree plantations in the tropics

Introduction

The dominant tree and shrub crops of the tropical and subtropical areas of the world are coffee, cocoa, bananas, palm, tea and rubber. In addition, there are a variety of tropical fruit crops like citrus, papaws, mangoes, pineapples, avocadoes and a wide range of other non-typical fruit crops such as apples, berries and grapes. However, local utilization of tree cash crops is often limited and increasing production and quality of these crops is generally driven by the demand of regional or global markets. As market demand goes up, governments and individual farmers are encouraged to expand farmland and establish farming systems that are more productive, but at the same time maintain their ecological functionality (e.g. providing a habitat for biodiversity; being independent of pesticides and fertilizers). Here two innovative approaches are described of how an organic farmer can achieve this win-win situation.

The first approach is of a more general nature, propagating the adoption of innovative successive agro-forestry systems as a key to maintaining biodiversity and enhancing productivity. For particularly light-dependent crops such as oranges and pineapples, and annual crops such as corn (maize) and beans, which are important in Central America and parts of South America, farmers are often reluctant to adopt agro-forestry systems. However, monocultures of these light-dependent crops have been shown to be improved in terms of biodiversity and productivity by establishing innovative agro-forestry systems based on natural succession.

Successive agro-forestry systems are complex and dynamic stratified systems which evolved through combining scientific knowledge of the 'western world' and traditional indigenous knowledge of agriculture in the tropics. The system relies on converting the forest into a 'forest garden' by controlling native herbs, shrubs and trees as well as utilizing the succession stages of the native vegetation. The goal is to reproduce the natural succession of vegetation communities from annual pioneers to forest. All naturally occurring plant ecotypes as well as spontaneously establishing vegetation are integrated into the system – including 'weeds'. Additionally seeds from surrounding secondary and primary forest communities are collected and distributed in the plantation. This supporting flora is of high importance since it stimulates growth and increases the carbon cycling in the system which in turn enhances soil fertility and therefore the productivity of the whole system. The developing forest garden comprises of a high biodiversity (more than a hundred species) even if some domesticated crops such as cocoa, oranges, bananas, pineapples or others dominate at certain times in order to ensure economic production levels.

Although stimulating natural succession and enhancing species diversity means increased workload due to increased management work such as periodical trimming and pruning of trees, the investment pays off due to increased productivity even in short term.

By understanding the function of each species and the niche it occupies within the natural succession processes, it is possible to achieve or even duplicate what nature originally does without the intervention of man. Successive agro-forestry systems build on this concept in following the principles outlined below:

1. Density of plantations

In the case of pioneers and short lived secondary species, poly-cultures are planted by spacing them as if they were single crops. The density at which other tree or shrub-like species are normally planted is increased by a factor of 5, 10 or 20. From the start of the plantation, species from all the different consortiums that make up a system, i.e. pioneer, secondary, transition and primary species are included. As many species as possible are planted in order to make use of all the niches the ecosystem at a given site can offer. The succession of the different consortiums (from pioneer to primary) of a system is anticipated and analyzed for a given period of time. Likewise, the stratification of the species of a consortium is taken into account. This way, species do not compete with each other, but maximize each other's potential and therefore complement each other as well providing the biological environment for those that will follow.

2. Occupy all niches

Nature occupies all niches that are not occupied with crops. These species help optimize the living conditions of the area. Under natural conditions, though, there would be no areas where the soil is exposed. If there is an imbalance, grasses and other herbs will occupy barren spots. This calls for the farmer's intervention: generally by weeding. However then it is not possible to improve the conditions in the area where the weeding took place - the soil condition may thus deteriorate. If all niches are occupied with suitable species, then nature would no longer try to "help" by covering the ground with grasses and other 'weeds'. When weeds appear in the fields it means that the farmer is not making good use of space and has not filled all the niches offered by the system.

3. Selective weeding

Instead of weeding indiscriminately, young plants are left. Weeding is done selectively; it aims at recycling plants, cutting only the grasses and herbs that are ready to flower.

4. Accelerate the carbon flow by incorporating organic matter into the soil

Increased productivity of a system is based on the flow of carbon within it. The more organic matter the system recycles the more it produces, and the more it produces the more it can recycle. By pruning trees and by ensuring selective weeding of all mature plants, large quantities of organic matter can be recycled and reincorporated into the system.

5. Stratification, adequate consortiums and synchronization of the system

When an agro-ecosystem, for example with cocoa as the main crop, is established, it is important that all species in the system are synchronized with the growth rhythm of cocoa. For example if cocoa flowers late, all other plants must be synchronized with the change in flowering and maturation rhythm of the cocoa. When growing naturally, the cocoa tree occupies a low or medium low stratum. Many trees from the medium high stratum to the emerging trees that peak the forest canopy grow above it. Before the cocoa begins to flower, the majority of trees from the high stratum as well as many of the emerging trees lose their leaves. The increase in light stimulates the flowering of the cocoa trees. Likewise, the sprouting of new leaves on the surrounding trees will later on stimulate and support the competitive growth of the cocoa tree, making the system very dynamic. In successive agro-forestry systems this same phenomenon of the dynamic ecosystem is duplicated, either by planting trees of the high stratum that lose their leaves during the dry season or, if that is not possible, where *Ingas ssp*. are used as shade trees, by strong pruning, removing up to 80% of the branches (keeping the main structure of the tree) at the time the trees from the higher stratum would ordinarily lose their leaves. In that way the system is synchronized, giving the cocoa optimum conditions to grow and to produce fruits. At the same time, full advantage is taken of the capacity of other species to produce organic matter and sprout after being trimmed. This same synchronization is suggested for citrus plants, coffee and other crops in successive agro-forest systems.

6. Pruning to rejuvenate and eliminate individuals who completed their cycle to accelerate natural succession processes

All consortiums in a system are planted at the start. To keep the dynamics of the system at optimum levels an intervention is necessary as soon as a given species begins to mature. Trees are mature once insects begin to eat the leaves, or when the tips of the leaves begin to dry, when branches or whole plants are infested by parasites or when certain diseases begin to appear in a plant. In this case the damaged parts should be cut or the whole plant should be eliminated. Pruning is important to synchronize the system and to accelerate the flow of organic matter. This enhances the sprouting of new leaves and the resulting foliage is often thicker than before. Consequently, the plants pruned and those surrounding them are stimulated as more organic matter is produced. It is widely believed that citrus plants and the cocoa tree cannot grow beside or under an Inga, a Motacú (*Scheelea princeps*) or any other tree. This is true if the Inga, Motacú or any other tree is old and has no vigor. If, however, these trees are pruned to rejuvenate them, then the cocoa tree or the citrus plant underneath reacts and grows next to or under the "young" shade. Generally, however it should be noted that many cocoa or coffee plantations all over the world have failed because the species used to provide the shade had a shorter life

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cycle than the crops. Many ***Ingas ssp., Glyricida sepium, Erythrina ssp.***, etc., are recommended as shade trees, but if they are not pruned to rejuvenate them they limit the growth dynamics of the crop plants.

7. Managing borders and limits with neighboring plots

The vegetation found next to an agro-forestry plot has a considerable influence over its ecosystems and vice versa. For example, an agro-forestry intervention that borders on old fallow grounds is negatively influenced. The influence of this land will extend to a distance more or less corresponding to its height over the neighboring system. On the other hand, dynamic agro-forestry areas exercise a positive influence on their surroundings. The boundaries of adjacent activities that limit agro-forestry parcels should be pruned, penetrating inwards to a distance more or less equivalent to their height.

The second approach is more economic and specific, focusing on achieving enhancement of the environment via product branding. Coffee is a major export crop for many countries in eastern Africa as well as central and southern America. The east African countries, especially Kenya and Ethiopia, for example, produce high quality Arabica coffee, which is commonly used for blending with coffee grown in Asia, Central and South America.

Innovations

1. Establishing a successive agro-forestry system.

2. Organic production of coffee

Innovation 1

Establishing an successive agro forestry system

Biodiversity (++)	Economy (++)
Increased species richness, maintained ecosystem function	Enhanced production, sustainable soil fertility, reduced pests and disease

Implementation

The steps for imposing a successive agro-forestry system on crop tree plantations can be seen in this example of orange production. Quite commonly oranges are cultivated as single crops; in the best cases, they are allowed some green cover. However, experience from Bolivia has demonstrated that orange plantations are more productive and associated with fewer problems if they are grown in agro-forestry systems that have been adapted to the requirements of this crop. In Bolivia, such a system was established in 1989. It incorporated the following measures:

- Oranges were planted in 6x6m quadrants on a plot of 1.25 ha.
- Legumes (*Pueraria phaseoloides*) were seeded to establish a ground cover. Due to plant diseases, however, the conversion of this plantation into a successive agro-forestry system

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only started in 1996. To start the conversion, bananas (Cavendish type in combination with local tall growing shade tolerant types) were planted every 3m in the row of the oranges.

- Additionally seeds of Inga spp in combination with other secondary tree species, as well as primary forest species and palm trees were sown or occasionally planted every 0.5 m. Also coffee was planted in between.
- The trees planted to occupy the high stratum were selected to be species that lose their leaves in the dry season (i.e. Ceiba, Cedrillo (*Spondias mombin*), Ochóo (*Hura crepitan*), Tarara (*Centrolobium ochroxylum*).
- Furthermore Guinea grass (*Panicum maximum*) was planted on notably nutrient poor areas in the plot in order to increase the initial biomass production within these. This grass produces a large amount of mulch material provided it is cut regularly, allowing the soil to be uniformly covered by organic matter. During the first years pineapples can be included in the system and two crops that adapt perfectly to the lower stratums are coffee and cocoa.
- To synchronize the plantation according to the oranges, all trees were pruned two months before the flowering time of the citrus trees, leaving them almost fully exposed to the sun.

Impact on biodiversity

Successive agro-forestry systems conserve, maintain or even re-establish ecosystem functioning and therefore provide services such as biodiversity enhancement through habitat conservation, soil fertility and carbon sequestration which reach far beyond food security and a sustainable livelihood for the farmer.

Impact on farm economy

In the first year the farmer is able to harvest crops for home consumption such as corn, beans, manioc, Pigeon pea (*Cajanus cajan*) as well as others for marketing, such as hibiscus, papaya, bananas, pineapples. This leads to a fast investment return as the additional workload arising through pruning and increased management can be financed through these quickly established crops

Case study

After following the steps described in the implementation heading, the plantation described above now includes 50 types of timber and fruit trees in different canopy layers below and above the citrus trees. 650 trees and palms are present per hectare and soil fertility has increased in line with the development of the supporting flora within the plantation. During droughts it was particularly evident that compared to normal plantations in the region, this system did not show signs of stress and maintained productivity (yield). Generally the yield harvested in the agro forestry systems was relatively constant and above the average yield of the region. The time invested in pruning and management resulted in and continues to enhance soil fertility, which cannot be said about monocultures. Within 2-3 years the system produced sufficient organic

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matter to maintain a permanent ground cover of material originating from pruning and fallen foliage, sustaining a high flow of carbon. Therefore no input of fertilizers was needed. Within 3 years the income from the Cavendish bananas was sufficient to cover the total maintenance costs of the plantation. From 2005, cocoa (which were only integrated into the plantation in 2000) was harvested and fruits of palm trees (*Bactris gasipae*) were collected and sold on the local market or used in the household. Although labor time is needed for pruning, generally the intensity is similar to that in monocultures: since there is no need for weed control. However, it is important that the pruning of the shade trees is done in time (ca. two month before the development of flowers in the oranges). If pruning is not done in time yield will decrease due to lack of light stimulus which is required to kick-start orange flower development.

Fig 3.4.3(1). (late valencia) orange monoculture in Bolivia (see case study)

Fig 3.4.3(2). The same plantation as in fig 3.4.3 (1). Seven years after switching to a successive agro-forestry system. Refer to the described case study.

Lessons learned

- Employing the principles of successive agro forestry enables a sustainable agriculture even for light demanding crops such as oranges.
- The successful implementation of such systems requires a good understanding of natural succession in the area and knowledge of indigenous trees and shrubs.
- It is important that management steps such as pruning of the plantation are well executed and in tune with the physiological needs of the plantation.

Activity/Practical Demonstration

To do this it is important to identify a small site which can be used to plant already tested agro-forestry systems for demonstration. Significant improvement of the systems can be achieved quickly by introducing just a few of the species at high density, and simultaneously supporting the naturally developing shrub and tree vegetation. In Bolivia interested farmers are invited onto an agro-forestry plantation. The health of the trees and their fruits as well as the significant amount of foliage and braches on the ground of the plantation are pointed out to the visiting farmers. Interested farmers are also allowed to try the fruits. After that a neighboring plantation with a monoculture system is visited and the plant health problems of trees of the same age to those in the agro-forestry system as well as the problems with soil fertility are pointed out. Then a training course is arranged on which the general principles of successive agro-forestry systems are taught and practical exercises concerning the management of these plantations are conducted. Also technical advice and on-farm visits by experts or experienced producers are offered to the interested farmers.

Recommended reading

- Sociedad Española de Agricltura Ecológica (SEAE) I er Conferencia Internacional de Citricultura Ecológica Resumen Gandia 3 al 5 de noviembre de 2005

Recommended websites

- www.ecotop-consult.de

Innovation 2

Produce coffee under organic conditions for quality improvement and branding.

Biodiversity (++)	Economy (-)
Production ensures biodiversity conservation by optimizing land use and avoiding use of inorganic farm inputs.	Specialty coffee is in high demand and fetches premium prices than conventionally grown coffee.

Implementation

Specialty coffee refers to a product of defined quality grown in unique settings like the Civet Coffee in the Philippines, which is one of the world's most expensive. With only 500 kg produced a year, the roasted beans sell for more than US $115 a kilogram. In Ethiopia, coffee grown under natural forest shade has captured a niche in the global market. The coffee is produced on natural and organic farming systems with no inorganic inputs for soil fertility or pest and disease control. The farming system allows, and indeed encourages, increase of species diversity and natural pollination. High quality specialty coffee is grown to meet a select and specific market requirement. Adoption of this type of production and branding is an innovative approach, which makes coffee growing friendly to the environment, healthy for the consumers and economically viable. In central Ethiopia, where coffee is endemic and grows naturally in upland forests, coffee plants are managed in their natural state. In other countries like Kenya, selected high quality coffee plants are grown under shade, while in South America, naturally growing indigenous tree species are the main shade trees used. The coffee plants form part of a natural system in terms of different ecological processes, such as pollination and nutrient renewal. There are no chemical fertilizers, pesticides or herbicides used and pollinating species come from the surrounding natural habitat. The coffee harvested is of high quality due to the particular, often unique conditions under which it is grown. Specialty coffee products are in great demand and fetch premium prices in the international market.

Impact on biodiversity

Production of coffee under natural shade has minimal impact on natural forest diversity. The coffee trees take up a relatively small area and thus help to save natural forest, which has been steadily declining in tropical countries of Africa, Asia and Latin America. This system of coffee production allows for normal population dynamics for natural pest and biological control agents so no pesticides are required. The production system also allows the existence of a rich diversity of birds, which facilitate pollination and seed dispersal for forest regeneration. The accumulation of organic matter ensures a stable nutrient pool, retains water and conserves soil. In the face of declining tropical forests, the described system contributes significantly to amelioration of the effects of climate change, as it acts as a carbon sink.

Impact on farm economy

Production of specialty coffee is primarily for the export market. It is a viable enterprise due to high yields per unit area, high demand and the premium prices that the coffee fetches in the world market. The production system is cost effective since it requires minimal inputs other than labor. The system allows for high diversity of bird species and hence ecotourism through controlled bird watching tours. This brings additional income to the local communities.

Lessons learned

The premium price from specialty coffee encourages farmers and the communities around such systems to conserve biodiversity. The system would be good to adopt, especially since added income from bird watching is shared with members of the community other than the coffee farm owners.

Recommended reading

- Franzel, S. and Scherr, S. J. (2002). Trees on the farm: Assessing the adoption potential of agroforestry practices in Africa. CABI Publishing, in association with World Agroforestry Centre. PP197
- Ong, C. K. and Huxley, P. (1996). Tree-crop interaction: A Physiological approach. CABI Publishing, in association with World Agroforestry Centre. PP386
- Patrick Maundu and Bo Tengnas Edrs (2005). Useful trees and shrubs for Kenya. Technical Handbook No. 35. World Agroforestry Centre. PP 484
- Pena, J. E., Sharp, J. L. and Wysoki, M. (2002). Tropical fruit pests and pollinators: Biology, economic importance, natural enemies and control. CABI Publishing. PP 430

3.5. Hotspot-areas for biodiversity and landscape quality

3.5.1. Examples of types and significance

Introduction

Biodiversity and landscape elements are unevenly distributed over farm lands (Fig. 3.5.1.(1)). Areas on the farm with a high level of diversity, such as spots, lines or other elements with a specific function for the preservation or enhancement of biodiversity and landscape character, need particular attention. Such hotspot areas are defined here as areas within the farm perimeter where the primary purpose is to support biodiversity or to serve as a particular landscape element with an aesthetical or cultural emphasis. In many cases – and this is an important point – hotspots on farms contribute not only to the diversity but are also relevant areas for agricultural production. Thus they are not 'additional' or separate elements on a farm, like a nice decoration. In other cases, hotspots may be non-agricultural elements like brooks, set aside areas or 'virgin' ecosystems like primary forest patches.

A good example of an agriculturally used hotspot is an extensively cultivated meadow. In the temperate zones these meadows can support 60-80 or more plant species per square meter – more than any other ecosystem in the world what concerns this species density. This type of meadow depends a regular agricultural use. Without mowing, bushes and trees would establish within a few years and eliminate most of the previous species richness. Because of the availability of fertilizer today that increases the yield of meadows significantly by turning them into intensively cultivated meadows, farms cannot produce economically any more based only on less-intensively cultivated meadows. Nevertheless, maintaining a certain percentage of such species rich meadows, e.g. 10 to 30% of all the meadow area on a farm, can fulfill many practical purposes. Many farmers use hay from species-rich meadows as medicinal fodder as it contains many medicinal plants. Others use it particularly for calves or non-lactating cows because of the high fiber content. Less-intensively cultivated meadows may also be a consequence of a lack of available dung as fertilizer preventing intensification. Less-intensively cultivated meadows can also be an important factor to obtain subsidies for farmers in some countries in Europe.

Single trees represent another important type of hotspots. They can considerably increase landscape quality or serve as nesting places for birds and habitat for hundreds of different insect species. Additionally, a tree can produce fuel, fruit and shade for human beings as well as for grazing animals. A further type of hotspots are traditional wooden fences, which are very characteristic for the cultural landscape, e.g. in Central and North European countries. They combine the function of a normal fence with landscape shaping (Fig. 3.5.1.(2).

The different types of hotspots on a farm and the various measures to conserve, improve or create such hotspots are practically unlimited. Nevertheless, different regions, landscapes and ecosystems support typically a characteristic subset of hotspots. A comprehensive collection of mid European perspectives and examples including literature references is available (in German) at www.agraroekologie.ch/checklisteNLtab.php. A less comprehensive overview that is more specific to the situation in the UK is available at http://www.defra.gov.uk/erdp/pdfs/es/hls-handbook.pdf. The latter document includes also more detailed descriptions of management measures

Innovations

1. Restoration of species rich meadows.

2. Further Examples see e.g. chapter 3.3.1 and 3.3.2., 3.4.2, or 5.

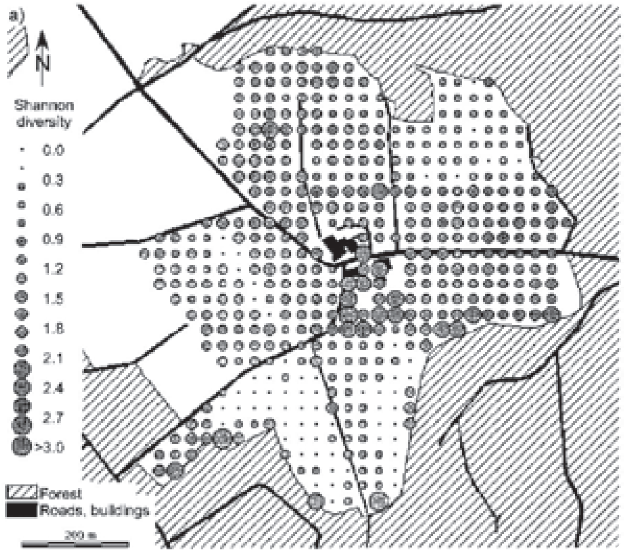

Fig. 3.5.1(1). A complete inventory of the cultivated areas of farm Litzibuch (www.litzibuch.ch) shows the uneven distribution of plant diversity. 93% of the species that were present within the farm area were found in the field margins, i.e. on an area accounting for only 3% of the total farm area. In contrast the agriculturally used area (97% of the surface) included only 55% of the species, and species diversity tended to decrease with distance from the field margins. Thus field margins in this farm are a typical hotspot. Source: von Arx, G., A. Bosshard & H. Dietz 2002: land-use intensity and border structures as determinants of vegetation diversity in an agricultural area. Bulletin of the Geobotanical Institute ETH 68, 3-15.

Fig. 3.5.1(2). A traditional wood fence used both as a biodiversity and landscape hotspot . Photo by A. Bosshard.

Innovation 1

Restoration of original flora using hay of species rich meadows

Biodiversity (++)	Economy (+)
Regionally extinct species return	Possible positive health effect by medicinal plants

Implementation

An important step in restoring the original biodiversity of important grassland types like meadows or grazed/mown/uncultivated field margins is the re-introduction of target plant species from within the local region. An established and generally practical method applied widely in Central Europe is to harvest fresh grass from nearby species-rich target-vegetation (green hay method) and to distribute the harvested grass on the field, margin or plot to be restored. This procedure involves the following steps:

- Prepare a good, fairly compacted seed bed on the target site. Plowing and subsequent harrowing (twice) is recommended. Under dryer and/or steeper conditions it is also possible to use a rotary harrow only (normally three times within a few weeks), or to cover the soil with black plastic film for some weeks. To achieve good results it is critical that the previous vegetation is destroyed completely.
- Identify grassland in the surrounding area that harbors the target species diversity and that corresponds also with the site conditions (exposure, soil etc.) with the area to be restored.
- Harvest the meadow when most species have ripe seeds (normally one to three weeks later than the traditional hay cut of a meadow). To prevent seed loss it is recommended to harvest during rain or early in the morning.
- Carry the harvested grass directly to the prepared site and distribute it evenly over the seed bed (by fork or, in the case of larger areas, with a manure spreader).
- Cut for the first time when the vegetation starts to cover the soil completely. In many cases no cut is necessary in the first year. It is completely normal that in the first year over 90% of the emerging vegetation are annual 'weeds'. This does not endanger the success of the restoration measure.
- Starting with the second year, the restored meadow can be used in the traditional way.

This method is particularly suitable for poor soils and other low productivity sites (shaded or wet sites for example). It is highly recommended to remove existing turf before attempting to enrich grassland with target species.

Instead of the green hay method, re-introduction of target species could be done conventionally by sowing the plots with seeds if seeds of the target species are readily available. When obtaining seeds, it is paramount to verify that the seeds are of locally adapted ecotypes and of regional provenance. Alien ecotypes may harm the original flora by disrupting adaptation to the local conditions; therefore, introduction of such seed material should be prevented.

