superfarms and the coastal environment: an in-depth look at a large-scale problem

Ever since white men have inhabited the area, the vast swampy reaches of North Carolina's Albemarle-Pamlico Peninsula have been considered a wasteland, useful only for logging and an occasional small farming venture. Over the last few years, however, great changes have been in the making for this long disregarded region. Spurred by increasing grain prices and postwar advances in farm technology, a number of large corporations have bought up vast amounts of acreage in the coastal area with the idea of conducting large-scale agricultural operations.

Whether "superfarms" on the coast are a blessing or a curse has yet to be determined. Historically, the region has been economically depressed. Attempts at small scale farming have consistently failed. Thus, large scale farm ventures are looked upon as the solution to economic woes. Further, agricultural experts view the farms as posing no serious threat to the environment but, instead, as affording a great opportunity for converting a wasteland into profitable farmland. Environmentalists, however, are worried about the possible adverse impacts on the immediate wetland area and, more importantly, on the surrounding estuaries and marshlands which provide spawning and nursery areas for shellfish and commercial fisheries.

Never before has such a large-scale farm effort been launched in so sensitive an ecosystem. Thus, virtually no information is available on its potential impact on the coastal environment. This article will examine both the natural features of the coastal area and the activities involved in setting up and operating a superfarm. Hopefully, by juxtaposing these two elements, the environmental impacts of superfarms can be predicted and the issue placed in better perspective.

recent history

Acquisition by corporations of land for superfarms first began around 1970. At present, 414,000 acres or two-thirds of the Albemarle-Pamlico peninsula have been purchased, including parts of Washington, Tyrrell, Dare, and Hyde Counties. Another superfarm of 45,000 acres has been established in northern Carteret County. The corporations involved include American Cyanamid and John Hancock Mutual Insurance which jointly purchased the 35,000-acre Mattamuskeet Farms; Shima American Corporation of Illinois, a Japanese-owned firm, which bought 7,500 acres; and Atlantic Farms, which bought about 40,000 acres. In northern Carteret, Ferruzi of Ravenna, Italy, bought 40,000 acres to start Open Grounds Farms, Inc. But the largest purchase was made by Malcolm McLean in 1973 when he bought Westvaco's holdings, Atlantic Farms and other small farms totaling over 370,000 acres to establish First Colony Farms, Inc. With the purchase of this superfarm in 1973 came the first major concern over the environmental impact of the large farming operations.

Concerned scientists have perceived that the superfarms are by no means ordinary agricultural projects. The surrounding area is largely a wilderness of swamps and bogs underlain by peaty organic soils, except for areas cleared and ditched in past farming attempts. To convert such land into fields suitable for crops, vegetation must be cleared and swamps drained. Such massive alterations cannot help but have a significant effect on such a sensitive environment.

description

The physical environment of the Albemarle-Pamlico Peninsula can be described as an almost flat terrace sloping slightly towards the sounds and estuaries at a rate of about .7 foot per mile. The highest elevation on the Peninsula is twenty feet above sea level, occurring along the western portion. However, more than two-thirds of the area is at an elevation of less than five feet above sea level.

The drainage system of the region is limited to a few short streams, found mostly in the western

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portion, and a few large streams penetrating a small part of the interior. The four lakes in the area aid little in the drainage system since they are shallow and partially surrounded by ridges which block overland runoff.

With such a poor drainage network, the water table is very high — occurring at the surface in wetland areas. Because of the slight gradient and the high water table, runoff from the region is small and water has collected in the lower areas causing the formation of peat, (a soil composed of organic deposits). Over, time the peat has deepened enough to cover most of the Peninsula, hiding the actual variations in the underlying topography.

The soil is of two major types (1) mineral and (2) organic. Mineral soils consist of a mix of sand, silt and clay and are generally suitable for agriculture. Eighty to ninety percent of the region contains organic or peat soils consisting of organic materials mixed with small to moderate amounts of sand, silt, and clay to a maximum of twelve feet. In addition, the deep organics often contain large woody materials such as stumps and logs preserved for thousands of years by the acidity of the organic or peat soil.[1]

Peat is very acid with a pH around 4 so the pH must be raised in order to grow crops. Furthermore, fertilizer must be added to the organic soil which lacks nutrients such as phosphorus and inorganic nitrogen necessary for plant growth. Because the soil is waterlogged, the peat remains cold longer in the spring and becomes cold sooner in the fall. Thus, before the land can be farmed, the growing season must be lengthened by draining the soil.[2]

