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Land Management Alternatives for the Nemunas River Polder Region

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Abstract
In order to design a land management plan that provides a good balance between agricultural production and natural values in the polders, a land management alternatives analysis was conducted for the region. The analysis was based on an integrated database assembled for the polder area and the AGNPS, which was adapted to Lithuanian conditions using modeling techniques. Six polders on Rusne Island were used to represent both summer and winter polder conditions in the model.

Disciplines
Agriculture | Natural Resources Management and Policy

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LAND MANAGEMENT ALTERNATIVES FOR THE NEMUNAS RIVER POLDER REGION

Introduction

The main portion of the Kurðiø Lagoon coastal wetlands is associated with the Nemunas River delta reach that stretches from the Jûra River confluence in the Silutë region to the Kurðiø Lagoon (Figure 1). The flooded delta area is 52,400 ha; agricultural land comprises 75 percent of the flooded area (39,600 ha), of which 80 percent are pastures and perennial hay meadows. There are also 7,700 ha of woodlands and wetlands, 2,000 ha of water bodies, and 3,100 ha of other land covers. Thirty-four polders have been established in the portion of the Kurðiø Lagoon wetland area that belongs to Lithuania (Figure 2). Eighteen are summer polders and sixteen are winter polders; summer polder embankments are protected from summer floods while in winter polder embankments are protection from all floods. Forty-four pump stations, 302 km of embankments, 1,856 km of ditches, 14,430 ha of tile drainage, 1011 culverts and.64 dams have been constructed in the flooded area.

Four years ago, the polders' main production was grass powder. Forty thousand tons of grass powder, consuming 300 to 500 kg of liquid fuel per ton produced, were sold every year. When diesel fuel prices increased more than 1,000 times, grass powder production became unprofitable and the processing plants were closed.

Forty-six villages with 3,285 total inhabitants are located in the polders. Most are in the winter polders (Rusne, Skirvyte and Uostadvaris), or on the uplands of the summer polders. When the agrarian reform began, some polder land was distributed, but the majority remains state land. One thousand forty-four farmers occupied 25 percent of the polder land (6685 ha). The land was rented to 46 agricultural companies and householders (however, the land use distribution is not yet stabilized). Only one-third of the meadows and pastures were mowed and grazed in 1995. The most intensive use was in winter polders and in summer polders close to private homes. The current lack of stability in land use and occupancy presents an opportunity to intervene with sound management planning to safeguard environmental quality, both in the delta region and in the Kursiø Lagoon.

Coastal lagoons and wetlands are of critical importance as "multi-purpose ecosystems," and this function is now clearly recognized. These habitats serve as important pollution buffers for the Baltic Sea by acting as natural traps and filters and also provide variable levels of of biodegradable waste treatment. They also provide critical habitats for a rich diversity of flora and fauna, including several endangered species and many species of migratory birds. The development of management plans for coastal lagoons and wetlands in the Baltic region is an important component of the Joint Comprehensive Environmental Action Program adopted by all countries around the Baltic Basin in 1992. The HELCOM convention announced a decision by the Baltic Basin states to reduce the 1987 nitrogen runoff level by 50 percent.

Our analyses of agricultural water pollution show that the most nitrate nitrogen (40,000 tons) transported to the Kurðiø lagoon and Baltic Sea was in 1992. Nitrate nitrogen runoff has stabilized over the last two years and currently averages about 30,000 tons per year.

In order to design a management plan that provides a good balance between agricultural production and natural values in the polders, we conducted a land management alternatives analysis for the region. The analysis was based on an integrated database assembled for the polder area and the Agricultural Nonpoint Source Pollution Model (AGNPS), which was adapted to Lithuanian conditions using sophisticated modeling techniques provided by U.S. participants. For the modeling effort, we selected six polders on Rusne Island that represent both summer and winter polder conditions (Figure 2).

We understand that land use changes in the River Nemunas delta reach cannot make a great impact on Kurðiø Lagoon water quality, because the polder area is only 0.53 percent of the Nemunas River watershed. The main watershed pollutant sources are municipal and industrial wastes; however, pollution from the polder area is significant because it flows almost directly into the Kurðiø Lagoon. In addition, pollutants from upstream sources flow through the polders; wetlands can, to some extent, buffer their effects in the lagoon. Therefore, land use improvements in the polders can initiate water quality restoration in the Kurðiø Lagoon.

Nitrogen, Phosphorus and Chemical Oxygen Demand (CHOD) in Rusne Island Polders in 1989 and 1994

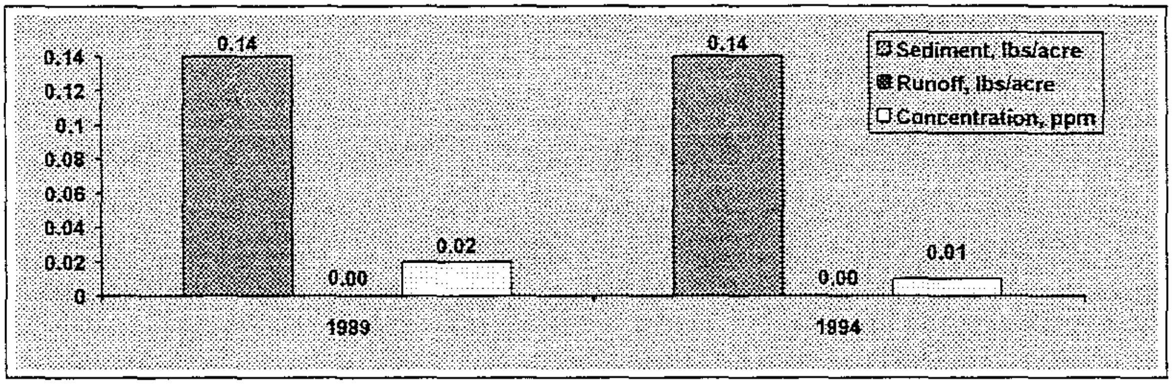
To assemble initial and input data for the AGNPS model, we used 1:10,000 scale base maps of roads, polder boundaries, settlements, farmsteads, pump stations, banks, ditches, topography, soil and land use. The AGNPS model was adapted to Lithuanian conditions as described in the first report in this series. Input data sets were assembled from the mapped data described above and from relevant hydrological and meteorological tabular data. Models were created for two scenarios: high agricultural production in 1989 and low production in 1994. We used AGNPS model version 5.0. Two winter and four summer polders with various agricultural activities were selected for modeling (Table 1).

