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EVALUATING AGRICULTURAL PESTICIDE USE AND RISK
FOR THE CHESAPEAKE BAY

by

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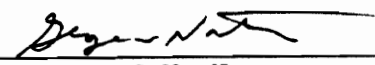
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(ABSTRACT)

Although agricultural pesticide use is suspected of being a major contributor to the risk of toxic contamination of the Chesapeake Bay, little information concerning the nature and extent of that risk is available. Such information is essential however, for setting pesticide risk management priorities and for designing policies to reduce the risk of toxic pollution from agricultural sources.

To help meet the information needs of Bay region water quality management, a model of agricultural pesticide risk is developed and used to assess pesticide risk in Virginia's Chesapeake Bay Region. Information generated by the model includes: an inventory of which chemicals are used; where they are used; estimates of aggregate chemical use for counties and crops; and an evaluation of the potential adverse environmental effects of that use. This information is provided for both current (1990) and future (2000) pesticide risk.

An econometric model of land use in the Bay region is used to predict acreage in various crops to which pesticides will be applied in 1990 and

2000. Next, acreage estimates are combined with pesticide application rates to yield estimates of aggregate use of each pesticide. Finally, environmentally relevant characteristics of the pesticides (toxicity, persistence, mobility, etc.) are used to evaluate the potential environmental risk associated with that use.

The policy implications of this modelling are then explored. Particular attention is paid to the potential for targeting of pesticide risk management programs at chemicals, sub-regions, or production systems (i.e. crops) that represent the greatest risk of toxic contamination of the Chesapeake Bay.

Results indicate that while urbanization in the Chesapeake Bay region will reduce the amount of land devoted to crop production, the reduction in the acreage to which pesticides may be applied will not greatly reduce pesticide risk in the near future. The risk evaluation effort reveals that pesticide risk is highly concentrated in a small subsets of the crops grown in the Bay region, of the pesticides used on those crops, and of the counties located in the region.

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CHAPTER ONE: INFORMATION NEEDS FOR PESTICIDE RISK MANAGEMENT

"Virtually everyone involved in pesticide issues will concede that accurate and complete data on pesticide use is not available."

- Virginia Council on the Environment, 1989

The Chesapeake Bay Environment

The Chesapeake Bay, the largest bay in the United States and possibly one of the nation's most important ecosystems, provides a wide variety of natural resource services to the middle Atlantic region and to the nation. Its waters provide access to several major east coast ports and support commercial oyster, crab and fin-fishing industries. The Bay also fosters recreational activities such as sport fishing, hunting and sailing. Furthermore, wetlands adjoining the Bay are important habitats for migratory birds, waterfowl, the endangered bald eagle and the nations largest population of osprey. Striped bass, perch and other salt-water fish find spawning grounds in the Bay's tributaries. (EPA, 1980)

The Chesapeake Bay region is also home to a large and growing human population. As that population increases, (possibly by as much as 40 percent by the year 2020), the demand for each of the Bay's environmental resources will increase, perhaps to the point at which the

Bay's ability to sustain its natural resources is diminished. (EPA, 1980) Because so many of the Bay's resources are linked to water quality, one of the most important factors in the Bay's future is the ability of the Bay's water to absorb and process increasing quantities of pollutants. Industrial and municipal wastes, heat from electric power generating plants, and run-off of soil and chemicals from agricultural and non-agricultural lands must be assimilated by the Bay. Therefore, ensuring the ecological and economic health of the Bay requires controlling the release of each of these pollutants into the Bay and its tributaries. (Chesapeake Bay Commission, 1987)

The Environmental Protection Agency concluded in 1983 that the environmental resources of the Chesapeake Bay are indeed deteriorating due to the effects of pollution from both point and nonpoint sources (EPA, 1988). EPA also identified the release of toxic substances into the Bay as a major contributor to that deterioration. To address that aspect of the Bay's pollution problems, the signatories of the Chesapeake Bay Agreement have adopted a Basinwide Toxics Reduction Strategy, the goal of which is:

"To work towards a toxics free Bay by eliminating the discharge of toxic substances from all controllable sources. By the year 2000 the input of toxic substances from all controllable sources to the Chesapeake Bay will be reduced to levels that result in no toxic or bioaccumulative impacts on the living resources that inhabit the Bay or on human health." (Chesapeake Bay Program, 1990)

Agricultural Pesticides and Environmental Risk

For some sources of toxic pollution, such as effluent from a paper mill or run-off from highways, the risk of environmental damage is incidental to some other activity, such as producing paper or driving. For these sources, toxic contamination could be reduced through the adoption of policies and technologies designed to reduce contact between the environment and potential contaminants. For example, improved effluent treatment or stricter automobile emission control guidelines could reduce the exposure of the environment to toxic contamination risk.

The nature of agricultural pesticide use in the Chesapeake Bay region however, may preclude the application of such straightforward solutions to the problem of toxic pollution from agricultural sources. Several aspects of that nature presents a unique challenge to the design of policies to manage pesticide risk in general, and to the Toxics Reduction Strategy in particular.

First, exposing the environment to the risk of toxic contamination by pesticides is not an incidental effect of some other activity. Rather, it is the activity. To be effective, pesticides must be toxic, at least to the target organism. And because those organisms live in and are part of the environment, their exposure to the pesticide cannot occur without the pesticide's release into the environment (Virginia Council

on the Environment, 1989).

Second, the environmental risk associated with pesticide use has several dimensions, making it difficult to characterize and quantify. Jack Moore, former Acting Deputy Administrator of the Environmental Protection Agency, has proposed a concept of environmental risk that combines exposure to a substance with the hazards associated with that exposure (Moore, 1989). In the case of agricultural pesticides, both exposure and hazards are determined by several factors. Thus, measuring the risks of pesticide use is even more difficult.

Exposure to a pesticide, or the amount of the pesticide that enters the environment, depends on the amount of land used for agricultural production, which particular crops are grown on that land, and the rate at which the pesticide is used in the production of those crops. The hazards associated with pesticide use depend on the physical and chemical characteristics of the pesticides as well as on certain characteristics of the land on which they are applied. Relevant pesticide characteristics include its degree of toxicity to fish, birds or other "non-target" organisms, whether it is likely to leach into groundwater and surface water, and how long after its release the pesticide is likely to remain poisonous. Relevant land characteristics are soil type, the timing and amount of rainfall, and hydrogeological factors influencing the degree to which pesticides applied to field

surfaces could be transported to groundwater and surface water. By this notion of risk, pesticides that are used in vast quantities, but are not highly toxic, may pose a low environmental risk. Conversely, a high environmental risk may be associated with the limited use of highly toxic pesticides, those that readily runoff into surface water or those that persist in the environment for long periods.

Third, to design policies to reduce the environmental risk of pesticide use, it is necessary to have some notion of the current magnitude of that risk (Gianessi, 1987a). To date however, no comprehensive effort to measure pesticide risk in Virginia has been undertaken. Indeed, Virginia's efforts to address the problems associated with toxic contamination resulting from pesticide use have been hampered because "... the state has faced a chronic lack of data about what chemicals are used on our lands, where and in what quantities" (Virginia Council on the Environment, 1989).

Fourth, the design of pesticide risk-reduction policies must consider how and why that risk may change over time. As the population of the Chesapeake Bay region of Virginia grows, increasing urbanization may induce the conversion of land from agricultural to non-agricultural uses (Hrezo, 1980). A parcel of land that is used to grow corn, wheat and soybeans in 1990 may be used for residential housing or a shopping mall by the year 2000. Such changes will not eliminate the need to be

concerned about pesticide risks, but they will change the nature of the problem as well its potential solutions. As is the case with current pesticide risk, no systematic study of future pesticide risk exists.

Fifth and finally, if resources available for pesticide risk reduction are limited, it is desirable to identify those vectors of pesticide risk that represent the greatest contributions to overall pesticide risk. That is, if pesticide risk is concentrated in certain production systems, pesticides or geographic sub-regions, achieving greater reductions in pesticide risk per dollar spent could be achieved by targeting pesticide risk management programs towards those vectors. Currently, no attempts have been made to generate the information necessary for large-scale program targeting.

Study Objectives

Given the lack of information on current and future pesticide use, Virginia's environmental quality managers will have difficulty designing policies to reduce the risk of toxic chemical pollution of the Chesapeake Bay that are associated with that use. To ease that difficulty, this study has been undertaken with these objectives:

1. To provide comprehensive information concerning the nature and extent of agricultural pesticide use in the Chesapeake Bay region

of Virginia in 1990 and 2000;

2. To identify the counties, crops, or pesticides that pose the greater potential risk to water quality in the Chesapeake Bay region; and
3. To provide recommendations for the design of pesticide risk management strategies that target high risk counties, crops, or pesticides.

Meeting that objective requires that the following three tasks be completed:

1. Determining the amount of land in the Chesapeake Bay region of Virginia devoted to agricultural crop production in 1990 and in 2000;
2. Estimating aggregate pesticide application to that land; and
3. Assessing the risk to the Chesapeake Bay environment associated with that application by adjusting total application according to the toxicity of applied pesticides and their potential for loss to surface water.

Study Overview: Scale and Scope of Inquiry

Geographic Area

Nearly two thirds of Virginia's land area is drained by streams and rivers that empty into the Chesapeake Bay. Much of the Chesapeake Bay watershed however, lies in the region commonly referred to as "Tidewater Virginia." And it is that region that has been designated by the Commonwealth as an area in which special attention to the preservation of the Bay is needed. To meet the challenge of protecting the Bay's resources in a region experiencing rapid economic growth, the Chesapeake Bay Preservation Act of 1988 directs the local governments of Tidewater Virginia to:

"...incorporate general water quality protection measures into their comprehensive plans, zoning ordinances, and subdivision ordinances; [and] ...establish programs, in accordance with criteria established by the Commonwealth, that define and protect certain lands, hereafter called Chesapeake Bay Preservation Areas, which if improperly developed may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries..." (Code of Virginia, §10.1, Chapter 21)

The Act applies to all Virginia localities at or below the fall line that contain, or are adjacent to, the Chesapeake Bay or its tributaries. (Counties and cities that lie both above and below the fall line, such as Henrico county and the city of Richmond, are included in their entirety.) This definition also roughly describes Virginia's "Golden Crescent," the metropolitan corridor circumscribed by the Bay and interstate highways 95 and 64 (de Voursney, 1989:p.22).

Tidewater Virginia represents only 22 percent of Virginia's land area, yet it contains 62 percent of the state's population, represents 65 percent of the assessed value of its land, and supports 30 percent of the harvested cropland in the state, based on data for 1987 (Spar, 1989; U.S. Department of Commerce, 1989). This combination of factors makes Tidewater Virginia particularly interesting for this study; the level of agricultural activity suggests that pesticide risk originating on the region's land may currently be significant, and the disproportionately high land values and population density in the region suggest that urbanization pressure could change that risk in the future.

For these reasons, this study focuses on assessing pesticide risk in Tidewater Virginia. The study area includes the 29 counties and 19 cities that make up Tidewater Virginia as defined in the Chesapeake Bay Preservation Act (Code of Virginia, §10.1-2101).¹ Because some of the data necessary for estimating pesticide risk are not available for one county and are not available at the city level for all but three of these cities, these 48 jurisdictions are combined into the 28 counties and three cities for which separate data are available.²

¹ Due to a typographical error, two cities, Manassas and Manassas Park, are excluded from the "Tidewater" definition appearing in the Code of Virginia. They are included in this study.

² Arlington county, for which sufficient data on agricultural land is not available, is treated as a city within Fairfax county. This definition is not likely to have serious repercussions in the model, since Arlington contains almost no agricultural land (one farm with fewer than 10 acres in 1987) to which pesticides would be applied.

Data for cities, namely population, are added to the data for the county out of which the cities were formed. For three cities, Petersburg, Richmond and Williamsburg, land from two counties formed each city. Petersburg, composed of land formerly in Dinwiddie and Prince George counties, is counted with Prince George county. Richmond, which straddles the James river dividing Henrico and Chesterfield counties, is counted with Henrico County. And Williamsburg, originally part of James City and York counties, is counted with James City County. Hereafter, the 31 jurisdictions are all referred to as counties. A complete list of these counties and the cities they include appears in Appendix A.

Crops and Pesticides Considered

Cropland devoted to 53 crops grown in the 31 Tidewater Virginia counties is considered in the model. Because some groups of these crops receive identical pesticide treatments, the 53 crops are condensed into 37 crop groups. For example: wheat, rye, barley and oats are reclassified as "small grains;" and peaches and nectarines are classified as simply "peaches."

For eleven of these crop groups, no information on pesticide application rates is available. Land used for six of these crops is added to land in crops that are likely to be similar in terms of pesticide application. Though not ideal, this arrangement should have little

impact on aggregate pesticide risk estimates, because the acreage in those six crops is very small compared to total crop acreage in the study area. Three more crops are combined with a fourth group, "Other Vegetables." Although pesticide use on "Other Vegetables" and the remaining crop group, "Nursery Products," cannot be estimated, those two crop groups are retained so that all harvested cropland acreage is included. The final crop groupings are listed in Appendix A, Table A.1.

For the remaining 26 crop groups, applications of 74 insecticides, nematocides, herbicides and fungicides are considered. (Hereafter, these chemicals are collectively referred to as pesticides.) On average, the crops covered in the study receive applications of ten different pesticides per growing season. The number of different pesticides applied to any one crop ranges from two, for alfalfa, to 27, for peanuts. Appendix C, Table C.1 contains the pesticide application rates, and Appendix D, Table D.1 contains a list of the pesticides considered in this study.

In summary, the study considers the environmental risk posed by the use of 77 pesticides on 28 crops grown in the 31 Tidewater Virginia counties.

Study Overview: Factors Affecting Pesticide Risk

As mentioned above, several factors influence the nature and extent of the environmental risks associated with the use of agricultural pesticides. These factors include the level and pattern of agricultural land use, the rate of pesticide use on that land, the hazards associated with the pesticides used, and certain properties of the land on which the pesticides are applied.

An ideal model of agricultural pesticide risk would consider the current role of each of those factors as well as any changes in the factors and their contributions to pesticide risk over time. For some risk factors however, such as properties of the land to which pesticides are applied, information necessary for assessing the factors' current role in pesticide risk is simply not available. For others, such as pesticide application rates, information necessary for making accurate predictions concerning future contributions to pesticide risk is lacking. Thus, this study is restricted to a consideration of those risk factors about which adequate information is available.

Pesticide Risk Factors Not Considered

One major pesticide risk factor necessarily excluded from this study is the properties of the land on which the pesticides are applied. These properties affect the degree to which pesticides applied to field surfaces can be transported to groundwater and surface water, and

include: type of soil; depth to groundwater; rainfall; and slope of the land. Each of these properties may vary considerably within a given county, and may even vary from field to field on a single farm. Therefore, incorporating these factors into the pesticide risk evaluation model would require land use data (i.e. acreage in each crop) at the field level. Because those data exist only at the county level or higher, however, the role of land characteristics in pesticide risk are not considered in this study.

For several risk factors, it is information concerning future contributions to aggregate pesticide risk that is not available. Nor do those risk factors seem to change in a manner that would make fruitful the prediction of future contributions based on current information. For that reason, this study does not incorporate changes in these risk factors into the evaluation of future pesticide risk. Thus, pesticide application rates, the choice of pesticides and pesticide hazard characteristics are assumed to remain constant throughout the study period.

Changes in per-acre pesticide application rates and in the characteristics of the applied pesticides frequently are driven by advancements in crop protection technology. Those advancements however, may not change agricultural pesticide risk in any systematic or predictable way. For example, many older insecticides were "broad-

spectrum," that is, they were intended to be toxic to several insects. Because different insects emerge at different times during the growing season, those insecticides had to persist in the environment for long periods. Newer insecticides, however, tend to be targeted at a narrow group of pests, and therefore need not be as persistent as the agents they replaced; they must remain toxic only long enough to control the target pest.

The net effect of this sort of change on pesticide exposure is difficult to assess. On one hand, the newer pesticides are generally applied at a lower rate per acre than older pesticides. On the other hand, several pesticides are now used to control the same group of pests that one pesticide once controlled, so total per acre pesticide application may not have changed that much. Judging the effect on the environmental hazard associated with pesticide exposure is similarly ambiguous.

Today's pesticides are often less toxic and less persistent than their predecessors, but because more agents are used, total environmental risk may have increased, decreased or stayed the same.

Other technological factors inhibiting the ability to forecast pesticide exposure and risk include: changes in pests' resistance to pesticides currently in use; and the degree to which biotechnological advances such as new pest-resistant plant varieties or genetically engineered beneficial insects supplant conventional pest control methods (Osteen

and Szmedra, 1989).

The effect of changes in state and federal agricultural and environmental policies on pesticide risk is also difficult to predict. Agricultural policies, such as those that promote the adoption of integrated pest management, may alter pesticide use directly (Gianessi, 1990a). Or they may have indirect effects on pesticide use, as is the case for some soil conservation policies. Promoting reduced tillage, for example, may result in a greater need for herbicide use (Gianessi, 1987a, 1990b).

Another type of regulatory action, pesticide bans, add more uncertainty to the problem of assessing future pesticide risk. First, it is doubtful that one could predict which pesticides currently in use are likely to be banned in the future. Three years ago, for example, few would have guessed that daminozide (Alar/Kylar), a relatively non-toxic chemical used on only two crops, would be banned today. Further uncertainty stems from questions concerning which chemicals will replace the banned pesticides, and whether the replacements will be more or less hazardous than the material that is banned (Gianessi, 1987a).

Given the complexity of this issue and the uncertain nature of future technological and regulatory change, this study forgoes any attempt to predict changes in the application rates or pesticide characteristics

that affect pesticide risk. Instead, this study's predictive function is restricted to forecasting changes in the land area to which pesticides are applied. Speculation over the nature and magnitude of future technological change is just that, and is not likely to provide information useful for designing pesticide management policies. But by focussing on land use change, which is better understood, this study is more likely to produce reasonable estimates of future pesticide risk.

Pesticide Risk Factors Considered

The model developed for this study considers three primary determinants of pesticide risk. The first is the amount of land employed in crop production, which represents the pool of land on which agricultural pesticides might be applied. Historical data concerning the allocation of Tidewater Virginia lands to agricultural production are used to forecast the amount of land devoted to production of 28 crops for the years 1990 and 2000.

The second determinant is the intensity of pesticide use on that land, or the rate of pesticide application per acre for each of the crops harvested. By combining the first and second components, (i.e. multiplying crop acreage by per-acre pesticide application rates) an estimate of aggregate pesticide exposure is obtained.

The third determinant is the hazards posed by the use of each pesticide to which the environment is exposed. For each pesticide, toxicity and mobility factors are used to stratify aggregate pesticide use according to the potential for adverse environmental consequences arising from the exposure to the pesticide.

Study Overview: A Three-Stage Model of Pesticide Risk

Because Virginia does not require pesticide applicators to report their use of pesticides, the information sought by this study cannot be observed directly. And because no effort to make a comprehensive survey of chemical use in Virginia has been undertaken, that information cannot be extrapolated from a statistically reliable sample of applicators. Therefore, meeting the objectives of this study (without exceeding the amount of time and resources available for its completion) requires that an alternative approach be followed. Namely, agricultural chemical use is estimated through a model of pesticide use.

As noted above, the risk associated with pesticide use is composed of the exposure of the environment to pesticides as well as the hazards associated with that exposure. The first two stages of the model employed in this study deal with estimating the exposure of the Chesapeake Bay environment to pesticides. In the third stage, the

hazards of the pesticides used are analyzed, and the risk associated with their use is evaluated. .

Stage One: Agricultural Land Use Forecasting

As discussed, changes in pesticide use (at least those that can be predicted) are driven in this study by changes in agricultural land use. The first stage or task of the model therefore, is to estimate the amount of land likely to receive pesticide doses now and in the future. That estimation is accomplished through an econometric analysis of the effect of urbanization on agricultural land use.

More specifically, the first stage uses regression techniques to forecast harvested cropland in Tidewater Virginia for the years 1990 and 2000. Urbanization in the region, as reflected in rising land values and population densities, is used to predict total cropland. Because land use data for individual crops is available only in the form of "harvested cropland," and because such information is necessary for linking land use and pesticide application rates, the portion of total cropland that is actually harvested is then estimated.³ Finally,

³ It may seem that harvested cropland should be estimated directly, rather than taking this rather circuitous route. Changes in harvested cropland however, may be driven by many factors, such as drought, that are not related to urbanization. It is the total amount of land devoted to crops that, it is hypothesized, responds to urbanization pressure, so total cropland is examined in this portion of the model.

harvested cropland is allocated to the 28 crop groups according to recent historical trends.

Stage Two: Pesticide Exposure Estimation

The second stage of the model combines acreage estimates for individual crops with pesticide application rates for those crops. These application rates, which represent typical insect, weed and disease control measures for these crops in Virginia, have two components. The first component is an estimate of the proportion of the acreage in each crop that is likely to be treated with each pesticide in a given season. (For a given crop, only a fraction of the acreage will require treatment for a given pest, and the same pesticide is not likely to be used on all treated acreage.) The second component is the rate, expressed in pounds of the pesticide's active ingredient per acre, at which each pesticide would be applied to the treated acreage.

Pesticide exposure is then computed by multiplying the acreage estimate from the first stage by the proportion of acreage treated and the per-acre application rate from the second stage. Since 266 combinations of crop and pesticide are considered in the model, and crop acreage for 31 counties is estimated, some 8,246 combinations of county, crop and chemical are possible. Of course, many crops are not grown in most of the counties, so the realized number of pesticide exposure estimates will be much smaller.

Stage Three: Pesticide Hazard and Risk Evaluation

The third and final stage involves using information about the environmental hazards of individual pesticides to transform the 8,246 exposure estimates into some manageable measure of pesticide risk. Two components of pesticide hazard are considered. The first is the degree of toxicity of the pesticide, which represents the pesticide's potential to harm the Bay or the organisms that inhabit it. The second is the degree to which the pesticide could be transported to surface water. This latter component represents the potential of the pesticide to get to a place where it could do environmental harm (i.e., the Bay's water).

Pesticide toxicity and potential mobility are combined to form an index of the environmental hazards of each pesticide. By multiplying this index by the amount of the pesticide applied for each county-crop-pesticide combination, an ordinal measure of gross pesticide risk is obtained. Gross pesticide risk then indexed to a zero to one hundred scale, with region-wide pesticide risk in 1990 serving as the base. Using this index of relative pesticide risk, the pesticides, crops or counties that contribute the most to agricultural pesticide risk in Tidewater Virginia can be identified and trends in pesticide risk can be analyzed.

Summary of the Pesticide Risk Evaluation Model

Figure 1.1 below depicts the three-staged model employed in generating an assessment of current and future pesticide risk for Tidewater Virginia. To summarize, the model begins by forecasting the amount of land devoted to 28 crops grown in 31 Tidewater Virginia counties for the years 1990 and 2000. Next, pesticide application rates are used to estimate the total exposure of the Tidewater Virginia region to agricultural pesticides. Environmentally relevant pesticide characteristics are then used to construct an index of the potential hazards of that exposure. Next, the index of pesticide hazards is used to adjust pesticide exposure to reflect pesticide risk. Finally, pesticide risk is standardized to facilitate intra- and intertemporal comparisons of potential pesticide risk.

