This paper was peer-reviewed for scientific content.
Pages 288-292. In: D.E. Stott, R.H. Mohtar and G.C. Steinhardt (eds). 2001. Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organization Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.

Sustainable Land Use: An Interdisciplinary Demonstration Project in Northeast Germany

T. Kalettka, K. Helming, H. Kächele, A. Khorkov, K. Müller, and H.-J. Philipp*

ABSTRACT

Economically sound agricultural practices often contradict ecological and aesthetic land management objectives. Financial incentive programs are one possibility to promote more sustainable land use practices by identifying sensitive areas and providing financial incentives to landowners for preventing landscape degradation. These incentive approaches require knowledge of the interaction between land management techniques and the natural environment, as well as the determination of ecological standards.

The paper describes a project in Germany involving the creation of a state-administered financial incentive program. The demonstration project for application of this program is the young pleistocene landscape of northeastern Germany. Predominately an agricultural region, the terrain is characterized by 'potholes', or glacial depressions of less than one ha size, which are located within the cultivated fields. Potholes are ecologically important for wildlife habitat and provide an aesthetic feature to the landscape. Due to agricultural runoff and soil erosion processes, the potholes may degenerate to eutrophic levels. The objective of the demonstration project is to prevent the degradation of the pothole landscape from agricultural practices. The project includes the analysis of the major processes that lead to the degeneration of the potholes, the identification of agricultural best management practices to prevent the degradation of the pothole landscape, the determination of the farmers‘ costs for the respective conservation techniques, the surveying and analysis of social preferences for ecological measures, and the identification of financial incentives to implement the conservation techniques. This paper describes the initial results of the ongoing interdisciplinary demonstration project.

INTRODUCTION

Landscapes perform a variety of societal and environmental functions including food production, wildlife habitat, water and air purification, buffering of weather conditions, and recreation. Often the simultaneous demand for various uses results in conflicts, for example, between agriculture practices and environmental functions. The type and degree of ecological degradation which results depends on the applied agricultural production practice as well as the regional natural conditions.

Agricultural production in Germany is foremost determined by European Union political framework conditions that initially had food provision securement as a goal. Today agricultural overproduction throughout the EU region has resulted in the simultaneous demand to conform production to global market conditions as well as ensure farmers‘ welfare. An additional recent objective is the maintenance of biotic and abiotic landscape characteristics through sustainable land use. Sustainable agricultural land use is understood according to De Groodt (1994) as the management of the human use of the land within the carrying capacity of the supporting ecosystem, so that the integrity and proper functioning of its natural processes and components is not impaired. This goal of sustainable land use is often not realized due to subsidy programs that inadequately address the unique local and regional landscape and ecosystem characteristics as well as the negotiation terms of farmers. This dilemma creates the motivation for an interdisciplinary study.

Using the upper pleistocene landscape of northeastern Germany as a demonstration region, the goal of the project is to demonstrate the entire interdisciplinary process from the identification of the specific landscape and its potential for ecological endangerment to the implementation of a financial incentive system for avoidance of ecological problems. The study area is located in the German state of Brandenburg northeast of Berlin.

The study is comprised of five steps: 1. The identification of ecologically significant landscape elements and an analysis of the degradation processes. 2. Development of conservation techniques for agricultural production to avoid impairment of the ecologically significant landscape elements. 3. Calculation of operational costs which result from the implementation of the conservation measures. 4. Identification of the social preferences and financial support for conservation measures. 5. Development of a financial plan for the implementation of the conservation measures. The intention of this paper was to briefly illustrate every aspect of the interdisciplinary approach and its mutual interrelations rather than to detailed discuss specific disciplinary problems of the project.

*T. Kalettka, Dept. Hydrology, K. Helming, Dept. Soil Landscape Research; and H. Kächele, A. Khorkov, K. Müller, H.-J. Philipp, Dept. Socioeconomics, all at the Center for Agricultural Landscape and Land Use Research (ZALF), Eberswalder Str. 84, D-15374 Muencheberg, Germany. *Corresponding author: khelming@zalf.de.