Table 1. Characteristics of the Rusnë island polders

Item Type	Pakalne Summer	Rusne Winter	Skirvyte Winter	Uostadvaris 1 Summer	Uostadvaris 2 Winter	Vorusnë Summer
				acres		
Watershed area	1363.44	2370	326.04	3515.5	98.8	1966.12
Cell area	9.88	39.5	9.88	39.5	9.88	9.88
Storm precipitation	2.57	2.57	2.57	2.57	2.57	2.57
Storm energy intensity value	27.1	27.1	27.1	27.1	27.1	27.1
Nitrogen in precipitation	1.95	1.95	1.95	1.95	1.95	1.95
Outlet cell number	59	30	2	2	6	32
Calculated runoff volume (inches)	0.23	0.76	0.78	0.49	1.85	0.36
Peak runoff rate (cfs)	81.23	343.14	95.54	862.89	94.93	114.43

First we compared nitrogen, phosphorus and CHOD runoff for the same polder in 1989 and 1994 (Figures 3 through 8).

Nitrogen



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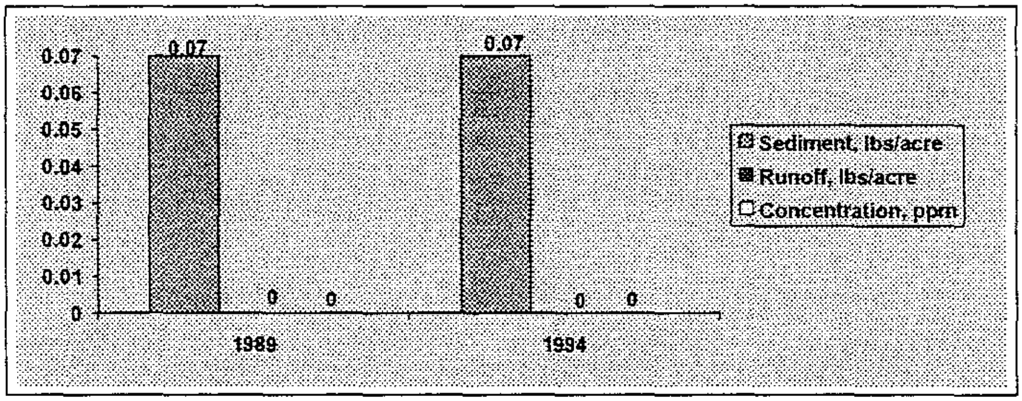


Soluble CHOD

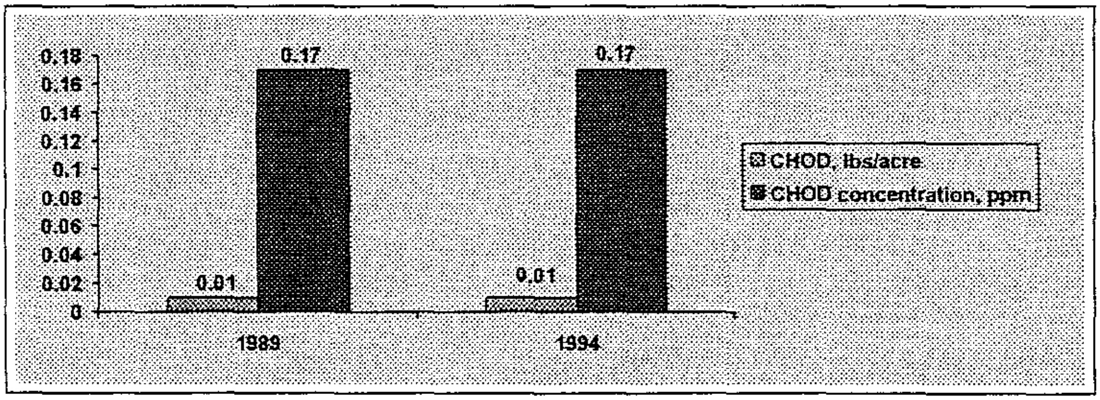
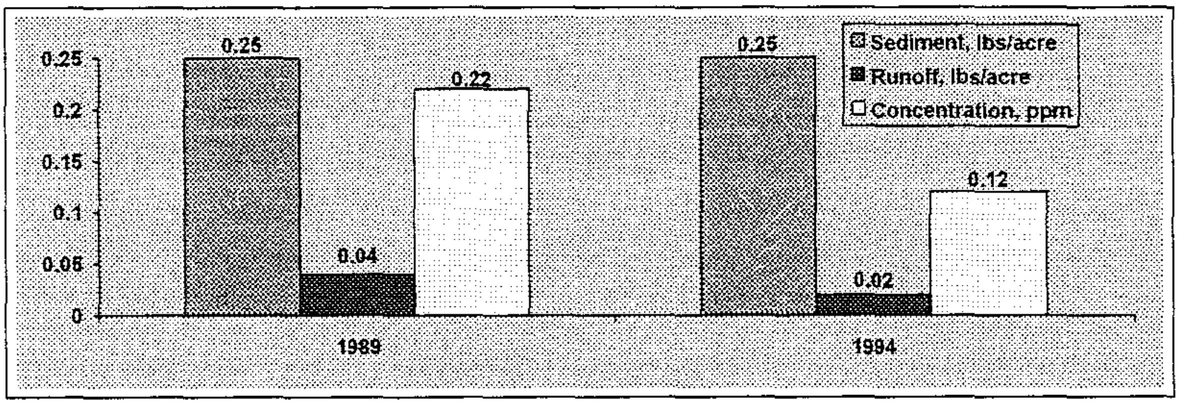
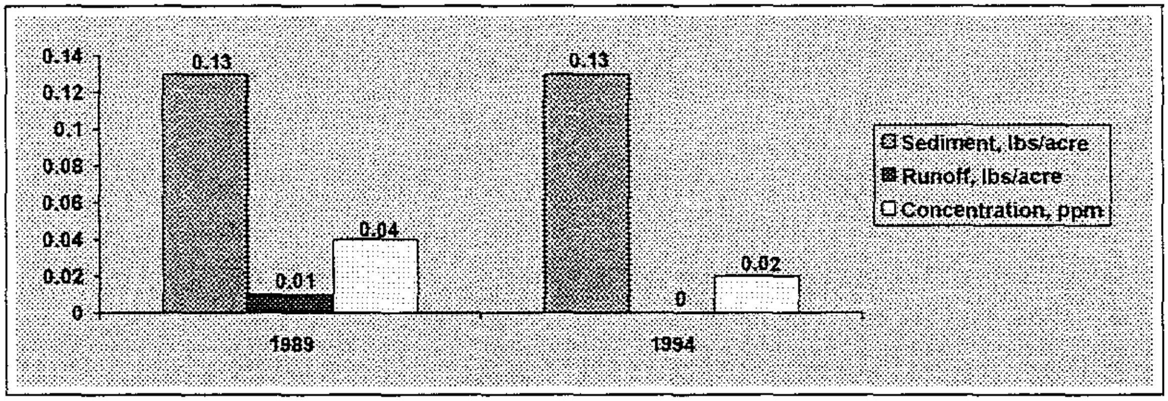


