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Determinants of Farm Size and Structure

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Boehlje/Alternative Models of Structural Change in Agriculture and Related Industries

Hornbaker and Denault/Recent Changes in Size and Structure of North Central Agriculture: A Study of Selected States in the North Central Region

Ahearn, Whittaker and Glaze/Cost Distribution and Efficiency of Corn Production

Atwood and Hallam/Farm Structure and Stewardship of the Environment

Casler/Firm Level Agricultural Data Collected and Managed at the State Level

Carlin and Saupe/Structural Change in Agriculture and Its Relationship to Rural Communities and Rural Life

Tweeten/Government Commodity Program Impacts on Farm Numbers

Helmets, Watts, Smith and Atwood/The Impact of Income Taxes on Resource Allocation and Structure of Agriculture

Cooke and Sundquist/Scale Economies, Technical Change, and Competitive Advantage in U.S. Soybean Production

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FARM STRUCTURE AND STEWARDSHIP OF THE ENVIRONMENT*

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1. Introduction

Agricultural structure is linked to environmental outcomes through the impacts of the production technologies associated with the structure. Coincidentally, environmental (and agricultural) policies impact the structure of agriculture through their effects on the profitability of alternative production technologies. Some types of structure change the decision environment and affect the choice of production practices. Some aspects of structure are the result of the choice of practices. Therefore, a set of two-way causal relationships exist between the state of the environment, the chosen mix of environmental and agricultural policy, and the structure of agriculture. Or, where causal relationships may not exist, associations are at least apparent.

The current political climate for agriculture includes a mix of intertwined agricultural and environmental policies (for example, the conservation compliance provisions of the 1985 Food Security Act (Glaser, 1986)). Recent agricultural income and commodity policies have been blamed for adverse impacts on the environment (American Farmland Trust, 1990; Osteen, 1985; and Reichelderfer and Phipps, 1988). The treadmill theory of Cochrane (1979) provides a direct positive link between income and commodity policies and farm size. Hence, it seems that direct links between farm structure and the environment might exist.

The 1980's agriculture finance crisis has increased the rate of farm failures and the turnover of asset ownership. At the same time the perceived agricultural damage to the environment has greatly increased. To some extent the political forces for environmental regulation have also endorsed the "small farm" aspect of agricultural structure (Center for Rural Affairs; The Land Stewardship Project). As farms grow they typically become subject to more stringent existing regulations, for instance, large feedlots must meet industrial waste management standards.

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The desire for increased environmental regulation of agriculture is increasing both from within and from outside the sector (American Farmland Trust, 1990; Batie, 1988; Benbrook, 1989; Reichelderfer and Phipps, 1988). Batie (1988) explains that much of the agricultural policy agenda is now controlled by non-agricultural interests for the following reason. Agriculture is increasingly perceived as a problem rather than a solution, particularly with regard to environmental problems. The rights traditionally associated with cultivating the soil are giving way to restraints.

Clearly, concern over the environment and over the health of the agricultural sector is leading to increased environmental regulation. Despite some lobbyists inferring a direct link, the cause and effect relationship between the structure of farming and the perceived environmental damage is not readily apparent. In this paper some possible links between changes in agricultural structure and qualitative aspects of the environment are suggested. Though empirical data to support the proposed links are lacking, some reasoning and available studies are used to suggest relevant policy issues and some possible areas of further study.

2. A Conceptual Model of Policy, Farm Structure and Environmental Impacts

A conceptual model illustrating the two way relationships (or at least associations) between agricultural and environmental policy, farm structure and environmental impacts is shown in Figure 1. Different structures of farming are associated with different choices of production methods. Various production methods result in more or less environmental damage. Policies addressing the perceived environmental damage impact the profitability of different production methods and the overhead cost of farming. Different farm structures fare better or worse as overhead costs and relative production technology profitability changes. These links, or associations, indicated by arrows in Figure 1, are carefully defined in this section of the paper. The remainder of the paper gives detail and reviews existing studies relative to this model.

Structure's Link to Production Practice Choice

Different farm structures have access to different production technology choices or else face differing relative profit levels for the same choices. Different practices may result in more or less environmental damage per unit of resource. Costs of the alternative production choices often fail to account for environmental externalities. Changing farm structure may lead to changes in comparative advantages across regions. Detailed regional analysis of input use levels and resulting environmental damage by farm size is required for policy evaluations.