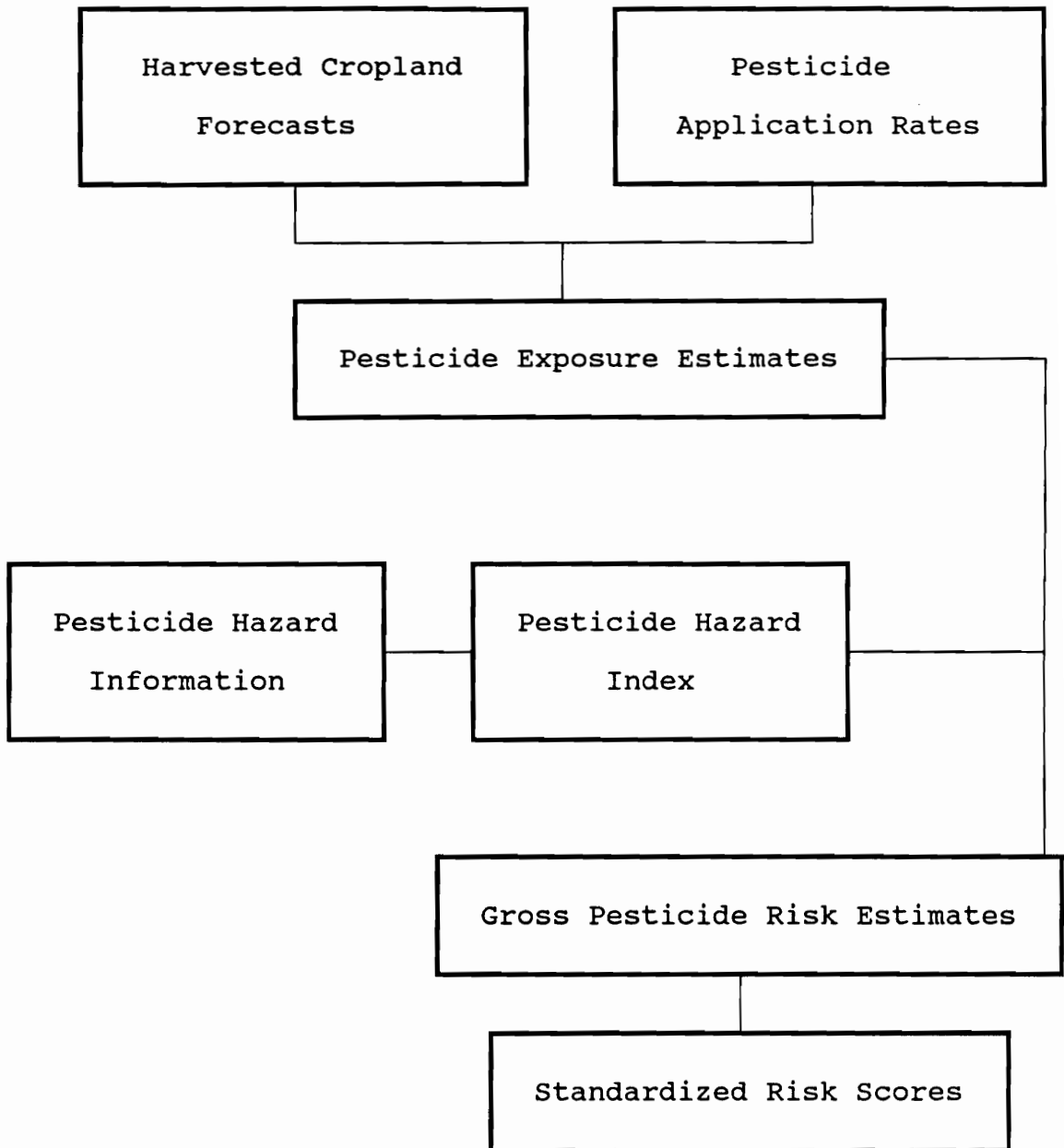


Figure 1.1. The Pesticide Risk Evaluation Model

Organization of the Thesis

The following chapter describes the first component of the model. A conceptual model of agricultural land use is developed, given empirical content and the results are discussed. Chapter three presents the concepts, procedures and general results of the second and third components. The fourth chapter presents more detailed results relating to relative pesticide risk among the various counties included, crops grown and pesticides used in Tidewater Virginia.

Chapter five contains a discussion of the policy and research implications identified through the conduct of this study. First, any changes in pesticide risk arising from changes in agricultural land use are examined to determine whether agricultural pesticide risk is likely to remain an important source of environmental risk in the Bay region. Second, because separate estimates of pesticide risk are generated for each combination of crop, chemical and county, the information provided by this study is used to explore the potential for targeting pesticide management programs to the crops, chemicals or counties that represent the greatest risk to the Bay environment. Finally, direction is provided for further research to obtain the information necessary for achieving actual cost-effective program targeting.

CHAPTER TWO: AGRICULTURAL LAND USE FORECASTING

Aggregate Land Use Change in Urbanizing Areas

Viewed from a historical perspective, conversion of agricultural land to urban uses is almost inevitable. In an earlier age, when transporting agricultural products was very costly, agricultural production tended to be carried out near population centers, and population tended to accumulate near the most productive agricultural land. Growing urban populations embodied a growing demand for food, bidding up the price of agricultural products. As those prices increase by enough to cover the higher transportation costs associated with farming farther from the population center, new land is brought into production.

Growing urban populations also embody increased demands for non-food items, including land for residential, commercial and recreational uses. As these uses compete with agricultural production for the fixed land base, the price of land of a given quality and location will be bid up, with land allocated to its most highly valued use. Urban land uses, at least as long as food is plentiful, are likely to be more highly valued than agricultural production, so land is often converted from agricultural to urban uses (Barlowe). Agricultural production either is resumed on land that is poorer and/or farther from the population center or is abandoned in favor of more lucrative activities. Food needs would

then be met through importation from other regions.

Von Thunen's land use theory explains the arrangement of land uses around the population center for a given point in time. In von Thunen's theory, the presence of transportation costs leads to an arrangement in which the most highly valued goods are produced on land closest to the population center (Brooks). In an agrarian economy, the most highly valued agricultural goods are produced closest to the population center, and those with lower values are produced farther away. In a mixed economy, more valuable urban activities occupy the land closest to the population center while agricultural production, if present, occupies more distant land (Barlowe).

Because von Thunen's theory is static, it does not explain how land use patterns might evolve over time. Land use evolution might be intra-regional, as would be the case when a region shifts from an agrarian- to an urban-based economy or when growth occurs in an already mixed regional economy. Nor does von Thunen's theory deal with inter-regional effects that may arise as the growth of neighboring regions leads to competition for the land that once separated them.

The "growth pole concept" offers temporal and inter-regional improvements to von Thunen's theory while preserving the essential elements of the spatial distribution of land to different valued uses.

Growth pole theory holds that regional growth occurs at two levels: at the pole, or population center (highest-valued land uses); and in the hinterland (lower-valued land uses) (Moseley). Over time, as the pole becomes more complex through growth and development, both the pole and the hinterland expand. Growth adds more potential land users and more wealth to the region while development may add more potential land uses to the region. Each of these effects will increase competition for land within the region. As discussed above, this competition is likely to drive up the price of land, thus increasing the opportunity cost of using land for lower valued uses (i.e. agriculture).

In addition to affecting markets for land, regional growth and development is likely to affect markets for labor and capital as well. As urban-oriented businesses locate in the region, urban employers become better able to compete for the services of farm workers and managers. Also, more opportunities arise for farm owners, managers and laborers to seek potentially more lucrative off-farm employment. As a result, more farm managers may become part-time farmers, while working full or part time in urban jobs, and farm owners may be less able to hire sufficient labor to operate larger farms.

For similar reasons, farm operators may find it more difficult, or at least more costly, to obtain capital as urbanization progresses. The price of capital may be bid up as new businesses add to the pool of

demanders of capital, and the attention of lending institutions may become partially diverted toward new, possibly more profitable, accounts.

Lopez, Adelaja and Andrews (1988) identify several additional effects of urbanization on agriculture including regulatory, technical, speculative, and market effects. Regulatory effects are the result of more stringent ordinances designed to mitigate the off-farm effects of agricultural production. Technical effects are those that change the technical efficiency of agricultural production. These effects include vandalism and the difficulty in obtaining inputs and farm-support services as the businesses that supplied those inputs close due to a lack of sufficient demand. Speculative and market effects are the distortions in farmers' land use decisions caused by such effects of urbanization as rising land values and an increase in the number of potential alternative land uses.

Stage One Procedures: Land Use Forecasting

Based on the preceding discussion, one can quickly identify several factors that may determine the amount of land devoted to agricultural production in an urbanizing region. These factors include: the price of agricultural and non-agricultural land; agricultural and non-agricultural wages; population and housing densities; property tax

rates; the existence of regulations designed to control farm-source pollution; and the diversity of the regional economy (i.e., the existence of potential competitors for farm land, labor and capital).

Each of these factors are measurable in one way or another, and may be considered ideal for inclusion in an econometric model of agricultural land use. In fact, several studies have used observed data on these and other determinants to explain agricultural land use in urbanizing regions (Healy, 1985; Lopez, Adelaja and Andrews, 1988; Alig, 1986; Alig and Healy, 1987; Alig, White and Murray, 1988). This study, however, attempts to forecast future land use, and therefore, requires information concerning future trends in the determinants of land use. Because forecasts are to be generated for individual counties, the study further requires that both historical and projected data be available at the county level.

These requirements greatly restrict the choice of determinants to be included in the forecasting model. Given the objective of this portion of the study, however, a conceptually incomplete set of determinants is acceptable as long as the forecasts they generate are reasonably accurate. The following sections describe the set of information concerning the determinants included in the model, the model's efficacy in forecasting agricultural land use, and the model's results.

Variable Selection and Data Sources

According to the conceptual model adopted for this study, change in agricultural land use in urbanizing areas is driven by changes in the opportunity cost of holding and managing land for agricultural purposes. In the language of growth pole theory, poles within the region grow and become more complex, transforming the hinterlands as new urban-oriented uses arise for the resources of the hinterlands.

As with many models of economic behavior, the land use decisions being modeled are assumed to be taken in response to farmers' perceptions of opportunity costs. And the decisions are assumed to take the form of expectations of what land use will be. Unfortunately, with the exception of information concerning expected farmland values, information on farmers' expectations and perceptions is not generally available. What is available is observed information on land use decisions that farmers have taken in the past, and on phenomena that may be associated with expectations concerning opportunity costs for land and labor.

County-level information on past land use decisions and past expectations regarding land values is available from the Census of Agriculture. The Census of Agriculture is a survey of farms, conducted periodically by the U.S. Department of Commerce, that yields estimates of the acreage designated as cropland and harvested cropland and of the

value of farm land and buildings for the 31 counties of Tidewater Virginia.

Cropland and harvested cropland estimates represent the actual amount of farmland on which crops were produced in the year covered by the survey. The Census of Agriculture also contains estimates of the value per acre of farms in Tidewater counties. The estimates of farmland value represent the surveyed farmers' "estimate of what the land and buildings would sell for under current market conditions," so they are well suited to a model of land use change that is based on expectations concerning land values (U.S. Department of Commerce, 1984:p.A-3).

Nominal farmland values are converted to real farmland values by deflating by the consumer price index. The CPI is used because it is the value of current farmland for all potential uses (i.e. the opportunity cost of farmland) that is of interest in this study. Thus, it is desirable to use a deflator that is general enough to encompass a wide range of prices.

Data for the 31 counties and for the Census of Agriculture years 1969, 1974, 1978, 1982 and 1987, are combined to form a pooled data series spanning an 18-year period and including necessary information on land use and land values (U.S. Department of Commerce, 1972, 1977, 1981, 1984, and 1989). Still lacking from the data series is some measure of

urbanization, or, more specifically, the regulatory, technical and market impacts of urbanization on agricultural land use decisions. Because urbanization is frequently associated with increasing population density, population density is chosen as a proxy measure of urbanization. Similar measures also have been shown to be useful for estimating agricultural land use in other studies (Alig, 1986; Alig and Healy, 1987; Alig, White and Murray, 1988).

Estimates of each county's population in past years are extracted from bulletins issued by what is now the Center for Public Service at the University of Virginia (Gilliam, 1969; Gilliam and Serow, 1975; Martin and Spar, 1979; Center for Public Service, 1989). Population density per acre is computed by dividing the county population (including the population of any cities within the county) by the total land area of the county. Population density is computed for each of the years for which Census of Agriculture data are used, i.e. 1969, 1974, 1978, 1982, and 1987. Population density for the future years, 1990 and 2000, is computed in a similar manner, but using population projections generated by the Virginia Department of Planning and Budget and reported in the Virginia Statistical Abstract (Center for Public Service, 1989). The population density data are then combined with the land use/land value data series.

Three additional variables are included in the pooled data series. The first is a time variable, defined as the number of years between 1969 and the year to which a given observation applies. This variable is used in the econometric model to account for any time trend in the conditional mean of cropland and farmland values over time. Because the Census of Agriculture has not been completed at even intervals, the time variable is also useful for smoothing those intervals.

The second variable is really a set of nine dummy variables, one for each of the nine planning districts represented in Tidewater Virginia. Together, these dummy variables indicate the planning district to which each county belongs. For each of the 31 counties, the variable representing the planning district to which the county belongs takes the value one; the remaining planning district variables are set to zero.

Because land use decisions are not likely to be affected by only those forces within a given county, the planning district variables also serve to group the counties into the larger areas that contain more of the factors influencing those decisions. For example, a farmer is not likely to forgo off-farm employment simply because the job would entail commuting across the county line. Or, an urban developer would not necessarily lose interest in buying farmland simply because it lies within one county or another, other things being equal.

In a sense, the planning districts can be interpreted as representing growth poles within Tidewater Virginia. Because all growth poles are not likely to evolve at the same rate or in the same way, the planning district variables should help to capture any differences in land use change that arise due to differences among the growth poles. Growth in the already highly urbanized Northern Virginia planning district, for example, is not likely to proceed in the same manner as in the relatively rural Northern Neck planning district.

The third variable is total cropland acreage in 1969. This variable, which takes a unique value for each county, may help to determine whether inertial forces are present in land use trends. A county that is already highly urbanized at the beginning of the study period may experience more rapid land use change than one that is more rural at the beginning of the period. The reason for this is that once urbanization begins, it may be difficult, due to rising land values and disappearing farm-support services, such as grain storage and pesticide application, for farmers to resist increasing incentives to sell their land for still more urban uses (Lopez, et al., 1988). Conversely, farmers in counties in which urbanization is not well advanced may be more willing or able to keep land in agriculture.

The complete data set contains all of the relevant information for estimating harvested cropland acreage up to 1987 (population density and

farmland values) and some of the relevant economic information for forecasting harvested cropland acreage to the year 2000 (population density). The data set contains 217 observations, one for each county-year combination. The following variables are included for each county-year observation:

CNTYCODE:	a unique 2-digit identification code assigned to each county;
YEAR:	the year (1969, 1974, 1978, 1982, 1987, 1990, or 2000);
DT:	the number of years between 1969 and the year to which the observation applies;
CROPLAND:	total cropland (acres);
CRPLND69:	CROPLAND in 1969;
HARVLAND:	total harvested cropland, a subset of total cropland (acres);
RVALFRM:	the real value per acre of farmland and buildings in 1982-84 dollars;
POPDENS:	the population density per acre;
PD08:	whether the county is in the 8 th planning district, Northern Virginia;
PD15:	whether the county is in the 15 th planning district, Richmond Regional;
PD16:	whether the county is in the 16 th planning district, Radco;
PD17:	whether the county is in the 17 th planning district, Northern Neck;
PD18:	whether the county is in the 18 th planning district, Middle Peninsula;
PD19:	whether the county is in the 19 th planning district, Crater;

- PD20: whether the county is in the 20th planning district, Southeastern Virginia;
- PD21: whether the county is in the 21st planning district, Peninsula; and
- PD22: whether the county is in the 22nd planning district, Accomack-Northampton.

Appendix B, Table B.1 contains the essential information for constructing the complete data set.

Construction of the Forecasting Model

Based on the conceptual and data availability considerations described above, the following model representing agricultural land conversion is postulated:

$$\begin{aligned}
 2.1 \quad \text{CROPLAND}_{j,t} = & \beta_0 + \beta_1 \text{CRPLND69}_j + \beta_2 \text{RVALFRM}_{j,t} \\
 & + \beta_3 \text{POPDENS}_{j,t} + \beta_4 \text{DT}_t \\
 & + \gamma' \text{PD}_j + u_{j,t}
 \end{aligned}$$

where: j is the index in the cross-sectional dimension (i.e. 1,2,...,31);

t is the index in the time-series dimension (i.e. 1969, 1974, 1978, 1982, 1987, 1990, 2000);

γ' is shorthand for the vector of parameters, $(\gamma_1, \gamma_2, \dots, \gamma_8)'$;

PD represents the vector of planning district indicators, $(\text{PD08}_j, \text{PD15}_j, \text{PD16}_j, \text{PD17}_j, \text{PD18}_j, \text{PD19}_j, \text{PD20}_j, \text{PD21}_j)'$;⁴ and

⁴ PD22 is excluded from the model due to the perfect collinearity of the planning district dummy variables.

$u_{j,t}$ is the unsystematic component of $CROPLAND_{j,t}$, which is the actual value of $CROPLAND_{j,t}$ minus the estimated value.

If this model were intended to simply **estimate** the historical effect of population density, land values and time-series and cross-sectional effects on cropland acreage, no more information would be required than that contained in the data set described above. One of the tasks of this study however, is to **forecast** future land use based on variables such as future population density and land values. It is therefore necessary to have some idea of what the future levels of those independent variables will be.

DT, the time trend, can easily be computed for future years. It is assumed that planning district boundaries are fixed, so planning district indicators will be identical in each year. Population projections have been supplied by a State agency. The passage of time will not change historical (1969) cropland acreage, so the lagged variable can simply be carried forward to future years. That leaves farmland values, for which no independent projections are available. To fill this gap in the set of independent variables, farmland values for 1990 and 2000 are forecast using the following model:

$$\begin{aligned} 2.2 \quad RVALFRM_{j,t} = & \alpha_0 + \alpha_1 POPDENS_{j,t} + \alpha_2 DT_t \\ & + \delta' PD_j + v_{j,t}^5 \end{aligned}$$

⁵ Different letters are used here to emphasize that the parameters of 2.2 are not identical to those of 2.1.

The usefulness of this model for forecasting unknown future farmland values is judged according to its accuracy in forecasting known past farmland values. To assess that accuracy, a test data set containing all of the information for the 1969 - 1982 period plus the independent variables for 1987 is constructed. Model 2.1 is then used with that data set to forecast the dependent variable, $RVALFRM_j$, for 1987. Finally, that forecasted value is compared to the observed values of $RVALFRM_j$ for that year via Theil's inequality coefficient, which is:

$$U = \frac{(\frac{1}{m} \sum_{j=1,31} v_{j,1987}^2)^{\frac{1}{2}}}{(\frac{1}{m} \sum_{j=1,31} y_{j,1987}^2)^{\frac{1}{2}}}$$

where: $y_{j,1987}$ represents the observed value of $RVALFRM$ for county j in 1987 (adapted from Maddala, 1977:pp.346-7).

U , which takes a value between zero and one, is minimized when the parameters of the estimated model are closest to the parameters of the true model, i.e. when the relationship postulated in 2.2 most closely approximates the relationship that gives rise to the observed data. The closer the model is to "truth," the smaller will be the error term, $v_{j,1987}$, and the smaller will be U . For equation 2.2, the inequality coefficient is 0.365, suggesting that the model is fairly effective in predicting farmland values.

Estimated farmland values for the future years 1990 and 2000 are then incorporated into the data set to permit the use of equation 2.1 for forecasting cropland acreage in those years. The efficacy of equation 2.1 is assessed using a procedure similar to that used for assessing the farm value model, 2.2. First, actual 1987 farmland value and cropland acreage figures are removed from the 1969 - 1987 data set. Second, forecasted farmland values for 1987 are substituted for the actual values for that year. Third, the cropland model, 2.1, is estimated and forecasted cropland acreage for 1987 is obtained. Finally, Theil's inequality coefficient is used to compare the 1987 forecasts with actual 1987 cropland acreage. The coefficient is 0.146, allowing acceptance of the combination of 2.2 and 2.1 for forecasting cropland acreage.

As noted above, meeting the objectives of this study requires that total cropland be converted into harvested cropland. This conversion is accomplished through the following model:

$$2.3 \quad \text{HARVLAND}_{j,t} = \phi_0 \text{CROPLAND}_{j,t} + \psi' \text{PD}_j + w_{j,t}$$

This model has no intercept because HARVLAND (harvested cropland) is a subset of CROPLAND (total cropland). The planning district indicators allow the model to pick-up regional differences in the mix of crops planted, weather and other factors that would give rise to regional differences in the allocation of cropland to harvested cropland.

The predictive accuracy of equation 2.3 is evaluated using a procedure similar to that followed for the previous models: farmland values, cropland acreage and harvested cropland acreage for 1987 are removed from the 1969 - 1987 data set; equation 2.2 forecasts 1987 farmland values; equation 2.1 forecasts 1987 cropland acreage; and equation 2.3 then estimates the proportion of cropland that is harvested cropland in 1987. Comparison of actual and estimated harvested cropland acreage yields an inequality coefficient of 0.194. Thus, the sequence of regression equations is deemed effective for forecasting harvested cropland acreage.⁶

Based on the observation that the sequence of equations described above is useful for forecasting harvested cropland for 1987, all available data are then restored to the data set and the model is used to forecast farmland values, cropland acreage and harvested cropland acreage for the years 1990 and 2000.

The final task for the first stage of the model is to allocate total harvested cropland among the 28 crop groups. To accomplish this, the

⁶ It may seem that a more direct means of obtaining this information would entail estimation of a reduced form model such as: $HARVLAND_{i,t} = a_0 + a_1 CRPLND69_j + a_2 POPDENS_{j,t} + a_3 DT_t + b' PD_j + e_{j,t}$. Such an approach however, would have the effect of using estimated farmland and cropland values for all years. In contrast, the approach used in this study uses estimated values only for those years for which data are unavailable. Thus the chosen approach avoids some of the error that a reduced form approach would generate.

proportion of total harvested cropland in each of 53 individual crops is computed for the census years 1978, 1982 and 1987. The average of these proportions is calculated across the three Census' for each combination of county and crop. It is assumed that these proportions will not change appreciably over the 1990-2000 period, so land devoted to each of the 53 crops can be calculated by multiplying forecasted harvested cropland by the proportion in each crop. Acreage in the 28 crop groups is obtained by summing the acreage in all crops within each group.

Stage One Results: Land Use Forecasts

Farmland Value Forecasts

Forecasts of harvested cropland are obtained by forecasting total harvested cropland then allocating the total among 28 crops grown in Tidewater Virginia. The first step in this process involves forecasting real farmland values for 1990 and 2000 to complete the set of independent variables necessary for forecasting cropland. Econometric results for this portion of stage one are presented in Table 4.1, below.

Farmland values seem to be most strongly related to population density and whether the farm is located in one of two planning districts in which urbanization is particularly advanced. As expected, farmland values tend to rise with increasing population density. Farmland values

also appear to be higher in the Northern Virginia and Peninsula planning districts. This phenomenon may be attributed to urbanization in these planning districts in excess of that which might be associated with increasing population density alone. If the Washington DC metropolitan area, and the cities of Hampton, Newport News, Poquoson and Williamsburg are considered to be regional growth poles, above average increases in land values in the Northern Virginia and Peninsula planning districts may be the result an increasing alternative uses for agricultural land in those areas.

In contrast, the Middle Peninsula planning district, which contains no major metropolitan areas (i.e. smaller growth poles), has had lower than average farmland values over the study period.⁷ Based on the estimation results in Table 2.1 however, the relationship does not appear to be as strong as for the Northern Virginia or Peninsula planning districts.

Forecasted farmland values for the Tidewater region are contained in Table 2.4. Forecasts for each county are included in Appendix E. On average, farmland values are expected to increase by 4.76 percent from \$1858 to \$1947 per acre between 1990 and 2000.

⁷ The fact that the parameter estimate for PD18 is negative does not imply that farmland values are declining in the Middle Peninsula planning district. Rather, because the linear regression equation is simply an expression of the mean of the independent variable, the negative parameter estimates imply only that the mean of RVALFRM for the Middle Peninsula is declining relative to the mean for the tidewater region as a whole.

Table 2.1. Farmland Value Forecasting Model Results

DEPENDENT VARIABLE: RVALFRM

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROBABILITY > T
INTERCEPT	1317.2675	179.4499	7.341	0.0001
POPDENS	747.7768	74.7096	10.009	0.0001
DT	3.0093	6.9322	0.434	0.6649
PD08	1660.2331	273.2960	6.075	0.0001
PD15	-217.9311	202.3253	-1.077	0.2832
PD16	13.6449	207.9551	0.066	0.9478
PD17	-199.9636	206.1249	-0.970	0.3336
PD18	-403.3103	238.3420	-1.692	0.0928
PD19	-78.6104	195.1765	-0.403	0.6877
PD20	-117.5033	215.0533	-0.546	0.5857
PD21	1110.2008	250.7853	4.427	0.0001

F(10,142) = 50.85
(Probability > F = 0.0001)

Adjusted R² = 0.7663

VARIABLE KEY:

RVALFRM = real farmland value per acre
 POPDENS = population density per acre
 DT = time in years since 1969

PLANNING DISTRICT DUMMY VARIABLES: (1 for the planning district to which the observation applies; 0 for all others)

PD08 = Northern Virginia planning district
 PD15 = Richmond Regional planning district
 PD16 = Radco planning district
 PD17 = Northern Neck planning district
 PD18 = Middle Peninsula planning district
 PD19 = Crater planning district
 PD20 = Southeastern planning district
 PD21 = Peninsula planning district

Cropland Forecasts

The second step of stage one is to forecast total cropland based on cropland in 1969, forecasted farmland values and population density, time and planning district indicators. Table 4.2 presents the econometric results of this forecasting.

Like farmland values, cropland acreage seems to be strongly related to population density. Unlike farmland values however, cropland acreage declines as population density increases. As demonstrated by the RVALFRM model above, farm values and population density are highly correlated, so the two variables may be measuring similar effects in the CROPLAND model. This collinearity may account for the relatively weak relationship between cropland and farmland values in the CROPLAND model.

The strongest indicator of current cropland is the amount of cropland in the base year, 1969. Counties that had more cropland in the past may be expected to have more cropland today, other things being held constant. Cropland acreage also seems to be higher than average for the Crater planning district, of which Prince George and Surry county are members.