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Because of the high water table and the peaty soils, the biological communities of the area consist mainly of wetlands such as bogs, wooded swamps, irregularly flooded marshes and fresh marshes. Wetland soils are often either waterlogged or covered by water during the growing season depending on the type of wetland. Marshes are the wettest areas and so support various grasses and other marsh plants. Wooded swamps are covered by water a lesser portion of the year so that hardwoods prosper in this environment. Cypress and atlantic white cedar occur in the wetter areas and gum, bay, oak, and pine are found in slightly drier sites.[3]

Bog, which consists mainly of pocosin, makes up the majority of the wetland acreage. Pocosin, an Indian term meaning "swamp on a hill," occurs in low upland flats which are the driest of the wetland portions. Pocosin requires dry periods during the summer to generate the natural fires necessary for the pond pine (its dominant tree species) to survive.[4]

The artificial drainage system greatly increases the natural drainage efficiency

Courtesy of the Soil Conservation Service

drainage system

To utilize the wetlands for agriculture the waterlogged peat must be dried. So the first and most crucial step in farming the region is lowering the water table below the root zone by means of an artificial drainage system.

Three types of ditches are generally constructed. The first type consists of main canals which connect the inland system of ditches with a stream or sound. The materials dredged from the canals are used to construct access roads along the canals. The width varies from 15 to 20 feet and the depth from 10 to 15 feet.

The second type of ditches are collector ditches which are dug perpendicular to the main canals and spaced one-half mile apart. The width varies from 10 to 15 feet and the depth from 6 to 8 feet.

Parallel to the main canals and perpendicular to the collector ditches are a third type of channel called field ditches. These are spaced from 260 to 300 feet apart depending upon the hydraulic conductivity of the soil. For instance, deep organic soils have poor hydraulic conductivity so it is necessary to place the ditches closer together to achieve maximum drainage. Field ditches are V-shaped with a width of 5 feet at the top and one foot at the bottom. The depth is usually 5 feet.

Typical dimensions of a superfarm field are one-half mile by 330 feet. The ditches provide an average of 20 miles of channels per square mile of land. This is a highly efficient system compared to the average Coastal Plain drainage density of only 1.4 miles per square mile of land. It is clear, then, that the artificial drainage system increases the efficiency of drainage greatly.

The drainage efficiency is further increased in the process of field preparation. After six months or more, when the soil is drained enough to support farm equipment, the marketable pulpwood and sawtimber are removed and the remaining vegetation is piled in long windrows. Since the gradient is slight, the next step is to disk and shape the field so that it slopes towards the field ditches. This augments the drainage efficiency and accelerates the water movement through the system.

water

The effect of the increase in drainage efficiency is a significant change in the water budget of the region. The ditches lower the water table level from an average of one foot to four feet below the surface. This seeming slight change in water table is estimated to reduce the ground water recharge by 50 percent.

With this reduction in ground water replenishment, salt water intrusion of the lower aquifers will be accelerated. However, because such a large amount of freshwater is involved, salt water encroachment will not happen suddenly. The more immediate problem of encroachment is in the higher, more shallow aquifers especially the uppermost Quaternary deposits. Since the bottoms of the ditches are several feet below sea level, brackish water can enter and travel long distances inland depending on the rate of freshwater outflow in the ditches. This brackish water will then filter down to the Quaternary aquifers used for water supply.

Saltwater encroachment of the upper aquifers can be prevented by placing controls on the ditches to insure a constant amount of freshwater outflow. At present, however, ditch controls are being used to keep the water levels as low as possible to obtain the maximum drainage. Thus, a pathway is provided for brackish water to enter the field ditches and encroach on the shallow aquifers.

The greater efficiency of the water movement through the system will also cause an increase in the rates of water runoff to streams and estuaries. The overall annual increase in runoff is expected to be only one inch, but this masks the expected sizeable increase in the maximum runoff during storms and the minimum runoff during dry periods.

Below is a comparison of the water budget before and after drainage.

	BEFORE	AFTER
Precipitation	51.0	51.0
EvapoTranspiration	36.0	35.25
Runoff	14.5	15.5
Groundwater Recharge	0.5	0.25

The increase in surface runoff affects the surface water in two ways. Firstly, it could affect salinity patterns or the amount of saltwater content in the surrounding coastal water. Since the region's inflow of freshwater makes up only a small portion of the total, it is doubtful that the overall salinity pattern will change significantly. However, this may not hold true for small tidal streams and marshes in which the freshwater input is naturally small. A slight increase in the volume of runoff to a small stream may raise the overall percentage of total freshwater 100 or 200 per cent and thus upset the delicate balance of salinity essential to shellfish and spawning organisms.