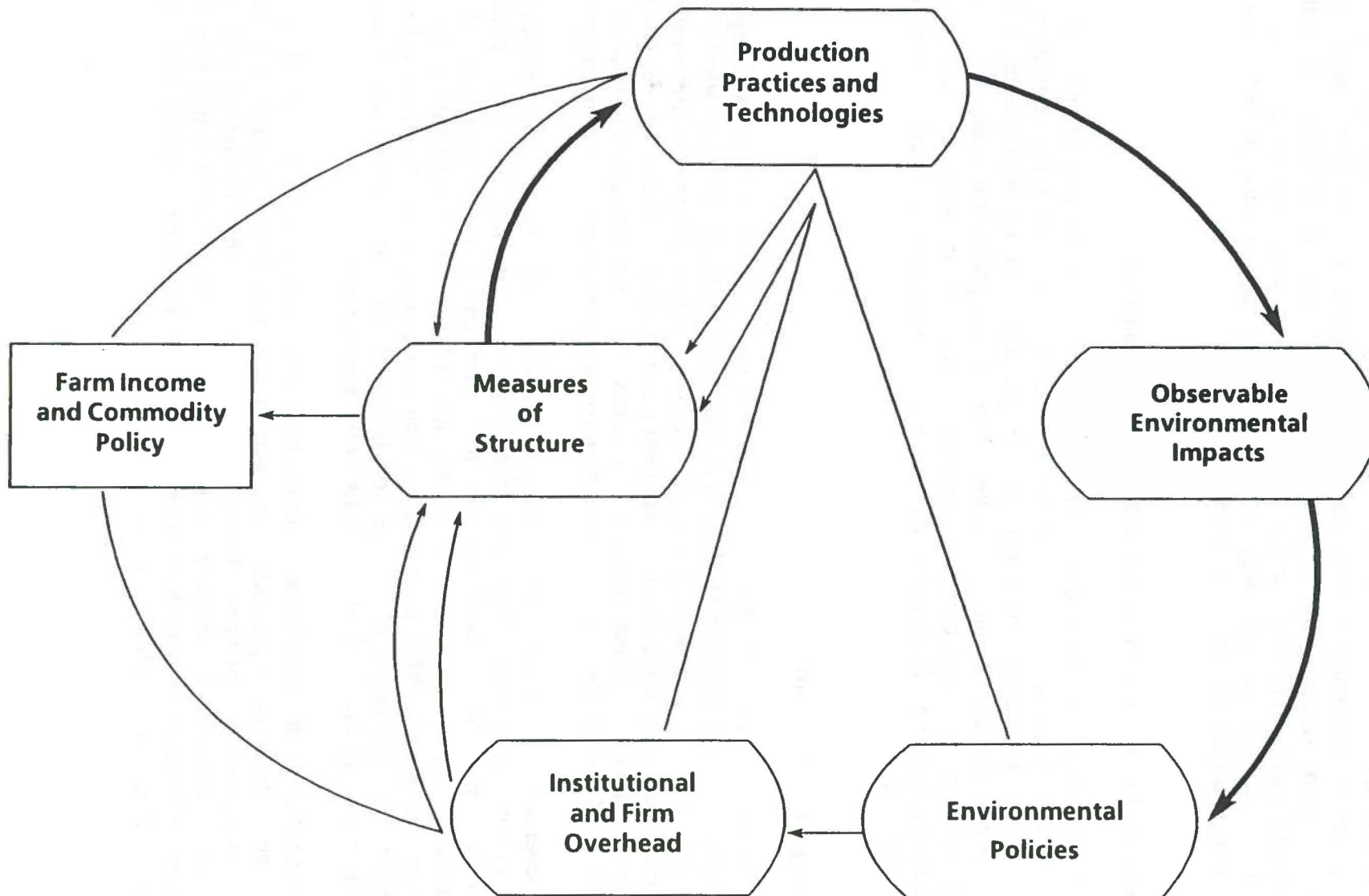


Figure 1. Relationships between policy, the structure of agriculture and environmental outcomes.

Production Practices and Environmental Outcomes

Alternative production practices result in differing environmental outcomes. Continuous mono-cropping culture instead of rotations results in more erosion and sediment generation, more susceptibility to pests, and greater rates of chemical application. Confinement feeding of livestock leads to a concentration of waste and results in a disposal problem. No-till cropping technology reduces erosion damage, requires more horsepower for planting, and may require more chemicals.

Environmental Outcomes (Perceived or Real) Impacts on Policy

Public perception of environmental problems leads to formulation of environmental policy. As postulated in Figure 1, the public observes some undesirable environmental impacts or risks which seem to be associated with agriculture. Research to determine which production practices are responsible for the environmental problem is conducted. Public policies are formulated and corrective programs initiated to mitigate the causes of the environmental problem. Research to determine less damaging agricultural practices may also be sponsored.

Policy Impact on Structure

Policies have indirect affects on structure in two ways. First, policies change the relative profitability of alternative technologies and some structures fare better when certain technologies are relatively more profitable. Secondly, policy affects the firm overhead requirements and again some structures are better able to adopt. Often policy designed for one purpose will not only affect structure but also have other direct negative impacts on the environment. For example, an erosion reduction policy may result in use of more chemicals.

Several studies on the factors leading to formulation of state level water pollution legislation have been done. Wise and Johnson (1990) found that for state legislators involved in formulation of new regulations, the "expert" advice or information put out by economists and other academicians have very little influence on the decision to sponsor legislation. Batie et al. (1989) find two factors that in combination lead to state level water regulations: a dependence of a large population on the water source and available information on high use levels of chemicals by the area farmers.

Factors of Production Choice. Policies, both agricultural and environmental, impact the relative profitability of production alternatives and some farm structures fare better under a given policy than do others. Examples are requirements that the method of manure application to cropland be injection or that a certain type of waste water treatment equipment be installed. In both these examples, there may be a returns to scale factor such that smaller farms leave rather than comply.