Figure 3. Nitrogen, phosphorus and CHOD runoff in the summer polder Pakalne in 1989 and 1994

Nitrogen



Phosphorus



Soluble CHOD

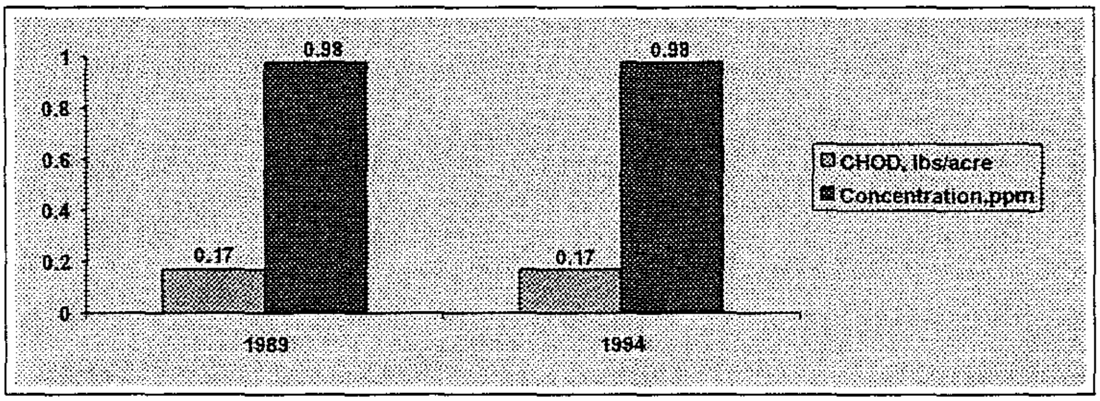
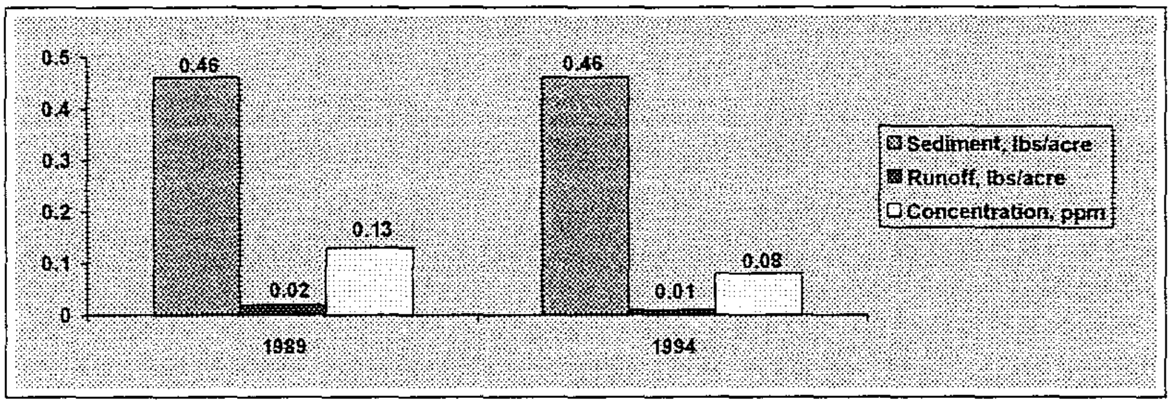
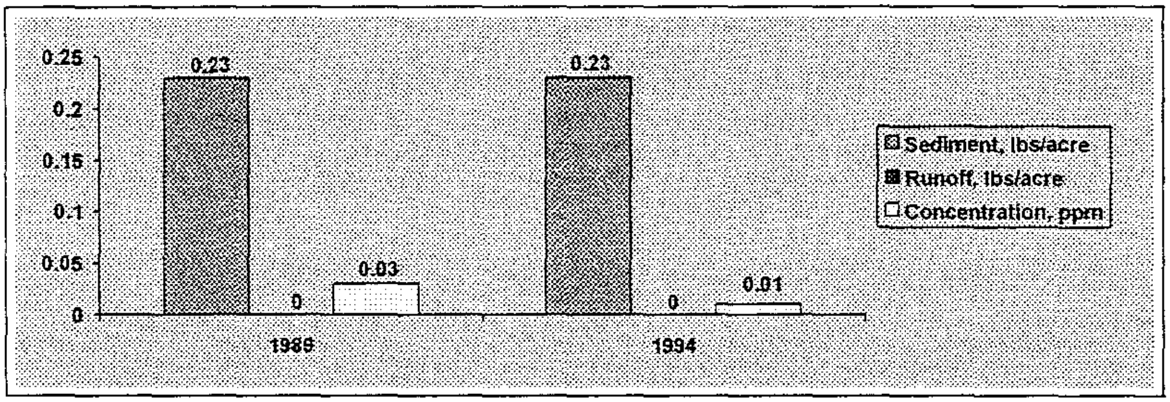


Figure 4. Nitrogen, phosphorus and CHOD runoff in the winter polder Rusne in 1989 and 1994

