Staff Papers Series

Staff Paper P91-22 June 1991

VOLUME I: ENVIRONMENTAL QUALITY AND LAND VALUES

Second Annual Conference on

AGRICULTURAL POLICY AND THE ENVIRONMENT

Proceedings of a Conference Sponsored by

University of Minnesota
Center for International Food and Agricultural Policy

Agricultural Development Regional Agency (ESAV)

University of Padova

Lake Itasca, Minnesota, U.S.A.
September 22-29, 1990

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

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VOLUME I: ENVIRONMENTAL QUALITY AND LAND VALUES

VOLUME II: TARGETING AND MODELING APPROACHES IN THE U.S. AND ITALY

VOLUME III: INSTITUTIONAL INNOVATION AND ENVIRONMENTAL QUALITY

FORWARD

The papers in this volume are the result of the Second Annual Conference on Agricultural Policy and the Environment, held at Lake Itasca, Minnesota, U.S.A., September 22-29, 1990. This conference resulted from the collaboration of the University of Padova, University of Minnesota and the Ente di Sviluppo Agricolo (the Veneto Regional Development Authority). The University of Minnesota Center for International Food and Agricultural Policy has entered into a long-term agreement with these Italian counterpart institutions to study problems of land use, land values, agricultural production and their impact on environmental quality. In both countries, the agriculture/environment linkage is of growing importance.

The conference proceedings are divided into three volumes, according to the sessions presented.

The next such conference is scheduled to take place in Motta Di Livenza, Italy, in June of 1992.

September 19, 1990

Agricultural and Environmental Policy Developments 1989-90

C. F. Runge*

The purpose of this brief overview is to describe developments in agricultural and environmental policy in the U.S. during 1989-90. Apart from major economic and political developments, this paper will review the progress of the 1990 Farm Bill (which has yet to achieve final form) and the conservation provisions of the bill, together with other Agricultural Policy legal actions in the environmental sphere.

The Farm Bill of 1990 was developed against a backdrop of a considerably improved farm economy compared with the 1985 bill, which was written in the midst of a farm financial crisis. Net cash income in 1990 is expected to reach a record high, in the range of $59 to $63 billion, up about 10 percent from 1989.[1] This compares with a previous high of $57.2 billion in 1988. (Net farm income is the value of agricultural production, both sold and stored, plus government payments, minus all

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[1] *Agweek*, September 10, 1990, p. 33.

costs including depreciation. It is calculated for a calendar year.) In the last two months, however, oil price increases have increased fuel costs, and may cut into these farm income increases. A $10 a barrel increase translates roughly into a 10 percent increase in fuel costs, suggesting a roughly proportional relationship between the increase in a barrel of crude and the percentage by which farm costs will rise. In addition to the direct effects on fuel prices, oil price increases will affect longer term prices of fertilizer and other farm chemicals. They will also affect the demand side by increasing recessionary pressures both in the domestic U.S. economy and overseas. Major armed conflict in the Middle East would disrupt trade and export flows, creating additional problems for export-dependent American farmers.

Apart from the ominous developments in the Middle East, the 1990 farm bill faces more direct pressures likely to reduce government spending on agricultural programs. These pressures arise from the domestic budget deficit, a crisis which has deepened due both to general weakness in the U.S. economy (which has reduced projected revenues) and the worsening condition of the savings and loan (S&L) industry and banking system in general, for which U.S. government guarantees have created additional Treasury obligations. By October 1, Congress and the President are obligated to find sufficient revenues and spending cuts to bring the budget within the previously mandated Graham-Rudman budget "targets." If they fail to do so, an automatic "across the board" spending cut will go into effect.

Informed opinion in Washington indicates that such across the board cuts would lead to as much as a 38 percent reduction in agricultural commodity program spending. The size of such cuts in agriculture is indicative of why Congress and the President are not likely to allow the automatic spending cut mechanism to occur, and will find a way in the "budget summit" to reach the targets (more or less). Even so, the result in agriculture is likely to be cuts in the 15 to 20 percent range if the targets are to be reached. Such cuts are still substantial.

The key to understanding what is likely to occur is that Congress need not cut "target prices" or "loan rates" in order to find such revenues. All that is needed is to reduce the total number of "base" acres eligible for payments. In return, farmers would be granted "planting flexibility" on the acres exempted from payment eligibility. By converting to something similar to the "triple base" or "flexible base" option (described last year at the Padova research conference), the U.S. government could largely meet the spending cuts targets without altering the politically sensitive target price and loan rate numbers. Such a move is really an incremental step in the director of "decoupling," and thus would garner credit for the U.S. in the final GATT meetings leading up to the December 1990 finale in Brussels. Planting flexibility, if substantial, might also bring certain environmental benefits, if it overcame the current disincentives to rotate crops and to diversify crop production. However, even a "triple base," in which as much as one third of all base acres were allowed to "flex," would be unlikely to achieve as much flexibility as would be necessary to encourage substantially more crop rotations and crop diversification.

In short, the final form of the 1990 Farm Bill will be largely dictated by domestic budget pressures. The necessity of spending cuts is likely to be touted as a virtue by the U.S. in its final efforts in the

GATT negotiations. By increasing planting flexibility, modest environmental benefits will occur, though less than under a scheme of more total flexibility.[2]

Environmental Policy

The conservation elements of the 1990 Farm Bill are further evidence of the tightening constraints represented by environmental policy as it affects farmers. Although some provisions (such as the "swampbuster" and "sodbuster" requirements) are likely to be loosened, the overall effect of the 1990 Farm Bill will be to confirm and strengthen the importance of environmental interventions in the farm economy. The Center for Rural Affairs notes the following Developments, which are extracted from the Center's most recent Newsletter.[3]

Commodity Programs

Integrated Farm Management Program Option (IFMPO): Both House and Senate bills contain provisions allowing farmers to sign multi-year agreements to reduce soil erosion, water pollution, and use of purchased nonrenewable resources in return for being permitted greater commodity program flexibility. They will be able to plant resource conserving crops on program base acres without losing program crop base or deficiency payments, and their set-aside requirements will be reduced to help make up

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[2]Jared R. Creason and C. Ford Runge, Agricultural Competitiveness and Environmental Quality: What Mix of Policies Will Accomplish Both Goals? Center for International Food and Agricultural Policy, University of Minnesota, St. Paul, MN 55108, July 16, 1990.

[3]Center for Rural Affairs, Walthill, Neb., Newsletter, September, 1990, pp. 3-5.

for any loss of production attributable to the shift from program crops to conserving crops.

The Conference Committee will have to resolve some differences between the two IFMPO versions. The Senate requires 5-year plans, the House 3-10 year plans; both versions protect the deficiency payments only if the conserving crops are not hayed or grazed, but the Senate permits grazing of the small grain residue during the periods when set-aside acres can be grazed, while the House permits both haying and grazing during that period or anytime after harvesting a small grain. Also, the House allows an IFMPO farmer complete flexibility to plant any program crop on up to 100 percent of base without losing base for any particular crop.

Finally, the Senate requires USDA to enroll at least 3 million new acres each year, but no more than 5 million acres, while the House limits participation only in counties with high Conservation Reserve Program (CRP) acres by linking unharvested IFMPO acres to the limit placed on CRP enrollment (25 percent of the acres in a county).

<u>Payment Protection for Conservation Compliance</u>: Under the House bill (but not the Senate), farmers who plant a resource conserving crop such as a small grain-legume mixture on base acres in order to meet conservation compliance rules would not lose base acres or program crop payments. The conserving crop could not be cut for hay nor grazed before grazing is permitted on set-aside acres.

<u>Oats Target Price</u>: The Senate raises the oats target price (encouraging rotation with corn) by $.10 per year for four years (from $1.45 to $1.85). The House freezes oats target price at $1.45.

<u>Set-Asides</u>: Both bills allow farmers to enroll up to one-half their

set-aside acres in a multi-year set-aside, providing cost-share (25 percent in the Senate, an unspecified percentage in the House) to establish a cover crop (annual or perennial in the House, perennial only in the Senate). The actual land placed in the multi-year set-aside can be rotated under the House bill.

Also, the Senate bill (but not the House) requires farmers to plant cover crops on at least 50 percent of all set-aside acres (up to 5 percent of their total base), whether they go into the multi-year set-aside or not. The House (but not the Senate) also allows end-rows to be entered as set-aside if they are planted to a perennial cover crop (under present law set-asides must be of a minimum size parcel, thus excluding end-rows).

Flexible Base: The Senate allows farmers to designate up to 25 percent of their program crop base as "flexible acres" on which they can plant any crop, including conserving crops but excluding fruit and vegetables, without losing their base. However, if they choose to plant a program crop on these flexible acres, they have to reduce other program crops so that their total program crop planting does not exceed 100 percent of their base. The House provides for flexible acreage designation on up to 25 percent of program crop **and oilseed** base, allows planting to exceed base if the increase is in oats, and specifies a limited range of other crops that can be planted on "flex" acres.

Base Adjustment: The Senate allows farmers to receive an adjustment in the crop bases in order to help them meet conservation compliance provisions (for example, an increased small grain base as a trade-off for a decreased corn base might help). The House has no such provision.

Cost Share for Legumes: The House (but not the Senate) provides 50 percent cost share for planting short-term soil building legumes as part of a resource conserving rotation.

Conservation Provisions

Compliance: Under current law, farmers can lose all farm program benefits for failing to comply with commitments they have made to reduce soil erosion. Both bills help farmers meet this obligation by making more flexible use of the CRP, adding the IFMPO discussed above, protecting base and providing cost share for legumes. Both bills also provide for reduced penalties for those who fail to comply if they have made a "good faith" effort to comply; the Senate says fines of $750 to $10,000 for those who have not made more than one violation in a ten-year period; the House says $375 to $2,500 fines for violations no more frequent than once in five years. The House also would allow new or revised farm conservation plans to meet a much weaker standard for soil erosion -- no more than a 50 percent reduction in current erosion rates would be required, even if current rates are far above tolerable levels.

Conservation Reserve Program: Both House and Senate allow land planted to windbreaks, shelter belts, contour grass strips and other conservation measures to be enrolled in the Conservation Reserve Program without enrolling the whole field in which these measures are established. This will help farmers meet conservation compliance requirements. Both bills also provide incentives to plant trees on CRP acres, including longer contracts (15 years rather than 10 years), the right to convert already enrolled CRP land to trees (hardwoods only in the Senate version) 50-75 percent cost share to establish and maintain or even replant tree stands. In addition, the House (but not Senate) allows sustained yield harvesting of trees during the last three years of contract if the farmer agrees to permanently retire the crop base on those acres.

Post-Contract Base Protection on CRP Land: The Senate bill gives USDA the discretion to allow CRP land to remain in program crop base even after the ten-year contract expires as long as it remains in a conserving use. The House limits this extension of base protection to ten years, but requires USDA to extend the protection if the producer agrees to maintain conserving use of the land. The House bill also allows certain sustainable uses of this land, such as haying or grazing (CRP land cannot now be used for any economic purpose). The Senate also allows farmers to bid the least erodible CRP land out of the CRP contract if erosion control will remain as good.

Agricultural Research

Research Purposes: The senate clearly states that the purpose of agricultural research and extension is to enhance the "competitiveness and sustainability" of U.S. agriculture, and it lists specific objectives such as increased rural employment, environmental protection, and strengthening the family farm. It also requires the Secretary of Agriculture to develop guidelines to implement these objectives. The House bill doesn't include such a statement, but key House leaders agreed to support the concept embodied in a similar amendment that was not acted on by the House.

Low-Input Sustainable Agriculture (LISA): Both House and Senate define sustainable agriculture (the Senate more adequately); authorize up to $40 million per year for LISA research (now funded at $4.45 million/year), including priorities for research involving farm cooperators; require preparation of LISA technical guides; provide matching grants to state sustainable agriculture programs; and require training for all extension field personnel.

The Senate bill also calls for the creation of training centers, appointment of integrated crop management specialists in each state, and competitive grants to organizations providing short courses on sustainable agriculture. The House also establishes a sustainable agriculture outreach effort in each state, places greater emphasis on farm tours and other extension activities, and provides for regional sustainable agricultural extension specialists in each state.

In addition to legislative actions, several developments in the courts may have far-reaching significance for the environmental consequences of farm production. These arise from the growing number of court cases in which liability for environmental damages is being assessed to farmers, their bankers or other credit sources such as fertilizer and chemical suppliers. A federal law, the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), says that if a lender acts in such a way as to go outside the protection of its "security interest" in a borrower's actions, it may be found liable for the borrower's environmental mismanagement. Lenders are thus increasingly putting environmental compliance conditions in loan agreements, since the cost of being found liable may be as much as 1,000 times that of the loan itself.

Especially when lenders decide not to foreclose and work with farmers to reduce and restructure debt, their involvement may lead to greater liability than simply initiating a loan and/or foreclosing on it. In May, 1990, the 11th Circuit Court decided in U.S. v. Fleet Factors (901 F2d 1550) that a lender is liable for the environmental harm created by a borrower if its "involvement with the management of the facility is sufficiently broad to support the inference that it could affect hazardous waste disposal decisions if it so chose."

This judgement means that it is not necessary for the secured creditor to participate in management decisions leading directly to environmental damages such as release of hazardous wastes. Merely having the capability to participate is sufficient to lead to liability.[4] The Court went on to say in U.S. v. Fleet Factors: "Under the standard we adopt today, a secured creditor may incur liability without being an operator, by participating in the financial management of a facility to a degree indicating a capacity to influence the corporation's treatment of hazardous waste."

This decision, and others like it, have led to a growing emphasis on the environmental consequences of farm (and non-farm) behavior, which are likely to have wide reaching influence in the years ahead. As the court stated in Fleet Factors:

> Our ruling today should encourage potential creditors to investigate thoroughly the waste treatment system and polices of potential debtors. If the treatment system seems inadequate, the risk of CERCLA liability will be weighed into the terms of the loan agreement.

By affecting the costs of doing business for both lender and borrower, such court decisions are yet another way in which environmental regulation will

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[4]St. Paul Bank for Cooperatives, News, 4(July-August, 1990): 2-4.

intrude on farm level decisions.

Aside from such legal questions, concerns are growing over what will happen to land currently retired as part of the Conservation Reserve Program (CRP). As the 10-year contracts in the program begin to expire, a way will need to be found to retain highly vulnerable land in protected status. At the same time, lands brought into the CRP at relatively high prices will need to be reexamined in light of budget pressures. The situation presents a prime opportunity to employ a targeting scheme, such as that developed by Taff and Runge,[5] to differentiate between lands that should be left in the CRP, taken out, or given 3-5 year "intermediate" status.

In sum, 1990 is likely to be an unstable year in U.S. agriculture, due to a combination of recession, Middle East politics, oil price fluctuations, changing environmental standards, and last and probably least, the GATT talks.

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[5]Taff, Steven J. and C. Ford Runge, "Wanted: A Leaner and Meaner CRP," Choices, First Quarter 1988, pp. 16-18.

LAND VALUES AND ENVIRONMENTAL REGULATION

Michael D. Boehlje
Philip M. Raup
Kent D. Olson*

Environmental regulation, controls, litigation, and concerns have been an increasingly important dimension of the social and business climate in the U.S. Historically, these concerns have been focused on urban areas and industrial sources of pollution or environmental deregulation. But increasing concern about air and water pollution and soil erosion have stimulated the debate about the impact of environmental concerns in rural areas.

The focus of this discussion is on the impact of environmental regulations on land values, land use, and siting decisions. The issues to be discussed include the impact of the Conservation Reserve Program (CRP) on land values and land use, the impact of "swampbuster" and wetlands use regulation on land values, the impacts of management practices to reduce soil erosion or water pollution, the unique environmental problems of animal agriculture including siting decisions and waste disposal, and the impacts on land appraisal and lending practices.

Impacts of the Conservation Reserve Program

The Conservation Reserve Program was incorporated in the National Food Security Act of 1985. Under this program, funds were appropriated to enable the federal government to lease from landowners lands that were subject to erosion; and that would contribute to wildlife habitat improvement and surplus commodity reduction. Leases are for ten years at rates proposed (bid) by landowners, indicating the minimum annual payment per acre they would accept to remove the land from production. Bids at or below a maximum rate per acre set by the U.S. Department of Agriculture and varying by regions or parts of states were accepted if the erosive character of the land was certified by local offices of the U.S. Soil Conservation Service.

Beginning in March 1986 and through October 1989, a total of 33,922,565 formerly cropped acres had been entered in the Conservation Reserve. This is approximately 10 percent of the total area of harvested cropland and 3.5 percent of the total area of land in farms as reported in the <u>1987 Census of Agriculture</u>.

Regional Concentration

The overwhelming majority of the CRP acres have been planted to grasses or were formerly harvested grasslands, accounting for 29.7 of the 33.9 million acres entered. The distribution of entries by type of conservation practice applied and the projected annual government cost are shown in Table 1.

Figures 1 and 2 provide an overview of the regional significance of these entries. Figure 1 shows in broad outline the major agricultural regions of the U.S. Figure 2 shows a dot-map distribution of acres entered in the CRP. The concentration of entries is clearly the winter and spring wheat regions, portions of the western corn belt, and eastern and western segments of the cotton belt.

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* Professor, emeritus professor, and assistant professor, respectively, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul. We are indebted to Steven J. Taff for aid in preparing the section on the Impacts of the Conservation Reserve Program.

The most notable feature of the distribution of entries is the concentration in wheat-producing areas. To the extent that the CRP reduced the acreage planted to crops for which product prices have been supported by federal acreage-reduction programs, the CRP to-date has been primarily a wheat program.

Taff has estimated that the CRP achieved a total reduction in base acres (acres on which planting of price-supported crops is permitted) of 19.6 million acres through the eighth round to February 1989, of which 9.5 million acres or just under one-half had been designated for planting to wheat (Taff, 1990). In contrast, of the total reduction in base acreage achieved by the CRP, corn accounted for 18.1 percent, barley 11.7 percent, soybean 10.5 percent, cotton 5.8 percent, oats 5.2 percent, and all other program crops (rice, tobacco, peanuts) together, 0.4 percent (Table 2). In acreage terms, the big impact of the CRP has been on wheat.

This comparison in terms of acres is misleading if attention is shifted from land use to volume of output. Corn yields in the U.S. average three to four times wheat yields, depending on the region. In terms of physical output quantities, the estimate by Taff of a CRP-induced reduction in base acres in corn of 3,548,357 acres through February 1989 involves a substantially greater reduction in tons of output than does the estimated reduction of 9,489,759 in base acres for wheat (Taff 1990, p. 93). Although one goal of the CRP is the reduction of crop surpluses, it is beyond the scope of this discussion to explore the consequences of the CRP for crop production and total output. Attention is focused, instead, on the implications for land use shifts and resultant impacts on the market for land, and on the environment.

Environmental Effects

The potential environmental effects of the CRP can be seen more clearly by referring to the historical record of drought in the Great Plains. Figure 3 outlines the high risk areas as they were defined by the severe drought years of the 1930s. This definition is reenforced by Figure 4, showing areas of the Great Plains with deficient rainfall of under 20 inches (508 mm.) per year. A reference back to the dot-map of CRP entries in Figure 2 shows how heavily concentrated the entries are in drought-prone regions.

The Great Plains states in which drought is the major environmental threat (Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming) account for 19.9 of the 33.9 million acres entered to-date in the CRP (ASCS, 1990). This is 58.7 percent of the total. Adding in drought-prone but non-Great Plains areas of Idaho, Minnesota, Oregon, and Washington raises the total to approximately two-thirds of all CRP lands for which drought is the principal hazard and wind erosion is the primary environmental concern.

Due to its concentration in these drought-prone areas, the major contribution that the CRP can make will be in the reduction of wind erosion. Much of the emphasis in the debate that led to the adoption of the CRP in 1985 stressed the need to control soil loss through water erosion. This remains a major goal, especially in the corn and cotton belts. But the predominant influence of the CRP will probably not be adequately measured until drought returns to the Great Plains.

Changes in Land Use and Prices

This regional overview obscures the wide variety of land use situations in which the CRP is changing the rural landscape. The method chosen here to illustrate this variety is to focus on one state, Minnesota, for which the data base is well developed.

From the first round of bids in March 1986 through the ninth round in October 1989, a total of 1,830,217 acres have been entered under the CRP program in Minnesota (Table 3). This is 6.9 percent of the area of land in farms in the state, as reported in the 1987 Census of Agriculture. For the state as a whole, approximately one out of every fifteen acres of farmland is now removed from crop use by the CRP. This is double the proportion of land withdrawal achieved by the CRP for the continental U.S. (48 states) as a whole.

Entries under the CRP program are highly concentrated in a few counties and regions, although there are CRP entries in all but three counties (Figure 5). Fourteen of the state's eighty-seven counties in which CRP entries total over 10 percent of the land in farms account for 51 percent of total CRP entries by acres. The concentration is especially marked in the northwest district as defined in Figure 6.

The nine counties in that district, for example, have 18 percent of the total land in farms in the state, but 38.7 percent of total CRP entries. For the district as a whole, CRP entries cover 14.8 percent of all land in farms or almost one of every seven acres, twice the statewide frequency (Table 4).

Within the northwest district, CRP entries are concentrated in the portions of the counties lying outside the lake plain of the Red River Valley, in areas that include some of the lowest priced farmland in the state (Govindan and Raup, 1990). Disaggregation on a county basis fails to reveal the full measure of this concentration. One rule governing the acceptance of entries into the CRP is that total entries shall not exceed 25 percent of the farmland in a given county. As Figure 5 shows, this rule has been exceeded in Pennington and Red Lake counties. This would also be the case if eastern portions of Marshall and Polk counties were considered separately. In this area to the east of the Red River Valley lake plain, there are entire townships in which CRP entries approach or exceed half of all land in farms.

In contrast, the eighteen counties of the southwest district containing the state's highest priced farmland include 24.9 percent of the state's total area of land in farms, but account for only 13.2 percent of the acres entered under the CRP. Within the southwest district, the concentration is marked, with 49 percent of all CRP entries in the district located in three counties, Lincoln, Lyon, and Yellow Medicine. These three counties contain much of the lowest priced farmland in the southwest district.

Other areas of concentration of CRP entries include a band of counties running south from Becker through Otter Tail, Grant, Douglas, Stevens, Pope, and Kandiyohi counties. In the southeast district, there is a notable concentration in Le Sueur and Rice and a less marked concentration in Olmsted and Fillmore counties.

With the exception of the southeastern counties, CRP entries tend to be concentrated in counties or parts of counties with sales prices well below the statewide average. This is not surprising, given the environmental hazards that must be present to qualify land for entry under the CRP. It does have the effect of removing lower priced lands from the frequency base of lands that are sold. Although lands entered in the CRP can be sold, sales of these lands have been infrequent.