Impact on biodiversity

Many agriculturally intensively used landscapes are on large scales depleted of species that once were common and typical of those landscapes. Once a species has disappeared, recolonization of restored habitats and sites may not occur at all, or may take decades, depending on the distance to the next occurrence of that species. This is particularly true for plants, but also for many animals, like butterflies or beetles. Experiments indicate a mean expansion speed of only 1 m per year for meadow plants. Well-known examples of slow expanders are marguerite and sage. Both plant species have previously been common in European landscapes and today are rare or even missing in many regions. To bring them back to those landscapes it is necessary therefore to introduce them deliberately. Using the methods described above it is possible to successfully re-introduce many plant species that once were part of the local flora. Research found evidence that restored grasslands are subsequently recolonized by animals themselves, for example, by butterflies and by grasshoppers.

Impact on farm economy

Sites that are selected for restoration are usually those areas with a low potential productivity due to poor site conditions or those land parcels with a shape or location that impedes efficient farming. Therefore, no significant reduction of total yield of the farm is expected when such sites are restored. Because in some countries subsidies are paid for species-rich areas, restoring such sites brings even about a positive effect on the farm economy.

Restoring species-rich meadows offers also other economically relevant effects. For instance, many farmers are convinced that the hay of species rich meadows improves the health of their animals and thus reduces related costs (this effect is not yet scientifically substantiated due to inherent difficulties). The fodder of these meadows is particularly suitable for non-lactating cows and for calves. A further economically positive effect is that these meadows harbor many beneficial organisms (for example spiders and Carabid beetles) that help to reduce pest damage in nearby crop fields. This aspect of biological control is particularly important on organic farms where application of herbicides is banned.

Case study

In the UK, Luxembourg, Germany and Switzerland, many efforts have been made to encourage farmers to use the green-hay restoration method in order to extend the area of species rich meadows. In Saxony (Germany) suitable source meadows were evaluated and mapped (see www.spenderflaechenkataster.de). In Switzerland, an established network of experts for ‘green-hay-seeding’ supports farmers with advice, carries out inventories of source meadows and conducts experiments to improve the methods. This network also offers individual solutions that meet a high professional standard (see e.g. http://www.ecology.ch/begruenungen.php).

Lessons learned

- In most cases a successful restoration of species rich grassland – e.g. meadows or field margins – is impossible without the introduction by seed.
- The green hay method is generally the most biodiversity friendly method to restore species rich grasslands. Its application is only limited by the availability of a suitable source meadow in the vicinity.

- Seeds from the market should only be used if regional ecotypes are guaranteed.

Activity/Practical Demonstration

The best way to demonstrate the values of species rich grasslands or field margins and the power and success of the green-hay-seeding method is to organize excursions to restored meadows. The difference of a restored and non-restored meadow under the same cultivation regime is easily visible when counting the known plant species or the number of flowers per square meter (e.g. with the help of a 1 m x 1 m frame).

Recommended websites

- www.defra.gov.uk/rds/publications/technical/tan_28.pdf and www.parishgrasslandsproject.org.uk/images/pdf_files/HT05% 20Enhancing%20your%20Grassland.pdf
- www.spenderflaechenkataster.de
- www.ecology.ch/begruenungen.php
- www.ecology.ch/wiesenrenaturierung.php
- http://e-collection.ethbib.ethz.ch/show?type=diss&nr=12922

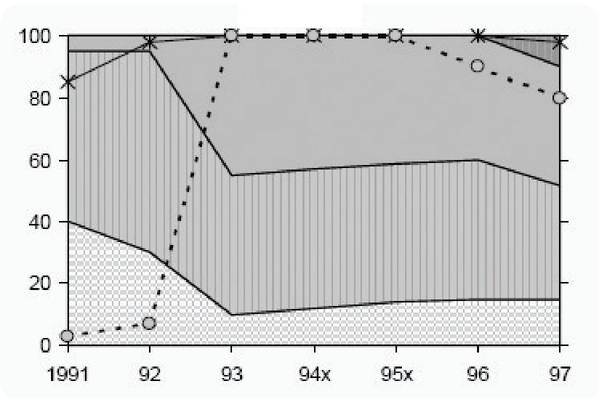

Fig. 3.5.1(3). In the first years after restoration, the plant species composition of a meadow is usually unstable. After 2-7 years, stabilisation takes place (source: Bosshard 1999). Legend (from top to bottom): percentage of herbs, legumes, grasses, meadow flowers. Dots: cover of legumes, x-axis: %, y-axis: years.

Fig. 3.5.1(4). Using a rotary harrow, a strip is prepared within an existing, species- poor turf. From the strip the established species disperse into the surrounding grassland. Photograph by A. Bosshard

4. Improving ecosystem diversity in a whole farm context

4.1. General Introduction

Biological diversity (or biodiversity) on a farm can be classed into three major elements:

- Genetic diversity of crop and livestock varieties on the one hand and of wild biota on the other (genetic level of biodiversity, subject of chapter 2.).
- The diversity of species on fields, plots or in specific cropping systems (species level of biodiversity, subject of chapter 3.).
- The diversity of vegetation communities, and crop types as well as livestock and wildlife populations and landscapes, and interactions of these in the whole farm (ecosystem level of biodiversity).
  Figure. 4.1.(1) shows that one part of the diversity of the whole farm depends on the natural conditions (geology, soils, relief, vegetation, fauna), while the other part depends directly and indirectly on the cultivation of the farm and is therefore determined by human activities (anthropogenic).
  A farm influences the ecosystem diversity in all sectors both intentionally and unintentionally. Furthermore, the farm provides a setting which places controls that may either limit or foster biodiversity.
  Diversity of ecosystems is not an end in itself, but is important since it provides many functions within the agricultural context:
    - It contributes to the quality of agricultural production
    - It functions as ecological equilibrium and provides capacity for self-regulation
    - It supports biological pest control
    - It provides natural and cultural heritage
    - It shapes the scenic identity of a region

Every farmer is familiar with the importance of crop rotation: it primarily serves to keep the soil healthy and efficient and to avoid plant diseases. In order to conduct crop rotation, different acreages have to be cultivated in a certain temporary sequence, thus the rotation's health function can develop. A similar pattern applies to the functions of the ecosystem: there needs to be a sufficient network (quantitative and qualitative) of ecological compensation areas, (areas that are left as natural habitats within and between agro-ecosystems) so that all the functions of ecosystem diversity mentioned above can take place.

Natural, semi-natural, or extensively used agricultural lands provide a solid basis as ecological areas of value, but a good and satisfactory functionality of the ecosystem can only be achieved through adequate size, sufficient quality and networking of these areas and structures. This can be compared with many other supply services, for example it could be likened to a nation's electricity supply which only works satisfactorily and safely if there is both enough power generation (analogue: sufficient areas, where wild plants and animals live and propagate), and on the other hand an adequate number of lines that distribute the power (analogue: biotope networking – the linkages between different biological communities in their habitats).

Biotope networking differs in the various landscapes as it depends on the prevailing types of habitats. Biotope networks may consist of hedge or coppice elements, but could also be ditches, brooks and marsh areas (in some cases without any tree or bush within the landscape), or even dry and pastured slopes that stretch along the course of a river.

A minimum acreage and amount of network structures is essential for biotope networking and the guarantee of landscape functioning. This can be explained by taking into account the necessary minimal size of habitats of plants and animals (e.g. birds' hatching territories), as well as a minimal number of a species' population – this is of relevance for the landscape level - to guarantee existence and survival within a landscape. These minimum requirements vary naturally between habitats and species, and are dependent on many factors. This makes it difficult to give accurate data. However, there are now empirical records from large areas that provide a quantitative guide for the surface required for a net of functioning areas for habitat and biotope networking. These required amounts consist of: 10-30% surface of species-rich areas (acreage like farmland or grassland), 5% of landscape elements (including marginal areas of adjacent forests, lanes, water bodies), and 1 % of scarce cultural species (for the maintenance of the genetic diversity). More information on this can be found in the paragraph Innovation 1 of chapter 4.3.1 and the related references (Oppermann 2001, Oppermann et al. 2005).

Amongst these scientific statements about the diversity of ecosystems in arable farm areas, there is also an emotional aspect which should not be left aside: someone may have a favorite place or places within the farm where they like to spend time and feel comfortable. If a closer look at these places it appears that it is often the very diverse and less intensively used areas with a mixture of different structures and surfaces that are preferred. Further discussion and implications of this are found in chapter 6.1.

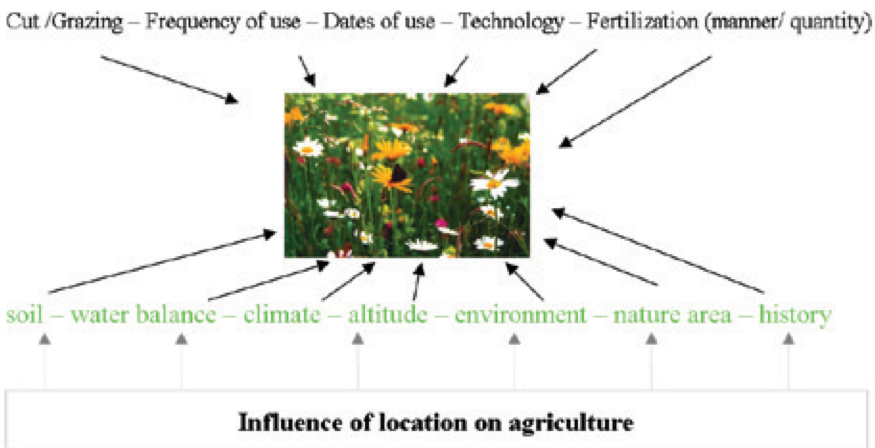

Fig 4.1(1): The way of agricultural use has a manifold influence on the characteristics of the vegetation and fauna.

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4.2. General cases

4.2.1. Examples from farms in temperate zones

Introduction

Many different types of farms can be found in temperate zones: pure arable farms (mainly on favorable farmland), pure grassland farms (in areas with high rainfall patterns, e.g. the Alps), mixed farms and of course a certain number of specialized businesses (e.g. wine, special crops etc.). In order to demonstrate the need for ecosystem diversity on a farm, the most appropriate type to consider is the mixed farm, as it usually consists of a coexistence of arable and grassland areas, and livestock plays an integral part. Nonetheless, most of the results and case studies mentioned here can also be adapted to arable and grassland farms.

For the promotion of ecosystem diversity of the entire farm, two innovations are described which complement each other. One is to systematically investigate the complexity of ecosystem diversity on a farm (ecological farm assessment) as well as to demonstrate the benefits and capacities for improvement with the help of a 'nature balance'. The second is an experimental approach which, after individual investigation, provides an understanding of the schemes that can promote biodiversity on all relevant types of areas and crops. With both approaches a lot can be achieved and initiated. Another element is the nature conservation plan, where biodiversity promoting schemes are precisely plotted on the farm.

Innovations

1) Application of an ecological farm assessment and a farm 'nature balance'.

2) Experimental implementation of biodiversity promoting methods in all operating areas and crop types.

Innovation 1

Application of an ecological farm assessment and a farm nature balance

Biodiversity (+)	Economy (-)
It shows the actual and the potential ecological benefit of the farms	Work time for the preparation 1-2(-5) days, possibility for using this as image promotion

Implementation

The 'Nature balance' is an environmental evaluation method for the positive demonstration of ecological benefits of farms, the presentation of potential improvements and for public relations. This method can be used by the farmer or an agricultural consultancy. The 'nature balance' consists of four elements:

- landscape structure (landscape elements and extensively used areas)
- diversity of species

- management/farmstead
- cultivation management

The first step is the recording of all those ecological benefits that are directly visible at the farm and on all its acreage (this generates the ecological farm assessment). The 'nature balance' is the evaluation of this data and it results from the appraisal of points (the conversion of the percentage of areas from the ecological assessment into points). By summing up the points, a value for each of the sectors mentioned above is arrived at as well as an overall total. For this procedure the target value lies at 100 points, with the maximum score of 140 points. Thus the 'nature balance' is a method which sets a clear target (100 points) and also allows comparison of farms. This technique shows ecological benefits using a scoring method, and equally can emphasize positively the outstanding ecological achievements of a farm and enable potential improvements to become clear. Using this approach and using available aerial views, the survey and the evaluation of an averaged size farm of approximately 100 hectares will take up to two working days. For the presentation of the results a table (ecological farm assessment), a written description (nature balance), and a bar chart are used.

Impact on biodiversity

At first, the ecological farm assessment and the nature balance present only an objective survey and evaluation of the given ecological situation of a farm. They do not have a direct influence on biodiversity. However, the aim of this assessment is to initiate and/or to support a good and stable 'nature balance' for different resources. This can be achieved through creating awareness of the ecological situation, through examining the different elements, and through a comparison with the 'values to be achieved', which are predetermined in the 'nature balance' assessment. The background to the evaluation framework of the 'nature balance' method, provides the assumption that with the achievement of the target impact on farm economy score (100 points) of all the farms within a landscape or in a country, abundant biodiversity is present and there are hardly any problems regarding the maintenance of it. Additionally, a balanced structure of natural, semi-natural, and extensively used areas adjacent to more intensively used farm areas exists. The 'nature balance' also considers specific attempts on the farm-stead as well as diverse individual steps that cannot be assessed area wide (e.g. the existence of breeding areas for swallows or a farm tree in the yard).

The 'nature balance' gives an ecological efficiency statement at the farm management level. The development of the ecological farm assessment and the 'nature balance' will cost 1-2 working days plus the added costs for the work of a landscape ecologist if this work has been contracted externally. However, the farm can profit from these expenses in a twofold way: firstly, the 'nature balance' provides a foundation for the integration of the farm into the landscape in a positive and landscape-ecological manner. This means the active consideration of the presented results and inclusion of their implications within the development of the farm (for example, creating a system of ecological compensation areas to enhance biological pest control). Secondly, the

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nature balance can be used for additional customer information and public relations within direct marketing. The economic consequence of this image and advertising effect cannot be quantified, but it can be of major importance especially for organic farms.

Case Study

In 2002, a cooperative was initiated from a Local Agenda 21 working group of ten farms in Gengenbach, Black Forest, (Fig. 4.2.1(2)). In this case, a specialist developed the ecological farm assessment and the 'nature balances'. The results of this work were discussed with the farmers and a certificate was provided. These results were of immediate value as many of the farms practice direct marketing. Furthermore, the results were presented within a discussion group. For some of the farms this was the first time that positive ecological aspects of their cultivation methods was realized; at the same time other farm owners announced interest and willingness for stronger future investment in those issues that concern nature. A quantification of these efforts has not been carried out yet.

Lessons learned

- With the application of an ecological farm assessment and the 'nature balance' method, positive features of a farm can be presented and used for public relations.
- At the same time potential improvements are shown and can be approached systematically in terms of an improvement of the 'nature balance'.

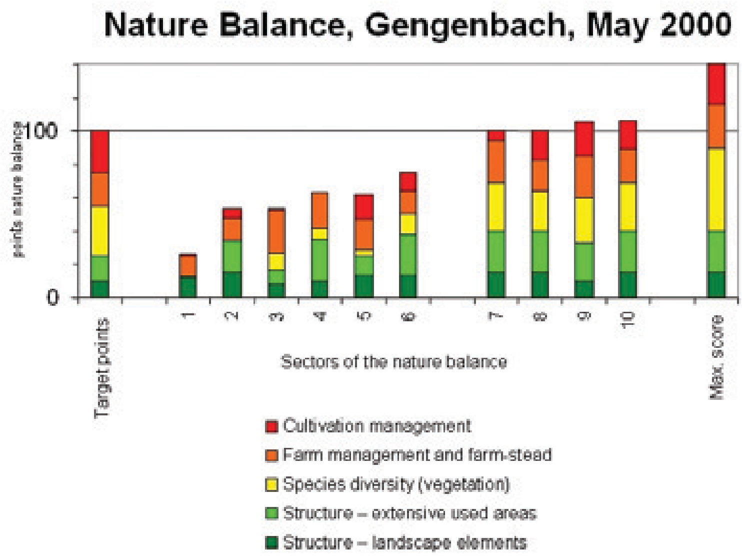

Fig. 4.2.1(1): On ten farms in Gengenbach nature balances were developed. Quite a few farms obtained relatively good results. The nature balance consists of the results from the four sectors: structure (landscape elements and extensively used areas), species diversity, farm management / farm stead and cultivation management. The target score (altogether 100 points) is shown on the left, the maximum score (140 points) on the right.

Fig. 4.2.1(2): Farm achievements in maintaining 'landscape diversity' are reflected by recording natural indicators within the farm's utilized agricultural area (uaa). In this example there are extensively used orchards with many other landscape elements in the foreground, and species rich meadows in the center and background; these different habitats contribute substantially to the good 'nature balance' values of the farms. The photo shows the landscape of Gengenbach (Kinzig-valley/black forest/south-west Germany).

Activity/Practical Demonstration

Several models for successful implementation of the 'nature balance' have proven value and can be tried:

- There can be exchanges between farmers and a landscape ecologist, who observes the environmental landscape, the fauna and flora of the environment as well as the ecological potential. This mutual exchange shares knowledge and through specific examples potential improvements are directly encouraged.
- A press release in a local newspaper which reports on the positive ecological benefits of a farm could be advantageous. This strengthens positive images of the agricultural community and the efforts being put into maintenance and improvements of the area's ecological needs.

Where several farms within a certain area employ an ecological farm assessment and a nature balance, group meetings and regular exchanges about the particular positive elements and the potential improvements are recommended. Farm holders learn from each other and hence the awareness of landscape ecological needs is commonly encouraged. Also, a mutual exchange and a network of contact persons should be established.

Recommended reading

- Bosshard, A.., R. Oppermann and Y. Reisner (2002): Vielfalt in die Landschaftsaufwertung! -Eine Ideen-Checkliste für Landwirtschaft und Landschaftsplanung. Naturschutz und Landschaftsplanung 34 (10): 300-308.
- Oppermann, R., (2001): Naturschutz mit der Landwirtschaft. Ökologischer Betriebsspiegel und Naturbilanz: Wie naturfreundlich ist mein Betrieb? – Stuttgart / Singen, 56 S.
- Oppermann, R., (2003): Nature balance scheme for farms -evaluation of the ecological situation. Agriculture, Ecosystems & Environment 98/1-3, pp 463-475.

- Oppermann, R., D. Braband and S. Haack (2005): Naturindikatoren für die landwirtschaftliche Praxis. - Berichte über Landwirtschaft 83: 76-102.

Innovation 2

Experimental implementation of biodiversity promoting methods in all operating area and crop types.

Biodiversity	Economy
Achievement of direct effects for biodiversity in all farm sectors	Development of operating methods that fit into the total farm management

Implementation

The application of biodiversity supporting methods in all farm management issues (i.e. on arable land, grassland, crop diversity and species diversity, landscape elements etc.) requires a high level of eagerness to experiment. At the same time, it provides an interesting opportunity or trial for the farm, not only in terms of ecosystem diversity but also with regard to economic optimization (e.g. low-input-systems).

Some farms were awarded with the 'Healthy Nature' farm award which was given in Germany in 2006. They showed exemplary achievements in nature conservation and at the same time demonstrated a solid economic structure.

Simple conservation measures practiced in Central Europe to increase ecosystem diversity of the whole farm include:

- Making piles of rocks or branches on pastoral land or meadows. These form important overwintering sites for insects, spiders, small mammals and reptiles and provide opportunities for wild bees and solitary wasps to nest.
- Nest boxes for birds are installed. Birds of prey are attracted if perches are erected.
- The arrangement of the farm and its buildings offers many opportunities to encourage wildlife. Optimizing the conditions required by swallows and other bird species and also bats, unsealing the surfacing on farmyards, creating diverse gardens and tolerating species rich flora on waste ground and track margins are some examples of how, through intentional development of the farm, its customers can be given an understanding of the concerns of organic farming with regard to the association between nature and agriculture.
- Increased ecosystem diversity can also be achieved e.g. through flowering strips, with crop mixtures and by ensuring the existence of some low-input -systems on the farm.

Impact on biodiversity

The specific effects on biodiversity will vary with site and farm, however, in general all approaches that encourage the toleration or the promotion of wild herbs, or the diversity of crop species on parts of the farm, have positive effects on the biodiversity of plants and animals.

Impact on farm economy

At first glance, and in comparison to conventional cultivation techniques (even in organic cultivation), such biodiversity promoting methods seem to bring disadvantages and damage to the economic results of the farm, especially, if parts of the areas are not harvested at the 'ideal moment' or not harvested at all. Under closer observation though, by reducing the frequency of intervention, the farm creates structures that are nearly natural and at the same time mean lesser workload; some areas might gain middle or long term stability. In order to evaluate if low-input-systems are economically more favorable than conventional cultivation, the cases of different farms have to be regarded separately.

Some farms also take short-term low percentage economic losses into account in order to realize a more balanced farm management concept for the middle and long-term.

Case study

The farm of Uwe Wuest in Koenigheim (South-West Germany) was one of the main award -winners in the competition for the 'Healthy Nature' farm award. On his 139 ha large mixed farm he managed to realize an impressive diversity of species and crops through numerous innovative approaches.

Farmland cultivation

- Cultivation of new forage-mixtures, e.g. gold-of-pleasure (*Camelina sativa*) and crown vetch (*Coronilla varia*).
- Leaving small parts of crops on the arable land (e.g. marginal strips or placing strips amid the fields): these strips stay over winter and serve as a refuge for animals and plants during summer, autumn and winter. The segetal flora can spread seeds and the farm tolerates these little losses in income.
- Cultivation of rare species and selective sowing of some segetal herbs together with the usual crops (e.g. corn-cockle - *Agrostemma githago*).

Grassland cultivation

- Harvesting of on-farm diverse grassland seeds with the combine harvester in order to extract meadow seeds for the establishment of new species-rich grassland.
- Leaving efflorescing and seed-bearing strips in the grassland during the cut.
- Cultivation of blooming field-fodder in order to create compensation areas at the time of the mowing of the meadows.

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Furthermore, many other methods were tested on this farm which cannot all be described here (e.g. tree fodder management to complement the livestock-feeding, free- ranging for pigs, cultivation of rare crops, testing of innovative machines etc.). For both, this explosion of innovative ideas and the enthusiasm shown by the farmer, who has also tried to transfer this to the diverse groups of visitors he receives, the farm won a major award for nature sound farms.

Lessons learned

- On every farm there are many different possibilities for the integration and promotion of biodiversity on the land and in the farm management.
- These can be carried out either through the introduction of established methods and/or through testing of innovative and experimental approaches.

