The Ark File

EXPLORATION OF SELF-SUFFICIENCY
AT THE P.E.I. ARK

An Address to:

International Conference on Basic Techniques
in Ecological Agriculture

INTERNATIONAL FEDERATION OF ORGANIC AGRICULTURE MOVEMENTS

By

Kenneth T. MacKay
Director, The Ark Project
Institute of Man and Resources
Spry Point, R.R.#4 Souris
Prince Edward Island

Montreal, Quebec October 2nd-4th, 1978

In the last forty years, Prince Edward Island, one of Canada's two island provinces, has changed from being nearly self-sufficient in food to being heavily dependent on the rest of Canada and on other countries.

As in many other countries, monoculture and mechanization have made Island farmers dependent on cheap energy and imported, manufactured farm inputs, and farm numbers are dwindling. Soil fertility is decreasing at an alarming rate, while the emphasis on potatoes as the single cash crop grows. Markets for potatoes are becoming harder to find, although P.E.I. stores are flooded with other imported foods.

A key to survival in a resource-short world must be the <u>localization</u> of production and distribution of goods. Provinces, villages, even individual households must strive for greater self-sufficiency in food and energy production. This truth is particularly obvious in Prince Edward Island, Canada's smallest province. Because of our small economy, geographical isolation, short growing season, and total reliance on offshore oil, the crunch will come to us sooner than to most other parts of North America. Therefore, Prince Edward Island is already working on ways to become more self-sufficient. The Ark Project is an important part of this effort.

The Ark is a research and demonstration project and, like many other such projects in Canada, we rely largely on government funding.[1] The building itself is not self-sufficient in terms of energy, nor do we who

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[1]The Ark Project (Institute of Man and Resources) is funded jointly by the federal Departments of the Environment and Energy, Mines and Resources through the Canada-P.E.I. Agreement on Renewable Energy Development.

work there produce all our own food. However, we are exploring ways in which the Ark Project and Prince Edward Island can become more self-sufficient; and we have become a hopeful symbol of a new way. Our research efforts focus on food, energy (production) and shelter design.

As energy costs increase, freight rates will become prohibitive and most Canadians will have to give up fresh winter vegetables from California, Florida and Mexico. We can provide reasonably varied and nutritious year-round diets by freezing or otherwise processing produce grown in the summer. However, costs of factory-processed food will rise disproportionately since most processing operations are energy-intensive. Even home freezing can be an expensive option--an ordinary home freezer consumes over 1,000 kilowatt hours of electricity per year which costs more than $70.00 per year on P.E.I. with electrical rates rising.

But problems can present opportunities, and we expect that prohibitive transportation and processing costs will create local economic opportunities. Specifically, an opportunity will be created for expansion of Canada's small greenhouse industry. Production of diverse fruit and vegetable crops in winter could enable local growers to recapture fresh markets which go only to those who can offer a steady, year-round supply.

The problem with greenhouse production in Canada has always been energy costs. In the past, growers have relied on energy-inefficient greenhouses which are heated with fossil fuels costing in excess of $\$6.00/m^2$ each year. This has meant that very few food crops can be raised profitably in Canadian greenhouses. In fact, it takes ten times as much energy to produce a head of lettuce in a conventional greenhouse in central Canada as it does to grow the lettuce in California and ship it. Therefore, design and management of solar greenhouses is one of the Ark Project's highest research priorities.

Our larger greenhouse has operated for three winters; it maintains temperatures above 6^{o} C, even on nights when the outside temperature drops to -20 or -25^{o} C. The only energy which must be expended is electricity for a circulating fan, and no supplemental heating has been required.

The floor of our main, 178 m^2 greenhouse is a metre below grade and the north wall is heavily insulated. It is covered by south-facing, double-layered acrylic glazing (Acrylite-SDP). Thermal mass is provided by 86 m^3 of rock storage, by 53,000 L of water used for aquaculture, and by the concrete and earth floor. Heat storage is accomplished by a circulating fan which draws warm air into a duct at the top of the greenhouse and blows it into the rock storage. The air re-emerges through registers spaced along the growing benches. Daytime heat is thus stored in the rocks and retrieved at night.