The result has been to reduce the probability that lower priced lands will be represented in the listing of lands sold in 1987, 1988, and 1989 with the same frequency that prevailed before the CRP. In areas where CRP entries are concentrated, there is thus an upward drift in reported sales prices over the last three years. This drift could be the result of a truncation of the lower priced tail of the sales distribution, or it could reflect increased demand for the reduced quantities of land not included in the CRP.

By districts, this phenomena can affect the relative significance of districtwide average sales prices. Statewide, it shifts the frequency of reported sales toward the higher priced segments of the market.

In the absence of detailed data on the quality of land actually sold, it is impossible to quantify the effect of this reduction in the frequency of sales of lower priced land. Since CRP contracts are for ten years, it is probable that this "CRP effect" will distort the interpretation of average sales prices until at least the mid-1990s. One effect is to widen the difference between the estimated value of farmland and prices received in actual sales. In the sales prices, the lower end of the land quality scale is currently underrepresented.

Effectiveness and Other Impacts

In terms of a reduction in environmental risk in farming, the CRP in Minnesota can be considered as moderately successful. Much of the land in the program is in areas of the state that have suffered from drought in the past or that have an erosion-prone topography. This reduction in risk to the physical environment has been achieved at a price that is most likely understated if measured by the dollars paid to landowners by the federal government.

An unmeasured, and perhaps unmeasurable, cost has been the disruption to the cultural and commercial environment in areas with the heaviest CRP participation. The volume of local business has declined, out-migration has accelerated, and the social fabric represented by schools, churches, formal and informal clubs, and community activities has been torn.

CRP has resulted in an upward sift in land values in areas of high concentrations of CRP entries. Whether this is a data quirk of underreporting of sales of lower priced properties or a reflection of strong demand for remaining (non-CRP encumbered) properties is unclear. To the extent that increased land values reflect increased rental rates (which appears to be the case in numerous cases), the higher prices are, in part, a result of reduced supplies. In this situation, land values would be expected to soften as CRP properties become more "marketable" at the termination of the ten-year contract.

The CRP program can be viewed as a transitional measure, designed to conserve land while it is held out of production in "protective custody" for possible future needs. In this light, the CRP can be praised. If a more permanent retirement of fragile or environmentally-sensitive land is the goal, then the concept of the environment that has guided policy to-date needs rethinking. Human beings and their institution are a part of that environment.

A land use policy that focuses only on the physical dimensions of use is defective. The ten-year leases that now define the CRP leave unanswered the basic question of, what is to be done with the land when the leases expire? They also ignore the effect on rural communities. It is distressing that so little attention was given to these issues in the discussions resulting in the agricultural policy legislation now before the U.S. Congress. For these reasons, a definitive judgement on the merits of the CRP must be postponed. The crucial decisions are yet to come.

Impacts of Wetlands Regulations

Wetlands are defined in various ways, but generally include those land areas where surface water or water logged soils prohibit typical crop or timber production practices or, at a minimum, make them extremely difficult during the critical growing season. Wetlands originally accounted for about 215 million acres in the U.S., but more than half of this acreage has been drained and converted to other uses and only about 99 million acres of rural wetlands remained in the late-1970s (Tiner). These wetlands are located throughout the U.S. and range from coastal swampland in the southern and southeastern states to "prairie potholes" of the Upper Midwest and Great Plains states. Most of the conversion of wetlands has been to agricultural uses; agricultural and urban development have accounted for 87 percent and 8 percent of the losses of wetlands, respectively. In Minnesota, an estimated 9 million acres of pothole wetlands have been converted to agricultural uses (Tiner).

The value of wetlands has traditionally been realized by conversion to agricultural and other uses as evidenced by the high conversion rates. But we are becoming increasingly aware of the value of wetlands as a breeding ground and habitat for fish and wildlife; to maintain water quality and regulate the microclimate in the locale; and to provide socioeconomic benefits in the form of flood and erosion control, water supplies, timber products, recreation, hunting, fishing, and trapping services, and aesthetics (Tiner). Consequently, public policy has changed from incentives for wetland conversion such as tax writeoffs and low interest loans for drainage to restrictions and/or penalties for conversion and incentives to restore wetlands. The 1985 Food Security Act contained a "swampbuster" provision which made farm operators ineligible for any and all government payments or loans on all land farmed if crops were planted on converted croplands. In 1990, President Bush incorporated a "no-net-loss of wetlands" provision in his budget message to Congress. Changes in federal tax policy in 1986 and 1987 eliminated or restricted the tax breaks for land clearing, soil and water conservation deductions including drainage, and capital gains on land which reduced the tax incentive to convert wetlands to agricultural production. Although the effectiveness of some of these new policies in maintaining wetlands has been questioned based on the problems of targeting and implementation of such a broad, blunt policy instrument as withholding farm program payments, public opinion and policy has changed significantly from encouraging conversion of wetlands to at least maintaining those wetlands that remain.

The prairie pothole region, which extends from central and western Minnesota northwest through the Dakotas and Montana into Canada, is one of the critical wetlands in the U.S. It is "North America's most valuable waterfowl breeding ground" (Heimlich and Langner, p. 21). Almost half of the original wetlands have been converted to other uses, primarily farmland. One characteristic of the prairie pothole region that significantly impacts both the costs and benefits of conversion of wetlands to farming is the relatively small size of the wetland areas and the dispersion of these small wetland areas among larger areas of relatively productive cropland.

Numerous studies have been completed of the economics of drainage and conversion of wetlands. The studies reveal a wide variation in conversion costs between regions. Generally, conversion costs are higher in the coastal areas of North Carolina ($1,000-$1,500 per acre) and the swamps of Mississippi and Louisiana ($400-$450 per acre), compared to the prairie pothole region of Minnesota ($150-$300 per acre) (Heimlich and Langner). These high costs and the capital outlays required can be a significant barrier to conversion. But when scattered wetlands surrounded by productive cropland reduce the overall efficiency of using largescale equipment and straight row farming, as is frequently the case in the prairie pothole region of Minnesota and the Dakotas, the total benefits over the total farm acreage can be large compared to the total cost of draining a few acres. A Canadian study based on 1985 data indicates that the net present value to the farmer of drained wetland compared to preserved wetland totaled $738 per acre ($1,824 per hectare) (van Vuuren and Roy).

Furthermore, conversion will likely result in increased land values as well as increased income. In an econometric study of the effects of erosion control and drainage on farmland values in North Carolina, Palmquist and Danielson state that "the soil wetness coefficient suggests that draining wet soils would increase land values by 34 percent on average" (p. 60). Upon evaluating estimates of drainage costs, they conclude "Thus, the market is near equilibrium, with drainage costs approximately equal to the increase in land values" (p. 60).

The benefits of conversion of wetlands to agricultural production are sizeable and can typically be captured by the owner through increased income. The benefits of preserving or restoring wetlands are both more difficult to assess and more difficult to capture by the owner. These benefits, as noted earlier, typically accrue in the form of improved habitat for fish and wildlife, a better ecological balance in terms of improved water quality and reduced flooding, and recreational benefits in terms of hunting, fishing, hiking, birdwatching, etc. Many estimates indicate large public benefits per acre, particularly when measures of ecological balance are included. The Canadian study noted earlier estimated that the net present value to the public of preserved wetlands exceeded the agricultural value of drained wetlands by $347 per acre ($858 per hectare). However, it is extremely difficult for a private owner to capture even a modest portion of these public benefits; so without regulation or other incentives, conversion is likely to continue.

So what is the overall impact of wetlands regulations on land values? As long as the private benefits of conversion exceed the private benefits of preserving wetlands, regulations to restrict conversion will reduce private benefits and, thus, the market value of wetlands as well as parcels of land that contain scattered wetlands as is common in the prairie pothole region of the U.S. and Canada. Parcels and/or farms where government program crops are important and the risk of losing program benefits is substantial will be the most significantly impacted. This impact would be mitigated if mechanisms are implemented or expanded to compensate owners for some of the public benefits of preserving wetlands through the payment of annual rents or acquisition of permanent easements. Such mechanisms are available through the USDA Water Bank Program, the Fish and Wildlife Services' Small Wetland Acquisition Program, and the revised Conservation Reserve Program.

Management Strategies

Farmers are expressing significant interest in adopting management strategies that will reduce environmental degradation. Part of this growing interest is stimulated by increased awareness of the environmental impacts, particularly with respect to groundwater and surfacewater pollution, of certain agricultural practices and sincere concern about the environment as well as the health of family members and neighbors. Part of the interest is an attempt to adopt practices that reduce the costs of production, enhance profits, and reduce dependence on purchased inputs. And the prospect of future regulations that would substantially restrict the use of certain practices has certainly stimulated producers to evaluate alternatives.

The management strategies that could be adopted to reduce environmental degradation can be classified into three general categories: (1) changes in the use of purchased inputs such as banding of herbicides and reduced applications of fertilizer that will reduce the potential of runoff of chemicals into surface water or leaching into groundwater, (2) changes in management practices that require capital investments such as terracing, contour farming, or nonconventional tillage practices such as ridge tilling or chisel plowing to reduce soil erosion, and (3) changes in land use patterns that would include the production of more forage crops and small grains and less corn, soybeans or other row crops. These categories can be viewed as those changes which require (1) little, (2) moderate, and (3) large amounts of capital and management input.

The impact of various strategies on land values can best be determined by analyzing the change in profitability or net income per acre if these strategies are adopted and capitalizing this income in a net present value model. Numerous studies of the profitability of these strategies have been completed. Generally, changes in the use of purchased inputs have the least impact on per acre incomes, whereas changes in land use patterns that reduce the production of row crops have the most impact. In fact, there is increasing evidence that better and more timely placement of fertilizer and chemicals may reduce costs, enhance per acre returns, and reduce application rates so as to reduce the risk of surface or groundwater pollution (Olson and Weber; Madden and O'Connell; Lyman et al.; and other studies in Olson and Weber, Journal of Soil & Water Conservation, Vol. 45, No. 1, January-February 1990). Similarly, studies have indicated that adopting some tillage practices, such as ridge tillage, can increase income per acre even after accounting for the capital costs of the new equipment and machinery needed (e.g., Apland et al.).

But if changes in land use patterns from row crops to forages and small grains are required, per acre returns typically decline. Dabbert and Madden report a 7 percent decline in residual returns in a simulation for a case farm in Pennsylvania with changes from "conventional" management to "organic" farming or more sustainable production practices. The most significant change in management practices was to use legume-based rotations to reduce erosion and as a source of nitrogen, and to replace corn acreage with rotations that included high proportions of wheat, alfalfa, and soybeans. Similarly, a Maryland study of conventional, compared to "low-input," agriculture reported an 8 percent decline in farm profitability with the low input option, primarily because of a shift from a concentration in corn and soybeans to more acreage in small grains and forage legumes (Hanson et al.) Crosson and Ostrov review numerous studies of more environmentally sound "alternative agriculture" practices and conclude "alternative agriculture is less profitable because what it saves in fertilizer and pesticide costs is not enough to compensate for the additional labor required and for the yield penalty it suffers relative to conventional farming. The main reasons for the yield penalty appear to be the necessary rotation of main crops with low value legumes and the difficulty of controlling weeds without herbicides" (p. 36).

In his study of removing certain pesticides from the market, Cox developed estimates of yield reductions using mechanical weed control versus chemical weed control for corn. When both methods received good weather, the "mechanical" yield was estimated to be 95 percent of the "chemical" yield. Mutually exclusive adverse weather affected both yields. Dry weather after planting allowed mechanical control to take place but did not allow the herbicide to be as effective so the "chemical" yield was estimated to be 80 percent of the good weather yield. Wet weather after planting increased the efficiency of herbicides but did not allow mechanical control to take place in a timely fashion dropping the "mechanical yield" to 60 percent of the good weather, "chemical" yield. Adverse weather for chemical control was estimated to have occurred in 38 percent of the past 60 years; for mechanical control, 19 percent.

In addition to the Conservation Reserve Program and the penalties for conversion of wetlands, the 1985 Food Security Act included conservation compliance provisions that require farmers to develop and have approved by 1990 a plan to control soil erosion and reduce water pollution. As with wetlands conversion, the penalty for violating the approved plan (or not developing a plan) is the loss of federal farm program payments and loans. One of the more recent studies of the required adjustments in management practices to reduce soil erosion and improve water quality so as to satisfy the conservation compliance provisions of the 1985 Food Security Act has been completed by Wollenhaupt and Blase. They assess the impact of using various crop rotations and mechanical tillage practices to reduce soil erosion to acceptable soil loss tolerance levels. Conservation practices included various combinations of contouring, conservation tillage with 30 percent residue after planting, and terraces. Enterprise budgeting was used to analyze the impact on per acre returns for different soil types and land capability classes in northern Missouri. Wollenhaupt and Blase conclude that the result of conservation compliance for soil-climatic conditions similar to northern Missouri will be "lower economic returns to land and management and, subsequently, to the value of the land itself. This will be especially critical on erodible land in capability classes III and higher [the more erosive soils]" (p. 158-159). A second conclusion is that much of this more erosive soil will be converted to low input pasture land. "This land is the type presently enrolled in CRP for a maximum bid of $65 per acre in Missouri. The CRP will have placed an artificially high floor price under this land if this return is capitalized into land values" (p. 159).

The impact of management practices to reduce environmental degradation and satisfy conservation compliance regulations on land values will, thus, depend on the land class and the technology or management practice used. For more erosive soils requiring significant changes in cropping patterns to low valued crops or pasture and/or major investments in terraces or other technologies to reduce erosion, land values could decline significantly because of the reduced capitalized value of the income stream. For less erosive soils and/or where changes in the application and use of purchased inputs is all that is required to reduce environmental degradation, land values may not be significantly impacted. In fact, such land may increase in value because of higher net incomes as well as increased demand for land that is environmental benign. One conclusion is straightforward--the differential in value between land that is highly erosive or has other environmental problems and land that is environmentally benign will widen with increased environmental regulation.

Challenges of Animal Agriculture

Most discussions of land values would not include a review of the concerns and challenges of animal agriculture, but animal agriculture could have an impact in certain locales on land values. The most obvious impact is in the forage and grass growing areas of the U.S. where land values are primarily a function of the profitability of cattle and sheep production, forage production, and grazing rights. As suggested earlier, the eventual disposition of CRP acres when they are no longer under government contract will be important in determining the supply or availability of grazing land; if these acres stay in grass, they will increase supplies in the short run and tend to weaken at least annual rents for grass land or grazing rights, if not pasture land values.

But animal agriculture has additional impacts on land values, and these impacts are increasingly important and typically are environmentally-driven. With the exception of grazing activity, animal agriculture is becoming increasingly concentrated in terms of size and geography. A concentrated livestock sector presents new environmental problems, primarily because of the large volumes of waste produced and the potential for both water and air pollution from feedlot runoff, lagoon seepage or inappropriate disposal of animal wastes. A further problem can arise from the large quantities of water required by largescale concentrated livestock operations.

Consequently, siting or location decisions, as well as adoption of the appropriate technology to reduce the potential of air and water pollution, have become major considerations in livestock production. No longer can producers decide to locate livestock facilities nearby or include them as part of the "farmstead" for convenience or security reasons as was commonly the case in the past. The siting decision must include considerations of location relative to streams and waterways where runoff during heavy rainstorms or as a result of accidental spills could result in water pollution. It must consider soil characteristics if a lagoon or other waste storage facility is to be built with preference for high clay content soils that can be packed to eliminate or reduce the potential of seepage or leaching of high concentrations of nitrates and other potential pollutants into underground water supplies. Also of concern is the issue of location relative to urban centers and/or neighbors who may be subject to odors or air pollution from the production facility or from the disposal of animal wastes. For some of the recent siting decisions for largescale hog production facilities (for example, National Farm's decision to locate near Greeley, Colorado), the availability of adequate acreage for land based disposal of animal wastes contiguous to the production facility that can be purchased or leased was a major consideration.

Most of the siting considerations briefly reviewed here are now reflected in state or local regulations. Most states require a state permit from an appropriate environmental quality agency for new construction of livestock facilities exceeding specified sizes. In Minnesota, a Pollution Control Agency permit is required for new or modified facilities that will exceed 10 animal units (approximately 10 feeder steers, 1,000 chickens or 25 hogs). In many states, considerations in issuing such permits include location relative to watersheds, soil type and slope, location relative to neighbors and urban centers, technology to be used in waste storage and disposal, availability of land for waste disposal, etc. Furthermore, local county zoning authorities also have jurisdiction over siting decisions and frequently hold public hearings to obtain citizen input prior to issuing construction permits. These regulations and "bad press" resulting from such hearings can be a factor in the final decision to locate a livestock production facility at a particular site as evidenced by National Farm's move from a site in South Dakota to one in Colorado and PFS's move from a site in Iowa to one in Missouri.

The eventual impact of the livestock facility siting and location decisions on land values is, thus, relatively localized. Individual parcels that have unique location and physical characteristics that make them attractive for siting livestock facilities may benefit from increased demand and exhibit higher prices than other parcels that do not possess these characteristics. But this phenomena is not expected to have a significant impact on land values that would be detectable in most surveys. The more significant impact of these regulations and decisions will be on land use patterns and investment and operating costs in livestock production. Generally, livestock facilities will be sited in less populous areas; away from lakes, streams, and waterways; in areas with heavier clay type soils; and for unenclosed lots where the climate is relatively dry and hot. Or, alternatively, they will be sited in states or counties where environmental regulations are less restrictive. Regulations concerning the storage and disposal of animal wastes will require additional investments in land and equipment and facilities resulting in higher costs of production.

Impacts on Land Appraisal and Lending Practices

Environmental concerns will have a significant impact on farm real estate appraisal and lending practices. In addition to the financial and economic analyses that have been the traditional focus of farm real estate appraisal, an environmental audit should also be included in the appraisal process. An environmental audit should answer the following questions (Arthur).

(1) If there is an active well on the property, where is it located with respect to fuel tanks, livestock facilities, etc., and has it been tested for water quality?

(2) Are there any abandoned wells on the property? If so, have they been used as a waste disposal site or have they been capped?

(3) If the property includes livestock facilities, what has been and is the animal waste disposal method used; how close are the facilities to streams or waterways, towns, and other personal residences; and have proper state and federal permits for construction and waste disposal been obtained?

(4) Has there been any potentially hazardous construction material such as asbestos, foam insulation, or lead based paint used in the construction of any of the buildings or facilities on the property?

(5) Are there any disposal sites for empty chemical containers on the property and, if so, where are they located with respect to wells and waterways; what chemicals are included in the site; and what are the soil characteristics underlying the disposal site?

(6) Are there any known or suspected spills or other dumping of chemicals, petroleum products or hazardous or toxic materials on the property and, if so, what cleanup or containment and disposal methods were used?

(7) Are there storage facilities for chemicals such as fertilizer and pesticides on the property and, if so, what is the condition of these facilities, location with respect to water supplies and protection and containment structures in case of leakage or accidental spills?

(8) What facilities are used to store fuel or petroleum products; what is the location of these facilities vis-a-vis water supplies; and what protections are used to contain and prevent damage from leaks and accidental spills?

(9) Are there or have there been any underground storage tanks for fuel or other chemicals on the property; if so, have they been removed or inspected; are there or have there been any known or suspected leaks; and what cleanup procedures were used?

(10) Has part of the property ever been used as a site for production, formulation, distribution or storage of agricultural chemicals such as herbicides, fertilizer, pesticides or petroleum; if so, how were the facilities removed and the site cleaned up and were there any known or suspected spills or other contamination from this site?

(11) Has industrial waste or municipal sludge ever been used as fertilizer on the farm or has any part of the property ever been used as a waste disposal site, municipal dump, or landfill; if so, what disposal techniques and procedures were used, where proper permits obtained, and what is the location of these sites with respect to ground- and surfacewater sources?

(12) Is the property in compliance with all federal and state rules and regulations with respect to soil erosion and runoff, conservation practices, and CRP land management practices, tiling and conversion of wetlands, etc., and, if not, what procedures are necessary to obtain compliance and what will be the cost?

Although many of these questions can be answered by the property owner, the technical and economic implications of potential environmental problems will frequently require more expertise such as that provided by engineers and economists. An environmental audit can be costly and time-consuming, but the cost and risk of not doing one can be very high--as evidenced by the numerous cases where an owner (or lender upon foreclosure) has had to incur thousands of dollars of expense to clean up property containing a chemical spill or a leaking underground storage tank prior to abandonment of the property.

A significant dimension of agricultural environmental issues that is of particular concern to lenders is the issue of the contingent liability for environmental damages and cleanup costs. This contingent liability can become a reality in a number of ways. First, if a lender receives property under foreclosure or repossession procedures that requires cleanup, the lender will typically be required to incur the cleanup costs. Furthermore, if the property is inflicting environmental damage on others, the lender would be subject to litigation and potential damages by the injured party. And these liabilities would be incurred in addition to the likelihood of a loss in value of the property due to the environmental problem.

Secondly, there may be a wider liability concern. In 1989, Congress passed the U.S. Comprehensive Environmental Response, Compensation and Liability Act, commonly referred to as the "Superfund Law." This legislation identifies those responsible for cleanup and containment costs on contaminated property as any and all of the "potentially responsible parties." Although the applicability of this legislation to agriculture is unclear and case law is still developing in this area, "potentially responsible parties" has been interpreted in some commercial property cases to include lenders as well as present and past owners and operators. Even if lender liability isn't established, the popular perception that the lender has "deep pockets" will likely result in the lending institution being a party to any litigation and having to incur at least legal expenses in its defense. Furthermore, state legislatures are also concerned about establishing regulations on and incentives to prevent environmental damage and to impose financial responsibility for cleanup activities. Thus, a significant financial impact of agricultural environmental problems on lenders may be the liability for cleanup or environmental damages on secured property.

A second impact of agriculturally-driven environmental concerns on farm lenders is on loan purpose and volume. If environmental regulations combined with a move to low input sustainable agriculture (LISA) result in reduced demand for purchased inputs such as fertilizer and chemicals, operating loan volume will decline. In contrast, more funds will likely be necessary to comply with environmental regulations and/or reduce the potential of agricultural pollution. Examples include the expenditures to store and dispose of animal wastes, to clean up and maintain acceptable pesticide container disposal sites, to clean up unexpected chemical spills from storage and transportation facilities, to replace and correct environmental damage from underground storage tanks, and to clean up or replace contaminated wells. Even if these expenditures are not funded from loan funds, the fact that they do occur will reduce the cash flow available for servicing operating or real estate loans. And the use of borrowed funds for such expenditures presents potentially serious repayment problems because most such expenditures do not generate additional volume or revenue, nor are the funds expended for assets or investments that provide marketable collateral for the loan. In summary, environmental concerns can have a very direct impact on the loan purpose and volume of agricultural lenders.