Nitrogen



Phosphorus



Soluble CHOD

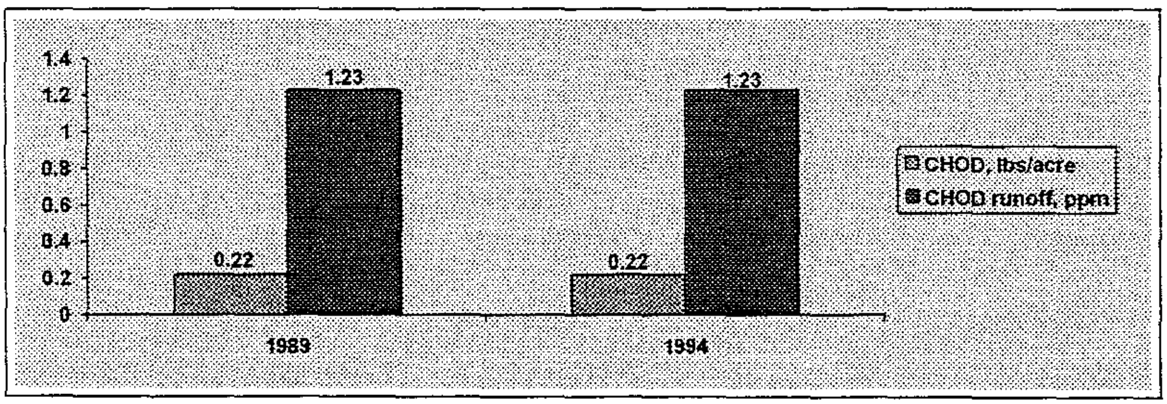
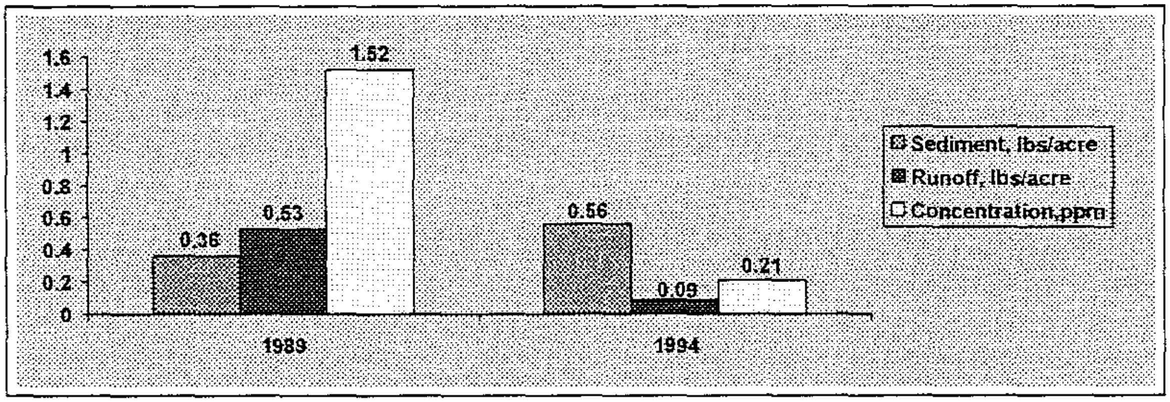
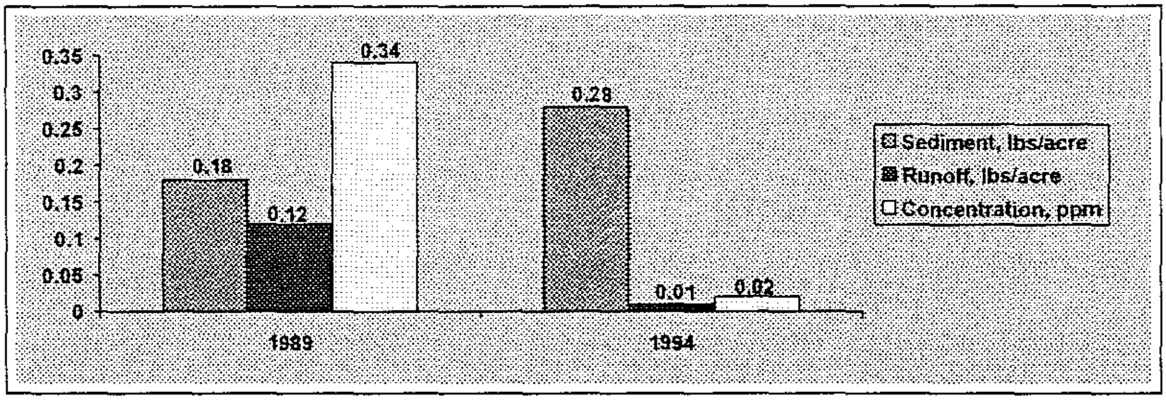


Figure 5. Nitrogen, phosphorus and CHOD runoff in the winter polder Skirvyte in 1989 and 1994

