"Summary of articles by Jane Rissler and Margaret Mellen: Environmental Risks Posed by Transgenic Crops International Implications of Commercialization *and* Conclusions and Recommendations on Regulation of Transgenic Crops" in Frontier Issues in Economic Thought, Volume 6: A Survey of Sustainable Development. Island Press: Washington DC, 2001. pp. 172-175

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"Summary of articles by Jane Rissler and Margaret Mellen: Environmental Risks Posed by Transgenic Crops International Implications of Commercialization *and* Conclusions and Recommendations on Regulation of Transgenic Crops"

The commercialization of transgenic crops may pose a spectrum of risks -- from ill effects on humans and animals that consume engineered crops to the disruption of ecosystems. In these chapters, the authors discuss two major categories of environmental risks -- those posed by the transgenic crops themselves, and those associated with the movement of transferred genes (transgenes) into other plants. An assessment of these risks leads to specific recommendations for stronger regulatory controls on genetically engineered crops.

Transgenic Crops May Become Weeds

The definition of the term "weed" depends on context and human values. It is used to refer to plants which interfere with agricultural and other human activities, as well as to invasive species which disrupt wildlife habitat. Nearly all food and fiber crops have close relatives that are regarded as weeds in some areas. Many plants purposefully introduced as food or forage crops or as ornamentals have later become weeds, including crabgrass, kudzu, purple loosestrife, tamarisk, and water hyacinth. These have all caused major ecosystem disruption and displacement of native species. Invasive weeds reduce agricultural output, clog waterways, and have adverse health impacts on humans and animals. In the United States, billions of dollars are spent annually to control weeds, and hundreds of millions of pounds of herbicides are applied.

Weeds are characterized by *persistence* and/or *invasiveness*. Once introduced, weeds are difficult to extirpate and may spread rapidly to other sites. Research has suggested that transgenes may confer or enhance these "weedy" qualities in some crops. Alteration of traits such as seed dormancy and germination, stress tolerance, and growth patterns could increase a plant's ability to outcompete other species. While some crops such as corn are unable to survive without human cultivation, and are therefore unlikely to become weeds through gene modification, other crops already possess some characteristics of weeds. Crop plants which are "on the edge of weediness" could be pushed over the edge by the addition of one or two genes. Crops such as sunflowers, strawberries, ryegrass, and broccoli have already established themselves as weeds in some areas. Others such as rice, barley, lettuce, oats, potatoes, sorghum, wheat, and alfalfa have close relatives which are weeds. Small genetic changes such as the insertion of disease- or insect-resistant genes might dramatically increase persistence or invasiveness in such plants.

Ecosystem Impacts of Transgenics

The introduction of genetically modified plants into an ecosystem may set off *cumulative or cascading effects* in an ecosystem. For example, salt-tolerant rice planted near coastal wetlands might invade nearby salt-water ecosystems, displacing native salt-tolerant species and setting off cascading effects on other organisms such as algae, microorganisms, insects, arthropods, amphibians, and birds. While complex ecosystems often possess resilience which allows them to absorb perturbations, species with transgenic traits may stress natural systems beyond their ability to react and recover. If gene-transfer technology becomes widespread, hundreds of transgenic organisms will be released into the world's ecosystems, with unpredictable outcomes.

Some transgenics are of special concern due to their ecotoxicity. When plants are engineered to produce pesticides and other drugs, it is predictable that non-target species will be affected. Beneficial insects and soil fungi may be harmed by the *Bacillus thuringiensis* (Bt) toxin and fungicidal transgenes now being engineered into a wide array of crops. The spread of Bt-engineered crops could also accelerate the development of pest resistance to Bt, thereby the destroying the benefits of this widely used organic insecticide. (When Bt is engineered into a plant, it creates continuous pest exposure rather than the carefully limited applications characteristic of organic farming.) Similar pest-resistance problems are likely to develop from the insertion of other pest-control genes into plants.