Institutional and Farm Overhead Impact on Structure. Policies may also impact the institutional and financial overhead of the farm leading to changes in structure. An example of overhead expense is the requirement that pesticide usage be recorded and reported. The cost of meeting these requirements would likely vary by farm size. If small farms could not cope with the regulation and left the industry farm structure, as measured by farm size, would increase.

3. Structural Change Indicators Relevant to the Environment

The structure of agriculture is a size issue, but the units of measurement may be acres cultivated, value of produce sold, number of livestock unit produced, or number of input units employed. Value added has been suggested as the ideal measure, but data are generally unavailable (Reimund et al., 1987). Structural definitions sometimes consider other characteristics, such as educational levels, tenure, and owner occupations. Empirical testing is required before environmental links can be definitely stated. For the sake of brevity the interrelationships or correlations between these structural indicators is not covered in this paper.

- 1) Farm size (acres operated, gross sales, acres planted, etc.).
 - a. Size of enterprises (equipment and investment) of the farm.
 - b. Whether or not the farm is a contiguous parcel or not.
- 2) Education levels of the farm population.
 - a. Operator, owner, and laborers.
- 3) Degree of labor intensity (versus other factors).
- 4) Degree of specialized management.
 - a. Computerization.
 - b. Use of integrated pest management (IPM).
- 5) Use of commercial or leased operations versus self.
- 6) The ownership of resources and the right to the stream of income, i.e., whether farming is by an owner/operator or by a tenant.
- 7) Aspects of ownership characteristics in the utility function.
 - a. Family farm versus corporate (farm and non-farm corporate).
 - b. Degree of prevalence of "hobby", "part-time" and "limited resource" farmers.
- 8) Changing set of "property rights" associated with farming.
- 9) Degree of vertical and/or horizontal integration.

10) Use or non-use of irrigation.

Common measures of farm size are acres operated and value of sales. Enterprise size and the associated machine use, field size and whether the farm is one contiguous parcel or not are also structural issues. The impact of farm size on technology choice and hence on environmental outcomes depends on treatment of individual resource units. As farms grow they may remove existing conservation measures and feedlots may exceed the waste assimilative capacity of the area; however, the larger farms may involve higher levels of education and may be more subject to existing legislation.

Educational level of the farm population would seem to have an impact on the operation of the farm relative to the environment. Owners and operators who understand both the on-site and off-site impacts of their practices may be more likely to be more careful. Farm labor with higher levels of education perform their tasks more precisely and are likely to have fewer accidents. On the other hand, more education may imply a higher profit motive and a better ability to circumvent existing legislation, perhaps resulting in higher levels of environmental damage.

Labor intensity, particularly skilled or management labor, has decreased steadily relative to chemicals and machinery since 1920. As chemicals and machinery have become cheap relative to labor, farmers have increased their use with some undesirable impacts on the environment. However, whether "large" farms differ relative to small "farms" in chemical use per unit of resource is an empirical issue.

The degree of specialized management occurring in agriculture is increasing continually. The use of computers and management models such as integrated pest management (IPM) enable much better management of production externalities relative to the environment. The continuous monitoring and updating required for specialized management is clearly more possible with larger, more specialized farm structures.

Some farm operations, such as fertilizer application, may increase in relative proportions as farm structure changes. These operations may be more carefully completed by farm operators than when done by commercial off-farm people. On the other hand, a degree of specialization exists within the agri-business community and for a given operation professionals may be more precise in applying inputs than the farm labor.

Bender (1987) argues that larger equipment, which is more likely to occur in farm operations of larger farms, is beneficial to the environment. Large equipment enables timeliness for application of chemicals, and for avoiding field work when conditions are poor. Weight per foot of tilled soil will be less and fewer turns mean less compaction. Larger equipment is also generally more fuel efficient.

The proportion of farmers who are renting versus those being owner/operators is increasing and is an important aspect of structural change. The issue is whether having legal

right to the value of the future stream of income from the resources leads to more careful management relative to the environment or not (Basu, 1989).

Ownership characteristics are aspects of structural change which likely have impact on the environment. The impact on the environment likely comes through the differing utility function arguments between those who live in the rural areas and are associated with the land and those separated from the land but who derive profits from its use. It has been claimed that ownership of farmland by large non-farm corporations leads to increases in undesirable environmental outcomes (The Land Stewardship Letter and the Center for Rural Affairs Newsletter).

How the increase in the mix of "hobby", "part-time" and "limited resource" farmers impacts the environment is not clear (Gertel et al., 1985). These farmers may not have the appropriate education and or freedom to make the best management choices. On the other hand, these farmers are more likely to use pastoral type management techniques which though perhaps not as productive, are less damaging. Being educated in other areas may lead to more of a conservation ethic for these farmers.

As farm structure changes, particularly as small production units are combined into large ones, the property rights associated with resource units employed by the farm change. For instance, local regulations relative to the environment usually become effective as the sales of the farm increase. Also, the availability of various farm subsidies depend on farm size and the subsidies distort resource use which then results in undesirable outcomes (Batie, 1988; Benbrook, 1989; Osteen, 1985; and Reichelderfer and Phipps, 1988).