Nitrogen



Phosphorus



Soluble CHOD

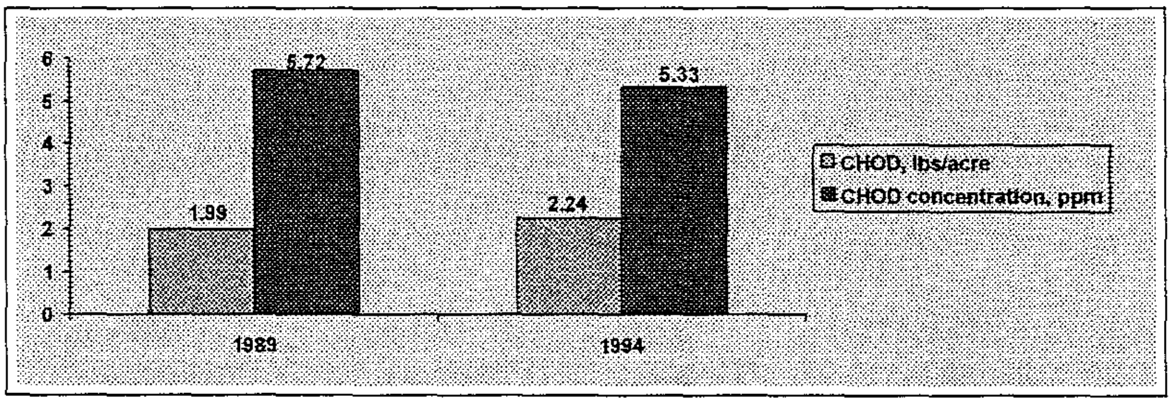
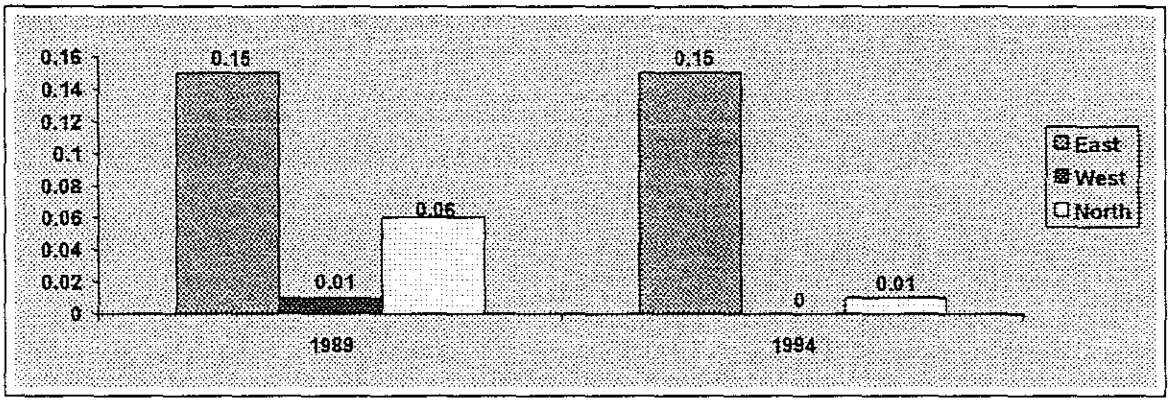
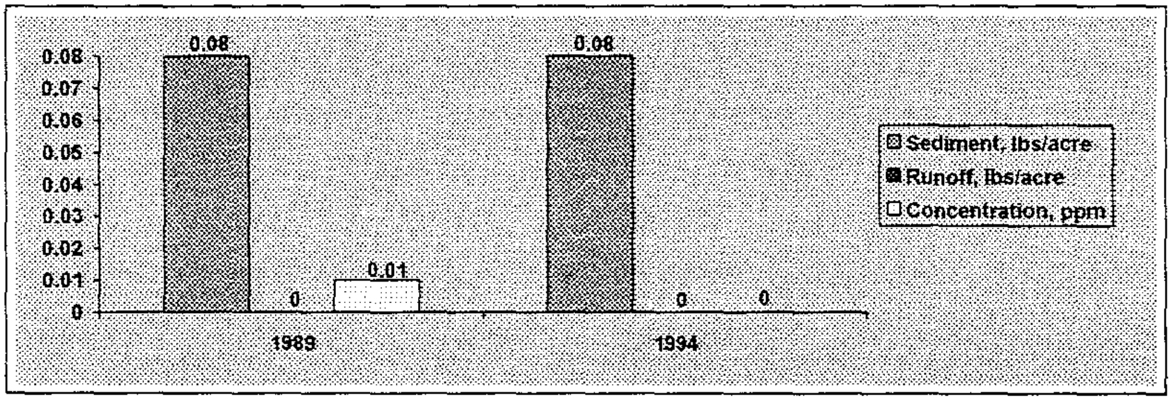


Figure 6. Nitrogen, phosphorus and CHOD runoff in the winter polder Uostadvaris in 1989 and 1994

Nitrogen



Phosphorus



Soluble CHOD

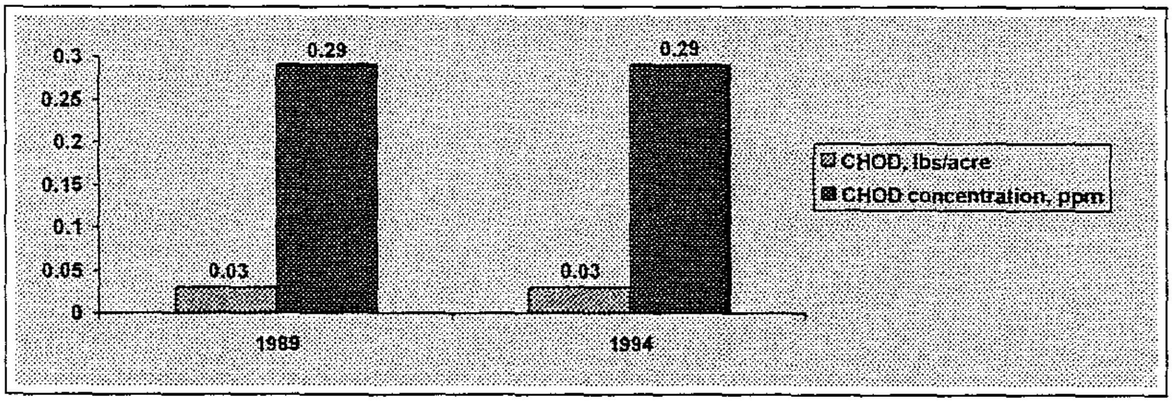
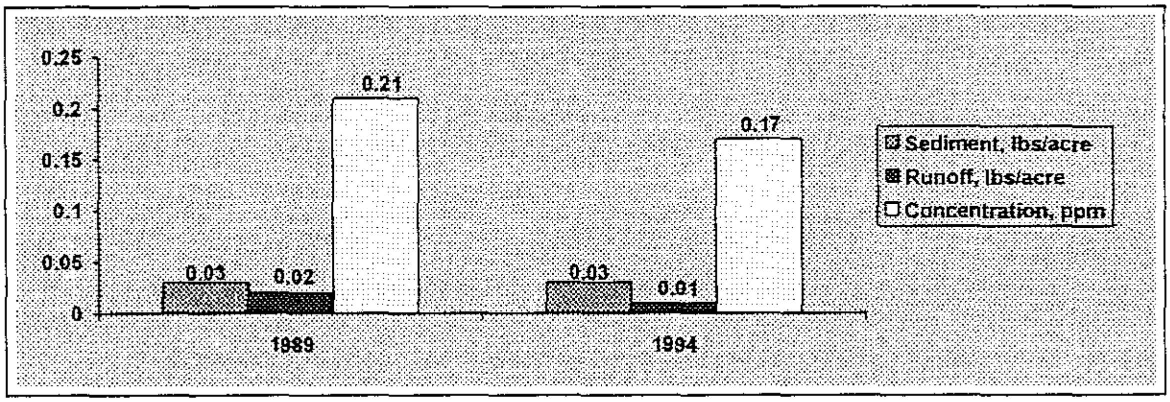
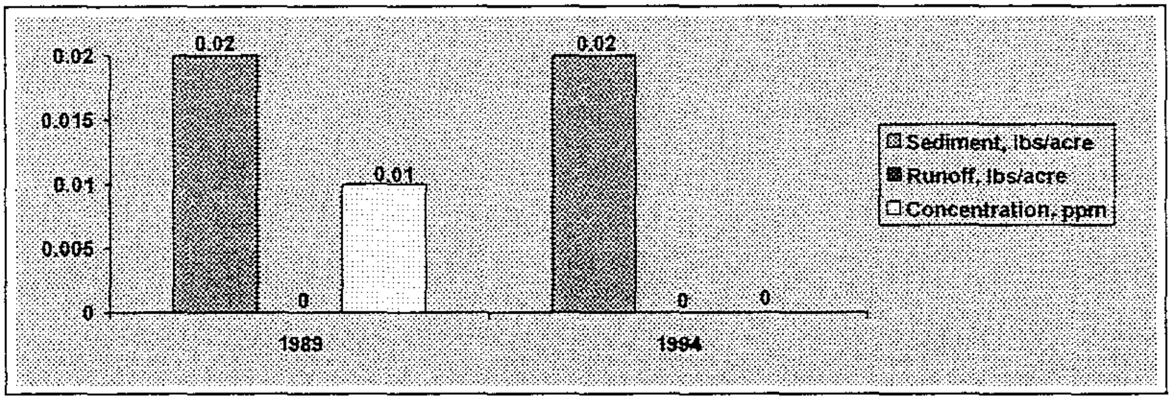


