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ANALYSIS

Risk-indexed herbicide taxes to reduce ground and surface water pollution: an integrated ecological economics evaluation

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Abstract

Public policy toward pesticide use in agriculture can benefit from data coming from models that integrate ecological and economic constraints into cropping decisions and pesticide use. Herein we use such a model to focus on the environmental and economic effectiveness of a specific set of tools used to promote sustainable agriculture with less pesticide runoff — incentive-based instruments created by *risk-indexed herbicide input-taxes*. We measure risk by health advisory levels and by an ecological economic simulation model that estimates predicted exposure levels. We explore whether this innovative solution of herbicide input-taxes does better at reducing losses to farm net returns, and surface and groundwater loadings than quantity restrictions. Using the integrated CEEPES model, our results suggest that risk-indexed input taxes by information about individual herbicide exposure levels can be a cost-effective tool to reduce predicted groundwater exposures. No single policy, however, was efficient at simultaneously improving groundwater and surface water quality. Instead we construct an efficient policy set. We find exposure-induced taxes were most efficient for small percentage reductions in overall exposure, bans were efficient for medium reductions, and flat taxes were efficient for high reductions. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

A major research question in ecological economics is ‘what regulatory or incentive-based instruments are most appropriate for assuring sustainability?’ (Costanza et al., 1991, p. 15). This question is especially relevant when considering the goal of sustainable agriculture, in which high

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productivity levels are maintained by many actions including pest control. People control pests such as weeds, diseases, nematodes and insects because they are constraints that reduce net returns in agricultural production. They maintain financial returns by controlling pests through pesticides including herbicides, insecticides, and rodenticides.

Pesticides are estimated to be a good investment — $1 spent on a pesticide yields an average $3–6 savings in reduced crop damage (see Headley (1968) and Carrasco-Tauber (1990)). People like good investments, as revealed by the estimate that about 2.5 million tons of 55 000 pesticide products are applied annually worldwide (Pimentel et al., 1992), in which 80% are used in developed economies like Canada and the United States.[1] The United States Department of Agriculture (1991) estimates that people use pesticides on about 92% of the corn acres, 95% of the acres in the six largest cotton states, and 95% of the soybean acres. Use of the popular pesticide atrazine during the 1980s, for example, was estimated at nearly eighty million pounds of active ingredient, accounting for about 12% of total herbicide use (United States Environmental Protection Agency, 1990). For corn alone, atrazine use is estimated at nearly 60 million pounds of active ingredient over 64% of all treated acres (Center for Agricultural and Rural Development, 1993).

But pesticides are also perceived to pose a risk to human and environmental health including toxicity to non-target organisms such as pollinators and wildlife, environmental contamination of soil, water, and air affecting ecosystem functions such as nutrient cycles, selection of resistant pests, and acute and chronic toxicity to humans. Pesticides are best viewed as part of an overall pest control strategy aimed at providing abundant food at reasonable prices — an objective with which few would disagree given the broader goal of sustainable agriculture. But when pesticides threaten the sustainability of human and environmental health due to their persistence, mobility, and toxicity to non-target species, the public often asks policymakers to rethink how these inputs are used.[2] The public push for a more sustainable agriculture asks these decision makers to better understand the nature of pesticide risks to humans and natural resources, how people perceive and react to these risks, and how specific public policy tools can help or hinder private actions. Understanding which policy tools work best for risky choices under both economic and ecology constraints can provide additional information to help policymakers promote effective sustainable agricultural — more food and less pesticide risk for more people.

The World Health Organization (1990) estimated that over 3 million cases of acute pesticide poisoning occur annually worldwide, including 735 000 cases of long-term chronic impacts, and 37 000 cases of cancer. In the U.S., pesticides as a source of non-point pollution have also been accused of damaging an estimated 16% (206 179 miles) of the rivers in 40 surveyed states and 20% (5.4 million surface acres) of lakes. In addition, one or more of 46 pesticides have been detected in the groundwater of 26 states. Based on this evidence, the final report of the U.S. Congress on section 319 of the Clean Water Act states that '...information indicates very clearly that non-point source pollution has caused severe damage to aquatic communities nationwide and has destroyed the aesthetic values of many of our treasured recreational waters' (United States Environmental Protection Agency, 1992, 1–2).

Effective policies to promote sustainable agriculture through reduced pesticide pollution require information on how alternative policy tools affect the economic and environmental relationships involved in crop or livestock production. In general, three general management tools exist to address the human and environmental risks asso-

[1] In 1985, herbicide use in Canada increased to about 23 million hectares (51% of all cultivated land), up from about 8.6 million hectares in 1970, while 1985 insecticide use increased to 4.6 million hectares (10% of cultivated land) from about 900 000 hectares in 1970. In the United States, the use of pesticides has increased tenfold from 1945 to 1989, nearly tripling in crop production between 1964 and 1985 (MacIntyre 1987; Pimentel et al., 1991, 1992, and Pimentel et al., 1993).

[2] See, for example, Wargo (1997) and the papers in Russell and Shogren (1993).