Legal property rights are also changing as the list of allowable actions associated with property decrease. For example, the farmer may not allow runoff to escape his field or his feedlot and he may face restrictions on input usage. Agriculture is increasingly seen as a threat to the well-being of society which must be regulated by outside interests (Batie, 1988). A study by Batie et al. (1989) found that state regulation of agricultural practices relative to groundwater were being developed in areas where a large population depended on groundwater for consumption and where it was observed that farmers were using large quantities of chemicals.

The degree of vertical and/or horizontal integration existing in agriculture has clear impacts on the environment. An example is the increasing trend in specialization from mixed farming to either crop or livestock production. Also, there is an increase in the number of very large feedlots not producing their own feed on adjacent land to which waste can be applied. On the other hand these integrated farms are really "firms" and so are typically operated with a higher level of education and are subject to more of the industrial type regulations.

The adaptation and/or reliance on irrigation is also an important measure of the structure of agriculture (Reisner, 1986). Irrigation often involves higher uses of chemical,

fertilizers and sometimes results in degraded quality of the soil and water resources. The existence of legal entitlements for irrigation water for agriculture which prohibit use of the water in higher valued uses also indirectly impose environmental costs as alternative resources must be used for other purposes, such as in the case of fossil fuel electrical generation when hydro power lack water rights.

4. Production Practices Linking Farm Structure to the Environment

For any given structural change indicator various environmental outcome levels might be correlated with levels of the indicator with the choice of production practices being the link. Some of the production practices that might change as structure changes and which would give differing environmental outcomes are listed below this paragraph.

- 1) Degree to which a "farm" becomes subject to existing environmental regulation as its size and/or scope of activity changes.
- 2) Landscape alterations such as changes in fence rows, terraces, ponds, etc.
- 3) Adoption of Low Input Sustainable Agriculture (LISA).
 - a. Chemical use.
 - b. Soil stewardship.
 - c. Purchased versus non-purchased inputs.
- 4) Timeliness of operations.
 - a. Chemical management.
 - b. Residue management.
 - c. Product quality.
- 5) Choice of input formulation/carrier.
- 6) Use of IPM.
- 7) Choice of machine complement.

Existing environmental regulations on production activities generally have different provisions depending on the size of the firm. At a minimum it is typical for small farms to escape most of the existing water and air quality regulations. As farms grow in size (the current trend in structural change) more of the existing regulations become effective. At the same time, as regulations increase not all firms will be able to comply and so the regulations force some farmers out, which in turn causes further structural change.

The landscape of U.S. agriculture has definitely changed, with drastic decreases in both natural and man-made conservation measures. Examples include terraces, fence-rows, filter strips, and wetlands. These landscape changes have caused well documented environmental problems. It is not completely clear how changes in these conservation measures are linked with the various measures of structural change.

Adoption of LISA production techniques could be considered as a separate measure of structural change, i.e., the degree of LISA adoption in the sector could be considered as a qualitative aspect of structure. A more interesting issue is whether current structural changes lead to a greater or lesser adoption of LISA. Empirical studies are needed on the use of chemicals, soil stewardship and purchased versus produced fertilizer and other inputs.

A large part of the debate over the impact of agriculture on the environment evolves around the question of timeliness of operations. Better chemical and tillage management would go a long way towards reducing the negative environmental impacts. The link between timeliness and structure is an empirical issue since farmers with larger more efficient equipment may have proportionately larger enterprises.

The formulation or carrier of chemicals and fertilizers also influence the way agriculture impacts the environment. As structure changes the choice of carrier or formulation may change due to timeliness, education, etc.

The use of advanced management techniques, such as IPM or computer simulation, can also indirectly impact the environment since more accurate input use decisions can be made. The link between the use of these techniques and the structure of agriculture is not clear.

The choice of machine complement may be correlated with changes in agricultural structure and with changes in the environment. For example, if higher education leads to the choice of ridge till, or if high profits lead to a complete replacement of machinery, then practices change as well as do environmental outcomes.

5. Environmental Problems Associated with Agriculture

The environmental outcomes listed below are associated with agriculture and might be linked to structural change. Following this list of impacts, each will be discussed in detail.

- 1) On-site environmental impacts of agriculture.
 - a. Local amenity values, such as odor, visual impact, etc.
 - b. Productivity of the natural resource used for production.
 - c. Quality rating of the wildlife habitat.

- d. Quality of the ground water for other uses.
 - e. Operator safety and household hazards.
- 2) Off-site environmental impacts of agriculture.
- a. Air pollution (chemical and particulate).
 - b. Surface water quality.
 - c. Food safety.

Amenity value includes all those items detectable by the sensory functions, i.e., odor, visual, and sound. Livestock production activities as well as meat processing operations give off unpleasant odors. Many non-farm dwellers derive satisfaction from viewing a pastoral scene in the countryside, i.e., fence rows, ponds, pastures, etc. All agricultural operations involve sound and as the structure changes these sounds may be both larger and nearer to non-farm populations.