Forecasted cropland acreage for the Tidewater region is contained in Table 2.4. Forecasts for each county are included in Appendix E. Cropland is forecasted to decrease by 2.48 percent, from 935,931 to 912,693 acres between 1990 and 2000. As a proportion of total land

Table 2.2. Cropland Forecasting Model Results

DEPENDENT VARIABLE: CROPLAND

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROBABILITY > T
INTERCEPT	-2088.1197	3142.1686	-0.665	0.5077
CRPLND69	1.1116	0.0333	33.338	0.0001
RVALFRM	-1.0880	0.7862	-1.384	0.1692
POPDENS	-1566.3483	804.7588	-1.946	0.0542
DT	-56.1589	77.0071	-0.729	0.4674
PD08	1402.9622	2508.2000	0.559	0.5771
PD15	3536.3344	1924.1775	1.838	0.0688
PD16	3391.2052	1939.1123	1.749	0.0831
PD17	2923.9952	1919.6808	1.523	0.1306
PD18	-520.5648	2090.1095	-0.249	0.8038
PD19	5824.4880	1962.3812	2.968	0.0037
PD20	-1174.9867	1647.5143	-0.713	0.4772
PD21	3110.2087	2487.3160	1.250	0.2138

F(12,110) = 255.868
(Probability > F = 0.0001)

Adjusted R² = 0.9616

VARIABLE KEY:

CROPLAND = acres of cropland

Other variables are defined as for farmland value model (see Table 4.1).

area, this change represents a decrease from 16.4 to 16.0 percent. This decrease suggests that cropland's share of all land uses will not change drastically over the next ten years.

Harvested Cropland Forecasts

The final econometric task of stage one is to estimate harvested cropland acreage as a function of cropland and planning district dummy variables. Table 2.3 presents the results of this model.

According to those results, 88.24 percent of cropland, on average, is harvested. The number of acres harvested in different counties varies according to the planning district to which the county belongs. Fairfax County, located in the 8th Planning District, would have some 7,821 fewer acres of harvested cropland than would be expected by virtue of cropland acreage alone. Similarly, Lancaster county and the other counties in the Northern Neck (17th Planning District) would be expected to have almost 600 more acres of harvested cropland than would be predicted by cropland acreage.

These interregional differences in the ratio of harvested cropland to total cropland arise because cropland, as defined in the Census of Agriculture, includes land on which crops failed, land idled or placed in state and federal set-aside programs, land used only for pasture or grazing, and several other types of land on which harvesting would not

take place. The amount of land in the categories that make up CROPLAND is not the same for each region, so the ratio of cropland to harvested cropland would be expected to vary between regions. Furthermore, the relative mix of crops planted is not constant across regions. So in a drought year, for instance, regions with relatively fewer drought resistant crops would have a higher crop failure rate and less harvested cropland than other regions. Also, not all crops are covered by federal acreage limiting programs, so the interregional differences in the relative prominence of various crops will affect the amount of cropland that has been idled.

Estimates of harvested cropland acreage for the Tidewater region are contained in Table 2.4. Forecasts for each county are included in Appendix E. Harvested cropland in Tidewater Virginia is expected to decrease by some 19,000 acres, or 2.51 percent, to 752,156 acres over the next ten years. In terms of the proportion of total land devoted to harvested cropland, this decrease represents a conversion of only three tenths of one percent of total Tidewater land area from harvested cropland to other uses. Thus, according to these estimates, agricultural crop production is likely to remain an important use of land for the remainder of the century.

Table 2.3. Harvested Cropland Forecasting Model Results

DEPENDENT VARIABLE: HARVLAND

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROBABILITY > T
CROPLAND	0.8824	0.0124	70.903	0.0001
PD08	-7820.7167	1025.2657	-7.628	0.0001
PD15	-3372.5478	695.3101	-4.850	0.0001
PD16	-4426.7898	773.4508	-5.723	0.0001
PD17	592.9842	790.6751	0.750	0.4545
PD18	-2126.0188	1057.0679	-2.011	0.0462
PD19	-346.7966	648.7986	-0.535	0.5938
PD20	-488.1940	950.0541	-0.514	0.6081
PD21	-120.3313	1041.8516	-0.115	0.9082

F(12,110) = 1628.077
(Probability > F = 0.0001)

Adjusted R² = 0.9896

VARIABLE KEY:

HARVLAND = acres of harvested cropland

Other variables are defined as for the farmland value and/or cropland models (see Tables 4.1 and 4.2).

NOTE: This model has no intercept because, by definition, harvested cropland is a subset of cropland.

Table 2.4. Agricultural Land Use Summary for Tidewater Virginia, 1990 & 2000

LAND USE VARIABLE	1990	2000	PERCENT CHANGE
TOTAL AREA (ACRES)	5,698,539	5,698,539	--
REAL FARMLAND VALUE (\$ PER ACRE)	1858	1947	4.76
CROPLAND (ACRES)	935,931	912,693	-2.48
% OF TOTAL AREA	16.4	16.0	
HARVESTED CROPLAND	771,535	752,156	-2.51
% OF TOTAL AREA	13.5	13.2	
TOTAL HARVESTED ACREAGE ^a	881,649	859,506	-2.51

a. Total harvested acreage exceeds harvested cropland due to multiple cropping

Acreage in 28 Crops

Forecasted harvested cropland is next allocated among the 28 crop groups according to the average allocation for the census years 1978, 1982, and 1987. Table 4.5 contains estimates of the acreage in each crop for 1990 and 2000, and the percentage change between those years.

In both 1990 and 2000, the dominant group of crops is row crops, which represents 96 percent of the acreage harvested in each year. Within this crop group, most of the harvested acreage (88 percent of row crop acreage) is taken by corn, soybeans and small grains. Among vegetables, which make up of 3.6 percent of all harvested acreage, beans, tomatoes, cucumbers and sweet corn account for 42 percent of harvested acreage.

Since the proportion of harvested cropland in each crop has been assumed to remain fixed over the next decade, the percentage decrease in harvested acreage for all crops is identical to the decrease in harvested cropland (2.51 percent). Because each county has a different mix of crops, regional acreage in each individual crop does not decline by that same amount. Acreage in row crops (particularly tobacco and hay), in berries, in tree fruit, and in nursery products is expected to decline by more than the average of 2.51 percent. Vegetable acreage, on the other hand, will decline by less than the average.

Table 2.5. Land Harvested in 28 Crops, 1990 & 2000

CROP GROUP	1990	2000	PERCENT CHANGE ^b
TOTAL, ALL CROPS ^a	881,649	859,506	-2.51
CORN	234,884	228,783	-2.60
SORGHUM	951	924	-2.78
SMALL GRAINS	165,862	161,682	-2.52
SOYBEANS	342,225	333,756	-2.47
ALFALFA HAY	6,908	6,700	-3.01
OTHER HAY	54,351	52,321	-3.74
PEANUTS	37,982	37,467	-1.36
TOBACCO	296	270	-8.75
IRISH POTATOES	14,737	14,586	-1.02
SWEET POTATOES	1,913	1,893	-1.04
BEANS	4,911	4,849	-1.27
COLE CROPS	697	686	-1.59
CUCUMBERS	3,828	3,784	-1.13
MUSKMELONS	430	420	-2.39
LETTUCE	4	4	-1.62
PEPPERS	346	342	-1.28
PUMPKINS	258	245	-4.99
SPINACH	727	720	-0.97
SUMMER SQUASH	399	393	-1.34
SWEET CORN	1,265	1,226	-3.14
TOMATOES	3,136	3,095	-1.33
WATERMELONS	677	662	-2.18
OTHER VEGETABLES	178	176	-1.36
BERRIES	313	300	-4.12
APPLES	231	221	-4.24
PEACHES & NECTARINES	302	294	-2.84
GRAPES	79	77	-3.01
NURSERY PRODUCTS	3,760	3,631	-3.44

a. Total harvested acreage exceeds total harvested cropland (see Table 4.4) due to multiple cropping.

b. Because these figures represent an average across counties with different crop mixes, the change from 1990 to 2000 is not the same for all crops.

CHAPTER THREE: ESTIMATING PESTICIDE EXPOSURE, EVALUATING PESTICIDE RISK

The first stage of the model, described in the preceding chapter, has produced 1,736 separate harvested cropland forecasts (28 crops grown in 31 counties in two years). The second and third stages, described in this chapter, combine this land use information with per-acre chemical application rates and pesticide hazard data to yield information on pesticide exposure and risk in those years and in those counties and on those crops.

Stage Two: Estimating Pesticide Exposure

Forecasted acreage in each of the 28 crop groups is multiplied by the per-acre pesticide application rate for those crops to yield an estimate of aggregate pesticide exposure in Tidewater Virginia. For a given crop and pesticide, the application rate represents the number of pounds of the pesticide's active ingredient that would typically be applied to one acre planted in that crop in one season. Because not every acre in every crop will receive every possible pesticide treatment, multiplying total acreage by the pesticide application rates would overstate pesticide exposure. Therefore, it is first necessary to adjust the forecasted acreage by multiplying by the percentage of that acreage

likely to be treated with the pesticide.

Information on the percentage of harvested cropland treated and on pesticide application rates is derived from three sources. The major and best source of this information is based on the opinion of pest control experts in the Virginia Cooperative Extension Service.

Resources for the Future has conducted a survey of entomologists and weed scientists specializing in many of the crops covered in this study (Gianessi, 1990c). Information obtained through the survey consists of the experts' best estimates of actual producer practices. In some cases, (apple insecticides, for example), those estimates are based on surveys of producers. In others, the estimates are based on the expert's knowledge and experience. For the crops included in the survey, this information is likely to be the best possible characterization of pesticide use in Virginia.

For several crops however, such information is not available, or it is available for only one type of chemical. For these crops, chemical application profiles are constructed or completed using data from two alternative sources.

The percentage of harvested cropland treated with insecticides, fungicides and herbicides is derived from information in the 1987 Census of Agriculture, which reports total crop acreage treated for insects,

nematodes, diseases or weeds (U.S. Department of Commerce, 1989). Dividing these treated acreage figures by total harvested cropland for 1987 yields a proxy for the percentage of harvested cropland treated with insecticides (including nematicides), fungicides and herbicides. In 1987, 33.8, 5.6 and 50.2 percent of harvested cropland was treated with insecticides, fungicides, and herbicides, respectively.

The alternative source of per-acre application rates is a set of crop "budgets" published by the Virginia Cooperative Extension Service (O'Dell). The crop budgets, though designed primarily for financial planning purposes, do contain limited information on producer's chemical use. The budget for each crop typically lists one chemical for each pest problem (e.g. weeds or insects) and the rate at which the chemical would typically be applied. These application rates plus the information from the Census of Agriculture provide a second-best characterization of Virginia pesticide use.

For two crop groups, "Other Vegetables" and "Nursery Products," no recommendations exist at all. Together, these crops represent less than one half of one percent of forecasted harvested cropland in 1990, so their share in overall pesticide exposure is likely to be small. For that reason, and because no means of constructing pesticide application profiles for these crops is apparent, no attempt is made to estimate pesticide exposure associated with these crops.

The completed data base of pesticide application profiles consists of 266 records, one for each combination of crop and pesticide. To allow this data to be combined with the harvested cropland data base, these records are reorganized so that each crop has only one record. Each record contains a crop group identification code and from 2 to 27 pesticide application profiles. Each profile consists of a pesticide identification code, the percent of total acres treated and the per-acre pesticide application rate. A complete list of these profiles study is contained in Appendix C, Table C.1.

Records from the harvested cropland data base are matched by crop group identification code with records from the reorganized pesticide application profile data base. Pesticide exposure for each pesticide applied to each crop grown in each county in 1990 and in 2000 is then calculated according to the following formula:

$$\text{EXPOSURE}_{h,i,j,t} = \text{ACRES}_{i,j,t} * \text{PERCENT}_{h,i} * \text{RATE}_{h,i}$$

where: $\text{ACRES}_{i,j,t}$ is the number of acres of crop i harvested in county j in year t ;

$\text{PERCENT}_{h,i}$ is the percentage of the land in crop i that is treated with chemical h ; and

$\text{RATE}_{h,i}$ is the rate in pounds per acre of active ingredient h applied to crop i .

The combined data base includes 9,622 records, each describing a "pesticide exposure event," the application of one chemical to one crop in one county in one year. This data can be used to characterize aggregate pesticide exposure in Tidewater Virginia. Such a characterization appears in Table 3.1.

Table 3.1 reveals that while 881,649 acres of crops are expected to be harvested in 1990, the number of pesticide exposure events (i.e. acres treated with one pesticide) exceeds 2.5 million. Those exposure events represent total application of more than 2,000 tons of pesticide application to Tidewater Virginia cropland in 1990. Pesticide exposure, is expected to decrease over the next 10 years, but not by as much as the decrease in harvested crop acreage.

Stage Three: Evaluating Pesticide Risk

Pesticide Hazards Index

Pesticide risk, as defined in this study, consists not only of the application of pesticides to agricultural land, but also of the hazards to Chesapeake Bay water quality represented by that application. Those hazards include: 1) the potential for the pesticides to reach the Bay or its tributaries; 2) the degree to which the pesticides could damage

Table 3.1. Pesticide Exposure Summary for Tidewater Virginia, 1990 & 2000

EXPOSURE MEASURE	1990	2000	10-YEAR CHANGE
HARVESTED ACREAGE	881,649	859,506	-2.51 %
ACRES TREATED WITH PESTICIDES	2,530,644	2,471,953	-2.32 %
PESTICIDE EXPOSURE (TONS OF ACTIVE INGREDIENT)	2,084	2,041	-2.08 %

water quality once they have reached those waters; and 3) the length of time during which they are likely to be capable of harming water quality.

For this study, an index of these factors is constructed to reflect those hazards. The index is based on the potential for each pesticide to leach into groundwater or runoff into surface water and the pesticide's toxicity. Both mobility and toxicity are measured in relation to other pesticides. The length of time the chemicals could remain harmful, is factored into the measure of potential for ground- and surface-water loss, so all three pesticide hazards factors are considered in the construction of the index.

The index reflects the rank of the various pesticides when placed in order of their potential mobility or toxicity. Thus, despite the necessity of assigning cardinal values to the mobility and toxicity ranks, the index for a given pesticide reflects its potential hazards relative to all other pesticides, and not the absolute level of the hazard. The index is not purely ordinal, however, because the choice of numeric values for the ranks introduces some cardinality to the index. A different set of values might result in a different final hazard index, and therefore, different conclusions regarding the relative riskiness of the pesticide.

Information on the potential for pesticide loss to ground- and surface-water is obtained from the Soil Conservation Service and the Agricultural Research Service (Goss; Wauchope and Goss). Researchers at those institutions have developed an algorithm for assessing the leaching and runoff potential of almost all of the pesticides considered in this study.⁸ Leaching and runoff potential are based on the half-life and organic matter partitioning coefficient of the pesticides.

A pesticide's half-life can be interpreted as a relative measure of the length of time the pesticide could remain harmful. The organic matter partitioning coefficient (K_{OC}) measures the degree to which the pesticide sticks to soil particles. Because runoff to surface water is often the result of soil erosion, pesticides with high K_{OC}'s are likely to have a higher potential for runoff. Because these pesticides adhere more readily to soil particles, they are will generally have a lower potential for leaching into groundwater. Chemicals with a low K_{OC}, on the other hand, would be more likely to leach into groundwater and less likely to runoff into surface water.

⁸ For one of the four chemicals included in this study but not covered by the ARS/SCS data, the information necessary for calculating leaching and runoff potential has been obtained directly from the pesticide's manufacturer. For the remaining three chemicals, the average leaching and runoff potential of all the other pesticides is assumed.

The algorithm rates each pesticide as having a relatively large, medium or small leaching or runoff potential. For the purposes of this study, those ratings are assigned numerical values as shown in Table 3.2 below.

Potential for leaching is assigned lower values because any pesticides that leach in groundwater in the Chesapeake Bay region would leach into shallow aquifers as opposed to confined aquifers. Water from the shallow aquifers is eventually returned to Chesapeake Bay surface water. Because this process takes time, because pesticides generally become less harmful over time, and because it is surface water quality that is of interest to this study, pesticide leaching is considered to be less hazardous than surface runoff.

The leaching and runoff scores are added to form a single measure of the pesticides' potential for being transported to the Chesapeake Bay's water. The herbicide benefin, for example, has a small potential for loss to groundwater and a large potential for loss to surface water. Benefin's potential mobility score is therefore 7 (the leaching score of 1 plus the runoff score of 6). Table 3.3 below displays all possible mobility scores and their corresponding leaching and runoff scores.

Table 3.2. Pesticide Leaching and Runoff Scores

ARS/SCS Rating	Leaching Score	Runoff Score
Small	1	2
Moderate	3	4
Large	5	6

Table 3.3. Pesticide Mobility Scores^a

Leaching Score	Runoff Score			
		2	4	6
	1	3	5	7
	3	5	7	9
	5	7	9	11

- a. The Potential Mobility Score is the sum of the Leaching Score and the Runoff Score.

The other hazard factor, the potential for the pesticide to do environmental damage once it has been transported to water in the Bay or its tributaries, is measured by the toxicity of the pesticides. Ideally, the toxicity of the pesticides to organisms such as the eastern oyster or mallard ducks, that live in and around the Bay would be used for this measure. It would also be preferable to have information on the long-term toxic effects of these chemicals. Unfortunately, such data are available only for a limited number of pesticides -- mostly insecticides and some herbicides -- so an alternative measure of pesticide toxicity is used.

The only measure of pesticide toxicity that is available for all of the pesticides considered in this study is the acute oral LD_{50} . The LD_{50} , or "lethal dose 50," is "dosage of milligrams per kilogram of body weight required to kill 50% of test animals when given a single dose by mouth" (Weaver, 1988:p.21). LD_{50} doses are the basis for assigning pesticides to four toxicity classes. The classes are numbered one through four, with one being the most toxic.

For constructing the pesticide hazard index, it is desirable to have the higher numbers represent greater environmental hazards. Therefore, the reciprocal of the numeric toxicity class is used as a toxicity score in this study. Table 3.4 lists the original toxicity classes, the toxicity score for this study, and the LD_{50} s to which the toxicity

Table 3.4. Pesticide Toxicity Classifications and Scores

Original Toxicity Class ^a	Redefined Toxicity Class	LD ₅₀ Range ^a		
1 - Highly Toxic	1.00	LD ₅₀ ≤ 50		
2 - Moderately Toxic	0.50	50	< LD ₅₀	≤ 500
3 - Slightly Toxic	0.33	500	< LD ₅₀	≤ 5000
4 - Almost Non-Toxic	0.25	5000	< LD ₅₀	

- a. Source: Weaver, M.J. Agricultural Pesticides in Virginia: Introduction, Regulations and Basic Information for the Safe Use of Pesticides in Virginia, 1988-89. Virginia Cooperative extension Service, Publication 456-001, 1988.

classifications correspond. Toxicity classes of the pesticides covered in this study are obtained from the Farm Chemicals Handbook, 1990 (Fisher, 1990).

The final step in constructing the potential pesticide hazard index is to multiply the redefined toxicity class by the pesticide mobility score. The completed index, which embodies the pesticides potential for reaching the Bay's waters as well as its potential for causing environmental damage once it gets there, is defined as follows:

$$\text{HAZARD}_h = \text{TOXICITY}_h * \text{MOBILITY}_h$$

where: TOXICITY_h is the relative toxicity of the active ingredient h ; and

MOBILITY_h is the relative potential for the active ingredient to enter groundwater and surface water.

Picking up the previous example, benefin is almost non-toxic to rats (toxicity class 4), so its toxicity score is 0.25. The pesticide hazard index for benefin is $0.25 * 7$ (its mobility score), or 1.75. Table 3.5 presents all the possible values for HAZARD_h and the number of pesticides to which each value applies. Complete pesticide hazard information for the 74 pesticides considered in this study are recorded in a pesticide hazards data base. (A listing of the hazards data base appears as Appendix D, Table D.1.)

Table 3.5. Toxicity Classes, Mobility Scores and Hazard Indices for 74 Pesticides

TOXICITY	MOBILITY SCORE	HAZARD INDEX	NUMBER OF PESTICIDES	PERCENT OF TOTAL
0.25	3	0.75	1	1.4 %
0.25	5	1.25	3	4.1
0.25	7	1.75	7	9.5
0.25	9	2.25	2	2.7
0.25	11	2.75	1	1.4
0.33	3	1.00	3	4.1
0.33	5	1.67	5	6.8
0.33	7	2.33	16	21.6
0.33	9	3.00	6	8.1
0.33	11	3.67	0	0.0
0.50	3	1.50	0	0.0
0.50	5	2.50	4	5.4
0.50	7	3.50	9	12.2
0.50	9	4.50	1	1.4
0.50	11	5.50	0	0.0
1.00	3	3.00	1	1.4
1.00	5	5.00	4	5.4
1.00	7	7.00	9	12.2
1.00	9	9.00	2	2.7
1.00	11	11.00	0	0.0
TOTALS:			74	100.0 %

Pesticide Risk Scores

To obtain a measure of pesticide risk, the pesticide hazards data base is first combined with the pesticide exposure data base described above. For each record in the combined data base, (with each record pertaining to one pesticide exposure event), pesticide risk is calculated according to the following:

$$RISK_{h,i,j,t} = EXPOSURE_{h,i,j,t} * HAZARD_h$$

where h, i, j, and t identify the pesticide, the crop, the county and the year, respectively.

In addition to providing a measure of aggregate pesticide risk in Tidewater Virginia, the pesticide risk data base can be used to identify the crops, pesticides and counties that represent the greatest risk to Chesapeake Bay water quality. The data base also allows comparison of current and potential future pesticide risk.

It must be emphasized however, that comparisons of this sort are relative. The measures of pesticide hazards are not absolute measures, so there is no particular meaning in the value of $RISK_{h,i,j,t}$ as defined above. Interpretation of any relative differences must also be handled carefully. To say that crop X contributes ten times as much to Chesapeake Bay pesticide risk as does crop Y, for instance, would be a misleading use of the data. The risk posed by the two crops could just

as easily differ by a factor of 20 or 100 if the pesticide hazard index or its components had been defined differently.

To make this point explicit in the information generated by this study, and to make comparisons of relative pesticide risk more manageable, aggregate pesticide risk estimates are standardized to a zero to one hundred scale with total pesticide risk in Tidewater Virginia in 1990 serving as the base. For each pesticide exposure event, the risk score (the risk associated with that event relative to all exposure events in 1990) is defined as:

$$\text{RISK}_{h,i,j,t}^* = (\text{RISK}_{h,i,j,t} / \Sigma \text{RISK}_{h,i,j,1990}) * 100$$

RISK* represents the risk associated with a given pesticide exposure event as a portion of total pesticide risk in 1990. Using this measure, total risk in 2000 can be compared to total risk for 1990, or 1990 to 2000 changes in risk for individual counties, crops or chemicals can be examined. Also, for a given year, the relative pesticide risk posed by various crops, counties or pesticides can be evaluated.

Pesticide Exposure and Risk Evaluation for Tidewater Virginia

Table 3.6 presents estimates of total pesticide exposure and risk for the Tidewater region for 1990 and 2000. Total harvested acreage is

included in that table to illustrate the difference between harvested acreage and acres treated with pesticides. For a given acre in any crop, more than one pesticide exposure event could occur; the acre could receive more than one application of a particular pesticide, or it could be treated with more than one pesticide.

In 1990, some 2.5 million pesticide exposure events are expected to occur, leading to a total pesticide exposure of 2,084 tons of pesticide active ingredients. Put differently, the harvested cropland in Tidewater Virginia will receive an average of 2.9 pesticide applications at an average rate of 1.6 pounds of active ingredient per acre. By the year 2000, 2.3 percent fewer pesticide exposure events are expected to occur. This estimate is roughly the equivalent of 59,000 acres receiving one less pesticide application. Note that the percentage decrease in pesticide exposure events is less than that for harvested acreage. This result occurs because, on average, less than 100 percent of each crop is treated with a given pesticide.

For the same reason, the percentage decrease in harvested acreage or in the number of pesticide exposure events is not matched by a reduction in pesticide exposure, which is expected to decrease by only 2.08 percent over the next decade. This estimate suggests that greater decreases in acreage will occur for crops on which pesticides are used less intensively. That is, for the harvested acreage that remains at the end

of the decade, each exposure event is likely to have a higher application rate per acre than for the harvested acreage that disappears.

For example, harvested peanut acreage is expected to decline by 1.36 percent over the 1990-2000 period. This decline is less than the average decrease of 2.51 percent. Alfalfa hay, on the other hand, is expected to decline by 3.01 percent (more than average). An acre of peanuts receives more than twice the amount of pesticide active ingredient per treated acre than does alfalfa. This disparity, combined with the fact that peanut acreage is greater than alfalfa acreage at the beginning of the period, contributes to the result that pesticide exposure may not decline in direct proportion to the decrease in harvested or treated acreage.