THE ECOLOGICAL LANDSCAPE APPROACH

Conflicts Between Ecological Functions of the Landscape and Agricultural Land Use

The young Pleistocene area in northeastern Germany is characterized by 10 to 100 ha watersheds centered around 0.01 to 1 ha glacial depressions, or 'potholes', formed from post-glacial melting of large blocks of ice. Pothole frequency in this region varies between 0.6 and 40 potholes per km². Runoff and interflowing water from the surrounding watersheds are retained in the depressions due to limited hydraulic conductivity of the underlying pothole soil layer. The pothole water level is of a permanent or periodic nature with fluctuations reflecting the annual precipitation amounts as well as the pattern of summertime water loss when evapotranspiration exceeds precipitation. In this predominately agricultural region, potholes impede tillage activities and farm machinery traffic, and as a result, many have been filled, leveled, and/or tile-drained during the intense agricultural development period since the late 1950's. Consequently, 28 to 88 % of the original potholes in the study region no longer exist. As a result of runoff and erosion from agricultural activities, the remaining potholes experience nutrient enrichment, siltation, and degradation of the surrounding natural vegetation (Frielinghaus and Vahrson, 1998; Kalettka, 1996; Kalettka et al., 1998). In addition, the nutrient enrichment may lead to trace greenhouse gas emissions such as nitrous oxide and methane (Merbach et al., 1996).

In the glacial landscape, potholes are ecologically important as sinks for water and organic matter; moist, natural habitats for wildlife; aesthetic elements; and microclimatic regulatory functions. Due to site variations, potholes have a high structural and species diversity. In northeastern Germany, 275 different species of macrophytes were found in pothole areas, 28 of which are registered on the list of endangered species in Germany. Additionally, potholes provide habitats for species typically found in open landscapes. With more than 12 different species of amphibians observed, ten of which acknowledged as endangered species, potholes are among the most species-rich small, lentic waters in Europe. The preservation of the potholes and their weak eutrophic characteristics is therefore crucially important for the survival of the regional biocenoses. Nature conservation strategies in this region should therefore aim to preserve and re-instate a pothole mosaic with minimal pollutant loads, low eutrophic levels, typical water level dynamics, various vegetational series, and an enhanced pasture and meadow landscape for development of integrated biotope systems (Kalettka, 1996; Luthardt and Dreger, 1996; Schneeweiß, 1996). For realization of these conservation measures, an in-depth understanding of the natural system processes of the various pothole types is of paramount importance.

The agronomic approach: agricultural conservation measures to sustain the ecological functioning of the landscape

Two different strategies are necessary to conserve the ecological functioning of potholes and the glacial landscape: direct measures for pothole restoration and indirect land use conservation measures. The direct restoration aims at reducing nutrient loads of the potholes and re-establishing of the pothole water storage volume. This project focuses on the indirect measures that affect the land use strategies and minimize the transport of nutrients and material matters from the agricultural areas into the potholes. These land use conservation measures (CM) must coincide with agricultural production purposes in the landscape and with the farmers' financial needs. As a major contributing process to organic matter and sediment loadings of the potholes, measures to prevent erosion are among the most important conservation strategies. The most effective erosion prevention technique is the conversion of land use from crop cultivation to pastures or meadows with continuous vegetative cover (below characterized as CM1). This measure implies the greatest restrictions in agricultural production opportunities, but at the same time, suggests a synergetic effect with the ecological purpose to develop integrated biotope systems including potholes and meadows. The maintenance of crop cultivation systems requires more appropriate erosion prevention measures, some of which have been found to be effective in the study area. Grassed waterways in the thalwegs (CM 2) and grassed buffer strips around the potholes (CM 3) effectively slow runoff velocity, reducing the risk of ephemeral gully development as well as the sediment load in the runoff water (Kemper et al., 1992).

Silage corn and sugar beet are two typical regional crops used in crop rotations that create the greatest risk for soil erosion. Due to the delayed late spring seeding time for these crops, the soil is exposed for an appreciably long time span. Soil conservationists therefore recommend either substituting these crops with other rotational crops (CM 4) or cultivating silage corn and sugar beet with conservation tillage practices, including inter-crop cultivation during the winter (CM 5), cultivation of undersown (CM 6), and mulch-seeding techniques (CM 7). Using these techniques, continuous soil cover is ensured and the risk of surface sealing, runoff generation, and soil erosion is minimized (Frielinghaus et al., 1992; Roth and Helming, 1994). The specific costs of these conservation techniques should be evaluated for financial incentive strategies for land use conservation purposes.

THE ECONOMIC APPROACH

The Costs of Agricultural Conservation Techniques at the Individual Farm Level

The implementation costs of the agricultural conservation measures (CM1 – CM7) were calculated for two typical farm types. The economic consequences of the implementation of the suggested techniques with respect to the change in agricultural production technology are estimated by analyzing the marginal costs and benefits, inclusive of European Union subsidies (MELF 1997). Additional administrative costs, which may arise from the implementation of the techniques, were not considered.