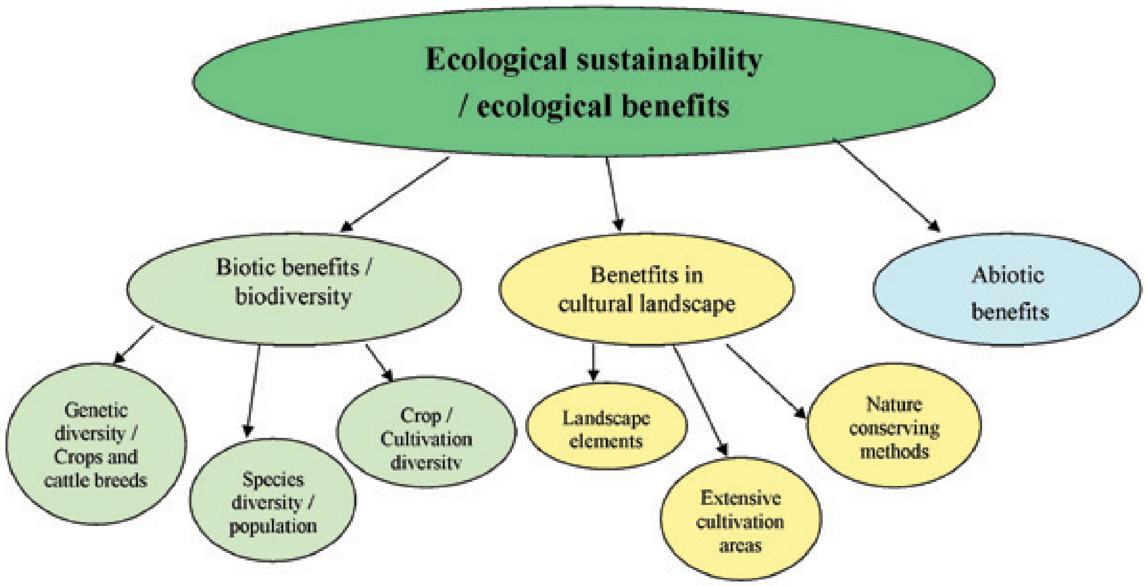

Fig 4.2.1(3): The ecological benefits of agriculture consist of achievements from three sectors: biotic, cultural-landscape and abiotic. For organic cultivation there are six key factors in which a farm can generate ecological benefits and possibly aim for improvements:
Genetic diversity with the choice of crops and animal races: usage of rare crops such as emmer wheat as grain and livestock husbandry of rare farm breeds contribute to good scores.
Species diversity and populations: the kind of utilization and management is responsible for the maintenance and creation of species diversity and habitats for increasing populations of wild species of plants and animals.
Methods for increasing diversity of cultivated areas: e.g. integration of wild flower strips or areas into fields.
Landscape elements: maintenance and improvement of structures, e.g. fringes along hedges and edges of forests.
Extensively used areas: creation of mosaic structures, e.g. with mowing mosaics of grassland and cultivating of bright acreages (reduced number of seeding rows) for grain cultivation
Nature-sound techniques: adoption of nature-sound machines, - e.g. mowing techniques in grassland and low weight machines.

Fig 4.2.1(4). The Wüst farm integrates wild flower strips into the farm concept and thus creates diversity (left) in the usually empty agricultural landscape (right).

Fig 4.2.1(5). Experimentation with 'colorful' crop-mixtures (here: gold of pleasure (camelina sativa) and crown-vetch (coronilla varia)) to create new habitats for insects and other animals (left). Open strips and acreages, which give space to wild growing and seeded herbs, are another way to integrate diversity into the cultivated area (right).

Activity/Practical Demonstration

An award for farm management that is good for natural systems and good for the farm, like that promoted in Germany in 2006, could also be offered on a regional level, and in other countries. At regional level different actors from the agriculture and conservation sectors (e.g. assemblies of farmers and conservationists) as well as from politics and public could be integrated (e.g. as members of the jury). Together with accompanying public relations from all media forms (printed media, radio, television, exhibitions etc.) the information will be carried out to a broader public. A good example is of a competition in Bavaria (see cited website below) and in some other places.

Recommended websites

- www.soel.de/projekte/naturschutzhoefe.html
- www.bund-naturschutz.de/fakten/landwirtschaft/wettbewerb.html

4.2.2. Examples from farms in tropical zones

Introduction

In many temperate zones of the world mans' transformation of habitats led to biodiversity loss as no compensation areas were created or the local biodiversity was not integrated into the agricultural system. Today loss of biodiversity is generally believed to destabilize supporting ecosystem processes, resulting in reduced crop production and a wide range of environmental problems.

In the tropics there is a high diversity of wild and domesticated plants, many of which are important to man. Wild fruits and vegetables, for example, contribute a significant proportion of the daily food intake of rural families serving as food security or a reserve that is especially important during periods of food shortage or adverse climatic conditions. Therefore, in many parts of Africa, India and China, most traditional farmers maintain small enclaves of natural vegetation in the farm that serves as a source of special foods and medicine. Croplands, however, are the main sources of food and livelihoods for the majority of rural communities. These are expanding rapidly as this is driven by socio-economic factors such as population pressure and its demand for land, food and water; increased demand for non-food crops in the internal local markets and low yields (Bolwig et al. 2004). As these croplands in the tropics are derived from natural vegetation such as grasslands, woodlands or tropical forests, compensation for or integration of the biodiversity into tropical agricultural cropping systems is important if biodiversity is to be maintained and lessons from many temperate zones are to be applied.

Here two innovations are mentioned to give examples of how biodiversity could be integrated into productive farms in the tropics.

Innovations

1 Maintain or integrate aspects of local and traditional farming practices into modern farming systems.

2 Grow different crops on the same farm/field (multiple cropping)

Innovation 1

Experimental implementation of biodiversity promoting methods in all operating area and crop types.

Biodiversity	Economy
Achievement of direct effects for biodiversity in all farm sectors	Development of operating methods that fit into the total farm management

Implementation

Local and traditional farming practices that combine different farming systems on the same farm are often multifunctional, not only providing food and maintaining livelihoods but also maintaining many different "ecosystems" for wild and domesticated biodiversity on a single farm. Some aspects of traditional farming practices in parts of Africa are as follows:

- Some patches or fields of natural vegetation on the farm or natural vegetation plot boundaries are never cultivated and completely left to nature.
- Different types of crops are simultaneously cultivated on the same piece of land (see innovation 2 of this section below)
- Fish is combined with vegetable farming if abundant running water is available. The integrated crop and fish farming system maximizes the use of the land and diverse resources. Fast-growing fish species are reared in small ponds that are bordered by a wide range of vegetable crops. The vegetables are used to feed the family, the fish and the small livestock on the farm.
- Multipurpose crops are grown. These are crops that can provide seeds or leaves for food, fuel wood and fodder for livestock. Local crops are best adapted to prevailing environmental conditions.

Impact on biodiversity

Farms with remnants of the original natural vegetation provide refuges and natural corridors for beneficial invertebrates, farmland birds and mammals and a high diversity of crop species grown is closely associated with high on-farm biological diversity.

Impact on farm economy

Patches or fields of natural habitat serve as sources of special traditional foods and medicine. Production of crops such as rice, vegetables, arrow root yams and legumes on the same piece of land increases food yield per hectare. Where water supply is regular, production of different crops and fish species can be maintained throughout the year. Farmers can therefore produce enough food for the family and the surplus is sold to generate financial income. The crops grown, especially vegetables and legumes are also used to prepare natural fish food and thus farmers avoid buying commercial food.

Case study

On many small scale farms in tropical Africa individual landowners grow crops and on the same land rear cattle and goats for production of meat, milk and skins or sheep, pigs, rabbits and poultry for the production of meat and eggs. Some farmers also keep horses, donkeys and oxen for animal power for various farm activities. In these systems the manure from the animals is used to improve soil fertility to improve crop production, while the crops residue and grass is used as fodder.

The traditional diversified farming approach improves soil fertility and maximizes land use, especially where family land is small. It also provides food security and helps immensely in the fight against rural poverty. Diversified farming therefore also improves conservation of farmland biological diversity because farmers can raise a wide range of crops and livestock. By using compost as the principal soil fertilizer and growing a wide range of food and fodder crops, this type of multifunctional farming stabilises and nurtures itself. It also ensures optimal utilization of plant foliage on the farm, especially wood and fodder. Therefore the traditional mixed rural farming systems have been widely adopted by urban farmers in East Africa and for that reason; urban agriculture is contributing significantly to better livelihoods and to national food production targets in the region, thus contributing to UN Millennium Development Goals (1 & 7).

In Kenya, India and Madagascar farmers have become major partners in research aimed at retrieving diminishing genetic diversity of cowpeas, pigeon peas, groundnuts, green grams and other leguminous annual crops. The participation of farmers in seed selection, field adaptation trials of nominated varieties and propagation of approved seeds is an innovative approach that promises success in recovery of traditionally used varieties and thus genetic resources.

Case study 2

Farmers in northern Uganda use traditional methods of pest control. A small black predatory ant, known locally as ngininginі, of the genus *Acantholepis* is effective against the usual crawling pests found on cotton. The farmers gather ants from existing colonies using grass or sweet potato vines left at colony sites, and transfer them to suitable new nest sites within the cotton field (under trees or banana plants)(Pule, 2008). Farmers also interplant the field with millet or other grains to bring in early aphids, which are attractive to the predators. As the ant does not fly, it is ineffective against cotton stainers, but for this, 'malakwang' or okra (both vegetables of the Hibiscus family) can be planted in places within the field slightly after the cotton to act as diversionary or trap crops. The addition of the ant-banana tree-Hibiscus vegetable system improves overall biodiversity and eco-system services. (van Elzakker, 2000)

Lessons learned

Good and reliable aspects of sustainable farming are often reflected in many traditional rural farming systems which have evolved over the generations. Integrating these aspects into modern farming systems often contributes significantly to better livelihoods and to national food production targets in the region more than intensified modern agriculture.

Recommended reading

- FAO (2002). Biodiversity and the ecosystem approach in Agriculture, forestry and fisheries. Proceedings of the Ninth Regular Session of Commission on Genetic Resources for food and agriculture. FAO. PP 312

- Nature's benefits in Kenya: An atlas of ecosystem and human well-being (2007). World Resource Institute, Washington and Nairobi. PP 148

Recommended websites

http://www.newfarm.org/international/index.shtml

Innovation 2

Grow different crops on the same farm/filed.

Biodiversity (+)	Economy (+)
Increases agro-biodiversity	Food security, diversified diet

Implementation

Multiple cropping involves the simultaneous cultivation of several crop types on the same farm. In Kenya, traditionally, legumes are grown as a cover crop amongst cereals, such as maize and sorghum. The cereals benefit from nitrogen fixed by bacteria lodged in the root nodules of leguminous plants, such as pigeon peas and beans. With this system better crop yields can be achieved since crop pollinators and predators of insect pests are supported, soil fertility is improved, and soil erosion is reduced. The competition effect of weeds is also reduced and nutrients are added through leaf fall by different types of crops grown together. Biomass produced by different crops can also be fed to livestock and therefore milk and meat production can be maintained on the farm.

The average number of crop varieties grown in single parcel or unit of land of known size is a good measure of agro-biodiversity, which in these cases is particularly high. High agro-biodiversity is closely linked to crop preferences or a management regime adopted by the farmer, and often reflects knowledge and awareness of ecological processes that support crop production.

Impact on biodiversity

Growing multiple crop species simultaneously or sequentially over the course of a single season contributes to agro-biodiversity and maintains ecological processes such as nutrient cycling as the system yields ample and diverse biomass.

Impact on farm economy

Cultivating many crop types at once is an adaptation by farmers to local climatic and socio-economic conditions. In the arid and semi-arid environments, it is a strategy adopted to minimize the risk of food shortage and to improve nutrition. In the humid and sub-humid areas of the tropics, multiple cropping is a strategy of diversifying diet and increasing income from the sale of different food crops and animal products.

Case Study

Studies on small holder mixed crop farms that use organic and inorganic fertilizers have shown that use of inorganic fertilizers and low crop plant diversity impacted negatively on the abundance and diversity of birds (Brenner 1991, Beecher et al 2002). High incidence of poly cropping and use of organic fertilizers for soil fertility improvement in both smallholder and large-scale farms has been associated with high levels on-farm biological diversity. The system of multiple cropping is increasingly being adopted by farmers, especially on small-scale farms due to direct benefits to the farmer and its indirect contribution to dynamic stability of tropical agro-ecosystems. In the central highlands of Kenya, for instance, farmers grow about eight different crop species at one time. In East Africa, multiple cropping is common practice in the Lake Victoria Basin; it is also seen among small-scale farmers in the tropical regions of Central and South America and southern Asia. Furthermore multiple cropping encourages farmers to select seeds of crops grown over generations and to establish seed banks. Community seed banks have made significant contributions to the conservation of crop genetic diversity in the tropics over time in countries like India, Madagascar, Eastern Kenya and Jordan.

Case Study 2

Organic cotton farmers in Tanzania integrate sun flowers on cotton plots for both oil seed production and as a trap crop for the American bollworm ***Helicoverpa armigera***, which is the most important cotton pest in the area. The bollworm moths prefer to lay their eggs on the sunflower reducing the attack on the cotton plants. Other natural enemies are also attracted to the sunflower, such as ants, which further reduce the eggs and small caterpillars of the bollworm. The balance can be so efficient that bollworms are reduced by 85% (van den Berg & Cock, 2000) and the sunflower production is hardly affected, thus providing good harvests of both crops. Traditional use of intercropping systems allows for both innovation and quick adoption of such solutions when pest problems are seen.

Lessons learned

Community seed banks are easy to adapt and manage, are sustainable and ensures seed diversity and security. Exchange of seed at local markets ensures availability of planting material.

Recommended reading

- Beecher, N. A., Johnson, R. J., Brandle, J. R., Case, R. M. & Young, L. J. (2002). Agro-ecology of birds in organic and non-organic farmland. Conservation Biology 16:1620- 1631.
- Bolwig, S. Mushabe, D., Nkuutu, D., Pomeroy, D.E & Tushabe, H. (2004). Biodiversity in Uganda's farming systems in relation to agricultural intensification, submitted to the IFPRI Strategic Criteria for Rural Investment in Productivity (SCRIP) program in Uganda, International Food Policy Research Institute, Washington D. C. & Makerere University Institute of Environment and Natural Resources, Kampala.

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- Brookfield, H., Padoch, C., Parsons, H. and Stocking, M. (eds) (2002) Cultivating Biodiversity: Understanding , Analysing & Using Agricultural Diversity. The United Nations University, ITDG Publishing, London. Chapters 14,15, and 16
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Activity/Practical demonstration

A farm map is a useful tool for intentionally planning to use the synergies coming from interplanting and trap crops.

The whole farm should be mapped and the natural resources and current crops and livestock indicated. Local knowledge on the benefits of specific crop interplanting or proximity to natural resources, (such as the presence of frogs and dragonflies from water bodies) can be listed. Gaps in the system or particular pest problems can be identified and the appropriate plans drawn up for the following season.

4.3. Special cases

4.3.1. Examples from relay- and intercropping cropping systems

Introduction

Sustainable agriculture seeks to use nature as the model for system design. Since nature consistently integrates the plants and animals into a diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity. When early humans replaced hunting and gathering of food with domestication of crops and animals, the landscape changed accordingly. Since the industrialization of agriculture, humankind has greatly reduced biological diversity by using a limited selection of crop plants and animals. Annual crop monoculture represents a typical example. In response to this man-made biological simplification, nature has struggled to restore diversity. The occurrence of weeds and pests, for example, can be seen as an effort of nature to restore the biodiversity in a monoculture. However, farmers often continue to manipulate nature towards less diversity by using chemicals to kill insects and weeds without taking into account that these occur because they make nature lose diversity, and that continued loss of diversity will ultimately lead to environmental situations which are problematic

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for humans. Therefore, man should realize the benefits of diversity and act accordingly, for example, by planting mixtures of different crops or intercropping with green manure and non-crop plants. There is much more co-operation than competition among species in nature. There exist mutually beneficial relationships between species within a community. Inter and relay cropping systems are examples which build upon these benefits in order to produce healthy crops and to improve the productivity per unit of land. Clever intercropping can reduce the ability of the pest insects to recognize their host plants. Thrips and white flies, for example, are attracted to green plants with a brown soil background, ignoring the vegetation-covered or mulched areas. Also, as some insects recognize their host plants by smell, so intercropping onions into carrots can mask the smell of carrots from carrot flies. It was even documented that, in field conditions, the tomato smell in systems where cabbages are intercropped with tomato prevents butterflies from laying their eggs on the cabbage. The potential of relay and intercropping systems is shown by the following innovations:

Innovations

1 Relay-cropping tomato into leafy brassica

2 Intercropping with tomato into turfgrass

3 Cabbage intercropped into crimson clover that is attractive to ladybirds and favors other predators such as frogs.

4 Biodiversity enrichment for pests control in soil-based greenhouses by mulching plant residues along the walls.

Fig. 4.3.1(1). Left: a tomato seedling relay intercropped into a garlic field. Right: green onions relay intercropped into a tomato field after garlic was harvested.

Innovation 1

Tomato relay-cropped into leafy brassica

Biodiversity (++)	Economy (+)
Intergrateted organic pest management	Tomatoes are less infected by phytophthora and other leaf blights.

Implementation

Relay-cropping tomato into a leafy brassica for pest control was successfully practiced in the Natural Farming Research Centre in Hata, Japan according to the following set-up:

- In a soil-based greenhouse four rows of leafy brassica were grown in a ridged bed 100 cm wide and two rows of tomato seedlings were transplanted into the leafy brassica two weeks before the leafy vegetable was harvested.
- Seedlings were large enough to compete for the space and light in the canopy of leafy brassica. If the seedlings are small, the brassica will shade the tomato seedlings and they will be too weak to compete in the mixed canopy.
- Enough soil fertility was ensured before the sowing of brassica leafy vegetable. Dressing fertilization was and should be avoided because it can cause leaf blight infections.

Impact on biodiversity

Tomato is susceptible to many diseases and prone to aphid infections if the nitrogen nutrition is in excess at the seedling or vegetative growth stage. However, the growth will not be good enough to reach an expected fruit yield if sufficient fertilization is not ensured. Relay-intercropping of tomato into leafy brassica can improve the biodiversity of the field and also avoid the excessive supply of nitrogen to tomato seedlings.

Impact on farm economy

Initially tomato plants relay-intercropped into brassica will not grow as well (leaves in yellowish green color) as those in chemical farming systems. However, at the later stages, the intercropped tomato plants will be less infected by leaf blights and produce more fruit. Data on this system shows that nitrate and amino acids are in lower concentrations compared with those in usual plants without intercropping. This suggests that relay-intercropping can adjust the supply of nitrogen from the soil to the crops. When a brassica leafy vegetable is sown before greenhouse tomato seedlings are transplanted, the leafy vegetables absorb the mineralized nitrogen when the young tomato seedlings do not need so much of it. Therefore, the nitrogen metabolism is smooth and makes the tomato crop healthy. As a consequence, the tomato plants are less infected by leaf blight and yield more fruit at the later growth. Fruit yield and quality of tomato relay-intercropped into leafy brassica are both improved because excessive nitrogen and leaf blights are avoided. In addition to the yield increase and quality improvement in tomato fruit, the leafy brassica is harvested with a similar normal yield as would be obtained without intercropping.

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Case study

A garlic-tomato-green onion relay-intercropping experimental system was set up under greenhouse conditions in Japan. Here winter crop garlic was planted in October. Tomato seedlings were relay-transplanted into the garlic crop at the beginning of May, about one month before the garlic was harvested. Seedlings of Green onion were relay-transplanted along both sides of the tomato rows. Also here results showed that crop diversity lowered the risk of leaf blights and consequently can increase the farm income.

Lessons learned

- Mixed cropping systems are less susceptible to pest and disease.
- Relay and intercropping systems with tomato and brassica or tomato and garlic and green onion showed that there can be biodiversity and economic benefits from employing mixed cropping systems.

Innovation 2

Tomato intercropped into turfgrass

Biodiversity (++)	Economy (+)
Intergrateted organic pest management	Tomatoes are less infected by phytophthora and other leaf blights

Implementation

Tomato intercropped into turf is practiced in the farming Research centre in Hata under the following conditions:

- Seeds of Kentucky blue grass (*Poa pratensis*) are sown in fall (autumn) and mown into a normal turf the following spring. At the beginning/middle of spring, a band 30 cm wide is cleared for tomato transplanting by turning the turf upside down into the soil.
- The green left is 90 cm wide and enough for the mower pass through. A bio-fertilizer (fine organic materials such as oil mill sludge, rice bran and fish meal are mixed and fermented using EM, a microbial inoculant, as starter) is applied at 200 g/m^2 on the total land basis.
- The grass residues mown off the turf are used for mulch on the soil surface in the cleared band where tomato plants are grown.
- No soil is left bare in any of the field and the tomato leaves never touch the soil even after a heavy rain, so that the plants are protected from being infected by the soil-borne pathogens. The turf is mown frequently and used as animal forage and other purposes. Because tomato is much taller than turf grass and the turf is mown short, there is no space and light competitive impact on tomato plants.

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Impact on biodiversity

Because turf grass grows between the tomato plants, and the naked soil is also mulched with grass residues mown off the turf, biodiversity is improved. Frogs, spiders and other animals and insects thrive in the field and earthworms in the soil. Mycorrhizae colonize the grass root with high density and the density is also much higher than in roots of tomato plants without turf intercropping. Turf grass adapts to hot and cold weather and the roots are alive with high activity throughout the year, mutually benefiting from mycorrhizae and other rhizosphere micro-organisms. Therefore, the mycorrhizae, active throughout the year, maintain a high soil biodiversity and suppress the pathogenic micro-organisms. Tomato intercropped into turf grass should be healthy as several diseases are avoided or suppressed by the biodiversity of the soil and rhizosphere systems.

Impact of farm economy

Tomato plants intercropped into turf showed high fruit yield because leaf blight is avoided. More investment for the turf mower is needed but a benefit is derived from the harvested grass, which can be used as animal forage. The total economy income should be higher than normal.

Case study

In an experimental field, tomato, intercropped with a turf grass, Kentucky blue grass (*Poa pratensis*), either in strips near each other or in mixed plantings, showed high resistance to *Phytophthora* and other leaf blights. The tomato fruit yield was significantly higher in the turf grass intercropping plots than that in controls. Although soil nutrient conditions were also improved, the disease avoidance might be the critical factor for the high fruit yield in the grass intercropping plots. The infection by leaf blight (*Alternaria solani* and *Fusarium oxysporum f.sp. licopersici* race 2) was much less severe in the intercropped tomato plants than in the control plot. This study demonstrated that the permanent turf grass root system colonized with mycorrhizae results in a living soil and improves soil conditions. This avoids tomato plant infection by soil-borne pathogens.

Lessons learned

A proper fertilization rate and a sustainable organic fertilizer are necessary for the tomato plants intercropped into turf grass.

Fig. 4.3.1(2). Tomato intercropped with turfgrass

Innovation 3

Cabbage intercropped into crimson clover that is attractive to ladybirds and favours other predators such as frogs.

Biodiversity (++)	Economy (-)
Crimson clover intercropped into cabbage can attract and supply with suitable living environment for ladybirds and frogs	Buffer the soil nitrogen nutrition, and consequently effective in controlling pest insects and diseases

Implementation

The following measures were taken to establish a cabbage-clover intercropping system in the farming research centre in Hata, Japan:

- Crimson clover (*Trifolium incarnatum L.*) was sown in two parallel rows as a band with inter-row space of 25 cm, and a 60 cm space for cabbage transplanting was left between the two clover bands.
- When the red clover was established, cabbages were transplanted with an inter-plant space of 30 cm.
- The soil was fertilized with a bio-fertilizer (oil mill sludge, rice bran and fish meal as materials and fermented with a microbial inoculant called EM as the starter) at a rate of 8 g N/m^2.

Impact on biodiversity

Crimson clover is usually used as a forage crop or intercropped into orchards or turf grass as a cover plant. Recently, crimson clover has been used as a cover crop in crop fields specifically to conserve field biodiversity. The flowers of crimson clover are attractive to or harbor bees and other beneficial insects and animals, especially the minute pirate bug (*Orius tristicolor*) that preys on various agricultural pests and ladybeetles that prey on aphids. Frogs also thrive in the canopy of crimson clover. Soil arthropods are more diverse in the intercropping fields than in the clean-tilled fields.