Conclusion

We have attempted to identify and discuss some of the key issues concerning the impact of environmental regulation on land values. The arguments have not benefitted from detailed empirical analysis, but provide useful hypotheses to guide that analysis. These hypotheses would include:

(1) The Conservation Reserve Program has resulted in an upward drift in land values because of the truncation of the lower tail of the land price distribution and/or the decreased supply of unencumbered land to the market.

(2) Regulations or policies to maintain and/or restore wetlands will result in lower values for effected properties because as long as owners cannot capture more of the public benefits of wetlands through public purchase of easements or other payments, the private net benefits to owners of conversion for agricultural uses generally exceed the benefits that owners can capture for maintaining wetlands.

(3) Adoption of management strategies to reduce soil erosion and chemical runoff and leaching may increase the value of environmentally benign land and will likely decrease the value of land that is more erosive or subject to environmental risks. Clearly, the differential in value between land that is highly erosive or has other environmental problems and land that is environmentally benign will widen with increased environmental regulation.

(4) Regulations on the siting of livestock production facilities to reduce the potential of air and water pollution will have a parcel-specific impact on land values, but most likely not one that is detectable in regional or statewide land value surveys. The more significant impact of these regulations will be on location of livestock facilities, land use patterns, and investment and operating costs in livestock production.

(5) Environmental concerns will require changes in land appraisal and lending practices. These changes include completing an environmental audit as part of the land appraisal process, adoption of procedures to protect the lender from the potential liability for environmental damages and cleanup costs, the prospect of reduced cash flows as farmers incur increased cash costs to comply with environmental regulations, and new demands for agricultural loans to reduce environmental problems.

Table 1. Conservation Reserve Program First Through Ninth Singup

Practice	Conservation Cover Summary by Practice		
	Acres	Cost-Share	Cost/Acre*
CP 1 Tame Grass	19,818,043	$740,958,422	$ 37.39
CP 2 Native Grass	8,121,510	365,093,838	44.95
CP 3 Trees	2,012,805	79,860,581	39.68
CP 4 Wildlife plantings	1,946,915	73,403,865	37.70
CP 5 Field Windbreaks	6,833	1,037,265	151.81
CP 6 Diversions	83,472	808,217	9.68
CP 7 Structures	38,017	1,871,487	49.23
CP 8 Waterways	14,960	1,925,047	128.68
CP 9 Wildlife ponds	12,285	1,108,531	90.24
CP10 Already in grass	1,767,440	42,230	0.02
CP11 Already in trees	84,793	39,258	0.46
CP12 Wildlife food plots	14,953	0	0.00
CP13 Filter strips	48,837	2,290,641	46.90
CP14 Wetland trees	83,299	4,826,014	57.94

* Some of the practices listed are usually applied to areas of less than an acre in size.

Source: The Conservation Reserve Program, Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture, Washington, D.C., January 22, 1990.

Table 2. Reduction in Permitted Planting Base for Program Crops Resulting from CRP Entries through the Eighth Round as of February 1989*

Crop	Reduction in Planting Base: Acres	Reduction in Planting Base: Percent of Total CRP Reduction
Corn	3,548,357	18.1
Wheat	9,486,759	48.3
Oats	1,024,904	5.2
Barley	2,304,011	11.7
Grain sorghum	2,054,270	10.5
All cotton	1,137,396	5.8
Peanuts	57,718	
Rice	22,495	0.4
Tobacco	5,559	
Total	19,641,465	100.0

* Computed from Using the Conservation Reserve Program in Minnesota, 1986-89, Enrollment Characteristics and Program Impacts by Steven J. Taff, Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul, 1990, p. 93.

Table 3. Total Acreage Under CRP Enrollment (1986-89) and Total Acreage Under Land in Farms (1987 census)

County	Total CRP Enrollment 1986-89 (Acres)[a/]	Total Land in Farms (Acres)[b/]	CRP Area as Percentage of Total Land in Farms
Aitkin	4274.0	178100	2.4
Anoka	229.3	74443	0.3
Becker	36704.7	397385	9.2
Beltrami	10591.3	243679	4.3
Benton	2741.2	184412	1.5
Big Stone	20074.1	277071	7.2
Blue Earth	11792.6	401557	2.9
Brown	5209.7	335559	1.6
Carlton	332.8	132863	0.2
Carver	2259.6	167532	1.3
Cass	2701.4	195569	1.4
Chippewa	8613.2	327916	2.6
Chisago	2982.8	152717	2.0
Clay	44628.2	588808	7.6
Clearwater	7203.5	229537	3.1
Cook	0.0	1283	0.0
Cottonwood	17455.0	377506	4.6
Crow Wing	3996.1	132410	3.0
Dakota	15141.7	219920	6.9
Dodge	1616.2	239443	0.7
Douglas	34403.8	260294	13.2
Faribault	3899.0	427986	0.9
Fillmore	48527.3	451054	10.8
Freeborn	25745.2	384001	6.7
Goodhue	17150.7	389539	4.4
Grant	25955.9	286857	9.0
Hennepin	722.9	91078	0.7
Houston	13594.5	285056	4.8
Hubbard	7331.0	123875	5.9
Isanti	3406.5	142998	2.4
Itasca	34.2	123555	0.02
Jackson	10960.7	394000	2.8
Kanabec	1961.7	164403	1.2
Kandiyohi	35903.3	377392	9.5
Kittson	80095.6	498253	16.1
Lake of the Woods	5226.7	118959	4.4
Le Sueur	31555.8	222523	14.2
Lincoln	60222.6	253044	23.8
Lyon	27553.4	368115	7.5
McLeod	5577.3	258172	2.2
Mahnomen	8957.8	197078	4.5
Marshall	158273.6	819664	19.3
Martin	3210.6	433285	0.7
Meeker	22303.0	298623	7.5
Mille Lacs	231.7	153315	0.2
Morrison	13871.2	430023	3.2
Mower	15614.1	385648	4.0
Murray	17844.3	372454	4.8
Nicollet	2077.6	250061	0.8
Nobles	5662.9	413816	1.4

Table 3. Total Acreage Under CRP Enrollment (1986-89) and Total Acreage Under Land in Farms (1987 census) (continued)

County	Total CRP Enrollment 1986-89 (Acres)[a/]	Total Land in Farms (Acres)[b/]	CRP Area as Percentage of Total Land in Farms
Norman	60301.0	472449	12.8
Olmsted	33399.9	318748	10.5
Otter Tail	90778.6	876319	10.4
Pennington	77166.4	305784	25.2
Pine	336.2	258878	0.1
Pipestone	11171.2	246804	4.5
Polk	95357.5	1075711	8.9
Pope	39937.6	328165	12.2
Ramsey	0.0	2146	0.0
Red Lake	58196.6	210348	27.7
Redwood	19748.8	514462	3.8
Renville	6050.2	563931	1.1
Rice	30972.9	225762	13.7
Rock	1766.4	260092	0.7
Roseau	125333.9	613736	20.4
St. Louis	136.0	180030	0.1
Scott	2229.2	134420	1.7
Sherburne	808.4	124288	0.7
Sibley	2560.9	336712	0.8
Stearns	32674.9	671895	4.9
Steele	18406.1	234126	7.9
Stevens	26393.5	295499	8.9
Swift	23979.5	395484	6.0
Todd	16838.5	418136	4.0
Traverse	11166.4	312130	3.6
Wabasha	15830.8	255550	6.2
Wadena	6170.1	178124	3.5
Waseca	10637.1	231788	4.6
Washington	1701.9	109442	1.6
Watonwan	3750.9	252824	1.5
Wilken	24086.2	426995	5.6
Winona	9971.0	310325	3.2
Wright	7859.4	288429	2.7
Yellow Medicine	29995.7	412568	7.3
State total	1830217.3	26573819	6.9

Sources:

a/ Steven J. Taff, The Conservation Reserve Program in Minnesota 1986-89 Enrollment Characteristics and Program Impacts, Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul, 1989; plus CRP entries for the ninth round as of February 26, 1990.

b/ 1987 Census of Agriculture.

Summary

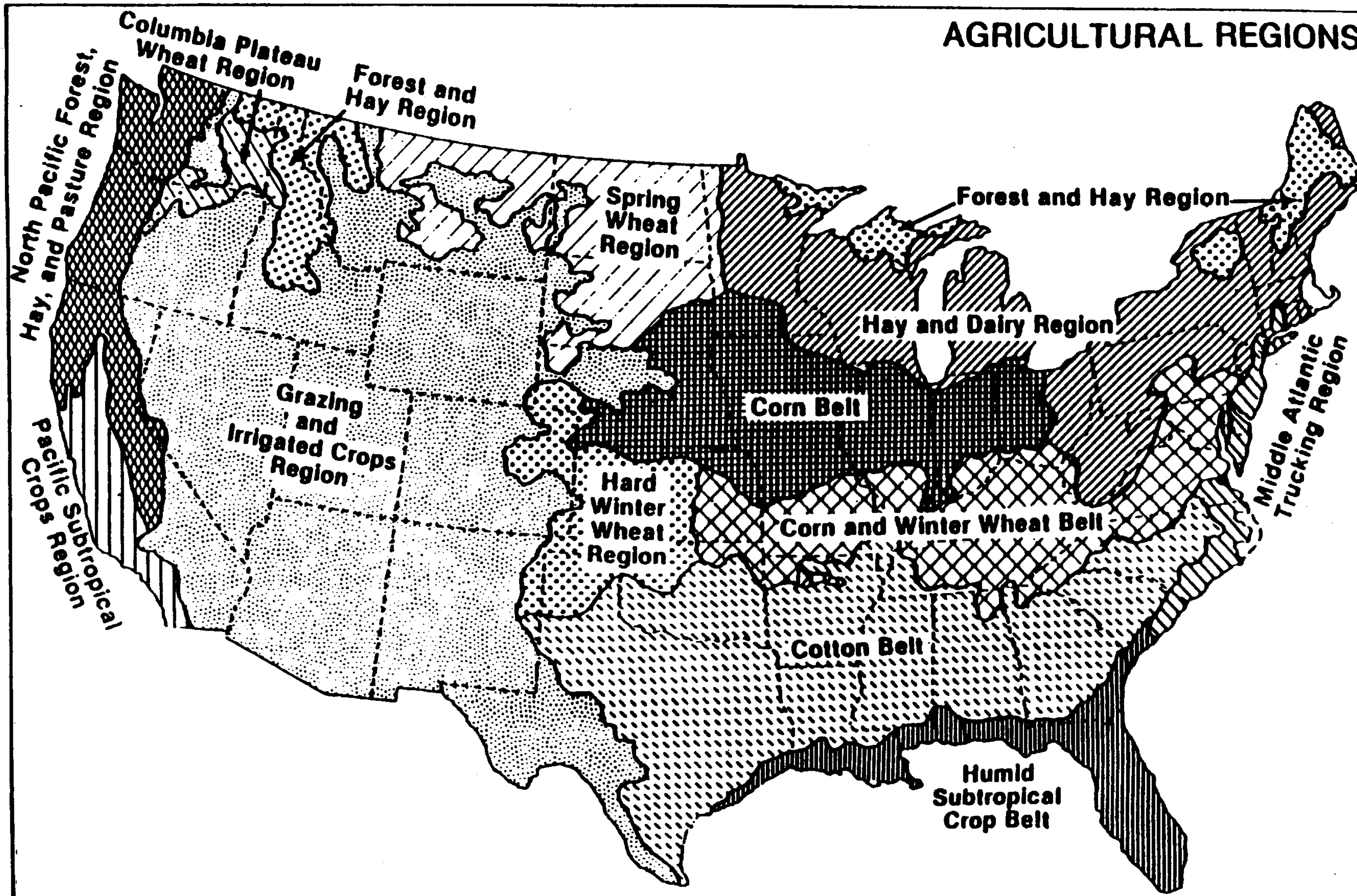
> 20%	4 counties
10-20%	10 counties
< 10%	73 counties

Table 4. Relative Significance of CRP Entries in the Northwest and Southwest Districts, Minnesota, 1989*

	Acres	Percent of State Total
Northwest District		
Area of land in farms	4,781,831	18.0
Area of land in CRP	708,312	38.7
Southwest District		
Area of land in farms	6,614,776	24.9
Area of land in CRP	240,934	13.2
Minnesota		
Area of land in farms	26,573,819	100.0
Area of land in CRP	1,830,217	100.0

* CRP entries through ninth round, October 1989. Area of land in farms from 1987 Census of Agriculture.

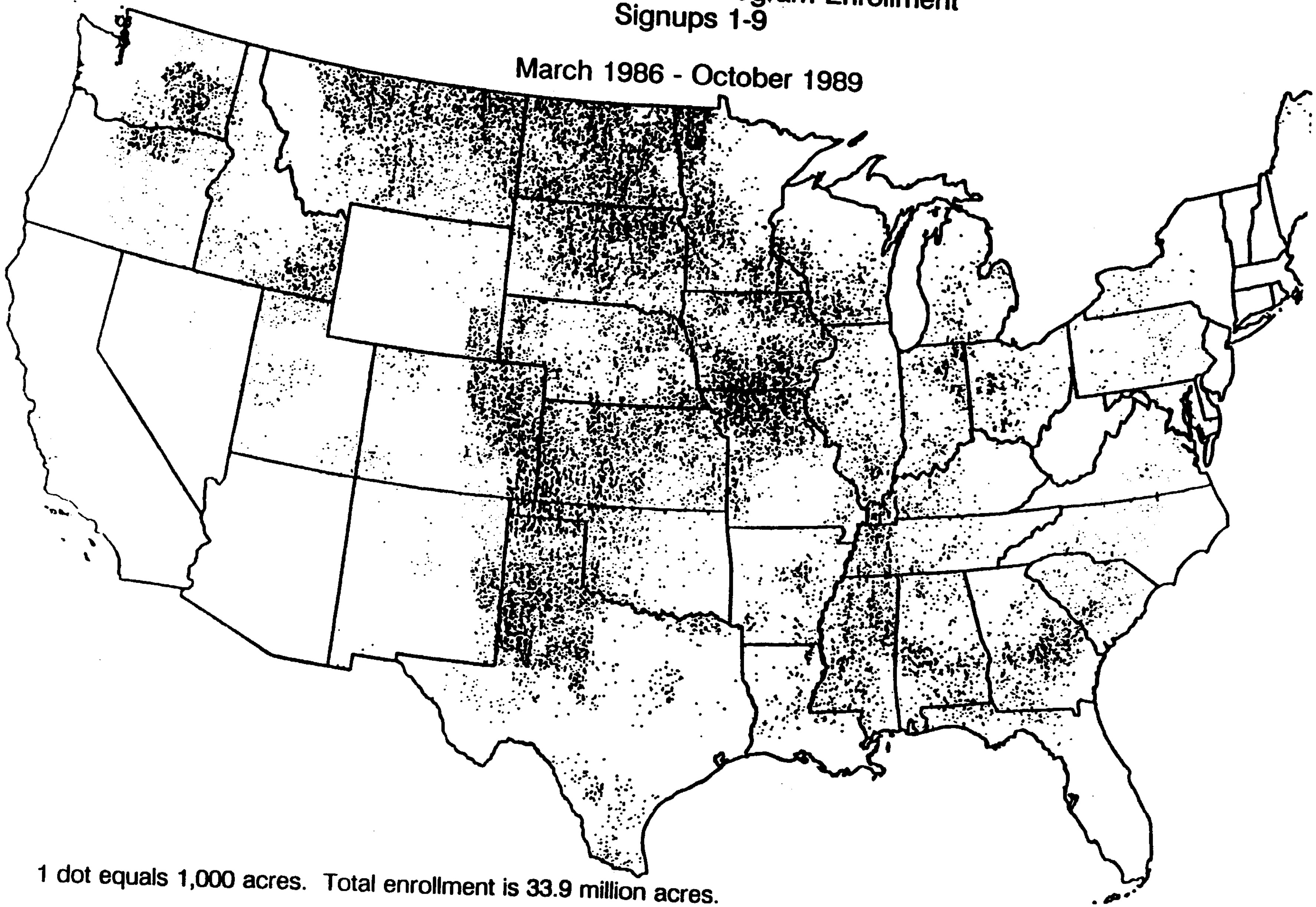
FIGURE 1



Source: Walter Sullivan, Landprints, Times Books, New York: Times Books Co., 1984, p. 340.

FIGURE 2
Conservation Reserve Program Enrollment
Signups 1-9

March 1986 - October 1989

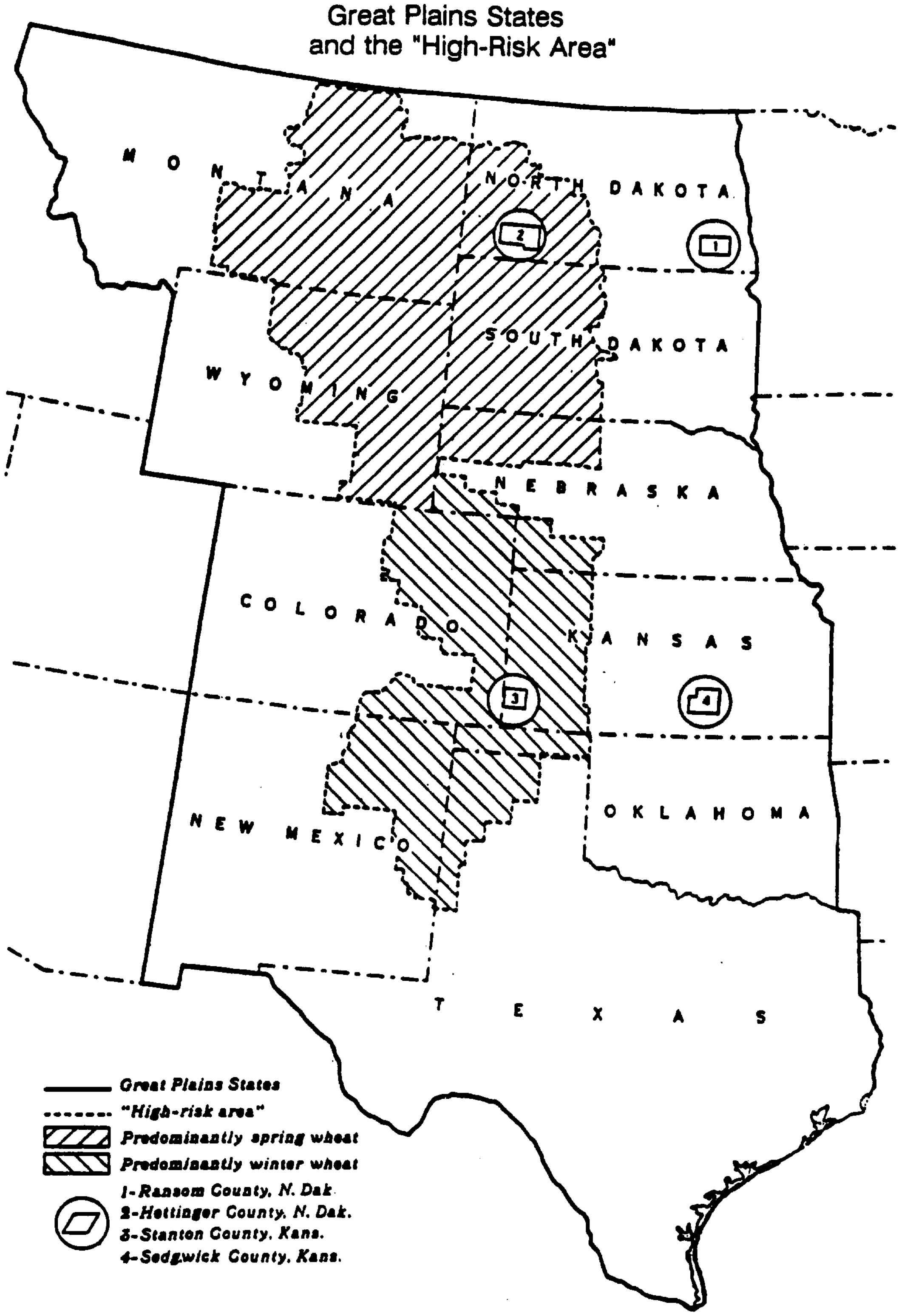


1 dot equals 1,000 acres. Total enrollment is 33.9 million acres.

Source: Economic Research Service, USDA

FIGURE 3

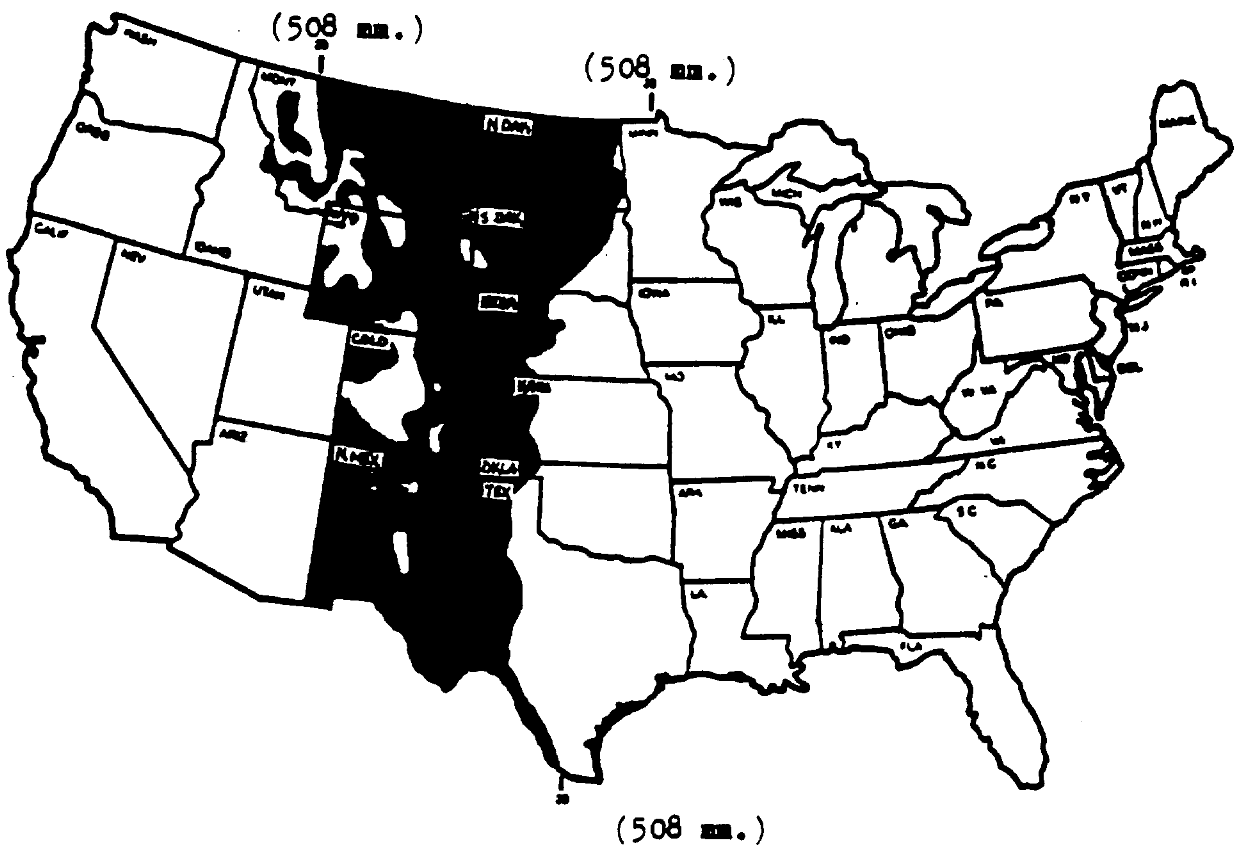
Great Plains States
and the "High-Risk Area"



Source: Orlin J. Scoville and James W. Gibson, <u>The Great Plains and the Supply of Wheat</u>, Bureau of Agricultural Economics, USDA, Washington, D.C., FM-23, May 1941.