The final observation to be made regarding Table 3.6 is related to changes in pesticide risk. Pesticide risk, as measured by the risk index will decline by an amount roughly equal to the percentage decrease in pesticide exposure events but greater than the percentage decrease in pesticide exposure. This result suggests that the decrease in exposure events is more prominent among the more hazardous chemicals (i.e. a higher hazard index applies to the exposure events that occur in 1990, but not in 2000), or, as illustrated in the peanuts/alfalfa example, among those that are applied at a lower rate per acre, or both.

Taken together, these observations suggest that while agricultural land use change will yield some reduction in pesticide exposure and risk over the coming decade, it will decrease exposure and risk by less than the full amount of the decrease in crop acreage. As noted in the previous section, decreases in harvested cropland acreage will be small, so it is not likely that the forces of urbanization alone will eliminate agricultural pesticide risk in the near future.

Table 3.6. Pesticide Exposure and Risk Summary for Tidewater Virginia,
1990 & 2000

EXPOSURE / RISK MEASURE	1990	2000	10-YEAR CHANGE
HARVESTED ACREAGE	881,649	859,506	-2.51 %
ACRES TREATED WITH PESTICIDES	2,530,644	2,471,953	-2.32 %
PESTICIDE EXPOSURE (TONS OF ACTIVE INGREDIENT)	2,084	2,041	-2.08 %
PESTICIDE RISK (INDEXED TO 1990 LEVEL)	100.00	97.70	-2.30

CHAPTER FOUR: RISK EVALUATION FOR COUNTIES, CROPS AND PESTICIDES

Review of Aggregate Results

Estimates of agricultural land use presented in Chapter Two show a small decrease in the amount of Tidewater Virginia land devoted to crop production over the remaining decade of this century. However, with the exception of two counties (Fairfax and York) for which forecasted cropland is zero for the year 2000, urbanization is not expected to eliminate agricultural production as an important use of Tidewater Virginia lands.

Since changes in pesticide use in this model are driven by land use, total estimated pesticide exposure presented in Chapter Three is lower for the year 2000 than for 1990. And, to the extent that pesticide risk is partially a function of pesticide exposure, pesticide risk is also expected to decline over the next ten years. The decreases in both pesticide exposure and pesticide risk are smaller than the decrease in cropland acreage. Therefore, just as urbanization will not eliminate agricultural production as a land use, neither will it eliminate agricultural production as a source of potential toxic chemical risk to the Chesapeake Bay.

Pesticide risk estimates presented below show that total pesticide risk is not distributed evenly or even proportionately among the counties,

crops or chemicals covered in the study. Due to differences in the mix of crops in different counties, in the intensity of pesticide use on different crops, and in the hazard characteristics of the pesticides used on those crops, pesticide risk is concentrated in a relatively small number of counties, crops and chemicals. This result suggests that targeting pesticide risk management programs at high risk counties, crops or chemicals could exploit potential efficiencies in reducing pesticide risk.

Comparative Results for Counties, Crops and Pesticides

Tables 4.1, 4.2, and 4.3, below, present pesticide exposure and risk summaries for counties, crops, and active ingredients, respectively. In each of these tables, only the most important contributors to pesticide risk are included.

Pesticide Exposure and Risk for Tidewater Virginia Counties

The five counties that contribute the greatest amount to pesticide risk in Tidewater Virginia are listed in Table 4.1. Some 41.4 percent of total 1990 pesticide risk is associated with pesticide exposure events occurring in these counties.

Some observations concerning Table 4.1 illustrate that pesticide risk is not a function of land use alone. Rather, the intensity of pesticide

use (per acre application) and the hazards of that use contribute to overall pesticide risk as well. The first observation is that only five counties account for 32 percent (less than their risk share) of all harvested acreage and 43 percent (more than the risk share) of all pesticide exposure in the Tidewater region. This comparison suggests that what makes this group of counties greater contributors to Tidewater pesticide risk is the intensity of pesticide use on the crops grown in those counties.

A second observation also illustrates the importance of the intensity of pesticide use. As mentioned above, peanuts receive more intensive pesticide treatments, on average, than do many other crops. It is no coincidence then that three of the region's most important peanut producing counties are among the five that contribute the most to Tidewater pesticide risk. (Isle of Wight county alone represents one half of the peanut acreage in Tidewater Virginia).

The final observation concerns the second and third counties on the list, Suffolk and Accomack. Accomack has more crop acreage, more acres treated, and more pesticide exposure than Suffolk. However, Suffolk county represents a larger pesticide risk than Accomack. This illustrates the importance of pesticide hazard characteristics to the determination of overall pesticide risk. (The chemicals applied to in Suffolk County must be more hazardous, on average, than those applied in

Table 4.1. Pesticide Exposure and Risk Summary: Top Five Counties^a

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
TIDEWATER TOTAL	1990	882	2,531	2,084	100.0
	2000	860	2,472	2,041	97.7
TOP 5 COUNTIES	1990	284	999	901	41.4
	2000	280	987	981	40.9
- - - - -					
ISLE OF WIGHT	1990	54	242	185	10.9
	2000	53	239	183	10.8
SUFFOLK	1990	57	242	180	10.7
	2000	57	239	178	10.6
ACCOMACK	1990	82	249	327	9.0
	2000	81	247	325	8.9
SURRY	1990	31	129	95	5.6
	2000	30	126	93	5.5
HANOVER	1990	60	137	114	5.2
	2000	59	136	112	5.1

a. Please see Appendix F, Table F.1 for a listing of all counties.

Accomack County).

Pesticide Exposure and Risk for Crops Grown in Tidewater Virginia

Just as much of the Tidewater region's pesticide risk is concentrated in a few counties, so is much of the risk concentrated in a few crops. The five crops that contribute the most to Tidewater pesticide risk, listed in Table 4.2, account for more than 95 percent of the risk associated with pesticide use on all crops. Those five crops represent 90 percent of all harvested acreage and 95 percent of all treated acreage, but only 75 percent of all pesticide exposure in the region. This fact suggests that the pesticide risk associated with these five crops as a group is more dependent upon the hazard characteristics of the pesticides used than on the rate at which those pesticides are used on the acreage treated.

For individual crops however, both land use (acres harvested) as well as chemical use (acres treated and exposure) and pesticide hazard characteristics contribute to the crops' inclusion in the list of five crops. For example, only one sixth as many acres of peanuts are harvested as are harvested of corn. Peanuts however, are treated with an average of 14.7 pounds of pesticide active ingredient per harvested acre while corn is treated with only 4.9 pounds per harvested acre. Thus the intensity of pesticide use on peanuts offsets the relatively

Table 4.2. Pesticide Exposure and Risk Summary: Top Five Crops^a

CROP GROUP	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
TIDEWATER TOTAL	1990	882	2,531	2,084	100.0
	2000	860	2,472	2,041	97.7
TOP 5 CROPS	1990	796	2,414	1,554	95.9
	2000	777	2,258	1,517	93.7
- - - - -					
SOYBEANS	1990	342	1,177	636	44.3
	2000	334	1,148	620	43.2
CORN	1990	235	662	570	31.3
	2000	229	645	555	30.5
PEANUTS	1990	38	343	279	16.3
	2000	37	338	275	16.1
IRISH POTATOES	1990	15	76	34	2.3
	2000	15	75	33	2.3
SMALL GRAINS	1990	166	156	35	1.6
	2000	162	152	34	1.6

a. Please see Appendix F, Table F.2 for a listing of all crops.

small peanut acreage to make peanuts one of the region's highest risk contributors.

A comparison of the results regarding irish potatoes and small grains illustrates the role of the pesticide hazard index in determining potential risk in this study. Small grains are harvested from 11 times the number of acres than from which irish potatoes are harvested. Although potatoes contribute more to pesticide exposure on a per-acre basis than do small grains, small grains contribute more to aggregate pesticide exposure than do potatoes. The fact that potatoes still provide more pesticide risk than small grains is therefore due to the greater hazards associated with the pesticides used on potatoes compared to those used to treat small grains.

Pesticide Exposure and Risk for Pesticides Used in Tidewater Virginia

A final perspective from which to examine aggregate pesticide exposure and risk is provided by Table 4.3, which lists the five pesticide active ingredients that represent the greatest potential risk in Tidewater Virginia. Together these five pesticides make up 34 percent of all pesticide exposure events (i.e., 34 percent of all treated acreage is treated with one of these pesticides), 41 percent of total pesticide exposure, and 56.8 percent of all pesticide risk in the region.

The information in Table 4.3 provides some insights into the linkage between the counties, crops and pesticides that contribute the greatest amount to Tidewater pesticide risk. For example, the top two pesticides, fenamiphos and aldicarb are primarily used in the production of peanuts, the third of the top five crops. Peanuts, as noted above, are important crops in three of the top five counties. The other three active ingredients are most prevalent in corn and soybean production; corn and soybeans top the list of risk generating crops.

One final observation illustrates the sensitivity of these results to individual pesticide hazard characteristics (i.e. toxicity and mobility) in evaluating pesticide hazards. Atrazine and metolachlor (4th and 5th on the list) are both herbicides used primarily in corn. Each is slightly toxic and has a moderate potential to run off into surface water. Atrazine has a high potential to leach into groundwater however, while metolachlor has a low potential to do so. This one difference between the two chemicals accounts for the fact that while more metolachlor is applied, atrazine represents a greater potential contribution to Tidewater pesticide risk.

Table 4.3. Pesticide Exposure and Risk Summary: Top Five Active Ingredients^a

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
ALL PESTICIDES	--	1990	2,531	2,084	100.0
		2000	2,472	2,041	97.7
TOP 5 PESTICIDES	--	1990	851	859	56.8
		1990	830	839	55.4

FENAMIPHOS	I/N	1990	76	130	16.0
		2000	74	127	15.6
ALDICARB	I/N	1990	104	106	13.1
		2000	102	104	12.8
ALACHLOR	H	1990	213	242	10.0
		2000	208	237	9.7
ATRAZINE	H	1990	236	178	9.4
		2000	230	173	9.1
METOLACHLOR	H	1990	222	203	8.3
		2000	216	198	8.1

a. Please see Appendix F, Table F.3 for a listing of all active ingredients.

b. Actions: I/N = insecticide/nematicide; H = herbicide.

CHAPTER FIVE: CONCLUSIONS, POLICY IMPLICATIONS AND INFORMATION NEEDS

What This Study Has Accomplished

Characterization of Agricultural Pesticide Risk

Pesticide exposure estimates presented in Chapters Three and Four represent perhaps the most comprehensive analysis of agricultural pesticide use for the Chesapeake Bay region of Virginia. Other studies have generated pesticide use estimates for certain sub-sets of the pesticide risk vectors considered in this study. Gianessi et al. (1987a,b), for example, estimated the use of triazine herbicides on corn and soybeans for the entire Chesapeake Basin for 1982.

In a more detailed study, Diebel (1990) estimated pesticide use and loss to surface water and groundwater of 15 pesticides in one Tidewater Virginia County. In contrast, this study provides estimates of the use of 74 pesticides on 28 crops in all 31 Tidewater Counties. In addition, pesticide use estimates are provided for both the current year (1990) and for the year 2000.

Identification of High-Risk Counties, Crops and Pesticides

More important than the estimates of pesticide exposure provided by this study is the procedure developed for evaluating and comparing potential

pesticide risk among counties, crops and pesticides in the Bay region. The results presented in the previous chapter demonstrate that several aspects of land and pesticide use influence aggregate pesticide exposure. The procedures followed for this study have taken as many of these factors as possible into consideration in evaluating pesticide risk. Aggregate land use, the distribution of land among various crops, the intensity of pesticide use on those crops, and the hazard characteristics of the pesticides used have each been incorporated into this study's evaluation of relative pesticide risk within the region.

Because all of these factors play a role in the evaluation of risk, it is possible to identify and analyze situations such as that involving potatoes and small grains, for example. Small grains are harvested from more land than are potatoes, but small grains account for more pesticide exposure than do potatoes. However, because pesticide hazard factors have been incorporated into the risk evaluation procedures, one can discern that potato production represents the greater potential pesticide risk.

Recommendations for Pesticide Risk Management Strategies

The results of this study demonstrate that targeting of pesticide management strategies may be fruitful, given that most of the potential risk in Tidewater Virginia is accounted for by a handful of pesticides. In light of that, it is reasonable that the Chesapeake Bay Program's

Toxics Reduction Strategy seek to identify and target, or, direct pesticide management efforts at, those chemicals representing the greatest threat to Bay water quality.

However, this study further demonstrates that agricultural pesticide risk is also highly concentrated among a handful of counties and a handful of production systems. It is therefore also reasonable that the Toxics Reduction Strategy (and other toxics management programs) target not only the most hazardous chemicals, but also the areas and activities in which the release of those chemicals is most prevalent. Targeting of pesticide risk management programs should not be limited to a single vector of pesticide risk, such as the chemical or the county.

Tables F.4 and F.5 of Appendix F include pesticide exposure and pesticide risk information that may be useful for designing pesticide management programs targeted along more than one pesticide risk vector. In addition to providing county, crop and active ingredient totals, these tables provide estimates for each county-crop combination and for each crop-active ingredient combination. That information should be useful for identifying, for example, the crops that represent the greater sources of pesticide risk within a particular county, or the chemicals that represent the greater risk for a particular crop.

What Remains to be Learned

Information Needed for Effective Pesticide Program Targeting

Once identified, the counties, crops and pesticides (or combinations thereof) that represent the greater potential risk to Chesapeake Bay water quality can serve as a first approximation of the appropriate targets of pesticide risk-reducing strategies. Whether targeting that set of risk vectors would be cost-effective however, is not an issue addressed by this study.

For example, the fact that peanuts represent a greater pesticide risk per acre than small grains does not prove that one could achieve greater reductions in pesticide risk per dollar spent by targeting peanuts rather than small grains. Before that could be proved or disproved, one would need to know what risks are associated with the alternative to the practice (treating peanut acreage with fenamiphos, for example) that would be discouraged by the targeted program. Alternative land use and pesticide use practices may represent more risk than the practice they would replace.

Cost-effective program targeting also requires considerable knowledge of the economic costs of changing to alternative land and pesticide use practices. Program planners would need to know how costly it would be to induce the change in practice. Peanut growers, because peanut

production is relatively more profitable than small grain production, may be reluctant to make changes in their pest management practices that could adversely affect yields. Thus, targeting peanut production could require greater outlays for education and other inducements per unit of risk averted than would be required if some other crop were to be targeted.

Information Needed for Risk Assessment

An important distinction exists between the characterization or evaluation of potential pesticide risk provided in this study, and the more formal notion of risk assessment. Risk assessment, rather than addressing broader questions of the relative riskiness of various pesticide exposure events, would more likely be concerned with estimating the expected damage ensuing from a particular pesticide exposure event (Orvos, 1990). For example, while this study has determined that corn production represents a greater potential pesticide risk than spinach production, a study of risk assessment might be more interested in the expected increase in cancer deaths due the contamination of well water with atrazine, a corn herbicide.

Although this study was not intended to assess pesticide risk in Tidewater Virginia, it may provide a basis for doing so. At a minimum, this study provides pesticide exposure estimates at a highly detailed level. These estimates could be used as inputs to agronomic and

hydrogeological models to generate estimates of actual (as opposed to potential) surface and groundwater loss of the pesticides. Using such estimates, one could then calculate expected pesticide concentrations in surface water and groundwater and assess the effect of those concentrations on human and/or animal health.

Final Observations

While there is much that this study has not attempted to discover, and numerous improvements on it will doubtless be accomplished, this study does provide Virginia's water quality managers with information urgently needed for making informed pesticide management decisions. Furthermore, it offers one possible blueprint to researchers and managers interested in evaluating pesticide and other toxic chemical risk in Tidewater Virginia, as well as in other regions.

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APPENDIX A

Planning District and County Composition

Crop Group Composition

Table A.1. Tidewater Virginia Planning Districts and Counties^a

NORTHERN VIRGINIA, PLANNING DISTRICT 8:

Fairfax County, including
Arlington County
City of Alexandria
City of Fairfax
City of Falls Church

Prince William County, including
City of Manassas
City of Manassas Park

RICHMOND REGIONAL, PLANNING DISTRICT 15

Charles City County

Chesterfield County, including
City of Colonial Heights

Hanover County

Henrico County, including
City of Richmond

New Kent County

RADCO, PLANNING DISTRICT 16

Caroline County

King George County

Spotsylvania County, including
City of Fredericksburg

Stafford County

Table A.1, continued

NORTHERN NECK, PLANNING DISTRICT 17

Lancaster County

Northumberland County

Richmond County

Westmoreland County

MIDDLE PENINSULA, PLANNING DISTRICT 18

Essex County

Gloucester County

King and Queen County

King William County

Mathews County

Middlesex County

CRATER, PLANNING DISTRICT 19

Prince George County, including
 City of Hopewell
 City of Petersburg

Surry County

Table A.1, continued

SOUTHEASTERN VIRGINIA, PLANNING DISTRICT 20

Isle of Wight County

City of Chesapeake,^b including
City of Norfolk
City of Portsmouth

City of Suffolk^b

City of Virginia Beach^b

PENINSULA, PLANNING DISTRICT 21

James City County, including
City of Williamsburg

York County, including
City of Hampton
City of Newport News
City of Poquoson

ACCOMACK-NORTHAMPTON, PLANNING DISTRICT 22

Accomack County

Northampton County

- a. This list includes only those counties defined as belonging to "Tidewater Virginia." Therefore, several of the planning districts listed contain counties not included in the study.
- b. Because appropriate land use data are available for these cities, they are treated as counties in this study.

Table A.2. Crop Group Composition

CROP GROUP	CROPS INCLUDED IN CROP GROUP
CORN	CORN GRAIN CORN SILAGE
SORGHUM	SORGHUM GRAIN SORGHUM SILAGE
SMALL GRAINS	BARLEY OATS RYE WHEAT
SOYBEANS	SOYBEANS
ALFALFA HAY	ALFALFA HAY
OTHER HAY	SMALL GRAIN HAY OTHER TAME HAY WILD HAY HAYLAGE & GRASS SILAGE RED CLOVER SEED OTHER FIELD & GRASS SEED
PEANUTS	PEANUTS
TOBACCO	TOBACCO
IRISH POTATOES	IRISH POTATOES EGGPLANT
SWEET POTATOES	SWEET POTATOES
BEANS	LIMA BEANS SNAP BEANS COWPEAS OTHER PEAS
COLE CROPS	CABBAGE COLLARDS KALE
CUCUMBERS	CUCUMBERS

Table A.2, continued

CROP GROUP	CROPS INCLUDED IN CROP GROUP
MUSKMELONS	MUSKMELONS
LETTUCE	LETTUCE
PEPPERS	HOT PEPPERS SWEET PEPPERS
PUMPKINS	PUMPKINS
SPINACH	SPINACH MUSTARD GREENS TURNIP GREENS TURNIPS
SUMMER SQUASH	SUMMER SQUASH
SWEET CORN	SWEET CORN
TOMATOES	TOMATOES
WATERMELONS	WATERMELONS
OTHER VEGETABLES	BEETS OKRA ONIONS
BERRIES	BERRIES
APPLES	APPLES PEARS
PEACHES & NECTARINES	PEACHES NECTARINES CHERRIES
GRAPES	GRAPES
NURSERY PRODUCTS	NURSERY PRODUCTS

APPENDIX B

Land Use Data Base

Table B.1. Land Use Data Base

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
ACCOMACK	22	1969	77487	72179	1002.72	0.092
		1974	73681	70258	1581.34	0.098
		1978	80368	75999	1608.90	0.105
		1982	79840	77962	1358.55	0.102
		1987	74134	67629	1213.03	0.106
		1990	.	.	.	0.106
		2000	.	.	.	0.108
CAROLINE	16	1969	35393	25498	607.63	0.042
		1974	39463	31073	1270.33	0.045
		1978	41499	34227	1325.15	0.050
		1982	42617	37465	1081.87	0.054
		1987	35790	28026	881.16	0.056
		1990	.	.	.	0.060
		2000	.	.	.	0.066
CHARLES CITY	15	1969	16365	12235	1460.49	0.057
		1974	21360	18705	1760.77	0.056
		1978	17040	15371	1711.66	0.057
		1982	15555	15163	1071.50	0.058
		1987	16240	13280	911.09	0.056
		1990	.	.	.	0.059
		2000	.	.	.	0.063
CHESTERFIELD	15	1969	12254	7879	1367.85	0.478
		1974	13903	8277	2476.08	0.405
		1978	11649	8330	1998.47	0.513
		1982	10360	7162	2287.05	0.599
		1987	9522	6203	1506.16	0.694
		1990	.	.	.	0.776
		2000	.	.	.	0.966
ESSEX	18	1969	33499	26735	604.90	0.045
		1974	36676	32745	1244.02	0.047
		1978	41893	38346	1292.94	0.048
		1982	51173	47656	1007.25	0.052
		1987	45843	37017	820.42	0.053
		1990	.	.	.	0.055
		2000	.	.	.	0.058

Table B.1, continued

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
FAIRFAX	08	1969	18452	8612	5585.83	2.743
		1974	10464	5919	6066.99	2.860
		1978	10777	6790	5503.07	2.927
		1982	8557	4699	5553.37	3.272
		1987	6378	2921	7419.01	3.660
		1990	.	.	.	3.651
		2000	.	.	.	3.937
GLOUCESTER	18	1969	18249	15110	948.23	0.094
		1974	18521	16692	2308.61	0.116
		1978	19003	17067	2156.44	0.125
		1982	20982	20125	1804.15	0.153
		1987	18315	14991	1934.86	0.204
		1990	.	.	.	0.208
		2000	.	.	.	0.260
HANOVER	15	1969	59035	39573	991.83	0.124
		1974	62332	43557	1555.02	0.152
		1978	63644	45416	1940.18	0.174
		1982	69300	52561	1390.67	0.174
		1987	60148	45230	1343.31	0.189
		1990	.	.	.	0.202
		2000	.	.	.	0.233
HENRICO	15	1969	19092	12400	1632.15	2.009
		1974	18055	13697	2083.73	2.092
		1978	14502	10345	2168.71	2.062
		1982	18411	14634	1648.70	2.120
		1987	16722	10946	1713.91	2.183
		1990	.	.	.	2.213
		2000	.	.	.	2.309
ISLE OF WIGHT	20	1969	57589	44368	989.10	0.093
		1974	60967	53500	1557.42	0.094
		1978	58461	49884	1792.94	0.100
		1982	64057	59082	1515.03	0.108
		1987	57343	45338	1109.15	0.123
		1990	.	.	.	0.120
		2000	.	.	.	0.128

Table B.1, continued

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
JAMES CITY	21	1969	13045	10222	1801.09	0.275
		1974	11613	10300	2916.27	0.290
		1978	9694	.	2299.08	0.319
		1982	9424	8903	3041.45	0.339
		1987	7448	6041	1926.94	0.387
		1990	.	.	.	0.418
		2000	.	.	.	0.486
KING AND QUEEN	18	1969	26609	21377	645.78	0.029
		1974	26518	24788	1258.37	0.028
		1978	26505	24643	1162.58	0.030
		1982	34256	32322	900.52	0.029
		1987	37863	30147	812.50	0.031
		1990	.	.	.	0.033
		2000	.	.	.	0.035
KING GEORGE	16	1969	19014	13304	953.68	0.070
		1974	21184	16624	1588.52	0.078
		1978	22914	18140	1472.39	0.085
		1982	21502	18306	1231.09	0.093
		1987	20601	14479	1228.87	0.106
		1990	.	.	.	0.111
		2000	.	.	.	0.130
KING WILLIAM	18	1969	30627	24029	618.53	0.045
		1974	29476	24956	1404.31	0.051
		1978	36026	31335	1348.16	0.048
		1982	40641	38246	953.37	0.054
		1987	42305	33991	953.35	0.058
		1990	.	.	.	0.062
		2000	.	.	.	0.068
LANCASTER	17	1969	18078	15092	1128.07	0.111
		1974	17668	16324	1839.71	0.113
		1978	18507	16973	1562.88	0.120
		1982	16465	15602	1287.05	0.121
		1987	14843	11715	1011.44	0.131
		1990	.	.	.	0.141
		2000	.	.	.	0.156

Table B.1, continued

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
MATHEWS	18	1969	6667	5246	1479.56	0.117
		1974	6398	5483	1777.51	0.142
		1978	7291	6160	.	0.147
		1982	6767	5784	2037.31	0.149
		1987	5801	4372	1945.42	0.158
		1990	.	.	.	0.170
		2000	.	.	.	0.188
MIDDLESEX	18	1969	15945	12990	866.49	0.072
		1974	17593	16432	1705.74	0.076
		1978	17586	15424	1610.43	0.086
		1982	17197	15888	1481.87	0.092
		1987	14024	11487	1366.20	0.100
		1990	.	.	.	0.105
		2000	.	.	.	0.115
NEW KENT	15	1969	13630	11100	822.89	0.037
		1974	15617	11010	1461.72	0.050
		1978	14349	12585	1432.52	0.057
		1982	14467	13286	1247.67	0.068
		1987	14187	11808	1051.94	0.079
		1990	.	.	.	0.086
		2000	.	.	.	0.100
NORTHAMPTON	22	1969	42901	37597	1198.91	0.112
		1974	45835	44697	1753.59	0.104
		1978	50333	47915	1693.25	0.106
		1982	53141	51657	1438.34	0.100
		1987	41831	35821	1361.80	0.100
		1990	.	.	.	0.102
		2000	.	.	.	0.103
NORTHUMBERLAND	17	1969	32924	28520	858.31	0.084
		1974	36436	34977	1562.20	0.078
		1978	35816	33639	1622.70	0.080
		1982	34662	33748	1292.23	0.084
		1987	35580	30405	1039.61	0.086
		1990	.	.	.	0.088
		2000	.	.	.	0.093