Impact on farm economy

In addition to the improvement in biodiversity, crimson clover improves soil nitrogen (N) nutrition with a yield of about 50 kg N/ha from the above-ground biomass and additional N release into the soil.

Example/Case study

Bugg et al. (1990) has also reported that convergent lady beetle (*Hippodamia convergens*) and seven-spotted lady beetle (*Coccinella septempunctata*) are found in substantial numbers in the canopy of crimson clover. Crimson clover is more tolerant of root knot nematode *Meloidogyne spp*. than are red, white, or arrowleaf clovers and is a good host for *Meloidogyne hapla* and other *Meloidogyne spp*. It is reported by Tillman et al. (2004) that densities of the predatory bug Geocoris punctipes and lady beetles are high in cotton fields previously planted with crimson

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clover. Intercropping cotton in live strips of cover crop was probably responsible for the relay of *G. punctipes* onto cotton in these crimson clover fields. Density of *Orius insidiosus* was not significantly different between cover crop and control cotton fields. Lady beetles seemed to relay from cover crops into cotton. Conservation of the habitat of fire ants during planting was probably responsible for the higher density of red fire ants observed in all conservation tillage cotton fields relative to control cotton fields. Reduction in the number of times in which economic thresholds for *heliothines* (Noctuid moth pests) were exceeded in crimson clover and rye compared with control fields indicated that the buildup of predaceous fire ants and *G. punctipes* in these cover crops subsequently resulted in reduction in the level of *heliothines* in conservation tillage cotton with these cover crops, compared with conventional tillage cotton without cover crops. Crimson clover is also resistant to viral diseases and tolerant of weeds. As shown in the picture, any other kinds of weeds or plants are suppressed by the canopy of the crimson clover.

Analyses of the crimson clover-cabbage intercropping system showed that the clover helps absorb Nitrogen (N) at the early growing stage of the cabbage and so avoids excess in N in the soil, and may also release N into the soil or transfer N to cabbage through *mycorrhizae* or root nodules. Therefore, crimson clover buffers the N nutrition in the soil and avoids diseases related with N excess. Other research has also found that N is transferred from crimson clover to intercropped cereals. In terms of total N content, crimson clover tended to be superior to other leguminous cover crops due to its large dry matter production. The mean N content of crimson clover was significantly greater than that of subterranean clover and common vetch. Soil organic carbon and organic nitrogen concentrations are increased in no-till crimson clover winter cover crop plots, as reported by Hargrove (1982).

Lessons learned

Intercropping crops such as cabbage with crimson clover has been shown to be an effective pest control measure.

Fig. 4.3.3(3). Cabbage intercropped with crimson clover.

Innovation 4

Biodiversity enrichment for pests control in soil-based greenhouses by mulching plant residuals along the walls.

Biodiversity (++)	Economy (-)
Provide a habitat for a range of fauna.	Spiders and beneficial ground beetles thrives in the organic materials in winter and early spring and acts as predators of the pest insects in the spring when leafy vegetables are established

Implementation

In IPM programs in conventional agriculture, pesticide treatments are made only when and where monitoring has indicated that the pest will cause unacceptable economic, medical, or aesthetic damage. Treatments are chosen and timed to be most effective and least-hazardous to non-target organisms and the general environment. However, no chemical pesticide is allowed in organic agriculture. One of pest control measures in organic agriculture is to enrich populations of natural enemies to pest insects. The process of finding and introducing natural enemies from their places of origin is a challenge. The introduced pest predator or parasite must undergo exhaustive testing before being released to be sure it will not harm non-target organisms. Failure can also be related to problems such as climate differences, prior pesticide use, disturbance of the habitat by other agricultural operations, and the removal of weeds that might otherwise offer food and shelter to the natural enemies. The following was done to introduce natural enemies to a soil based greenhouse at a farming research centre in Hata, Japan:

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- Organic materials such as crop residues, hay, twigs and rotten wood were piled in heaps up to 50 cm high and 50 cm wide, along the walls of the soil-based greenhouse where Brassica vegetables were grown, in order to encourage predators or "organic pest control" such as spiders (*Lycosa pseudoannulata*), frogs (*Hyla arborea japonica*) and Carabidae beetles (*Anthia spp.*).

Impact on biodiversity

In this approach pest numbers were kept low enough to prevent unacceptable damage or annoyance. As they are not eliminated a balance of organisms occurs, increasing overall biodiversity.

Impact on farm economy

Intercropping with attractive plants, nectar-producing plants and alternate host plants in and around fields, and intercropping different crops to provide habitat diversity are all management techniques that lead to the build-up of natural enemy populations and result in enhanced biological control of pests in organic crop production (Nentwig, 1988; Nentwig et al., 2000).

Lessons learned

- H. L. Xu and his colleagues have tried experiments over several years aimed at raising predators in waste organic materials placed along the walls of soil based greenhouses
- One year, spiders and beetles throve in winter time before the leafy brassica had not been established. When the leafy vegetable is established and pest insects appeared in the leafy vegetable field, the population peak of the predators disappeared.
- Maintenance of a sustainable population should be ensured for the predator. The dynamic changes in predator population should be observed so that action can be taken if needed.

Fig. 4.3.1(3). Organic materials placed along the walls of a greenhouse (left) where a brassica leafy vegetable is being grown.

Fig. 4.3.1(4). Natural enemies thriving in brassica plots (left: a spider (lycosa pseudoannulata) is fighting a green worm (autographa nigrisigna walker); right: two frogs patrolling on a brassica plant.

Case study

Method

A brassica leafy vegetable (*Brasscica campestris L. cv. Seitei*) were sown in an Andosol in polyethylene greenhouses at the end of April. Each greenhouse was separated in the middle with a net spreading from the roof to the soil surface. The conditions were kept the same in both compartments of the greenhouse. Along the walls of one part of the greenhouse, organic materials such as crop residues, hays, twigs and rotten wood were placed and piled up to 50 cm high and 50 cm wide, where predators such as spiders (*Lycosa pseudoannulata* (BOESENBERG and STRAND)), frogs (*Hyla arborea japonica Gunther*) and Carabidae beetles (*Anthia spp*.) were expected to thrive. As the control plot, in the other compartment of the greenhouse, a black polyethylene sheet was mulched onto the soil surface along the walls. In each part of the greenhouse, plots were separated as chemical fertilization and organic fertilization treatments. As treatment replications, three identical greenhouses were used for this experiment. The applied organic fertilizer is a bio-fertilizer anaerobically fermented using organic materials such as rice bran, oil mill sludge, and fish meal in the proportions of 3:2:1 in a closed container. A microbial material, which mainly contains lactic acid bacteria, yeast and photosynthetic bacteria, was inoculated to the organic materials before fermentation. The concentration of N, P and K of this organic fertilizer was 51, 18 and 19 g m-2, respectively. This organic fertilizer was applied at a rate of 300 g m-2. A compound chemical fertilizer (N-P-K: 15:15:15) was applied in the chemical fertilizer plots. Since it was considered that 30% of N in the organic fertilizer could not be used the present cropping season, in the chemical fertilization plots, the quantity of chemical fertilizer was applied with the total nitrogen equivalent to 70% of the total nitrogen in the organic fertilizer applied to the organic fertilization plots. The brassica leafy vegetables were harvested by thinning four times at an interval of 5 days from 45 days after sowing. Populations of pest insects and predators were examined before the third harvest.

Results and evaluation

Populations of natural predators, spiders (*Lycosa pseudoannulata* (BOESENBERG and STRAND)) and Carabidae beetles (*Anthia spp.*) were enriched by placing organic materials along the walls of a soil-based greenhouse. These two groups of predators thrived from the early spring in the mulched organic materials, where they preyed upon the insects in the decomposing organic materials before the insects in the field plots reached dense populations. The frog (*Hyla arborea japonica Gunther*) and parasitic bee (*Eretmocerus nr. Californicus*) populations were not affected by the mulching treatment because their origin was unrelated to the piled up organic materials. The spider population was higher in the organic fertilization plot than in chemical plot ($P \leq 0.05$). This might be attributed to more soil fauna in the organic fertilized plots as indicated by other research. Populations of frog and parasite bee were slightly higher ($P \leq 0.05$) in chemical fertilization plot than in organic fertilization plots. This might be related to populations of prey species pest insects, which were higher ($P \leq 0.01$) in chemical fertilization plots. Populations of all pest insects, including leaf miner (*Phytomyza nigricornis*), aphid (*Brevicoryne brassicae*) and semi looper (*Autographa nigrisigna Walker*), were lower in organic mulched plots than in cleaned plots. Results suggested that the practice of placing organic materials along the walls of a soil-based greenhouse to preserve natural predators effectively controlled pest insects of brassica leafy vegetables. Populations of pest insects were also lower in organic fertilization plots than in chemical fertilization plots. Similar observations were reported for other crops.

The spiders prey on the insects in the decomposed organic materials such as crop residues before the insects reach dense populations. This practice effectively controlled insects of brassica leafy vegetables in the greenhouse. Many practices similar to this one have been attempted using land margin spaces to enrich biodiversity and rear natural enemies (Baines et al., 1998; Sotherton, 1984).

Recommended reading

- Bajwa W.I. and Kogan M. (1996). Compendium of IPM Definitions (Electronic database), Corvallis, Oregon, USA, Integrated Plant Protection Center.
- Tillman G, Schomberg H, Phatak S, Mullinix B, Lachnicht S, Timper P and Olson D. (2004). Influence of Cover Crops on Insect Pests and Predators in Conservation Tillage Cotton. Journal of Economic Entomology: Vol. 97, No. 4 pp. 1217–1232.
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4.3.2. Examples from mutualism between paddy rice and duck or fish husbandries

Introduction

The Green Revolution in Asia has increased food yields through intensive mono-cropping and use of inorganic fertilizers, pesticides and herbicides. However, steady increases in the use of chemical fertilizers are now causing environmental pollution and income declines. Therefore, farmers need to develop alternative farming systems that prove sustainable and environmentally

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sound. Rice-duck and rice-fish mutualisms are unique traditional agriculture systems, practiced and improved for thousands years in China and other Asian countries. Rice-duck or rice-fish systems require no herbicides or insecticides. Ducks and fish in rice fields consume weeds, insects, mosquito larvae, and snails. Rice plants get fertilized by droppings, soil is improved and methane emission is reduced by their activities. The two components (rice and ducks or fish) can really benefit from each other in the integrated systems. These systems lead to the maximum utilization of resources and the promotion of health of both the agro-ecosystem and the entire environment. Here the history and the successful practices of mutualism between rice and duck and between rice and fish husbandries are reviewed and the positive and negative impacts of the mutualism systems on biodiversity and environment are discussed.

Innovations

1 Rice-duck mutualism – a method of rice farming that relies on ducks to eat insects and weeds and it is so-called *aigamo* paddy farming in Japan.

2 Rice-fish mutualism - a unique traditional agriculture practice that efficiently uses the space and natural resources to raise fishes in paddy field with mutual benefits from each other.

Innovation 1

Rice-duck mutualism

Biodiversity (++)	Economy (++)
Weed and pest controls, prevention of global warming by reducing methane emission, organic fertilization and soil improvement.	increases in economic income

Implementation

This is a method of rice farming that relies on ducks to eat insects and weeds, and is called *aigamo* paddy farming in Japan. The *aigamo* is a crossbreed of *kamo* (wild duck) and *ahiru* (domestic duck) (Asano et al., 1999). Because *kamo* is migratory, it was believed that using *ahiru* would be better for agriculture. According to some experts, though, *aigamo* have come to be used because they produce a large amount of tasty meat and are easier to obtain than *ahiru*. The *aigamo* method of growing rice involves the following:

- Releasing two-week-old *aigamo* ducklings into a rice paddy about one or two weeks after the seedlings have been planted.
- About 200 of birds are needed for one ha of farmland.
- A shelter is needed where the ducklings can rest and take refuge from rain.
- The field is usually surrounded by net fences to protect ducks from dogs, cats, weasels, and crows.

Impact on biodiversity

There are 4 major ways in which biodiversity benefits from rice-duck mutualism

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1) Weed and Pest Controls.

The ducks help the rice plants grow by eating both insects and weeds in the paddy fields. Other pest and weed controls are not needed; in fact total weed biomass is controlled in aigamo plots better than in plots applied with an agrochemical. It was observed by Cagauan (1997) from on-station research in the Philippines that the total weed biomass in the paddy field was reduced by ducks at rates ranging from 52% to 58 %. The mechanism of weed control by ducks is direct consumption of plant parts and seeds, and disturbance of weed germination and growth through the feeding activities. In Japan it was seen that the hoppers in rice paddy fields were depressed by *aigamo* during the early growth stage of rice. In the Philippines, ducks have effectively controlled the herbivorous golden apple snail. According to Liu et al. (2004), releasing about 250 ducklings with body weights of 150 g into one ha of rice paddy reduced sheath blight by 56.0% and the disease control effect was even higher than applications of antibiotics. Wang et al. (2005) reported that rice-duck mutualism suppressed weeds by 99.4%, reduced pest insects and diseases, increased soil nutrition and dissolved oxygen, and consequently improved the rice yield and quality. Releasing 300-450 ducklings with 200 ~ 400 g body weight postponed the incidence peak of rice borer *Chilo suppressalis* larva for 9 - 14 days and reduced the second generation of larvae by 53.2-76.8% and the third generation by 62.2%.

2) Fertilization and Soil Improvement

The ducks' droppings become an important source of natural fertilizer. In addition, the ducks stir up the soil in the rice paddy fields with their feet and bills, disturb the weed seeds preventing germination, increase the oxygen concentration in the soil, and make the soil more nutritious for the seedlings. Furuno (1996) observed on his farm that movements and feeding activities of ducks in the paddy fields disturbed the soil, resulting in improvement of soil physical property and consequently better rice root systems and enhanced tillering. Yu et al. (2004) reported that the rice-duck system improved paddy rice canopy with fewer non-productive tillers, improved canopy light transmittance, increased green leaf area and chlorophyll content, enhanced root activity and leaf photosynthetic capacity, consequently resulting in a 5% yield increase.

3) Improvements in Biodiversity and Natural Harmony

It is said that practices similar to *aigamo* paddy farming have been used in Japan for 500 years. However, much modern agriculture looks at a single answer to a specific problem, a very analytical approach that can destroy the parts of the ecosystem with rice, weeds and insects, ducks and fishes as its components. Originally, the duck or *kamo* was also a component of the system. The inhabitants of the paddy field are not only the ducks. The duckweed, an aquatic fern (*Azolla*), which harbors a blue-green bacterium as symbiont, is also grown on the surface of the water. The *Azolla* is very efficient in fixing nitrogen, attracting insects for the ducks and feeding ducks by itself. The plant is very prolific and grows fast so that it can be harvested for cattle-feed as well. In addition, the plants spread out to cover the surface of the water, providing hiding places for another inhabitant, the roach. The roach grows well in the paddy fields and feeds on duck feces, *daphnia* and worms, which in turn feed on the plankton. The fish and ducks provide

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manure to fertilize the rice plants. The rice plants in turn provide shelter for the ducks. It is very interesting that the "stimulation effect" of duck activities around the young rice plants leads to stockier rice stems and actually changes the way the rice grows. Before the ***aigamo*** technology was adopted by thousands of farmers throughout Japan and eastern Asia, any Japanese farmer who used to watch wild ducks floating on his paddy fields and consuming weeds and pests might imagine that a similar system would be successful on paddy farms. Nature is able to live with itself. These animals and plants including ducks, fishes, insects, weeds and rice plants can live in harmony and nature gives them the power to interact and live together. This principle should be brought back into agriculture.

4) Prevention of Global Warming by Reducing Methane Emission

Methane contributes about 19% of the greenhouse effect and CO_2 about 64%. However, on unit volume basis, methane contributes to greenhouse effect by a factor of 20 to 25 over CO_2. Rice paddies release 12% of all methane to the atmosphere. Without a doubt, controlling methane from rice paddies is of great importance in slowing the greenhouse effect. It is interesting that ducks can do the job. Theoretically, in a rice paddy, methane is mainly produced by methanogens (microorganisms) that consume hydrogen and acetic acid in the paddy soil, where ferric iron (Fe III) is constantly changed to ferrous iron (Fe II) by Fe III-reducing micro-organisms, or so-called iron reducers, which also consume hydrogen and acetic acid in the process of conversion. The consumption of iron reducers is faster than that of methanogens. Therefore, as long as Fe III is provided regularly, development of methane is controlled. Once the Fe II moves into water from the soil, it is oxidized to Fe III. Fe III goes back to the soil and everything starts over again. The Fe II is stuck in the soil and spreads in the water very slowly. Morii and his team set up a small experimental environment similar to a rice paddy at a lab, mixing up the water for different periods of time in order to help promote Fe II that is stuck in the soil in the water. As a result, when the water was mixed for two hours, the development of methane was controlled over the following 24 hours. When mixed for 7.5 hours, it was controlled for the next three days. Morii was confident of his theory and experimental laboratory work, but concerned with how his experimental work could be applied to rice paddies outside a lab. From a local TV news program reporting on duck-rice farming, he discovered that the ducks could do the job. The constant paddling of the ducks in the paddy fields, helps to spread Fe II stuck in the soil and promotes the cycle from Fe III to Fe II and back to Fe III. Later on, Morii conducted experiments in paddy fields in cooperation with Furuno, a well known innovative aigami rice farmer. Morii established a control area surrounded by a 25 cm-height iron frame, which prevented water in the control area from being contaminated by muddy water. A net was attached to keep the area free from ducks. One month later, concentrations of Fe III in the water and soil in both plots were measured and it was found that the Fe III concentration in water was 267 times higher in the plot with the ducks than in the control, while the Fe III concentration in soil in the duck plot was only 9% of that in the control plot. Since iron reduction in the process of change from Fe III to Fe II is much faster than the fall of soil particles including Fe III in the muddy water down to the soil, the amount of Fe III in the soil may not increase as it does in water. Therefore, it is

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suggested that ducks in the rice paddy suppress the release of methane from the rice field. In recent years, similar active experiments have also been conducted in China. Gan et al. (2003) reported that methane emission was much lower, the dissolved oxygen concentration in rice-duck paddy fields was 38.4-44.7% higher, the soil redox potential was 11 and 18 mV higher, and the concentration of reduced matters such as Fe II was higher in rice-duck paddy fields than in the control fields. Similar results were obtained in other repeated experiments. By using anaerobic incubator technology, Deng et al. (2004) found that the rice-duck complex remarkably reduced the methanogens in the rice paddy soil and especially reduced the methane emission at rice heading stage which is the peak time of methane emission.

Impact on farm economy

In the 1940s many Japanese farmers released ducks into their paddy fields, as agricultural machinery was much less available at that time. However, the main reason for ducks to be used today is to optimize rice cultivation and produce rice of high quality, while in the past, the main reason was reducing costs and labor. ***Aigamo*** farmers do not only benefit from rice, they also get a profit from ducks at the same time in the same field. By combining two completely different things farmers can come up with wonderful results. The rice, duck meat, and other items, such as duck eggs and fish are available to contracted families through a ***Teikei*** system (a direct selling system from farmers to consumers). When the time comes to harvest the rice in the fall (autumn), the ducks have grown fat and can be sold for meat. Farmers can grow rice and produce duck meat and this suggests that the ***aigamo*** method really does kill two birds with one stone!

Aigamo paddy farming allows for the production of healthy and delicious rice while relying on less labor and external inputs than conventional methods. In Asian countries, people are also aware of the overuse of chemical fertilizers and pesticides and associated risks. The reported improved rice grain yield from duck raising in paddy fields can be attributed to the benefits previously discussed. Higher grain yield together with reduced costs due to less weeding, and no spraying and fertilizing contribute to the economic benefits derived from rice-duck farming. In South Korea, the increase in income derived from rice-duck farming ranged from 73-77 % compared to conventional rice farming.

Duck raising in paddy fields leads on to organic farming which has not only the benefits of reducing costs of fertilizers, pesticide and labor, but additionally 'organic rice' has a higher price than conventional rice in Asian countries. ***Aigamo*** organic rice has better agronomic characteristics and yield and better weed control than in other organic rice production. The profit of rice-duck system was twice to several times higher than those of other weed control systems. Data from Japan suggests that, compared with conventional rice production, the higher profit of the rice-duck system is attributed to both the income from duck meat selling and the higher price of organic rice. Furthermore, combined with organic fertilization, rice grown with ***aigamo*** method is more resistant to typhoons, lower temperatures and other adverse environmental problems.

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Lessons learned

Limitations and disadvantages to the duck-rice systems also exist. Even though the paddy field is managed organically, ducks can be affected by pesticides applied from neighboring farms, particularly when water comes from communal irrigation canals. The use of agro-chemicals in modern rice farming is threatening the traditional rice-duck farming. As observed by Manda (1996), there is a rapid decline in traditional rice-duck farming in Southeast and East Asia due to the introduction of herbicides, other pesticides and chemical fertilizers that result in environmental pollution and health hazards. Ducks can either also be stolen away or killed in the fields by outside animals if paddy fields are not fenced. The fencing cost is high in some Asian countries.

For ecological aspects, it is observed that ducks do not only eat harmful animals but also friendly ones, such as frogs. It is reported that ducks in paddy fields are also related to some health problems for farmers, such as dermatitis and adult flukes. Farmers should protect their feet with boots or medical cream when they get into a paddy field containing ducks.

Although there are some limitations to the rice-duck paddy farming, the systems can benefit farmers. Rice-duck farming can also be integrated with fish and the nitrogen-fixing aquatic fern *Azolla*, resulting in higher productivity. Nutrient recycling in an integrated rice-fish-*Azolla*-duck farming system is better and more efficient than rice-duck or rice-fish farming systems. The duck manure serves as an organic fertilizer for plankton production while the spilled feed can be directly consumed by the fish. Nutrients from the fish pond refuge may be dispersed to the paddy fields by irrigation water or by the movement of fish and ducks. Egg yolk coloration in mallard duck eggs and chicken eggs has been observed to be intensified with *Azolla* in the diet. Integrated rice-fish culture also has a long history in China and Southeast Asia.

In conclusion, there is a great potential for increasing the productivity of rice-duck farming systems, especially if it is integrated with fish and the nitrogen-fixing aquatic fern *Azolla*. As organic movements receive more and more attention and the demand for organic, safe food increases, the ***aigamo*** rice or rice-duck farming systems will continue to be promoted and of interest

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Social Benefits from the Aigamo Rice Farming Technology.