FIGURE 4

Cropland Areas of the Great Plains
With Deficient Rainfall
(less than 20 inches)

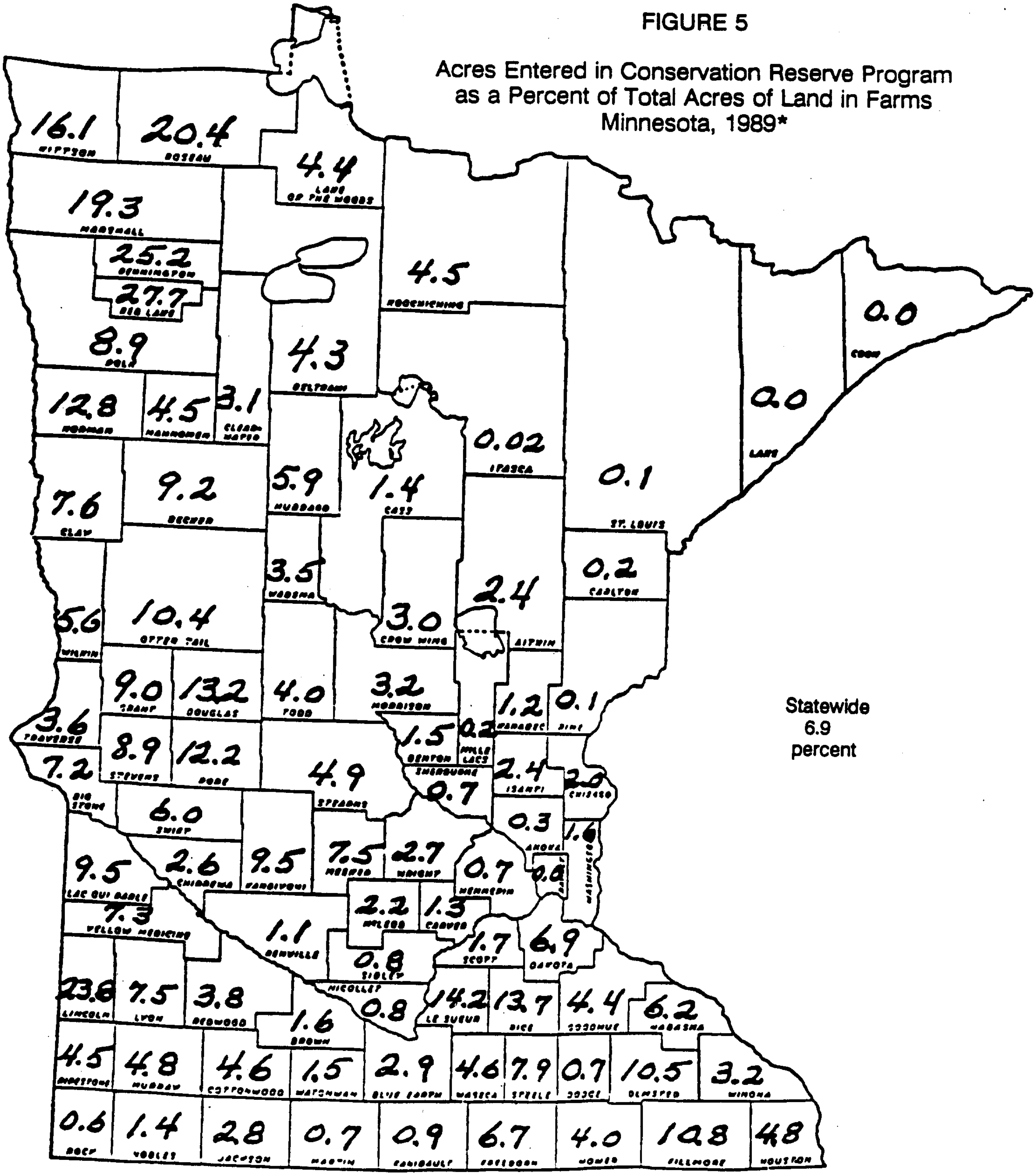


Source: Conservation Tillage in the Great Plains, U.S. Department of Agriculture, Extension Service, PA-1190, July 1977.

Adapted from Climatic Atlas, U.S. Department of Commerce, Environmental Service Administration, Environmental Data Service, 1968.

FIGURE 5

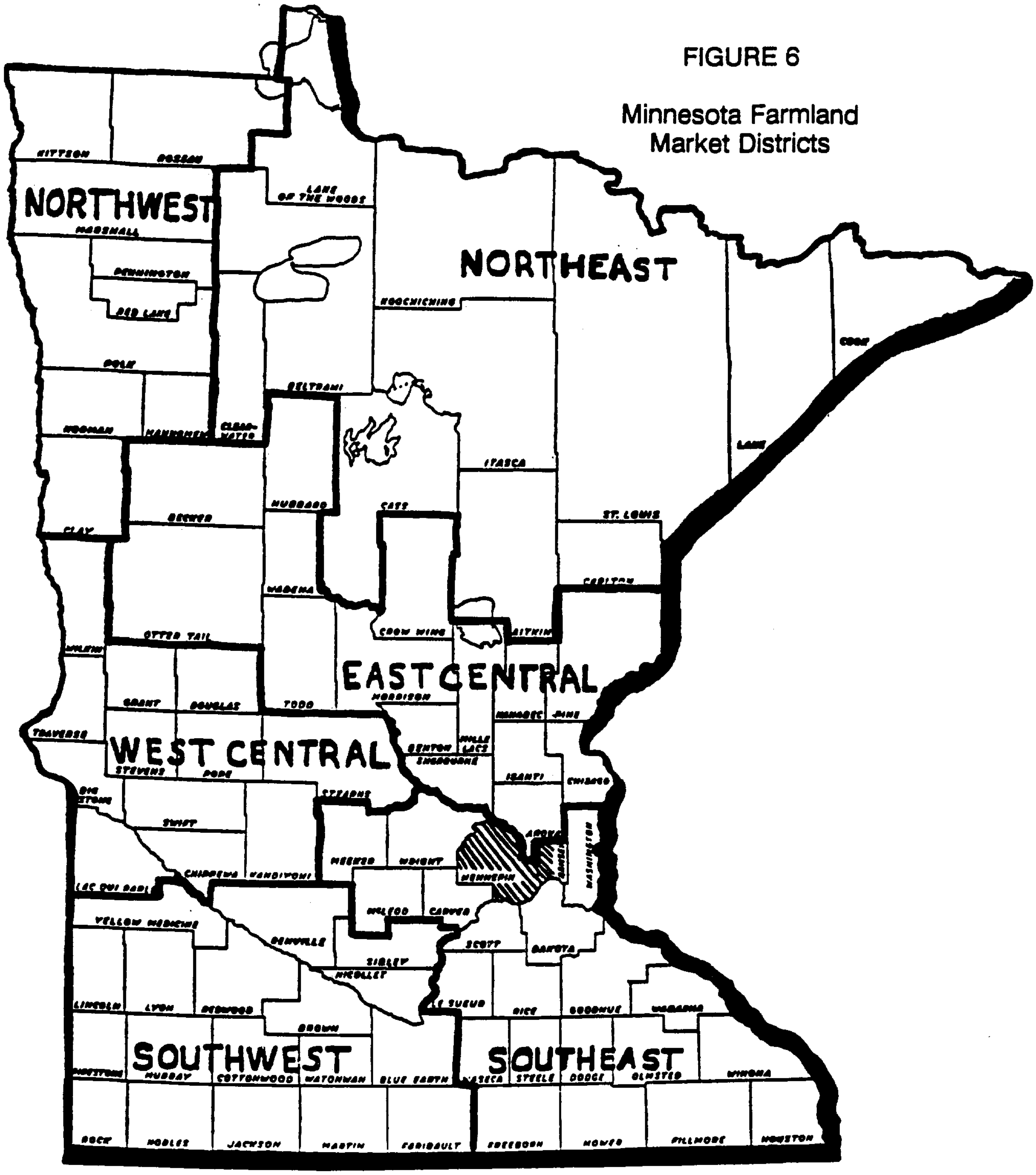
Acres Entered in Conservation Reserve Program
as a Percent of Total Acres of Land in Farms
Minnesota, 1989*



* CRP entries as of ninth round, August 1989. Acres of land in farms from 1987 Census of Agriculture.

FIGURE 6

Minnesota Farmland Market Districts



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METHODS OF LAND VALUATION
FOR ADMINISTRATIVE PURPOSES

by
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INTRODUCTION

Several methods of determining land value for administrative purposes have been developed in Italy since the '60s and their relative importance has increased within planning policy.

In this context, land refers not only to "farmland" for agricultural uses, but also to a resource to be used in different investments of planned development.

Traditional methods of land evaluation are primarily used in the relationship between individuals and public authorities: for fiscal assessment (stamp duty, capital gains taxation, etc.); for owner-occupier farms consolidation; for EC-directives application, etc. Market sales comparison approach, income capitalization approach and cost approach (as a part of an investment process) are mainly used in order to determine a land value estimate.

Conventional values of land are applied, furthermore, in expropriation and easement rights valuation procedures for public works in rural space (roads, highways, water channels, etc.) and for powerhouses and electric lines, etc.

Different methodologies and techniques are usually involved in the public interest, when a land valuation is required for environmental investments regarding natural resources (soils, water, etc.). In this context, benefit-cost analysis, cost effectiveness approach and the environmental impact assessment procedure are mainly used to fit requirements and comprehensive feasibility judgement as a support given to policy-decision makers.

This paper would offer some insight on this complex matter, from a methodological/operative point of view, taking into account the main economic events which require such types of valuation in Italy.

A TENTATIVE CLASSIFICATION

The main economic events which require a valuation process may be grouped in four categories, according to:
- the type of interest pursued (private or public),
- the type of operators involved (individuals and/or authorities).

Figure 1 visualizes a tentative classification of such events as follows (Grillenzoni, 1989a):

I - Appraised values in the private interest among individuals.

Main economic events:
- real estate transactions,
- land improvements within farms,
- farm production plan and related choices on processes, etc.

The valuation process used in Italy (figure 2a) is fairly similar to that suggested by the American Istitute of Real Estate Appraisers (cited, 1983) (figure 2a). So far, we think to spend no more words on it within the present paper (Grillenzoni, 1983 and 1989a).

More details will be given, on the other hand, in the other sections, in which an interesting evolution has taken place in Italy during the last twenty years.

II - Appraised values in the private interest between individuals and public authorities.

Main economic events:

- assessed incomes and values for fiscal purposes,
- estimates on incomes and values for owner-occupier farm consolidation (formation or enlargement),
- farm development plan, according to the EC directives and rules,etc.

III - Appraised values in the public interest of authorities over individual properties and rights.

Main economic events:

- expropriation procedures, through compulsory purchase,
- easement estimates for rights of way, waters, etc.,
- benefits estimates and costs allocation among landowners for land reclamation and maintenance activity, etc.

IV - Values and quanti/qualitative indicators in the public interest concerning public goods, works and services, even related to environmental quality.

Main economic events:

- administration and management of real estate (farms, parcels and/or buildings) owned by State and Local Authorities (Regioni, Provincie, Comuni, Enti Publici),
- projects valuation and feasibility of public works,
- environmental impact assessment - EIA, which in Italian is VIA ("Valutazione di Impatto Ambientale") in accordance with the EC directive 85/337.

APPRAISED VALUES IN THE PRIVATE INTEREST BETWEEN INDIVIDUALS AND PUBLIC AUTHORITIES

a) Assessed incomes and values for fiscal purposes

Assessed incomes and values for fiscal purposes are determined in Italy on a cadastral basis.

As far as farmland is concerned, two types of incomes are assessed:

1) **RD** = reddito dominicale, which represents the revenue (before taxes) of the landowner and includes rent and quasi-rent (for capital investments on land).
2) **RA** = reddito agrario, which represents the revenue imputed to the operating capital of the entrepreneur and to part (1/2 or 1/3) of the wage due to the farm director.

Currently, the two incomes are based on assessed figures 1978-1979 and will be adjusted on the 1988-89 base in the near future.

These incomes are applied primarily for the direct taxation (income tax) at the State and local level (respectively, IRPEF and ILOR).

Since 1986 the RD is used also for the indirect taxation on land transfers (market transactions, inheritance and real estate divisions) multiplying it by a certain coefficient. In detail:

1986-89 RD x 60 times

since 1990 RD x 75 times

Practically, the rate of capitalization decreased from 1.66 % to 1.33 %.

The assessed values for farmland usually lie below the market prices, as the following figures show (000 Lit per hectare):

	Croplands	Orchards	Meadows
RD (1978-79)	300	500	100
Coefficient	75	75	75
Assessed value	22,500	37,500	7,500
Average market prices 1990	30,000	45,000	10,000

This automatic procedure has been criticized, because it does not reflect the land market values over time, nor the structural changes occurred within the land use of the transferred farm. However, a positive judgement may be expressed, since the "ex-ante" valuation reduced the litigation between taxpayers and fiscal officers (Grillenzoni and Grittani, 1990).

The parameter RD is also used to determine the "legal" rent (equo canone) for tenancy contracts. In this case RD (still referred, according to the Law no. 203/1982, to the 1937-39 period) is multiplied by a range of coefficients varying from 100 to 140, plus 30-60 for buildings and land improvements.

b) Estimates on incomes and values for farm consolidation and development

We had the opportunity to present estimated "use" values last year at the Motta di Livenza Conference within the case study concerning the province of Ravenna in the Emilia-Romagna region (Bertazzoli and Grillenzoni, 1989).

These estimated values are required, according to the Law no. 590/1965 (and successive integrations), for financing the consolidation (formation and/or enlargement) of owner-occupier farms by loans.

Basically the "use" values estimated by specialized banks for agricultural credit are determined by the following formula:

$$V = [Vm + \frac{Rn}{r}] : 2$$

where:

Vm = estimated market value, by type of land use,

Rn = net income of the farm under consideration including capital income plus a percentage of labour income,

r = rate of capitalization, varying from 4% to 6% according to the type of land use.

The estimated value - V -, defined in Italian as "prezzo-congruo", is normally about 70-80% of the real market prices. In practical terms, significant variations of the mentioned percentages may occur region by region (and within provinces of the same region) depending on the behaviour of individual appraisers (operating as bank consultants), and of the SPAA (Servizi Provinciali Agricoltura e Alimentazione) officers (Grillenzoni and Gallerani, 1988).

A different farmland valuation procedure is used in Italy within the application of EC regulation 85/797 concerning the "farm development plan" (Jacoponi and Romiti, 1988). In particular, the Regional Department of Agriculture of Emilia-

Romagna suggests the estimation of the value of the farm involved in the plan in accordance with the VAM ("Valori Agricoli Medi"), which represent legal values of agricultural land primarily used in expropriation procedures.

APPRAISED VALUES IN THE PUBLIC INTEREST OF AUTHORITIES OVER INDIVIDUAL PROPERTIES AND RIGHTS

a) <u>The "average agricultural values"</u> (Valori Agricoli Medi - VAM)

The VAM were first introduced by Law no. 865/1971 (as revised by Law n. 10/1977).

These values are annually estimated by a Commission operating at the provincial level, in which "technical" experts of agriculture, forestry, housing and urban planning cooperate with public officers.

From a methodological point of view, the VAM are surveyed distinctly by type of land use (arable land, meadows, orchards, etc.) and aggregated within each "Agrarian Region", excluding from the surveyed values the incidence of rural or urban buildings, the costs of urbanization and the influence of agrarian contracts (tenancy, sharecropping, etc.), which may have the effect of either raising or lowering market prices of farmland.

Traditional appraisal procedures (sales comparison, capitalized income, cost approaches and related combinations) are usually applied to fit the law requirements.

The practical determination of VAM was improved over time (Grillenzoni, 1979). The definition of "type of use" was amplified and the corresponding values took several factors into account.

For example:

- different location of cropland within the "Agrarian Region";
- different farming techniques (orchards with low or high density of plantation);
- the "management" (or not) of forests, chestnut groves, etc..

Table 1 reproduces an example of the 1990 VAM for the province of Bologna.

b) <u>The application of VAM in the expropriation process</u>

As we previously pointed out, the VAM were primarily introduced for the expropriation processes concerning farmland conversion to other uses: public works in the countryside, housing in planned areas, etc..

Two stages are legally contemplated:

i) <u>Volontary transfer of land</u>

Indemnity is differentiated by type of farm operator as follows:

	Landowner	Owner-Occupier	Tenant and sharecropper
Basic indemnity	1 VAM	1 VAM	1 VAM
Added indemnity for volontary transfer	0.5 VAM	2 VAM	-
Total	1.5 VAM	3 VAM	1 VAM

No capital gains tax is levied if the expropriation is formally authorized in the public interest.

If the landowner is not satisfied with the amount of 1.5 VAM, mostly in the case of a partial taking, he may request a revision of the indemnity by the Commission (CPE = Commissione Provinciale Espropri).

ii) Compulsory purchase of land

The CPE is empowered to estimate the definitive indemnity for compulsory purchase of a parcel of land by authorities, taking into account:

- the real cultivation existing on the land involved in the process;
- the depreciation elements of the residual part of the land (Grillenzoni, 1989b).

Effective (and not average) land value is estimated at this stage, considering every price differential between the taking off part (A) and the residual one (B). In other words, the appraisal procedure may be expressed as follows:

$V_{(A)} = V_{(A+B)} - V_{(B)}$

The CPE decision may be appealed in Court. The Court provides a revision of the appraisal, through a judge's technical consultant (CTU).

A similar procedure is applied in the case of easement valuations. In particular, since the property remains in the hands of the original owner the capitalized value of taxes and tributes applied on the land is added to VAM.

c) Benefits/costs valuation with respect to land reclamation activity

More than two thirds of the Italian territory has been involved in land reclamation activity.

The cost of such activity is mainly supported by State funds (75% and over); the residual part is imputed to real estate owners, subdivided by categories in accordance with the received benefits. Historically, these benefits were estimated assuming the following parameters:

i) either the increase of the capital value of real estate (rural or urban);

ii) or the increase of the property income.

Most of the reclamation activity is now devoted to the maintenance of public works developed in the past and, therefore, the objective-function is to maintain the achieved level of real estate value and/or income.

The cadastral RD (previously mentioned) is normally assumed as the economic parameter to allocate operating costs among real estate owners.

A methodological proposal to review the criteria of costs allocation was recently set up in a context of environmental protection (Bazzani, 1990).

VALUE INDICATORS IN THE PUBLIC INTEREST

a) Administrative values of public property

Several categories of real estate (buildings, parcels, and agricultural land) are owned in Italy by Public Administrations, at the State and Local levels.

A Parliamentary Commission was appointed in 1985 (Ce.S.E.T., 1988):

i) to survey the assets of public real estate, identifying the location, the consistency, the utilization and the conservation conditions;

ii) to estimate the capital value of these assets and the related income flows;

iii) to examine the more convenient types of use, even valuing the possibility of selling or leasing part of them.

The result of this "inventory" operation is showed in table 2.

The prices for each real estate category were appraised according to prudential criteria:

- updating registered values in the account books for buildings, equipped areas and forested land;
- assuming, with adjustments, statistical values estimated by INEA (see our opening paper at the Motta di Livenza Conference) for agricultural land.

The surveyed public agricultural land represents more than 10% of the national total, while the forested land is about 1/4 of the corresponding total.

The distribution of the total estimated value (651,000 billions of Lit) is approximately the following:

- local administrations (Communes): 44%, 33% of which concerns land (mostly equipped);
- central administrations (State, etc.): 27%, 6% of which concerns land;
- other public administrations: 29%, almost 28% of which concerns land.

The equipped areas (more than 50% of the total estimated value) are mainly represented by public investments, like roads, freeways and highways, airports, harbours, channels, railways, ecc..

The other land, still classified as agricultural, but potentially changing to other uses, is mainly located in the urban-rural fringes or in areas of touristic interest. Most of the latter are going to be protected because of landscape and natural beauty (Grillenzoni, 1990b).

As we said, the Commission also made proposals in view of ameliorating the management of these public assets. Several operative options were formulated, specifying the methodological approaches of valuation, as follows:

- real estate for which the management will continue by actual ownership. In this case options would be selected by the expected IRRs (internal rate of return);
- real estate for which the management will continue ordinarily by concession, reviewing the actual rents (very low, indeed) on the base of updated capital value;
- real estate to be put in a "real estate fund " for which an "ex-ante" valuation is required to forecast income flows and expected capital gains;
- real estate for which a reconstruction (or transformation) may be suggested in accordance with "new" opportunities of convenient use;
- real estate for which the sale (or the transfer to other Administrations) is suggested in order to reduce the public debt. As far as the transfer is concerned, this option is related to an exchange within the ongoing expropriation processes [1].

b) Projects valuation and feasibility of public works

The "philosophy" of the Benefit-Cost Analysis (BCA) is quite known and applied in the United States for many public works since the '50s.

According to the Federal Inter-Agency River Basin Committee (1958), benefit-cost analysis is designed "to provide a guide for effective use of the required economic resources, such as land, labor and materials, in producing goods and services to satisfy human wants" (p.5) [2].

The BCA has been introduced in Italy fairly recently.

After occasional contributions finalized to scientific investigation, the BCA has been applied in Italy starting from the '80s, with the Mid-Term Plan 1981-83 by which a Valuation Committee was proposed and set up for Public Investments ("Nucleo di Valutazione degli Investimenti Publici").

Currently, several laws and financing agencies (FIO, Casmez,

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(1) The pending processes involve about 380 thousand m^2, since the Constitutional Court (sentence no. 5/1980) declared the VAM system unapplicable to the urban areas. The re-establishment of the "Just price" criteria for them involves, therefore, new (and more expensive) indemnities.