Figure 7. Nitrogen, phosphorus and CHOD runoff in the Summer polder Uostadvaris in 1989 and 1994

Nitrogen



Phosphorus



Soluble CHOD

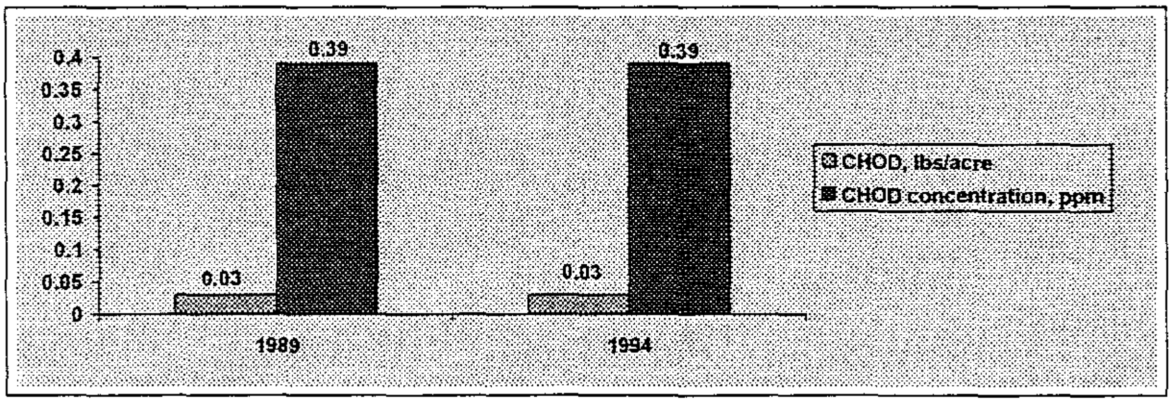


Figure 8. Nitrogen, phosphorus and CHOD runoff in the Summer polder Vorusnë in 1989 and 1994

It is evident that decreased fertilization results in significantly less nitrogen and phosphorus runoff and concentration. According to the model, total nitrogen and phosphorus in the sediments did not change when the fertilization level was decreased from the 1989 to the 1994 models. The same result occurred with total soluble chemical oxygen demand and its concentration in runoff. These values depend more on flow route, slope, land cover, and other factors.

The influence of land management can be determined by comparing nutrient runoff from polders under different land use regimes (Figures 9 through 11). The most intensive land use is in the winter polders Uostadvaris, Rusne and Skirvyte. Modeled average nitrogen, phosphorus, and CHOD concentrations in these polders are 10 to 50 times more than in summer polders (Figures 9 through 11).

Summer polders Vorusne, Pakalne and Uostadvaris are primarily meadow and pasture. The Vorusne polder also has some wetlands and old riverbeds with perennial water. Only on the upland areas of the summer polders are there private houses with associated plowed land.