Environmental pollution and food quality degradation caused by excessive uses of agricultural chemicals have received more and more attention from the world. Organic movements have also spread throughout the world. In addition, in many Asian countries, population pressure has been a fact of life for many years. The arable land is limited and the land area per capita is much less than it is in Latin America, Africa, and Australia. Of great importance is the control of disease and pest insects. At this moment the so-called "rediscovery of traditional rice farming practices in Asia" or "recalling the wisdom of traditional rice farming in Asia" becomes especially relevant. Rice-duck mutualism is part of the wisdom of Asia. Takao Furuno, a Japanese farmer, has promoted the rice-duck farming method and other organic practices for more than 30 years. Organic farmers face many difficulties, one of which is time-consuming labor. Weeding, in particular, requires long hours. Many farmers, wondering whether or not organic farming is worth the trouble, were advised to try rice-duck systems. They were convinced that the ducks do a good job removing weeds and pests and improving conditions in paddy fields. The results of this study done in co-operation with researchers clearly indicated that the paddy with ducks held several advantages for rice production. A report on the study was published and helped promote ***aigamo*** rice technology with an NGO called the Japan ***Aigamo*** Duck Association. Furuno has visited many Asian countries and shown his technology to the farmers. As described by Furuno, agriculture has evolved from human power to animal power, and then to fossil fuelled power, and ducks represent a "reconsideration of animal power". Over the last thousand years, the people of Asia have been devising means of producing more food in smaller areas under limited conditions. Crop rotation and cash crop methods require time to be effective, but farming with ducks is effective at once. In 1996, as an expert, Furuno visited Tanzania and transferred his rice-duck technology at the Kilimanjaro Agriculture Training Center. By using ducks and fish in rice-farming systems, it is expected that Tanzanian farmers could produce rice more effectively as well as increase their menu of high-protein dishes. Furuno has been invited as a guest lecturer by China mainland and Taiwan, Korea, Indonesia, Vietnam, Cambodia, and the Philippines, where he found opportunities to build a network of rice-duck organic rice production. Several books have already been published and some are translated into Korean, Chinese and Vietnamese. The rice-duck farming technology optimizes the power of nature in rice cultivation and promotes the food self-sufficiency of each farmer, particularly those in developing countries, thus tackling both global issues effectively. In fact, the ducks are so good at weeding that Third World farmers who have adopted the method now have time to sit and chat instead of spending up to 240 person-hours per hectare in manual weeding every year! Besides, weeds and other pests have been miraculously transformed into resources. The paddy field with ducks is really a complex, well-balanced, self-maintaining, self-propagating ecosystem. The only external input is the small amount of waste grain for the ducks, but the output is delicious, nutritious organic rice, duck and roach. This ***aigamo*** method also explodes the myth that organic farming always requires intensive labor. Actually, organic farming need not be labor intensive. This is also consistent with Okada and Fukuoka's nature farming philosophy 'let nature do and you do nothing'.

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Fig. 4.3.2(1). Rice-duck mutualism

Fig. 4.3.2(2). Rice-duck mutualism

Examples from around Asia

An estimated 10,000 farmers use this ***aigamo*** rice system in Japan, which has now been spread to other rice-growing countries such as Korea, China, Vietnam, the Philippines, Thailand, and India, where this technology is especially important for people still weeding and working a lot by hand.

Japan

Raising ducks in paddy fields is not actually a new idea. A book that was published 1000 years ago in China advocated the use of ducks in rice paddy fields, and it has been used since that time from the Chinese Yangtze River to the Asian monsoon zones. It was introduced to Japan about 500 years ago and handed down in the Kinki district. Hideyoshi Toyotomi, the first Shogun who

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ruled Japan about 500 years ago, recommended releasing ducks in paddy fields to improve rice cultivation according to the Chinese legend. It was then used throughout Japan after the Word War II when it was difficult to obtain food. In the 1980s, the practice was revived to fit modern agriculture by Takao Furuno, a farmer in Fukuoka Prefecture, who integrated rice farming with ***aigamo*** duck. Two month old ***aigamo*** ducks were released into paddy fields at a rate of at 400 birds/ha about two months after rice seedlings were transplanted. ***Aigamo*** ducks help control weeds and insects and lead to the non-application of pesticides. Recently, the ***aigamo*** rice farming has been part of organic agriculture in Japan. From the beginning, duck husbandry methods have been closely associated with paddy rice farming. The traditional practice of duck production in the South-Eastern Asian countries involves herding the birds into paddy fields after the rice is harvested. Duck herders transfer their flocks from one farm to another depending on food availability. Herders house their flocks in sheds usually along irrigation canals where water is available for the ducks. Duck grazing in the paddy fields after the rice is harvested helps economize on the high cost of feed. In some areas, duck raisers contract with rice farmers to look after their ducks (Chandrapanya and Pantastico, 1983) and the duck raisers come back and pay the farmers for their services. Ducks are also released in paddy fields to control mud snails (AICAF, 1988; Basilio, 1989) such as the herbivorous snail *Pomacea canaliculata Lamarck* which was a big problem as an exotic pest during the early 1980s.

China

In the last two years, the China Ministry of Agriculture has widely promoted environment-friendly ecological agriculture. The rice-duck system was then popularized in middle and lower reaches of Yangtze River, and it became a typically representative technology in organic production. It is called “rice-duck mutualism” in China and the widely confirmed advantages are 1) reducing uses of agricultural chemicals because the ducks controlled weed and animal pests, 2) increasing yield by about 200 kg per ha, and 3) increasing farmer’s incomes by extra production of 150 ducks per ha and by reducing external inputs. Farmers in China have summarized four key measures needed in the paddy duck technology:

1. Suitable rice varieties with optimum medium or large plant height, well-distributed canopy, thick stalk and high tillering ability,
2. Appropriate timing and space for rice-duck mutualism with about 180 ducklings per ha released two weeks after rice transplanting,
3. Good rice management with sufficient fertilization, and
4. Proper timing of driving ducks out of the paddy field just before the rice spikes sag down, to prevent the rice grain from being eaten by the birds (Asano et al., 1999).

Korea

The Korean Rice Farming Association has promoted the rice-duck system in organic agriculture movements. The rice produced by rice-duck systems is sold at 40-60 % higher than the rice grown with chemicals. The number of rice-duck farms and the areas farmed show a steadily increasing trend from 1993 (Kim, 1997). Farmers raise ducks for meat at a density of 200-350 birds per ha, which feed on Azolla growing naturally in the paddy fields and sometimes supplements in forms of commercial feed, rice bran, vegetable scraps, and kitchen scraps. The duck meat sells well in the autumn and winter.

Vietnam

In addition to the ducks raised throughout the year in backyards of farm households, most others are seasonally raised in integration with the growing paddy fields, and the paddy fields after rice harvest (Men, 1997). One week old ducklings are driven into the paddy field 20 days after rice seedlings are transplanted. Feed supplements such as rice by-products are supplied depending on the availability of food in the paddy fields. When rice plants start to flower, the ducks are driven out of the paddy fields to canals, ditches, lakes, and swamps. After the rice is harvested, ducks are herded into the paddy fields, where they forage on left-over rice grains, insects, fish, shrimps, snails and water plants during the day, and then driven to pens or sheds in the evening for night time. The paddy fields are efficiently used for duck raising during the fallow period between rice harvest and the next transplanting.

Indonesia

More than 30 million ducks are raised each year in Indonesia, one of the largest duck producing countries in the world. The rice-duck herding systems similar to the Philippines are widely employed in Indonesia.

The Philippines

Ducks rank next to chickens for egg and meat production. More than 10 million ducks were raised in the Philippines in 1991. Ducks require only inexpensive and non-elaborate housing facilities, little attention and less space than chickens. These animals are hardy and resistant to common avian diseases and feed on a variety of foods. Duck eggs are larger and more nutritious than chicken eggs.

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Innovation 2

Rice-duck mutualism

Biodiversity (++)	Economy (++)
Weed and pest controls, prevention of global warming by reducing methane emission, organic fertilization and soil improvement.	increases in economic income

Implementation

Many methods of rice–fish farming have been developed in China. Although they involve various production systems, these different methods are inseparable and interlinked. The common aim is to boost rice production by eliminating weeds and pests. Many different types of rotation are practiced (Ni and Wang, 1992). Some are described below:

- *Rice–Fish Mutualism*

  In the subtropical areas in Asia, paddy rice crops are cultivated three times a year in succession: early, middle, and late crops. Two kinds of fry (fingerlings and summer fry) are released directly into the flooded paddy fields. Specific practices include raising fingerlings in flooded paddy fields before transplanting, raising fish in paddy growing fields and in nearby ponds, planting rice on the ridges while raising fish in the furrows, and raising fish in the small channels prepared in the paddy fields.

- *Breeding Fry in Paddy Fields*

  Grass carp (*Ctenopharyngodon idella*) fry are released directly into early flooded paddy fields without feed supplied. After the middle rice crop is planted, 1000 fry, 3.3–5 cm in length, are harvested from the early paddy fields. Early release of the fry is advocated to take full advantage of plankton growth peak. About 45000 artificially hatched fry are needed per ha. Bank borders of the fields are raised 50–70 cm high before the fry are released into the field. Lime is applied 375– 750 kg per ha to kill leeches, eels, and other natural enemies of the fish. A week later, water is introduced into the field and then the rice seedlings are transplanted. Fish ditches are constructed of 30 cm wide and 30 cm deep. Net screens, each 100 cm wide and 80–90 cm tall, are installed in the water inlet and outlet. Each screen is arch-shaped with thin bamboo strips placed 0.2 cm apart and fry may then be released through into the field. When the weeds are eaten up by the fish before rice ripening, the canals and ditches are opened, the water is drained out slowly, and the fish are forced to gather in the canals and then driven into the ditch, where they are netted out.

- *Rice, Fish, and Azolla*

  Carp species C. idella or C. tilapia are organically raised with Azolla in the paddy fields. The fish feed on Azolla and rice is fertilized by fish excrement. Fish and Azolla grow in the wider spaces between every two rows of rice. Rice canopy is well ventilated and light use efficiency is maximized.

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- *Paddy field with Fish Raised in a Pond*

  When the time difference between the early rice growing season and the hatching of summer fingerlings is about a month, it is not good for the rice and fish to be mixed together. Instead small ponds or ditches are prepared around the paddy field. Each pond is 10–30 m^2 large and about 1.5 m deep, linked by a bank to the paddy field. The pond can also be used to hatch the fry. After the early rice is transplanted and the fish canals are prepared in the field, the pond and paddy field are then linked to allow the fish in the pond swim across into the paddy field. Just before the early rice is harvested, the fish are driven back into the pond. Then the second rice crop is transplanted and the fish in the pond are allowed back into the paddy field again.

- *Raising Fish in Paddy Fields with Wide Ditches*

  This method is used to raise winter fingerlings. Ditches, about 1 m wide and 1 m deep, are prepared on the water inlet side and inside the field bank borders. The area of the ditches is about 5–10% of the area of the paddy fields. The ditch ridge is raised 25 cm above field level. A 24 cm opening every 3–5 m links the ditches with the field and allows the fish to move freely from the ditches to the field. Long before the rice-transplanting season, winter fingerlings are put in the ditches so that they can enter the paddy field for food as soon as the early rice seedlings turn green. Jiangxi Province devoted 6670–9330 ha of paddy fields to this method in 1985–86 and reported a 20–50% increase in rice output.

- *Rice-on-Ridges and Fish-in-Furrows*

  Ridges and furrows are prepared in the fields. Rice seedlings are planted on the ridges and fish are raised in the furrows. This method was developed on the basis of a semi-dry cultivation method. Root growth and activity are enhanced, soil aeration and rice canopy conditions are improved, and fish move well in the furrows.

- *Rotating Rice and Fish*

  Rice and fish are alternatively raised in one paddy field. Rice crop is grown once a year, and the rest of the time is used to raise fish. When the rice and fish are harvested, the straw is left in the field. Adult fish are then released into the empty paddy field. The method can also be applied in double-cropping areas, but the fish are only raised in winter.

- *Rotating Rice and Fish in Low-Lying Land*

  The paddy field is planted with a late rice crop and then remains fallow for the rest of the year. Fish ditches, each 50 cm wide and 27 cm deep, are prepared and then rice seedlings are transplanted at a density of 11.5 x 17 cm. The fish are grown for about two months without extra feed being supplied.

- *Raising Fish in Winter Paddy Fields*

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In these systems, the paddy fields are efficiently used in wintertime from the harvest of the late rice crop to the middle rice crop transplanting. In some areas, fingerlings are released right after late rice is transplanted, and the fish are harvested either before the spring in January or February or before the next early rice crop is transplanted. During the winter season, most paddy fields store water full of plankton and organisms. In general, rice-fish culture techniques can be divided into three categories: a) rice-fish mutualism: rice and fish together in the field during the same period, b) rotating rice and fish with fish culture in the paddy field after the rice is harvested, and c) combination of a) and b). In a rotation of rice and fish, the fallow field left after rice harvest is used to raise fish. After the rice is harvested, the straw is left in the field. When the field is irrigated, the straw decays and makes the water suitable for feeding adult fish. In this form of rice-fish culture, fish have more space to move around and feeds can be conveniently spread, although the growth period is longer. Fish productivity is higher than in the normal rice-fish mutualism. Rotation of rice and fish is widely used in fallow winter fields because it provides good economic benefits.

- *Rice-Crab culture*

  Rice-crab culture was introduced to crop production in 1990s. River crab or mitten-handed crab (Eriocheir sinensis) is easily sold because of its delicious taste. River crabs adapt to various ecological environments. Paddy fields with one crop a year near a water source are selected. A surrounding trench, 3 m wide and 1 m deep is prepared in the paddy field. A nursery or harvest pond, about 40 m^2 large and 1 m deep, is prepared that is in contact with the paddy field. The aquaculture area accounts for 15-20% of the total under rice cultivation. Anti-escape fence walls, such as plastic or corrugated sheet with rounded corners, are set up around the paddy field. Crabs mainly feed on natural rotifers, Daphnia and water worms in the rice fields in addition to artificially supplied feeds such as trash fish, snails, clam, animal slaughter waste, blood meal and fishmeal, vegetables, rice or wheat bran, oil mill cakes, and terrestrial grass or duckweeds.

- *Rice-Shrimp Culture*

  A trench surrounding the field of 5 m wide and 1.2 m deep, and ditches inside the fields are prepared with mesh screen inlets and outlets. Aquatic plants such as eelgrass, stone-wort and pond weed are introduced and cover 1/2-1/3 of water surface. The shrimp stocking density is 4 kg per ha, equivalent to 30 million larva per ha. Feed such as soya milk and fish gruel is supplied to the shrimp larva 3 times a day. A week later, pellet feeds or mixed feeds of wheat or rice bran with some animal food is supplied. Shrimps of marketable sizes can be harvested in late November while smaller ones are left in the fields for further growth until next May or June.

Impact on biodiversity

Promotion of the benefits of the rice-fish production systems can increase its use and thus increase biological and eco-system diversity in rice growing areas. The conditions for living organisms of eco-system; the producers (*autotrophs*) and consumers (*heterotrophs*) and also the abiotic conditions such as water, heat, light, air, nutrients and soil as well as time and space can be efficiently used in rice-fish culture. The rice-fish culture also stimulates the ecological and organic agriculture movement by the mutualism between crop production and aquaculture, comprehensive and efficient utilization of rural resources, improvement in the rural environment and therefore maintenance of biodiversity and balance in rice field ecosystems. Application of agricultural chemicals are reduced or exempted. The rice-fish culture also helps eliminate mosquito larva harmful to human health, and methane emission, which contributes to global warming. Measures such as vaccines, cultures of *Azolla* and other aqua-ferns have been tried for the elimination of Japanese encephalitis and malaria, the potentially fatal diseases transmitted by mosquitoes in many Asian countries, but the best control is through developing rice-fish culture, which eliminates mosquito breeding in paddy fields. It is reported that the annual incidence of malaria has decreased dramatically as the area of rice–fish culture increased.

The key point of the new concept of rice-fish mutualism is the improvement in rice production through using herbivorous fish to eliminate weeds and other pests and improve the ecological conditions in the paddy fields. Traditionally, the idea was simply to raise fish with rice as an additional source of food or income. Rice fish farming systems appear to be globally important in terms of three global environment issues: climate change, shared waters, and biodiversity. Methane is a major greenhouse gas emitted by rice fields. The rice-fish mutualism is also an innovative agricultural system, with a variety of local designs adapted for cultural attributes, appropriate rice and fish species for husbandry, different kinds of water resources availability, timing and drainage, natural and artificial nutrient inputs for growth, biological and chemical control of pests and diseases, and for soil and water conditions. In the biological community of the paddy field ecosystems, rice is predominant, but in mutualism it co-exists with weeds, plankton, and photosynthesis microbes together as the primary producers. However, weeds often compete with rice and may cause rice to lose its dominant position. If fish, especially herbivorous and omnivorous fish, are introduced into the paddy fields, the link or the food web is balanced. In rice-fish ecosystems, materials move in a benign cycle and the energy flows in directions favorable to both rice and fish. The paddy fields nourish the fish, and the fish nourish the rice. Mutualism means a mutual relationship whereby two different species live together and benefit from each other. The difference of the modern rice-fish systems from those occurring naturally, is that fish in the system are controlled by the farmer and an optimum balance and the maximum productivity can be expected by extending the mutualism period and coinciding the peaks of both the primary producers and the consumer.

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Impact on farm economy

The rice-aquaculture system is characterized by low cost, quick effectiveness and better economic returns through an additional source of food and income than the normal crop production in rural areas. Usually a 10%-15% grain yield increase is expected in addition to about 800 kg of fish per ha of paddy fields.

Examples/Case study

The rice-fish culture system, a unique traditional agriculture practice, has been used for 1700 years in Asian countries. Unearthed relics and some ancient books suggest that rice-fish culture dates back to the East Han Dynasty (25-220). In 2005, the rice-fish system was listed in Globally Important Ingenious Agricultural Heritage Systems(GIAHS) by the Food and Agriculture Organization of the United Nations (FAO) for its outstanding contribution to food and livelihood security, its importance in terms of biological diversity and genetic resources, landscape diversity, aesthetic beauty and cultural values and the indigenous knowledge of land and water management developed to address harsh biophysical and socio-economical constraints. According to FAO, GIAHS are defined as remarkable land use systems and landscapes which are rich in biological diversity evolving from the ingenious and dynamic adaptation of a community/population to its environment and the needs and aspirations for sustainable development. In China, rice-fish mutualism has been practiced for over 1,200 years since the time that people in Qingtian, Zhejing Province, started raising fish in rice fields. The origin of rice-fish system comes from farmers, who by leading brooks into the fields for irrigation caused fish from these streams to colonize the fields naturally. Therefore, the cultural system of natural rice-fish mutualism was formed after a long period of domestication and evolvement. Now, the rice-fish system has become one of the modern ecotypic agricultural systems, whereby fish and rice grow well together and help and depend on each other. In this system, rice provides shade and organic substances, while fish help to remove aquatic weeds, provide oxygen, reduce plant diseases and insect pests, and bring nutrients to the rice. It has been proved through practice that the rice-fish system helps to make efficient use of resources such as water, biological and abiotic substances in paddy fields, leading to benefits in aspects of environment, society and economy. Rice-fish systems not only provide grain and protein but also improve biodiversity, water use and nutrient cycling and retention, flood control and adaptive management to mitigate local climate variation and changes. Rice-fish systems are also important in global environmental issues such as climate change by reducing emission of greenhouse gases from rice fields. Rice-fish systems are now globally distributed with the expansion of rice production; however, they have so far been developed mainly in Asia.

Lessons learned

Rain fed rice-fish farming systems are threatened by excessive application of chemicals, particularly pesticides, intensification of rice cultivation, mono-species fish culture, and modern irrigation systems. The management of rice-fish farming needs more labor and village

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co-operation than mono-culture rice production. The rice-fish system is a remarkable model of the biodiversity-enhancing agriculture system. There is good potential for integrating the traditional rice-fish culture into those promoted under new policies (Lightfoot et al., 1993).

Rice-fish systems are important in terms of aquatic biodiversity conservation from a global environmental perspective. However, rice-fish systems function within a matrix of farming systems which, in turn, lie within catchments and river basin dynamics. The adequacy of biodiversity at the genetic and species levels, and at the farm, catchments and river basin level, needs to be assessed against design goals, biodiversity adequacy measures, and potential risks.

Rice-fish farming can be a low-cost, low-risk option for poor rice farmers in rice-farming countries, including Malawi, Bangladesh, China, India, Indonesia, Korea, Laos, Madagascar, Malaysia, the Philippines, Thailand, Cambodia, and Vietnam.

Traditional rice-fish systems need to be improved. Paddy fields used to raise fish in the traditional systems do not have ditches or pits. The low volume of water in these paddy fields results in insufficient dissolved oxygen and lower amounts of plankton, higher water temperature in summer, and less space for the fish to hide from predators. Fish species used in improved modern rice-fish systems should be those that are characterized by fast growth and low jumping habit for prevention from escaping. As needed, artificial feed should be supplied when there is no sufficient natural feed in paddy fields, especially when plankton and weeds decrease as the fish grow during the middle and late growing stages. Late releasing and early harvest as well as short growing period of the fish are the main factors limiting the fish yield. It is better to arrange a longer period for rice and fish to grow together. It is easier for large-scaled farmer to manage rice-fish systems with improved technology than the small-scaled ones. Currently almost all of the paddy farmers in China and Japan are small-scale, so to expand the effective scale of their farms rice-fish farmers could opt to co-operate with neighbors.

Activity/Practical Demonstration

Some promotional activities are suggested:

1. Documenting patterns of the local traditional rice-fish system;
2. Evaluating and identifying impacts of applicable policies and technologies on practices of the rice-fish systems;
3. Setting up representative demonstration sites with partnership between local communities or government and farmers;
4. Identifying and demonstrating successful adaptations to social-economic changes, and exploring the multiple values of the rice-fish system in food safety, eco-agriculture, eco-tourism and ecological conservation;
5. Developing networks on conservation and sustainable management of the rice-fish system among communities, local governments, and farmers.

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Fig. 4.3.2(3): Rice-fish mutualism according to Wang et al. with modifications

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5. Improving biodiversity in the whole landscape context

5.1. General Introduction

Focus on landscape scale conservation efforts has recently attracted much attention. These efforts are not only important for the conservation of biodiversity, but are also critical for the provisioning of ecosystem services. For example, the current and mysterious collapse of European honeybee hives in the United States, whose pollination services are valued at $68 million per year, begs the question as to whether efforts to conserve natural pollinators may not be more profitable and sustainable than depending on the services of a single introduced species. In a similar situation, coffee farms in Costa Rica have valued forest fragments adjacent to coffee farms at $60,000 for a single farm, for their capacity to provide native pollinators. Landscape planning may also have an effect on human diseases. Studies from the North-eastern United States have found that small forest patches with low mammal diversity amplify lyme disease, whereas large forest patches with higher mammal diversity reduce the incidence of the disease. As a final example, each spring the Gulf of Mexico becomes a biological desert as fertilizer run-off from the Mid-Western states makes its way down the Mississippi River into the Gulf where the nitrates and phosphates from the water cause massive algal growths that remove oxygen from the water. Planting riparian buffers along streams and rivers is a successful means of removing excess fertilizer from the water as demonstrated by experiments in the Bear Creek watershed of Iowa (see website listed below). However in order to have an impact on fisheries in the Gulf of Mexico, a massive effort involving stakeholders from dozens of states would be required. Whether we refer to habitat for native pollinators in the Sacramento Valley of California, coffee farms in Central America, the protection of large forest fragments in the Northeast, and riparian buffers in the Midwestern states, landscape level conservation strategies are critical in regulating and enhancing ecosystem services of importance to human communities as well as to preserving species diversity.

In shifting the focus from farm level conservation to landscape levels, land-managers may find themselves the targets of various interest groups wanting the agricultural matrix to be managed to favor particular ecosystem services. Whether these interest groups are conservation organizations wanting biodiversity conservation, utilities such as dam owners wanting to prevent siltation, or fishermen in Louisiana concerned about the effects of fertilizer on shrimp fisheries, integrative solutions that bring stakeholders to the table to identify win-win solutions are ultimately the most successful.

5.1.1. Examples from tropical and temperate zones

Introduction

The most critical component of landscape planning for biodiversity is the inclusion of important stakeholders in the decision-making process. In order for landscape level conservation efforts to be effective, they must have a critical mass of actors. A single farmer working in isolation is

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Social Benefits from the Aigamo Rice Farming Technology.