(2) As Barlowe (1986) pointed out BCA "is not the only basis for approving or disapproving resource development projects, ... but insofar as economic considerations prevail, benefit-cost valuations can point the way to efficient use of public funds in land resource developments".In detail, the BCA assumes that:
"1) projects have economic value only to the extent that need or desire exists for their services;
"2) each project should be developed at the scale that provides the maximum excess of benefits above cost;
"3) every project or separable segment thereof should be developed at the least practicable cost commensurate with the overall objectives of the project;
"4) the development priorities assigned to various projects should follow the order of their economic desiderability" (p.173).

etc.) establish the criterion for judging the projects on the basis of the BCA in view of the economic and social objectives of the Mid-Term Plan (Pennisi et al., 1985).

Every project for a public work must be submitted for formal approval, and is subjected to a 4 steps procedure:

i) identification of the more satisfying project, through a pre-feasibility analysis, examining possible alternatives and priorities in terms of technological solutions and of the financial resources involved;

ii) feasibility study, which focuses on every aspect of the selected project, so that a comprehensive judgement can be expressed with respect to the overall objectives, including the environmental restraints, the community involved, etc.;

iii) financial [3] and economic [4] valuation, generally developed through monetary procedure (BCA), sometimes integrated by non monetary procedures (for example, EIA = Environmental Impact Assessment) when required, as we will explain further;

iv) final statement, with recommendations and/or suggestions for the decision-makers.

The methodological aspects of BCA are fairly well known in literature (Misham, 1971), as well as in land resource development (Barlowe, 1986) and conservation (Ciriacy-Wantrup, 1961). Let us say, for a better understanding, that after the identification of benefits (primary, intangible, and secondary) and costs (direct, associated, external and secondary) the most relevant problems come from:

i) the determination of the relevant time period within which the project effects might be exhaustive versus the financial pay-back period;

ii) the selection of the more appropriate discount rate.

As far as the Italian operating rules are concerned, public financement is actually limited to projects, which do not exceed a time period of 25 years; the discount rate of benefits and costs varies within a range of 5-8% (Grillenzoni-Grittani, 1990).

Even if the BCA has been accepted for several public investments and improvements have been recently incorporated in the techniques applied in Italy, "critics of benefit-cost analysis have argued that it is at best a system of partial analysis; ... the data used in computations of benefits and costs are often inadeguate and incomplete, with the result that benefits are sometimes underestimated and on other occasions inflated. ... Significant impacts such as the projects effects may have on the natural environment or on local prospects for economic growth are ignored" (Barlowe, cited, p.179).

For these reasons the overall valuation of projects involving public interest has been recently integrated by new approaches in Europe, including the CIE (Community Impact Evaluation) (Lichfield, 1988) and the EM - Evaluation Method, based on multidimensional analysis proposed by Albers and Nijkamp (1988) in planning assessment. The EM is a non-monetary analysis, which is recognized and is able to handle quantitative and qualitative

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[3] This analysis is market-oriented in terms of prices and costs related to an individual operator (either private or public).

[4] This analysis is strictly developed in the public interest, according to the community requirements to be fitted from a social and a political point of view.

information according to a continuous and repeateable decision function.

c) <u>Environmental impact assessment</u>

The EIA - Environmental Impact Assessment "should be viewed as an integral part of the project planning process, beginning with an early identification of project alternatives and the potentially significant environmental impacts associated with them, and continuing through the planning cycle to include an external review of the assessment document and involvement of the public" (UNECE, 1987).

Almost at the same time, the Council of the European Communities issued Directive no. 337 on "the assessment of certain public and private projects on environment" [5].

The Directive applies to different project typologies, which are likely to have significant effects on the environment as a result of their nature, size and location. The projects are identified in two lists, as follows:

i) Annex 1 contains a list of 9 classes of relevant projects for which the VIA (Valutazione di Impatto Ambientale) is always to be taken;

ii) Annex 2 contains a long list of classes of projects covering agriculture, extractive industry, manufacturing, energy production, infrastructure and waste disposal, which shall be assessed where Member States consider that their characteristics so require.

A comparative graphic analysis between EIA and VIA is shown in figure 3, which visualizes:

a) the process; b) the statement and c) the procedure.

An important moment of this context is the <u>consultation</u>, both of the authorities and of the public, to check the sensitivity of the receiving environment.

In Italy, citizens are generally involved when the SIA (Studio di Impatto Ambientale) has almost completed the valuation procedure; in the USA, citizens are involved much earlier in the planning process, beginning with scoping: the first hearing usually takes place before the preparation of the EIS draft.

Most of the VIA literature deals with methodologies and techniques to be used for assessing the environmental impacts of development actions (Polelli, 1989; Bresso, et al., 1985; Schmidt di Friedberg, ed. 1987).

Among the various tested techniques, the multidimensional valuation "family" ("multi-objectives" and "multicriteria" analyses) seems to be the most suitable approaches to treat the complexity of the environment (Fusco Girard, ed. 1989 and Ragazzoni, 1990).

d) <u>Final remarks</u>

The previous analysis, concerning the projects valuation and the environmental impact assessment, is specifically related to the planning processes of urbanization and of industrialization

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[5] Member States had to comply with the Directive within 3 years of the date of notification (June 27, 1985).

including infrastucture.

Limiting our attention to natural resources, a recent Italian law (no. 183/1989) provides comprehensive rules for a "new functional assessment and management of soil and water protection" (Martuccelli, 1989, and Federbim, 1990).

The law is a complex one, since it involves the competence of several Ministries: firstly, Environment and Public Works; secondly, Agriculture and Forestries, Civil Protection, and the Agency for the "Mezzogiorno"; thirdly, the corresponding Regional Departments. Furthermore, at the local level, the law involves the activity of public authorities (Provinces and Communes) and of land institutions like "Comunita' Montane", "Consorzi di bonifica ed irrigazione", "Consorzi di bacino imbrifero montano".

The body of rules enlarges the meaning of "soil protection", visualizing it as an intersectorial and interdisciplinary activity, finalized to four main objectives:

i) soil arrangement, hydraulic regulation and prevention;
ii) recovery of surface and underground water;
iii) rational use of water resources;
iv) maintenance of protection works and conservation.

Several actions are listed by the law in this context of objectives. These actions need to be defined within each catchment basin/area through a "basin plan".

The general scheme of a "basin plan" is shown in figure 4.

As far as methodological aspects are concerned, the planned actions must be submitted to BCA and VIA procedures to express appropriate feasibility judgement on each project. This involves priorities and the ordering of actions in a 3-year period. Therefore, the "basin plan" management entails adjustments over time.

A first act of application (D.P.C.M. 23 marzo 1990) of the cited law recognizes the necessity to face the main crisis or emergency situations within each basin. So far, the 1989-91 period should be primarily devoted to maintanance actions, for which the suggested valuation approach is the cost-effectiveness analysis (Pearce, 1971, Wolfe, 1973).

At the same time, the law suggests the setting up of "basin pilot-plans" at the regional level, using the existing information supports and technical competences, available at the more efficient land institutions previously mentioned.

The setting up of an Information-System at the national level seems to be more complex, since this operation implies the re-arrangement of the main "Technical Services" [6] and the implementation of appropriate data banks and thematic cartography.

After these technical aspects, for which the time requirements are supposed fairly long because of studies needed, modern EDP instruments and qualified personnel availability and formation, what worries to a greater extent is the spoils system and the subdivision of administrative competences [7]

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[6] In details, the technical services of national level presently are the following: hydrographic, marigraph, seismic, geological, dams.

[7] For example, the Tevere river (which represents one of the 11 "basins" of national level) depends on 3 Ministeries, 6 Regions, 20 Provinces, hundreds of Communes and of local institutions.

(Grillenzoni 1990a).

In conclusion, for the evident complexity of the matter, a realistic opinion is that Law no. 183/89 has to be properly interpreted, before its generalized application. This would involve a significant process of institutional innovation. However this paper is mainly devoted to valuation methods, so these problems will be better investigated during the third session of this conference.

We will attend it!

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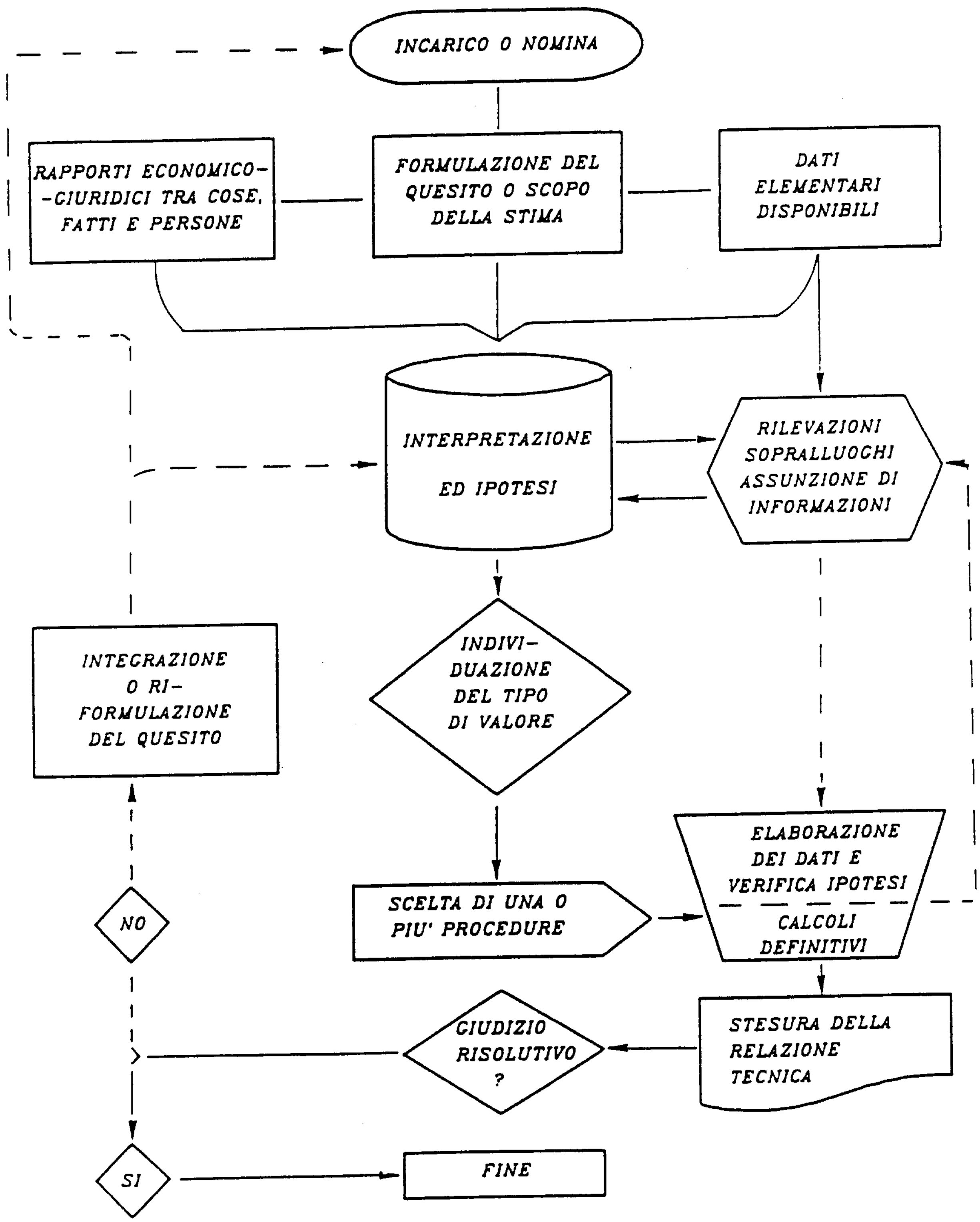
Figure 1 - MAIN ECONOMIC EVENTS WHICH REQUIRE A VALUATION PROCESS WITHIN:

PRIVATE INTEREST AMONG INDIVIDUALS I	PRIVATE INTEREST BETWEEN INDIVIDUALS AND PUBLIC AUTHORITIES II
III PUBLIC INTEREST OF AUTHORITIES OVER INDIVIDUAL PROPERTIES AND RIGHTS	IV PUBLIC INTEREST OF AUTHORITIES CONCERNING PUBLIC GOODS, WORKS AND SERVICES, ENVIRONMENTAL QUALITY INCLUDED

Figure 2a - SCHEMATIZZAZIONE DEL PROCESSO DI VALUTAZIONE IN ITALIA



Source: Grillenzoni - Grittani, 1990, p. 193.

Figure 2b - THE VALUATION PROCESS IN THE UNITED STATES

Definition of the Problem

Identification of real estate	Identification of property rights to be valued	Date of value estimate	Use of appraisal	Definition of value	Other limiting conditions

Preliminary Analysis and Data Selection and Collection

General	Specific (Subject and Comps)
Social	Site and improvement
Economic	Sales
Government	Cost
Environmental	Income/expense

Highest and Best Use Analysis

Land as though vacant
Property as improved

Land Value Estimate

Application of the Three Approaches

Sales comparison | Income capitalization | Cost

Reconciliation of Value Indications and Final Value Estimate

Report of Defined Value

Source: Am. Inst. of Real Estate Appraisers, 1983, p. 30.

Figure 3 - ENVIRONMENTAL IMPACT: A COMPARATIVE GRAPHIC ANALYSIS

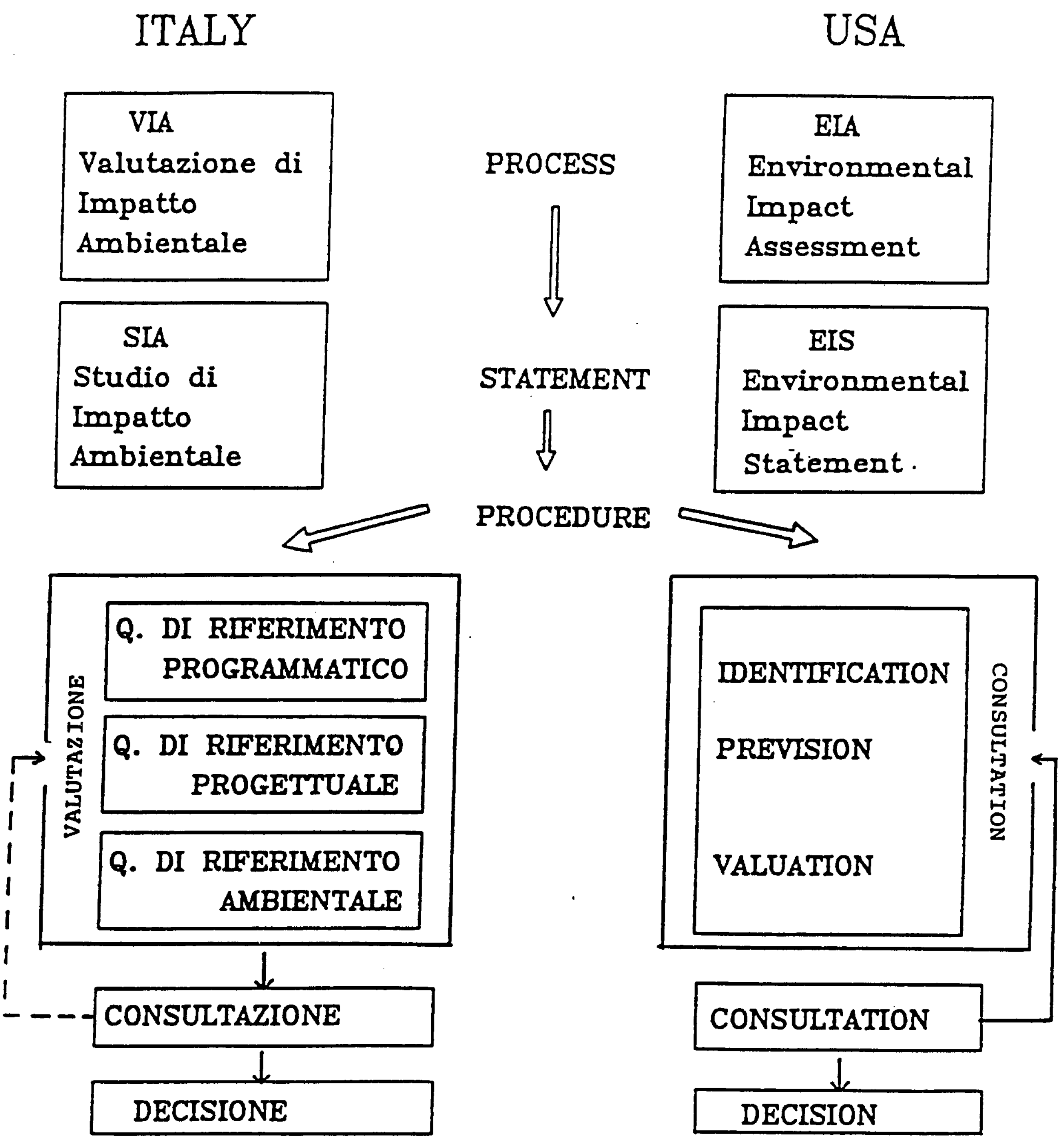


Figure 4 - SCHEME OF THE "BASIN PLAN" (Law no. 183/89)

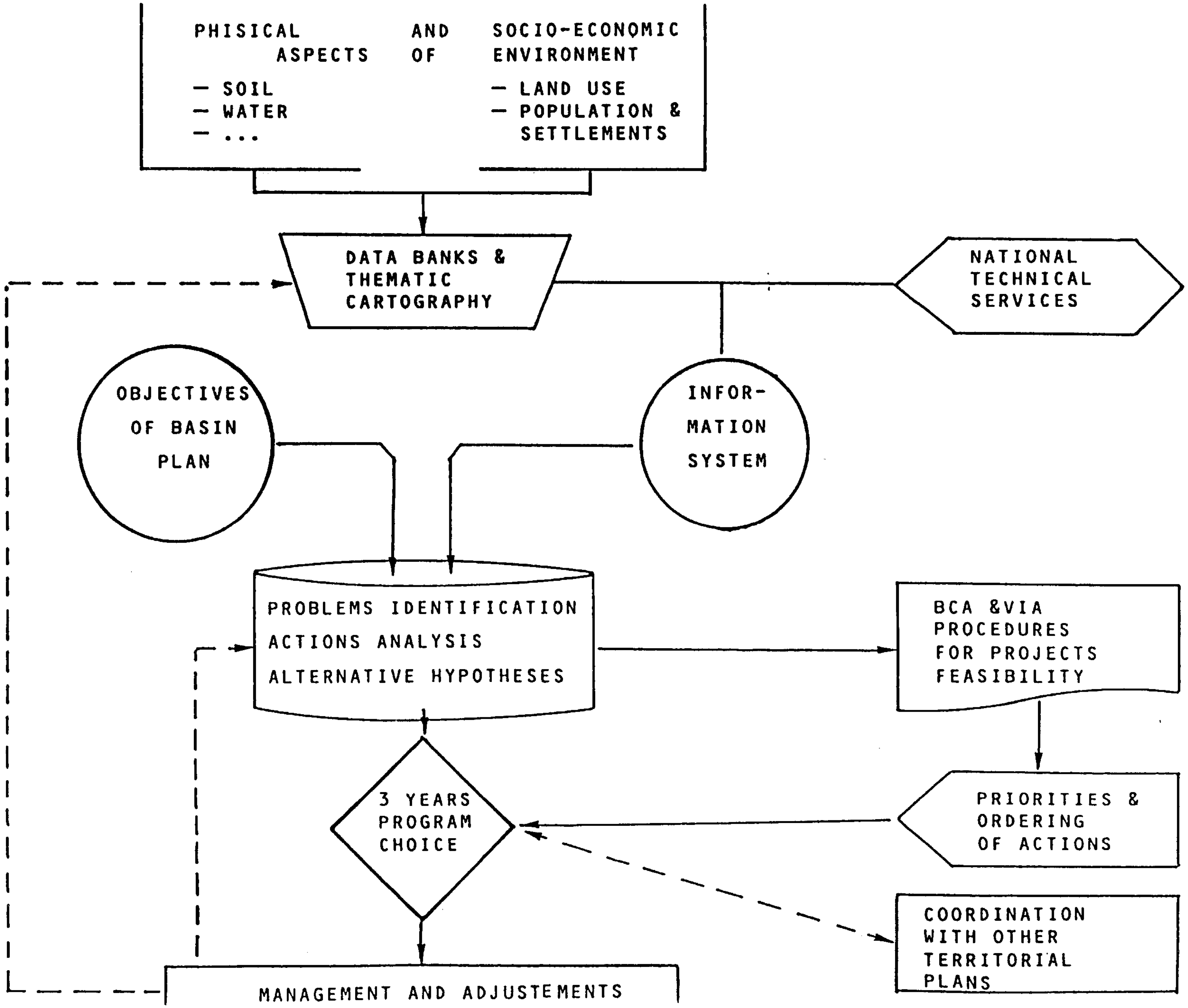


Table 1 - AVERAGE AGRICULTURAL VALUES (VAM) FOR 1990 (Lit/hectare).