Incorporation of the aquaculture facility is equally important to the success of our greenhouse design. Preliminary mathematical modelling indicates that over 60 percent of the winter heat storage comes from the large, translucent fish tanks. The greenhouse solar design has enabled us to produce winter crops of lettuce, broccoli, chard, and other cool-weather plants--heating only with the sun. This year we obtained a spring/summer and a fall crop of tomatoes with yields of 7 kg/year/plant space, equivalent to those in conventionally-heated greenhouses.

The greenhouse has also been used to produce bedding plants for transplanting to the outdoor gardens. A number of ornamental shrubs, grapes and small fruits have been successfully started from stem cuttings under our mist propagator. We have grown a large variety of ornamental plants in order to look at the suitability of our solar greenhouse environment for this sort of commercial operation. The flowers add diversity and serve as nectar sources for some of the beneficial insects.

We are experimenting with ecological, self-sufficient greenhouse management techniques. Permanent, deep beds are fertilized with compost made from local manure, seaweed and hay, and with water from the aquaculture. We use seaweed from our own beach as a mulch and seaweed extract as a foliar spray.

We are gradually enlarging our range of biological pest controls. Lady beetles have kept aphid populations at acceptable levels, and Encarsia formosa, a small parasitic wasp, has been effective against whiteflies. Encarsia overwinters well, thus eliminating the need to reintroduce these predators. However, it is necessary to ensure the whiteflies are not exterminated in order to maintain the Encarsia population.

Of particular interest are two wild insect species which have infiltrated the greenhouse and are now part of the aphid control program. These are a parasitic wasp, Aphelinius aschysis, and a parasitic gall midge, Aphidoletes aphidimyza. Aphidoletes, which is particularly effective, has not been reported in use elsewhere in North America for aphid control. However, the Russians and other Europeans have been studying its potential for use in greenhouses and field crops.

We are discovering some interesting problems associated with solar greenhouses. The insulated north wall on the Ark greenhouse blocks light, and as a result, it receives less light than conventional greenhouses do. Furthermore, the lower temperatures and the low rate of air infiltration due to the tight construction result in a high relative humidity in the winter. This excess moisture condenses on the inner glazing, further reducing light levels. The high R.H. also promotes fungus diseases. We have recently installed an air-to-air heat exchanger which lowers the relative humidity, thus increasing light levels, and also increasing the carbon dioxide concentration.

Other problems which have surfaced are associated with the use of natural soil-compost mixtures in the beds. Some growth abnormalities and fungus diseases seem to be caused by mineral imbalances which occur when compost and fish waste are used for fertility. We are currently examining available nutrient levels in the compost in order to rectify this situation.

The aquaculture facility is an integral part of the greenhouse ecology: the facility provides thermal mass for passive heat storage, and nutrient-rich water from the tanks is used on the plants. There are also linkages in the other direction. Plant wastes, earthworms and trapped insects from the greenhouse have been used as food for the fish. Locating the aquaculture facility inside a solar greenhouse provides water temperatures which are suitable for many types of fish, even in midwinter. The symbiotic relationship between plant-raising and fish-raising activities in our greenhouse exemplifies the integration which is a design goal for the entire Ark Project.

The aquaculture facility in our main greenhouse consists of 28 1,700 L tanks made of an inexpensive, translucent fibreglass which is normally used for greenhouse glazing. The high light transmittance of this material makes it easy to grow dense blooms of green algae which act as a biopurifying system, metabolizing ammonia and carbon dioxide, and returning oxygen needed by the fish. The growth rates of the brook and rainbow trout, and salmon in our hatchery greatly exceed those of conventionally managed fish hatcheries.

The water purifying action of the algae is supplemented by a wide variety of plants grown hydroponically. Some plants, especially the tomatoes, celery and peppers, seem to respond very well to the fish wastes, producing yields greater than our normal greenhouse yields.