Nassauer (1989) conducted a survey of Minnesota rural dwellers to determine feelings about conservation and aesthetic values. Nassauer found that herbicides and conservation measures with high visual impact were applied beyond cost effective levels due to the perceived visual indicator of good stewardship of clean, well managed fields. On the other hand, conservation tillage and land idled in the Conservation Reserve programs was considered to give an unkempt appearance. Nassauer states that "the aesthetic value of good stewardship depends upon whether people can tell that they are looking at planned conservation practices."

Resource productivity is an intertemporal issue in that current negative impacts imply higher costs for the next generation, an example being erosion of topsoil. While soil productivity is an on-site problem, agriculture also impacts the resource costs of other industries through, for example, changes in the quality of water which other industries use for production processes. A good example is the cost of surface water sediment removal.

Wildlife habitat suitability can be characterized both by total organism populations as well as by specie diversity. Total populations depend on crop cover quantity while specie diversity depends on the mix of vegetation available. Wildlife is also impacted by the effect of agriculture on nearby water resources.

On-site water quality concerns are reflected in the growing awareness that agricultural producers are the most dependent on the water that they are contaminating. Farmers and their livestock drink the water and water is also applied to crops where irrigation is prevalent. Irrigation water return flow typically has a higher concentration of salts than before use.

Operator safety may be impaired by environmental conditions such as dust impaired vision or by the mix of inputs (for example, chemicals) used for production. Agricultural labor must deal with more lethal and ever changing chemical mixes as well as larger and

more complex equipment. Operator fatigue also becomes an issue where specialization is increasing. The air quality investment in livestock confinement buildings likely depends on whether it is the owner who will do the work in the building or whether work is assigned to hired labor.

Air pollution impacts may include changes in the chemical composition of the air, changes in physical qualities of the air such as temperature or moisture content, and changes in the particulate loading.

Surface water quality characteristics that may be impaired include the chemical loading and its affect on human health and industrial processes, sediment loadings which impact use of the water directly and which also fill reservoirs, temperature of the water and the value of the water for recreational quality.

Food safety concerns evolve around chemical residues in the food chain, animal health, and nutrient makeup of the finished product (examples being fat or cholesterol levels).

6. Policy and Institutional Impacts on Structure and Environment

In this section of the paper the mechanisms by which policies impact structure and production technology choice are reviewed. Other factors of the economy, labeled institutional here, also have an impact by the same mechanisms and are briefly discussed here.

- 1) Debt/equity ratios and profit margins.
- 2) Tax laws.
- 3) Technological change.
- 4) Food Grading and Marketing Orders.
- 5) Crop Insurance and Disaster Payments.

Debt/equity ratios and profit margins definitely impact the farming decisions, resulting in changes in environmental outcomes (Nielsen et al., 1989). However, the relationship between these factors and the structure of agriculture is not so clear. Farmers with good cash flow and/or wealth positions may feel more positive about the future and be willing to invest current income to increase future income. Conservation measures, or environmental stewardship in general, may be a consumer good and increase with better financial situations.

Tax laws greatly impact the management of the natural resources used in agriculture. Even with the tax code held constant as farm structure changes, the evolving farms become subject to other aspects of the code.

Technological change impacts the set of profitable production activities but the relationship between technological change and the structure of agriculture is not clear, particularly with regard to the adoption of "sustainable" systems. The argument that no-chemical farming can be accomplished seems to imply a drastic change in the production function from that in existence at the time chemicals were sought after.

A comprehensive 1982 study (National Research Council) of existing conditions finds that technological change is having several adverse environmental effects: prevalence of larger, contiguous fields devoted to single crops is increasing; improved varieties of crops capable of growing on marginal soils are available; fertilizer and pesticide crop responses are greater with improved varieties and larger quantities of these inputs are applied; and expansion of drainage and irrigation development occurs at the expense of natural ecosystems. It seems clear that larger farms have the comparative advantage for larger, contiguous fields, for drainage of lowlands, and for irrigation development.

Federal grading standards or standards adapted under market orders encourage high chemical use for crops and high concentrate rations for livestock (National Research Council, 1989). Chemicals must be used on fruits and vegetables to meet cosmetic requirements that have little to do with nutritional value. Similarly, meat and dairy standards require a high fat content in the food product.

Crop insurance and disaster payment regulations currently require certification of use of "Best Management Practices" which typically require use of high levels of fertilizer and pesticides.

7. Studies on Structure and the Environment

The policy issue of soil erosion generated numerous studies on structural impacts on conservation decisions in the 1980s. Many of these studies examined the off-site, externality aspects of the soil erosion problem. Many of the factors impacting farmer's decisions about soil conservation are likely to have the same type of influence on environmental stewardship as a whole. Since studies on general environmental stewardship are lacking the relevant conservation studies are reviewed in this section.

Factors Impacting Conservation Attitudes and Decisions

Factors influencing government program participation, attitudes about conservation, and resulting farming decisions have been examined relative to farm structure in several studies. These studies have a narrow soil conservation focus but some implications can be generalized to stewardship of the environment as a whole.