Table B.1, continued

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
PRINCE GEORGE	19	1969	27647	19213	1040.87	0.527
		1974	30603	22337	1265.55	0.487
		1978	27164	23135	1377.30	0.503
		1982	25175	21827	996.89	0.510
		1987	23531	17322	982.39	0.518
		1990	.	.	.	0.528
		2000	.	.	.	0.544
PRINCE WILLIAM	08	1969	36754	16269	2228.88	0.468
		1974	33156	16212	3406.70	0.617
		1978	39761	21172	2964.72	0.698
		1982	33995	23043	2605.18	0.806
		1987	27448	15341	2923.42	0.953
		1990	.	.	.	0.987
		2000	.	.	.	1.265
RICHMOND	17	1969	28353	24469	705.72	0.055
		1974	27529	25395	1337.32	0.052
		1978	28285	26630	1575.15	0.055
		1982	31300	30786	944.04	0.057
		1987	26395	22027	846.83	0.062
		1990	.	.	.	0.060
		2000	.	.	.	0.062
SPOTSYLVANIA	16	1969	31757	17301	910.08	0.122
		1974	32516	20269	2215.31	0.148
		1978	34733	24396	1684.05	0.177
		1982	34365	25300	1359.59	0.196
		1987	31246	18071	1764.96	0.232
		1990	.	.	.	0.256
		2000	.	.	.	0.313
STAFFORD	16	1969	16373	7873	1335.15	0.134
		1974	12573	7569	2667.46	0.169
		1978	13929	9114	2084.36	0.214
		1982	15463	11233	1850.78	0.254
		1987	15158	7984	.	0.307
		1990	.	.	.	0.327
		2000	.	.	.	0.406

Table B.1, continued

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
SURRY	19	1969	35864	27154	776.57	0.034
		1974	32412	28669	1464.11	0.031
		1978	36329	31935	1349.69	0.032
		1982	34577	31726	1154.40	0.034
		1987	32836	25545	1029.93	0.036
		1990	.	.	.	0.036
		2000	.	.	.	0.037
WESTMORELAND	17	1969	34621	28985	822.89	0.086
		1974	37077	33475	1337.32	0.091
		1978	40034	37107	1432.52	0.094
		1982	43522	41158	1145.08	0.097
		1987	41176	33604	851.23	0.103
		1990	.	.	.	0.101
		2000	.	.	.	0.105
YORK	21	1969	6122	3053	2904.63	1.908
		1974	2105	1444	5303.83	1.905
		1978	2503	1799	4226.99	1.970
		1982	2201	1726	3432.12	2.041
		1987	.	1342	5369.72	2.171
		1990	.	.	.	2.213
		2000	.	.	.	2.362
CHESAPEAKE	20	1969	49964	38736	1588.56	1.899
		1974	44445	41330	2315.79	1.846
		1978	47067	45682	2725.46	1.850
		1982	47589	46357	2566.84	1.821
		1987	44638	37256	1791.37	1.967
		1990	.	.	.	1.492
		2000	.	.	.	2.069
SUFFOLK	20	1969	61439	46218	1239.78	0.184
		1974	64422	57189	1822.97	0.183
		1978	65487	59158	2122.70	0.179
		1982	62063	58714	1620.73	0.181
		1987	66946	54862	1366.20	0.199
		1990	.	.	.	0.212
		2000	.	.	.	0.246

Table B.1, continued

COUNTY	PLANNING DISTRICT ^a	YEAR	TOTAL CROPLAND ^b	HARVESTED CROPLAND ^b	REAL FARM VALUE ^c	POP. DENS. ^d
VIRGINIA BEACH	20	1969	43766	36822	2054.50	1.024
		1974	32413	31259	2844.50	1.277
		1978	34824	32617	2973.93	1.477
		1982	41939	40522	2650.78	1.728
		1987	31742	26489	1700.70	2.137
		1990	.	.	.	2.214
		2000	.	.	.	2.602

- a. Please see Appendix A, Table 1 for Planning District Names
b. Acres
c. 1982-84 dollars per acre
d. Persons per acre

APPENDIX C

Pesticide Application Profiles

Table C.1. Pesticide Application Profiles

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
CORN	CARBARYL	I	1.0	1.500
	CHLORPYRIFOS	I	20.0	1.325
	DIAZINON	I	2.0	0.500
	FONOFOS	I	4.0	4.000
	MALATHION	I	1.0	1.000
	PERMETHRIN	I	13.0	0.962
	TERBUFOS	I	3.0	1.950
	TRICHLORFON	I	1.0	1.000
	CARBOFURAN	I/N	15.0	1.292
	ETHOPROP	I/N	5.0	1.995
	METHOMYL	I/N	2.0	0.375
	ALACHLOR	H	30.0	2.500
	ATRAZINE	H	100.0	1.500
	EPTC	H	5.0	5.000
	METOLACHLOR	H	40.0	2.000
	SIMAZINE	H	40.0	1.500
SORGHUM	CARBARYL	I	1.0	1.500
	CHLORPYRIFOS	I	20.0	1.325
	DIAZINON	I	2.0	0.500
	FONOFOS	I	4.0	4.000
	MALATHION	I	1.0	1.000
	PERMETHRIN	I	13.0	0.962
	TERBUFOS	I	3.0	1.950
	TRICHLORFON	I	1.0	1.000
	CARBOFURAN	I/N	15.0	1.292
	ETHOPROP	I/N	5.0	1.995
	METHOMYL	I/N	2.0	0.375
	ALACHLOR	H	30.0	2.500
	ATRAZINE	H	100.0	1.500
	EPTC	H	5.0	5.000
	METOLACHLOR	H	40.0	2.000
	SIMAZINE	H	40.0	1.500

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
SMALL GRAINS	CARBARYL	I	2.0	1.000
	DIMETHOATE	I	3.0	0.540
	DISULFOTON	I	6.0	0.750
	MALATHION	I	5.0	1.000
	CARBOFURAN	I/N	2.0	0.250
	METHOMYL	I/N	6.0	0.450
	2,4-DB	H	25.0	0.500
	BROMOXYNIL	H	5.0	0.420
	DICAMBA	H	20.0	0.120
	DICLOFOP-METHYL	H	5.0	1.800
	THIAMETURON	H	15.0	0.023
SOYBEANS	CARBARYL	I	5.0	1.600
	DIMETHOATE	I	1.0	0.500
	MALATHION	I	17.0	1.476
	ALDICARB	I/N	15.0	3.000
	CARBOFURAN	I/N	3.0	1.750
	ETHOPROP	I/N	8.0	3.000
	FENAMIPHOS	I/N	20.0	3.600
	ACIFLUORFEN	H	30.0	0.370
	ALACHLOR	H	35.0	2.000
	BENTAZON	H	5.0	0.750
	CHLORIMURON	H	50.0	0.050
	FLUAZIFOP-BUTYL	H	10.0	0.150
	LINURON	H	60.0	0.600
	METOLACHLOR	H	30.0	1.500
	METRIBUZIN	H	15.0	0.300
	ORYZALIN	H	15.0	0.750
	PENDIMETHALIN	H	15.0	0.300
	SETHOXYDIM	H	10.0	0.150
ALFALFA HAY	CHLORPYRIFOS	I	104.6	0.659
	CARBOFURAN	I/N	85.6	0.861
OTHER HAY	METRIBUZIN	H	12.0	0.500
	PARAQUAT	H	30.0	0.500
	SETHOXYDIM	H	5.0	0.375
	SIMAZINE	H	15.0	1.000
	TERBACIL	H	10.0	0.800

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
PEANUTS	ACEPHATE	I	5.0	0.750
	CARBARYL	I	10.0	1.000
	CHLORPYRIFOS	I	34.0	1.950
	DISULFOTON	I	9.0	0.900
	ESFENVALERATE	I	5.0	0.060
	FONOFOS	I	15.0	2.000
	MONOCROTOPHOS	I	4.0	1.562
	PHORATE	I	11.4	1.200
	PROPARGITE	I	6.0	3.250
	ALDICARB	I/N	128.3	1.050
	CARBOFURAN	I/N	57.5	1.950
	ETHOPROP	I/N	2.4	1.950
	FENAMIPHOS	I/N	18.8	1.950
	2,4-DB	H	100.0	0.125
	ACIFLUORFEN	H	75.0	0.250
	ALACHLOR	H	60.0	3.000
	BENEFIN	H	10.0	1.000
	BENTAZON	H	50.0	0.500
	ETHALFLURALIN	H	25.0	0.750
	METOLACHLOR	H	40.0	3.000
	PARAQUAT	H	60.0	0.125
	PENDIMETHALIN	H	15.0	1.000
	VERNOLATE	H	30.0	2.039
	CAPTAN/PCNB	F	1.0	10.000
	CHLOROTHALONIL	F	60.0	4.504
	CU. HYDROXIDE	F	30.0	6.464
	IPRODIONE	F	40.0	2.000

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
TOBACCO	ACEPHATE	I	127.5	0.699
	BACILLUS THURIGIENSIS	I	20.0	0.313
	CARBARYL	I	5.0	1.000
	CHLORPYRIFOS	I	12.5	2.500
	DIAZINON	I	1.0	2.500
	DISULFOTON	I	10.0	3.000
	ENDOSULFAN	I	5.0	0.750
	FONOFOS	I	1.0	0.150
	METHYL PARATHION	I	1.0	1.250
	ALDICARB	I/N	17.5	2.000
	CARBOFURAN	I/N	10.0	4.000
	ETHOPROP	I/N	1.0	6.000
	METHOMYL	I/N	5.0	0.338
	BENEFIN	H	5.0	1.000
	ISOPROPALIN	H	10.0	1.500
	NAPROPAMIDE	H	20.0	1.500
	PEBULATE	H	3.0	4.000
	PENDIMETHALIN	H	10.0	1.000
	METALAXYL	F	5.6	2.500
IRISH POTATOES	ENDOSULFAN	I	15.0	0.750
	ESFENVALERATE	I	85.0	0.150
	PARATHION	I	20.0	0.380
	PERMETHRIN	I	85.0	0.600
	PHOSMET	I	30.0	1.000
	ALDICARB	I/N	25.0	2.000
	CARBOFURAN	I/N	40.0	1.500
	OXAMYL	I/N	40.0	1.000
	EPTC	H	3.0	4.500
	LINURON	H	30.0	0.750
	METOLACHLOR	H	65.0	1.750
	METRIBUZIN	H	65.0	0.500
	CAPTAN	F	5.6	1.350
	CHLOROTHALONIL	F	5.6	0.500
SWEET POTATOES	CARBARYL	I	25.0	1.500
	ENDOSULFAN	I	35.0	0.750
	ETHOPROP	I/N	90.0	4.000
	NAPROPAMIDE	H	50.2	1.350

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
BEANS	ACEPHATE	I	75.0	2.250
	CARBARYL	I	30.0	2.000
	DIMETHOATE	I	25.0	0.750
	ESFENVALERATE	I	30.0	0.050
	METHOMYL	I/N	45.0	0.900
	TRIFLURALIN	H	50.2	0.750
	CHLOROTHALONIL	F	5.6	0.250
COLE CROPS	CHLORPYRIFOS	I	20.0	1.000
	DIMETHOATE	I	25.0	0.750
	ENDOSULFAN	I	30.0	0.750
	ESFENVALERATE	I	45.0	0.050
	MEVINPHOS	I	25.0	0.375
	PERMETHRIN	I	25.0	0.400
	METHOMYL	I/N	40.0	0.900
	NAPROPAMIDE	H	50.2	1.750
	TRIFLURALIN	H	50.2	0.750
	CHLOROTHALONIL	F	5.6	0.250
CUCUMBERS	AZINPHOS-METHYL	I	30.0	0.750
	CARBARYL	I	30.0	0.750
	DICOFOL	I	30.0	0.750
	ENDOSULFAN	I	50.0	1.250
	ESFENVALERATE	I	50.0	0.050
	CARBOFURAN	I/N	25.0	2.000
	METHOMYL	I/N	30.0	0.675
	BENSULIDE	H	5.0	4.000
	NAPTALAM	H	40.0	2.000
	CHLOROTHALONIL	F	5.6	0.250
MUSKMELONS	AZINPHOS-METHYL	I	20.0	0.500
	ENDOSULFAN	I	70.0	2.250
	ESFENVALERATE	I	30.0	0.040
	PERMETHRIN	I	40.0	0.400
	CARBOFURAN	I/N	50.0	2.000
	METHOMYL	I/N	5.0	0.400
	BENSULIDE	H	50.2	2.000
	NAPTALAM	H	50.2	1.000
	CHLOROTHALONIL	F	5.6	9.720
	TRIADIMEFON	F	5.6	0.020

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
LETTUCE	DIAZINON	I	33.8	0.500
	PERMETHRIN	I	33.8	0.750
	NAPROPAMIDE	H	50.2	1.000
	TRIFLURALIN	H	50.2	0.750
PEPPERS	ACEPHATE	I	75.0	2.400
	ESFENVALERATE	I	10.0	2.400
	PERMETHRIN	I	40.0	1.200
	CARBOFURAN	I/N	75.0	5.000
	METHOMYL	I/N	10.0	0.600
	NAPROPAMIDE	H	50.2	6.500
PUMPKINS	ENDOSULFAN	I	75.0	2.250
	CARBOFURAN	I/N	75.0	2.000
	CHLORAMBEN	H	50.2	3.000
	BENOMYL	F	5.6	1.000
	CHLOROTHALONIL	F	5.6	11.520
SPINACH	DIMETHOATE	I	35.0	1.000
	MEVINPHOS	I	50.0	0.750
	PERMETHRIN	I	20.0	0.300
	METHOMYL	I/N	30.0	0.675
SUMMER SQUASH	ENDOSULFAN	I	33.8	2.880
	CHLORAMBEN	H	50.2	3.000
	CHLOROTHALONIL	F	5.6	5.760
SWEET CORN	ESFENVALERATE	I	30.0	0.120
	PERMETHRIN	I	50.0	0.400
	CARBOFURAN	I/N	40.0	3.000
	METHOMYL	I/N	75.0	2.000
	ATRAZINE	H	50.2	2.000

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
TOMATOES	AZINPHOS-METHYL	I	50.0	1.330
	ENDOSULFAN	I	50.0	1.000
	ESFENVALERATE	I	50.0	0.150
	METHOMYL	I/N	30.0	0.900
	OXAMYL	I/N	30.0	1.000
	METRIBUZIN	H	100.0	0.250
	NAPROPAMIDE	H	10.0	0.844
	PARAQUAT	H	50.0	0.250
	TRIFLURALIN	H	25.0	0.750
	METHYL BROMIDE	FUM	85.0	350.000
	CHLOROTHALONIL	F	5.6	10.500
	METALAXYL	F	5.6	8.120
WATERMELONS	CARBARYL	I	25.0	2.000
	DICOFOL	I	30.0	0.750
	DIMETHOATE	I	20.0	1.250
	ENDOSULFAN	I	40.0	1.250
	ESFENVALERATE	I	40.0	0.063
	METHOMYL	I/N	30.0	0.900
	BENSULIDE	H	50.2	2.000
	NAPTALAM	H	50.2	1.000
	CHLOROTHALONIL	F	5.6	9.720
	TRIADIMEFON	F	5.6	0.020
BERRIES	CHLORPYRIFOS	I	33.8	2.000
	NAPROPAMIDE	H	50.2	4.000
	TERBACIL	H	50.2	0.800
	BENOMYL	F	5.6	1.500
	CAPTAN	F	5.6	4.500

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
APPLES	AZINPHOS-METHYL	I	89.1	0.295
	CARBARYL	I	73.3	3.540
	CHLORPYRIFOS	I	57.9	2.087
	DICOFOL	I	38.6	2.055
	DIMETHOATE	I	36.7	0.882
	ENDOSULFAN	I	43.6	1.920
	ESFENVALERATE	I	20.3	0.203
	FORMETANATE	I	39.6	1.014
	METHYL PARATHION	I	82.6	2.280
	PARATHION	I	19.4	0.707
	PERMETHRIN	I	20.3	0.203
	PHOSMET	I	39.8	2.655
	PROPARGITE	I	61.9	1.654
	PETROLEUM OIL	I	62.8	50.800
	METHOMYL	I/N	89.6	3.186
	OXAMYL	I/N	42.6	1.027
	2,4-DB	H	20.0	2.000
	DICHLORBENIL	H	10.0	6.000
	GLYPHOSATE	H	15.0	3.000
	PARAQUAT	H	30.0	0.750
	SIMAZINE	H	30.0	3.000
PEACHES	AZINPHOS-METHYL	I	130.0	0.956
	CARBARYL	I	40.0	3.750
	CHLORPYRIFOS	I	75.0	3.300
	DICOFOL	I	40.0	1.313
	ENDOSULFAN	I	65.0	1.715
	FENVALERATE	I	20.0	0.153
	FORMETANATE	I	50.0	0.920
	METHYL PARATHION	I	40.0	0.734
	PARATHION	I	270.0	0.889
	PERMETHRIN	I	20.0	0.191
	PHOSMET	I	80.0	1.469
	PROPARGITE	I	40.0	1.800
	PETROLEUM OIL	I	30.0	47.040
	METHOMYL	I/N	90.0	0.562
	2,4-DB	H	20.0	2.000
	DICHLORBENIL	H	10.0	6.000
	GLYPHOSATE	H	15.0	3.000
	PARAQUAT	H	30.0	0.750
	SIMAZINE	H	30.0	3.000

Table C.1, continued

CROP GROUP	PESTICIDE ACTIVE INGREDIENT	ACTION ^a	PERCENT OF ACRES TREATED	RATE APPLIED (lbs/acre)
GRAPES	CARBARYL	I	33.8	6.400
	ORYZALIN	H	50.2	0.900
	CAPTAN	F	5.6	1.000

a. Actions: F = fungicide; FUM = fumigant; H = herbicide;
I = insecticide; N = nematocide.

APPENDIX D

Pesticide Hazard Information

Table D.1. Pesticide Hazard Information

ACTIVE INGREDIENT	ACTION ^a	TOXICITY CLASS ^b	LEACHING POTENTIAL	RUNOFF POTENTIAL	HAZARD INDEX
ACEPHATE	I	III	SMALL	SMALL	1.00
AZINPHOS-METHYL	I	I	SMALL	LARGE	7.00
BACILLUS THURIGIENSIS	I	III	N/A	N/A	.
CARBARYL	I	II	SMALL	MEDIUM	2.50
CHLORPYRIFOS	I	II	SMALL	LARGE	3.50
DIAZINON	I	II	MEDIUM	MEDIUM	3.50
DICOFOL	I	III	SMALL	LARGE	2.33
DIMETHOATE	I	II	MEDIUM	SMALL	2.50
DISULFOTON	I	I	SMALL	MEDIUM	5.00
ENDOSULFAN	I	I	SMALL	LARGE	7.00
ESFENVALERATE	I	II	SMALL	LARGE	3.50
FENVALERATE	I	II	SMALL	LARGE	3.50
FONOFOS	I	I	MEDIUM	LARGE	9.00
FORMETANATE	I	I	SMALL	LARGE	7.00
MALATHION	I	III	SMALL	SMALL	1.00
METHYL PARATHION	I	I	SMALL	MEDIUM	5.00
MEVINPHOS	I	I	MEDIUM	SMALL	5.00
MONOCROTOPHOS	I	I	LARGE	SMALL	7.00
PARATHION	I	I	SMALL	LARGE	7.00
PERMETHRIN	I	II	SMALL	LARGE	3.50
PHORATE	I	I	SMALL	LARGE	7.00
PHOSMET	I	II	SMALL	MEDIUM	2.50
PROPARGITE	I	III	SMALL	LARGE	2.33
PETROLEUM OIL	I	III	SMALL	MEDIUM	1.67
TERBUFOS	I	I	SMALL	MEDIUM	5.00
TRICHLORFON	I	II	LARGE	SMALL	3.50
ALDICARB	I/N	I	LARGE	SMALL	7.00
CARBOFURAN	I/N	I	LARGE	SMALL	7.00
ETHOPROP	I/N	II	LARGE	MEDIUM	4.50
FENAMIPHOS	I/N	I	MEDIUM	MEDIUM	7.00
METHOMYL	I/N	I	LARGE	MEDIUM	9.00
OXAMYL	I/N	I	SMALL	SMALL	3.00
2,4-DB	H	III	SMALL	MEDIUM	1.67
ACIFLUORFEN	H	III	MEDIUM	MEDIUM	2.33
ALACHLOR	H	III	MEDIUM	MEDIUM	2.33
ATRAZINE	H	III	LARGE	MEDIUM	3.00
BENEFIN	H	IV	SMALL	LARGE	1.75
BENSULIDE	H	II	SMALL	LARGE	3.50
BENTAZON	H	III	LARGE	MEDIUM	3.00
BROMOXYNIL	H	II	SMALL	MEDIUM	2.50

Table D.1, continued

ACTIVE INGREDIENT	ACTION ^a	TOXICITY CLASS ^b	LEACHING POTENTIAL	RUNOFF POTENTIAL	HAZARD INDEX
CHLORAMBEN	H	IV	LARGE	SMALL	1.75
CHLORIMURON	H	III	LARGE	SMALL	2.33
DICAMBA	H	III	LARGE	SMALL	2.33
DICHOLOBENIL	H	III	LARGE	MEDIUM	3.00
DICLOFOP-METHYL	H	III	SMALL	MEDIUM	1.67
EPTC	H	III	MEDIUM	MEDIUM	2.33
ETHALFLURALIN	H	IV	SMALL	LARGE	1.75
FLUAZIFOP-BUTYL	H	III	SMALL	LARGE	2.33
GLYPHOSATE	H	III	SMALL	LARGE	2.33
ISOPROPALIN	H	IV	SMALL	LARGE	1.75
LINURON	H	III	MEDIUM	LARGE	3.00
METOLACHLOR	H	III	MEDIUM	MEDIUM	2.33
METRIBUZIN	H	III	LARGE	MEDIUM	3.00
NAPROPAMIDE	H	III	LARGE	MEDIUM	3.00
NAPTALAM	H	IV	MEDIUM	SMALL	1.25
ORYZALIN	H	IV	SMALL	MEDIUM	1.25
PARQUAT	H	II	SMALL	LARGE	3.50
PEBULATE	H	III	MEDIUM	MEDIUM	2.33
PENDIMETHALIN	H	III	SMALL	LARGE	2.33
SETHOXYDIM	H	III	SMALL	SMALL	1.00
SIMAZINE	H	IV	LARGE	MEDIUM	2.25
TERBACIL	H	IV	LARGE	MEDIUM	2.25
TRIFLURALIN	H	IV	SMALL	LARGE	1.75
VERNOLATE	H	III	SMALL	MEDIUM	1.67
THIAMETURON	H	IV	LARGE	SMALL	1.75
METHYL BROMIDE	FUM	II	N/A	N/A	.
BENOMYL	F	IV	LARGE	LARGE	2.75
CAPTAN	F	IV	SMALL	SMALL	0.75
CAPTAN/PCNB	F	IV	SMALL	MEDIUM	1.25
CHLOROTHALONIL	F	IV	SMALL	LARGE	1.75
CU. HYDROXIDE	F	III	N/A	N/A	.
IPRODIONE	F	III	SMALL	MEDIUM	1.67
METALAXYL	F	III	LARGE	SMALL	2.33
TRIADIMEFON	F	III	MEDIUM	MEDIUM	2.33

a. Actions: F = fungicide; FUM = fumigant; H = herbicide;
I = insecticide; N = nematocide.

b. Toxicity Classes: I = highly toxic; II = moderately toxic; III = slightly toxic; IV = almost non-toxic.