Biopurification has eliminated the need for sophisticated pumping and filtering systems. We have designed a simple air-lift pumping system which circulates and aerates the water. Using the concept of biopurification, a closed-system salmon and trout hatchery has been designed and successfully tested in the greenhouse. Experience so far has led us to the tentative conclusion that it can be more efficient to raise both plants and fish in a single, solar-powered facility than to raise either separately.

Maximum use of natural, indigenous materials is also a goal of our work in outdoor food production. Long-range plans call for the study of cropping and management processes which do not depend on manufactured inputs. This approach is already being demonstrated in the Ark Project's gardens. As in the greenhouse, we treat the garden soils with animal manures, green manures, seaweed and compost. After three years, we have excellent, highly productive plots. No pesticides are used, and problems have been negligible. We are comparing the suitability and pest resistance of different varieties, weighing harvest and keeping detailed records of production. We hope that as we accumulate experience, our garden projects will serve as examples and sources of information for local householders who wish to produce more of their own food in the most efficient, healthful manner.

Compost is the most important ingredient in maintaining the soil fertility of the greenhouse and gardens. We have carried out experiments to test a number of compost starters and ingredients. Compost piles have been made up of seaweed, hay, manure and bonemeal. These piles have been monitored for temperature, pH and chemical composition, and we are also establishing methods for bioassays. Preliminary results indicate very little difference in chemical composition, but considerable biological differences. We are now planning to expand our compost experiments to Island farms.

Traditionally, P.E.I. farmers spread mussel mud on their fields to improve fertility. This mud was actually the sludge from P.E.I. estuaries and was rich in calcium and other nutrients from fossilized oyster shells. With the coming of commercial fertilizers and crushed limestone, farmers gradually stopped using this natural and locally-occurring amendment. Now, however, there is renewed interest in mussel mud, and the Ark is setting up an experiment to compare the long term use of mud with limestone as a soil amendment.

Before concluding, I should say a little about our work in shelter design and energy production on Prince Edward Island. The Ark itself is a large solar and wood-heated building which incorporates not only greenhouses and an aquaculture facility, but also lab space, offices and a modern home.

From the solar designer's point of view, the Ark's conservation and passive solar features are most successful. A berm of earth on the north side deflects cold winter winds up and over the sloping roof. The Ark is tightly built with 16 cm of insulation in the walls and 32 cm in the roof. There are a minimum of north-facing doors and windows. The Ark sits low to the north and the living room floor is actually 1.3 metres below grade.

In contrast, the Ark rises high on the south to meet the sun for maximum passive collection. It is long on the east/west axis to provide more southern exposure. Expanses of greenhouse glazing admit the sun's warmth and the living area and the domestic greenhouse are combined into a single, light-filled space.

The Ark also has an active solar heating system. The system uses 65 m^2 of flat plate collectors. For heat storage there are 60,000 L of water in insulated basement tanks. Water is also used as the transfer medium. The collectors drain automatically when the circulating pump goes off. Heat is extracted from storage with a fan-coil heat exchanger, and warm air is distributed to the living quarters through ordinary ducts and registers.

On Prince Edward Island, with approximately 4,700 heating degree (C) days, this active solar system will carry the Ark through the winter, thanks to the building's good heat retention and passive solar characteristics. However, we feel that this type of sophisticated active solar system is too costly for single family residences. Simpler passive and semi-passive systems seem more appropriate, and with wood back-up, more self-sufficient for P.E.I. The economics of active solar systems look better, of course, in larger, multi-unit residences and in commercial or institutional buildings. The Ark's domestic hot water is also heated with solar energy. Since savings are realized year-round rather than just during the winter, the economics of solar domestic hot water look more promising than for space heating. The Institute of Man and Resources is carrying out a pilot program on P.E.I. to test domestic solar hot water systems in private homes. The architects responsible for the Ark's design have selected some of the building's features and used them in creating a series of "conserver homes" which are cost-competitive with new, low-cost housing on P.E.I. but which require less than half the energy for space heating of other comparable homes. The lesson from experience with the Ark is obvious: self-sufficiency is easier when you conserve and use less.

The Ark is a step towards a future when we will become more self-sufficient again--a future in which our homes, communities, provinces, regions and countries will supply more of our own needs.