Environmental pollution and food quality degradation caused by excessive uses of agricultural chemicals have received more and more attention from the world. Organic movements have also spread throughout the world. In addition, in many Asian countries, population pressure has been a fact of life for many years. The arable land is limited and the land area per capita is much less than it is in Latin America, Africa, and Australia. Of great importance is the control of disease and pest insects. At this moment the so-called "rediscovery of traditional rice farming practices in Asia" or "recalling the wisdom of traditional rice farming in Asia" becomes especially relevant. Rice-duck mutualism is part of the wisdom of Asia. Takao Furuno, a Japanese farmer, has promoted the rice-duck farming method and other organic practices for more than 30 years. Organic farmers face many difficulties, one of which is time-consuming labor. Weeding, in particular, requires long hours. Many farmers, wondering whether or not organic farming is worth the trouble, were advised to try rice-duck systems. They were convinced that the ducks do a good job removing weeds and pests and improving conditions in paddy fields. The results of this study done in co-operation with researchers clearly indicated that the paddy with ducks held several advantages for rice production. A report on the study was published and helped promote ***aigamo*** rice technology with an NGO called the Japan ***Aigamo*** Duck Association. Furuno has visited many Asian countries and shown his technology to the farmers. As described by Furuno, agriculture has evolved from human power to animal power, and then to fossil fuelled power, and ducks represent a "reconsideration of animal power". Over the last thousand years, the people of Asia have been devising means of producing more food in smaller areas under limited conditions. Crop rotation and cash crop methods require time to be effective, but farming with ducks is effective at once. In 1996, as an expert, Furuno visited Tanzania and transferred his rice-duck technology at the Kilimanjaro Agriculture Training Center. By using ducks and fish in rice-farming systems, it is expected that Tanzanian farmers could produce rice more effectively as well as increase their menu of high-protein dishes. Furuno has been invited as a guest lecturer by China mainland and Taiwan, Korea, Indonesia, Vietnam, Cambodia, and the Philippines, where he found opportunities to build a network of rice-duck organic rice production. Several books have already been published and some are translated into Korean, Chinese and Vietnamese. The rice-duck farming technology optimizes the power of nature in rice cultivation and promotes the food self-sufficiency of each farmer, particularly those in developing countries, thus tackling both global issues effectively. In fact, the ducks are so good at weeding that Third World farmers who have adopted the method now have time to sit and chat instead of spending up to 240 person-hours per hectare in manual weeding every year! Besides, weeds and other pests have been miraculously transformed into resources. The paddy field with ducks is really a complex, well-balanced, self-maintaining, self-propagating ecosystem. The only external input is the small amount of waste grain for the ducks, but the output is delicious, nutritious organic rice, duck and roach. This ***aigamo*** method also explodes the myth that organic farming always requires intensive labor. Actually, organic farming need not be labor intensive. This is also consistent with Okada and Fukuoka's nature farming philosophy 'let nature do and you do nothing'.

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- Neighboring farmers work together to identify and discuss how these fragments could be connected with corridors.
- It is most effective if the most important fragments of natural vegetation are connected first, progressively moving to smaller fragments. Corridors connecting fragments come in numerous forms and are often found on farm and field boundaries. In tropical forest habitats for example, corridors often consist of living fences and riparian areas, whereas in natural grassland habitats, keeping field margins un-mowed can suffice.
- Not all corridors are created equal. Generally biodiversity and specifically endangered species are heavily dependent on the natural vegetation and consider the agricultural matrix to be hostile. Creating complex, wide linear habitats that comprise of a diverse assembly of native plants of varying heights is ideal. For example, farmers in Latin America are accustomed to using live fences comprised of a single row of a single species of tree. In addition, the live fences are often pruned annually and the vegetation at the base of the trees is removed. The conservation value of these live fences could be dramatically improved by planting fences that are three or four trees wide (or more!), comprised of multiple species of trees, that are not pruned or mowed (or at least less frequently).

Some key considerations for managing or planning corridors include:

- Natural vegetation is mimicked as much as possible.
- As many alternative paths as possible are provided between reserves.
- Disturbance is minimized as much as possible (pruning, mowing, weeding etc...)

For more information on how live fences (hedgerows) can be managed for biodiversity conservation refer to chapter 3.3.1

Impact on biodiversity

It is important to recognize that providing connectivity for large mammals such as bison, puma, or jaguars is very different from the methods described here. The innovation that was referred to works well for plants and insects as well as for birds and small mammals such as sloths and monkeys in the tropics, or weasels, raccoons, cuckoos in temperate zones. Ensuring connectivity for large mammals, however, requires a much larger scale of focus, and may require taking large portions of the agricultural landscape out of production or dramatically changing the management from row crops to pasture or complex agro-forestry systems, for example.

Impact on farm economy

Incorporating linear elements into the landscape is often preferred by farmers because they minimize the amount of land taken out of production and they permit farmers to continue their usual practices in the field centers. In many cases the intervention may be a lower cost option than the traditional farm practices or might contribute to the overall productivity of the farm. Farmers in the tropics favor live fences because they provide shade for livestock, protect the crop from high winds, provide forage during the dry season, and because maintaining a fence of live trees is less work than maintaining a fence comprised of posts (high heat and humidity in the tropics causes posts to rot excessively quickly). However initial implementation of conservation measures often has high costs associated with them, such as acquiring tree saplings and barbed wire for living fences, or the cost of land taken out of production. A 2.5 m buffer around 1 ha of land is equal to taking 10% of the productive field out of production. Decisions on where to place linear elements should include several considerations:

- What field margins are available?
- To reduce the impact on farm productivity, are there marginal lands that would better serve as conservation areas than for production?
- Do the conservation efforts contribute to the productivity of the farm by providing either pollinator or pest control services? What is the value of these services?
- Do conservation efforts from the farm provide landscape level services that other stakeholders would be willing to support financially or otherwise?

Case study

The first image that comes to mind when referring to cattle ranching in the tropics is deforestation. Though it is difficult to argue that pressure from cattle farmers on remaining forest is non-existent, relatively simple changes can be implemented that help to conserve biodiversity in pasture dominated landscapes. In our fieldwork we have seen sloths, howler, capuchin and spider monkeys using live fences and riparian forests as a means to move across the landscape. A herpetologist working with us on reptiles and amphibians in silvo-pastoral systems was shocked to find more than 40 species, including several forest dependent species occupying this managed landscape. Though we need to be cautious about over-estimating the conservation value of the agricultural matrix, it does appear that integrative, multi-stakeholder landscape scale efforts to conserve biodiversity can make significant contributions to conservation.

In Central America, much of the formerly forested landscape has been converted to pasturelands with significant loses of biodiversity and ecosystem services. Current efforts to make direct payments for ecosystem services (PES) in an agricultural landscape are being undertaken by the Regional Integrated Silvopastoral Ecosystem Management Project that is piloting the use of PES to favor adoption of silvo-pastoral practices in several sites in Nicaragua, Costa Rica and Colombia. Silvo-pastoral practices such as live fences, riparian forests, conservation of forest fragments and increasing the density of trees in pastures substantially improve biodiversity conservation and service provision while retaining agricultural production. The Silvopastoral Project increased adoption of these systems by paying farmers for the expected increase in biodiversity conservation and carbon sequestration that silvo-pastoral practices provide. The project succeeded in encouraging farmers to increase the use of silvo-pastoral systems with more than 24% of the total area under the project experiencing some form of land use improvement.

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For example the area of degraded pasture fell by two thirds, while pastures with high tree density increased substantially, as did fodder banks and live fences. On-going monitoring indicates that these land use changes are in fact generating the desired services.

Figure 5.1.1(1) Forest fragments (5% cover).
The landscape of Matiguas, Nicaragua where researchers and farmers have joined forces to conserve biodiversity and increase productivity in pasture dominated landscapes. The following figures 5.1.1(1-4) Show how corridors such as riparian forests, live fences and silvopastoral systems with high tree density increase the connectivity and effective landscape under forest cover.

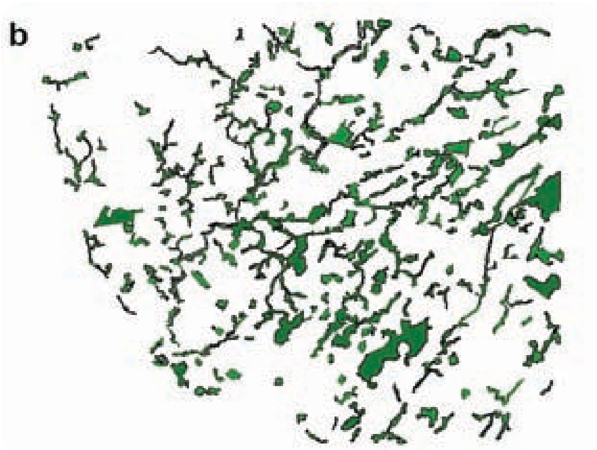

Fig. 5.1.1(2). Forest fragments plus riparian forests (14% total)

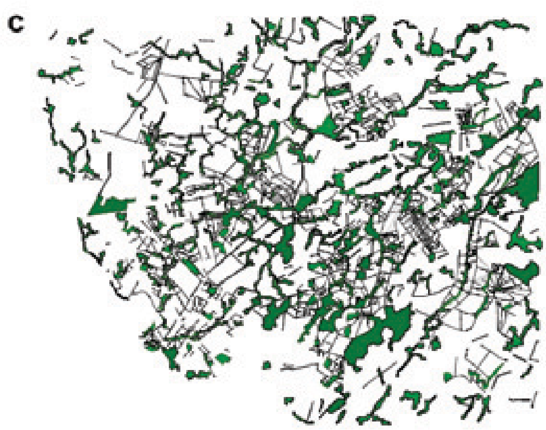

Fig. 5.1.1(3). Live fences added (16% total)

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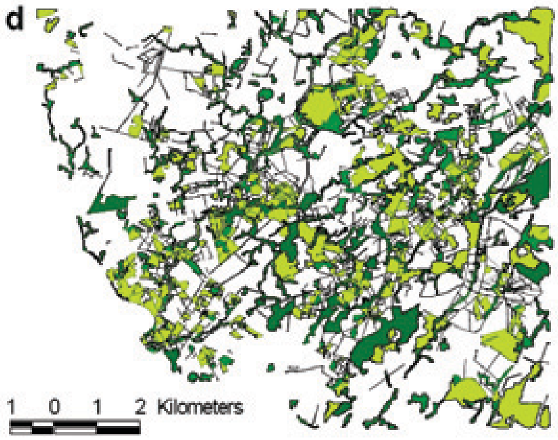

Fig 5.1.1(4) Forest fragments (5%), forest fragments plus riparian forests (14% total), live fences (16% total), and pastures with high tree density added lead to a biodiversity friendly habitat of 31% in total. Map and model developed by C. Useche

Activity/Practical Demonstration

Cattle ranchers and farmers are under increasing pressure to preserve linear elements in the landscape, but often question the benefits that they receive. Frequently conservation measures benefit off-site stakeholders, for example in the case of improving water quality through riparian buffers. When this is the case farmers should explore payment schemes for the interventions they make whether in the form of government programs or credit systems. However, conserving linear elements of the landscape can also increase the economic and social value of the farm. For example, a farmer in Iowa with a well established riparian buffer sells hunting rights on his property, and enjoys fishing in the buffer with his grandchildren. In Nicaragua and Honduras, silvo-pastoral systems provide farmers with fuel wood, timber, and medicinal plants all of which have economic and/or cultural values. Other values of these linear habitats can be more difficult to quantify but should be considered such as providing habitat for pollinators and predators of plant pests, or even reduction of the movement of plant pathogens.

Recommended reading

- Pagiola et al. 2007. Paying for the environmental services of silvopastoral practices in Nicaragua. Ecological Economics (in Press).
- McNeely, J.A. and S. J. Scherr. 2003. Ecoagriculture: Strategies to feed the work and save wild biodiversity.
- Sara J. Scherr and Jeffrey A. McNeely, eds. 2007. Farming with Nature: The Science and Practice of Ecoagriculture. Island Press: Washington, DC. (co-published by Ecoagriculture Partners and World Conservation Union-IUCN)

Recommended websites

- Center for Research and Education in Tropical Agriculture (CATIE): www.catie.ac.cr
- EcoAgriculture Partners: www.ecoagriculturepartners.org

- The Nature Conservancy: www.nature.org/
- Bear Creek Riparian Buffers: http://www.ipm.iastate.edu/ipm/icm/1999/6-14¬1999/riparian.html

Innovation 2

Farmers and specialists should take the advantage from learning from each other.

Biodiversity	Economy
Creating space for biodiversity in actively managed fields.	Management practices are altered rather than productive space lost.

Implementation

Through farmer initiative and co-operation with nature conservation groups or other stakeholders, space can be created for biodiversity conservation in actively managed lands. We are often unaware that small changes in our management procedures can have tremendous impacts on biodiversity conservation. Agriculture's most significant impact on biodiversity comes in several forms, the most important however is the replacement of stable, relatively infrequently disturbed habitats for a land use that is continually disturbed such as an annual tillage systems. Reducing the rate of disturbance in the system can help create a stable space for biodiversity. This can be difficult to impossible in landscapes dominated by row crops and is much easier to implement in systems dominated by perennials. When reducing disturbance levels is not possible, changing the timing of the disturbance in co-ordination with specific needs of local biodiversity can be as important. Cattle farmers in Nova Scotia for example, found that delaying the harvest of cut grass by a month permitted young birds to fully fledge before the harvest with minimal impact on productivity and forage quality. In the Yolo Bypass Wildlife Area (see case study) farmers collaborate with California Department of Fish and Game officials to create space for waterfowl during the winter when rice is not actively being cultivated, and when waterfowl depend of this space for their winter migration. Other measures such as reducing or eliminating the use of pesticides and chemical fertilizers can have a tremendous impact on biodiversity conservation.

Impact on biodiversity

This intervention is particularly well suited to species or groups of species that tolerate agricultural disturbances, but require small changes in management strategies to maintain stable or growing populations. Where agricultural practices cover large land areas, the practice can have a significant impact on conservation. Land managers should consider not only resident species in the landscape, but also migratory species that use the landscape either at the same time as peak agricultural productivity, or more ideally, at times when agricultural productivity is low. Generally, win/win situations with respect to the farm economy and a biodiversity friendly management of the landscape can be achieved by discussing the following questions with other stakeholders in the landscape such as conservation bodies:

- How can the disturbance on the farm be reduced?
- Can the timing of the disturbance be adjusted with due regard to sensitive times for species of concern (e.g. nesting times)?
- Can conventional management strategies be replaced by those that mimic natural vegetation patterns and processes?

Impact on farm economy

Impacts on farm economy can be minimal, or even reduce management costs depending on the interventions, however the cost should be considered on a case-by-case basis. For example delayed harvest of grain crops may have no cost associated with it and adopting low or no till systems may reduce the labor, material and fuel costs associated with winter tillage. In other cases, the conserved biodiversity may play an important role in farm management controlling pests, or facilitating the recycling of farm wastes as in the case of waterfowl in rice fields of California (see below). However sometimes conservation practices may incur costs. In these situations, payment for ecosystem service schemes should be considered, and stakeholders should be asked to contribute to the cost of conservation.

Case study

The Yolo Bypass Wildlife Area is of one of the United State's most exciting developments in wetland conservation and agriculture. Covering 25 square miles (65 km^2) and home to nearly 200 species of birds, the Wildlife Area is located within the main flood control channel for the Sacramento Valley, one of the country's richest agricultural areas. The ever present backdrop of the bustling Sacramento metropolitan area is possible only because of the flood protection provided by this wildlife area, which also provides a critical stepping point for bird species on their annual migration through the Pacific Flyway. Though the conservation efforts are local, the effects are truly international. The 16,000-acre (6,475 ha) Yolo Bypass Wildlife Area is one of the largest public/private restoration projects with 5,000 acres of land in the Yolo Bypass floodway restored to wetlands and other associated habitats, with more restoration in the works. The California Department of Fish and Game manages the Yolo Bypass Wildlife Area to promote an increase in waterfowl and shorebird populations while farmers cultivate rice both within and directly outside the wildlife area. The Yolo Bypass Wildlife Area is managed for many uses and provides a wide variety of benefits including:

- Flood Control
- Wildlife and habitat management
- Agricultural Production
- Recreation and educational uses

The true success of the Wildlife area lies in the collaborative efforts of biologists, farmers, engineers, conservationists, educators, politicians and others working together to meet multiple demands and provide a variety of ecosystem services.

Lessons learned

Understanding how the species that we are trying to protect uses the landscape, and identifying how management practices threaten this species are critical first steps in identifying simple changes in management that will ultimately leading to win/win situations.

Figure 5.1.1 (5). During the fall, finger millet is cultivated in the yolo bypass wildlife area. The same area provides flood protection to the city of sacramento seen in the background.

Activity/Practical Demonstration

While farmers, conservationists, urban dwellers and hunters have often maintained a certain degree of disdain for one another, successful management of the Yolo Bypass Wildlife area-demonstrates that more can be gained by having the groups collaborate rather than working in isolation and often in opposing directions. Certainly compromises will be made, but often stakeholders will realize that they share many of the same values. In addition, although establishing collaborative efforts between diverse stakeholders requires a tremendous amount of energy, the critical mass formed by these groups helps to draw both media attention and funding to these efforts. Most importantly, the collaborative effort of this group is making a tremendous impact on global efforts to conserve biodiversity, educating the public, and changing perceptions about the role of agriculture in conservation.

Figure 5.1.1(6). The Yolo bypass wildlife area serves as an important rest stop and over-wintering site for thousands of waterfowl migrating south each winter. Rice fields and the city of Sacramento are visible in the distance. The wildlife area also provides the people of Sacramento with hunting and wildlife viewing opportunities

Recommended reading

- Daily, G.C. (ed). 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press. Washington DC.
- Rosensweig, M.L. 2003. Win-Win Ecology: How the earth's species can survive in the midst of human enterprise. Oxford University Press.

Recommended websites

- The Yolo Basin Foundation: http://www.yolobasin.org/
- The California Department of Fish and Game: www.dfg.ca.gov/lands/wa/region3/yolo/

6. Conserving rare and endangered species: Challenges, limitations and opportunities

6.1 General introduction

Globally, approximately 1.5 million species have been identified and described, a small fraction of the 10 to 100 million species that are thought to share the earth as habitat with us (Gewin 2002). Throughout the history of classification, we have been heavily influenced by the world that is directly visible to us, and thus biodiversity assessments mainly concentrated on the plant, animal and fungi kingdoms within the eukarya domain (this domain is completed by the protista kingdom comprising of those eukaryotes that cannot be classified in any of the other kingdoms of fungi, animals, or plants). Today even within these "visible, relatively known" kingdoms many species are still unexamined. Furthermore, about 90% (Lopez-Garcia et al. 2001) of all biodiversity at the species level is represented by the "invisible, generally unknown" microbial world (containing the domains of bacteria and archaea) and this certainly represents a completely new arena for us (merely app. 4500 species described today, Curtis et al. 2002, Lopez-Garcia et al. 2001, Torsvik et al. 2002). The little biodiversity that we know about already offers many direct and indirect vital services to us, such as the vast amount of medicine, food and fiber we take from the flora of this planet. In the light of the immense unknown dimension of biodiversity, it also presents an incredible unexplored potential to us. However, in order to tap into that it is important that all facets of biodiversity, the known and the unknown, are maintained. Today, as recorded within the well documented fraction of biodiversity which presumably is of most direct importance to us, that is the flora and fauna, thousands and perhaps even millions of species are unfortunately moving towards extinction without anyone marking their passing. According to the World Conservation Union (IUCN), nearly 24% of all mammals, 12% of birds, and almost 14% of plants are threatened with extinction.

Extinction is not new, and life on our planet has gone through a tumultuous history consisting of both flowering of new species and mass extinctions. We have identified at least five major extinction episodes in the history of the planet caused by a diversity of factors including catastrophic volcanic eruptions, and the famous collision with a comet near the Yucatan. We currently are in the midst of the sixth major period of extinction at present. The distinction between this episode and the five previous is that for the first time, a biological organism, mankind, is the cause. Extinction is rarely due to a single causal factor, rather it typically is the consequence of multiple factors working together and leading to higher rates of extinction than predicted by habitat destruction alone. However, other important drivers of extinction including invasive species, and global climate change are ultimately also the result of the human footprint. Though the current rate of species extinction from habitat fragmentation is poorly known, projections estimate that extinction rates are somewhere around 1,000 species per decade per million species. The consensus is that biodiversity is being lost at a rate that is two to three orders of magnitude faster than is normal in geological history.

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What are threatened and endangered species?

Generally, an ***endangered species*** is a species that is in danger of extinction throughout all or a significant portion of its range. A ***threatened species*** is one that is likely to become endangered in the foreseeable future. The World Conservation Union (IUCN), which maintains the most comprehensive global list of endangered species, defines nine categories of threat for a species. The first two, extinct, and extinct in the wild denote species for which there is no reasonable doubt that the last individual has died, or when it is known only to survive in cultivated or domesticated forms, or in captivity. This is followed by three categories regarding species of concern, including Critically Endangered, Vulnerable, and Near Threatened. The first two, Endangered and Vulnerable classify species as threatened and refer to species facing a high risk of extinction in the wild. The Near Threatened category applies to species that do not qualify for the endangered of vulnerable criteria, but which are likely to qualify for a threatened category in the near future. Least Concern applies to species that are widespread and abundant and which therefore do not face any extinction risk. The final two categories apply to species where data is lacking (Data Deficient), or which have not yet been evaluated (Not Evaluated).

Challenges

Most efforts to protect biodiversity have focused on the creation and establishment of reserves, what some call reservation ecology. The international community has set a goal of having at least 10% of every habitat type under effective protection by 2015, a strategy that will protect many species and ecological communities. However, even if this plan was successful and we managed to conserve biodiversity in 10% of the terrestrial landscape, 30-50% of the world biodiversity would still be lost for two principle reasons. First, we estimate that more than half of all species exist principally outside protected areas, mostly in agricultural landscapes; and second, most reserves would be too small, or too fragmented to support viable populations. The concept of agriculture as ecological “sacrifice” areas where no attempts are made to protect and conserve biodiversity is changing because of the increased recognition that agricultural lands both perform services and provide essential habitat to many species, that these lands can be managed to meet the dual goals of biodiversity conservation and production, and the conservation of biodiversity cannot occur unless we include areas outside of reserves. Rosensweig (2003) states, “We must abandon any expectation that reserves by themselves, whether pristine or restored, will do much more than to collect crumbs. They are the 5%. We need to work on the 95%.”

Thus the Convention on Biological Diversity (CBD) agreed in 2002 to aim for 30% of agricultural lands worldwide to be managed to protect wild flora by 2010. With the expansion of the conservation community’s “ecosystem approach” to conserving biodiversity, agricultural communities play an increasingly strong role providing a supportive matrix of land and water use, and creation of biological corridors, and as habitat in their own right. A growing number of examples exist demonstrating this role. For example, conservation of wetlands within agricultural landscapes is critical for wild bird populations (see chapter 5.) demonstrating the critical role that farmers play in collaborating or leading conservation initiatives. The global challenge to the farming community is to find new ways of sustaining the increasing food and fuel needs of a growing and developing global population while increasing the amount of critical habitat for rare and endangered species. The actions of farming communities are reflected far beyond the farm boundaries. Efforts to protect rare and endangered species should not be considered solely in terms of "Which rare and endangered species exist on, or near my farm that I can protect by altering my management practices?" The extinction footprint of agricultural is felt far beyond farm fence lines as has been demonstrated by the dramatic loss and alteration of aquatic communities in the Gulf of Mexico, and in the Sea of Cortez due to spring fertilizer and pesticide applications in the Mid Western United States and the Imperial Valley of California.