APPENDIX E

Agricultural Land Use Summary, by County

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: TIDEWATER TOTAL

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	5,698,539	5,698,539	--
REAL FARMLAND VALUE ^b	1858.37	1946.86	4.76
CROPLAND ^a	935,931	912,693	-2.48
HARVESTED CROPLAND ^a	771,535	752,156	-2.51
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	881,649	859,506	-2.51
CORN	234,884	228,783	-2.60
SORGHUM	951	924	-2.78
SMALL GRAINS	165,862	161,682	-2.52
SOYBEANS	342,225	333,756	-2.47
ALFALFA HAY	6,908	6,700	-3.01
OTHER HAY	54,351	52,321	-3.74
PEANUTS	37,982	37,467	-1.36
TOBACCO	296	270	-8.75
IRISH POTATOES	14,737	14,586	-1.02
SWEET POTATOES	1,913	1,893	-1.04
BEANS	4,911	4,849	-1.27
COLE CROPS	697	686	-1.59
CUCUMBERS	3,828	3,784	-1.13
MUSKMELONS	430	420	-2.39
LETTUCE	4	4	-1.62
PEPPERS	346	342	-1.28
PUMPKINS	258	245	-4.99
SPINACH	727	720	-0.97
SUMMER SQUASH	399	393	-1.34
SWEET CORN	1,265	1,226	-3.14
TOMATOES	3,136	3,095	-1.33
WATERMELONS	677	662	-2.18
OTHER VEGATABLES	178	176	-1.36
BERRIES	313	300	-4.12
APPLES	231	221	-4.24
PEACHES	302	294	-2.84
GRAPES	79	77	-3.01
NURSERY PRODUCTS	3,760	3,631	-3.44

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: ACCOMACK COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	304,435	304,435	--
REAL FARMLAND VALUE ^b	1460.05	1491.12	2.13
CROPLAND ^a	81,109	80,511	-0.74
HARVESTED CROPLAND ^a	71,567	71,040	-0.74
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	82,095	81,490	-0.74
CORN	7,643	7,587	-0.74
SORGHUM	35	35	-0.74
SMALL GRAINS	14,298	14,193	-0.74
SOYBEANS	43,584	43,263	-0.74
ALFALFA HAY	75	74	-0.74
OTHER HAY	363	361	-0.74
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	8,336	8,274	-0.74
SWEET POTATOES	1,122	1,114	-0.74
BEANS	1,859	1,845	-0.74
COLE CROPS	88	88	-0.74
CUCUMBERS	1,671	1,658	-0.74
MUSKMELONS	17	17	-0.74
LETTUCE	0	0	.
PEPPERS	57	56	-0.74
PUMPKINS	4	4	-0.74
SPINACH	431	428	-0.74
SUMMER SQUASH	71	70	-0.74
SWEET CORN	29	29	-0.74
TOMATOES	1,300	1,291	-0.74
WATERMELONS	49	49	-0.74
OTHER VEGETABLES	22	22	-0.74
BERRIES	10	10	-0.74
APPLES	3	3	-0.74
PEACHES	45	45	-0.74
GRAPES	3	3	-0.74
NURSERY PRODUCTS	979	972	-0.74

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: CAROLINE COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	341,694	341,694	--
REAL FARMLAND VALUE ^b	1439.19	1473.88	2.41
CROPLAND ^a	37,805	37,196	-1.61
HARVESTED CROPLAND ^a	28,931	28,393	-1.86
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	32,302	31,702	-1.86
CORN	9,431	9,256	-1.86
SORGHUM	72	70	-1.86
SMALL GRAINS	5,659	5,554	-1.86
SOYBEANS	14,414	14,147	-1.86
ALFALFA HAY	287	282	-1.86
OTHER HAY	2,282	2,240	-1.86
PEANUTS	0	0	.
TOBACCO	30	30	-1.86
IRISH POTATOES	0	0	.
SWEET POTATOES	3	2	-1.86
BEANS	4	4	-1.86
COLE CROPS	0	0	-1.86
CUCUMBERS	1	1	-1.86
MUSKMELONS	10	10	-1.86
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	-1.86
SWEET CORN	34	34	-1.86
TOMATOES	8	8	-1.86
WATERMELONS	24	24	-1.86
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	41	40	-1.86
PEACHES	1	1	-1.86
GRAPES	0	0	-1.86
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: CHARLES CITY COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	116,128	116,128	--
REAL FARMLAND VALUE ^b	1206.96	1239.63	2.71
CROPLAND ^a	17,053	16,451	-3.53
HARVESTED CROPLAND ^a	11,675	11,143	-4.55
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	14,012	13,374	-4.55
CORN	4,191	4,000	-4.55
SORGHUM	68	65	-4.55
SMALL GRAINS	3,400	3,245	-4.55
SOYBEANS	5,797	5,533	-4.55
ALFALFA HAY	96	91	-4.55
OTHER HAY	456	435	-4.55
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	0	0	.
TOMATOES	0	0	.
WATERMELONS	0	0	.
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	0	0	.
GRAPES	0	0	.
NURSERY PRODUCTS	3	3	-4.55

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: CHESTERFIELD COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	282,828	282,828	--
REAL FARMLAND VALUE ^b	1743.14	1915.21	9.87
CROPLAND ^a	10,777	9,731	-9.71
HARVESTED CROPLAND ^a	6,137	5,214	-15.04
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	6,773	5,754	-15.04
CORN	690	586	-15.04
SORGHUM	52	44	-15.04
SMALL GRAINS	1,149	976	-15.04
SOYBEANS	2,731	2,320	-15.04
ALFALFA HAY	61	51	-15.04
OTHER HAY	1,642	1,395	-15.04
PEANUTS	0	0	.
TOBACCO	155	132	-15.04
IRISH POTATOES	1	0	-15.04
SWEET POTATOES	1	1	-15.04
BEANS	2	2	-15.04
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	16	14	-15.04
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	11	9	-15.04
TOMATOES	3	3	-15.04
WATERMELONS	0	0	.
OTHER VEGATABLES	0	0	.
BERRIES	15	13	-15.04
APPLES	15	13	-15.04
PEACHES	11	9	-15.04
GRAPES	0	0	-15.04
NURSERY PRODUCTS	219	186	-15.04

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: ESSEX COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	168,051	168,051	--
REAL FARMLAND VALUE ^b	1343.24	1375.11	2.37
CROPLAND ^a	38,245	37,645	-1.57
HARVESTED CROPLAND ^a	33,399	32,870	-1.59
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	41,582	40,923	-1.59
CORN	12,246	12,052	-1.59
SORGHUM	0	0	.
SMALL GRAINS	10,709	10,539	-1.59
SOYBEANS	17,725	17,444	-1.59
ALFALFA HAY	64	63	-1.59
OTHER HAY	796	783	-1.59
PEANUTS	0	0	.
TOBACCO	6	6	-1.59
IRISH POTATOES	1	1	-1.59
SWEET POTATOES	0	0	.
BEANS	6	6	-1.59
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	19	19	-1.59
TOMATOES	4	4	-1.59
WATERMELONS	3	3	-1.59
OTHER VEGETABLES	0	0	.
BERRIES	0	0	.
APPLES	1	1	-1.59
PEACHES	1	1	-1.59
GRAPES	1	1	-1.59
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: FAIRFAX COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	283,204	283,204	--
REAL FARMLAND VALUE ^b	5770.89	6014.86	4.23
CROPLAND ^a	6,648	5,373	-19.18
HARVESTED CROPLAND ^a	0	0	.
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	0	0	.
CORN	0	0	.
SORGHUM	0	0	.
SMALL GRAINS	0	0	.
SOYBEANS	0	0	.
ALFALFA HAY	0	0	.
OTHER HAY	0	0	.
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	0	0	.
TOMATOES	0	0	.
WATERMELONS	0	0	.
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	0	0	.
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: GLOUCESTER COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	144,121	144,121	--
REAL FARMLAND VALUE ^b	1457.51	1526.52	4.73
CROPLAND ^a	20,930	20,212	-3.43
HARVESTED CROPLAND ^a	18,121	17,487	-3.50
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	20,123	19,419	-3.50
CORN	6,592	6,362	-3.50
SORGHUM	0	0	.
SMALL GRAINS	2,123	2,049	-3.50
SOYBEANS	10,104	9,750	-3.50
ALFALFA HAY	359	346	-3.50
OTHER HAY	881	850	-3.50
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	-3.50
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	2	2	-3.50
TOMATOES	0	0	.
WATERMELONS	5	5	-3.50
OTHER VEGETABLES	0	0	.
BERRIES	4	4	-3.50
APPLES	8	8	-3.50
PEACHES	8	8	-3.50
GRAPES	0	0	.
NURSERY PRODUCTS	36	34	-3.50

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: HANOVER COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	299,155	299,155	--
REAL FARMLAND VALUE ^b	1313.76	1366.60	4.02
CROPLAND ^a	64,144	63,477	-1.04
HARVESTED CROPLAND ^a	53,225	52,637	-1.11
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	59,571	58,912	-1.11
CORN	13,838	13,685	-1.11
SORGHUM	213	211	-1.11
SMALL GRAINS	10,113	10,001	-1.11
SOYBEANS	20,514	20,287	-1.11
ALFALFA HAY	1,712	1,693	-1.11
OTHER HAY	11,039	10,917	-1.11
PEANUTS	0	0	.
TOBACCO	37	37	-1.11
IRISH POTATOES	249	246	-1.11
SWEET POTATOES	37	37	-1.11
BEANS	104	103	-1.11
COLE CROPS	261	258	-1.11
CUCUMBERS	36	36	-1.11
MUSKMELONS	195	193	-1.11
LETTUCE	0	0	.
PEPPERS	25	25	-1.11
PUMPKINS	80	79	-1.11
SPINACH	131	130	-1.11
SUMMER SQUASH	83	82	-1.11
SWEET CORN	180	178	-1.11
TOMATOES	211	209	-1.11
WATERMELONS	253	250	-1.11
OTHER VEGATABLES	53	52	-1.11
BERRIES	43	43	-1.11
APPLES	10	10	-1.11
PEACHES	21	21	-1.11
GRAPES	1	1	-1.11
NURSERY PRODUCTS	130	128	-1.11

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: HENRICO COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	190,828	190,828	--
REAL FARMLAND VALUE ^b	2817.35	2919.55	3.63
CROPLAND ^a	14,959	14,135	-5.51
HARVESTED CROPLAND ^a	9,827	9,100	-7.40
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	10,630	9,844	-7.40
CORN	3,094	2,865	-7.40
SORGHUM	0	0	.
SMALL GRAINS	1,876	1,737	-7.40
SOYBEANS	4,214	3,902	-7.40
ALFALFA HAY	168	156	-7.40
OTHER HAY	1,125	1,042	-7.40
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	-7.40
SWEET POTATOES	0	0	.
BEANS	0	0	-7.40
COLE CROPS	0	0	.
CUCUMBERS	1	1	-7.40
MUSKMELONS	2	2	-7.40
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	3	2	-7.40
SPINACH	2	2	-7.40
SUMMER SQUASH	0	0	-7.40
SWEET CORN	12	11	-7.40
TOMATOES	4	4	-7.40
WATERMELONS	1	1	-7.40
OTHER VEGATABLES	0	0	.
BERRIES	4	4	-7.40
APPLES	3	2	-7.40
PEACHES	2	2	-7.40
GRAPES	0	0	.
NURSERY PRODUCTS	116	108	-7.40

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: ISLE OF WIGHT COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	204,454	204,454	--
REAL FARMLAND VALUE ^b	1352.57	1388.88	2.68
CROPLAND ^a	57,912	57,298	-1.06
HARVESTED CROPLAND ^a	50,611	50,069	-1.07
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	53,530	52,957	-1.07
CORN	20,532	20,312	-1.07
SORGHUM	67	66	-1.07
SMALL GRAINS	4,742	4,691	-1.07
SOYBEANS	12,803	12,666	-1.07
ALFALFA HAY	0	0	.
OTHER HAY	376	372	-1.07
PEANUTS	14,916	14,757	-1.07
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	6	6	-1.07
BEANS	1	1	-1.07
COLE CROPS	5	5	-1.07
CUCUMBERS	0	0	.
MUSKMELONS	4	4	-1.07
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	13	13	-1.07
TOMATOES	0	0	.
WATERMELONS	24	24	-1.07
OTHER VEGETABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	40	40	-1.07
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: JAMES CITY COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	101,292	101,292	--
REAL FARMLAND VALUE ^b	2802.94	2883.97	2.89
CROPLAND ^a	10,639	9,883	-7.11
HARVESTED CROPLAND ^a	9,267	8,600	-7.20
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	11,475	10,649	-7.20
CORN	2,517	2,336	-7.20
SORGHUM	0	0	.
SMALL GRAINS	2,292	2,127	-7.20
SOYBEANS	4,824	4,476	-7.20
ALFALFA HAY	137	127	-7.20
OTHER HAY	1,369	1,271	-7.20
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	3	3	-7.20
SWEET POTATOES	4	3	-7.20
BEANS	2	2	-7.20
COLE CROPS	0	0	.
CUCUMBERS	1	1	-7.20
MUSKMELONS	27	25	-7.20
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	76	71	-7.20
SPINACH	0	0	.
SUMMER SQUASH	1	1	-7.20
SWEET CORN	92	86	-7.20
TOMATOES	17	16	-7.20
WATERMELONS	60	55	-7.20
OTHER VEGATABLES	0	0	.
BERRIES	3	2	-7.20
APPLES	39	36	-7.20
PEACHES	13	12	-7.20
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: KING AND QUEEN COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	202,982	202,982	--
REAL FARMLAND VALUE ^b	1326.54	1358.47	2.41
CROPLAND ^a	30,640	30,039	-1.96
HARVESTED CROPLAND ^a	26,688	26,159	-1.98
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	27,844	27,292	-1.98
CORN	10,500	10,292	-1.98
SORGHUM	12	11	-1.98
SMALL GRAINS	7,008	6,869	-1.98
SOYBEANS	9,619	9,428	-1.98
ALFALFA HAY	74	73	-1.98
OTHER HAY	508	498	-1.98
PEANUTS	0	0	.
TOBACCO	2	2	-1.98
IRISH POTATOES	1	1	-1.98
SWEET POTATOES	4	4	-1.98
BEANS	9	9	-1.98
COLE CROPS	1	1	-1.98
CUCUMBERS	1	1	-1.98
MUSKMELONS	3	3	-1.98
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	-1.98
SUMMER SQUASH	1	1	-1.98
SWEET CORN	81	79	-1.98
TOMATOES	4	4	-1.98
WATERMELONS	6	6	-1.98
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	1	1	-1.98
PEACHES	10	9	-1.98
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: KING GEORGE COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	115,244	115,244	- -
REAL FARMLAND VALUE ^b	1477.16	1521.53	3.00
CROPLAND ^a	19,478	18,838	-3.28
HARVESTED CROPLAND ^a	12,760	12,195	-4.42
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	14,062	13,440	-4.42
CORN	4,217	4,030	-4.42
SORGHUM	0	0	.
SMALL GRAINS	4,282	4,092	-4.42
SOYBEANS	3,623	3,463	-4.42
ALFALFA HAY	210	201	-4.42
OTHER HAY	1,640	1,567	-4.42
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	2	2	-4.42
SWEET POTATOES	0	0	.
BEANS	21	20	-4.42
COLE CROPS	0	0	.
CUCUMBERS	1	1	-4.42
MUSKMELONS	2	2	-4.42
LETTUCE	0	0	.
PEPPERS	0	0	-4.42
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	3	3	-4.42
SWEET CORN	20	19	-4.42
TOMATOES	10	10	-4.42
WATERMELONS	6	6	-4.42
OTHER VEGATABLES	0	0	.
BERRIES	1	1	-4.42
APPLES	7	7	-4.42
PEACHES	3	2	-4.42
GRAPES	14	14	-4.42
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: KING WILLIAM COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	177,766	177,766	--
REAL FARMLAND VALUE ^b	1348.12	1382.42	2.54
CROPLAND ^a	35,037	34,429	-1.73
HARVESTED CROPLAND ^a	30,568	30,032	-1.75
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	34,884	34,272	-1.75
CORN	11,286	11,088	-1.75
SORGHUM	0	0	.
SMALL GRAINS	6,685	6,568	-1.75
SOYBEANS	15,225	14,958	-1.75
ALFALFA HAY	321	315	-1.75
OTHER HAY	1,283	1,261	-1.75
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	5	5	-1.75
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	11	11	-1.75
TOMATOES	0	0	-1.75
WATERMELONS	15	14	-1.75
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	23	23	-1.75
PEACHES	29	28	-1.75
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: LANCASTER COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	85,043	85,043	--
REAL FARMLAND VALUE ^b	1286.02	1327.54	3.23
CROPLAND ^a	18,131	17,500	-3.48
HARVESTED CROPLAND ^a	16,591	16,035	-3.35
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	20,418	19,733	-3.35
CORN	5,916	5,717	-3.35
SORGHUM	0	0	.
SMALL GRAINS	4,740	4,581	-3.35
SOYBEANS	9,369	9,055	-3.35
ALFALFA HAY	11	11	-3.35
OTHER HAY	300	290	-3.35
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	2	2	-3.35
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	4	4	-3.35
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	3	3	-3.35
TOMATOES	63	61	-3.35
WATERMELONS	0	0	.
OTHER VEGETABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	2	2	-3.35
GRAPES	0	0	.
NURSERY PRODUCTS	7	7	-3.35

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: MATHEWS COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	55,776	55,776	--
REAL FARMLAND VALUE ^b	1429.22	1472.72	3.04
CROPLAND ^a	8,146	7,509	-7.82
HARVESTED CROPLAND ^a	6,841	6,279	-8.22
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	7,415	6,805	-8.22
CORN	2,242	2,058	-8.22
SORGHUM	0	0	.
SMALL GRAINS	793	728	-8.22
SOYBEANS	3,897	3,577	-8.22
ALFALFA HAY	0	0	.
OTHER HAY	369	339	-8.22
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	0	0	.
TOMATOES	0	0	.
WATERMELONS	0	0	.
OTHER VEGETABLES	0	0	.
BERRIES	9	8	-8.22
APPLES	0	0	-8.22
PEACHES	6	5	-8.22
GRAPES	0	0	-8.22
NURSERY PRODUCTS	98	90	-8.22

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: MIDDLESEX COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	85,728	85,728	--
REAL FARMLAND VALUE ^b	1380.36	1418.30	2.75
CROPLAND ^a	18,615	17,995	-3.33
HARVESTED CROPLAND ^a	16,078	15,531	-3.40
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	18,983	18,338	-3.40
CORN	5,041	4,870	-3.40
SORGHUM	24	23	-3.40
SMALL GRAINS	4,334	4,187	-3.40
SOYBEANS	8,768	8,470	-3.40
ALFALFA HAY	220	213	-3.40
OTHER HAY	478	462	-3.40
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	7	7	-3.40
TOMATOES	81	78	-3.40
WATERMELONS	0	0	.
OTHER VEGETABLES	0	0	.
BERRIES	0	0	.
APPLES	4	4	-3.40
PEACHES	25	24	-3.40
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: NEW KENT COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	136,256	136,256	--
REAL FARMLAND VALUE ^b	1226.74	1267.26	3.30
CROPLAND ^a	13,950	13,323	-4.50
HARVESTED CROPLAND ^a	8,937	8,383	-6.20
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	10,425	9,779	-6.20
CORN	3,327	3,121	-6.20
SORGHUM	0	0	.
SMALL GRAINS	2,220	2,083	-6.20
SOYBEANS	4,361	4,091	-6.20
ALFALFA HAY	32	30	-6.20
OTHER HAY	366	343	-6.20
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	1	1	-6.20
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	-6.20
MUSKMELONS	21	19	-6.20
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	40	38	-6.20
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	4	4	-6.20
TOMATOES	10	10	-6.20
WATERMELONS	38	36	-6.20
OTHER VEGETABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	3	3	-6.20
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: NORTHAMPTON COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	144,601	144,601	- -
REAL FARMLAND VALUE ^b	1457.00	1487.61	2.10
CROPLAND ^a	42,674	42,078	-1.40
HARVESTED CROPLAND ^a	37,654	37,128	-1.40
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	47,589	46,924	-1.40
CORN	577	569	-1.40
SORGHUM	0	0	.
SMALL GRAINS	11,829	11,664	-1.40
SOYBEANS	21,492	21,192	-1.40
ALFALFA HAY	16	16	-1.40
OTHER HAY	147	145	-1.40
PEANUTS	62	61	-1.40
TOBACCO	0	0	.
IRISH POTATOES	6,111	6,026	-1.40
SWEET POTATOES	694	684	-1.40
BEANS	2,469	2,435	-1.40
COLE CROPS	39	38	-1.40
CUCUMBERS	2,075	2,046	-1.40
MUSKMELONS	8	8	-1.40
LETTUCE	0	0	.
PEPPERS	259	256	-1.40
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	183	181	-1.40
SWEET CORN	91	90	-1.40
TOMATOES	1,087	1,072	-1.40
WATERMELONS	40	39	-1.40
OTHER VEGETABLES	93	92	-1.40
BERRIES	7	7	-1.40
APPLES	12	11	-1.40
PEACHES	30	30	-1.40
GRAPES	0	0	.
NURSERY PRODUCTS	265	261	-1.40

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: NORTHUMBERLAND COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	118,105	118,105	--
REAL FARMLAND VALUE ^b	1246.35	1280.24	2.72
CROPLAND ^a	34,760	34,153	-1.74
HARVESTED CROPLAND ^a	31,263	30,728	-1.71
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	38,904	38,238	-1.71
CORN	11,269	11,076	-1.71
SORGHUM	0	0	.
SMALL GRAINS	10,861	10,675	-1.71
SOYBEANS	16,304	16,025	-1.71
ALFALFA HAY	55	54	-1.71
OTHER HAY	312	306	-1.71
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	1	1	-1.71
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	2	2	-1.71
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	7	7	-1.71
TOMATOES	80	78	-1.71
WATERMELONS	0	0	.
OTHER VEGETABLES	0	0	.
BERRIES	0	0	.
APPLES	1	1	-1.71
PEACHES	12	11	-1.71
GRAPES	0	0	-1.71
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: PRINCE GEORGE COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	176,620	176,620	--
REAL FARMLAND VALUE ^b	1372.17	1413.69	3.03
CROPLAND ^a	24,623	23,992	-2.56
HARVESTED CROPLAND ^a	19,600	19,044	-2.84
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	20,108	19,537	-2.84
CORN	4,683	4,550	-2.84
SORGHUM	28	27	-2.84
SMALL GRAINS	2,195	2,133	-2.84
SOYBEANS	8,743	8,495	-2.84
ALFALFA HAY	375	364	-2.84
OTHER HAY	1,110	1,079	-2.84
PEANUTS	2,805	2,726	-2.84
TOBACCO	38	36	-2.84
IRISH POTATOES	4	3	-2.84
SWEET POTATOES	4	4	-2.84
BEANS	10	9	-2.84
COLE CROPS	2	2	-2.84
CUCUMBERS	3	3	-2.84
MUSKMELONS	21	21	-2.84
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	4	4	-2.84
SPINACH	2	1	-2.84
SUMMER SQUASH	0	0	.
SWEET CORN	37	36	-2.84
TOMATOES	7	6	-2.84
WATERMELONS	23	22	-2.84
OTHER VEGETABLES	0	0	.
BERRIES	2	2	-2.84
APPLES	4	4	-2.84
PEACHES	2	1	-2.84
GRAPES	1	1	-2.84
NURSERY PRODUCTS	7	7	-2.84

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: PRINCE WILLIAM COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	223,589	223,589	--
REAL FARMLAND VALUE ^b	3778.81	4016.93	6.30
CROPLAND ^a	33,332	32,076	-3.77
HARVESTED CROPLAND ^a	21,590	20,482	-5.13
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	23,272	22,077	-5.13
CORN	8,026	7,614	-5.13
SORGHUM	0	0	.
SMALL GRAINS	1,943	1,844	-5.13
SOYBEANS	1,037	984	-5.13
ALFALFA HAY	522	495	-5.13
OTHER HAY	11,368	10,785	-5.13
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	4	4	-5.13
COLE CROPS	0	0	.
CUCUMBERS	1	1	-5.13
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	60	57	-5.13
TOMATOES	1	1	-5.13
WATERMELONS	1	1	-5.13
OTHER VEGATABLES	0	0	.
BERRIES	3	3	-5.13
APPLES	11	11	-5.13
PEACHES	4	4	-5.13
GRAPES	8	8	-5.13
NURSERY PRODUCTS	281	267	-5.13

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: RICHMOND COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	123,334	123,334	--
REAL FARMLAND VALUE ^b	1225.37	1257.28	2.60
CROPLAND ^a	29,745	29,145	-2.02
HARVESTED CROPLAND ^a	26,839	26,310	-1.97
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	32,310	31,672	-1.97
CORN	9,179	8,998	-1.97
SORGHUM	0	0	.
SMALL GRAINS	8,928	8,752	-1.97
SOYBEANS	13,228	12,967	-1.97
ALFALFA HAY	55	54	-1.97
OTHER HAY	722	708	-1.97
PEANUTS	0	0	.
TOBACCO	1	1	-1.97
IRISH POTATOES	0	0	.
SWEET POTATOES	9	9	-1.97
BEANS	2	2	-1.97
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	5	5	-1.97
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	1	1	-1.97
SWEET CORN	29	29	-1.97
TOMATOES	87	85	-1.97
WATERMELONS	0	0	.
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	0	0	.
GRAPES	0	0	.
NURSERY PRODUCTS	63	62	-1.97