The calculations were made for two farm types located in a region with average soil quality according to a national soil quality estimation (Table 1). Type A is a cash crop farm and Type B a combined cash crop / dairy farm. Without

Table 1. Definition of the reference scenario for calculating the economic effects of conservation measures.

Farm type	cash crop	cash crop and dairy
Site quality	mean value in national soil quality estimation	
Original crop rotation	wheat / sugar-beat / rye	wheat / silage-corn / rye
Prices and subsidies	according to the situation in 1998	
Compulsive rate of set aside land	10 %	
Average gross margin	533,- EUR ha^{-1}	527,- EUR ha^{-1}

agricultural conservation measures, the gross margin of the agricultural production is 533 EUR ha^{-1} for Type A farms and 529 EUR ha^{-1} for Type B farms (1,- EUR approximates to 0,9 to 1,- US $). The calculations were based on EU-regulated prices and subsidies in 1998 (BML 1998a; BML 1998b). In this context, subsidies for grain production (240,- EUR ha^{-1}) and for set aside land (308,- EUR ha^{-1}) are of primary importance.

Converting the arable land in the pothole area to grassland (CM 1; for our purposes, half of the entire area was included in the calculations) results in an income loss of 211 EUR ha^{-1} for Type A and 175 EUR ha^{-1} for Type B farms (Table 2). Costs are reduced considerably by introducing grassed waterways (CM 2). Then, only 15 % of the arable land has to be converted into grassland. The reduction of the gross margin, most significantly as a result of difficulties in cultivating the remaining arable land (Henning 1999), is about 41 EUR ha^{-1} for Type A or 36 EUR ha^{-1} for Type B farms. The creation of pothole buffer strips (CM 3) requires converting only 5 % of the arable land and may be realized by shifting the obligatory set aside area around the potholes. Therefore, this activity results in marginal costs of approximately 3 EUR ha^{-1} for both farm types.

By altering the crop rotation near the potholes for soil conservation purposes, summer row crops with high erosion potential, such as sugar beet (Type A) or silage corn (Type B), are replaced by winter cultures, such as canola or grass/clover mixtures. This change in the crop rotation (CM 4) creates a gross margin reduction of 49 EUR ha^{-1} for Type A and 96 EUR ha^{-1} for Type B farms. Some conservation practices are oriented towards a change in the production system through conservation tillage practices including mulch-seeding techniques and inter-crop cultivation. The cultivation of intermediate crops (CM 5) reduces the gross margin by 30 EUR ha^{-1} for both types of farms; the cultivation of undersown (CM 6) reduces the gross margin by 41 EUR ha^{-1} for Type A or 5 EUR ha^{-1} for Type B. Conservation tillage (CM 7) results in costs of approx. 50 EUR ha^{-1} for both types of farms. In summary, the calculations show extreme differences in agricultural conservation costs between the discussed alternatives (Table 2). The loss of gross margin varies between 221 EUR ha^{-1} and 3 EUR ha^{-1}. This result emphasizes the importance of a problem-appropriate choice of conservation measures that address the prevailing situation in the research area. Implementation of the appropriate measures, however, requires a change in the farmers' behavior that may be achieved through land use requirements and restrictions or according to economic theory by creating economic incentives to compensate for income losses.

Table 2. Opportunity costs of different conservation measures on an individual farm level

Conservation Measure	Opportunity Costs on Individual Farm Level			
	Cash Crop Farm		Cash Crop and Dairy Farm	
	EUR ha^{-1}	%	EUR ha^{-}	%
(CM 1) conversion of 50 % arable land to grassland	211	39.6	175	331
(CM 2) grassed waterways on 15 % of the arable land	41	7.7	36,	61
(CM 3) pothole buffer strips on 5 % of the arable land	3	0.6	3	0.6
(CM 4) altering crop rotation by reducing row crops	49	9.2	96	18.1
(CM 5) cultivation of intermediate crops	30	5.6	30	5.7
(CM 6) cultivation of undersown	41	7.7	5	0.9
(CM 7) conservation tillage	50	9.4	50	9.5

THE SOCIAL SCIENCE APPROACH

Social Preferences Concerning the Sustainable Functioning of Pothole-Inclusive Watersheds in Upper-Pleistocene Landscapes.