Limitations

Loss of habitat is the number one cause of loss of biodiversity globally. This poses one of the greatest limitations to conservation of endangered species. If agricultural conversion is the primary driver of extinction, can we reverse the situation and make agricultural landscapes one of the primary drivers of species conservation? At the start of the millennium, this concept would have been ridiculed by conservationists and farmers alike. Conservation goals and production goals were regarded as diametrically opposed. However, conservationists, and farmers are increasingly showing interest in collaboration with important results as is demonstrated throughout this guide. This is no small challenge, with the limitations particularly glaring as we increasingly demand our farming communities to not only provide us with food and fiber, but now also fuel. There is also ample room for opportunities, however, with the greatest gains made through win-win opportunities between conservation and production.

Opportunities

There are two overarching strategies for protecting endangered species in agricultural landscapes that are driven by the state of knowledge on endangered species. We have only identified between 10-20% of the worlds biodiversity, and the easiest species to identify at that. Of the known species, we often know little more than the name; of the unidentified species we know close to nothing at all. This means that there are really two kinds of endangered species, those that we know are endangered (by far the minority), and those that we have no idea are endangered (the vast majority). Therefore conservation of endangered species encompasses two predominant strategies. The first is a species-specific approach, where a landscape is specifically managed for a known and identified threatened species. And the second is the ecosystem approach which assumes that we do not know the majority of the threatened and endangered species and whose strategies aim to conserve the matrix.

Lessons learned

Nature protection that tries for new approaches, more communication and the support of quality of life for animals, plants and humans becomes more and more important as "Integrative Nature Protection". Quality characteristics of this integrative nature protection include the following aspects:

- *socio-economic* integration: the realization of nature protection objectives with other land users and the population
- *time* integration: the search for long-term sustainable solutions
- *spatial* integration: sustainable and environmentally friendly development of entire spatial entities.
- *functional* integration: the consideration of aspects of abiotic resource protection

6.1.1. Examples of different conservation approaches

Single Species Approach

To preserve known and identified endangered species within agricultural landscapes we must learn what they need. We must carefully study their natural habitats and understand what is essential to their survival and what they can do without. We must understand what the drivers of their extinction are. We must then reassemble the critical components into 'critical habitats' within our managed landscapes. Using the single species approach and targeting endangered species requires identifying which of the habitat requirements critical to the species in question is limiting. The seven primary criteria of habitat include (1) nesting sites, (2) protection against predators, (3) clean water, (4) access to breeding territory, or leaving migratory routes unimpeded, (5) access to food sources in all seasons, (6) a balance between predator and prey levels, and (7) the presence of other beneficial or interdependent species, for example, a critical pollinator in the case of animal pollinated plants.

Loggerhead shrikes (*Lanius ludovicianus*) (Fig. 6.1.1.(1)) are a species of once abundant bird which like to perch on a tree or post and hunt for large insects and reptiles. Shrikes in general are particularly well known for their habit of capturing prey and "spiking" it on to a twig or barbed wire where the lizard is then left to die in the sun. Apparently, the female shrikes find this quite attractive and are drawn to make territories where hanging prey is abundant, a sign of the male's prowess. However populations of the shrike are endangered. Careful studies by ecologists found that pastures where shrike populations were declining had plenty of prey, and plenty of nesting sites, but that there appeared to be a shortage of perching site from which shrikes could observe and pounce on their prey in the grass. By regularly placing fence posts throughout the farm, conservationists successfully increased the hunting habitat for the shrike, with 60% increase in shrike numbers within a year and no negative impact on farm productivity.

Management of rare and endangered species is often much more difficult than in the case of the shrikes, and can at time cause significant conflicts between conservationists and farmers. However by carefully understanding species habitat requirements, and limitations, often relatively simple solutions can be devised to support populations of threatened species.

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Fig. 6.1.1.(1).The loggerhead shrike (lanius ludovicianus).

Ecosystem Approach

Managing for a single species is often complex, requiring detailed and minute information regarding the species interaction with the environment and other species in the community. Gathering this information is difficult, time consuming, and expensive. In addition, with the exception of birds, mammals, and some reptiles, we often have very little idea of which species are endangered. In this case, an ecosystem approach that is focused on maintaining communities rather than species may be much more practical. The ecosystem approach recognizes that ecosystems must be managed as a whole, where protected areas function as reservoirs of wild biodiversity within a matrix of land management that enhances habitat value and provides a range of benefits to people. The ecosystem approach has been widely accepted, and largely successful in large national parks, most famously Yellowstone National Park in the North-western United States where preserving communities, rather than species has predominated. Only recently has the concept gained ground in agricultural landscapes. To help apply the ecosystem concept to managed landscapes, McNeely and Scherr (2003) propose strategies:

1. Create biodiversity reserves that also benefit local farming communities: Establish new biodiversity reserves in agricultural landscapes that focus on environmental services that clearly benefit farmers and the communities in surrounding lands. For example, riparian buffers can provide hunting opportunities, and play a critical role in maintaining water quality for both human and animal communities.

2. Develop habitat networks in non-farmed areas: Integrate non-farm areas into networks of habitat for wild species that are compatible with farming particularly targeting networks that link existing protected areas.

3. Reduce and reverse conversion of wild lands to agriculture through agricultural intensification: Increase productivity and sustainability on lands already under agricultural use and slow the expansion into wild habitats.

4. Minimize agricultural pollution: Use more resource efficient methods of managing nutrients, pests and waste. Organic agriculture is a principle example of this strategy and has implications that extend far beyond the boundaries of the farm. Chemical pollution rarely remains on the farm itself, but quite rapidly makes its way to the nearest stream, river, and bay. The impact of agricultural pollution can be measured within large bodies of water including the Gulf of Mexico and the Sea of Cortez where pulses of nutrient laden water severely alter aquatic communities each spring.
5. Modify management for soil, water and vegetation: Modify resource use to enhance habitat quality in and around the farm including fallows, riparian strips, and hedgerows.
6. Modify farming systems to mimic natural ecosystems: Incorporate economically useful perennial vegetation in ways that mimic the natural structures and composition, and create suitable habitat for wildlife.

Case study

To all intents and purposes, the pasture dominated landscape of Matiguas, Nicaragua is heavily fragmented with only 10% of the original forest remaining. It also is a region of extreme poverty with 40% of national population living there on less than $1 per day. However, biodiversity studies in the region show that biodiversity remains high, with over 100 species of birds identified, over 40 species of reptiles and amphibians, and numerous mammals including howler monkeys, capuchin monkeys, and sloths. When evaluating the role of the managed portions of the landscape we found that although only 11 percent of the landscape is forested, that much of the landscapes is either in riparian forests, live fences, and pastures with high densities of trees (see figure in chapter 5). This is far from ideal; however the local community, aided by a small army of research institutions, NGO's, Banks and Government projects are slowly increasing forest cover in this landscape. Farmers are re-evaluating their farms, identifying the most productive portions of the landscape and intensifying management on these portions while converting areas with steep slopes to forests or forest plantations. Community efforts are beginning to recognize the importance of riparian forests for water quality, and several streams have now been closed to cattle while biologists monitor the return of biodiversity. The number of live fences in the area is also increasing. Currently 70% of the forest fragments are connected to adjacent fragments by at least one line of fences, often the connection is through a complex network of fences increasing options for movement by wildlife. Many of these interventions not only benefit wildlife, but also play a critical role in farm productivity by decreasing the cost of farm maintenance, providing shade and fodder for cattle during the dry season, and providing alternative sources of fuel.

Fig. 6.1.1.(2). The black rhino is a typical example for a critically endangered species. In Namibia, cattle farmers with marginal rangeland and highly erratic rainfall are increasingly switching to “farming” of rare and endangered wildlife that is adapted to the local conditions. Their product is eco-toursim. In the light of this new farming approach populations of many rare species are rapidly recovering in namibia and farmers are experiencing a more stable income, increasingly realizing and tapping the direct economic value of their wildlife. Photo by Hiltrud Reinhard.

Recommended reading

- Scherr, S.J. and J.A. McNeely (eds). 2007. Farming with Nature: The Science and Practice of Ecoagriculture. Island Press. Washington.
- Scherr, S.J. and J.A. McNeely (eds). 2003. Ecoagriculture: Strategies to feed the world and save wild biodiversity. Island Press. Washington.
- Splett, G., 2000 Erfolgskontrollen bei integrativen Naturschutzprojekten. Natur und Landschaft, Nr. 75 (1), pp. 10¬16).
- Rosensweig, M.L. 2003. Win-Win Ecology: How the earth’s species can survive in the midst of human enterprise. Oxford University Press.

Recommended websites

- Convention on Biodiversity: www.cbd.int/
- World Conservation Union: www.iucn.org

7. Improving landscape quality and function
a new challenge for agriculture

7.1. General Introduction

When organic farmers are asked why landscape development should be an issue for farming today, they make reference to nature, and species and habitat conservation and maintenance. Some may go further and place an emphasis on the significance of an intact landscape which is capable of providing healthy food as well as pleasant and healthy working and living conditions for people; landscape that should also be developed in such a way that beneficial insects are encouraged, in order to minimize crop pests and finally, they want to be part of a movement for a holistic, responsible, caring approach to landscape: a symbiosis between people and nature.

All these responses seem to have something to do with the attitude of human beings to nature, but there are obviously a number of standpoints from which we can view landscape and the natural world. Firstly, the landscape is used for the cultivation of agricultural products and thus for feeding people. Secondly, unspoilt landscape also contributes to people's relaxation, to sensorial nourishment. Furthermore, landscape used for agriculture 'nourishes' a multitude of organisms that have found habitats only through agricultural activity. Many species of bird, butterfly, orchid and arable weed were introduced into northern landscapes through putting post-glacial forests under cultivation. Agriculture was not always the greatest cause of species extinction or environmental destruction that it is today. On the contrary, regionally differentiated and species-rich cultural landscapes that today are regarded as in decline only arose through historical land use. Indeed, farming caused many animal and plant species to move in.

What is the connection between the changing understanding people have of nature and these two contrasting effects of human activities on nature – one which once led to its enrichment and the other which now causes its impoverishment? There are also contrasts in the contemporary debate on nature conservation. Whereas conservative nature conservation aims at protecting nature from people, organic agriculture places people in the centre; makes human beings the very foundation. Many an approach in organic agriculture restricts itself to farming in a way that is as 'environmentally friendly' as possible, i.e. has the least possible impact on the existing natural world. What are the motives behind nature conservation and landscape development in organic agriculture? Landscapes being used for farming are not only production areas but cultural landscapes. Natural landscapes dominated by different vegetation, i.e. forests in Central Europe as the final stage of natural succession, were certainly never uniform, as they were structured by dynamic rivers and also influenced by large grazing animals. But human influence displaced the climax stadiums in favor of earlier stages of succession. In contrast to the natural landscape these cultural landscapes are not stable on their own, but depend on human intervention. This diversity of use led to an increase in diversity of biotopes and species (Van Elsen, 2000) and to a differentiation of the landscape. Specific plant communities developed where there were different intensities of use and site factors. Weeds from the Near East and the Mediterranean region found a habitat on the regularly tilled arable fields worldwide. In many cases cultural modification of the landscape remained compatible with the natural environment and rather enhanced qualities of nature than made them disappear, although the historical forms of agriculture had not been at all sustainable. Examples for this are the history of heathland or large erosion problems in areas with sandy soils. But despite these environmental problems the diversity of species and biotopes often increased compared to the natural situation. With the decrease in employment of people in agriculture, the standardized product quality and economic measures that demand mechanization, specialization and growing size of fields, the development of diverse landscapes came to a turning point. In favorable areas (high yields) agriculture became intensified, in other regions agriculture was abandoned (Van Elsen, 2000). The rapid change in intensity and use of land, water body eutrophication, increasing environmental pollution, fragmentation and isolation of habitats and climatic changes have the biggest impact on the diversity of species (Ssymank, 1997). Today many species are threatened and often wildlife cannot find conditions in which to survive (Van Elsen, 1996).

The different qualities of a landscape contain physical conditions, like soil, water, the geographical site and the climate, but also the history of human use. The activities of former generations have built the landscapes and their scenery, and many landscape elements are remains of their purposes and human work. For example, the motive to plant hedgerows was to use them as living fences and to harvest leaves and branches as winter fodder and as fire wood and also fruit for human consumption. Furthermore the landscape of a farm is a mirror of the way that the different productive areas like arable fields, meadows and pastures are composed into a whole; they are influenced by the different animals kept, the economic conditions, and the amount of people working on the farm.

Becoming aware of this composition of the present farm landscape is a good starting point for modern landscape development. Today diverse landscapes only develop if they are consciously wanted, when landscape work is integrated into the goals of farming. This applies even to traditionally small-scale farming systems and organic farming approaches. The development of cultural landscapes can be understood and realized as a process where interested individuals participate in order to collect and share perceptions and thus come to a common conclusion of what the landscape consists of and what its special character or Genius Loci is. By integrating different perceptions and viewpoints a solid basis for landscape work can grow (Baumgart & van Elsen 2007). A helpful tool to discover the special character of a place is to do perception exercises with a group of people. An example for such activities is described in the following chapter. Special qualities of biotopes and parts of the land can be described, mapped and visualized. By discovering certain characteristics of different parts of the farmland, values can be described. Through conscious activity and a communication process the “right” measures can be found, that on the one hand aim to fit all the interests of the people concerned who live in the landscape, and on the other hand “fit” harmoniously into the landscape and express its uniqueness. A big challenge for the future is finding combinations of wildlife habitats which at the same time create value for agriculture. One problem to be solved is how to implement features that can either maintain themselves or provide income.

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7.1.1. Examples and perspectives for a conscious and effective enhancement of landscape quality

Introduction

There are several conditions that have to be fulfilled for modern landscape work on organic farms that not only restores landscape elements, but tries to develop the landscape as part of a process integrating experts, practitioners and different stakeholders.

Such work needs:

- a participatory approach (bottom-up instead of top-down planning)
- a qualified advisory service for farmers who are willing to improve their impact on biodiversity
- support for farmers by better agri-environmental schemes, which help farmers to realize locally adapted concepts
- good education at agricultural schools and universities.

The integration of nature preservation is not only a question of natural or environmental sciences, but a social question of how people with different professions and backgrounds can work together: the farmers with their unique experience in managing the land, the environmentalists and biologists, who know the species, and customers and friends of the farm, who can practically give a hand to support the farmer to improve the landscape, and who care for biotopes.

In order to help and to support farmers, an advisory service for organic farming was implemented at the "Competence Centre for Organic Farming" in the German state of Lower Saxony in November 2001, after a test period of four months. The intention of this offer was to support farmers with an on-farm advice service to put more means of nature protection into practice on their farms.

The advisory service is an "all-round service" including support on the following issues that often consists of more than only advisory talks:

- Development of ideas and practical actions that can be implemented on the farm
- Practical realization of these actions
- Advice for financial support activities
- Communication support if there are issues to be discussed with nature conservationists
- Organizing actions together with nature conservationists and other groups

The advisory service is based upon the needs and the interests of the farmers. They are supported in developing and realizing their own ideas and to optimize approaches under the aspect of nature conservation. Many farmers have taken advice and a lot of measures have been implemented successfully on their farms. Additionally, it leads towards a more sensitive attitude to the value of nature on the farmland has been seen. The recognition of such values is dependent on the farmers' perceptions, and to this end PETRARCA, the European Academy for the Culture of Landscape, has carried out many seminars on farms.

Innovations

1. Realizing nature and landscape development as a value for the farm.
2. Integration of people from outside the farm into a participatory process.

Innovation 1

Realizing nature and landscape development as a value for the farm

Landscape (+)	Economy (+/-)
Conscious care for plants, wildlife and biotopes supports landscape	Landscape activities take time and cost money, but can be used for marketing

Implementation

In a German research project farms were investigated that integrate nature conservation approaches into their practice (Van Elsen et al., 2003b, 2004). The results show that the motives of the farmers are intrinsic to the individuals' characters. Individual experiences in their personal history have built the background of their attitude towards care for the wildlife and nature on their farmed land. Their relationship to nature is especially important. Two types can be discerned, one of which is an "intimate" relation to nature, which is characterized by a close connection to nature and landscape including feelings and the ability of "living within". The other type is characterized by a "more distant" relationship to nature. With respect to the reasons for those who act, again two types can be found: On the one hand the protection of endangered plant and animal species and biotopes for their own sakes, and on the other hand a phenomenological approach, one that considers things only for their importance to human consciousness; both still have a strong connection and reflection of a person's own experiences. These latter farmers rather have the whole farm in their mind, and for them, aesthetic criteria and the process of perceiving and taking decisions are at least as important as the measures themselves. Advice and communication within seminars can support these inner desires of farmers to care for the landscape

Impact on landscape/biodiversity

When farmers are asked what practical measures they took to develop the landscapes of their organic farms, the first thing that comes to mind is usually the planting of hedges. Hedges develop as 'linear woodland margins' into exceedingly valuable biotopes that provide habitats for many plant and animal species. Many other habitats can also be redeveloped using limited resources. Dry stone walls built with stone gathered from the fields and left to develop vegetation spontaneously provide a particular microclimate for animal species requiring warmth. A newly established pond in part of a field, (where otherwise each year the tractor gets stuck in the mud!), is a magnet for all sorts of creatures that are driven out of the cultivated areas. Such measures can allow scope for further developments, i.e. to give back to nature some room for maneuver. The formation of pioneer biotopes and areas of successional vegetation on which plants are free to develop without intervention, grassland subject to drainage reversal and newly established ponds or lakes all offer such development potential. Where for legal reasons the establishment of hedges for dividing large fields is problematic, it is nevertheless possible to introduce species rich 'flowering strips' with annuals or perennials.

Impact on farm economy

On the investigated farms these 'landscape measures' had been carried out despite the fact that the farmers had to spend time and money. In some cases, agri-environmental schemes could be used to support implementation, but there are also cases where organic farmers are trying to go beyond the familiar uses of hedgerows as support for beneficial insects or as protection from erosion – for instance by using leaves and branches of the shrubs as a valuable supplement to winter fodder, as was the case in the past. In doing so they are also reviving old techniques such as pollarding and coppicing. Further landscape development options with timber include planting single trees and the establishment and management of meadowland orchards of standards (long-stemmed trees). The use of hedgerows for biomass will certainly be an issue in the future. Also some of the farmers use their landscape activities for marketing purposes to convince consumers to buy products that have been produced in a species rich landscape.

Case study

The results of bottom up activities at farm level depend on the interests and values of the farmers, but also on the different landscapes in which the farms are situated. Two quite different examples are Surcenord Farm in the French Vosges Mountains, and Medewege farm in Northeastern Germany.

Surcenord Farm is an organic grassland farm founded in 1978. The farm is situated on about 100 ha of largely sloping land at 850-1140 m amsl in the Vosges. It is managed as pasture and mowed for forage. The management of Surcenord Farm is working to open the landscape, part of which has become scrubby with broom, by planned clearing. Farmer André Frommelt stresses that they are of course not trying to revert to the 'monotony' of the bare hillsides that was there at the end of the 19th century but rather that they value a 'diversity of habitats' on the land they manage and strive to "maintain and further develop" them. During tree-felling, individual pines, firs, rowans, junipers, dogrose and whitebeam are preserved. The fellings are used in the woodchip central-heating system which meets all the heating and hot water requirements of the living accommodation and the farm buildings.

Medewege Farm is a biodynamic farm of 80 hectares outside the gates of Schwerin in eastern Germany. Recently, 150 additional hectares have been leased, 120 of which are adjacent. The process of landscape development by using participatory methods is described in the second innovation of this chapter.

Figure 7.1.1(1). Organic farmer proud of his pond

Lessons learned

Realizing that nature and landscape development is a value for the farm can be the starting point for a bottom up process of landscape development on farm level. The farmer needs help and advice; examples show that landscape elements can sometimes support the farm economy, but usually depend on financial support.

Activity/Practical Demonstration

The starting point in Medewege was a huge undulating glacial grain field, lacking all structure except for a few dried up kettles (glacial depressions). It would have been easy to plan the crop rotation and subdivisions of the surface area from a desk. However, one of the cultivators decided to really meet this new piece of land by organizing a seminar. The seminar started with basic exercises helping participants to become aware of the process of perception and the role of different backgrounds, professions and worldviews when deciding which measures should be taken into account.

By experiencing of the special character of the landscape there emerged overriding perspectives for what concrete measures might be meaningfully taken in that context – it is "dialogue" between the people responsible, the landscape and its potential. The planning process that was followed, with the different people involved, is described in the second innovation of this chapter.

Figure 7.1.1(2). Hedgerows can be used as dairy fodder.

Figure 7.1.1(3). Field on Medewege farm.

Figure 7.1.1(4). The Surcenord farm. (Picture: A. Frommelt).

Recommended reading

- Köppl, K., van Elsen, T. (2005): Kulturlandschaft durch Ökologischen Landbau im Saint-Amarin-Tal (Südvogesen). –In: van Elsen, T. (Hrsg.): Einzelbetriebliche Naturschutzberatung – ein Erfolgsrezept für mehr Naturschutz in der Landwirtschaft. Beiträge zur Tagung vom 6.-8. Oktober 2005 in Witzenhausen. FiBL Deutschland e.V., Witzenhausen: 164-178.
- van Elsen, T. (2000): Species diversity as a task for organic agriculture in Europe. – Agriculture, Ecosystems & Environment 77 (1-2). Special Issue: „Criteria for sustainable Landscape Development": 101-109. Elsevier, Amsterdam/ Lausanne/ New York/ Oxford/ Shannon/ Tokyo.
- van Elsen, T., Röhrig, P., Kulessa, V., Schreck, C., Heß, J. (2003): Praxisansätze und Naturschutzpotenziale auf Höfen des Ökologischen Landbaus zur Entwicklung von Kulturlandschaft. – Angewandte Landschaftsökologie 60, Bonn, 359 S.

Recommended websites

- www.naturschutzberatung.info
- www.uni-kassel.de/Frankenhausen

Innovation 2

Integration of people from outside the farm into a participatory process

Landscape	Economy
Working together supports the development of the landscape	Participatory processes take time, but deliver solid base

Implementation

At the Medewege farm seminar several experts were brought together. At the start one exercise involved participants abandoning their own worldview and observing the landscape in relation to its mineral, plant, animal and human aspects. It is clear how much can be gained from studying the landscape in a consciously one-sided way, unprejudiced by your usual viewpoint. It is always exciting to see how strongly the reports of the groups differ when exchanging experiences on the observation of the landscape. Of course that depends also on the season and the composition of the landscape that is used for such an exercise. A second step involves sketching the shape of the terrain (see figure 7.1.1(5). & 7.1.1(6).). After initial perplexity when faced with such an apparently unstructured area, sudden discoveries included: "It is not one solid area at all"; it is "amazingly diverse"; "we walked through different landscapes". Later the group occupied themselves with one of the kettles (depressions left by melting glaciers in the ice age), which was looked at from any perspective desired. Participants "learned to value the place a little"; "before, I thought, there is no starting point here, it is dried up anyway and no longer intact, one might worry about it later"; "How can the special qualities that I value in it be encouraged, so that it develops? How do we maintain this objective in spite of all the other daily necessities on the farm?"; "How can shaping the new area become a shared aim of the farm community?"