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: SPOTSYLVANIA COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	264,470	264,470	--
REAL FARMLAND VALUE ^b	1585.81	1658.32	4.57
CROPLAND ^a	33,297	32,567	-2.19
HARVESTED CROPLAND ^a	24,953	24,309	-2.58
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	27,044	26,347	-2.58
CORN	8,221	8,009	-2.58
SORGHUM	0	0	.
SMALL GRAINS	2,995	2,917	-2.58
SOYBEANS	5,349	5,211	-2.58
ALFALFA HAY	1,469	1,431	-2.58
OTHER HAY	8,968	8,737	-2.58
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	9	8	-2.58
SWEET POTATOES	0	0	.
BEANS	3	3	-2.58
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	2	2	-2.58
TOMATOES	2	2	-2.58
WATERMELONS	1	1	-2.58
OTHER VEGETABLES	5	5	-2.58
BERRIES	0	0	.
APPLES	13	13	-2.58
PEACHES	3	3	-2.58
GRAPES	0	0	.
NURSERY PRODUCTS	3	3	-2.58

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: STAFFORD COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	173,510	173,510	--
REAL FARMLAND VALUE ^b	1638.47	1727.61	5.44
CROPLAND ^a	16,029	15,247	-4.88
HARVESTED CROPLAND ^a	9,716	9,026	-7.10
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	10,210	9,484	-7.10
CORN	3,119	2,897	-7.10
SORGHUM	0	0	.
SMALL GRAINS	1,746	1,622	-7.10
SOYBEANS	1,863	1,731	-7.10
ALFALFA HAY	325	302	-7.10
OTHER HAY	3,135	2,913	-7.10
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	1	1	-7.10
SWEET POTATOES	0	0	.
BEANS	0	0	-7.10
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	4	4	-7.10
TOMATOES	0	0	.
WATERMELONS	0	0	.
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	1	1	-7.10
PEACHES	0	0	-7.10
GRAPES	4	4	-7.10
NURSERY PRODUCTS	10	9	-7.10

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: SURRY COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	180,057	180,057	--
REAL FARMLAND VALUE ^b	1003.73	1034.66	3.08
CROPLAND ^a	34,929	34,332	-1.71
HARVESTED CROPLAND ^a	28,694	28,167	-1.84
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	30,859	30,292	-1.84
CORN	9,514	9,339	-1.84
SORGHUM	281	275	-1.84
SMALL GRAINS	4,176	4,100	-1.84
SOYBEANS	9,491	9,317	-1.84
ALFALFA HAY	0	0	.
OTHER HAY	247	243	-1.84
PEANUTS	7,123	6,992	-1.84
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	2	2	-1.84
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	4	4	-1.84
TOMATOES	0	0	.
WATERMELONS	21	20	-1.84
OTHER VEGATALES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	0	0	.
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: WESTMORELAND COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	145,049	145,049	--
REAL FARMLAND VALUE ^b	1255.77	1288.95	2.64
CROPLAND ^a	36,616	36,012	-1.65
HARVESTED CROPLAND ^a	32,901	32,368	-1.62
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	40,168	39,517	-1.62
CORN	11,643	11,454	-1.62
SORGHUM	18	17	-1.62
SMALL GRAINS	10,895	10,718	-1.62
SOYBEANS	15,342	15,093	-1.62
ALFALFA HAY	137	135	-1.62
OTHER HAY	962	946	-1.62
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	6	6	-1.62
SWEET POTATOES	4	4	-1.62
BEANS	196	193	-1.62
COLE CROPS	10	10	-1.62
CUCUMBERS	7	7	-1.62
MUSKMELONS	42	42	-1.62
LETTUCE	4	4	-1.62
PEPPERS	4	4	-1.62
PUMPKINS	1	1	-1.62
SPINACH	2	2	-1.62
SUMMER SQUASH	47	46	-1.62
SWEET CORN	78	77	-1.62
TOMATOES	134	131	-1.62
WATERMELONS	27	26	-1.62
OTHER VEGETABLES	0	0	.
BERRIES	12	12	-1.62
APPLES	9	9	-1.62
PEACHES	5	5	-1.62
GRAPES	40	39	-1.62
NURSERY PRODUCTS	543	534	-1.62

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: YORK COUNTY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	157,900	157,900	--
REAL FARMLAND VALUE ^b	4145.81	4287.20	3.41
CROPLAND ^a	0	0	.
HARVESTED CROPLAND ^a	0	0	.
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	0	0	.
CORN	0	0	.
SORGHUM	0	0	.
SMALL GRAINS	0	0	.
SOYBEANS	0	0	.
ALFALFA HAY	0	0	.
OTHER HAY	0	0	.
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	0	0	.
BEANS	0	0	.
COLE CROPS	0	0	.
CUCUMBERS	0	0	.
MUSKMELONS	0	0	.
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	0	0	.
SPINACH	0	0	.
SUMMER SQUASH	0	0	.
SWEET CORN	0	0	.
TOMATOES	0	0	.
WATERMELONS	0	0	.
OTHER VEGATABLES	0	0	.
BERRIES	0	0	.
APPLES	0	0	.
PEACHES	0	0	.
GRAPES	0	0	.
NURSERY PRODUCTS	0	0	.

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: CHESAPEAKE CITY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	270,656	270,656	- -
REAL FARMLAND VALUE ^b	2378.59	2840.52	19.42
CROPLAND ^a	46,171	44,202	-4.26
HARVESTED CROPLAND ^a	40,251	38,514	-4.32
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	48,056	45,982	-4.32
CORN	14,391	13,770	-4.32
SORGHUM	82	79	-4.32
SMALL GRAINS	8,641	8,268	-4.32
SOYBEANS	22,619	21,643	-4.32
ALFALFA HAY	107	103	-4.32
OTHER HAY	1,117	1,069	-4.32
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	0	0	.
SWEET POTATOES	2	2	-4.32
BEANS	69	66	-4.32
COLE CROPS	91	87	-4.32
CUCUMBERS	2	2	-4.32
MUSKMELONS	1	1	-4.32
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	1	1	-4.32
SPINACH	6	6	-4.32
SUMMER SQUASH	3	3	-4.32
SWEET CORN	186	177	-4.32
TOMATOES	3	3	-4.32
WATERMELONS	1	1	-4.32
OTHER VEGETABLES	3	3	-4.32
BERRIES	16	15	-4.32
APPLES	19	18	-4.32
PEACHES	14	13	-4.32
GRAPES	4	4	-4.32
NURSERY PRODUCTS	678	648	-4.32

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: SUFFOLK CITY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	261,868	261,868	--
REAL FARMLAND VALUE ^b	1421.44	1477.24	3.93
CROPLAND ^a	61,972	61,296	-1.09
HARVESTED CROPLAND ^a	54,193	53,597	-1.10
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	57,466	56,834	-1.10
CORN	20,045	19,824	-1.10
SORGHUM	0	0	.
SMALL GRAINS	5,488	5,427	-1.10
SOYBEANS	17,578	17,384	-1.10
ALFALFA HAY	19	19	-1.10
OTHER HAY	606	599	-1.10
PEANUTS	13,075	12,931	-1.10
TOBACCO	27	27	-1.10
IRISH POTATOES	1	1	-1.10
SWEET POTATOES	9	9	-1.10
BEANS	59	59	-1.10
COLE CROPS	180	179	-1.10
CUCUMBERS	3	3	-1.10
MUSKMELONS	2	2	-1.10
LETTUCE	0	0	.
PEPPERS	0	0	.
PUMPKINS	5	5	-1.10
SPINACH	144	143	-1.10
SUMMER SQUASH	0	0	.
SWEET CORN	67	66	-1.10
TOMATOES	6	6	-1.10
WATERMELONS	71	70	-1.10
OTHER VEGETABLES	0	0	.
BERRIES	4	4	-1.10
APPLES	2	2	-1.10
PEACHES	0	0	.
GRAPES	1	1	-1.10
NURSERY PRODUCTS	74	73	-1.10

TABLE E.1. AGRICULTURAL LAND USE SUMMARY: VIRGINIA BEACH CITY

	1990	2000	PERCENT CHANGE
TOTAL AREA ^a	163,795	163,795	--
REAL FARMLAND VALUE ^b	2918.35	3238.79	10.98
CROPLAND ^a	37,563	36,045	-4.04
HARVESTED CROPLAND ^a	32,656	31,316	-4.10
HARVESTED ACREAGE BY CROP ^a			
ALL CROPS	39,542	37,919	-4.10
CORN	10,915	10,467	-4.10
SORGHUM	0	0	.
SMALL GRAINS	9,740	9,340	-4.10
SOYBEANS	17,605	16,883	-4.10
ALFALFA HAY	0	0	.
OTHER HAY	380	364	-4.10
PEANUTS	0	0	.
TOBACCO	0	0	.
IRISH POTATOES	12	12	-4.10
SWEET POTATOES	10	10	-4.10
BEANS	88	85	-4.10
COLE CROPS	19	18	-4.10
CUCUMBERS	22	21	-4.10
MUSKMELONS	60	57	-4.10
LETTUCE	0	0	.
PEPPERS	1	1	-4.10
PUMPKINS	28	27	-4.10
SPINACH	8	7	-4.10
SUMMER SQUASH	5	5	-4.10
SWEET CORN	180	173	-4.10
TOMATOES	14	13	-4.10
WATERMELONS	9	9	-4.10
OTHER VEGATALES	3	2	-4.10
BERRIES	179	172	-4.10
APPLES	3	3	-4.10
PEACHES	13	12	-4.10
GRAPES	0	0	.
NURSERY PRODUCTS	249	239	-4.10

Notes:

1. Total Area, Cropland and Harvested Cropland are measured in acres.
2. Real farmland value is measured in 1982-1984 dollars per acre.

APPENDIX F

Pesticide Exposure Estimation and Risk Evaluation Results

Table F.1. Pesticide Exposure and Risk Summary for Counties, in Descending Order According to Pesticide Risk Score.

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
TIDEWATER TOTAL	1990	882	2,531	2,084	100.00
	2000	860	2,472	2,041	97.70
ISLE OF WIGHT	1990	54	242	185	10.90
	2000	53	239	183	10.79
SUFFOLK	1990	57	242	180	10.69
	2000	57	239	178	10.57
ACCOMACK	1990	82	249	327	8.97
	2000	81	247	325	8.90
SURRY	1990	31	129	95	5.64
	2000	30	126	93	5.54
HANOVER	1990	60	137	114	5.16
	2000	59	136	112	5.10
CHESAPEAKE	1990	48	129	81	5.05
	2000	46	124	78	4.83
NORTHAMPTON	1990	48	140	233	4.86
	2000	47	138	230	4.79
ESSEX	1990	42	106	66	4.05
	2000	41	105	65	3.99
VIRGINIA BEACH	1990	40	102	65	3.94
	2000	38	98	62	3.78
WESTMORELAND	1990	40	99	81	3.76
	2000	40	97	79	3.69
NORTHUMBERLAND	1990	39	99	72	3.75
	2000	38	97	71	3.68
KING WILLIAM	1990	35	93	59	3.63
	2000	34	91	58	3.57

Table F.1, continued

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
CAROLINE	1990	32	85	54	3.30
	2000	32	83	53	3.23
RICHMOND	1990	32	81	62	3.06
	2000	32	79	61	3.00
PRINCE GEORGE	1990	20	73	51	3.05
	2000	20	71	49	2.97
KING AND QUEEN	1990	28	70	46	2.76
	2000	27	69	45	2.70
GLOUCESTER	1990	20	57	36	2.26
	2000	19	55	35	2.18
LANCASTER	1990	20	54	42	2.06
	2000	20	52	41	1.99
SPOTSYLVANIA	1990	27	54	34	2.03
	2000	26	52	33	1.98
MIDDLESEX	1990	19	50	42	1.91
	2000	18	48	41	1.84
PRINCE WILLIAM	1990	23	38	25	1.41
	2000	22	36	24	1.34
CHARLES CITY	1990	14	36	22	1.36
	2000	13	34	21	1.30
KING GEORGE	1990	14	30	20	1.12
	2000	13	29	19	1.07
JAMES CITY	1990	11	28	20	1.12
	2000	11	26	19	1.03
NEW KENT	1990	10	27	19	1.06
	2000	10	25	17	0.99

Table F.1, continued

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
HENRICO	1990	11	26	17	1.01
	2000	10	24	16	0.94
MATHEWS	1990	7	21	13	0.82
	2000	7	19	12	0.75
STAFFORD	1990	10	20	12	0.73
	2000	9	18	12	0.68
CHESTERFIELD	1990	7	15	9	0.54
	2000	6	12	8	0.46
FAIRFAX	1990	0	.	.	.
	2000	0	.	.	.
YORK	1990	0	.	.	.
	2000	0	.	.	.

Table F.2. Pesticide Exposure and Risk Summary for Crops, in Descending Order According to Pesticide Risk Score.

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
ALL CROPS	1990	882	2,531	2,084	100.00
	2000	860	2,472	2,041	97.70
SOYBEANS	1990	342	1,177	636	44.32
	2000	334	1,148	620	43.23
CORN	1990	235	662	570	31.28
	2000	229	645	555	30.46
PEANUTS	1990	38	343	279	16.33
	2000	37	338	275	16.11
IRISH POTATOES	1990	15	76	34	2.32
	2000	15	75	33	2.30
SMALL GRAINS	1990	166	156	35	1.63
	2000	162	152	34	1.59
OTHER HAY	1990	54	39	12	0.59
	2000	52	38	12	0.57
CUCUMBERS	1990	4	11	6	0.48
	2000	4	11	6	0.47
ALFALFA HAY	1990	7	13	5	0.46
	2000	7	13	5	0.45
TOMATOES	1990	3	15	472	0.43
	2000	3	15	466	0.42
SWEET POTATOES	1990	2	4	5	0.35
	2000	2	4	5	0.35
BEANS	1990	5	13	8	0.35
	2000	5	13	8	0.34
SWEET CORN	1990	1	3	2	0.29
	2000	1	3	2	0.28

Table F.2, continued

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
APPLES	1990	0	2	6	0.26
	2000	0	2	5	0.25
PEACHES	1990	0	3	4	0.24
	2000	0	3	4	0.23
SORGHUM	1990	1	3	2	0.13
	2000	1	3	2	0.12
PEPPERS	1990	0	1	2	0.12
	2000	0	1	2	0.12
MUSKMELONS	1990	0	1	1	0.09
	2000	0	1	1	0.09
WATERMELONS	1990	1	2	1	0.08
	2000	1	2	1	0.08
COLE CROPS	1990	1	2	1	0.06
	2000	1	2	1	0.06
PUMPKINS	1990	0	1	1	0.06
	2000	0	1	1	0.06
SUMMER SQUASH	1990	0	0	1	0.04
	2000	0	0	1	0.03
TOBACCO	1990	0	1	0	0.03
	2000	0	1	0	0.03
SPINACH	1990	1	1	0	0.03
	2000	1	1	0	0.03
BERRIES	1990	0	0	1	0.03
	2000	0	0	1	0.03
GRAPES	1990	0	0	0	0.00
	2000	0	0	0	0.00

Table F.2, continued

COUNTY	YEAR	ACRES HARVESTED (000S)	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
LETTUCE	1990	0	0	0	0.00
	2000	0	0	0	0.00
OTHER VEGATABLES	1990	0	.	.	.
	2000	0	.	.	.
NURSERY PRODUCTS	1990	4	.	.	.
	2000	4	.	.	.

Table F.3. Pesticide Exposure and Risk Summary for Pesticides, In Descending Order According to Pesticide Risk Score.

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
ALL PESTICIDES	--	1990	2,531	2,084	100.00
		2000	2,472	2,041	97.70
FENAMIPHOS	I/N	1990	76	130	16.03
		2000	74	127	15.64
ALDICARB	I/N	1990	104	106	13.09
		2000	102	104	12.81
ALACHLOR	H	1990	213	242	9.95
		2000	208	237	9.71
ATRAZINE	H	1990	236	178	9.37
		2000	230	173	9.12
METOLACHLOR	H	1990	222	203	8.31
		2000	216	198	8.12
CARBOFURAN	I/N	1990	85	63	7.80
		2000	83	62	7.64
ETHOPROP	I/N	1990	42	57	4.53
		2000	41	56	4.42
FONOFOS	I	1990	15	25	3.89
		2000	15	24	3.80
LINURON	H	1990	210	63	3.34
		2000	205	62	3.26
SIMAZINE	H	1990	103	75	2.97
		2000	100	73	2.89
CHLORPYRIFOS	I	1990	68	47	2.89
		2000	66	46	2.82
CHLOROTHALONIL	F	1990	24	53	1.63
		2000	24	52	1.61

Table F.3, continued

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
CU. HYDROXIDE	F	1990	11	37	1.51
		2000	11	36	1.49
EPTC	H	1990	12	30	1.25
		2000	12	30	1.22
PERMETHRIN	I	1990	45	19	1.16
		2000	44	18	1.13
METHOMYL	I/N	1990	21	7	1.04
		2000	21	6	1.02
CARBARYL	I	1990	30	22	0.97
		2000	30	22	0.95
ACIFLUORFEN	H	1990	131	23	0.93
		2000	128	22	0.90
MALATHION	I	1990	69	48	0.85
		2000	67	47	0.83
METRIBUZIN	H	1990	71	12	0.64
		2000	69	12	0.62
TERBUFOS	I	1990	7	7	0.61
		2000	7	7	0.59
BENTAZON	H	1990	36	11	0.59
		2000	35	11	0.58
ENDOSULFAN	I	1990	8	4	0.53
		2000	8	4	0.52
DISULFOTON	I	1990	13	5	0.47
		2000	13	5	0.46
IPRODIONE	F	1990	15	15	0.45
		2000	15	15	0.44

Table F.3, continued

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
PENDIMETHALIN	H	1990	57	11	0.43
		2000	56	10	0.42
ORYZALIN	H	1990	51	19	0.42
		2000	50	19	0.41
2,4-DB	H	1990	80	13	0.38
		2000	78	13	0.37
PARAQUAT	H	1990	41	6	0.35
		2000	40	6	0.34
VERNOLATE	H	1990	11	12	0.34
		2000	11	11	0.34
PHORATE	I	1990	4	3	0.32
		2000	4	3	0.32
DICLOFOP-METHYL	H	1990	8	7	0.22
		2000	8	7	0.21
AZINPHOS-METHYL	I	1990	3	2	0.21
		2000	3	2	0.21
OXAMYL	I/N	1990	7	3	0.18
		2000	7	3	0.18
CHLORIMURON	H	1990	171	4	0.18
		2000	167	4	0.17
PETROLEUM OIL	I	1990	0	6	0.17
		2000	0	6	0.16
PROPARGITE	I	1990	3	4	0.16
		2000	3	4	0.16
MONOCROTOPHOS	I	1990	2	1	0.15
		2000	1	1	0.14

Table F.3, continued

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
DIMETHOATE	I	1990	10	3	0.13
		2000	10	3	0.13
PARATHION	I	1990	4	1	0.12
		2000	4	1	0.11
PHOSMET	I	1990	5	3	0.11
		2000	5	2	0.11
ETHALFLURALIN	H	1990	9	4	0.11
		2000	9	4	0.11
NAPROPAMIDE	H	1990	2	2	0.11
		2000	2	2	0.10
FLUAZIFOP-BUTYL	H	1990	34	3	0.11
		2000	33	3	0.10
ACEPHATE	I	1990	6	5	0.09
		2000	6	5	0.09
TERBACIL	H	1990	6	2	0.09
		2000	5	2	0.09
DICAMBA	H	1990	33	2	0.08
		2000	32	2	0.08
ESFENVALERATE	I	1990	21	1	0.08
		2000	20	1	0.08
BROMOXYNIL	H	1990	8	2	0.08
		2000	8	2	0.07
DIAZINON	I	1990	5	1	0.07
		2000	5	1	0.07
TRICHLORFON	I	1990	2	1	0.07
		2000	2	1	0.07

Table F.3, continued

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
BENEFIN	H	1990	4	2	0.06
		2000	4	2	0.06
BENSULIDE	H	1990	1	1	0.06
		2000	1	1	0.06
SETHOXYDIM	H	1990	37	3	0.05
		2000	36	3	0.05
CAPTAN/PCNB	F	1990	0	2	0.04
		2000	0	2	0.04
TRIFLURALIN	H	1990	4	1	0.04
		2000	4	1	0.04
NAPTALAM	H	1990	2	2	0.04
		2000	2	2	0.04
METALAXYL	F	1990	0	1	0.03
		2000	0	1	0.03
DICOFOL	I	1990	2	1	0.03
		2000	2	1	0.03
METHYL PARATHION	I	1990	0	0	0.02
		2000	0	0	0.02
CHLORAMBEN	H	1990	0	0	0.02
		2000	0	0	0.01
MEVINPHOS	I	1990	1	0	0.01
		2000	1	0	0.01
FORMETANATE	I	1990	0	0	0.01
		2000	0	0	0.01
THIAMETURON	H	1990	25	0	0.01
		2000	24	0	0.01

Table F.3, continued

ACTIVE INGREDIENT	ACTION ^b	YEAR	ACRES TREATED (000S)	EXPOSURE (TONS)	RISK SCORE
DICHLORBENIL	H	1990	0	0	0.01
		2000	0	0	0.01
CAPTAN	F	1990	1	1	0.01
		2000	1	1	0.01
GLYPHOSATE	H	1990	0	0	0.00
		2000	0	0	0.00
BENOMYL	F	1990	0	0	0.00
		2000	0	0	0.00
PEBULATE	H	1990	0	0	0.00
		2000	0	0	0.00
ISOPROPALIN	H	1990	0	0	0.00
		2000	0	0	0.00
BACILLUS THURIGIENSIS	I	1990	0	0	0.00
		2000	0	0	0.00
FENVALERATE	I	1990	0	0	0.00
		2000	0	0	0.00
TRIADIMEFON	F	1990	0	0	0.00
		2000	0	0	0.00
METHYL BROMIDE	FUM	1990	3	467	.
		2000	3	460	.
N/A		1990	.	.	.
		2000	.	.	.

a. Actions: F = fungicide; FUM = fumigant; H = herbicide;
I = insecticide; N = nematicide.