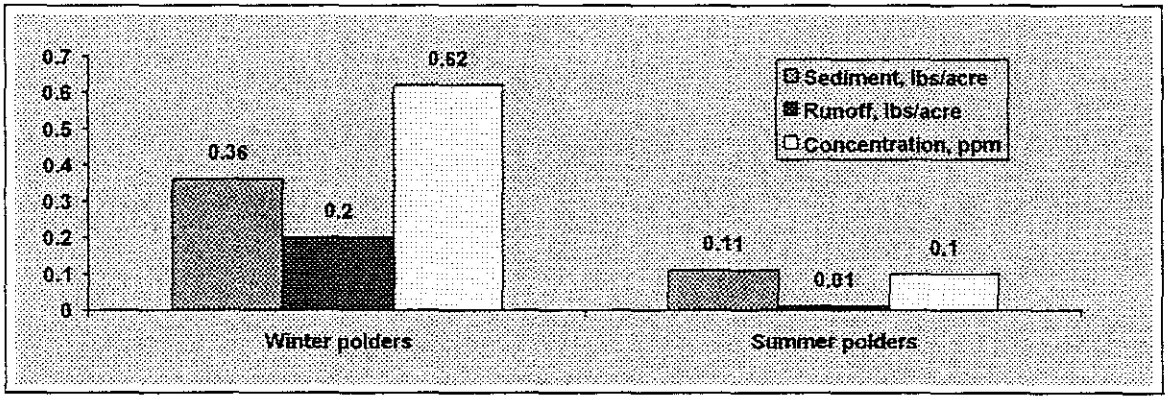


Figure 9. Nitrogen at the winter and summer polders' outlet in 1989

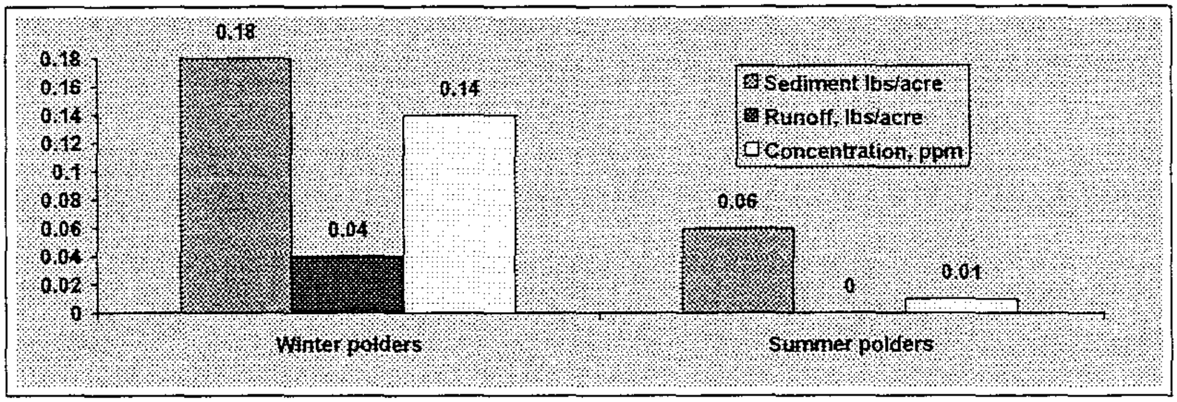


Figure 10. Phosphorus at the winter and summer polders' outlet in 1989

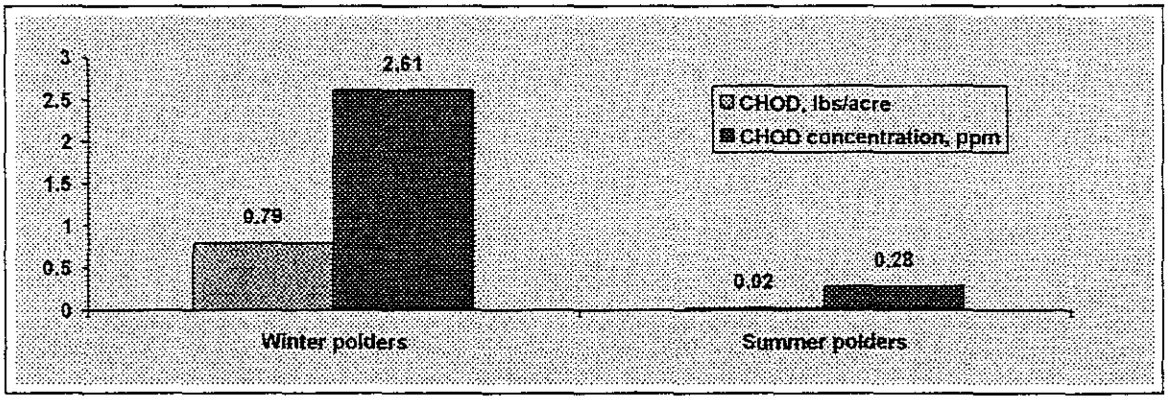
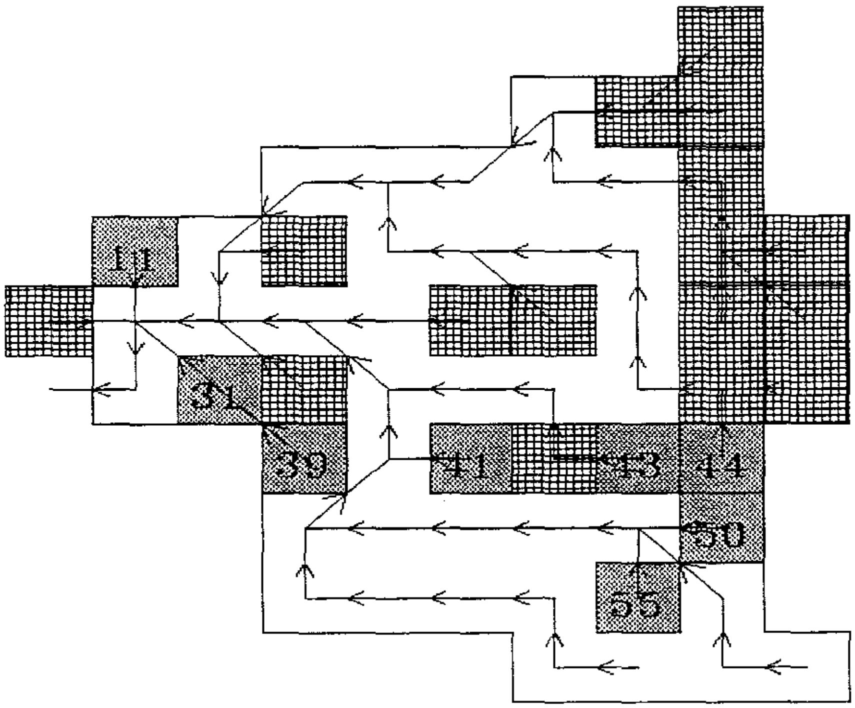


Figure 11. Soluble CHOD at the winter and summer polders' outlet

The average nutrient load at the outlets of winter and summer polders does not indicate the location of the most significant pollution sources. Therefore, we plotted the model grid graphs to show dispersion of the nitrogen load, identify sources of pollution, and determine their magnitudes. This analysis was conducted only for nitrogen concentration because it is the primary agricultural nonpoint source pollutant causing eutrofication of coastal lagoons. The AGNPS model variables for the polders were plotted to highlight cells where nitrogen concentration exceeds the limit of 2.0 mg/l permissible for fish (Figures 12 through 14).



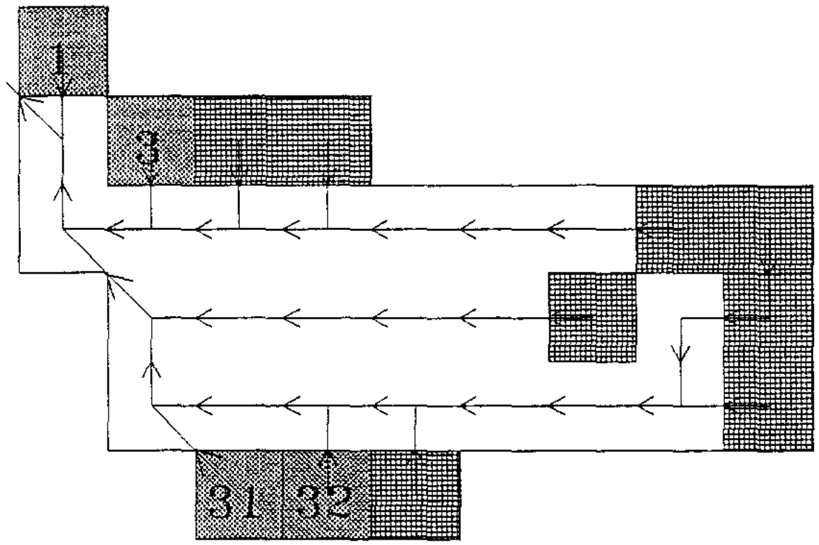
Cells with nitrogen concentration 2.0-4.0 ppm