A survey by Demissie (1989) finds that educational level is a major factor of non-participation in government programs by limited resource farmers in the South. Many of the farmers did not know about current commodity and conservation programs. The informational materials available and the delivery systems of the responsible agencies were inadequate for these farmers. For many farmers who had heard about the programs, the paperwork required for participation was considered too complex.

In their Alternative Agriculture report the National Research Council (1989) makes the following statement (page 9): "Alternative farming practices typically require more information, trained labor, time, and management skills per unit of production than conventional farming." For alternative agriculture livestock and crop mixes and timeliness of operations are all more complex. A structure of agriculture with less education, less reliance on specialized management tools, and more hobby and part time farmers will have trouble moving to environmentally less damaging alternative agriculture techniques.

Lee (1980) found no significant differences nationally in erosion rates by landownership type after adjustment for inherent erodibility. Differences in erosion by ownership type in the Southeast could be attributed to the specialized crops grown by some large farms and by the small, undercapitalized nature of many of the region's farmers. Lee also found no significant difference between tenure groups or for net income classes at the national level. For the full owner operator class erosion rates decreased as income increased but results were insignificant for other classes. Bromley (1980) questioned Lee's use of legal descriptions of farm ownership categories as proxies for different types of decision units. This criticism applies to other studies cited in this section also.

Lee and Stewart (1983) found that full owner operators and landowners have lower minimum tillage adoption rates than do other groups and that the corporate structure of non-family farmers has no impact on tillage choice. Lee and Stewart conclude that a small operating size poses a larger problem for conservation tillage adoption than does separation of ownership from operation.

Nowak and Korsching (1983) proposed a model showing factors leading to the adoption and maintenance of Best Management Practices and applied the model with Iowa data. They rejected the idea that large corporate farms "mine the soil" and propose that more complex forms of legal arrangements of ownership and operation coincide with higher levels of education, more availability of discretionary funds, and the ability to bear risk (or experiment on a small scale basis). Nowak and Korsching found that Soil Conservation Service (SCS) cooperator farmers were likely to have owned the farm longer and also to have higher incomes than non-cooperators.

A more complete model of conservation behavior is proposed by Ervin and Ervin (1982). Four sets of factors (personal, institutional, physical, and economic) simultaneously impact and cause feedback between three stages of behavior (perception of an erosion problem, decision to use one or more conservation practices, and actual reduction in

erosion). Ervin and Ervin applied their model to Monroe County, Missouri data and found the following results. Less experienced (or younger) farmers are more likely to accept the merits of a wider range of conservation practices. Younger farmers have higher educations, a better perception of the erosion problem, lower risk aversion/shorter planning horizons, and, on the negative side, a lack of adequate capital to engage in all the conservation practices they desire. Cash grain farmers use less conservation options but this is likely due to their crop specialization choice. Participation in SCS programs did not have a significant impact on either the number of practices used or the resulting erosion outcome. Higher erodibility did not imply a higher degree of use of practices.

Concepts from social psychology and economics were merged to generate an indirect utility function, $U_m = U_m(y_m, P_m, A_m, F_m)$, by Lynne et al. (1988) where m is the level of conservation effort, y_m is income, P_m is the price of conservation practices, A_m reflects attitudes about farming and conservation, and F_m is farm features. The model was applied to data from three counties in the Florida panhandle and the following results were found. Renters use less conservation effort than owners, but this may be due to the owners having larger farms with different crops. Full owners expended the most conservation effort. Higher inherent erodibility and stronger views on the need to preserve the non-renewable resources and on the responsibility for externalities generated by one's own actions all lead to more conservation effort. Strong beliefs about the probability of technology offsetting resource problems led to less conservation effort. The discount rate and strong professional feelings about farming as a way of life had little impact on conservation decisions. Those willing to bear more risk expended more conservation effort. Over the income range of the data, effort increased with income at an increasing rate.

The national impact of cropland rental versus cropland ownership by the operators on soil conservation was studied by Bills (1985). Bills found that erosion rates of renters and owner operators were not significantly different when adjustments for land quality and other factors were made. The erosion potential of rented and owner-operated land is about equal. However, nearly two-thirds of leased land is used for erosive row crops compared to about half of the owner operated. Owner operators grow more non-erosive crops (hay and pasture) than do renters. Use of conservation practices (crop rotations, tillage practices, crop residue management, terraces, etc.) were nearly similar by both classes of farmers. Bills argues that some important soil-conserving management practices are neutral with regard to tenure because they are so cost effective in their own right.

Kraft et al. (1989) survey 264 southern Illinois farmers about their primary and secondary goals for the farming operation. The farmers were stratified into 20 categories based on size, age, type of enterprises, tenure and off-farm income. Soil conservation was chosen as the primary goal by on 1.8 percent of the sample. Of farmers with moderate to large size enterprises, aged early 50s, not working off the farm and owning most of their land, 13 percent stated conservation as their main goal. The only other group (2.6 percent) with conservation as the main goal were the very small farmers deriving more than 70 percent of their income from off-farm sources. Seven groups had some proportion listing

conservation as their second most important goal, but five of these had less than 15 percent making that choice.