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Secondly, the effect of an increase in surface water runoff could increase the turbidity of streams in the area. This increase is not thought to be significant because organic soils add little suspended solids to the water compared to mineral soils normally used in agriculture. However, estimates on a similar environment predict an increase of 12,000 tons of sediment a year, an amount never before experienced in estuarine waters. Although some estuarine waters are naturally turbid, a question still remains as to the effect of sedimentation on waters not naturally turbid.[5]

land

The major impact of drainage on peat soils is subsidence. Subsidence, or the tendency to compact and shrink, results from exposure to air and a lack of enrichment from litter deposited by natural vegetation. According to a study made by Dolman and Buol on North Carolina tidewater soils, as much as one-third of the thickness of the soil to the water table can be lost due to subsidence. The average rate in North Carolina is thought to be one inch per year. Subsidence can be minimized by maintaining a high water level in ditches, but will continue to occur regardless. Thus, the depths of the ditches will continue to be reduced exposing the woody material preserved in the acid deep peats.

Another problem in draining deep organic soils is a condition called irreversible drying. Under extremely dry conditions, usually during the summer, peat hardens into clogs which lose their hydraulic properties of holding and transmitting water. This condition can be controlled by maintaining a high water level in the ditches.[6]

The process of soil oxidation, in which the soil unites with oxygen and further subsides, can also become a problem when peat is drained. It occurs naturally in wetlands; however, the rate depends on the depth to the water table. So by draining the soil and thereby lowering the water level, the depth of the soil to the water table is increased and the rate of oxidation is accelerated. Since the surface of the soil is more likely to be dry enough to ignite after drainage than it would naturally, the likelihood of fire is increased. The pocosin of eastern North Carolina has one of the highest potentials for generating natural fires in the world because it spans large continuous tracts containing combustible peat soil and has few natural barriers. So, an increase in the possibility of wildfires could be dangerous unless preventive measures are taken. These include shelterbelts or windbreaks to block predominantly southwesterly winds which can spread wildfires once they start.

air

Wind erosion is another possible problem. When the land is cleared and drained but not yet planted, the wind can easily carry away the fine grained surface materials. Shelterbelts, or windbreaks or, preferably, natural vegetation can reduce blowing in areas up to several times the height of the vegetation.[7]

ecosystem

The major effect of drainage on the ecosystem is to adversely alter its ability to perform valuable services such as water table maintenance, flood control, water filtration, pollutant storage and wildlife habitat.

Swamps and bogs maintain the water table naturally by recharging the groundwater or filtering water down into the deeper aquifers, especially during wet periods when stream levels are high. The effect of this vertical drainage of water is a large hydraulic head of freshwater which retards saltwater intrusion of the lower aquifers. Since ditches lower the water table and transmit the water horizontally instead of vertically, groundwater recharge is reduced and saltwater intrusion is accelerated.

The ability of swamps and bogs to control flooding downstream is altered in two ways. First,

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vegetation is removed so that the water entering the swamp or bog is not slowed before entering downstream areas. The result is an increase in the frequency of downstream flooding. Second, ditching reduces the ability of the soil to absorb floodwaters so that the volume of water entering downstream areas is not diminished.

Water filtration and pollutant storage is also greatly hampered by drainage and field preparation. Vegetation important in trapping and storing nutrients, pollutants and particulate matter is destroyed. Also, by ditching and grading peat soils, the effects of waterlogging that limit soil processes such as decomposition of nutrients are reversed.

Specialized tractors till the highly organic soils of the Albemarle-Pamlico peninsula

Courtesy of the Soil Conservation Service

This causes a loss in the soil's ability to store nutrients, pollutants and particulate matter and slowly release these materials to downstream estuaries. The end result is an increase in nutrients, toxic substances, sediments, and other potential pollutants that not only contaminate estuarine waters, but also increase the probability of eutrophication of estuaries (which causes a decrease in oxygen available to shellfish, spawning organisms and other animals).[8]

Drainage also affects wildlife by greatly altering their habitats. In changing the physical environment, some animals benefit but others are adversely affected. Of the terrestrial animals, the black bear and the bobcat are most affected by the fragmentation of swamps and bogs caused by drainage. These animals need large continuous tracts of swamp and bog in which to roam and will become extinct in eastern North Carolina if wetlands are destroyed or greatly modified by agriculture.