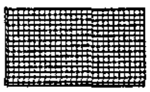
Numbered cells with nitrogen concentration 4.01-6.75 ppm

← Water flow path

Figure 12. Nitrogen concentration and water flow path in Rusne winter polder in 1989

The highest loaded cells are 31, 39, 41, 43, 44, 50 and 55; analysis of input data sets shows that intensive land use is the main reason. The average fertilization level for bare fallow soil by households with a barn for a cow, calf, and two pigs increased nitrogen concentration in runoff.




Cells with nitrogen concentration 2.0-4.0 ppm

Numbered cells with nitrogen concentration 4.01-6.75 ppm

← Water flow path

Figure 13. Nitrogen concentration and water flow path in the Skirvyte winter polder in 1989

Table 2. Nitrogen concentration change depending on land use in Uostadvaris winter polder

		Nitrogen concentration, ppm		
Cell Number	Area, lb/acre	Intensive agriculture	Sustainable agriculture	Pastures for grazing
1	9.88	6.36	3.45	1.57
2	19.76	3.98	3.61	1.5
3	9.88	10.27	0.99	0.79
4	9.88	7.73	0.74	0.6
5	9.88	2.61	2.61	1.57
6	98.8	1.52	1.30	1.45
7	69.16	2.63	1.50	1.6
8	29.64	4.26	0.68	0.45
9	19.76	4.89	2.73	0.98
10	9.88	6.64	.360	2.14

Note: Cells where nitrogen concentration exceeds 2.0 ppm are highlighted.

Analysis of agricultural practices in the Uostadvaris winter polder (Table 2) shows that the outlet nitrogen concentration will decrease significantly in response to more sustainable practices. Nitrogen concentration decreases in proportion to fertilization reduction. Changing from cropland to unfertilized pasture in the most overloaded cells yielded the best results in the Uostadvaris winter polder. Significant changes in nitrogen concentration in cells 3 and 4, where there was a large duck complex in 1989, demonstrate that large animal complexes are unsuitable in cells with little drained area.

The same modeling was conducted for the overloaded cells in winter polders Rusne and Skirvyte (Table 3).

Table 3. Nitrogen concentration change depending on land use in the Rusne winter polder

		Nitrogen concentration in ppm		
Cell Number	Area, lb/acre	Intensive agriculture	Sustainable agriculture	Pastures for grazing
1	39.50	2.41	2.41	0.52
3	118.50	3.59	2.02	0.36
4	39.50	2.68	1.61	1.61
10	197.50	2.34	1.29	1.33
11	39.50	4.54	1.08	1.08
13	39.50	2.92	1.73	1.73
18	158.00	2.49	1.48	1.46
19	39.50	2.68	1.61	1.61
20	39.50	3.83	2.19	0.55
25	39.50	2.61	1.57	1.57
26	39.50	2.61	1.57	1.57
28	39.50	2.51	1.48	0.54
29	39.50	2.42	1.48	0.54
31	79.00	4.22	2.28	0.34
32	39.50	2.92	1.73	1.73
37	118.50	2.82	1.61	1.79
38	39.50	2.43	2.41	0.52
39	39.50	6.75	3.65	0.55
41	39.50	6.74	3.64	0.53
42	79.00	3.36	1.85	0.27
43	39.50	5.38	2.95	0.52
44	39.50	5.38	2.95	0.52
50	39.50	5.39	2.96	0.54
55	39.50	5.39	2.96	0.54

Table 4. Nitrogen concentration change depending on land use in the Skirvyt winter polder

		Nitrogen concentration, ppm		
Cell Number	Area, lb/acre	Intensive agriculture	Sustainable agriculture	Pastures for grazing
1	9.88	7.6	4.33	1.11
3	9.88	6.74	3.64	0.53
4	9.88	3.51	2.02	0.53
5	9.88	2.41	1.46	0.52
13	9.88	3.21	1.88	0.58
14	9.88	3.18	1.85	0.52
20	9.88	3.25	1.92	0.66
22	19.76	2.02	1.19	0.39
30	9.88	2.67	1.59	0.52
31	9.88	5.38	2.95	0.52
32	9.88	5.61	3.07	0.95
33	9.88	3.18	1.85	0.52

Conclusions

Modeling results (Tables 2 through 4) show that low fertilization rates greatly improve polder outlet water quality. Therefore, it is recommended that intensive crop reduction should be avoided in favor of pasture and grassland, and that large poultry and animal complexes should not be reopened in winter polders. These measures will reduce nitrogen runoff in the Rusne, Skirvyte, and Uostadvaris winter polders 94.13 lb. for every 5 percent probability storm event, according to the models. In reality, however, the savings will be much higher because the model was developed on a theoretical background and does not evaluate losses due to improper storage of manure (that will be avoided if the animal complexes are left closed). The best land use for summer polders is natural meadows for hay and pastures for grazing without fertilization. Model results show that this type of farming ensures good water quality not only in the polders' outlets but also in the whole polder. Pastures should be arranged and animals kept in the upland of the summer polders because flooding of manure storage areas, currently very common in the summer polders, is a significant source of pollution.

Implementation of such management practices must be facilitated by a combination of regulations, extension services and incentives. Standards should be developed to set animal density limits, manure storage and handling technologies and rates, and water regimes for pastures and meadows.

The Lithuanian government needs to stimulate the implementation of sustainable agricultural practices and land use change from cropland to meadows and pasture. The government should guarantee reasonable prices for ecologically clean agricultural products and compensate income losses for local inhabitants who sign long-term contracts for establishment of meadows and pastures.

In addition to these measures, it is very important to establish education, information, and extension programs for polder farmers and residents. School education on the beauty, biodiversity and fragility of the Nemunas River lowland should be implemented. Farmers, householders and agricultural company employees need to be informed about local farming restrictions, stimulation measures, and be taught how to insure a sufficient income with sustainable agriculture and governmental support.