Tipo di coltura	MOUNTAIN		HILL			PLAIN		
	Regione agraria n. 1 Valori medi a Ha	Regione agraria n. 2 Valori medi a Ha	Regione agraria n. 3 Valori medi a Ha	Regione agraria n. 4 Valori medi a Ha	Regione agraria n. 5 Valori medi a Ha	Regione agraria n. 6 Valori medi a Ha	Regione agraria n. 7 Valori medi a Ha	Regione agraria n. 8 Valori medi a Ha
Seminativi e seminativi arborati:								
di pianura	-	-	33.000.000	24.000.000	25.000.000	28.000.000	28.000.000	30.000.000
di collina	8.000.000	-	20.000.000	16.000.000	16.000.000	20.000.000	-	20.000.000
di montagna	6.500.000	6.500.000	-	10.000.000	10.000.000	-	-	-
Seminativi irrigui e seminativi arborati irrigui:								
di pianura	-	-	40.000.000	30.000.000	30.000.000	30.000.000	30.000.000	35.000.000
di collina	-	-	23.000.000	-	-	-	-	-
Prati:								
di pianura	-	-	30.000.000	18.000.000	18.000.000	18.000.000	18.000.000	18.000.000
di collina	4.000.000	4.000.000	14.000.000	11.000.000	11.000.000	-	-	-
Prati coltivati	6.300.000	6.000.000	-	11.000.000	11.000.000	14.000.000	-	14.000.000
Prati arborati	-	-	-	-	-	-	-	-
Prati irrigui	-	-	-	-	-	-	-	-
Prati arborati irrigui	-	-	-	-	-	-	-	-
Pascoli	1.800.000	1.800.000	2.700.000	2.700.000	2.700.000	-	-	-
Pascoli arborati	-	-	3.200.000	3.200.000	3.200.000	-	-	-
Pascoli cespugliati	1.500.000	1.500.000	1.800.000	1.800.000	1.800.000	-	-	-
Orti	12.600.000	11.700.000	-	-	-	-	-	-
Orti arborati	-	-	-	-	-	-	-	-
Orti irrigui	-	-	41.000.000	30.000.000	30.000.000	30.000.000	33.000.000	35.000.000
Orti arborati irrigui	-	-	-	-	-	-	-	-
Orti a coltura floreale	-	-	-	-	-	-	-	-
Orti irrigui a coltura floreale	-	-	-	-	-	-	-	-
Risaie	-	-	-	-	-	-	32.000.000	-
Vivai	20.000.000	20.000.000	44.000.000	30.000.000	30.000.000	33.000.000	33.000.000	33.000.000
Vivai a coltura floreale	-	-	-	-	-	-	-	-
Vigneti	15.300.000	15.300.000	35.000.000	30.000.000	30.000.000	25.000.000	26.000.000	30.000.000
Vigneti irrigui	-	-	-	-	-	-	-	-
Vigneti D.O.C.	-	-	40.000.000	35.000.000	35.000.000	28.000.000	-	35.000.000
Vigneti irrigui D.O.C.	-	-	-	-	-	-	-	-
Uliveti	-	-	-	-	-	-	-	-
Frutteti di actinidia	-	-	-	-	45.000.000	-	-	45.000.000
Frutteti di pomacee:								
a bassa e media densità	-	-	35.000.000	28.000.000	26.000.000	30.000.000	30.000.000	32.000.000
ad alta densità (n. 1500 piante-Ha)	-	-	40.000.000	30.000.000	27.000.000	32.000.000	32.000.000	34.000.000
Frutteti irrigui di pomacee:								
a bassa e media densità	-	-	40.000.000	32.000.000	29.000.000	32.000.000	32.000.000	35.000.000
ad alta densità (n. 1500 piante-Ha)	-	-	42.000.000	-	-	34.000.000	34.000.000	38.000.000
Frutteti di drupacee:								
a bassa e media densità	-	-	38.000.000	30.000.000	33.000.000	32.000.000	32.000.000	34.000.000
ad alta densità (n. 1500 piante-Ha)	-	-	-	-	-	-	-	-
Frutteti irrigui di drupacee:								
a bassa e media densità	-	-	44.000.000	35.000.000	35.000.000	35.000.000	35.000.000	38.000.000
ad alta densità (n. 1500 piante-Ha)	-	-	-	-	-	-	-	-
Canneti	-	-	13.500.000	13.500.000	13.500.000	13.500.000	13.500.000	13.500.000
Gelseti	-	-	-	-	-	-	-	-
Pioppeti: (1) (2)								
golenali	-	-	15.000.000	15.000.000	15.000.000	15.000.000	17.000.000	17.000.000
di ripa	-	-	14.000.000	14.000.000	14.000.000	14.000.000	15.000.000	15.000.000
Castagneti:								
specializzato (marrone)	13.000.000	13.000.000	-	13.000.000	15.000.000	-	-	-
governato	8.000.000	7.000.000	-	11.000.000	10.000.000	-	-	-
degradato	3.200.000	3.600.000	-	3.600.000	4.100.000	-	-	-
Castagneto da paleria	7.000.000	7.000.000	-	7.000.000	7.000.000	-	-	-
Boschi d'alto fusto: (2)	6.300.000	7.200.000	-	6.300.000	6.300.000	-	-	-
Boschi misti:								
governati	6.300.000	6.300.000	7.500.000	7.500.000	7.500.000	7.000.000	5.000.000	5.000.000
degradati	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.600.000	1.600.000
Boschi cedui:								
governato	5.400.000	5.4[illegible]	6.000.000	6.000.000	6.000.000	6.000.000	4.500.000	6.000.000
degradato	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.400.000	1.600.000
Coltivi abbandonati	3.600.000	3.600.000	15.000.000	10.000.000	9.500.000	14.400.000	14.400.000	14.000.000
Incolti produttivi	1.400.000	1.400.000	9.000.000	2.000.000	2.000.000	9.000.000	9.000.000	9.000.000
Incolto sterile	700.000	700.000	900.000	900.000	900.000	900.000	900.000	900.000

NOTES :

(1) Per i pioppeti impiantati su seminativo, il prezzo di riferimento è quello dei corrispondenti terreni a seminativo;

(2) In queste colture i soprassuoli vanno valutati a parte;

- I valori sopraindicati si intendono al netto dell'incidenza dei fabbricati o manufatti eventualmente esistenti sul terreno e non sono comprensivi dei fru: pendenti, ove sussistano;

Table 2 - VALUATION OF PUBLIC PROPERTY IN ITALY

REAL ESTATES CATEGORIES	Quantity (billions of m²)	Estimated Price (Lit/m²)	Approximate Value (billions of Lit)	(%)
1. *Buildings*	1.03	215,000	220,000	33.8
2. *Equipped land*	1.65	200,000	330,000	50.7
3. *Agricultural land*				
a) potentially extra-agr. use	5.15	17,500	90,000	13.8
b) strictly agr.use				
- plain (15%)	4.00	1,000	4,000	
- hill (25%)	6.50	300	2,000	
- mountain (60%)	16.00	60	1,000	
SUBTOTAL	26.50		7,000	1.1
4. *Forested land*	15.55	250	4,000	.6
TOTAL			651,000	100.0

SOURCE: Estimates by "Commissione Cassese", 1987.

DETERMINANTS OF FARM REAL ESTATE VALUES

by

F. Mari (*) and L. Venzi (**)

1. INTRODUCTION

Dealing with land values, the appraisal doctrine postulates that farm real estate has a double character: as an imput, but also as an assett, with a high degree of peculiarities. Many are in fact the variables which concur to the physical conformation of farm capital and therefore, in the greatest majority of cases, the result is such that each farm has its own peculiarity, that sometimes makes very difficult to find out a similar one, even in the neighborood.

Following this considerations, the difficulties, which usually are encountered when we have to determine value appraisals, are evident. In a country like Italy, appraisal of values is even more difficult since very few, and not reliable, are the information which can be found out relating to the farm real estate market. This in particular happens mostly because the data banks relating to this sector are in reality still relatively new and therefore we lack a great deal of information, which can be acquired from them.

Other sources of data, particularly those of official origin, present a poor selection of quantitative features. It is very well known in fact, that the dealers are often oriented to

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understate both the number of transactios and the values relating to them.

The above mentioned situation is, therefore, one in which research workers of the farm market find themselves many times in trouble. However, despite of this adverse situation, several other factors cooperate in homogenizing the characteristics of farm real estate.

One of those cases is well represented by the philbert nuts in the Viterbo area. The peculiar pedo-climatic conditions of this area, together with the high profitability of the crop, in fact, managed to determine in the last 20 years a promising development of the crop itself and of the local economy on the whole.

Considering also the rising costs for manpower, this crop has undergone various technological innovations, achieving a great uniformity in the production processes. We experienced in reality a process which, activated by economic motivations, ended up inevitably with implications on the farm structure and therefore on the whole landscape of the area, earning, again at the same time, a great degree of homogeneity.

Considering the goals of the present paper, we have to treat other features as well, and another very important component of the agricultural economy of the area, that is the local market structure for philbert nuts. It is in fact possible to say that, their supply is basically dispersed in small and medium size enterprises, and the marketing channel, served by several intermediaries, faces a demand activated by a very small number of firms, under oligopoly whith price leadership. The latter firms, moreover, are characterized by a great variability in their economic outlets.

The economic implications from this imperfect market form will be dealt with in detail later on. At the moment, however, this implies that the price of the product is fixed and therefore it is the same for all the farms. In such a situation this fact is of great importance, as the price of the product appears to be one of the most relevant variables, if not the only one, in the formation of the farmers' income. To this variable, therefore, a great deal of care is given and also from its variability may depend farmers' attitudes to land capital.

A great homogeneity is present in the farm structure as well as in the behaviour of all the farmers. All that obviously ends up by orienting land market flows fairly well defined both in direction and in intensity. At this stage, it seems reasonable to ask to what extent the farm value is a function of variables embodied in the land itself and, otherwise, to what extent it is a function of variables of more general nature such as, for instance, product price, crop income, technological development, and so on. This is the question to which the paper will try to look for an answer.

Before entering into details and in order to give a better understanding of what is being considered here we shall proceed to deal with a brief note on the present economic situation of the philibert nuts production in the Viterbo area and a short description of the area under investigation.

The specification and formulation of an explanatory model will follow relating to farm real estate values, to the dependent and independent variables, to the results achieved by the model. Final considerations will conclude this paper.

2. FEATURES OF THE FILIBERT NUTS PRODUCTION IN VITERBO PROVINCE

The most suitable area in Viterbo province for Philibert nuts is located around lake of Vico, on the western, southern and eastern rim of the volcanic crater. It amounts to roughly 12.500 HA of arable land. More precisely, that area is located in the territories of the small towns of Capranica, Caprarola, Carbognano, Ronciglione and Vallerano. Presently, in fact, almost 50% of the total surface at Philibert culture of the whole province of Viterbo, which amounts to 18.500 HA, is concentrated in that area. That means that in many of the above mentioneted towns, the crop covers almost 80% of the arable total cropping surface.

This amazing development of the Philibert nuts crop, of at least 700% in the last 30 years in terms of invested land, has its principal motivation in the peculiar soil and climatic characteristics of the area and the very satisfactory incomes due to high prices.

The average size of farm is about 2 HA and it determines their part-time management and, therefore, an inadequate technical expertize by these farmers. That means that cropping practices are run under a loose empyrical control, with particular reference to the pest and weeds treatments. These features, together with those connected with dust, caused by ground picking of the nuts made by vacuum machinery, affect also the quality of local enviroment. In fact, given the high intensity of the crop, these factors are heavily abused and present quantitative-qualitative aspects that badly can be reconcilied with the ecological and naturalistic image of our zone (it is included there the Natural Reserve of Lake Vico).

Coming back to agronomic features, it is possible to say that the above mentioned nut development has been sustained and paired by a thorough revolution in the cropping techniques. Not too long ago, the majority of operations were performed by hand, but nowadays, with the exception of light pruning, all other operations are carried out mechanically. This has been made possible because of the widespread diffusion of agricultural machinery, especially that of reduced size and power and therefore more adaptable to small scale farms.

The high cost of labour and the difficulties encountered regarding its supply have determined a continuos evolution of the cropping techniques. Obviously, this was geared towards lowering production costs. In fact, presently, there are many areas where already existing irrigation structures, mostly drop irrigation, have recently been adapted for fertilizer-irrigation and also for leaf fertilization. All this occurs, of course, in advanced technology farms and where normally we also find the adoption of greening the soil, by the diffusion of lawns, in lieu of frequent soil cultivations. It is not too risky to assume, therefore, that it is in this direction that we can expect an evolution in cultural techniques, mostly because it responds to economic motivations, as well as to ecological ones, above described.

With respect to the goals of the present paper, moreover, we feel that a quick review of the economic issues of the crop under observation is quite necessary. A few years ago, however, the destiny of the filibert nuts crop has completely changed, to the point that what was before considered as a crop least needy of care, now appears, instead, to be in great difficulties, particularly for the outlet of its produce on domestic and foreing markets. It turned into a crop which finds great difficulty to pay back for the inputs employed. Such crisis of the Italian filibert nuts is well synthetized by the evolution of its prices for the product, shown in Fig.1. As we can see the price from 1985 onwards results in a continuous and persistent down slope. The reasons for such phenomenon are, obviously, many, but the most relevant of these can be summarized as follows:

a) high competition from Turkish production;

b) manufacturing destination of the product: it determines that the most delicate taste and other qualitative characteristics of our production are not taken any longer into consideration, (Tabl. 1 & 2: shell free productions = industrial uses; production in shells = direct consuption) . To that matter it is relevant to consider that the baking industry, including national firms, are ever more undergoing a concentration process in the hands of multinational companies;

c) high elasticity of the demand with respect to its price. This is due to the fact that filibert nuts have many substitutes, particularly in industrial uses (cocoa);

d) high production costs of the Italian filibert nuts, with the exception of the produsts from Viterbo, in fact, the increase of filibert nuts production is not due to its extensive cultivation, rather to the intensification of its croping techniques. This has determineted relevant increases in production costs;

f) poor organization in the marketing process of the product. In the Viterbo area, the few harvesting and marketing firms, not having a common supply strategey, end up in a fierce competition amongst themselves when they face the baking firms. This phenomenon is more pronounced, not only by the presence of small co-operative producers on the market, but also by the presence of small firms having their own drying plants, or even without thoce ctruoturee, and, therefore, unable to stock the products;

g) unfavourable EEC policy for the product. By Regulation 4115/86 EEC, a tariff of about 4% only is applied for the import from extra Comunity Countries, with an exemptiom for 25.000 tons.

At this stage we feel extremely relevant to produce also a brief panorama of the characteristics of the farm real estate market in the area above considered. It could be stated that this market has been, and still is, so highly dynamic and so selective, that it created many worries in the local populations. The phenomenon was so striking that the Cassa Rurale ed Artigiana (saving/co-operative bank) di Capranica, one of the towns in area considered, felt necessary to support an enquiry on the state of the land market, published last year. This research work referred basically to the territory within comunal boundaries. The most important data in it are synthetized in the following table (Tab.3).

Besides of land transactions, related to the territory and its farm structure, great interest derives from transactions between the residents and non-residents of Capranica. One of the main objectives of the above mentioneted study, in fact, was to work out the balance sheet of the local land still in the hands of residents. These sales, therefore, result as a sub set of those which occurred in reality and, nevertheless, they show that in the whole period 1975-86 there has been a flow of 34 HA/year of the Capranica territory which went out of the hands of local inhabitants. The latter figure is much more significant of what it can show at first sight, because, as it is well known, the transactions in the farm market are very scarse and particularly those with residents of different towns. In this specific case, instead, the 34 HA/year related to transaction esclusively with strangers and very often with residents of far distant towns, for example, with the inhabitants of Caprarola, about 35 Km far from Capranica. The latter farmers, in fact, were the major buyers of the said lands.

3. THE MODEL

A tentative model to explain the behaviour of real estate farm values is here proposed, specifying a structure which relates land value to other determinants of its price.

The literature is quite large on the subject and we can refer to it in the bibliography. Previously (1989) we tried to deal with the same problem by specifying a structure, where explanatory variables belonged to intrinsic features of the land itself (i.e. size of plots, distance from village, crop yields and income, land taxes, etc.).

That model performed quite well, but other variables have been proposed, by this very audience in Motta di Livenza, some of macro nature, and others again from the micro area. The structure that we propose now comes from many considerations relating to the purchasing patterns of the population of the towns in the area above mentioned. It is well known in that area that there is a strong seasonality in income flows, not a surprize, given its full dependance on the payment of filibert nuts sales in late fall. The purchases deal with consumer goods, but, more and more nowadays, also with durable goods (cars, domestic appliances, tractors) and fairly recently also with Treasury Bonds.

This development, as diverting from consumption to savings, provides certainly a relevant impact on the dynamics of the farm real estate market, signaling not only the achievement of a mature stage in the local economy, but also a diversion from investments in land to the more recently rewarding purchases of Treasury Bonds.

The dimension of this unprecedented activity is so far covered by bank secrecy, but rumors, relatin at least to the most buoyant town as land buyer in the area, indicate figures in the order of 5 billions lire per months on short terms bonds. Is it reflecting a new mood, or a storage of wealth, waiting to be reinvested again in the land?

Another aspect, exogenous to the local situation, deals with the growing size of Italian imports from the rest of the word (namely Turkey). It certainly affected the local market and consequently prices, acting as a challange to domestic supply for the national industry, but apparently also to our exports, since, by only relabelling the imported filibert nuts, these imports have been shipped abroad as Italian product.

The more imports grew, the more prices for the product went down, so did profitability and expectations in terms of increasing farm sizes and transforming arable land into filibert nuts orchards.

Taking into account all this , we introduce a new structure as:

$$Lv=f(Pfn,Fi,Imp,Tb)$$

where: Lv = land values, per metre;

Pfn = price of filibert nuts, per ton;

Fi = farm income, as gross margin;

Imp = filibert nuts imports;

Tb = treasury bonds rate.

The structure satisfies the rationale above explained by including, quite obviously, the first two variables, price of the basic production of the area and incomes from the farm records of specialized farms in the area producing filibert nuts. The last two variables reflect stimuli from the world outside the farm gate and could be considered proxies for macro-variables. Statistical tests performed on the structure, relating to the years from 1975 to 1989 , were surprisingly fairly good, as first computer output, that is without the usual refinements to improve their performance.

$$Lv = 1176.534 + 0.5340Pfn - 0.00043Fi + 0.119501Imp - 17.6736Tb$$

$$t = \quad (5.04) \quad (-2.60) \quad (5.93) \quad (-0.87)$$

$R2 = 0.86$

DW = no evidence of multicollinearity

Product prices and Treasury Bonds were complying with the expectations: a positive and a negative relationship with land values respectively, however, differing in terms of statistical significance of coefficients. Product price very significant and Bonds almost irrelevant.

The other two variables, although showing significant coefficients, expressed relationships with the dependent variable not complying withour expectations. It is hard to figure why land values should decrease when farm income, even if expressed by a proxy in terms of gross margin, increases. It is also not feasible that increasing imports of filibert nuts should determine increasing values in the land market. Nevertheless, the latter relationship is the strongest in terms of statistical significance.

These data encourage further enquiry and very likely suggest to work towards a full scale model, based on more structures, identifying at least the land supply, demand and the equilibrium statement. Unfortunately this means to run into many troubles dealing with the most appropriate variables relating to quantities, technological innovations, inflationary trends and so on.

The peculiar market form that runs the filibert nuts activities adds further complications and a competitive static equilibrium should be ruled out. Product prices will not result from intervention of the "invisible hand", but should be worked out by sophisticated game theories.

Further work needs to be carried out, more discussion on the situation and thorough investigation will be needed.

4. CONCLUDING REMARKS

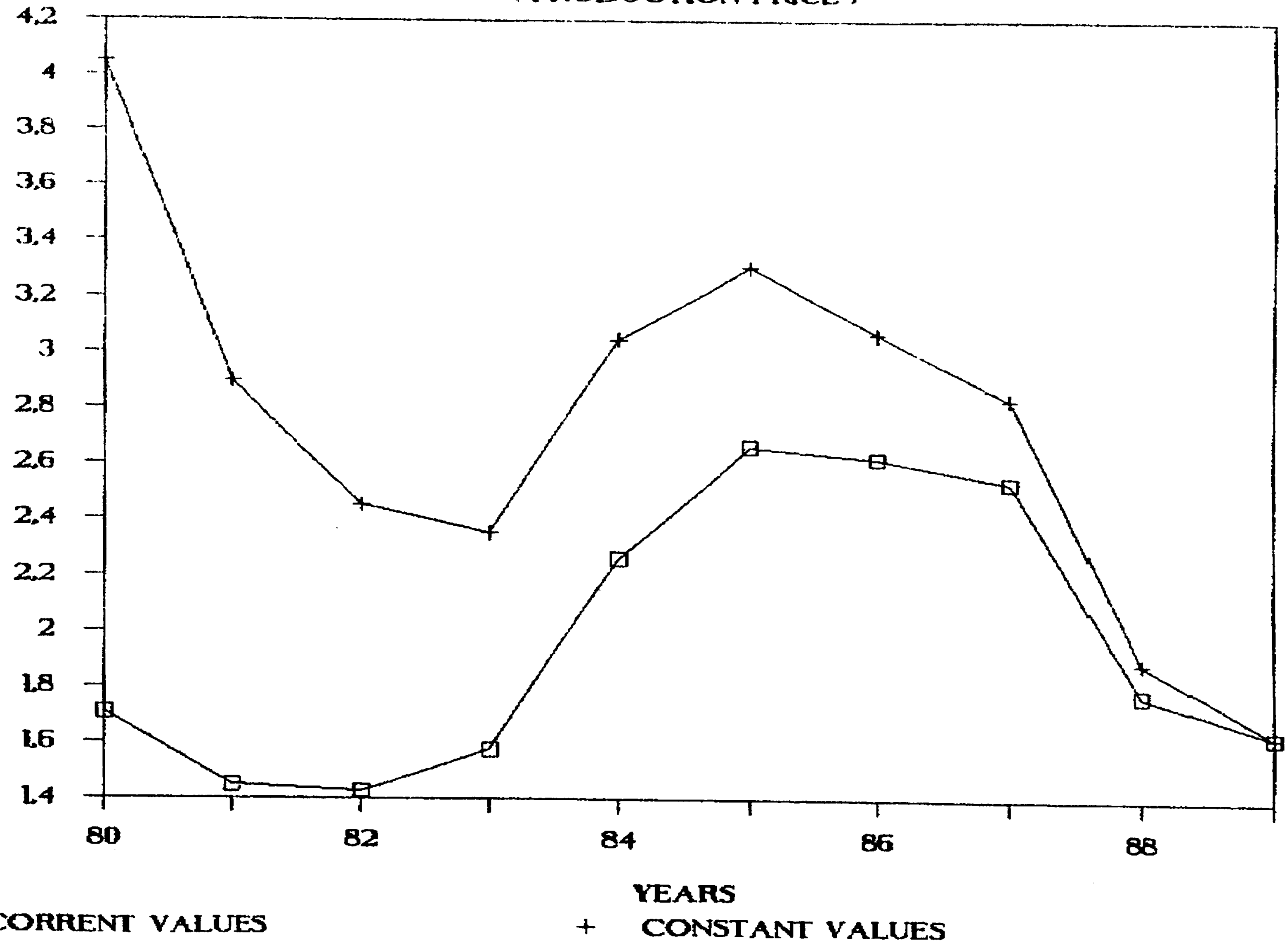
The paper proposed a different (from our previous) structure to explain value determinants for farm real estate. Statistical tests did not disqualify the model, but cast some doubts on the relevance of at least two variables: imports and farm incomes. On the other hand, the financial aspects proved very relevant in antagonizing farm values, meaning that by reducing interest rates, more money would flow from the savings in banks to the land as an assett. At least, this happened before, as high values for land were confronted by low (in real terms) interest rates for bonds.

Question is: nowadays, or in the next future, will low interest rates (if ever in Italy), determine again a flow of capital for land purchases, or will it move into other assetts? The unorthodox relationship, here achieved between farm income and farm values, contradicting the old say that a capital good is worth what it earns, could perhaps point out to the fact that the primary determinant of land is no longer the derived farm income, but other more relevant variables, such as building opportunities residential advantages, ease in running the business by contractors, and so on.

It is quite obvious now that the land market appeared with lack of orientation and motivations. Farm incomes are perhaps no longer the main drive for the quest of land, but other issues are not yet quite clear in their emergence to surface and certainly are manifolds and volatile.