The pothole conservation strategy to be developed by our project will be based on the last-mentioned approach (introduction of financial incentives). Consequently, of main interest are the procurement and use of the necessary funds. In the social science part of our interdisciplinary project, the preferences of various population categories with respect to the conservation of watersheds with potholes, as well as appropriate financing strategies, will be empirically investigated. For identification of these preferences, 18 to 75 year old inhabitants of several rural and urban communities in the research area, located north of Berlin, as well as a sample of the 3.5 million Berliners are being interviewed. The applied survey technique corresponds to the contingent valuation method to assess the benefits of environmental protection measures (Cummings et al., 1990; Rommel, 1998).

Centrally positioned in the standardized interviews are questions concerning, first, the financial compensation for ecological measures applied by farms operating within pothole watershed areas, and secondly, the willingness to pay for these conservation measures. The responses to these two areas of interest indicate the respondents' knowledge concerning potholes; their previous experience with potholes; and their ecological, aesthetic, and additional appreciation of potholes. In addition, income level and accumulated assets, nature and environmental protection interest and activity, the agricultural image, and other general characteristics of the interviewees are evaluated. Based on the individual preferences of the approximately 1200 respondents, social preferences will be determined by means of selection and aggregation.

Until now, data from 450 interviews have been processed and initially analyzed. The following are some provisional results:

- Although four-fifths of those 450 persons have had personal experience with potholes (e.g. wild animal observation, hiking in the vicinity, fishing, swimming, and farm work etc.), approximately every other person questioned regarded his knowledge self-critically as insufficient. Those with practical experience with potholes were more likely to have enjoyed rather than to have disliked their time spent there.
- In an image analysis, approximately two-thirds positively judged the potholes with which they were familiar (as aesthetically attractive, naturally diverse, ecologically valuable etc.). Nearly all believed the potholes have more favorable than unfavorable effects on nature and landscape, and, consequently, are worthy of protection.
- The human influences on potholes within the last decades, such as pollution, drainage, and leveling, were overwhelmingly judged as unfavorable. Potholes were most often viewed as slightly, and secondly, as moderately threatened by agricultural production.
- Nearly one-half of the respondents described themselves as hypothetically ready, first, to pay for, and secondly, to voluntarily participate in the maintenance and care of the potholes in the neighboring area, however the majority only to a modest extent. On the other hand, only one in six respondents is ready to participate in financially compensating the farmers for their implementation of protection measures, and if so, almost exclusively through a one-time or an annual amount of up to 25 EUR. The large majority preferred a budget restructuring of the German state of Brandenburg as a financial compensation strategy.

The above-mentioned results suggest that the interviewed population knows and appreciates the ecological benefits of potholes, but few are prepared to financially contribute for pothole protection.

THE POLITICAL APPROACH

Financial Incentives to Sustain the Ecological Functioning of the Landscape

The above-mentioned pothole conservation measures compete with alternative uses for limited funding resources. It is likely that a redirection and further development of the present governmental programs to strengthen ecological conservation efforts will occur. Efficient and effective use of resources, as well as general acceptance by the population, requires determination of the appropriate promotion policies for achieving the desired conditions.

Based on the principal of limited public sector resources, ecological conservation techniques (pothole protection) as well as alternative funding options (opportunity costs) will be considered in funding decision-making. Presently, the agricultural sector and rural areas in the state of Brandenburg are subsidized with about 665 Million EUR annually, 50 Million of which is allocated to general environmental protection projects (MELF, 1998). Specific measures to enhance sustainable land use such as outlined in this paper could be financed by reallocating part of these funds. Those reallocation options would better fit into the standards set by the current WTO negotiations and are part of a broad discussion on a new and more sustainable agricultural policy in Europe. With respect to testing of new concepts, such as the rewarding of ecological achievement in demonstration projects, practical knowledge concerning optimization of limited resources for natural resource protection and rural area development should be obtained. These results provide for further development and refinement of the existing methods and approaches.

CONCLUSIONS

The initial results of the continuing study demonstrate that an interdisciplinary cooperation between landscape ecologists, agronomists, business representatives, sociologists, and politicians is needed to develop a financial incentive system for ecological conservation and agricultural production. Realization of this objective requires consideration of regional initiatives, ecological processes, as well as social and political framework conditions. In this demonstration project, agricultural management strategies that prevent against soil erosion were identified as leading to more sustainable land use and the ecological integrity of the glacial potholes. A participative approach that ensures the consideration of all relevant interests is important to facilitate the successful implementation of the conservation strategies. Only on the basis of such interdisciplinary, regionally adapted, and participative approaches can an appropriate incentive system for rewarding ecological achievements be designed which successfully addresses the conflict between the economic interests of farmers and ecological objectives.