Land Improvement Investments and Structure

Investments in land improvements (conservation measures, drainage, and land clearing) have historically been used as a measure of good stewardship. Now the adverse environmental externalities of some of these practices are also recognized. However, some of the factors leading to these investments may also serve as proxies for causes of environmental stewardship. Recent national studies of factors impacting land improvement investment include Baron (1981), Gertel et al. (1985), and Nielsen et al. (1989). Some findings of these studies relevant to this paper are summarized here.

Gertel et al. (1985) used 1975-77 data and studied the impact of farm ownership and operator tenure on land improvement capital expenditures. They found that the proposition that absentee owners invest less in land improvement is not supported. Retired non-operator owners made the smallest investments and there was no significant difference between retirees living in or out of the same county as their land. Non-family operators made improvement expenditures to a greater extent than did individuals or families. A higher proportion of farm operator owners made capital expenditures for improvement than did owners who operated none of their land and this result held for all classes of ownership, i.e., for individuals, families, partnerships, and corporations.

Nielsen et al. (1989) utilized 1980-86 national farm expenditure data to evaluate the impact of financial and government policy factors on land improvement investment. Operators investing in improvements in 1983 operated 1.5 -2.0 times as much cropland as non-investors and also owned more acres. However, combinations of the three categories of land improvement on the same farm imply that much of the expenditure was on new, marginal cropland. It was also found that farmers with higher incomes were more likely to make improvements. An econometric investment model was estimated to link the expenditures to external factors. The estimated national level impacts are given in Table 1.

Relative Input Use Levels by Alternative Farm Structures

The National Research Council (1989) found that expenses for machinery, pesticides, fertilizers, and interest on operating capital vary more among farmers of in a region than across regions; these cost components (page 12) "account disproportionately for differences in per unit production costs." Environmental damage might also vary more within a region than across regions, and the variation may have to do with farm size. Interregional variance in costs and environmental outcomes may be a structural issue.

As an example of the kind of studies that can be constructed from available data, the relative expenditures by corn acres grown have been summarized at the national level (Ahearn et al., 1990). Ahearn et al.'s study is summarized in Table 2. Mid-sized farms (100-499 acres of corn) used less chemicals per acre than other sized farms. The mid-sized farms used more fertilizer than smaller farms but less than larger farms. The farms producing more than 500 acres of corn used more technical services, less custom operations and more hired labor than other categories.

Distribution of Land Ownership

With different types of owners and operators exhibiting different levels of conservation stewardship, it is important to evaluate the distribution of farmland. The most recent comprehensive national survey of farm ownership was by Lewis (1980). Lee (1983) provides a summary of Lewis' data. Recent studies on land transfer and changes in distribution include Harrington and Carlin (1987), Reimund et al. (1987), and Wunderlich (1989).

The following structural characteristics of land ownership are from Lee (1983). High quality and erosion prone cropland are distributed among classes of landowners in approximately the same patterns as total cropland, except for a slight concentration of prime cropland in medium sized holdings. Owners of potential cropland (land currently in range or forest production) tend to have smaller holdings, lower net farm income and are less involved in agriculture than current cropland owners. Range and forestland tend to be held in large tracts (1000 or more acres) by absentee landowners except for 22 percent of the total which is held in tracts of less than 100 acres by non-farmers. Non-operator landlords own 31 percent of cropland and 78 percent of cropland owners reside in the same county as their landholdings. Owners of pastureland tend to be employed in non-farm occupations. Cropland is owned by farmers (48 percent), retired people (17 percent) and white collar workers (10 percent).

Harrington and Carlin (1987) examine the impacts of farm financial stress in the early 1980s on farmland ownership transfer and conclude that the impact on food supply is minimal. Most farmland changing hands remained in production without even a year's break. About 75 percent of the land was purchased by continuing farmers. Most of the remaining 25 percent was purchased by retired farmers who kept the land in production. The land which is marginal for cropping and that reverts to other uses as well as the land lost to higher valued real estate purposes are all minimal and occur in areas away from the greatest financial stress and ownership change.

8. Conclusions

This paper suggests some economic policy relevant questions about the structure of agriculture and stewardship of the environment. It is clear that one cannot understand the relationship between the structure of agriculture and the environment without an understanding of the impact of structure on choice of production practices. Likewise, complete information on the other links of the model shown in Figure 1 is scarce.

Insufficient Information is Available for Policy Formulation

The major conclusion of this paper is that currently insufficient empirical studies exist to provide guidance for policy makers concerned about the impact of changing agricultural structure on the environment. The paper has shown that the most important area in which information is lacking is on how alternative farm structures treat individual resource units. A summary report on the status of sustainable agriculture in the U.S. contains the following statement (National Research Council, 1989): "There is inadequate scientific knowledge of economic, environmental, and social costs and thresholds for pest damage, soil erosion, water contamination, and other environmental consequences of agricultural practices. Such knowledge is needed to inform farm managers [and policy makers] of the trade-offs between on farm and off farm consequences." Existing U.S.D.A., Bureau of Census, state level, and private firm data could provide some answers if access to unaggregated raw survey results on farm structural characteristics and input use were made available and if sufficient funds for analytical work were provided.