In addition, if the shores of sounds and large lakes are modified extensively, the southern bald eagle and the osprey, both endangered species, will be threatened. The red cockaded woodpecker could also become extinct if unmanaged pine forests are destroyed.

Many small game species such as rabbit, deer, quail, and muskrat stand to benefit if substantial shelterbelts are provided. However, these animals, along with such undesirable bird types as starlings and blackbirds, will be attracted to the grain crops and could cause severe crop depredation.[9]

Aquatic biota is affected the most by the increase in runoff. During heavy rains, shrimp and other spawning organisms could be swept out of upstream tidal creeks and marshes to downstream areas where the bottom is too sandy for them to survive. Also, a change in the salinity of small tidal creeks, could adversely affect oysters, other shellfish and spawning fish important to commercial fisheries.[10]

preparation for crops

In preparing the soil for crops, the first item that must be added to the soil is lime. This is needed to raise the pH of the soil from about 4 to 6 or 7 and is accomplished by mixing 6 tons of lime into the top layer of the soil every two years. The addition of lime increases the rate of subsidence of the soil by further drying it. Lime also increases the pH of the water runoff. If the runoff is not sufficiently diluted, this increase in pH could significantly inhibit the primary production of plants vital to the rest of the food web (especially in small tidal creeks and marshes).

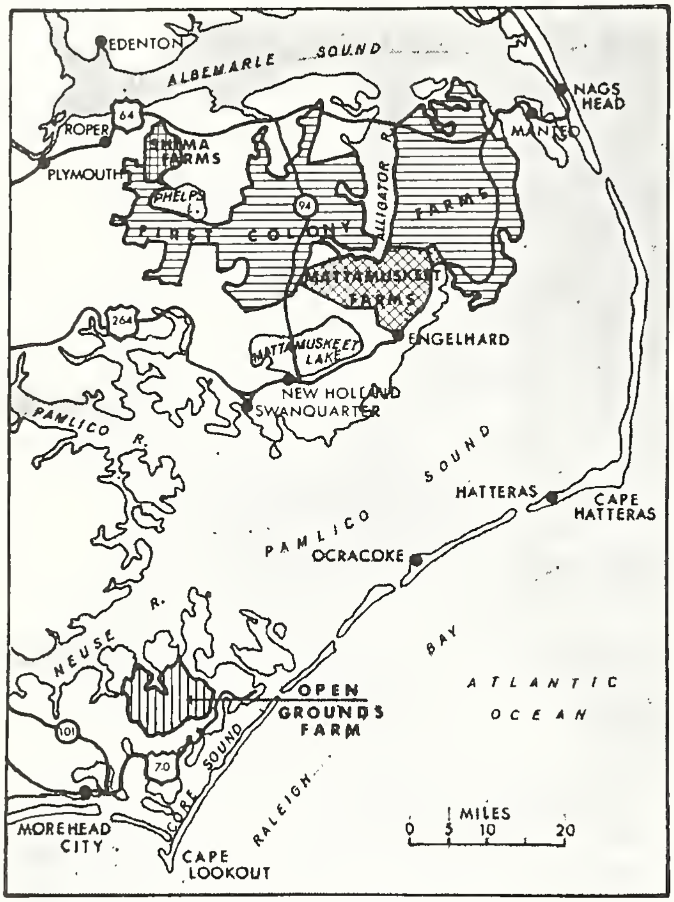
Since both mineral and organic soils are deficient in phosphorus, rock phospate must be added at a rate of 1000 pounds per acre to newly cleared organic soil. The increase in phosphorus in surrounding streams and sounds is not thought to be a problem since, according to Hobby's study in the Pamlico Sound, phosphorus is always available in amounts sufficient for an algal bloom.