REFERENCES

BML (Bundesministerium für Ernährung, Landwirtschaft und Forsten) 1998a. Die Europäische Agrarreform. Pflanzlicher Bereich für das Erntejahr 1999. 59 pp. (in german).

BML (Bundesministerium für Ernährung, Landwirtschaft und Forsten) 1998b. Die Europäische Agrarreform. Tierprämien. 48 pp. (in german).

Cummings, R.G., D.S. Brookshire, and W.D. Schulze. 1990. Valueing Environmental Goods, An Assessment of the Contingent Valuation Method. Rowman and Littlefield, Totowa, New Jersey.

De Groot, R.S. 1994. Towards indicators for measuring sustainable use of environmental functions. Invited contribution to the session on ‘Indicators of Envionmentally Sound and Sustainable Development’ during the 3rd meeting of the International Society of Ecological Economics: ‘Down to Earth: Practical Applications of Ecological Economics’, 24-28 October 1994, San Jose, Costa Rica, 15 pp.

Frielinghaus, Ma., and W. G. Vahrson. 1998. Soil translocation by water erosion from agricultural cropland into wet depressions (morainic kettle holes). Soil & Tillage Research 46:23-30.

Frielinghaus, Mo., D. Barkusky, and G. Kuehn. 1992. Bewertung von Nutzungssystemen im Hinblick auf den Bodenschutz im nordostdeutschen Tiefland. VDLUFA Kongress, pp. 615-618. (in German)

Henning, C. 1999. Ökonomische Effekte der Stillegung schlaginterner Mindererertragsflächen. Diplomarbeit an der Humbolduniversität zu Berlin. 83 pp. (in German)

Kalettka, T. 1996. Die Problematik der Sölle (Kleinhohlformen) im Jungmoränengebiet Nordostdeutschlands. - Naturschutz u. Landschaftspflege in Brandenburg, Sonderheft “Sölle”, 4-12. (in German).

Kalettka, T., J. Augustin, and S. Wirth. 1998. Pollution, microbial activity and trace gas emissions in riparian areas of potholes in Northeast Germany. 16th World Congress of Soil Science, CD-ROM, Montpellier 19.-26.8.1998, France.

Kemper, D., S. Dabney, L. Kramer, D. Dominick, and T. Keep. 1992. Hedging against erosion. J. Soil and Water Conservation 47: 284-288.

Luthardt, V., and F. Dreger. 1996. Ist-Zustandsanalyse und Bewertung der Vegetation von Söllen in der Uckermark. - Naturschutz u. Landschaftspflege in Brandenburg, Sonderheft “Sölle”, 31-38. (in German).

MELF (Ministerium für Ernährung, Landwirtschaft und Forsten des Landes Brandenburg). 1998. Bericht zur Lage der Land-, Ernährungs- und Forstwirtschaft des Landes Brandenburg 1998. Ministerium für Ernährungs-, Land- und Forstwirtschaft des Landes Brandenburg. 124 pp. (in German)

MELF (Ministerium für Ernährung, Landwirtschaft und Forsten des Landes Brandenburg). 1997. Richtwerte für die Betriebsplanung und betriebswirtschaftliche Bewertung landwirtschaftlicher Produktionsverfahren im Land Brandenburg: Deckungsbeiträge. 76 pp. (in German).

Merbach, W., J. Augustin, Th. Kalettka, and H. J. Jacob 1996. Nitrous Oxide and Methane Emissions from Riparian Areas of Ponded Depressions of Northeast Germany. Journal of Applied Botany 70, 134-136.

Rommel, K. 1998. Methodik umweltökonomischer Bewertungsverfahren. Regensburg, Transfer Verlag. 267 pp. (in German).

Roth, Ch. H., and K. Helming. 1994. Effect of seedbed preparation on dynamics of surface sealing, runoff and interrill soil loss on loess soils. Proceedings 13th Int. Conf. ISTRO, Aalborg, Denmark. Vol. I, S. 117-122.

Schneeweiss, N. 1996. Habitatfunktion von Kleingewässern in der Agrarlandschaft am Beispiel der Amphibien. Naturschutz u. Landschaftspflege in Brandenburg, Sonderheft “Sölle” 13-17. (in German)