FIG. 1: AVERAGE PRICE OF FILIBERT NUTS

(PRODUCTION PRICE)



Tab. 1: Italian export of filibert nuts (tons)

		1984	1985	1986	1987	1988
CEE						
- with	shell	6383	5958	3503	3890	4154
- without	shell	13490	19004	8931	10377	18292
Extra-CEE						
- with	shell	2865	4525	2599	2118	2833
- without	shell	10455	10550	8547	9199	12320
Total						
- with	shell	9248	10483	6102	6008	6987
- without	shell	23945	29554	17478	19576	30612

Source: ISTAT, Annuario del commercio estero

Tab. 2: Italian import of filibert nuts (tons)

		1984	1985	1986	1987	1988
- with	shell	272	339	368	224	185
- without	shell	3150	7181	4062	10591	8539

Source: ISTAT, Annuario del commercio estero

Tab. 3: Features of agriculture in Capranica

Total area (HA).............................4.037,89
Arable land (HA)............................2.696,69
No. farms with arable land.......................942
Average farm land (HA)..........................2,88
Area under filibert nuts (% of arable land)....74,26
Hectares bought and sold during the period
1975-1986 between residents.................187,665
and no residents..........................222,228
total.....................................409,893
Hectares bought and sold per year (average)....34,15

Source: "Capranica: i suoi noccioleti, il suo mercato fondiario"

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Groundwater contamination and the management of a conjunctive ground and surface water irrigation system*

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Irrigation water (including rainfall) that infiltrates the subsurface carries salts, pesticide and fertilizer residues, and other trace elements, thus causing a contamination of aquifers and soils. A similar situation occurs when irrigating with saline groundwater (aquifers containing saline water often are found in arid and semi-arid regions, where agricultural production depends critically on groundwater irrigation). Evaporation of the irrigation water increases salt concentration, causing salinization of soils and aquifers. Although not immediately noticeable, these quality deterioration processes will have long-term effects and therefore require careful management. The paper describes a general framework for the intertemporal management of a conjunctive ground and surface water irrigation system, taking into account the quality deterioration processes. Policy implications are discussed and the results are compared with those that come from a model which neglects quality effects.

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Groundwater contamination and the management of a conjunctive ground and surface water irrigation system

Yacov Tsur

1. Introduction

The conjunctive use of groundwater and surface water for irrigation is pervasive and has attracted much research, starting with the early work of Burt (1964a-b) followed by Brown and McGuire (1967), Cummings and Burt (1969), Burt and Cummings (1970), Cummings and Winkelman (1970), Domenico *et al.* (1970), Young and Bredehoeft (1972), Bredehoeft and Young [1983], Tsur (1990), and Tsur and Graham-Tomasi (1990) among others. The problem, in general terms, is that of allocating groundwater over time when the demand for groundwater varies according to available supply of surface water.

The term "conjunctive ground and surface water system" is applied to a number of systems; they differ according to the ground and surface water sources. The source of surface water may consist solely of stream flows emanating from the aquifer, it may be independent of the groundwater source (e.g., rainfall) or it may be a combination of the two. The groundwater aquifer may be confined (see examples in Margat and Saad [1985] and Issar (1985)) or replenishable, deep or shallow. The surface water source may be stable or it may stochastically fluctuate over time. Depending on the particular situation one wishes to study, the management problem of a conjunctive ground and surface water system can become quite involved.

Here we consider a situation in which the supply of surface water is stable and groundwater is derived from shallow aquifers. Groundwater quality can affect yield directly, if groundwater invades the root zone, and indirectly through irrigation. We shall focus attention on the first, direct effect. This effect is controlled via drainage activities.

We describe a framework for the management of an irrigation and drainage system, where irrigation is derived both from surface and groundwater sources. We begin, in Section 2, by laying out the basic principles underlying the management of a conjunctive ground and surface water system. After deriving the optimal rules for managing such a system we argue that, due to the open-access and/or common-property nature of groundwater resources, market forces are unlikely to generate water use patterns which satisfy these rules. Possible policies to restore the optimal management rules are then discussed. In Section 3 quality considerations are introduced. In Section 4 we derive the rules governing desirable irrigation/drainage management and extend the policy discussion of Section 2 to that context. In Section 5 we distinguish between policies designed to enforce the optimal irrigation/drainage rules and those aimed at affecting the environment within which the management problem rests. Some examples of the second type of policy are discussed.

2. Basic principles of the management of a conjunctive ground and surface water system

A conjunctive ground and surface water system consists of a surface water source (stream flows, rainfall, reservoirs), a groundwater source (aquifer) and an agriculture production process which requires water as an input. Figure 1 gives a schematic representation of such a system.

Figure 1.

Let F(x) denote the water response function, measured in dollar per hectare ($/ha), and x indicate the level of water input, measured in cubic meter per hectare (m^3/ha)[1]. The marginal water productivity is the change in F(x) resulting from a small (marginal) change in water input x and is indicated by $F_x = \partial F/\partial x$. It plays a central role in determining the management rules. In most cases F(x) increases in x at a diminishing rate, thus $F_x(x)$ is positive and decreasing in x (on different ways to estimate this function see Howitt *et al.* (1980) and Paris and Knapp (1989)).

The quantities of surface and groundwater applied for irrigation at time t are denoted by S_t and g_t, respectively; total water input is thus $x_t = S_t + g_t$. The amount of rainfall relevant for irrigation (during the growing season) is assumed stable at the level R and is included in S_t, thus $S_t \geq R$. The stock on hand of groundwater at time t, denoted by G_t, changes over time as extraction takes place and as some of the water input (irrigation) infiltrates the aquifer:

$$dG_t/dt = \dot{G}_t = -(1-\delta)g_t + \delta S_t, \tag{1}$$

where δ is a permeability parameter indicating the fraction of the water applied for irrigation that permeates into the aquifer (when the aquifer reaches its capacity level, $\dot{G}_t$ equals the minimum between the right-hand side of (1) and zero)

The cost of pumping groundwater at a rate g is given by z(G)g, where z(G) is the unit cost of groundwater extraction when the groundwater stock is at the level G. z(G) is non-increasing in G (a larger G means a higher

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[1] F(x) is derived in the following manner. Let f(x,k) be an agricultural production function whose arguments are a water input, x, and a vector of other inputs, k. Given the prices of output, p, and of all inputs other than water, v, and given the level of water input, $k^*(x,p,v)$ represents the value of k that maximizes pf(x,k) - vk. The water response function is given by

$$F(x) = pf(x,k^*(x,p,r)) - r\cdot k^*(x,p,r).$$

where the fixed prices p and v are suppress from the notation.

groundwater table, a shorter distance to the surface and hence lower extraction costs). The unit cost of surface water irrigation (except for rainfall) is denoted by w. The instantaneous profit generated by S_t and g_t is thus given by

$$F(g_t+S_t) - z(G_t)g_t - w(S_t-R).$$

The amount of irrigation water may be subject to capacity constraints. We let C and B indicate these capacity limits, thus $g_t \le C$ and $S_t \le B$ for all $t \ge 0$.

A water management policy entails setting S_t and g_t for all time periods $t \ge 0$; it generates the benefit (the present value of the profit stream)

$$\int_0^\infty [F(g_t+S_t) - z(G_t)g_t - w(S_t-R)]e^{-rt}dt,$$

where r is the time rate of discount. We seek the policy that maximizes this benefit.

Let V(G) be the maximum feasible benefit when the current stock of groundwater is G:

$$V(G) = MAX \int_0^\infty [F(g_t+S_t) - z(G_t)g_t - w(S_t-R)]e^{-rt}dt$$

subject to: Eq. (1), $0 \le g_t \le C$, $R \le S_t \le B$, $G_t \ge 0$ and $G_0 = G$. (2)

The change in V(G) caused by a marginal (small) change in G is the unit value of the groundwater stock and is denoted by $V_G(G)$. It represents the future benefit forgone as a result of pumping a unit groundwater today and is referred to as the shadow price or the royalty value of the aquifer.

Using a dynamic programming approach, we obtain for each time period (see appendix) the following relation:

$$rV(G_t) = \underset{g_t, S_t}{MAX} \left\{F(g_t+S_t) - [z(G_t)+V_G(G_t)(1-\delta)]g_t - [w-V_G(G_t)\delta]S_t + wR\right\}. \quad (3)$$

In words, the optimal conjunctive ground and surface water policy $(S_t^*, g_t^*, t\ge0)$ is the one under which the right-hand side of (3) is maximized in each time period (subject, of course, to the constraints given in (2)). The object of maximization on the right-hand side of (3) is the instantaneous profit corrected to account for intertemporal effects. The intertemporal effects are effects of current decisions on future profits and are represented by the shadow prices $V_G(G_t)$. Thus the cost associated with one cubic meter of groundwater applied for irrigation today consists of (a) the pumping and distribution costs as given by $z(G_t)$, and (b) the effect on future profits resulting from the drop in the stock of groundwater, which occurs due to higher pumping costs in the future and increased scarcity of groundwater. This second cost component is represented by $V_G(G_t)[1-\delta]$ (the factor $1-\delta$ accounts for the fact that only $(1-\delta)$ m^3 of each 1 m^3 pumped is lost, as δ m^3 leaches back into the aquifer). The economic cost of groundwater is therefore given by $z(G_t)+V_G(G_t)[1-\delta]$, which is the coefficient of g_t on the right-hand side of (3). Similarly, the economic cost of surface water is $w-V_G(G_t)\delta$, which consists of the engineering cost, w, minus the contribution of surface water to future profits via its effect on the groundwater stock derived from the fraction δ of the surface water irrigation that leaches into the aquifer.

In view of (3) the characterization of the optimal policy becomes a straightforward exercise. Disregarding for a while the capacity limits (i.e., assuming they are not binding) and without rainfall (i.e., R=0) the following management rules apply:

(i) As long as the economic cost of groundwater exceeds that of surface water, i.e., $z(G_t)+V_G(G_t) > w$, only surface water is used for irrigation at a level that equates the marginal productivity of water to its cost:

$$F_x(S_t^*) = w - \delta V_G(G_t).$$

(ii) As long as the economic cost of groundwater falls below that of surface water, i.e., $z(G_t)+V_G(G_t) < w$, only groundwater is used for irrigation at a level that equates the marginal productivity of water to its cost:

$$F_x(g_t^*) = z(G_t)+V_G(G_t)(1-\delta).$$

(iii) When the economic costs of ground and surface water are equal, i.e.,

$z(G_t)+V_G(G_t) = w$, irrigation water is derived from both sources at a level that satisfies

$$F_x(g_t^*+S_t^*) = w - V_G(G_t)\delta$$

and at the mix $g_t^*/S_t^* = \delta/(1-\delta)$ such that the groundwater stock remains constant ($\dot{G}_t = 0$).

With the above interpretation of the economic costs of ground and surface water, these management rules make perfect intuitive sense. Some modifications, however, are needed in the presence of binding capacity limits and with positive rainfall; they are outlined in the appendix.

The dynamic behavior of the system is depicted in Figure 2. At all stock levels G for which $z(G)+V_G(G)$ lies above w, groundwater is more expensive than surface water, thus only the latter is applied for irrigation (cf. (i)). This causes the groundwater stock to increase, which in turn diminishes the pumping cost z(G) and the shadow price $V_G(G)$ of groundwater, as represented by the declining curve labeled $z(G)+V_G(G)$. When the groundwater stock reaches the level $\hat{G}$, the cost of groundwater coincides with that of surface water and surface water is applied conjunctively with groundwater so as to retain the aquifer at this stock level (cf. (iii)). For stock levels above $\hat{G}$, groundwater is cheaper than surface water and irrigation water is derived solely from the aquifer (cf. (ii)). This causes the groundwater stock to decline toward $\hat{G}$. The groundwater stock level $\hat{G}$ is called the steady state; the period in which the system moves toward $\hat{G}$ is called the transition period (stage); the period in which $G = \hat{G}$ is called the steady period (stage).

Policy intervention

The management rules (i)-(iii) differ from the myopic rules under which the instantaneous profit is maximized in each time period. The myopic rules are derived from (i)-(iii) by setting the shadow prices $V_G(G_t)$ equal to zero. A question then arises as to whether the individual growers are motivated to follow the intertemporal rules (i)-(iii) or whether they behave myopically? Unfortunately, the second possibility is more likely to prevail. The problem is similar to that of a "common property" situation (see Dasgupta (1982), Negri (1989)) in which the effect of each individual's extraction on the aquifer is negligible but is not at all negligible with respect to his or her own profits. Following the intertemporal rules entails giving up some present profits in return for future profits. But the future gains will materialize only if *all* (or most) growers follow the intertemporal rules. Now, if most growers follow the intertemporal rules, it is in the interest of the individual farmer to behave myopically because his or her effect on the aquifer is negligible and he can enjoy larger profits both in the present and in the future. On the other hand, if all other growers behave myopically then the grower should do the same, since otherwise there will be no future gains to compensate for the present losses. Realizing that this line of reasoning is not exclusive to any particular individual, the grower has good reasons to suspect that others will not follow the intertemporal rules, in which case he should not obey them either (this is, in a nutshell, the free rider problem). Clearly, some regulatory policies (quota, taxes) or market mechanism (water rights) to restore intertemporal considerations are in order. We shall briefly discuss the tax and quota options (on water rights see Gisser and Sanchez (1980), Gisser (1984) and Anderson, Burt and Fractor (1983), among others).

Optimal tax schedule: The engineering costs of ground and surface water ($z(G)$ and w, respectively) do not reflect their economic costs ($z(G)+V_G(G)[1-\delta]$) and $w-V_G(G)\delta$, respectively). A tax schedule to correct for this discrepancy consists of taxing each cubic meter of groundwater by the amount $V_G(G_t)[1-\delta]$ and subsidizing each cubic meter of surface water by the amount $V_G(G_t)\delta$. The problem with such a tax schedule is that it depends on the stock of groundwater and thus must be adjusted constantly during the transition period. This might be hard to administer, since it requires constantly monitoring the aquifer level. Furthermore, it is likely to be objected by farmer who prefer stable water prices. An alternative scheme is therefore to impose the steady state tax schedule: a fixed tax of $V_G(\hat{G})[1-\delta]$ on groundwater and a fixed subsidy of $V_G(\hat{G})\delta$ on surface water. Such a tax schedule ensures a smooth transition to the steady state (though it may lengthen the transition period relative to that under the schedule described above), is easy (hence cheap) to administer, and is stable thereby facilitating compliance by growers.

Optimal water quotas: The management rules (i)-(iii) determine also the desirable quantities of ground and surface water to be applied for irrigation. During the transition period, if the aquifer stock lies below (above) its steady state level $\hat{G}$, the optimal policy is to prevent the use of ground (surface) water altogether; as a result only surface (ground) water is applied for irrigation and the aquifer stock increases (decreases) until it reaches the steady level $\hat{G}$, at which point the quota on ground and surface water is changed so as to retain the steady state, as described in (iii). The problem with this policy is that it entails a discrete jump in water policy as the system moves from the transition period to the steady stage, a jump that may require a change in the agricultural structure (e.g., crop mix) of the region. Furthermore, the option of banning the use of a particular source of water may simply be (legally) impossible. Such a policy, however, should be fairly simple to administer and is ensured to achieve the desirable water allocation.

A combined tax and quota schedule: A third option to be considered by water policy-makers is that of a combined quota/tax schedule. Such a policy consists of setting the prices of ground and surface water at their steady levels $z(\hat{G})+V_G(\hat{G})[1-\delta]$ and $w-V_G(\hat{G})\delta$, respectively, and at the same time regulating the quantities of the more expensive water source in order to expedite the transition to the steady stage. The tax part of such the policy ensures smooth transition to the steady stage whereas the quantity regulation can be used to shorten the undesirably long transition period associated with the pure tax policy.

Policy implementation

The minimum information required to implement a tax policy contains the steady state level of the aquifer $\hat{G}$ and the shadow price $V_G(\hat{G})$ at that level. To obtain this shadow price one needs to solve Problem (2), along the line of (3), which requires knowledge of the water response function F(x) and of the permeability parameter δ. A solution of Problem (2) consists of the series S_t^* and g_t^* and the associated stock and shadow price processes G_t and $V_G(G_t)$, $t \geq 0$, and is in principle attainable (perhaps only numerically). While this is fairly easy to achieve in the simple case represented by Problem (2), it is more complicated in the realistic case described in the next section. For such cases there exist methods that provide approximates to the optimal management rules. Such a method, which approximates the steady state solution by solving a properly defined equivalent static problem, was proposed by Burt and Cummings (1977).

Closing remarks

This completes our account of the basic principles of the conjunctive management of ground and surface water for irrigation. Reality, of course, is more complicated than the simple situation considered above. Thus, numerous authors have extended and applied this framework to particular real world situations. Young and Bredehoeft (1972), for example, considered a situation in which the only source of surface water is stream flows emanating from aquifers. Cummings and Winkelman (1970), on the other hand, analyzed a system in which surface water is independent of groundwater sources.

Tsur (1990) introduced elements of uncertainty to surface water supplies and argued that groundwater, in addition to its role of increasing the supply of irrigation water, serves also as a buffer that mitigates the undesirable fluctuations in the water supply. Tsur (1990) calculated the value associated with the buffer role (the buffer value) of groundwater for wheat growers in the Israeli Negev region and found it to exceed the value associated with the increase in the water supply (the latter is the benefit that would be obtained from the groundwater had surface water supplies been stable at the mean). Tsur's (1990) analysis lacks some elements of dynamics since it considers the huge fossil water aquifer underlying the Negev to be effectively unlimited. While this may be justifiable in the particular case of the Negev, it is not so in general. Thus, Tsur and Graham-Tomasi (1990) extended this framework to the case of a finite aquifer.

We proceed now to incorporate the groundwater quality effects, leaving out the consideration of the above mentioned extensions.

3. Groundwater quality

The groundwater quality comes into effect when two distinct processes which affect agricultural yield occur as irrigation water infiltrates the shallow aquifer. The first is the rise in the groundwater table toward the root zone as the groundwater stock G increases. The second is the deterioration in the quality of the groundwater as salts and other trace elements are washed into the aquifer. Incorporating quality effects requires allowing the water revenue function to depend also on the groundwater stock G, which represents the groundwater table, and on a groundwater quality index Q, representing the groundwater salinity level. We avoid, for the time being, salinity effects via the groundwater applied for irrigation (For more on salinity control in groundwater management problems see Cummings (1971) and Cummings and McFarland (1974)). Figure 3 provides a schematic presentation of such a system.

Figure 3.

The water response function F takes the form

$$F(x_t, G_t, Q_t).$$

As above, F is assumed to increase in a diminishing rate with the quantity of irrigation water ($F_x > 0$ and $F_{xx} < 0$). Both G and Q, on their own, do not contribute to yield and may even cause harm ($F_G \leq 0$ and $F_Q \leq 0$). The negative effect of the one is enhanced by an increase in the quantity of the other, i.e., their interaction is non-positive ($F_{GQ} \leq 0$). Thus, as the groundwater quality deteriorates (Q increases) the negative effect of the ground waterlogging is magnified (F_G decreases); likewise, as the groundwater table rises (G increases) the negative effect of Q is exacerbated (F_Q decreases).

Allowing for the application of drainage activities, which involves tiles to remove water to a drainage canal (see Figure 3), the change in the aquifer stock is represented by

$$dG_t/dt = \dot{G}_t = \delta S_t - (1-\delta)g_t - d_t, \qquad (4)$$

where S_t, g_t and δ are as defined in the previous section and d_t indicates the amount of drainage (m^3/ha).

The groundwater quality index Q_t changes as salts and other trace elements are washed into the aquifer by the permeating irrigation water. This change, which is an outcome of quite complicated hydrological processes, may be represented implicitly as:

$$dQ_t/dt = \dot{Q}_t = H(\delta x_t, G_t, Q_t).$$

The larger the amount of permeating water (δx), the greater the quantities of salts washed into the aquifer, so that H increases in δx. On the other hand, we expect that H decreases in G_t (the same amount of salt changes the salinity level of a small bucket more than that of a large one). For the sake of concreteness, we assume that H is of the form

$$H(\delta x_t, G_t, Q_t) = q(G_t, Q_t)\delta x$$

where the nonnegative function $q(G,Q)$ translates quantities of permeating water (or of accumulated salts) into changes in the aquifer salinity level. The change in groundwater quality is thus given by

$$\dot{Q}_t = q(G_t, Q_t)\delta[S_t + g_t]. \qquad (5)$$

A water management policy entails setting S_t, g_t and d_t for all time periods $t \geq 0$ and generates the payoff (the present value of the profit stream):

$$\int_0^\infty [F(S_t+g_t, G_t, Q_t) - z(G_t)g_t - md_t - w(S_t-R)]e^{-rt}dt,$$

where $z(G_t)$, w and r are as defined in Section 2 and m is the unit cost of drainage activities (m is fixed and independent of the groundwater table). We seek the policy that yields the highest payoff.

4. Irrigation and drainage management

Let $V(G,Q)$ represent the maximum available payoff when the current stock and quality of groundwater are G and Q, respectively. Formally

$$V(G,Q) = MAX \int_0^\infty [F(S_t+g_t, G_t, Q_t) - z(G_t)g_t - md_t - w(S_t-R)]e^{-rt}dt$$

subject to: Eqs. (4)-(5), $0 \leq g_t \leq C$, $R \leq S_t \leq B$, $0 \leq d_t \leq D$, $G_o = G$ and $Q_o = Q$, (6)

where, as above, the parameters C and B represent respectively the capacity limits on ground and surface water supplies and D is a capacity limit on drainage activities.

The changes in $V(G,Q)$ associated with a marginal (small) change in G or Q (i.e., the derivatives of V with respect to G or Q) are denoted by $V_G(G,Q)$ and $V_Q(G,Q)$, respectively. These quantities represent the unit value of G or Q and are thus referred to as the shadow prices of G or Q. We expect that V_Q is negative (one would be willing to pay a positive amount to have Q reduced and the groundwater quality improved), while V_G may be positive or negative. At low levels of G, where the groundwater table is well below the root zone, V_G

will be positive since the finite stock of the aquifer entails a positive royalty value (the forgone benefit of not being able to use in the future the unit of groundwater pumped today). On the other hand, at high G levels where groundwater has invaded the root zone, the damage to yield may outweigh the benefit of additional water, causing V_G to become negative.