Environmentalists fear that superfarms may upset the delicate ecosystem of the coastal waters

Courtesy of Department of Natural and Economic Resources

Inorganic nitrogen also must be added in spite of the abundance of organic nitrogen present in the soil. It is hoped that in the future, once drained and aerated, the soil will provide an environment in which soil microbes can denitrify organic nitrogen into inorganic nitrogen which plants can absorb. At present, however, large quantities of nitrogen (from 100 to 150 pounds per acre) are being applied.[11] Unlike phosphorus, nitrogen is a limiting factor in the eutrophication or enrichment of streams and sounds. According to Hobby, the Pamlico Sound already shows an upward trend in algal blooms indicating that it is approaching the threshold point above which it can not assimilate the incoming nitrogen increase.[12] In the Open Grounds Study, no change has been found in nitrogen concentration, but the 12,000 acres in production comprise only a fraction of the total expected acreage in production. Thus, it appears that nitrogen loads from the superfarms pose the greatest problem.[13]

To prevent disease and ward off various small pests, herbicides as well as other pesticides are being applied in large quantities to crops and pasture grasses. Most of the pesticides in use have short half-lives, from 3 to 4 days up to 6 weeks. However, if they are sprayed on the crops, pesticides could enter the field ditches and reach the estuaries before they decompose. Since estuaries are spawning and nursery grounds for fish and shellfish, pesticides entering estuarine waters threaten the survival of these organisms. Already, fish kills have



Location of superfarms in relation to the coastal area

occurred in field ditches. Furthermore, some pesticides are insoluable in water and upon reaching a stream, they sink to the bottom where filter feeders such as oysters, clams, and other shellfish can ingest them and become inedible. Because of the rapid settling rate of particulates in saltwater, pesticides could become available to filter feeders at an increased rate.

livestock operation

The livestock operation includes pastures and feedlots for cattle and sow parlors for hogs. Cattle are grazed in the pasture then transferred to feedlots for the final weeks. The hog operation, however, is more complex since the hogs are kept in houses and their wastes allowed to fall through the floor boards into pits underneath. The pits are connected and their contents pumped into a large lagoon. The proposed method of waste disposal is to place it on the land as fertilizer. However, if First Colony Farms, for example, is to achieve its goal of 25,000 500-sow units, 560 acres will be needed every year to dispose of the waste.

The major environmental concern with the livestock operation is the heavy nitrogen load it will place on the lagoons and fields. This load could be leached out of the soils into the groundwater and into the streams and lakes. This would add to the eutrophication problem in the nitrogen-limited estuaries and sounds and could degrade surface and groundwater quality.

Another concern is the percolation of bacteria from the waste in the lagoons and fields. These bacteria could leach out of the soil into the groundwater, be transmitted to estuaries and sounds and contaminate shellfish.[14]

summary

In the following chart, the effects of four possible alternative land uses on the environment will be analyzed. The first alternative is to leave the area in its natural state. In this way, the ecosystem will be allowed to perform the many valuable services it provides naturally.

The second alternative land use is managed forestry or silvaculture. This would involve draining and preparing the land for pine forest production since hardwoods are uneconomical to manage.

Agriculture with no controls or safeguards is the third alternative. This means that all the land would be drained and cleared, large quantities of lime, copper, fertilizer and pesticides would be applied and no controls would be placed on the ditches to regulate water quality and flow rates.

Controlled agriculture is the fourth alternative land use. This would involve a buffer of natural vegetation surrounding drained and cleared areas and along streams to retain functional units of ecosystem which provide valuable services, preservation of large undisrupted tracts of natural habitats for endangered species, regulation of discharge sites, water quality and flow rates so as to minimize erosion, salinity changes, nutrient enrichment, pesticide contamination and saltwater encroachment; and shelterbelts or windbreaks of natural vegetation oriented southeast by northwest to block southwesterly winds which aid in the spread of wildfires.

conclusions

Much of the research on the environmental impacts of the superfarms is in progress or proposed. Therefore, most of the information in this article is based on estimates of the effect of superfarms on the environment and should be viewed in that light. Keeping these assumptions in mind, some conclusions can be made about the environmental and economic aspects of each land use alternative.

The most environmentally sound use of the superfarm region is to leave it in its natural state to perform its various functions for the human environment for which no economic effects can be qualitively determined. The most economically efficient alternative is agriculture without any controls, but its environmental effects are the most adverse of the four. Forestry is not the best choice economically or environmentally since the rate of return is not worth the investment and the environmental effects are only slightly less adverse than uncontrolled agriculture. The best balance between economic