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	ALL COUNTIES	ACCOMACK	CAROLINE	CHARLES CITY
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	100.00	8.97	3.30	1.36
CROP				
CORN	31.28	1.02	1.26	0.56
SORGHUM	0.13	0.00	0.01	0.01
SMALL GRAINS	1.63	0.14	0.06	0.03
SOYBEANS	44.32	5.64	1.87	0.75
ALFALFA HAY	0.46	0.00	0.02	0.01
OTHER HAY	0.59	0.00	0.02	0.00
PEANUTS	16.33	.	.	.
TOBACCO	0.03	.	0.00	.
IRISH POTATOES	2.32	1.31	.	.
SWEET POTATOES	0.35	0.21	0.00	.
BEANS	0.35	0.13	0.00	.
COLE CROPS	0.06	0.01	0.00	.
CUCUMBERS	0.48	0.21	0.00	.
MUSKMELONS	0.09	0.00	0.00	.
LETTUCE	0.00	.	.	.
PEPPERS	0.12	0.02	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	ALL COUNTIES	ACCOMACK	CAROLINE	CHARLES CITY
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	0.06	0.00	.	.
SPINACH	0.03	0.02	.	.
SUMMER SQUASH	0.04	0.01	0.00	.
SWEET CORN	0.29	0.01	0.01	.
TOMATOES	0.43	0.18	0.00	.
WATERMELONS	0.08	0.01	0.00	.
OTHER VEGATABLES	.	.	.	.
BERRIES	0.03	0.00	.	.
APPLES	0.26	0.00	0.05	.
PEACHES	0.24	0.04	0.00	.
GRAPES	0.00	0.00	0.00	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	CHESTERFIELD	ESSEX	FAIRFAX	GLOUCESTER
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.54	4.05	.	2.26
CROP				
CORN	0.09	1.63	.	0.88
SORGHUM	0.01	.	.	.
SMALL GRAINS	0.01	0.11	.	0.02
SOYBEANS	0.35	2.30	.	1.31
ALFALFA HAY	0.00	0.00	.	0.02
OTHER HAY	0.02	0.01	.	0.01
PEANUTS	.	.	.	.
TOBACCO	0.02	0.00	.	.
IRISH POTATOES	0.00	0.00	.	.
SWEET POTATOES	0.00	.	.	0.00
BEANS	0.00	0.00	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	CHESTERFIELD	ESSEX	FAIRFAX	GLOUCESTER
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	0.00	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	0.00	0.00	.	0.00
TOMATOES	0.00	0.00	.	.
WATERMELONS	.	0.00	.	0.00
OTHER VEGETABLES	.	.	.	.
BERRIES	0.00	.	.	0.00
APPLES	0.02	0.00	.	0.01
PEACHES	0.01	0.00	.	0.01
GRAPES	0.00	0.00	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	HANOVER	HENRICO	ISLE OF WIGHT	JAMES CITY
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	5.16	1.01	10.90	1.12
CROP				
CORN	1.84	0.41	2.73	0.34
SORGHUM	0.03	.	0.01	.
SMALL GRAINS	0.10	0.02	0.05	0.02
SOYBEANS	2.66	0.55	1.66	0.62
ALFALFA HAY	0.11	0.01	.	0.01
OTHER HAY	0.12	0.01	0.00	0.01
PEANUTS	.	.	6.41	.
TOBACCO	0.00	.	.	.
IRISH POTATOES	0.04	0.00	.	0.00
SWEET POTATOES	0.01	.	0.00	0.00
BEANS	0.01	0.00	0.00	0.00
COLE CROPS	0.02	.	0.00	.
CUCUMBERS	0.00	0.00	.	0.00
MUSKMELONS	0.04	0.00	0.00	0.01
LETTUCE	.	.	.	.
PEPPERS	0.01	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

CROP	COUNTY			
	HANOVER	HENRICO	ISLE OF WIGHT	JAMES CITY
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
PUMPKINS	0.02	0.00	.	0.02
SPINACH	0.01	0.00	.	.
SUMMER SQUASH	0.01	0.00	.	0.00
SWEET CORN	0.04	0.00	0.00	0.02
TOMATOES	0.03	0.00	.	0.00
WATERMELONS	0.03	0.00	0.00	0.01
OTHER VEGETABLES	.	.	.	.
BERRIES	0.00	0.00	.	0.00
APPLES	0.01	0.00	.	0.04
PEACHES	0.02	0.00	0.03	0.01
GRAPES	0.00	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	KING AND QUEEN	KING GEORGE	KING WILLIAM	LANCASTER
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	2.76	1.12	3.63	2.06
CROP				
CORN	1.40	0.56	1.50	0.79
SORGHUM	0.00	.	.	.
SMALL GRAINS	0.07	0.04	0.07	0.05
SOYBEANS	1.25	0.47	1.97	1.21
ALFALFA HAY	0.00	0.01	0.02	0.00
OTHER HAY	0.01	0.02	0.01	0.00
PEANUTS	.	.	.	.
TOBACCO	0.00	.	.	.
IRISH POTATOES	0.00	0.00	.	.
SWEET POTATOES	0.00	.	.	.
BEANS	0.00	0.00	.	0.00
COLE CROPS	0.00	.	.	.
CUCUMBERS	0.00	0.00	.	.
MUSKMELONS	0.00	0.00	0.00	0.00
LETTUCE	.	.	.	.
PEPPERS	.	0.00	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	KING AND QUEEN	KING GEORGE	KING WILLIAM	LANCASTER
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	0.00	.	.	.
SUMMER SQUASH	0.00	0.00	.	.
SWEET CORN	0.02	0.00	0.00	0.00
TOMATOES	0.00	0.00	0.00	0.01
WATERMELONS	0.00	0.00	0.00	.
OTHER VEGATALES	.	.	.	.
BERRIES	.	0.00	.	.
APPLES	0.00	0.01	0.03	.
PEACHES	0.01	0.00	0.02	0.00
GRAPES	.	0.00	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	MATHEWS	MIDDLESEX	NEW KENT	NORTHAMPTON
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.82	1.91	1.06	4.86
CROP				
CORN	0.30	0.67	0.44	0.08
SORGHUM	.	0.00	.	.
SMALL GRAINS	0.01	0.04	0.02	0.12
SOYBEANS	0.50	1.14	0.56	2.78
ALFALFA HAY	.	0.01	0.00	0.00
OTHER HAY	0.00	0.01	0.00	0.00
PEANUTS	.	.	.	0.03
TOBACCO	.	.	.	.
IRISH POTATOES	.	.	0.00	0.96
SWEET POTATOES	.	.	.	0.13
BEANS	.	.	.	0.17
COLE CROPS	.	.	.	0.00
CUCUMBERS	.	.	0.00	0.26
MUSKMELONS	.	.	0.00	0.00
LETTUCE	.	.	.	.
PEPPERS	.	.	.	0.09

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	MATHEWS	MIDDLESEX	NEW KENT	NORTHAMPTON
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	0.01	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	0.02
SWEET CORN	.	0.00	0.00	0.02
TOMATOES	.	0.01	0.00	0.15
WATERMELONS	.	.	0.00	0.00
OTHER VEGATALES	.	.	.	.
BERRIES	0.00	.	.	0.00
APPLES	0.00	0.00	.	0.01
PEACHES	0.00	0.02	0.00	0.02
GRAPES	0.00	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	NORTHUMBERL- AND	PRINCE GEORGE	PRINCE WILLIAM	RICHMOND
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	3.75	3.05	1.41	3.06
CROP				
CORN	1.50	0.62	1.07	1.22
SORGHUM	.	0.00	.	.
SMALL GRAINS	0.11	0.02	0.02	0.09
SOYBEANS	2.11	1.13	0.13	1.71
ALFALFA HAY	0.00	0.02	0.03	0.00
OTHER HAY	0.00	0.01	0.12	0.01
PEANUTS	.	1.21	.	.
TOBACCO	.	0.00	.	0.00
IRISH POTATOES	.	0.00	.	.
SWEET POTATOES	0.00	0.00	.	0.00
BEANS	.	0.00	0.00	0.00
COLE CROPS	.	0.00	.	.
CUCUMBERS	0.00	0.00	0.00	.
MUSKMELONS	.	0.00	.	0.00
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	NORTHUMBERL- AND	PRINCE GEORGE	PRINCE WILLIAM	RICHMOND
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	0.00	.	.
SPINACH	.	0.00	.	.
SUMMER SQUASH	.	.	.	0.00
SWEET CORN	0.00	0.01	0.01	0.01
TOMATOES	0.01	0.00	0.00	0.01
WATERMELONS	.	0.00	0.00	.
OTHER VEGATALES	.	.	.	.
BERRIES	.	0.00	0.00	.
APPLES	0.00	0.00	0.01	.
PEACHES	0.01	0.00	0.00	.
GRAPES	0.00	0.00	0.00	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	SPOTSYLVANIA	STAFFORD	SURRY	WESTMORELAND
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	2.03	0.73	5.64	3.76
CROP				
CORN	1.09	0.42	1.27	1.55
SORGHUM	.	.	0.04	0.00
SMALL GRAINS	0.03	0.02	0.04	0.11
SOYBEANS	0.69	0.24	1.23	1.99
ALFALFA HAY	0.10	0.02	.	0.01
OTHER HAY	0.10	0.03	0.00	0.01
PEANUTS	.	.	3.06	.
TOBACCO	.	.	.	.
IRISH POTATOES	0.00	0.00	.	0.00
SWEET POTATOES	.	.	0.00	0.00
BEANS	0.00	0.00	.	0.01
COLE CROPS	.	.	.	0.00
CUCUMBERS	.	.	.	0.00
MUSKMELONS	.	.	.	0.01
LETTUCE	.	.	.	0.00
PEPPERS	.	.	.	0.00

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

CROP	COUNTY			
	SPOTSYLVANIA	STAFFORD	SURRY	WESTMORELAND
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
PUMPKINS	.	.	.	0.00
SPINACH	.	.	.	0.00
SUMMER SQUASH	.	.	.	0.00
SWEET CORN	0.00	0.00	0.00	0.02
TOMATOES	0.00	.	.	0.02
WATERMELONS	0.00	.	0.00	0.00
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	0.00
APPLES	0.01	0.00	.	0.01
PEACHES	0.00	0.00	.	0.00
GRAPES	.	0.00	.	0.00
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	YORK	CHESAPEAKE	SUFFOLK	VIRGINIA BEACH
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	.	5.05	10.69	3.94
CROP				
CORN	.	1.92	2.67	1.45
SORGHUM	.	0.01	.	.
SMALL GRAINS	.	0.08	0.05	0.10
SOYBEANS	.	2.93	2.28	2.28
ALFALFA HAY	.	0.01	0.00	.
OTHER HAY	.	0.01	0.01	0.00
PEANUTS	.	.	5.62	.
TOBACCO	.	.	0.00	.
IRISH POTATOES	.	.	0.00	0.00
SWEET POTATOES	.	0.00	0.00	0.00
BEANS	.	0.00	0.00	0.01
COLE CROPS	.	0.01	0.02	0.00
CUCUMBERS	.	0.00	0.00	0.00
MUSKMELONS	.	0.00	0.00	0.01
LETTUCE	.	.	.	.
PEPPERS	.	.	.	0.00

(CONTINUED)

TABLE F.4. PESTICIDE RISK SCORES, BY CROP AND COUNTY, 1990

	COUNTY			
	YORK	CHESAPEAKE	SUFFOLK	VIRGINIA BEACH
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	0.00	0.00	0.01
SPINACH	.	0.00	0.01	0.00
SUMMER SQUASH	.	0.00	.	0.00
SWEET CORN	.	0.04	0.02	0.04
TOMATOES	.	0.00	0.00	0.00
WATERMELONS	.	0.00	0.01	0.00
OTHER VEGATALES	.	.	.	.
BERRIES	.	0.00	0.00	0.02
APPLES	.	0.02	0.00	0.00
PEACHES	.	0.01	.	0.01
GRAPES	.	0.00	0.00	.
NURSERY PRODUCTS	.	.	.	.

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ALL ACTIVE INGREDIENTS	ACTIVE INGREDIENT		
		ACEPHATE	AZINPHOS- METHYL	BACILLUS THURIGIENSIS
		RISK SCORE	RISK SCORE	RISK SCORE
		TOTAL	TOTAL	TOTAL
ALL CROPS	100.00	0.09	0.21	0.00
CROP				
CORN	31.28	.	.	.
SORGHUM	0.13	.	.	.
SMALL GRAINS	1.63	.	.	.
SOYBEANS	44.32	.	.	.
ALFALFA HAY	0.46	.	.	.
OTHER HAY	0.59	.	.	.
PEANUTS	16.33	0.01	.	.
TOBACCO	0.03	0.00	.	0.00
IRISH POTATOES	2.32	.	.	.
SWEET POTATOES	0.35	.	.	.
BEANS	0.35	0.07	.	.
COLE CROPS	0.06	.	.	.
CUCUMBERS	0.48	.	0.05	.
MUSKMELONS	0.09	.	0.00	.
LETTUCE	0.00	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ALL ACTIVE INGREDIENTS	ACTIVE INGREDIENT		
		ACEPHATE	AZINPHOS- METHYL	BACILLUS THURIGIENSIS
		RISK SCORE	RISK SCORE	RISK SCORE
		TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	0.12	0.01	.	.
PUMPKINS	0.06	.	.	.
SPINACH	0.03	.	.	.
SUMMER SQUASH	0.04	.	.	.
SWEET CORN	0.29	.	.	.
TOMATOES	0.43	.	0.13	.
WATERMELONS	0.08	.	.	.
OTHER VEGATALES	.	.	.	.
BERRIES	0.03	.	.	.
APPLES	0.26	.	0.00	.
PEACHES	0.24	.	0.02	.
GRAPES	0.00	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	CARBARYL	CHLORPYRIFOS	DIAZINON	DICOFOL
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.97	2.89	0.07	0.03
CROP				
CORN	0.08	1.92	0.07	.
SORGHUM	0.00	0.01	0.00	.
SMALL GRAINS	0.07	.	.	.
SOYBEANS	0.60	.	.	.
ALFALFA HAY	.	0.15	.	.
OTHER HAY	.	.	.	.
PEANUTS	0.08	0.78	.	.
TOBACCO	0.00	0.00	0.00	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	0.02	.	.	.
BEANS	0.06	.	.	.
COLE CROPS	.	0.00	.	.
CUCUMBERS	0.02	.	.	0.02
MUSKMELONS	.	.	.	.
LETTUCE	.	.	0.00	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	CARBARYL	CHLORPYRIFOS	DIAZINON	DICOFOL
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	0.01	.	.	0.00
OTHER VEGETABLES	.	.	.	.
BERRIES	.	0.01	.	.
APPLES	0.01	0.01	.	0.00
PEACHES	0.01	0.02	.	0.00
GRAPES	0.00	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	DIMETHOATE	DISULFOTON	ENDOSULFAN	ESFENVALERA- TE
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.13	0.47	0.53	0.08
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	0.06	0.33	.	.
SOYBEANS	0.04	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	0.14	.	0.00
TOBACCO	.	0.00	0.00	.
IRISH POTATOES	.	.	0.10	0.06
SWEET POTATOES	.	.	0.03	.
BEANS	0.02	.	.	0.00
COLE CROPS	0.00	.	0.01	0.00
CUCUMBERS	.	.	0.15	0.00
MUSKMELONS	.	.	0.04	0.00
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	DIMETHOATE	DISULFOTON	ENDOSULFAN	ESFENVALERA- TE
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	0.00
PUMPKINS	.	.	0.03	.
SPINACH	0.01	.	.	.
SUMMER SQUASH	.	.	0.02	.
SWEET CORN	.	.	.	0.00
TOMATOES	.	.	0.10	0.01
WATERMELONS	0.00	.	0.02	0.00
OTHER VEGATALES	.	.	.	.
BERRIES	.	.	.	.
APPLES	0.00	.	0.01	0.00
PEACHES	.	.	0.02	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	FENVALERATE	FONOFOS	FORMETANATE	MALATHION
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.00	3.89	0.01	0.85
CROP				
CORN	.	2.98	.	0.02
SORGHUM	.	0.01	.	0.00
SMALL GRAINS	.	.	.	0.07
SOYBEANS	.	.	.	0.76
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	0.90	.	.
TOBACCO	.	0.00	.	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	FENVALERATE	FONOFOS	FORMETANATE	MALATHION
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	.	0.01	.
PEACHES	0.00	.	0.01	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	METHYL PARATHION	MEVINPHOS	MONOCROTOPH- OS	PARATHION
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.02	0.01	0.15	0.12
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	.	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	.	0.15	.
TOBACCO	0.00	.	.	.
IRISH POTATOES	.	.	.	0.07
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	0.00	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	METHYL PARATHION	MEVINPHOS	MONOCROTOPH- OS	PARATHION
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	.	.
SPINACH	.	0.01	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	0.02	.	.	0.00
PEACHES	0.00	.	.	0.04
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	PERMETHRIN	PHORATE	PHOSMET	PROPARGITE
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	1.16	0.32	0.11	0.16
CROP				
CORN	0.90	.	.	.
SORGHUM	0.00	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	.	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	0.32	.	0.15
TOBACCO	.	.	.	.
IRISH POTATOES	0.23	.	0.10	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	0.00	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	0.00	.	.	.
LETTUCE	0.00	.	.	.
PEPPERS	0.01	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	PERMETHRIN	PHORATE	PHOSMET	PROPARGITE
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	0.00	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	0.01	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	0.00	.	0.01	0.00
PEACHES	0.00	.	0.01	0.00
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	PETROLEUM OIL	TERBUFOS	TRICHLORFON	ALDICARB
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.17	0.61	0.07	13.09
CROP				
CORN	.	0.60	0.07	.
SORGHUM	.	0.00	0.00	.
SMALL GRAINS	.	.	.	.
SOYBEANS	.	.	.	9.48
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	.	.	3.15
TOBACCO	.	.	.	0.01
IRISH POTATOES	.	.	.	0.45
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	PETROLEUM OIL	TERBUFOS	TRICHLORFON	ALDICARB
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGATALES	.	.	.	.
BERRIES	.	.	.	.
APPLES	0.11	.	.	.
PEACHES	0.06	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	CARBOFURAN	ETHOPROP	FENAMIPHOS	METHOMYL
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	7.80	4.53	16.03	1.04
CROP				
CORN	2.80	0.93	.	0.14
SORGHUM	0.01	0.00	.	0.00
SMALL GRAINS	0.05	.	.	0.35
SOYBEANS	1.11	3.25	15.17	.
ALFALFA HAY	0.31	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	2.62	0.07	0.86	.
TOBACCO	0.01	0.00	.	0.00
IRISH POTATOES	0.54	.	.	.
SWEET POTATOES	.	0.27	.	.
BEANS	.	.	.	0.16
COLE CROPS	.	.	.	0.02
CUCUMBERS	0.12	.	.	0.06
MUSKMELONS	0.03	.	.	0.00
LETTUCE	.	.	.	.
PEPPERS	0.08	.	.	0.00

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	CARBOFURAN	ETHOPROP	FENAMIPHOS	METHOMYL
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	0.02	.	.	.
SPINACH	.	.	.	0.01
SUMMER SQUASH	.	.	.	.
SWEET CORN	0.09	.	.	0.15
TOMATOES	.	.	.	0.07
WATERMELONS	.	.	.	0.01
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	.	.	0.05
PEACHES	.	.	.	0.01
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	OXAMYL	2,4-DB	ACIFLUORFEN	ALACHLOR
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.18	0.38	0.93	9.95
CROP				
CORN	.	.	.	3.62
SORGHUM	.	.	.	0.01
SMALL GRAINS	.	0.30	.	.
SOYBEANS	.	.	0.78	4.92
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	0.07	0.15	1.40
TOBACCO	.	.	.	.
IRISH POTATOES	0.16	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	OXAMYL	2,4-DB	ACIFLUORFEN	ALACHLOR
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	0.02	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	0.00	0.00	.	.
PEACHES	.	0.00	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	ATRAZINE	BENEFIN	BENSULIDE	BENTAZON
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	9.37	0.06	0.06	0.59
CROP				
CORN	9.30	.	.	.
SORGHUM	0.04	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	.	.	.	0.34
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	0.06	.	0.25
TOBACCO	.	0.00	.	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	0.02	.
MUSKMELONS	.	.	0.01	.
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

CROP	ACTIVE INGREDIENT			
	ATRAZINE	BENEFIN	BENSULIDE	BENTAZON
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	0.03	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	0.02	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	.	.	.
PEACHES	.	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	BROMOXYNIL	CHLORAMBEN	CHLORIMURON	DICAMBA
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.08	0.02	0.18	0.08
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	0.08	.	.	0.08
SOYBEANS	.	.	0.18	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	.	.	.
TOBACCO	.	.	.	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	BROMOXYNIL	CHLORAMBEN	CHLORIMURON	DICAMBA
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	0.01	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	0.01	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	.	.	.
PEACHES	.	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	DICHLOBENIL	DICLOFOP- METHYL	EPTC	ETHALFLURAL- IN
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.01	0.22	1.25	0.11
CROP				
CORN	.	.	1.21	.
SORGHUM	.	.	0.00	.
SMALL GRAINS	.	0.22	.	.
SOYBEANS	.	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	.	.	0.11
TOBACCO	.	.	.	.
IRISH POTATOES	.	.	0.04	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	DICHLOROBENIL	DICLOFOP-METHYL	EPTC	ETHALFLURAL-IN
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	0.00	.	.	.
PEACHES	0.00	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	FLUAZIFOP- BUTYL	GLYPHOSATE	ISOPROPALIN	LINURON
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.11	0.00	0.00	3.34
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	0.11	.	.	3.25
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	.	.	.
TOBACCO	.	.	0.00	.
IRISH POTATOES	.	.	.	0.09
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	FLUAZIFOP- BUTYL	GLYPHOSATE	ISOPROPALIN	LINURON
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGATALES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	0.00	.	.
PEACHES	.	0.00	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	METOLACHLOR	METRIBUZIN	NAPROPAMIDE	NAPTALAM
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	8.31	0.64	0.11	0.04
CROP				
CORN	3.86	.	.	.
SORGHUM	0.02	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	3.16	0.41	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	0.09	.	.
PEANUTS	0.94	.	.	.
TOBACCO	.	.	0.00	.
IRISH POTATOES	0.34	0.13	.	.
SWEET POTATOES	.	.	0.03	.
BEANS	.	.	.	.
COLE CROPS	.	.	0.02	.
CUCUMBERS	.	.	.	0.03
MUSKMELONS	.	.	.	0.00
LETTUCE	.	.	0.00	.
PEPPERS	.	.	0.03	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	METOLACHLOR	METRIBUZIN	NAPROPAMIDE	NAPTALAM
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	0.02	0.01	.
WATERMELONS	.	.	.	0.00
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	0.02	.
APPLES	.	.	.	.
PEACHES	.	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	ORYZALIN	PARAQUAT	PEBULATE	PENDIMETHAL- IN
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.42	0.35	0.00	0.43
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	0.42	.	.	0.32
ALFALFA HAY	.	.	.	.
OTHER HAY	.	0.25	.	.
PEANUTS	.	0.09	.	0.12
TOBACCO	.	.	0.00	0.00
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	ORYZALIN	PARAQUAT	PEBULATE	PENDIMETHAL- IN
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	0.01	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	0.00	.	.
PEACHES	.	0.00	.	.
GRAPES	0.00	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	SETHOXYDIM	SIMAZINE	TERBACIL	TRIFLURALIN
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.05	2.97	0.09	0.04
CROP				
CORN	.	2.79	.	.
SORGHUM	.	0.01	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	0.05	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	0.01	0.16	0.09	.
PEANUTS	.	.	.	.
TOBACCO	.	.	.	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	0.03
COLE CROPS	.	.	.	0.00
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	0.00
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	SETHOXYDIM	SIMAZINE	TERBACIL	TRIFLURALIN
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	0.01
WATERMELONS	.	.	.	.
OTHER VEGATALES	.	.	.	.
BERRIES	.	.	0.00	.
APPLES	.	0.00	.	.
PEACHES	.	0.01	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	VERNOLATE	THIAMETURON	METHYL BROMIDE	BENOMYL
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.34	0.01	.	0.00
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	.	0.01	.	.
SOYBEANS	.	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	0.34	.	.	.
TOBACCO	.	.	.	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	.	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	VERNOLATE	THIAMETURON	METHYL BROMIDE	BENOMYL
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	.	0.00
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	.	.
WATERMELONS	.	.	.	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	0.00
APPLES	.	.	.	.
PEACHES	.	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	CAPTAN	CAPTAN/PCNB	CHLOROTHALO- NIL	CU. HYDROXIDE
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.01	0.04	1.63	1.51
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	.	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	.	0.04	1.58	1.51
TOBACCO	.	.	.	.
IRISH POTATOES	0.01	.	0.01	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	0.00	.
COLE CROPS	.	.	0.00	.
CUCUMBERS	.	.	0.00	.
MUSKMELONS	.	.	0.00	.
LETTUCE	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	CAPTAN	CAPTAN/PCNB	CHLOROTHALO- NIL	CU. HYDROXIDE
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PEPPERS	.	.	.	.
PUMPKINS	.	.	0.00	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	0.00	.
SWEET CORN	.	.	.	.
TOMATOES	.	.	0.03	.
WATERMELONS	.	.	0.01	.
OTHER VEGETABLES	.	.	.	.
BERRIES	0.00	.	.	.
APPLES	.	.	.	.
PEACHES	.	.	.	.
GRAPES	0.00	.	.	.
NURSERY PRODUCTS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	IPRODIONE	METALAXYL	TRIADIMEFON	N/A
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
ALL CROPS	0.45	0.03	0.00	.
CROP				
CORN	.	.	.	.
SORGHUM	.	.	.	.
SMALL GRAINS	.	.	.	.
SOYBEANS	.	.	.	.
ALFALFA HAY	.	.	.	.
OTHER HAY	.	.	.	.
PEANUTS	0.45	.	.	.
TOBACCO	.	0.00	.	.
IRISH POTATOES	.	.	.	.
SWEET POTATOES	.	.	.	.
BEANS	.	.	.	.
COLE CROPS	.	.	.	.
CUCUMBERS	.	.	.	.
MUSKMELONS	.	.	0.00	.
LETTUCE	.	.	.	.
PEPPERS	.	.	.	.

(CONTINUED)

TABLE F.5. PESTICIDE RISK SCORES,
BY CROP AND ACTIVE INGREDIENT, 1990

	ACTIVE INGREDIENT			
	I-PRODIONE	METALAXYL	TRIADIMEFON	N/A
	RISK SCORE	RISK SCORE	RISK SCORE	RISK SCORE
	TOTAL	TOTAL	TOTAL	TOTAL
CROP				
PUMPKINS	.	.	.	.
SPINACH	.	.	.	.
SUMMER SQUASH	.	.	.	.
SWEET CORN	.	.	.	.
TOMATOES	.	0.03	.	.
WATERMELONS	.	.	0.00	.
OTHER VEGETABLES	.	.	.	.
BERRIES	.	.	.	.
APPLES	.	.	.	.
PEACHES	.	.	.	.
GRAPES	.	.	.	.
NURSERY PRODUCTS	.	.	.	.

VITA

Spencer R. Phillips was born on October 26, 1963 in Reading, Pennsylvania to Claire Ann and Robert David Phillips Jr. He attended the University of Virginia, from which he received a B.A. in economics in 1985. In June, 1985, Mr. Phillips began a one year appointment as a research analyst in the Antitrust Division of the Bureau of Economics at the Federal Trade Commission. From July, 1986 through December, 1987, he worked as a research assistant at Pracon Incorporated's Center for Economic Studies in Medicine, in Reston, Virginia. Mr. Phillips advanced to the position of project analyst, as which he worked until August, 1988. Since then, Mr. Phillips has been employed as a graduate research assistant in the department of agricultural economics. During this period, he has also worked as a consultant for Resources for the Future in Washington, DC.

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