Larger Farm Structures Have the Ability for Stewardship

As argued by several studies cited in the previous section larger and more complex forms of farm ownership and operation indicate a higher level of education and managerial skill. In addition, the various conservation studies cited are either neutral or positive in their assessment of the conservation attitudes of the larger farms. It was noted that these larger farms, with higher levels of skill, will be much more flexible in their choices and so can adopt to new technology faster. However, when the profit margin is strong, this ability to adopt also may lead these farms to the use of marginal lands and temporary removal of existing conservation measures. The empirical studies cited did not find significant differences in conservation attitudes and practices between these farms and the midsize family farms.

Since mid to large size farms utilize a relatively larger portion of the natural resources, the findings of this paper imply that environmental policy incentives should be designed to take advantage of the flexibility and expertise of the larger farms. At the same time environmental policy (or commodity policy) must be structured so as to prevent rapid changes of land use at both extensive and intensive margins.

The Special Policy Needs of Smaller Farmers

The sources cited in this paper indicate that smaller farmers may control resources with a relatively higher environmental damage risk as well as have less capability of practicing good stewardship. These farmers derive more of their income from off-farm sources which implies that financial incentives of current policies may not be so attractive. These farmers may operate at such small scales as to make the acquisition of new information and/or technology unfeasible. The fact that off-farm employment is a major source of income implies that timing, overall labor and management decisions may be quite constrained for these farmers. In many cases the delivery mechanisms of current government programs are not compatible with the educational and or cultural capabilities of these farmers. Since the number of farmers in this group is large and they tend to have the more marginal resources, policies and programs to address their needs may be relatively more expensive what is currently considered.

Economics and Multi-disciplinary Studies are Needed

Analysis of farm structure and the environment can be categorized in the same manner as the model components shown in Figure 1. Detailed studies are needed in four main areas. First, identifying the environmental impacts of agriculture. Secondly, identifying the links between the environmental impacts and production practices in use. Third, identifying the association between production practices/technologies and various measures of structure. Fourth, identification of the impacts of policies on farm structure and on the choice of production technologies. Fifth, identification of the factors leading to formulation of policy. Economists could contribute cost/benefit information to interdisciplinary studies in all five of these areas of investigation. The feedback effects of policy action must also be taken into account, such as the fact that an environmental outcome leads to a policy change which leads to a change in farming methods which then changes structure. Once the five areas have been studied, a comprehensive models accounting for interactions could be constructed for use in policy analysis.

Table 1.

Factors impacting investments in land improvements, 1980-86

<u>Factor</u>	<u>Change in the factor</u>	<u>Change in Investment</u>
expected farm income	a \$100 increase	a \$1 increase
expected real interest rate	1 percentage point up	\$9 million decrease
government idled acreage	a 1 acre increase	\$2 increase
ratio of land improvement costs to land value	a 1 point increase	\$73 million decrease
land needing improvement	a 1 acre increase	\$2-3 increase
conservation subsidy	a \$1 increase	\$1.50

SOURCE: Nielsen, Elizabeth G., John A. Miranowski, and Mitchell J. Morehart. Investments in Soil Conservation and Land Improvements: Factors Explaining Farmer's Decisions. Washington, D.C.: U.S. Dept. Agri., Econ. Res. Ser. Agri. Econ. Rep. No. 601, 1989

Table 2.

Input use (cost) by corn production acreage class

		acres of corn			
		<25	25-99	100-499	500+
		Base	Value/ Base	Value/ Base	Value/ Base
Yield		91.00	1.16	1.33	1.41
Total variable	cost/acre	108.09	1.02	1.06	1.21
	cost/bu	1.19	0.87	0.80	0.87
Fertilizer	cost/acre	31.75	1.06	1.14	1.29
	cost/bu	0.35	0.91	0.86	0.91
Lime & Gypsum	cost/acre	1.72	1.52	1.56	0.73
	cost/bu	0.02	1.00	1.00	0.50
Chemical	cost/acre	19.15	1.01	0.99	1.17
	cost/bu	0.21	0.86	0.76	0.86
Custom operation	cost/acre	15.31	0.71	0.39	0.22
	cost/bu	0.17	0.59	0.29	0.18
Elec, Lube, Fuel	cost/acre	10.69	0.92	0.72	0.71
	cost/bu	0.12	0.75	0.50	0.50
Hired labor	cost/acre	1.79	1.94	3.98	7.01
	cost/bu	0.02	1.50	3.00	5.00
Technical ser.	cost/acre	0.07	2.71	3.43	6.00
	cost/bu	0.00	2.13	2.50	4.13
Irrigation	cost/acre	0.08	8.63	18.13	43.63
	cost/bu	0.00	7.22	13.33	30.33

SOURCE: Ahearn, Mary, Gerald Whittaker, and Dargan Glaze. 1990. "Cost Distribution and Efficiency of Corn Production." Paper presented at the NC-181 Meeting, Albuquerque, NM, January 6, 1990. The paper was based on the 1987 Farm Costs and Returns Survey, USDA, ERS.

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