ALTERNATIVE LAND USES

Environmental and Economic Categories	Natural	Silvaculture	Agriculture	Controlled Agriculture
I. Water				
A. Water Budget	no change	- slight increase in overall runoff, significant increase in minimum and maximum rates of runoff - decrease in ground water recharge	- slight increase in overall runoff, significant increase in minimum and maximum rates of runoff - decrease in ground water recharge	- runoff rate is regulated - slight decrease in ground water recharge
B. Groundwater	some saltwater encroachment through deep aquifer	- increase in salt water encroachment through deep aquifer and - through shallow canals	- increase in salt water encroachment through deep aquifer and - through shallow canals	- increase in salt water encroachment through deep aquifer - control gate to prevent encroachment through canals
C. Surface water 1. Salinity	- balanced saline and fresh water	- significant decrease in salinity of small tidal creeks during rapid runoff	- same	- discharge sites chosen to minimize salinity decrease in small creeks
2. Sediments (Turbidity)	- some turbid waters and clear waters	- short term significant increase during drainage and clearing - slight increase overall	- same - increase overall	- control gates regulate water flow rate to minimize sediment runoff - slight increase overall
3. pH	- no change	- slight increase in pH caused by lime	- increase in pH caused by lime	- slight increase in pH
4. Phosphorus	- high	- slight increase	- same	- same
5. Nitrogen	- limiting factor in eutrophication	- no change	- increase in eutrophication	- control fertilizers and water flow rate to minimize but still slight increase in eutrophication
6. Pesticides	- some background	- almost no increase in pesticide contamination	- increase in pesticide contamination	- control pesticide application and water flow rates to minimize, still slight increase
7. Coliforms (Bacteria)	- some background amounts	- no change	- increase in coliforms with hog waste application	- control water flow rates still slight increase with hog waste application

Environmental and Economic Categories	Natural	Silvaculture	Agriculture	Controlled Agriculture
II. Land				
A. Soil Subsidence	-almost none	-increase during draining, clearing and liming -slight increase during production	-same -increase at decreasing rate during production	-water level kept high but still slight increase overall
B. Slow Oxidation	-some	-increase during draining, clearing and liming -slight increase during production	-significant increase during draining, clearing and liming -increase during production	-water level kept high still slight increase overall
C. Wildfires	-some	-increase overall	-significant increase in wildfires during draining, clearing and liming -increase during production	-water control to minimiz drying and wildfires, still slight increase
D. Irreversible Drying	-almost none	-almost none	-increase overall	-water control to minimiz drying but slight increas
III. Air				
A. Wind Erosion	-none	-slight increase especially during clearing	-increase especially during clearing	-shelter belts to block winds, still slight increase
B. Odor	-none	-none	-significant increase due to hogs	-locate hogs to minimize odor, still increase
C. "Wings" grain elevator	-none	-none	-no significant increase	-same
IV. Ecosystem				
A. Services				
1. Flood control	-no change	-significant decrease	-destroyed	-preserve bog surrounding crops and along streams but still a decrease
2. Water filtration	-no change	-significant decrease	-destroyed	-same as above
3. Pollutant storage	-no change	-significant decrease	-destroyed	-same as above

Environmental and Economic Categories	Natural	Silvaculture	Agriculture	Controlled Agriculture
B. Vegetation	-species diversity and stability	-replace with monoculture of pines so stability decreases significantly -long term and possibly irreversible change	-replace with monoculture of hybrid grains so stability decreases significantly -long term and possibly irreversible change	-replace with monoculture of hybrid grains but leave buffer surrounding farmland so that the decrease in diversity and stability is lessened
C. Land Wildlife	-protection of endangered species: bear, bobcat and rare birds	-significant decrease and possibly irreversible change in the protection of bear, bobcat and endangered birds	-same	-preserve areas inhabited by endangered species
	-some deer	-increase in deer	-significant increase in deer	-same
	-small fur bearing animals	-increase in small fur bearing animals	-significant increase in undesirable birds	-same
D. Aquatic Wildlife	-shellfish and fish spawning	-slight decrease in shellfish concentration and fish spawning	-significant decrease in shellfish concentration and fish spawning	-control water flow rate to minimize rate and sediments but still slight decrease in shellfish concentration and fish spawning
/. Economic Effects A. Rate of Return	?	6%		6.3%
B. Jobs	none	200	1000	1000

and environmental factors seems to be agriculture with controls and safeguards. But its rate of return is only 6.3 per cent, hardly worth the investment unless other underlying benefits are considered. These include avoiding capital gains taxes, taking a loss deduction for tax purposes, increasing the market value of the land, and obtaining additional returns from secondary facilities such as food processing plants and slaughter houses. These other benefits have to be judged in the individual cases of superfarm owners.

The choice of alternatives thus depends on the tradeoffs decision-makers are willing to make between environmental quality and economic efficiency in an economically depressed area.

Footnotes

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