Movement of Transgenes into Other Plants

Once transgenic crops are planted in large numbers near wild or weedy relatives, transgenes will almost certainly flow via pollen to these other plants. If the hybrid plants thus created produce viable seed, the transgenes will enter the gene pool of the wild population. The transgenes most likely to be retained are those that confer a competitive advantage, creating new or more persistent weeds in farm and non-farm habitats. These new organisms may alter habitats, community structure, and food chain composition, ultimately affecting genetic and biological diversity. For example, the transfer of disease-resistance into a minor weed whose population has been controlled by plant pathogens could convert it to a major threat to crops or ecosystems. Herbicide-tolerant genes engineered into crops might transfer to weedy relatives, making the weed even more difficult to control and canceling out the economic advantage of herbicide-tolerant crops.

There are a number of precedents for gene transfer to weedy relatives, in some cases creating new weeds which mimic the original crops and are therefore difficult to identify and control. Gene flow from rice, sorghum, millet, corn and sugar beets has led to mimetic weeds in India, North and Central America, Africa, and Europe. Transgene characteristics are likely to create similar mimetic weeds possessing the same competitive advantages which the genetic engineers sought to create in the crop. The cumulative and cascading effects of transgenes which enter wild populations may be worse that those created by the original crop plants, since the weedy relatives are likely to be hardier and more invasive.

Threats to Rare Species and Crop Diversity Centers

Gene flow from crops can cause species extinction by overwhelming small wild populations. Hybridization with non-transgenic crops has already led to the extinction of wild crop relatives of hemp, corn, pepper, and sweet pea. Transgenics which convey tolerance to cold, heat, drought, or salt may lead to the extension of cropping to areas previously beyond pollination distance, endangering fragile ecosystems in these areas.

The threat of genetic degradation of ecosystems is particularly severe in the *centers of crop diversity* which serve as natural gene banks for future agricultural use. In Canada and the United States, such centers of diversity exist for berries, sunflower, Jerusalem artichoke, pecan, black walnut, and muscadine grape. Most other centers of diversity are in the developing world, and not all have yet been identified. These centers contain genetic resources which will be essential in responding to future environmental change or disease outbreaks. They are already losing genetic variability at an alarming rate. If they cannot be protected from invasive transgenics, the impact on future agricultural resilience could be profound.

Viral Resistance and New Viral Diseases

Many agricultural biotechnology labs are working to create virus-resistant plants. This may have an unintended effect of producing new strains of viruses or exacerbating existing viral diseases. This could occur through recombination -- the exchange of nucleic acids between transgenic plants and viruses. Recombination has already been observed in transgenic plants, for example between the cauliflower mosaic virus (CaMV) and a CaMV gene in transgenic turnips. Other genetic transfer processes may make it possible for viruses to broaden their host range or increase rates of crop infection. Transgenic viral products may also interact with other viruses to cause more severe diseases.

Some scientists contend that the risks of transgenic effects on viruses are no greater than those already associated with natural interaction among viruses. However, the difficulty of predicting the consequences of a technology in advance of its implementation should argue in favor of caution with respect to this and other potential risks of transgenics. Our understanding of physiology, genetics, and evolution is limited. Unexpected effects of new genes in a gene pool cannot be ruled out. Direct transfusion of new functional DNA into plants may be utterly new from an evolutionary standpoint, making risk assessment difficult and implying that as-yet unknown risks may exist.

International Implications and Policy Recommendations

Seed, pesticide, and biotechnology companies are now introducing transgene technology on a global basis. Engineered crops are potentially harmful to the environment. The dangers may vary with location; for example a transgenic insect-resistant soybean might pose minimal risk in the United States, but serious risks in China, where numerous wild relatives of soybean are endemic. Similarly, pest-resistant corn might not be a problem in the United States, but if used in Mexico could pose a serious danger to the genetic diversity of teosinte, the wild relative of corn whose genetic reservoir is an irreplaceable agricultural resource. Unfortunately, most countries are not prepared to control the ecological risks of transgenic crops.

To protect against the ecological risks of transgenic plants, the following recommendations are made for U.S. and United Nations policies:

1. Federal regulatory programs should be strengthened.
2. All transgenic crops should be fully evaluated for ecological risk and ecotoxicity.
3. The National Academy of Sciences should prepare an assessment of the risks posed by engineered crops to the international centers of crop diversity.
4. All transgenic seeds approved for U. S. use should bear a label stating that U.S. approval carries no implication of safe use in other countries.
5. The United Nations should develop international biosafety protocols to protect against the risks of genetically engineered crops.