The Dynamic Programming equation of the present system is (see appendix):

$$rV(G_t,Q_t) = \underset{S_t,g_t,d_t}{MAX} \Big\{ F(S_t+g_t,G_t,Q_t) - [z_t+V_{Gt}-\delta(V_{Gt}+V_{Qt}q_t)]g_t - [w-\delta(V_{Gt}+V_{Qt}q_t)]S_t - (m+V_{Gt})d_t + wR \Big\}, \quad (7)$$

where $z_t = z(G_t)$, $V_{Gt} = V_G(G_t,Q_t)$, $V_{Qt} = V_Q(G_t,Q_t)$ and $q_t = q(G_t,Q_t)$. Analogous to the simpler case of Section 2, the coefficients of g_t, S_t and d_t on the right-hand side of (6) represent the respective economic costs of these activities. These costs consist of the engineering costs plus terms containing the shadow prices V_G and V_Q, which represent intertemporal effects. We see that the economic costs of ground and surface water irrigation, compared to those of Section 2, contain also the term $-\delta V_{Qt}q_t$, which accounts for the salinity effect. Since V_{Qt} is negative and q_t is positive (see discussion above) this term is positive, implying that the salinization process of groundwater increases the (economic) cost of irrigation.

The conjunctive ground and surface water management rules of Section 2 must be changed to incorporate effects of salinization of groundwater and the drainage activities. In view of (7), and with no binding capacity limits on irrigation, it is straightforward to derive the following management rules:

(i') As long as the economic cost of groundwater irrigation exceeds that of surface water, i.e., $z_t+V_{Gt} > w$, irrigation water is derived only from surface sources at a quantity that equates the marginal productivity of water to the economic cost:

$$F_x(S_t^*, G_t, Q_t) = w - \delta(V_{Gt} + V_{Qt} q_t).$$

(ii') As long as the economic cost of surface water irrigation exceeds that of groundwater, i.e., $z_t + V_{Gt} < w$, irrigation water is derived only from the aquifer at a quantity that equates the marginal productivity of water to its economic cost:

$$F_x(g_t^*, G_t, Q_t) = z_t + V_{Gt} - \delta(V_{Gt} + V_{Qt} q_t).$$

(iii') When the economic cost of surface water irrigation equals that of groundwater irrigation, i.e., $z_t + V_{Gt} = w$, irrigation water is derived from both sources at a quantity that equates the marginal water productivity to the economic cost:

$$\begin{aligned} F_x(S_t^* + g_t^*, G_t, Q_t) &= z_t + V_{Gt} - \delta(V_{Gt} + V_{Qt} q_t) \\ &= w - \delta(V_{Gt} + V_{Qt} q_t); \end{aligned}$$

and the mix of ground and surface water is determined so as to preserve the condition $z_t + V_{Gt} = w$.[2]

(iv) Drainage activities are either applied to a full extent or not applied at all as $m + V_{Gt}$ is negative or positive, respectively:

$$d_t^* = \begin{cases} D & \text{if } V_{Gt} + m < 0 \\ 0 & \text{otherwise} \end{cases}.$$

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[2]This mix rule is self-enforced. Suppose a non-optimal mix is applied with too much surface water (though the quantity of irrigation water is chosen optimally). This would increase G above the level required to maintain $z_t + V_{Gt} = w$. As a result, $z_t + V_{Gt}$ falls below w so that water irrigation is derived only from the aquifer (Rule (ii')). As a result, G decreases and $z_t + V_{Gt}$ increases back toward w. Likewise, if the irrigation mix uses too much groundwater, G reduces and $z_t + V_{Gt}$ rises above w, which, in turn, prompts irrigation from surface water only (Rule (i')), causing G to increase and $z_t + V_{Gt}$ to diminish back toward w.

Rules (i'), (ii') and (iii') are similar in nature to their counterparts of Section 2. The main difference is in the levels of the irrigation activities, which in the present case are influenced also by the (shadow price of) salinity level of groundwater. The forth rule concerns the drainage policy. It states that drainage activities are applied only when V_{Gt} falls below -m.

In view of (iii'), a steady state in this problem is characterized by the condition $z_t+V_{Gt} = w$, i.e., z_t+V_{Gt} remains constant:

$$d[z(G_t)+V_G(G_t,Q_t)]/dt = z'(G_t)\dot{G}_t + V_{GG}\dot{G}_t + V_{GQ}\dot{Q}_t = 0$$

$(z'(G) = dz(G)/dG)$. As long as the salinity level Q affects V_G (see discussion in Section 3), G will not remain constant in the steady state. For suppose that the mix of ground and surface water irrigation is such that $\dot{G}_t = 0$ [which can be achieved by the mix $g_t^*/S_t^* = \delta/(1-\delta)$]. Then, the irrigation water that leaches into the aquifer increases Q which, in turn, reduces V_{Gt}. $z(G_t)$ is unchanged (since G_t is constant), thus z_t+V_{Gt} falls below w. As a result, groundwater irrigation is substituted for surface water irrigation (cf. (ii')), which causes G_t to fall. A similar argument can be use to rule out the possibility that G_t increases. Thus, as long as $V_G(G,Q)$ decreases with Q, preserving the equality $z_t+V_{Gt} = w$ requires that the groundwater stock decreases at the appropriate rate so as to counter-balance the salinity effect on V_{Gt}. A constant stock level will prevail in a steady state only when the groundwater table lies well below the root zone so that changes in the salinity level cannot harm yield, i.e., when V_G is independent of Q ($V_{GQ} = 0$).

Typically, $z(G)+V_G(G,Q)$ decreases in G. The situation $z(G)+V_G(G,Q) > w$ is therefore likely to occur at low G levels, where the groundwater table lies below the root zone. In such cases, the economic cost of groundwater exceeds that of surface water and groundwater salinity is not yet harmful; hence it is plausible that irrigation utilizes only surface water sources (cf. (i')).

As water permeates into the aquifer, the groundwater table raises toward the root zone and its quality deteriorates. This causes both the extraction cost, z(G), and the groundwater shadow price $V_G(G,Q)$ to fall. Eventually, the equality $z(G)+V_G(G,Q) = w$ holds, extraction begins and irrigation water is derived both from the aquifer and from surface sources at just the right mix so as to preserve the equality $z(G)+V_G(G,Q) = w$ (cf. (iii')).

What happens if surface water irrigation is implemented above its optimal level (say, because growers behave myopically)? Then the groundwater table and salinity continue to rise (as the stock increases and its quality deteriorates) and V_{Gt} diminishes (both because groundwater is less scarce and of lesser quality). As long as $z_t+V_{Gt} < w$ and $V_{Gt} > -m$, drainage activities are not required, but the situation is severe enough to warrant irrigation with groundwater only and the ceasing of surface water irrigation. The situation becomes drastic when the groundwater stock achieves a level in which its shadow price, V_{Gt}, falls below -m; in such a case drainage activities are in order (cf. (iv)).

The dynamics of the system are characterized in Figure 4. The level $\hat{G}$ is the maximum stock for which groundwater salinity does not affect the shadow price V_G (at stock levels below $\hat{G}$, the groundwater table is below the root zone and its salinity cannot affect yield, i.e., $V_{GQ}(G,Q) = 0$ for all $G \leq \hat{G}$). The different curves represent the function $z(G)+V_G(G,Q)$ at different Q levels. They coincide over the interval $0 \leq G \leq \hat{G}$ (since Q is irrelevant in this interval), and for $G > \hat{G}$ they tilt clockwise as Q increases. The curves abc, abd and abe correspond respectively to quality levels Q_1, Q_2 and Q_3 with $Q_1 < Q_2 < Q_3$. The curve ab$\hat{G}$ corresponds to the maximum possible level of groundwater salinity.

Suppose the initial stock and quality of groundwater are G_1 and Q_1, respectively (point α of Fig. 4). Since $z(G_1)+V_G(G_1,Q_1) < w$, irrigation water is derived solely from the aquifer. As a result G decreases, Q increases and the system moves along the line $\alpha\beta$ until it reaches the point β where $z(G)+V_G(G,Q) = w$ holds. From there on the system progresses along the line $\beta\gamma$ toward the point γ (cf. (iii')) as Q increases and G diminishes at just the appropriate rate so as to preserve the equality $z(G)+V_G(G,Q) = w$. Eventually (perhaps after a very long time), the system comes to a rest at the point γ.

When the initial groundwater stock is smaller than $\hat{G}$, say at G_2 (point φ of Fig. 4), and $z(G_2)+V_G(G_2,Q) > w$, then it pays to irrigate only with surface water (cf. (i')). As a result, G increases until it reaches the level $\hat{G}$ (point b of Fig. 4). At this stage it is still profitable to use only surface water for irrigation, so that both G and Q increase. The system progresses along the line $b\xi$ until it reaches point ξ, at which stage $z(G)+V_G(G,Q) = w$ holds. From there on the system progresses along the line $\xi\gamma$ toward the point γ as Q increases and G is reduced just at the appropriate rate to retain the condition $z(G)+V_G(G,Q) = w$.

Policy intervention

The above management rules differ from the myopic rules under which the instantaneous profit is maximized in each time period. The myopic rules are obtained by setting the shadow prices V_{Gt} and V_{Qt} equal to zero. It is clear from (iv) that, as long as drainage activities are costly (i.e., $m \geq 0$), no drainage activities are justified by the myopic rules. For reasons discussed in Section 2, with no policy intervention, the individual growers are likely to behave myopically. The available policy tools include taxes and/or quotas on irrigation water as well as drainage activities. The tax and quota policies are similar in nature to those discussed in Section 2; they will differ of course in the magnitudes of the taxes or quotas imposed (according to the difference between Rules (i)-(iii) and their primed counterparts). The drainage policy is unique to the present case; its implementation is characterized in (iv).

Implementing these policies requires knowledge of the shadow prices $V_G(G,Q)$ and $V_Q(G,Q)$, which can be obtained by solving Problem (6), along the line of (7). The task of solving this dynamic programming problem may turn out to be quite formidable; approximate solutions, such as the one proposed by Burt and Cummings (1977), should thus be considered.

5. Investment policies

It may be of interest to find out how the irrigation/drainage management rules and the associated benefit change as some of the system parameters, such as the capacity limits C, B and D, or the water response function $F(\cdot)$ vary. A policy aimed at changing these parameters is regarded as an *investment policy*. We shall briefly discuss a few such policies which appear to be of general interest.

Extraction and drainage capacities

The capacity limits on groundwater extraction, C, and on drainage, D, are important components in the irrigation/drainage management rules. At the one extreme, no extraction or drainage facilities (wells, pumps, tiles) are installed, i.e., $C = D = 0$, so that only surface water irrigation can be applied and the region is doomed to reach a point where no agricultural production is feasible. At the other extreme, these capacities are unlimited and drainage activities can be carried out so as to instantly reduce the groundwater stock to any desirable level. Obviously, from the irrigation/drainage management point of view, unlimited capacity is preferred. However, extraction and drainage capacities entail investment costs and the benefits associated with unlimited capacities may not justify the investment.

To determine the optimal level of the extraction and drainage capacities, let $V(G,Q;C,D)$ be the benefit of an irrigation/drainage policy when the levels of groundwater stock and salinity are G and Q, respectively, and given that extraction and drainage capacities are at the levels C and D, respectively. Let $E_c(C)$ and $E_d(D)$ be the investment costs required to achieve the capacities C and D, respectively (these technological relations depend, inter alia, on the hydrology, geology and topography of the region). Then the desirable capacity levels are those that maximize $V(G,Q;C,D) - E_c(C) - E_d(D)$.

Drainage Alternatives

It may be the case that more than one drainage alternative can be made available. Each drainage alternative entails operational costs (m in the notation of Sections 3 and 4) and the investment cost of making it available. The latter contains direct investment costs (canals, tiles, reservoirs) and possibly indirect environmental costs associated with its operation.

Suppose there are M drainage alternatives with the unit drainage cost m_i, $i=1,2,\ldots,M$. Denote the investment and environmental costs of the i'th drainage alternative by ID_i, $i=1,2,\ldots,M$. Let $V(G,Q;m_i)$, $i=1,2,\ldots,M$, be the benefit of an irrigation/drainage policy when the unit cost of drainage is m_i. The desirable choice of drainage alternative is the one that generates the highest $V(G,Q;m_i) - ID_i$. If a particular alternative generates prohibitive environmental effects, then the associated investment cost will be so high that it will not by selected.

Variety or crop choice

Different crops, or different variety of the same crop, respond differently to water salinity. Those which are more resistant will be affected to a lesser extent by the saline groundwater. Changing the crop mix or the level of salt resistance of a particular crop entails changing the water response function $F(\cdot)$ and thereby the irrigation/drainage policy. In general, higher levels of salt resistance require smaller levels of drainage activities and thus facilitate the management problem.

Appendix

A. Derivation of the Dynamic Programming equations

In deriving Eq. (3), we write

$$V(G) = MAX \int_0^\infty [F(g_t+S_t) - z(G_t)g_t - w(S_t-R)]e^{-rt}dt$$

as

$$V(G) = MAX\left\{\int_0^\tau [F(g_t+S_t) - z(G_t)g_t - w(S_t-R)]e^{-rt}dt + \int_\tau^\infty [F(g_t+S_t) - z(G_t)g_t - w(S_t-R)]e^{-rt}dt\right\}$$

$$= MAX\left\{[F(g_0+S_0) - z(G_0)g_0 - w(S_0-R)]\tau + o(\tau) + MAX\ e^{-r\tau}\int_0^\infty [F(g_t+S_t) - z(G_t)g_t - w(S_t-R)]e^{-rt}dt\right\}$$

$$= MAX\left\{[F(g_0+S_0) - z(G_0)g_0 - w(S_0-R)]\tau + o(\tau) + e^{-r\tau}V(G_\tau)\right\},$$

where $o(\tau)$ is such that $o(\tau)/\tau \to 0$ as $\tau \to 0$. Writing $e^{-r\tau} = 1 - r\tau + o(\tau)$ and $V(G_\tau) = V(G) + V_G(G)\dot{G}\tau + o(\tau)$, collecting terms, dividing by τ, letting $\tau \to 0$, and using Eq. (2) yields Eq. (3).

Eq. (7) is derived in a similar manner using $F(g_t+S_t,G_t,Q_t)$ instead of $F(g_t+S_t)$, noting that $V(G_\tau,Q_\tau) = V(G,Q) + [V_G(G,Q)\dot{G} + V_Q(G,Q)\dot{Q}]\tau + o(\tau)$ and using Eqs. (4) and (5).

B. The management rules of problem (2) in the presence of capacity limits and positive rainfall.

The parameters B, C, and D represent respectively the capacity limits on surface water, groundwater and drainage; R denotes rainfall.

(i) If $z(G_t) + V_G(G_t) > w$ then:

(a) S_t^* is determined from

$$F_x(S_t^*) = w - \delta V_G(G_t),$$

provided a solution S_t^* exists such that $R \le S_t^* \le B$; otherwise $S_t^* = R$ or B as $F_x(R) \le w - V_G(G_t)\delta$ or $F_x(B) \ge w - V_G(G_t)\delta$, respectively.

(b) $g_t^* = 0$ if $F_x(B) \leq z(G_t) + V_G(G_t)(1-\delta)$; otherwise g_t^* is the minimum between the solution of $F_x(B+g_t^*) = z(G_t) + V_G(G_t)(1-\delta)$ and C.

(ii) If $z(G_t) + V_G(G_t) < w$ then:

(a) g_t^* is determined from

$$F_x(g_t^*+R) = z(G_t) + {}_G(G_t)(1-\delta),$$

provided a solution g_t^* exists such that $0 \leq g_t^* \leq C$; otherwise $g_t^* = 0$ or C as $F_x(R) \leq z(G_t) + V_G(G_t)(1-\delta)$ or $F_x(C+R) \geq z(G_t) + V_G(G_t)(1-\delta)$, respectively.

(b) $S_t^* = R$ (its lower bound) if $F_x(C+R) \leq w - \delta V_G(G_t)$; otherwise S_t^* is the minimum between the solution of $F_x(C+S_t^*) = w - \delta V_G(G_t)$ and B.

(iii) If $z(G_t) + V_G(G_t) = w$ then:

(a) Total irrigation $x_t^* = g_t^* + S_t^*$ is determined from

$$F_x(x_t^*) = w - V_G(G_t)\delta,$$

provided a solution x_t^* exists such that $R \leq x_t^* \leq C+B$; otherwise $x_t^* = R$ or C+B as $F_x(R) \leq w - V_G(G_t)\delta$ or $F_x(C+B) \geq w - V_G(G_t)\delta$, respectively.

(b) If feasible, the desirable mix of ground and surface water satisfies $g_t^*/S_t^* = \delta/(1-\delta)$ such that $\dot{G}_t = 0$.

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Figure 1

Schematic representation of a conjunctive Ground and surface water system.

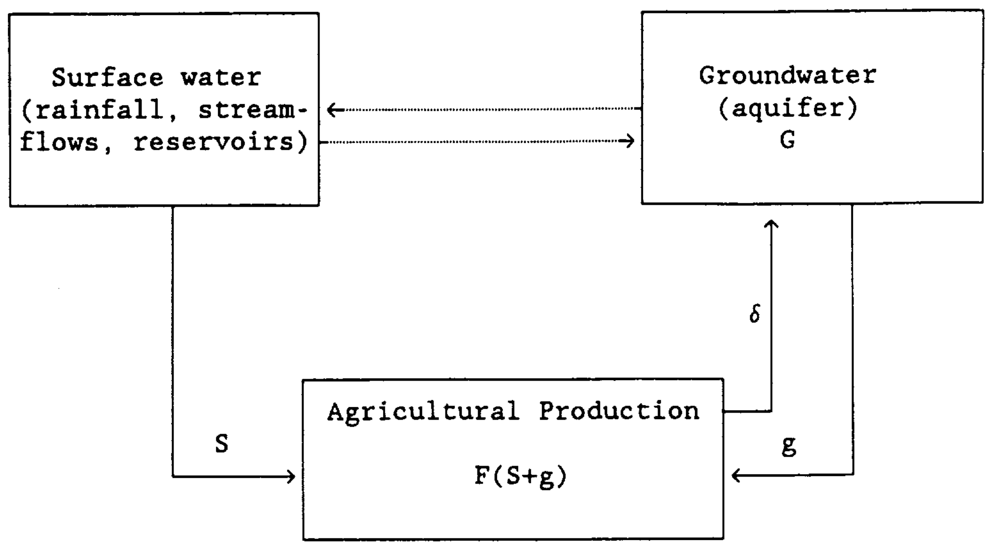

Figure 2.

Dynamic behavior of the solution of Section 2.

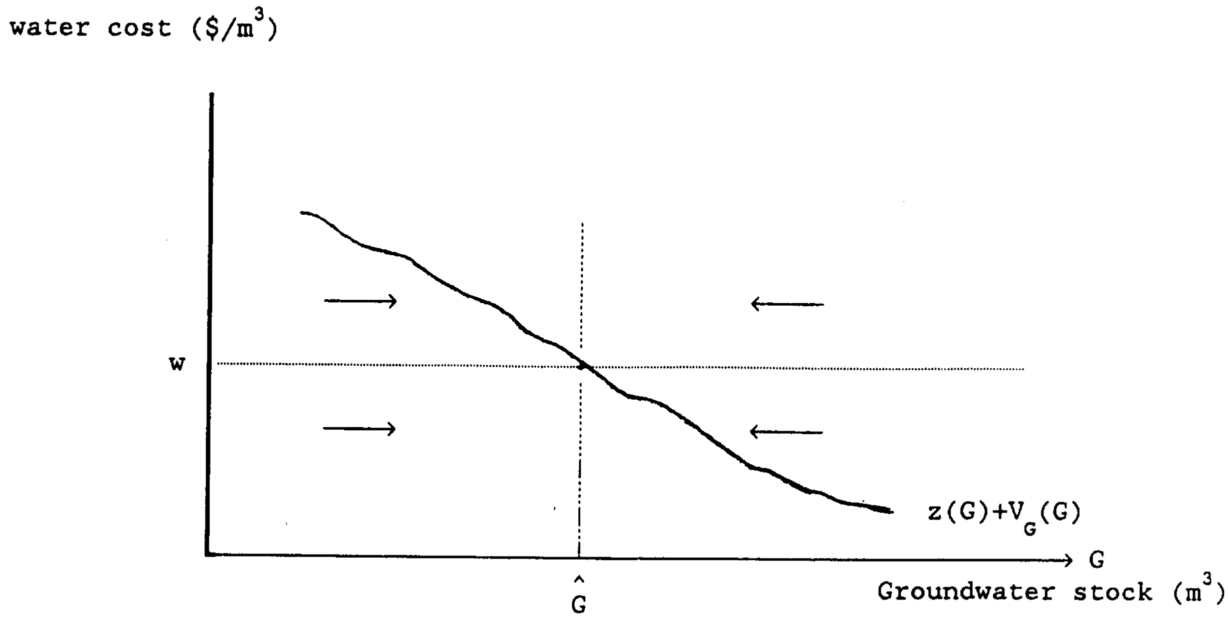

Figure 3.

A conjunctive Ground and surface water system with drainage.

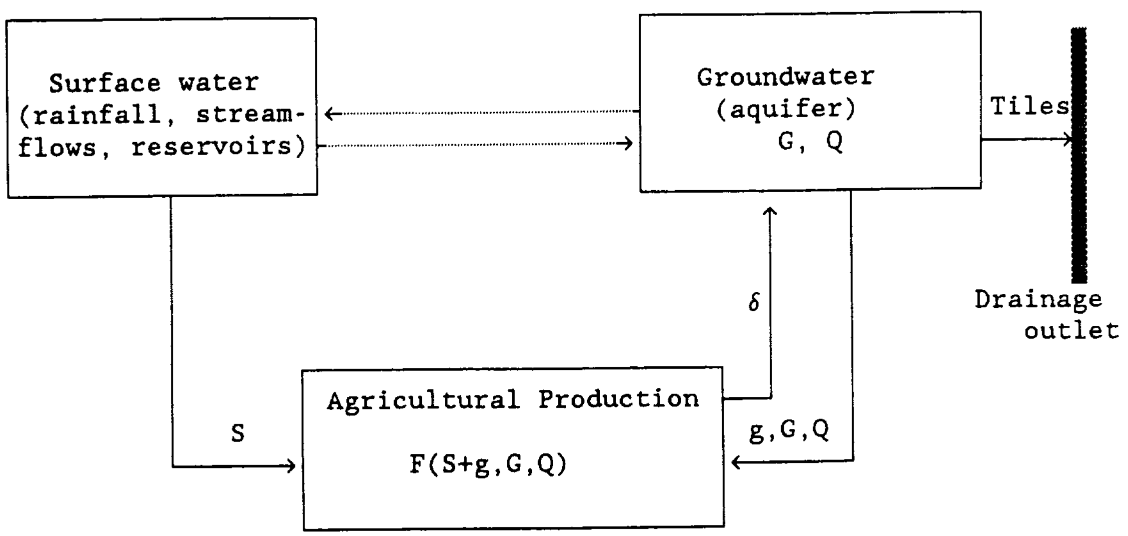

Figure 4.

Dynamic behavior of the solution of Section 4.