Impact on Landscape and Biodiversity

The exercises described in the implementation lead to new consideration of aspects of the landscape: A kettle in the field – is it a "place offering relief to drive around when plowing"? What about the "qualities in the surroundings" which affect cultivation? Apart from the adjacent meadowland brook and the telegraph poles, the kettles offered the only starting points for shaping the landscape. Many questions and new perspectives recorded above emerged from the short but intensive grappling with the kettle: these were very first steps and attempts to take the Genius Loci of the landscape seriously, no matter how depleted it is, taking one's starting point from one's own sensory impressions and beginning with the atmosphere, whose development is what counts! Landscape will be enhanced as a result of such a change in attitude of the farmers.

Impact on farm economy

The decision of the farmers to plan their new piece of land in a participatory way needs more time than a conventional top down planning process. Despite that there are several advantages: many different people and experts add their points of view, and so a solid base for further development is gained. Medewege farm was strongly supported by people from outside the farm even after the seminar had ended, so there certainly was compensation from an economical point of view as all the experts helped without requiring financial support. Although this cannot be generalized, it shows that it is possible to include people from outside the farm into such 'bottom up' planning processes.

Case study

The example of Medewege farm shows the potential of landscape development in a bottom up way on farm level. Farmers need support and advice to manage such tasks. Another example is the Adolphshof farm in northern Germany. Young farmers took over an organic farm with a long tradition of landscape care. In this case many people are involved in the landscaping: ornithologists who map the birds every year, the hunters who care for the hedgerows, and customers and friends of the farm that care for the orchards and ponds. On this farm a similar planning process took place. The question arose of whether a rather large field should be divided or enriched with another hedgerow. During a landscape seminar several exercises to perceive the special qualities of this landscape were carried out. Whilst at the start almost everyone agreed with planting another hedgerow, after the exercise it became clear that vertical not horizontal structural elements were lacking in the landscape. Additionally the farmers agreed to build a pond on a wet place on the field where the drainage system had been destroyed. The process at Adolphshof is a good example of how aims can shift after a real encounter with the qualities of a landscape.

Lessons learned

The integration of people from outside the farm into a participatory landscape planning process puts the task of preservation and development of biodiversity on additional shoulders. It helps the farmers to widen their perspective.

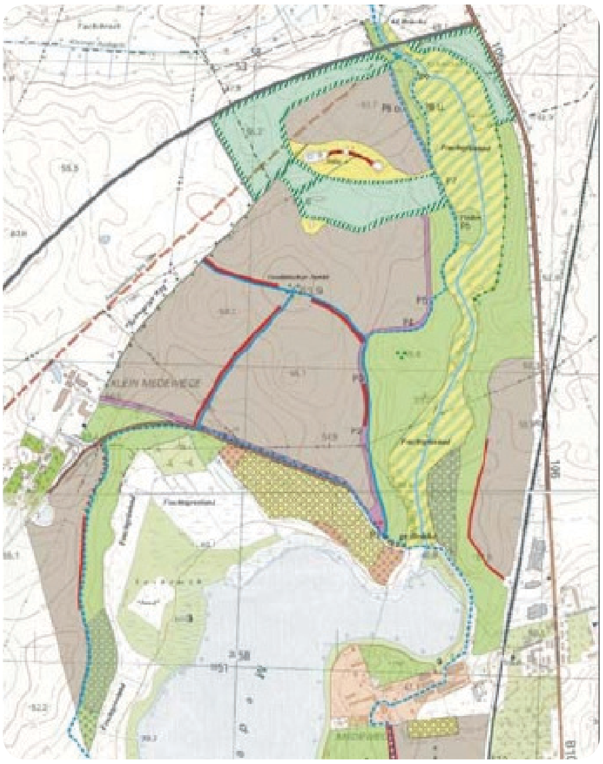

Fig. 7.1.1(5). Medewege farm. Map of a new field

Activity/Practical Demonstration

In general landscape seminars can support such processes. The aim is always to perceive landscape and its qualities anew. Many exercises have been developed by PETRARCA, the European Academy for the Culture of Landscape. For many years the pioneer work of the 'Landscape Weeks' at the Science Section of the Goetheanum in Dornach, Switzerland have contributed to the development of a new approach to nature which is appropriate for our time. Apart from Switzerland, these practical study weeks instituted by Jochen Bockemühl have so far taken place at various venues in Germany, Hungary, Russia, Norway, France, Scotland and the Netherlands. Each one involves observation exercises on the landscape and its development in order to create new connections or contexts through practical study. They are carried out at the locality together with the people and working groups who are concerned with nature and its development. To look at some examples, visit the website listed below.

Fig. 7.1.1(6). Planning the landscape in Medewege (picture: E. Grundmann)

Recommended reading

- Bockemühl, J. (Ed., 1992): Erwachen an der Landschaft. Naturwissenschaftliche Sektion, Goetheanum, Dornach/CH.
- van Elsen, T. (2002): Partizipative Landschaftsentwicklung im Ökologischen Landbau – Fallbeispiele und Entwicklungsperspektiven. – Nachhaltige Regionalentwicklung durch Kooperation – Wissenschaft und Praxis im Dialog. Culterra 29: 230-234, Freiburg.
- van Elsen, T., Grundmann, E., Goebel, T. (2003): Landschaftsentwicklung mit dem Ökologischen Landbau – das Beispiel Hof Medewege (Schwerin). – Beitr. 7. Wiss.-Tagung zum Ökol. Landbau: 583-584, Wien.

Recommended websites

www.petrarca.info

8. The Biodiversity and Landscape Management Plan

8.1. General Introduction

Farms function within and as part of a surrounding ecosystem. Understanding where the farm is positioned in relation to natural processes like drainage and wind patterns and the presence of wildlife and vegetation communities is essential in developing an effective plan to foster biodiversity. By carefully gathering information and planning, farmers can implement practices that provide highest returns in ecological services to their farming operation while restoring native species and ecosystems.

Assessing How the Farm Fits Into the Context of the Larger Landscape

The first task is to determine where the farm is situated in the watershed. Topographic maps are useful tools in acquiring this information. They are generally available through local government and resource conservation agencies. Besides water and wildlife movement, the locations of the nearest wildlands, open spaces, waterways, and protected areas should be identified. It is also helpful to research what species lived on the land prior to farming, and to document what wildlife and dominant plants are currently present. Locating the nearest intact ecosystem that resembles the land's original state and taking note of its natural communities can be a good means of reaching this objective.

The next step is to create a farm map or obtain an aerial photo of the land. Different types of cover, such as hedgerows, grassed waterways, brushy draws, wetlands, and woodlands, are delineated, which combine to form travel lanes for wildlife. Isolated areas that are not connected to other habitats are noted as are: hydrological and drainage conditions, invasive species, perennial cover, topography, soils, eroded areas, and special habitats like those used by priority species. Wildlife has different needs; providing a mix of habitat ensures wildlife diversity. Learning priority species' requirements, such as how much territory they need, what kinds of food they eat, and where they find cover, can help streamline the farmer's approach. Marking different habitat cover on the map is a helpful way to identify actions for improving habitat management. This information can be used to assess the farm for opportunities to support priority species and habitats, migration and movement of native species, and ecosystem processes in the watershed. Conservation goals on the farm should reflect the conservation needs of the greater bio-region. Regional priorities should be assessed in the broadest context by learning about highest priority species, natural communities, and ecological processes that require protection or enhancement, and regional invasive species that threaten natural areas. Discovering biodiversity conservation actions being taken by neighbors and organizations in the area can help farmers determine what they might contribute to or become leaders in a biodiversity strategy for the landscape. The United Nations Environment Program (UNEP) is a good resource for gathering ecological information pertinent to a specific region.

Whole Farm Biodiversity

Actions can be taken to increase biodiversity that will directly benefit the farm. Providing habitat for pollinators, insect predators, pest-eating birds, bats, and four-footed creatures can ensure that the farm receives their essential services. This can be achieved in part through constructing bird, bat, or bee boxes. Installing sequentially flowering native shrubs, hedgerows or windbreaks supports beneficials, and can be placed in unused areas such as field corners, and along roads and fence rows. Optimally, wide swaths that link to natural areas on and off the farm would be planted; maintaining or restoring native trees, dead snags, shrub and grass areas that provide natural roosting, nesting, denning and foraging sites. In addition, refuges of open ground can provide habitat for native ground nesting bees. The competing needs of crops, livestock, native species, and riparian ecosystems should be considered when using water on the farm. Practices that will help attain water conservation goals may include planting regionally appropriate crops, using irrigation systems that conserve water, managing water for priority species, retaining or restoring vegetated riparian buffers and wetlands, and protecting or improving the natural hydrology and ecological function of riparian areas. By using structurally diverse vegetation composed of trees, shrubs, grasses and forbs specific to the site, a multitude of wildlife can be supported, stream banks can be stabilized, and water will be naturally filtered of pollutants.

Managing for Biodiversity in Cropland Areas

A variety of farm practices can be geared towards accommodating the needs of wildlife. For instance, a farmer might use companion planting or intercropping to increase field diversity. Choosing to plant a variety of crops as opposed to just one or two can achieve a similar purpose. Cover crops can supply green browse and beneficial insect habitat, and can provide erosion control and wildlife cover. Fallow fields can be allowed to flood, if appropriate, providing habitat for waterfowl and shorebirds. Wildlife-friendly fences can be built to surround the crop fields only instead of the whole farm, thus providing a safe route for wild fauna. Adapting fences to be shorter in places of known migration routes, and using smooth wire instead of barbed, can make them easier and less dangerous to cross. When the farmer is only really concerned with excluding large animals, fences should allow passage for small ones. Farm activities can be scheduled with wildlife in mind. This can include avoiding disturbance of nesting, denning and spawning species during breeding season. If there are potential reproductive sites in non-crop vegetation that are slated for clearing, it is better to mow the sites before the species becomes established. Other strategies involve timing mowing and tilling practices. Some refuge can be present at all times when field grasses or cover crops are alternately mowed. By growing late-maturing hay, mowing can be done after grassland birds fledge. If the land will be left fallow after harvest, a portion of food and cover can be left behind in designated fields, ideally in patches or strips near native cover.

Water contamination can be prevented by contouring crop rows, planting grasses in roads and ditches, and placing sediment basins at the low end of fields to stop eroding sediment from leaving the farm. Eroding stream banks are protected with bio-engineering, which uses vegetation, soil and rocks instead of steel and concrete to stabilize the site. Nutrient pollution is avoided by

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calculating the fertility needs of crops and only applying amounts of the appropriate specific soil improvers needed there that can be taken up. Composts are stored away from waterways or wells to avoid contamination. If invasive plant or animal species are present, especially ones that threaten natural areas, taking actions to control them is fundamental to biodiversity management efforts. Learning which invasive species are on or around the farm is a critical first step. It is equally important to use weed and pest-free seed, planting stock, soil amendments, and mulches. If invasive species are not present, monitoring for new introductions should be done in order to prevent their spread. Upon detection, they should be immediately eradicated before they expand and become much more difficult to control. Once established, a variety of organic methods are available for suppressing invasive populations.

Livestock and Biodiversity

When livestock are involved, it is important to protect healthy, vegetated riparian areas and sensitive habitats. Ways of accomplishing this include preventing bank erosion, fencing to minimize impact to habitat, and controlling access to sensitive areas. If access to water is needed, a fence chute across a stream can be placed to restrict livestock impact. To help disperse livestock from riparian areas, food and mineral blocks are placed away from natural water sources, and off-stream water troughs are installed. Pasture or rangeland improvement is another important consideration. Guarding against overgrazing, reseeding and protecting trampled or eroded areas, planting native pasture, employing an ecologically sound grazing system, and controlled burning to eradicate weedy species (never as part of a slash and burn scenario) are some of the tools available. A variety of wildlife friendly management practices can be employed. Predation pressure from native carnivores can cause conflict, but by enlisting the services of guard animals, scheduling grazing when predators are less likely to be in the area, and housing livestock in protected areas at night, this potential tension can be alleviated. Making frequent and unpredictable appearances and herding large animals with smaller ones can also help. The circumstances of a livestock death should be recorded with an eye towards informing future management decisions. Non-predatory wildlife, such as native grazers, should be allowed to co-exist with livestock, as should all priority species.

Harvesting From the Wild

When harvesting from wild areas, collections should be made from stable and sustainable populations and environments. Collections should not threaten the existence of priority and other native species or special habitat areas. Erosion and the introduction of non-native invasive species need to be prevented. Effort should be made to determine if others are harvesting from the same resource, so that harvests can be coordinated to prevent negative ecosystem impacts.

Devising a Roadmap to Biodiversity

Prior to breaking ground on any conservation measures, the biodiversity and landscape management plan should clearly define goals, expectations, and a timeline for implementation of conservation practices. The plan should discuss how the operation would refrain from harming existing biodiversity resources and how the prioritized, economically feasible actions and practices that benefit biodiversity will be implemented over the short and long term. Another important step is ensuring the economic feasibility of conservation efforts. A variety of incentive programs are in place to assist farmers interested in promoting biodiversity. Help may be found with planning and implementation, such as habitat conservation programs, easements and green payments through local or national political agencies or through non-governmental organizations. Ecosystem dynamics are anything but static and the management plan should reflect that reality. Monitoring and revision goes hand-in-hand with creating the plan. A strategy for evaluating the success of the biodiversity practices should be implemented, a timeline determined, and the frequency for monitoring scheduled. Before and after photographs; water quality analysis; and plant, mammal, bird, reptile, amphibian, or insect surveys are all techniques helpful in assessing biodiversity successes. The monitoring should help determine whether the natural resources of the farm or surrounding area have benefited from the conservation measures. The plan, priorities, and timeline should be periodically reviewed and revised based on conditions and management results. Supporting farm biodiversity bolsters the land's resilience and benefits any associated natural areas. Preserving or maintaining natural processes like fostering pollination and stabilizing vegetation can save time and money in the long run, and the practices advocated here can be implemented in ways that do not interfere with production. Economic interests aside, contributing to regional conservation firsthand and educating others about the experience are valuable and rewarding experiences in themselves.

8.1.1. Making a plan

Introduction

There is a growing demand to improve the guidelines of organic farming and to integrate the task of nature development and the "production of biodiversity and enhancement of landscape quality" into the regulations. However, better landscapes are not produced by better regulations but by farmers who are willing to improve their land, who are convinced of this task, and who change their attitude towards nature. This demands advice and education; it needs a participatory approach and cooperation between landscape planners, farmers and experts from the nature conservation movement. Developing a biodiversity and landscape management plan can be a useful tool to reach that goal. Some important principles that form the biodiversity management plan in Germany are presented below.

Step 1. Assessment of landscape qualities – mapping the status quo

A helpful tool to assess the quality of the cultural landscape is a checklist. In Germany there are different checklists available. Some of them are easy to handle and do not need special knowledge; they can be a useful tool for farmers to become aware of strengths and weaknesses of their way of farming concerning biodiversity in the landscape. The more sophisticated checklists require knowledge of at least important indicator species. The checklists ask questions like these:

- Which kind of valuable biotopes are there on the farmland? Which care do they need to preserve or improve them?
- Is it possible to include landscape elements into farming, like the use of hedgerows for animal nutrition or as fire wood?
- Are there rare species found in these arable fields, meadows and pastures?
- What amount of structural elements exist in the farm landscape compared to the surrounding landscape? What is their quality?

Mapping the status quo is the first step on the way to developing a biodiversity and landscape management plan for the farm. If possible, experts should be included into this task. The farmer should make the most of the opportunity to learn from the specialist; the farmer is usually well aware of the different qualities of the land and can help the biologist or landscape planner to become familiar with the landscape.

The result of this first step will be a map of valuable biotopes and also places that could be developed to diverse biotopes.

Step 2. Collecting ideas for improvement

As was illustrated in previous chapters there are several simple ways to improve biodiversity on the farm.

Step 3. Forward from the status quo: ideas on managing the diversity in the landscape

The list of practical biodiversity measures that are possible is intended to be a compilation of ideas. Based on the mapping of the status quo, a ranking of priorities can be done, and thus the appropriate measures for these particular circumstances determined. The following questions have to be considered:

- Which of the mapped species and biotopes are in urgent need of preservation or increase?
- Which of the ideas mentioned above fit into the Genius Loci of the cultural landscape?
- How can the management be financed? Which sources of support exist? Is there special machinery needed?
- How can measures be integrated into the time schedule of the farmland management?
- Who can be integrated into the realization of the measures? Who might be interested in helping?
- How can the success of different interventions be monitored?

In most cases a step by step approach is useful. The management plan should be adapted when new aspects or problems occur.

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Case study

Hofgut Oberfeld: An example of a participatory approach developing a landscape management plan is that of Hofgut Oberfeld in Southern Hessia (Germany). The 100 ha arable farm is situated near the city of Darmstadt. An initiative involving the public was begun as the farm converted to organic. When the conversion process started, it became clear that a conscious landscape development should be integrated into it. Four landscape seminars were planned to involve everyone who was interested in the topic. The farmers, nature conservation experts and other interested members of the public gathered. Each of the five hour long work sessions started with exercises to bring out perceptions on qualities of the cultural landscape. Between the meetings special topics were discussed by sub-groups, e.g. the question of where to build a new glasshouse and how to integrate it into the landscape. Other topics were on the integration of permanent biotopes and the mowing regime on grassland. As many aspects had to be taken into account, one measure that could be easily implemented as a first move was the creation of flower strips.

As a result of the meetings a plan for managing the landscape to protect and increase biodiversity is being developed.

Fig. 8.1.1(1). Mapping the status quo of the farm.

Fig. 8.1.1 (2). Flowering strips, the first measure implemented at oberfeld

9. Terms and Glossary

Autochthonic	Originating where it is found; indigenous; endemic.
Biodiversity	Includes variety in all forms of life, from bacteria and fungi to grasses, ferns, trees, insects, and mammals. It encompasses the diversity found at all levels of organization, from genetic differences between individuals and populations (groups of related individuals) to the types of natural communities (groups of interacting species) found in a particular area. Biodiversity also includes the full range of natural processes upon which life depends, such as nutrient cycling, carbon and nitrogen fixation, predation, symbiosis, and natural succession.
Biotic/abiotic	Consisting of living organisms. An ecosystem is made up of a biotic community (all of the naturally occurring organisms within the system) together with the physical environment; hence abiotic – non living. The abiotic factors of the environment include light, temperature, and atmospheric gases.
Connectivity	The degree to which patches of habitat link to one another, allowing organisms and natural processes (e.g., fire and water flow) to travel between the patches.
Conservation network	A system of land and water managed for the primary purpose of conserving the representative ecological attributes of a region. It often includes lands used for such purposes as recreation and agriculture as long as ecological values receive special consideration. The network is configured to support native species and sustain the natural processes that clean our water and air and maintain thriving, diverse, natural ecosystems. Networks should include large core reserves— wilderness— linked by wildlife corridors and buffered by farmlands.
Ecosystem	A biotic community and its abiotic environment.
Ecosystem functions	A set of biophysical conditions and processes whereby an ecosystem maintains its integrity (e.g., primary productivity, food chain, biogeochemical cycles, etc.). Ecosystem functions include such processes as decomposition, production, nutrient cycling, gene flow, and disturbance.

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Ecosystem services	The beneficial outcomes that result from ecosystem functions (e.g., cleaner water, pollination, and reduced human health and ecosystem risks). These require some interaction with, or at least some appreciation by humans, but can be measured in physical terms (e.g., water quality, crop set, and human health).
Edaphic	Relating to the soil; also plant communities that are differentiated by their soil habitat rather than climate.
Endangered species	Species in danger of becoming extinct within the foreseeable future throughout all or a significant portion of their range.
Eutrophication	When a water environment becomes enriched with chemical nutrients, this can cause growth of micro-organisms which then affects the eco-systems by depleting the oxygen, blocking out sunlight and sometimes releasing toxins.
Genius Loci	A location's distinctive atmosphere, or the spirit of a place. In landscape architecture, this is the principle that landscape designs should always be adapted to the context in which they are located.
Habitat	The natural environment for the life cycle and growth of an organism.
Invasive species	Species that spread from human settings (gardens, agricultural areas, etc.) to wild or natural areas. Once in the wild, they continue to reproduce and displace native species, causing biodiversity to suffer. Invasive species are usually but not always non-native (i.e., humans introduce them into an area).
Keystone species	A species whose impacts on its community or ecosystem are often greater than would be expected from its abundance or biomass. Because it makes a significant contribution to the maintenance and modification of its ecosystem, its decline would lead to the decline of many other species. For example, the beaver is not endangered, but it is essential to its ecosystem because it actively expands and maintains the riparian habitats and functions upon which many other species depend.
Migratory species	These reside in more than one location during the year, moving with the seasons (e.g., many birds and some mammals and butterflies).
Natural areas	These are dominated by native vegetation and exist as a natural process of ecological succession.
Native plant or animal	Indigenous (produced, growing, or living naturally in a locale, country, or climate; not exotic; not imported) to a given location.

Priority habitats	Those in need of special conservation attention, usually determined by a state-wide or regional biodiversity assessment. Priority habitats have declined significantly from their historic range. For example, white oak savannas were historically common in Oregon and now only cover 1–2% of their previous range. Priority habitats may also be vegetation types not well represented in existing conservation networks.
Priority species	These are "threatened" and "endangered" species, "species of special concern," and "keystone species."
Riparian area	This is defined as "a zone of transition from an aquatic ecosystem to a terrestrial ecosystem, dependent upon surface or subsurface water that reveals through the zone's existing or potential soil vegetation complex the influence of such surface or subsurface water. A riparian area may be located adjacent to a lake, reservoir, estuary, pothole, spring, bog, wet meadow, muskeg or ephemeral, intermittent or perennial stream."
Ruderal	A weedy plant growing in waste or rubbish, or along the wayside. Ruderal habitats – waste land sites; ruderal communities – those organisms that grow there.
Sensitive habitats	Areas in which plant or animal life or their habitats are either rare or especially valuable. These include habitats containing or supporting "priority" species; all perennial and intermittent streams and their tributaries; coastal tide lands and marshes; and lakes, ponds, and shore habitat.
Sensitive species	Species that are prone to becoming threatened or endangered.
'Species of special concern'	An informal term used by many public agencies to identify species that are potentially at risk, declining in numbers, or in need of concentrated conservation actions to prevent decline; commonly referring to a species or subspecies that has entered a long-term decline in abundance or has become vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance. Categorization as a 'species of concern' generally carries no procedural protections.
Threatened species	Species likely to become endangered in the foreseeable future.

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Biodiversity and aesthetic landscape quality have been essential guiding principles in Organic Agriculture since the beginning of the movement. T However the realisation of concrete measures and visible effects on farms and fields constitutes a permanent challenge.

This present Guide Book is designed to provide substantial support for farmers and advisers. It presents a variety of working prototypes of different innovations from around the world that are able to substantially enhance biodiversity and sensual landscape quality within the economic and agronomic restrictions of a farm. The intention of each example is to inspire, to motivate and to provide information on how to undertake effective measures which work in favor of biodiversity and landscape quality.

To understand how and why the examples work, the chapters explain the most important underlying ecological and agricultural principles, facts and ideas in a comprehensive, easily understandable way.

The book covers a representative variety of farm types, climatic conditions, cultivation methods, conservation priorities, habitats and farming traditions. The more that farmers and advisers understand the potential benefits and effectiveness of the various possible actions, the more they will be able to develop their own solutions, visions and concepts in the particular context of their own farm or region. Accordingly, this guide is not merely addressed to those practising Organic Agriculture, but is appropriate for every form of farm and agriculture.

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